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TUNNELING: AN ANNOTATED BIBLIOGRAPHY WITH PERMUTED-TITLE AND KEY-WORD INDEX

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Trivial Word List

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TUNNELING: AN ANNOTATED BIBLIOGRAPHY WITH PERMUTED-TITLE AND KEY-WORD INDEX

G. A. Cristy and C. B. Brooks

Work supported by the Department of Housing and Urban Development and the U.S. Atomic Energy Commission under Interagency Agreement No. IAA-H-2-69 AEC 40-155A-68

DECEMBER 1970

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee
operated by
UNION CARBIDE CORPORATION
for the
U.S. ATOMIC ENERGY COMMISSION

Printed in the United States of America. Available from
National Technical Information Service
U.S. Department of Commerce, Springfield, Virginia 22151
Price: Printed Copy $3.00; Microfiche $0.65

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TUNNELING: AN ANNOTATED BIBLIOGRAPHY WITH PERMUTED-TITLE AND KEY-WORD INDEX

Introduction

The Oak Ridge National Laboratory undertook a study of tunneling problems with the goal of determining the research and development required to be performed in the near future to assure that the U.S. Department of Housing and Urban Development could meet its goals for rapid and economical underground installation of utilities in the urban areas without disturbing the surface users. As part of that study a review of the literature on tunneling was performed.

This Bibliography includes approximately 1200 articles and a dozen books, most of which were published between 1955 and early 1970. A few older articles and books with special significance to the subject were included. Essentially all of the abstracts included were written specifically for this bibliography.

The coverage in the abstracts reflects an emphasis on small diameter tunnels in urban areas. Many articles are included which are only indirectly related to tunneling, but are connected to subsystems involved in tunnel construction and utilization. A number of foreign articles are included, because of special areas of interest. For example, articles on hydraulic coal mining in Russia are included because of the recent interest at ORNL on the high-pressure hydraulic jet method of cutting rock. Some drilling references are included because of their relationship to the determining of rock properties and the direct bearing the

drilling industry has on tunneling; particularly in the field of blast hole drilling and the design of cutters for mechanical tunneling machines.

Copies of most of the articles and books referenced are on file in the Oak Ridge National Laboratory. While copies cannot always be furnished in answer to requests, help in obtaining them will be provided.

Bibliography Section

The references in this section are grouped into nine major fields which are identified by the first digit of the acquisition number:

0. General Interest and Historical
1. Geology and Rock Mechanics
2. Rock Disintegration Methods
3. Ground Control and Linings
4. Materials Handling
5. Environmental Control and Safety
6. Cost Estimates and Tunneling Records
7. Mechanical Tunneling Devices
8. Miscellaneous

Methods of publication are grouped into eight minor fields which are identified by the second digit of the acquisition number:

1. Commercially published book
2. Proceedings of symposia
3. Bound report published by or for a branch of government
4. Articles published in a technical journal with author identified
5. News articles and editorials
6. Company brochures
7. Correspondence
8. Patents

The nine digit acquisition number is divided into three parts separated by hyphens as shown in Figure 1. The first portion is a

FIELD YEAR MONTH ACQUISTION NUMBER CORPORATE AUTHOR KEYWORDS

02-68-05001 TUNNEL AND SHAFT SYSTEMS TODAY AND TOMORROW (EXCAVATION SYSTEMS DRILLS MUCKING BLASTING)
JACOBS, J. D. & JACOBS ASSOCIATES
TUNNEL AND SHAFT CONFERENCE, UNIVERSITY OF MINNESOTA, 16 PAGES, MAY 15, 1968. A GENERAL DISCUSSION OF ALL ASPECTS OF TUNNELING, INCLUDING DISINTEGRATION OF ROCK, PERCUSSION DRILLS, BLASTING, TUNNELING MACHINES, AND MUCK HANDLING. NEW TECHNIQUES IN THE ART OF TUNNELLING SUCH AS THE MAGIC CARPET METHOD ARE DESCRIBED. TUNNELS SMALLER THAN 11 OR 12 FT. IN DIAMETER RESTRICT THE SIZES OF EQUIPMENT TO THE EXTENT THAT UNIT OPERATING COSTS ARE GREATLY INCREASED. THE UNIT OPERATING COST TEND TO DROP WITH THE INCREASING LENGTH OF TUNNEL.

two digit number which represents the major field and the type of publication with the digits having the significance indicated above. The second portion is a two digit number which is the same as the last two digits in the year of publication. The third portion is a five digit field, the first two of which represent the month of the date of publication (e.g. January = 01, February = 02, etc.). The last three digits are serial numbers assigned (arbitrarily) to each document.

The assignment of documents to major fields was done at the discretion of the authors. In many cases more than one field was indicated. When this happened an attempt was made to assign the document to the field where it was most applicable and to include key words which would assist in retrieval from the other pertinent fields. Because of the overlapping of fields and the inclusion of material in articles from several fields, it is recommended that the key word index be used as the major approach to locating data for specific fields.

Bibliographic information includes the title, key words, authors, corporate affiliation of the principal author, reference, and the abstract. The key words added to the title by the authors are enclosed in parentheses to indicate that they are not part of the title.

Bibliography

FIELD 0 GENERAL INTEREST AND HISTORICAL

FIELD 01 BOOKS

01-78-00001 TUNNELING, EXPLOSIVE COMPOUNDS, AND ROCK DRILLS
DRINKER, H. S.
JOHN WILEY AND SONS, 1878. A HISTORY OF TUNNELING FROM THE REIGN OF RAMESES II TO NINETEENTH CENTURY, DETAILS OF PRACTICAL TUNNEL WORK, MODERN EXPLOSIVE COMPOUNDS, PRINCIPLES OF BLASTING, DESCRIPTION OF ROCK DRILLS AND COMPRESSORS, DESCRIPTION OF EUROPEAN AND AMERICAN SYSTEMS OF TIMBERING AND ARCHING, TABLES GIVING DIMENSIONS AND COST OF OVER 1700 TUNNELS IN EUROPE, NORTH AND SOUTH AMERICA, AND NEW ZEALAND. 1031 PAGES, 1086 FIGURES, 19 PLATES, 145 TABLES, 2 APPENDICES.

01-59-00001 TUNNEL ENGINEERING (HISTORICAL LINING-METHODS SHIELD-TUNNELING SUBAQUEOUS ROCK DIFFICULT-GROUND SURVEYING DESIGN ALIGNMENT GROUTING)
HAMMOND, R.
THE MACMILLAN CO., NEW YORK, 1959. THIS IS A COMPREHENSIVE SURVEY OF TUNNELING METHODS, WHICH INCLUDE THE TECHNICAL DEVELOPMENTS WHICH HAVE AFFECTED TUNNELING PRACTICE IN RECENT TIMES. VARIOUS CHAPTERS DISCUSS (1) THE HISTORY OF TUNNELING, (2) TUNNEL LINING METHODS, (3) METHOD OF SHIELD TUNNELING, (4) SUBAQUEOUS TUNNELING, (5) ROCK TUNNELING, (6) TUNNELING THROUGH DIFFICULT GROUND, (7) SURVEY METHODS, (8) CHARACTERISTICS AND PROBLEMS ENCOUNTERED IN DRILLING LONG TUNNELS. MANY ACTUAL PROJECTS ARE USED FOR ILLUSTRATION OF THE PRACTICES AND PRINCIPLES OF TUNNELING. 113 ILLUSTRATIONS, 32 REFS.

01-60-00001 TUNNELS (CANAL RAILROAD SUBWAY AUTOMOBILE WATER SEWAGE)
BOARDMAN, F. W., JR.
HENRY Z. WALCK, INC., NEW YORK, 1960. NATURE HAS BEEN FORMING TUNNELS AND CAVES SINCE THE WORLD BEGAN. PREHISTORIC MAN USED THEM. IN THE BRONZE AND IRON AGES TUNNELS WERE DUG TO QUARRY STONE AND MINE METALS FOR TOOLS AND WEAPONS. LATER WATER SUPPLY AND IRRIGATION TUNNELS WERE DUG. TODAY TUNNELS ARE CONSTRUCTED FOR RAILWAYS, CANALS, AUTOMOBILES, WATER AND SEWAGE, HYDROELECTRIC POWER AND ATOMIC RESEARCH. THE DEVELOPMENT OF TOOLS AND TECHNIQUES OF TUNNEL BUILDING AND THE SAFEGUARDS DEVISED TO ELIMINATE DANGERS ARE RELATED. A PICTORIAL HISTORY OF TUNNELS AND TUNNEL CONSTRUCTION OVER THE LAST ONE AND ONE HALF CENTURIES. 139 PAGES.

01-63-00001 TUNNELS (ADVANCE COST EQUIPMENT SURVEYING EXPLOSIVES SUPPORT DRILLING)
SANDSTROM, G. E.
HOLT RINEHART & WINSTON, NEW YORK, 1963. A COMPREHENSIVE REVIEW OF THE HISTORY OF TUNNELING FROM THE DAWN OF TIME WHEN RULERS DROVE THEIR SUBJECTS UNDERGROUND TO THE PRESENT DAY WHEN TUNNELING, REVOLUTIONIZED BY MODERN TECHNOLOGY, CONFRONTS NEW ENTERPRISES WITH INCREDIBLE PROBLEMS AND HAZARDS OF THEIR OWN. HIGHLIGHTS OF MAN'S UNDERGROUND SEARCH FOR WATER ARE GIVEN. THE RAILROAD USHERED IN THE GREAT AGE OF TUNNELS. VARIOUS TUNNELING METHODS ARE EXPLAINED. DETAILED ACCOUNTS OF FAMOUS TUNNELS ARE RELATED INCLUDING SUBAQUEOUS TUNNELING AND THE SUBWAYS OF LONDON AND NEW YORK. TUNNEL SURVEYING, THE STRANGE STORY OF EXPLOSIVES, ROCK DRILLING MACHINES, TOOLS FOR A NEW AGE AND UNDERGROUND POWER ARE DISCUSSED. IN THE U.S. AS COMPARED TO EUROPE SPEED IS AT A PREMIUM OVER COST. THE U.S. USES MORE MEN AND MACHINERY AT THE FACE, HAS A POORER POWDER FACTOR AND PULLS LESS WITH EACH SHOT WHICH GIVES A HIGHER COST PER FOOT BUT THEY ADVANCE ALMOST THREE TIMES AS FAST.

01-64-00001 EXCAVATION SCIENTIFIC AND TECHNICAL APPLICATIONS FORECAST - 1964
HUGHES TOOL CO HOUSTON TEX
OFFICE OF THE CHIEF OF RESEARCH AND DEVELOPMENT DEPT OF THE ARMY, WASH D.C. 1964. A STUDY BY HUGHES TOOL CO. OF THE PRESENT STATE OF THE ART OF THE EXCAVATION FIELD, A FORECAST OF NEW TECHNICAL APPLICATIONS AND A PLAN OF RESEARCH TO FULFILL THE FORECAST. INDIVIDUAL CHAPTERS ARE ABSTRACTED IN ENTRIES 03-64-00001 THRU 03-64-00008.

01-65-00001 STANDARD METHOD OF TEST FOR COMPRESSIVE STRENGTH OF NATURAL BUILDING STONE
ASTM STANDARDS, AMERICAN SOCIETY FOR TESTING MATERIALS 1965 ED. THE METHOD COVERS THE SAMPLING, PREPARATION OF SPECIMENS, AND PROCEDURE FOR DETERMINING THE COMPRESSIVE STRENGTH OF NATURAL BUILDING STONE.

01-67-00001 THE ART OF TUNNELLING (THEORY DESIGN CONSTRUCTION)
SZECHY, K. & TECH UNIV ENGR - BUDAPEST
AKADEMIAI KIADO BUDAPEST, 1967. THIS BOOK GIVES COMPREHENSIVE COVERAGE OF TUNNELING THEORY, DESIGN AND EXECUTION BASED ON A CRITICAL COMPILATION OF RECENT LITERATURE. SIGNIFICANCE OF TUNNELING IN TRANSPORTATION AND ECONOMY IS VERY GREAT AND SHOWS A TENDENCY TO INCREASE. TODAY TUNNELS ARE CONCERNED MAINLY WITH HIGHWAY, UNDERGROUND RAILWAY, WATER-SUPPLY, HYDROELECTRIC PRESSURE OR DIVERSION AND PUBLIC UTILITIES. LATEST UNDERGROUND STRUCTURES OF EVER GROWING IMPORTANCE ARE STORES, GARAGES, PARKING FACILITIES AND VARIOUS TYPES OF SUBWAYS, UNDERPASSES AND EXPRESSWAYS. A DETAILED PRESENTATION IS GIVEN OF PRELIMINARY STUDIES AND GENERAL DESIGN CONSIDERATIONS; ANALYSIS OF LOADS ON TUNNELS AND UNDERGROUND STRUCTURES; DESIGN OF TUNNEL SECTIONS AND CONSTRUCTION AND DESIGN OF TUNNELS. THIS TEXT CLOSES WITH A CHAPTER ON SERVICE, OPERATION AND MAINTENANCE OF TUNNELS. SHIELD TUNNELING IS GIVEN EXTENSIVE TREATMENT. DESIGN DATA ON 31 "REMARKABLE TUNNELS" ARE TABULATED. COST DATA ARE TABULATED FOR 19 OF THESE. 882 PAGES.

01-70-00001 RAPID EXCAVATION - PROBLEMS AND PROGRESS - PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968.
YARDLEY, D. H. & UNIV MINN MINNEAPOLIS MINN
SOCIETY OF MINING ENGRS OF AIMM & PE NEW YORK 1970. THIS BOOK CONTAINS ARTICLES PRESENTED AT THE TUNNEL AND SHAFT CONFERENCE UNIV MINNESOTA, MAY 15-17, 1968. FOR INDIVIDUAL ARTICLES (CHAPTERS) SEE: 02-70-00001 TO 02-70-00009 ; 12-70-00001 TO 12-70-00004 ; 22-70-00001 ; 32-70-00001 TO 32-70-00004 ; 52-70-00001 TO 52-70-00003 ; 72-70-00001 TO 72-70-00013.

FIELD 02 SYMPOSIA

02-56-04001 SOME VIEWS AND TRENDS IN MINING RESEARCH (DRILLING ROCK-BREAKAGE)
REED, J. J. & ST. JOSEPH LEAD CO
QUARTERLY OF THE COLO SCHOOL OF MINES FIRST SYMP ON ROCK MECHANICS, (51) N 3, 13-18, JULY 1956. A MINING RESEARCH DEPT SHOULD DEVELOP A QUANTITATIVE KNOWLEDGE OF THE FUNDAMENTALS OF THE MINING OPERATIONS WITH WHICH TO SUPPLEMENT THE EXPERIENCE OF THE OPERATING DEPARTMENTS AND ALSO TO DELVE INTO THE AREAS BEYOND THE REALM OF EXPERIENCE IN ORDER TO DEVELOP ENTIRELY NEW PRINCIPLES AND METHODS OF OPERATION. THE RESEARCH PROJECTS ACTIVE AT PRESENT ARE: FUNDAMENTAL ROCK BREAKAGE WITH EMPHASIS ON INCREASING THE EFFICIENCY OF PRIMARY ROCK BREAKING IN ALL PHASES OF MINING OPERATIONS; ROCK MECHANICS STUDIES OF SPECIFIC AREAS OF PROGRESSIVELY CAVING GROUND, OR AREAS WHERE PILLAR RECOVERY OR REPLACEMENT IS PLANNED; ROCK MECHANICS INSTRUMENTATION TO DEVELOP SUITABLE INSTRUMENTS FOR ANY MEASUREMENTS WHICH MUST BE MADE. EMPHASIS IS ON INSTRUMENTS FOR STRESS OR STRAIN MEASUREMENT IN THE ROCK OR CONCRETE STRUCTURE OF THE MINES SUCH AS A RECENT STRESS METER DEVELOPED BY PROF. POTTS IN ENGLAND AND A STRAIN METER DEVELOPED BY CANADIAN DEPT OF MINES AND

TECHNICAL SURVEYS; CONCRETE PILLAR PRE-LOADING TO DEVELOP A MEANS TO LOAD CONCRETE PILLARS IN THE MINES TO A LARGE PROPORTION OF THEIR ULTIMATE CAPACITY AS SOON AS THE CONCRETE IS PROPERLY CURED, ROTARY-PERCUSSION DRILLING TO DEVELOP FASTER MORE EFFICIENT MEANS OF DRILLING. A GERMAN DRILL IS BEING IMPORTED TO TEST THE PRACTICALITIES AND ADVANTAGES OF ROTARY-PERCUSSION DRILLING. FUTURE PROJECTS MAY INCLUDE IMPROVED PILLAR WRAPPING, PILLAR RECOVERY, FILLING STUDIES, AND HYDRAULIC HOISTING.

02-59-07001 TUNNELING IN THE U.S.A. (HARD-ROCK MECHANIZATION LABOR-COSTS DRILLING EXPLOSIVES MANAGEMENT MINING-ORGANIZATION)
KIMBALL, S. & HENRY J. KAISER CO OAKLAND
INST OF MINING ENGRS PROC OF THE SYMP ON SHAFT SINKING AND TUNNELING PAPER, N 18, 253-263, JULY 16, 1959. HARD ROCK TUNNELING METHODS USED BY AMERICAN ENGRS ARE DISCUSSED WITH PARTICULAR REFERENCE TO THE POLICIES OF MECHANIZATION TO OFFSET HIGH LABOR COSTS. STANDARD TUNNELING PRACTICES ARE DISCUSSED. SOME OF THE MAJOR ITEMS OF EQUIPMENT DESCRIBED AS WELL AS EXPLOSIVES USED AND VENTILATION SYSTEMS ADOPTED. TUNNEL TRANSPORT SYSTEMS AND EQUIPMENT ARE DISCUSSED. REFERENCE IS MADE TO THE IMPORTANCE OF MANAGEMENT TO THE PHYSICAL AND ECONOMIC SUCCESS OF TUNNELING. THE ADVANTAGE OF CORRECT MINING ORGANIZATION IS STRESSED. SOME OF THE MAIN AMERICAN TUNNELING ACHIEVEMENTS ARE BRIEFLY PRESENTED.

02-59-07002 TUNNELING IN THE UNITED STATES OF AMERICA (HARD-ROCK VENTILATION MUCKING DRILLING EXPLOSIVES JUMBO)
KIMBALL, S. & HENRY J. KAISER CO OAKLAND
PROCEEDINGS OF THE SYMPOSIUM ON SHAFT SINKING AND TUNNELING, 253-263, JULY, 1959 (THE INSTITUTION OF MINING ENGINEERS, 1960). THE HARD ROCK TUNNELING METHODS OF AMERICAN ENGINEERS ARE DISCUSSED WITH REFERENCE TO MECHANIZATION POLICIES TO OFFSET HIGH LABOR COSTS. MAIN DRILLING OPERSTIONS ARE DESCRIBED AND MAJOR ITEMS OF EQUIPMENT SUCH AS THE MOVABLE DRILL PLATFORM "JUMBO" ARE EXAMINED. DESCRIPTIONS OF METHODS OF BLASTING, VENTILATION, AND MUCK TRANSPORT ARE ALSO GIVEN. THE IMPORTANCE OF FIRST-CLASS MANAGEMENT AND CORRECT MINING ORGANIZATION IS STRESSED. SUCH MAIN AMERICAN TUNNEL ACHIEVEMENTS AS THE CLEAR CREEK TUNNEL IN NORTHERN CALIFORNIA ARE SURVEYED. A BRIEF DISCUSSION AND A DIAGRAMMATIC DRAWING OF A JUMBO DRILL ARE INCLUDED AT THE END OF THE PAPER.

02-59-07003 TUNNELING IN THE COAL MINES OF WESTERN GERMANY (EXCAVATION STONE-DRIFTS SYSTEMS METHODS DRILLING BLASTING VENTILATION MUCKING GROUND-SUPPORT MECHANIZATION
MIDDENDORF, H. & MATHIAS STINNES A.G.
PROCEEDINGS OF THE SYMPOSIUM ON SHAFT SINKING AND TUNNELING, 264-300, JULY, 1959 (THE INSTITUTION OF MINING ENGINEERS, 1960). DISCUSSION OF ALL ASPECTS OF TUNNELING METHODS, INCLUDING DRILLING, SHOTFIRING, GROUND SUPPORT, AND VENTILATION EQUIPMENT. THE IMPORTANCE OF MECHANIZED LOADING IS STRESSED. FULLY MECHANIZED OPERATIONS WOULD MAKE POSSIBLE ADVANCES OF OVER 200 M PER MONTH. THE NECESSITY FOR THOROUGH ORGANIZATION IN TUNNELING OPERATIONS IS EMPHASIZED.

02-59-07004 TUNNELING IN CANADA (JUMBO BLASTING SUPPORTS MUCKING VENTILATION DUST)
TWIDALE, M. A. + IGNATIEFF, A. & CANADA DEPT MINES OTTAWA CANADA
PROCEEDINGS OF THE SYMPOSIUM ON SHAFT SINKING AND TUNNELING, 332-349, JULY, 1959 (THE INSTITUTION OF MINING ENGINEERS, 1960). CANADIAN TUNNELING OPERATIONS ENCOUNTER A WIDE RANGE OF MINERAL DEPOSITS AND ROCK TYPES. THREE WIDELY DIFFERENT TUNNELING PROJECTS ARE DESCRIBED: THE 3445-FT PRINCESS COLLIERY TUNNEL, DRIVEN THROUGH STRUCTURALLY WEAK AND WATER-BEARING SEDIMENTS; THE KEMANO HYDRO-ELECTRIC TUNNEL, WHICH IS 40 FT WIDE, 1550 FT LONG, AND SOME 317 FT ABOVE BEDROCK, DRIVEN THROUGH IGNEOUS ROCK AND RATED AS THE THIRD HIGHEST OF ITS TYPE IN THE WORLD; AND THE GECO COPPER ZINC MINE DEVELOPMENT, OF MEDIUM SIZE, AT SHALLOW DEPTH IN COMPETENT ROCK.

02-59-07005 METHOD STUDY APPLIED TO SHAFT SINKING AND TUNNELING IN COAL MINES IN GREAT BRITAIN (RESEARCH-STUDIES SYSTEMS)
BOOTH, J. N. + WATT, R. G. & NATIONAL COAL BOARD ENGLAND
PROCEEDINGS OF THE SYMPOSIUM ON SHAFT SINKING AND TUNNELING, 350-368, JULY, 1959 (THE INSTITUTION OF MINING ENGINEERS, 1960). THE APPLICATION OF METHOD STUDY TO SHAFT SINKING AND TUNNELING IN THE RECONSTRUCTION PROGRAM OF THE NATIONAL COAL BOARD IS OUTLINED. THE DEVELOPMENT OF METHOD STUDY AND OPERATIONAL RESEARCH WITHIN THE ORGANIZATION OF THE BOARD IS DISCUSSED AND THEIR COMPLEMENTARY FIELDS OF OPERATION ARE INDICATED. EXAMPLES ARE GIVEN OF ACTUAL STUDIES INDICATING THE FACILITY WITH WHICH METHOD STUDY TECHNIQUES SHOW UP FACTORS WHICH LIMIT PERFORMANCE EVEN IN CASES OF APPARENTLY EFFICIENT OPERATIONS.

02-59-07006 TUNNELING IN BRITISH COAL MINES (EXCAVATION-METHODS SYSTEMS)
LANSDOWN, R. F. + MCCLUNIE, W. A. & NATIONAL COAL BOARD ENGLAND
PROCEEDINGS OF THE SYMPOSIUM ON SHAFT SINKING AND TUNNELING, 183-200, JULY, 1959 (THE INSTITUTION OF MINING ENGINEERS, 1960). THROUGH THE NATIONAL COAL BOARD'S ESTABLISHMENT OF A NATIONAL DEMONSTRATION TUNNEL AND TRAINING PROGRAM, IT HAS BEEN SHOWN THAT WITH EXISTING EQUIPMENT AND A HIGH STANDARD OF ORGANIZATION 10 TO 12 YDS OF TUNNELING PER DAY CAN BE MAINTAINED OVER LONG PERIODS. GENERAL DISCUSSION OF ALL ASPECTS OF TUNNELING METHODS BEING USED IN NCB TUNNELS, INCLUDING PERCUSSIVE-ROTARY DRILLING BLASTING, SUPPORT AND LININGS, AND MUCK HANDLING. METHOD STUDY IS EMPHASIZED AS THE GREATEST CONTRIBUTOR TO HIGHER EFFICIENCY AND SPEED.

02-60-01001 EFFORTS TO DEVELOP IMPROVED OILWELL DRILLING METHODS (COST PERCUSSORS BIT-ROTARY-SPEED ROCK-ATTACK AUTOMATIC-RIGS)
LEDGERWOOD, L. W., JR. & JERSEY PROD RES CORP
PETROLEUM TRANSACTIONS, AIME FIRST API DRILLING RESEARCH SYMP BILOXI MISS, (219) 61-74, JAN 13-14, 1960. THIS PAPER REVIEWS PAST AND PRESENT DEVELOPMENT EFFORTS ON ROCK ATTACK METHODS AND DRILL STRING TRAVEL IMPROVEMENTS WITH COSTS ESTIMATED IN TENS OF MILLIONS OF DOLLARS. EFFORTS ARE AIMED AT IMPROVING DRILLING TOOLS AND METHODS THAT WILL REDUCE DRILLING COSTS. MANY UNIQUE AND UNCONVENTIONAL ROCK ATTACK METHODS ARE DISCUSSED AND COMPARED WITH DATA PRESENTED IN 22 TABLES OF DATA AND INFORMATION. SKETCHES OF TOOL TYPES AND OPERATING CONCEPTS ILLUSTRATE THE ITEMS DESCRIBED. BASIC ROCK ATTACK SCHEMES ARE DESCRIBED INCLUDING PERCUSSIVE, ROTARY-BIT, PELLET, ABRASIVE, CHEMICAL, FLAME, ELECTRIC ARC, ELECTRIC, MAGNETIC, EXPLOSIVE AND ROCKET EXHAUST. THE PAPER OFFERS RECOMMENDATION OF DIRECTION THAT RESEARCH AND DEVELOPMENT SHOULD PURSUE. 73 REFS.

02-61-00001 ROTARY DRILLING OF LARGE DIAMETER VERTICAL HOLES (HOLLOW-DRILL-STEM ROLLER-CUTTER CIRCULATING-FLUID DRILL-STRING CASING)
BAWCOM, J. W. & NORTH AMERICAN DRILLING COMPANY
THE NORTHERN OHIO GEOLOGICAL SOCIETY, SYMPOSIUM ON SALT PROCEEDINGS, 1961. THIS PAPER DESCRIBES THE BASIC PRINCIPLES OF ROTARY DRILLING AND THE PROBLEMS THAT ARE INVOLVED IN UTILIZING THESE PRINCIPLES TO DRILL LARGE DIAMETER HOLES. THE DRILLING PLANT THE FUNCTIONS AND FACTORS INFLUENCING THE DESIGN OF ITS COMPONENT PARTS ARE DISCUSSED. A STUDY OF DRILLING PRACTICES IS GIVEN WITH EMPHASIS ON HOW VARIOUS FACTORS AFFECT THE SPEED AND EFFICIENCY. SPECIFIC RECOMMENDATIONS ARE MADE FOR THE SELECTION OF TECHNIQUES THAT SHOULD BE USED TO RESULT IN THE LOWEST DRILLING COST. REFERENCES ARE MADE TO PARTICULAR PROJECTS WHERE SHAFTS WERE DRILLED USING EQUIPMENT AND PRACTICES THAT YIELDED SATISFACTORY RESULTS. THE FUNCTIONS OF THE DRILLING FLUIDS ARE OUTLINED. THE CONDITIONS TO BE CONSIDERED IN DESIGNING SHAFT LININGS ARE MENTIONED AND INSTALLATION PROCEDURES DESCRIBED. REMEDIAL MEASURES ARE OFFERED FOR VARIOUS DRILLING PROBLEMS. THE ADVANTAGES OF ROTARY DRILLING METHOD OF SHAFT CONSTRUCTION ARE SUMMARIZED.

02-61-00002 DEVELOPMENT OF CONTINUOUS BORING MACHINES FOR SALT AND POTASH UNDERGROUND MINING (KERFS CUTTER-BITS CORES THRUST PENETRATION)
MCWHORTER, C. E. & GOODMAN MANUFACTURING COMPANY
THE NORTHERN OHIO GEOLOGICAL SOCIETY, SYMPOSIUM ON SALT PROCEEDINGS, 1961. THIS PAPER IS AN ILLUSTRATED

DESCRIPTION OF THE METHODS USED IN DEVELOPMENT OF FULL FACE CONTINUOUS MINING AND LOADING MACHINES. DEVELOPMENT STARTED WITH THE USE OF SMALL SCALE LABORATORY TEST APPARATUS TO PRODUCE THE DATA NEEDED FOR BUILDING AN UNDERGROUND PORTABLE FIELD TEST MACHINE WHICH PROVED OUT THE TEST DATA AND FURNISHED ADDITIONAL KNOWLEDGE FOR CONSTRUCTING THE ULTIMATE 60 TON, 500 H.P. PRODUCTION MACHINE UNDERGROUND. APPLICATIONS OF THE MACHINE ARE DESCRIBED.

02-63-08001 DESIGN AND PERFORMANCE OF MAMMOTH POOL POWER TUNNEL (UNLINED-TUNNELS)
LAVERTY, B. R. + LUDWIG, K. R. & SO CAL EDISON CO CAL
PROCEEDINGS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS JOURNAL OF THE POWER DIVISION, 9-43, SEPT 1963. ENGINEERING CONSIDERATIONS AND DESIGN CRITERIA USED IN THE LOCATION AND DESIGN OF THE 7 1/2 MILE HYDROELECTRIC MAMMOTH POOL POWER TUNNEL IN MADESA CO. CALF PERFORMANCE OF THE UNLINED PRESSURE TUNNEL IS REVIEWED.

02-64-03001 DISCUSSION OF PAPER "DESIGN AND PERFORMANCE OF MAMMOTH POOL POWER TUNNEL"
LAVERTY, B. R. + LUDWIG, K. R. & SO CAL EDISON CO CAL
PROCEEDINGS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS JOURNAL OF THE POWER DIVISION, (90) 97-105, MARCH 1964. QUESTIONS AND ANSWERS ABOUT SUBJECT TUNNEL ON PROFILE OF INVERT, ECONOMIC DIAMETER, SURGE CHAMBER AND ROCK TRAPS, PAVED INVERT, ROCK COVER CRITERIA. (REF. 02-63-08001)

02-64-09001 SUBWAY TUNNEL CONSTRUCTION IN NEW YORK CITY (ROCK-BOLTS DRILL-AND-BLAST ROCK-FALLS)
KNIGHT, G. B. & DRAKE AND PIPER NYC
PROCEEDINGS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS JOURNAL OF THE CONSTRUCTION DIVISION, (90) N 2, PAPER 4032, 15-36, SEPT 1964. CHOICE OF EQUIPMENT TYPE AND ITS USES FOR SUBWAY TUNNEL CONSTRUCTION IN NYC ARE CONSIDERED IN DETAIL. BLASTING WAS LIMITED BY NUMBER OF POUNDS PER DELAY TO PREVENT DAMAGE TO BUILDINGS. LOW POWDER COSTS (2 1/4 LB. PER CU. YD.) WERE OFFSET TO INCREASED MUCKING COSTS BY NOT BREAKING LARGE SLABS PROPERLY. BLASTING WAS NOT ALLOWED DURING RUSH SUBWAY HOURS. SUPPORTS INCLUDED ROCK BOLTS, TEMPORARY STEEL SUPPORTS, TEMPORARY TIMBER POSTS, PERMANENT STEEL SUPPORTS.

02-64-10001 SOFT-GROUND TUNNELING: DESIGN AND CONSTRUCTION (VEHICULAR MOLES SHIELDS COSTS)
NOSKIEWICZ, T. M. + RAMSEY, J. A. & W. S. ATHINS AND ASSO TORONTO
CANADIAN GOOD ROADS ASSN., GOLDEN JUBILEE CONVENTION, 139-153, OCT 1964. TODAY THE GREATHEAD SHIELD NORMALLY CONSISTS OF A STEEL CYLINDER EXTENDING FROM THE CUTTING EDGE AT THE FRONT TO A TAIL OVERLAPPING THE TUNNEL LINING AT THE REAR. IN BAD GROUND, THIS IS STILL THE BEST METHOD. CONSIDERABLY GREATER SPEEDS ARE POSSIBLE WITH ROTARY DIGGER SHIELDS. THESE ARE EXPENSIVE ($150,000 TO $200,000); SPEED IS THEIR ASSET. MECHANICAL TUNNELING MACHINES HAVE BEEN DEVELOPED FOR TUNNELING THROUGH SOFT OR MEDIUM ROCK. COMPRESSED AIR HAS BEEN USED IN WATER-BEARING GROUND AND FOR UNDERWATER CROSSINGS. THE MAIN HAZARDS INVOLVED HERE ARE SICKNESS OF MINERS AND POSSIBLE FAILURE OF AIR SUPPLY. THESE HAVE BEEN GREATLY REDUCED BY ELECTRICALLY DRIVEN COMPRESSORS. GROUND TREATMENT HAS BEEN DEVELOPED TO DECREASE THE PERMEABILITY OF THE SOIL. CHEMICALS, CLAY, AND CEMENT ARE INJECTED INTO THE SOIL. PRECAST CONCRETE LININGS AND FLEXIBLE JOINTED TUNNEL LININGS HAVE BEEN USED SUCCESSFULLY, THE LATTER FOR THE LONDON UNDERGROUND. THE SUNKEN-TUBE METHOD MIGHT BE RULED OUT BY SUCH THINGS AS SWIFT CURRENTS OR UNSTABLE SOIL, BUT UNDER CERTAIN CONDITIONS IS THE ONLY REASONABLE SOLUTION.

02-64-10002 UNLINED TUNNELS OF THE SOUTHERN CALIFORNIA EDISON CO. (GEOLOGY ROCK MECHANICS)
SPENCER, R. W. + LAVERTY, B. R. + BARBER, D. A. & SO CAL EDISON CO CAL
PROCEEDINGS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS JOURNAL OF THE POWER DIVISION, (90) N 3, 105-32, OCT. 1964. THE DESIGN CONSTRUCTION AND OPERATING EXPERIENCE OF ELEVEN UNLINED POWER TUNNELS IN THE SIERRA NEVADA RANGE ARE SUMMARIZED. THE TUNNELS VARY IN AGE FROM LESS THAN 5 YEARS TO MORE THAN 50 YEARS AND FROM 7 FT. TO 24 FT. IN DIAMETER. TOTAL LENGTH = 42 MILES. UNDER FAVORABLE GEOLOGIC CONDITION, UNLINED TUNNELS ARE PRACTICAL TO BUILD AND MAINTAIN.

02-64-10003 CONTRACTOR'S VIEW OF UNLINED TUNNELS (GEOLOGY COST COMPETENT-ROCK BLASTING)
PETROFSKY, A. M. & MORRISON-KNUDSON CO INC
PROCEEDINGS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS JOURNAL OF THE POWER DIVISION, (90) N 3, PAPER NO. 4086, 91-104, OCT 1964. COMPETENT ROCK IS BASIC NECESSITY FOR UNLINED TUNNELS. GIVEN THIS, SIZE, SHAPE, THE ATTITUDE OF BEDDING OR JOINTING, DEPTH BELOW SURFACE, INTENDED USE AND HYDRAULIC CONSIDERATIONS CAN BE RESOLVED. THESE ITEMS AND COSTS ARE DISCUSSED IN SPECIFIC EXAMPLES OF TUNNELS BUILT BY M-K. (SEE ALSO 02-66-01001 FOR COMMENTS DURING PRESENTATION OF THIS PAPER AT THE UNLINED TUNNEL SYMPOSIUM)

02-66-01001 CONTRACTOR'S VIEW ON UNLINED TUNNELS-CLOSURE BY AUTHOR (COST SWEDISH-TUNNELS)
PETROFSKY, A. M. & MORRISON-KNUDSEN CO INC
PROC OF THE AMERICAN SOCIETY OF CIVIL ENGR JOURNAL OF THE POWER DIV, 131-132, JAN 1966. DISCUSSION OF THE PAPER (SEE REF 02-64-10001) AFTER PRESENTATION AT THE UNLINED TUNNEL SYMP. M-K COSTS COMPARED WITH ESTIMATES BY CALIF DEPT OF WATER RESOURCES METHOD. ROCK BOLTS INCREASE SOUNDNESS OF ROCK. CONTRACTORS ARE BECOMING WARY OF MAXIMUM LUMP SUM CONTRACTS.

02-66-09001 ECONOMIC CONSIDERATIONS IN THE DESIGN OF NORTHUMBERLAND STRAIT CROSSING (HIGHWAY-TUNNEL RAIL-TUNNEL COST)
CLARKE, G. T. + GORDON, E. L. M. & PUBL WORKS OF CANADA OTTAWA CAN
PROC. CANAD. GOOD RDS. ASSN. 6-9, 217-228, FEB 1966. THE NORTHUMBERLAND STRAIT CROSSING WILL CARRY A TWO-LANE HIGHWAY WHICH WILL LATER BE CONVERTED TO FOUR LANES, AND A SINGLE TRACK RAILROAD. FOUR LANES WILL BE REQUIRED IN 20 YRS. THE LENGTHS OF THE BRIDGE AND CAUSEWAY ELEMENTS WERE SELECTED ON THE BASIS OF HYDRAULIC AND ECONOMIC REQUIREMENTS; THE LENGTH OF THE TUNNEL WAS GOVERNED BY NAVIGATION OPENING AND RAILWAY GRADIENT REQUIREMENTS. THE SEVERE CLIMATIC CONDITIONS PLAYED A MAJOR PART IN DESIGN. THE TUNNEL WAS DESIGNED AS A FOUR-LANE STRUCTURE, INSTEAD OF A TWO-LANE FOR ECONOMIC REASONS. THE LOCATION CLOSE TO THE SHORE PRESENTED THE LOWEST CAPITAL COSTS. ALSO, TO LOWER COSTS, MUCH OF THE TUNNEL SECTION IS BEING FLOATED IN.

02-68-05001 TUNNEL AND SHAFT SYSTEMS TODAY AND TOMORROW (EXCAVATION SYSTEMS DRILLS MUCKING BLASTING)
JACOBS, J. D. & JACOBS ASSOCIATES
TUNNEL AND SHAFT CONFERENCE, UNIV MINN, 16 PAGES, MAY 15-17, 1968. A GENERAL DISCUSSION OF ALL ASPECTS OF TUNNELING, INCLUDING DISINTEGRATION OF ROCK, PERCUSSION DRILLS, BLASTING, TUNNELING MACHINES, AND MUCK HANDLING. NEW TECHNIQUES IN THE ART OF TUNNELLING SUCH AS THE MAGIC CARPET METHOD ARE DESCRIBED. TUNNELS SMALLER THAN 11 OR 12 FT. IN DIAMETER RESTRICT THE SIZES OF EQUIPMENT TO THE EXTENT THAT UNIT OPERATING COSTS ARE GREATLY INCREASED. THE UNIT OPERATING COST TEND TO DROP WITH THE INCREASING LENGTH OF TUNNEL.

02-68-05002 TEHACHAPI MOUNTAINS CROSSING OF THE CALIFORNIA AQUEDUCT (HISTORY GEOLOGIC-CONDITIONS CONSTRUCTION DESIGN)
WINELAND, J. A. + O'NEIL, A. L. + ARNOLD, A. B.
TUNNEL AND SHAFT CONFERENCE, UNIV MINN, 26 PAGES, MAY 15-17, 1968. THE CALIFORNIA STATE WATER PROJECT WILL TRANSPORT WATER 444 MILES FROM NORTHERN TO SOUTHERN CALIFORNIA. FOUR TUNNELS ARE USED. STEEL LINED COMBINED LENGTH OF 16,000 FEET AND RANGE FROM 12.5 TO 14 FEET IN DIAMETER. THESE ARE LOW PRESSURE TUNNELS. FOR REINFORCEMENT OF WEAK ROCK DRY MIX SHOTCRETING IS BEING USED. THE AVERAGE RATE OF ADVANCE USING SHOTCRETE IS ABOUT 49 FEET/DAY COMPARED TO 27 FEET/DAY BY CONVENTIONAL METHODS.

02-68-05003 OUTLOOK FOR FASTER TUNNELING U.S. BUR MINES WASH D.C.
HOWARD, T. E.
TUNNEL AND SHAFT CONFERENCE, UNIV MINN, MAY 15-17, 1968. A LARGE AMOUNT OF TECHNOLOGY IS NEEDED IN THE FIELD. THE

CONTRACTORS MUST BE WILLING TO INVEST IN RESEARCH ON ALL ASPECTS OF THE ART. A BETTER DEFINITION OF THE PROBLEM IS NEEDED. THE NATIONAL ACADEMY OF ENGINEERING NATIONAL RESEARCH COUNCIL COMMITTEE WILL PUBLISH A STUDY ON THE PRESENT STATE-OF-THE-ART OF TUNNELING IN THE NEXT FEW MONTHS.

02-68-10001 OVERVIEW - NAE/NRC STUDY ON RAPID EXCAVATION (EXCAVATION SYSTEMS STUDIES SUBSIDY RESEARCH)
PFLEIDER, E. P. & UNIV MINN MINNEAPOLIS MINN
PROCEEDINGS OF THE SYMPOSIUM ON R/D IN RAPID EXCAVATION, 1-1/1-10, OCT. 28 AND 29, 1968. THE COMMITTEE ON RAPID EXCAVATION DETERMINED THAT SURFACE-EXCAVATION TECHNOLOGY IS MARKEDLY IN ADVANCE OF UNDERGROUND-EXCAVATION TECHNOLOGY. BY COMPARISON, UNDERGROUND MINING IS ABOUT ONE-TENTH AS EFFICIENT AS SURFACE MINING. DUE TO MASS TRANSPORTATION NEEDS, CONSERVATION TO PRESERVE THE EARTH'S SURFACE, WATER SUPPLY, AND DEFENSE NEEDS, UNDERGROUND EXCAVATION IS EMPHASIZED. THE COMMITTEE RECOMMENDED A $200-MILLION FEDERALLY FUNDED RESEARCH PROGRAM. SUCH RESEARCH COULD CUT UNDERGROUND EXCAVATION COST 30% AND INCREASE ADVANCE RATES 200 TO 300%.

02-68-10002 THE GROWTH OF DEMAND AND TECHNOLOGY IN RAPID EXCAVATION (EXCAVATION RESEARCH SUBSIDY STUDIES)
NEWCOMB, R. T. & PENN STATE UNIV
PROCEEDINGS OF THE SYMPOSIUM ON R/D IN RAPID EXCAVATION, 2-1/2-7, OCT. 28 AND 29, 1968. EXPENDITURES ON EXCAVATION OF ALL TYPES IS ESTIMATED TO EXCEED $500 BILLION OVER THE NEXT 20 YEARS. COMMENTS ARE MADE ON THE NATIONAL ACADEMY OF SCIENCE'S PANEL WORK ON EXCAVATING REQUIREMENTS. DISCUSSION CENTERS ON THE ACCURACY OF THE PANEL'S PREDICTIONS, THE PROFITS ASSOCIATED WITH RESEARCH AND DEVELOPMENT IN CERTAIN AREAS OF EXCAVATION TECHNOLOGY, AND THE IMPORTANT RELATION BETWEEN DEMAND GROWTH AND PRIVATE RESEARCH MECHANISMS.

02-68-10003 USE OF TUNNELS IN UTILIZING REGIONAL WATER RESOURCES (AQUEDUCTS WATER-TUNNELS EXCAVATION MOLES)
BELLPORT, B. P. & U.S. BUR RECL DENVER COLO
PROCEEDINGS OF THE SYMPOSIUM ON R/D IN RAPID EXCAVATION, 3-1/3-17, OCT. 28 AND 29, 1968. THE BUREAU OF RECLAMATION HAS 158 MILES OF COMPLETED TUNNELS AND 51 MILES OF UNCOMPLETED TUNNELS. DRILLING BY ROBBINS BORING MACHINES ON THE 8.6-MILE BLANCO AND 5-MILE OSO TUNNELS IN COLORADO SET WORLD RECORDS IN EXCAVATION RATES. A NEW SINGLE-DAY RECORD FOR EXCAVATION ADVANCE WAS SET BY THE OSO TUNNEL MOLE CREWS 403 FT. BESIDES BETTER TUNNEL DESIGN. EXCAVATION, AND CONSTRUCTION, OTHER AREAS OF RESEARCH INCLUDE WEATHER MODIFICATION AND DESALTATION OF SEA WATER AND BRACKISH INLAND WATERS.

02-68-10004 COLORADO METROPOLITAN WATER SUPPLY TUNNELS (AQUEDUCTS MOUNTAINS)
BARBER, M. E. & DENVER BOARD OF WATER COMM
PROCEEDINGS OF THE SYMPOSIUM ON R/D IN RAPID EXCAVATION, 4-1/4-8, OCT. 28 AND 29, 1968. THE DENVER WATER DEPT. CURRENTLY OPERATES 39 MILES OF TUNNELS AS AN INTEGRAL PART OF ITS SUPPLY SYSTEM, INCLUDING THE 23.3-MILE HAROLD D. ROBERTS TUNNEL. FUTURE PROJECTS CALL FOR 45-50 MILES OF TUNNELS WITH 6-12 FT DIA. BECAUSE OF THE COMPLEX GEOLOGIC CONDITIONS IN MOUNTAIN AREAS THE NEED FOR MORE VERSATILE TUNNELING METHODS IS EMPHASIZED.

02-68-10005 THE CHICAGO TUNNEL PROJECT - A SOLUTION FOR THE COMBINED SEWER PROBLEMS OF AN URBAN AREA (DISPOSAL COST SEWERS)
DATTON, F. E. + BACON, W. V. & METRO SAN DIST CHICAGO
PROCEEDINGS OF THE SYMPOSIUM ON R/D IN RAPID EXCAVATION, 5-1/5-38, OCT. 28 AND 29, 1968. DISCUSSION OF A DEEP TUNNEL PROJECT WHICH WILL PROVIDE IMPROVED OUTLETS FOR OLD AND NEW SEWERS AND INTERCEPTORS, INTERCEPT, CONVEY, AND STORE SEWER OVERFLOW, AND FINALLY RELEASE THE STORED WATERS AT A REDUCED RATE. 35 CONTROL STRUCTURES AND 38 VERTICAL SHAFTS, 5-15 FT DIA WILL BE NEEDED. 31 MILES OF CONCRETE LINED TUNNELS, 6-22 FT DIA WILL CONVEY THE WATER FLOW TO STORAGE CAVERNS 35 FT X 70 FT, 185 FT APART, WITH VOLUMES OF 6600 ACRE-FT. BECAUSE OF THE SUCCESS ON PAST PROJECTS, BORING MACHINES MAY REPLACE THE OLD DRILL AND BLAST METHOD OF TUNNEL EXCAVATION.

02-68-10006 TUNNELS TO TOMORROW (TRANSPORTATION RESEARCH COST)
SHEPHARD, R. J. & S.F. BAY AREA RAPID TRAN DIST
PROCEEDINGS OF THE SYMPOSIUM ON R/D IN RAPID EXCAVATION, 6-1/6-12, OCT. 28 AND 29, 1968. NEW AND IMPROVED METHODS OF TUNNELING CAN PLAY A VITAL, POSITIVE AND BENEFICIAL ROLE IN THE FUTURE OF URBAN MASS TRANSPORTATION. UNDERGROUND TRANSIT SYSTEMS ARE NOT ONLY OUT OF SIGHT BUT ALSO OUT OF HEARING, AND LEAVE NO PERMANENT BARRIER, EITHER PHYSICAL OR PSYCHOLOGICAL. RAPID TRANSIT CAN BE OPERATED EQUALLY FEASIBLY UNDERGROUND, IN OPEN CUT, ABOVE THE GROUND ON AERIAL STRUCTURES, OR AT GRADE. HOWEVER, THE UNDERGROUND METHOD, ALTHOUGH THE MOST EXPENSIVE, IS FAVORABLE BECAUSE OF ITS LEAST DISADVANTAGES. A TYPICAL SYSTEM WOULD COST FROM $7,650,000 PER MILE FOR CUT-AND-COVER TO $67,700,000 FOR SHIELD-DRIVEN TUNNELS.

02-68-10007 USE OF RAPID EXCAVATION TECHNOLOGY IN MINING APPLICATIONS (MARKET MINING)
STEWART, R. M. & ANACONDA CO BUTTE MONT
PROCEEDINGS OF THE SYMPOSIUM R/D IN RAPID EXCAVATION, 7-1/7-13, OCT. 28 AND 29, 1968. IT IS PROJECTED THAT FROM 1965-1985 MINING EXCAVATION WILL EQUAL 319 BILLION TONS. ACCOMPANYING TABLES GIVE CLASSIFICATION AND ANALYSIS OF DOMESTIC MINING EXCAVATION IN 1965 ALONG WITH PROJECTIONS OF FUTURE YIELDS.

02-68-10008 EXCAVATION FOR UNDERGROUND NUCLEAR EXPLOSIONS (JET-DRILLING NUCLEAR-WEAPON-DETONATION BIG-HOLE-DRILLING MINING)
SMITH, W. D., JR. & U.S. ATOMIC ENERGY COMM
PROCEEDINGS OF THE SYMPOSIUM ON R/D IN RAPID EXCAVATION, SACRAMENTO STATE COLLEGE, SACRAMENTO, CALIF., 8-1/8-5, OCT 28 AND 29, 1968. ABOUT 95% OF TODAY'S BIG-HOLE DRILLING IS ACCOMPLISHED UNDER ATOMIC ENERGY COMMISSION PROGRAMS. A NEW HIGH PRESSURE JET SYSTEM SUCCESSFULLY PERMITTED DRILLING A 120 IN. DIAMETER HOLE AT 6 FT. PER HOUR IN CENTRAL NEVADA. HOWEVER, THE CIRCULATING SYSTEMS' PARTS BROKE DOWN UNDER THE PRESSURE. FURTHER UTILIZATION OF SUCH A JET SYSTEM WILL REQUIRE REDESIGNING OF THE CIRCULATING SYSTEM'S PARTS. PRESENT METHODS OF CONTINUOUS DRILLING YIELD PENETRATION RATES OF 60-75 FT. PER DAY. EXTENSIVE RESEARCH IS NEEDED TO REDUCE TIME AND COST IN BASIC DRILLING PROJECTS. THE PLOW-SHARE PROGRAM DEALS WITH THE USE OF NUCLEAR EXPLOSIVES FOR OIL AND GAS PRODUCTION, MINING, AND GENERAL EXCAVATION.

02-68-10009 THE ROAD AHEAD FOR HIGHWAY TUNNELS (DEEP-TUNNELING RESEARCH SUBSIDY)
WASHINGTON, J. D. & U.S. DEPT OF TRANS
PROCEEDINGS OF THE SYMPOSIUM ON R/D IN RAPID EXCAVATION, SACRAMENTO STATE COLLEGE, SACRAMENTO, CALIF., 9-1/9-7, OCT 28 AND 29, 1968. THE MANY DISADVANTAGES OF THE PRESENT CUT-AND-COVER METHOD OF HIGHWAY TUNNELING SUCH AS RELOCATION OF UNDERGROUND UTILITIES, PRESERVATION OF REAL ESTATE AND REMOVAL OF PRICELESS OR IRREPLACEABLE AREAS, MAKES THE NEED FOR DEEPER TUNNELS EVIDENT. EMPHASIS IS PLACED ON RESEARCH TO REDUCE COSTS OF DEEPER HIGHWAY TUNNELING.

02-68-10010 TUNNELS FOR INTER-CITY TRAVEL (TRANSPORTATION SYSTEMS COST)
LUCKE, W. N. & U.S. DEPT OF TRANS
PROCEEDINGS OF THE SYMPOSIUM ON R/D IN RAPID EXCAVATION, SACRAMENTO STATE COLLEGE, SACRAMENTO, CALIF., 10-1/10-8, OCT 1968. A VARIETY OF ADVANCED CONCEPT HIGH SPEED GROUND TRANSPORTATION SYSTEMS ARE CURRENTLY UNDER CONSIDERATION FOR USE BETWEEN WASHINGTON, D.C. AND BOSTON. TUBE SYSTEMS UNDERGROUND WOULD COST IN EXCESS OF $5 BILLION. PROBLEMS ENCOUNTERED WOULD INCLUDE GROUND WATER LEAKAGE, MUCK HAULAGE, SHAFTING, AND SAFETY DEVICES. THESE TUNNELS MAY ALSO SERVE AS CIVIL DEFENSE SHELTERS. COMPUTERS ARE BEING USED TO ANALYZE VARIOUS COSTS. DRILLING METHODS UNDER CONSIDERATION INCLUDE MOLES, LASERS, AND HIGH VELOCITY FLUID JETS.

02-68-10011 TUNNELLING ON A SMALL SCALE: PROBLEM, PROSPECTS, AND PAY-OFF (UTILITIES)
MICHAELS, R. M. & U.S. DEPT OF HUD

PROCEEDINGS OF THE SYMPOSIUM ON R/D IN RAPID EXCAVATION, SACRAMENTO STATE COLLEGE, SACRAMENTO, CALIF., 11-1/11-8, OCT 28 AND 29, 1968. THERE ARE OVER 1 MILLION MILES OF WATER AND SEWER LINES IN THE U.S. IN SUBSURFACE TUNNELS WITH ANOTHER 100,000 ESTIMATED TO BE NEEDED BY 1972. EQUIVALENT MILEAGE WILL BE REQUIRED BY OTHER UTILITIES SUCH AS GAS, ELECTRICITY, AND TELEPHONE LINES. THESE SYSTEMS ARE OF TREMENDOUS COSTS. IN ORDER TO DEVELOP TRULY EFFECTIVE AND ECONOMIC TUNNELLING TECHNOLOGY THE HUD HAS STARTED A PROGRAM TO DEFINE THE COMPLETE SYSTEMS NEEDED FOR EFFICIENT PROVISION OF UTILITY DISTRIBUTION IN URBAN AREAS. THE ELEMENTS TO BE CONSIDERED ARE AN ANALYSIS OF ALTERNATIVE DESIGNS FOR UTILITY TUNNELS, A METHOD OF PROVIDING A CONDUIT FOR THE MATERIALS OR ENERGY TO BE TRANSPORTED, AND A METHOD FOR TAPPING INTO MAIN LINES FROM THE ULTIMATE USER.

02-68-10012 APPLICATION FOR RAPID EXCAVATION IN THE CORPS OF ENGINEERS (CONSTRUCTION EXCAVATION)
RENNER, R. L. & U.S. CORPS OF ENGRS
PROCEEDINGS OF THE SYMPOSIUM ON R/D IN RAPID EXCAVATION, SACRAMENTO STATE COLLEGE, SACRAMENTO, CALIF., 12-1/12-9, OCT 28 AND 29, 1968. THE U.S. ARMY HAS A THREE-FOLD MISSION ASSOCIATED WITH CONSTRUCTION AND CONSTRUCTION METHODS, EQUIPMENT AND TECHNIQUES WHICH INVOLVE EXCAVATION PROCESSES. THOSE ARE SUPPORT OF THE FIELD ARMY, STRATEGICAL FACILITY CONSTRUCTION, AND CIVIL WORK PROJECTS. MILITARY APPLICATIONS INVOLVE EXCAVATION FOR DEEP UNDERGROUND FACILITIES SUCH AS WEAPONS SYSTEMS AND COMMAND AND CONTROL CENTERS. THE NORAD PROJECT IS IN THIS COUNTRY. EXCAVATION PROJECTS OCCUR IN SUCH MATERIAL AS HARD ROCK, PERMAFROST AND FROZEN GROUND.

02-68-10013 A REVIEW AND A CHALLENGE (WATER-CONTROL PUMPING POWER-PLANTS AQUEDUCTS)
GIANELLI, W. R. & CAL WATER RESOURCES DEPT
PROCEEDINGS OF THE SYMPOSIUM ON R/D IN RAPID EXCAVATION, SACRAMENTO STATE COLLEGE, SACRAMENTO, CALIF., 14-1/14-13, OCT 28 AND 29, 1968. THE CALIFORNIA WATER PLAN IS A COMPREHENSIVE MASTER PLAN FOR THE CONTROL, PROTECTION, CONSERVATION, DISTRIBUTION, AND UTILIZATION OF CALIFORNIAN WATERS TO MEET PRESENT AND FUTURE NEEDS. THE STATE WATER PROJECT INCLUDES 20 DAMS, 21 PUMPING PLANTS, 8 POWER PLANTS, AND NEARLY 700 MILES OF AQUEDUCTS. THE KEY WATER CONSERVATION RESERVOIR OF THE SYSTEM IS OROVILLE DAM, THE HIGHEST DAM IN THE U.S. THE POWER PLANT FOR OROVILLE IS HOUSED IN A CAVERN CARVED FROM SOLID ROCK 550X69X120 FEET. FUTURE PROJECTS INCLUDE 35 MILES OF TUNNELS WITH I.D.'S UP TO 15 FEET, 850 MILES OF CANALS REQUIRING 180 MILLION CU. YDS. OF EXCAVATION, AND DAM EMBANKMENTS WITH PLACEMENTS IN EXCESS OF 150 MILLION CU. YDS.

02-69-10001 A SYSTEMS APPROACH TO EXCAVATION (MODELS COST COMPUTERS SPEED CONTROL)
BLEDSOE, J. D. & GEONAUTICS INC
SACRAMENTO STATE COLLEGE, CAL. SECOND SYMP. ON RAPID EXCAVATION, 12-1/12-21, OCT. 16, 1969. SYSTEMS HAVE BEEN MODELED MATHEMATICALLY AND RUN ON AN ELECTRONIC COMPUTER. WITH THE POSSIBLE EXCEPTION OF HETEROGENEOUS GEOLOGIC CONDITIONS A COMPLETE TUNNELING SYSTEM CAN BE PROGRAMMED AND THE SYNTHESIS OF A MATCHED EQUIPMENT ENSEMBLE CAN HOPEFULLY BRING THE TERM "RAPID" INTO EXCAVATION. A MATHEMATICAL MODEL IMPOSES A REQUIREMENT TO UNDERSTAND THE SYSTEM AND ITS COMPONENTS IN A PRECISE AND RIGOROUS MANNER. THIS SHOULD RESULT IN MORE REFINED BIDDING AND REDUCED EXCAVATION COSTS.

02-69-10002 PROGRESS TOWARD GOALS IN RAPID EXCAVATION (OECD RESEARCH DEVELOPMENT LININGS MUCKING SUPPORT HYDRAULIC-FRAGMENTATION COMPUTER-PROGRAM)
HOWARD, T. E. & U.S. BUR MINES
SACRAMENTO STATE COLLEGE, CAL. SECOND SYMP. ON RAPID EXCAVATION, 15-1/15-6, OCT. 16, 1969. THE GOAL IS AN ORDERLY UPGRADING OF AN ENTIRE FIELD OF TECHNOLOGY TO MAKE POSSIBLE ASSEMBLY OF AN UNDERGROUND EXCAVATION SYSTEM PERFORMING SIGNIFICANTLY BETTER THAN ANY SYSTEM WE CAN PUT TOGETHER TODAY. IN A YEAR'S TIME A COMPREHENSIVE COORDINATED TUNNELING PROGRAM HAS NOT YET BEEN INITIATED BUT MUCH RESEARCH IS IN PROGRESS. TUNNEL AND SHAFT LININGS, RAPID MUCK HANDLING, NEW SOFT GROUND TUNNELING CONCEPTS, COMPUTER PROGRAMMING, HEAT ASSISTED BORING, HYDRAULIC FRAGMENTATION AND GROUND SUPPORT AND STABILIZATION ARE BEING INVESTIGATED. THE ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT IS PLANNING A JUNE 1970 MEETING IN WASHINGTON, D. C. TO ASSESS THE ART OF TUNNELING AND RECOMMEND ACTION TO STIMULATE TUNNELING.

02-69-10003 SOME COMPLICATIONS IN THE FUTURE IMPROVEMENT OF TUNNELING TECHNIQUES (GEOLOGY SYSTEMS MAINTENANCE RESEARCH AUTOMATION SEISMICS ELECTRONICS ROCK-MECHANICS)
MATHEWS, A. A. & A. A. MATHEWS INC
SACRAMENTO STATE COLLEGE, CAL SECOND SYMP ON RAPID EXCAVATION, 14-1/14-12, OCT 16, 1969. TUNNEL EXCAVATION NEEDS IMPROVEMENT. FEDERAL GOVERNMENT, INSTITUTIONS OF HIGHER LEARNING AND OTHERS ARE CONTRIBUTING THEIR STUDY, RESEARCH, DEVELOPMENT AND DISCUSSION TO IMPROVED TUNNELING. GEOLOGIC INFORMATION IS VITAL TO PLANNED CONSTRUCTION AND SEISMIC, ELECTRONIC OR OTHER METHODS SHOULD BE DEVELOPED TO GIVE CONDITIONS SEVERAL HUNDRED FEET IN FRONT OF A HEADING. A BETTER UNDERSTANDING IS NEEDED OF THE MODE OF ROCK STRESS RELIEF AND THE METHOD OF TUNNEL SUPPORT. MUCK HANDLING SYSTEMS ARE VITAL AND ARE VERY DIVERSE. A COMPLETELY AUTOMATED TUNNELING SYSTEM COULD BE DEVELOPED BUT HAS ITS MAINTENANCE PROBLEMS. THE INTIMATE INTERRELATIONSHIP OF TUNNELING ASPECTS IS RECOGNIZED. AN OPENMINDED APPROACH WILL ASSIST IN SOLVING ALL PROBLEMS.

02-70-00001 OUTLOOK FOR FASTER TUNNELING (RESEARCH)
HOWARD, T. E. & U.S. BUR MINES WASH D.C.
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 1 A BRIEF SUMMARY OF PROJECTED NEEDS FOR TUNNELING BY MINERAL PRODUCES, WATER SUPPLY AND DISPOSAL, TRANSPORTATION, AND POWER DISTRIBUTIONS. NEW TECHNIQUES ARE MENTIONED AS WELL AS THE PROBLEMS OF MAKING THE NEW METHODS COMMERCIALLY PRACTICAL. SUGGESTS THAT PROFESSIONAL SOCIETIES DEVELOP AND PUBLISH THE TECHNICAL NEEDS FOR ADVANCING THE ART. PERIODICALLY PUBLISHED REVIEWS TO CONTINUE REFINEMENT OF THE FUTURE REQUIREMENTS OF THE FIELD IS SUGGESTED.

02-70-00002 TUNNEL AND SHAFT SYSTEMS TODAY AND TOMORROW (EXCAVATION DRILLS MUCKING BLASTING)
JACOBS, J. D. & JACOBS ASSOCIATES
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 6. SEE 02-68-05001 FOR ABSTRACT.

02-70-00003 INCENTIVE APPROACHES TO TUNNEL CONTRACTS (A-LINE B-LINE BLASTING MOLE)
WOLF, W. H. + LIPPOLD, F. H. & U.S. BUR RECL DENVER COLO
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 7. THE METHOD OF PAYMENT FOR ALL TUNNELS IN U.S. BUREAU OF RECLAMATION CONTRACTS HAS BEEN STANDARDIZED INSOFAR AS THE "A" AND "B" LINES ARE CONCERNED. IN BLASTED UNSUPPORTED TUNNELS THE DISTANCE BETWEEN "A" AND "B" LINES IS 10 INCHES. A SMALLER DISTANCE WAS ESTABLISHED FOR MACHINE-BORED TUNNELS. THE NEW METHOD OF PAYMENT IS INTENDED TO ENCOURAGE CONTRACTORS TO BID EITHER WAY, DEPENDING ON THEIR JUDGMENT AS TO THE MORE ECONOMICAL METHOD.

02-70-00004 CONTRACTOR-CLIENT LEGAL PROBLEMS IN UNDERGROUND CONSTRUCTION (CLAIMS CHANGED-CONDITIONS BIDS)
CARLSEN, C. E. & CARLSEN GREINER AND LAW-MINN
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 8. UNDERGROUND CONSTRUCTION HAS ALL THE LEGAL PROBLEMS COMMON TO THE CONSTRUCTION INDUSTRY PLUS SOME UNIQUE ONES OF ITS OWN. IT IS THE MOST HAZARDOUS OF ALL CONTRACT OPERATIONS BECAUSE NO ONE CAN FORESEE ALL THE CONDITIONS THAT WILL BE MET UNDERGROUND. A NEW CHANGED CONDITION CLAUSE HAS BEEN PUT INTO EFFECT ON ALL GOVERNMENT CONTRACTS TO CORRECT THE INEQUITIES - TO THE CONTRACTOR - OF THE OLDER CLAUSE. LEGAL CONSEQUENCES TO BOTH CONTRACTOR AND OWNER ARE EXPLORED.

02-70-00005 SEIKAN UNDERSEA TUNNEL (RAILWAY GEOLOGICAL-SURVEY VOLCANIC-ROCK CONCRETE-SPRAY BORING-MACHINE MOLE)
YOKOYAMA, A. & JAPAN RWY CONSTR CORP TOKYO
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 10. SEE 02-68-04001 FOR ABSTRACT.

02-70-00006 HORIZONTAL HOLES FOR UNDERGROUND POWER LINES (DRILLS SOIL-MECHANICS COSTS MOLE)
PACNE, J. + BRUCE, W. E. + MORRELL, R. J. & U.S. BUR MINES TWIN CITIES
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 9. A PARTIAL SUMMARY OF USBM INFORMATION CIRCULAR-8392,SEPT 1968. SEE 73-68-09001 FOR ABSTRACT.

02-70-00007 THE PH METHOD OF TUNNELING THROUGH ROCK (MOLE BLAST COMBINATION-METHOD HIGH-SPEED)
VAN WALSUM, E. & PER HALL ASSOCIATES MONTREAL
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 11. SEE 76-68-10002 FOR ABSTRACT.

02-70-00008 TEHACHAPI MOUNTAINS CROSSING OF THE CALIFORNIA AQUEDUCT (SHOT-CRETE SHIELD FAULTS)
WINELAND, J. A. + O'NEIL, A. L. + ARNOLD, A. B. & CAL WATER RESOURCES DEPT
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 13. SEE 02-68-05002 FOR ABSTRACT.

02-70-00009 HIGH SPEED SHAFT SINKING IN SOUTH AFRICA (PREGROUTING DRILLING)
LAMBERT, R. N. & SHAFT SINKERS LTD JOHANNESBURG
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 15. A DISCUSSION OF THE EVOLUTION OF HIGH-SPEED SHAFT SINKING IN THE GOLD FIELDS. CIRCULAR SHAFTS HAVE REPLACED THE POPULAR SQUARE SHAFTS. SPEED OF ADVANCEMENT HAS INCREASED FROM 500 FT/MONTH IN 1951 TO NEARLY 1300 FT/MO IN 1961. EACH STEP OF THE SHAFT SINKING PROCESS IS DESCRIBED IN DETAIL. TO OBTAIN SUCH HIGH RATES CREWS MUST BE HIGHLY TRAINED AND INSTILLED WITH A TEAM SPIRIT.

02-70-06001 CONFERENCE RECOMMENDATIONS (OECD TUNNEL-DEMAND SOCIAL-BENEFIT COST)
ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT, JUNE 25, 1970. A PRECONFERENCE SURVEY PRODUCED AN ESTIMATE OF AT LEAST 13,000 KM OF TUNNELS, EXCLUDING MINING, WITH AN ACCUMMULATED VOLUME OF 300 MILLION CU M WERE CONSTRUCTED DURING THE DECADE 1960-69 AT A COST OF $1000 MILLION. IT WAS ESTIMATED THAT THESE FIGURES WOULD DOUBLE DURING THE NEXT DECADE. THE GROWING DEMAND STEMS FROM INCREASED ACTIVITIES IN ALL THE CURRENT ACTIVITIES PLUS ANTICIPATED NEW AND SPECIAL NEEDS OF THE URBAN AREAS. THE CONFERENCE WAS USED TO FOCUS ATTENTION ON THE SOCIAL REQUIREMENTS AND BENEFITS OF UNDERGROUND ALTERNATES TO TODAY CONGESTED CITIES. CONSIDERABLE PROGRESS HAS BEEN MADE IN TUNNELING TECHNOLOGY SINCE 1960, IN SOME SPECIAL CASES, COSTS AND CONSTRUCTION TIMES HAVE BEEN REDUCED AS MUCH AS 50%. BUT CONSIDERABLE IMPROVEMENT IS STILL REQUIRED. GOVERNMENT ACTION IS CONSIDERED DESIRABLE TO HASTEN THE RATE OF ADVANCE IN THE TECHNOLOGY AND IS ABSOLUTELY NECESSARY FOR THE REDUCTION OF INSTITUTIONAL INHIBITIONS TO PROGRESS AND FOR AN ADEQUATE RECOGNITION OF THE MERITS OF THE UNDERGROUND. THE CONFERENCE RECOMMENDED THAT EACH COUNTRY ESTABLISH OR DESIGNATE AN EXISTING NATIONAL AGENCY TO SERVE AS THE FOCAL POINT FOR TUNNELING ACTIVITY OF THAT COUNTRY. THIS AGENCY SHOULD (1) COLLECT AND DISSEMINATE TECHNICAL TUNNELING DATA, (2) CONTINUE TO ASSESS THE ART TO IDENTIFY NEEDS FOR RESEARCH, (3) PERFORM PERIODIC REVIEWS OF DEMAND, (4) COMPILE GEOLOGIC DATA, (5) REVIEW LEGAL RESTRAINTS AND TRADITIONAL STANDARDS, (6) STUDY CONTRACTING PRACTICES, (7) TAKE ACTION TO IMPROVE PUBLIC UNDERSTANDING OF BENEFITS OF SUBSURFACE USE, (8) REVIEW ADEQUACY OF TRAINING OF ENGINEERS IN THE FIELD, AND (9) TO PARTICIPATE IN INTERNATIONAL ACTIVITIES. THE CONFERENCE RECOMMENDED THAT EACH URBAN AREA SHOULD HAVE A SINGLE AGENCY REQUIRED TO MAINTAIN RECORDS OF PRESENT USE OF THE SUBSURFACE AND PREPARE A MASTER PLAN FOR COORDINATION. THE CONFERENCE RECOMMENDED THAT IN THE EVALUATION, COMPARISON AND CHOICE OF PUBLIC INVESTMENT, ACCOUNT BE TAKEN OF THE INDIRECT AS WELL AS THE DIRECT COSTS AND BENEFITS OF SURFACE AND SUBSURFACE ALTERNATES. THE CONFERENCE RECOMMENDED THAT EACH COUNTRY SHOULD TAKE IMMEDIATE ACTION TO PROMOTE A MORE RAPID, EFFECTIVE AND WIDESPREAD USE OF TECHNICAL ADVANCES IN THE FIELD OF TUNNELING. THE CONFERENCE RECOMMENDED THAT CLOSE WORKING TIES BE ESTABLISHED BETWEEN NATIONAL FOCAL AGENCIES SO THAT INTERNATIONAL EFFORTS COULD BE DIRECTED TOWARD BETTER COORDINATION AND DISSEMINATION OF INFORMATION AND FOR DEVELOPMENT OF INTERNATIONAL STANDARDS.

FIELD 03 GOVERNMENT REPORTS

03-60-08001 SOURCES OF INFORMATION ON ROCK - PART II SYMPOSIA ON ROCK BEHAVIOR (BIBLIOGRAPHY)
BURGIN, L. & COLO SCHOOL OF MINES GOLDEN COLO
COLO SCHOOL OF MINES RES FOUND INC-PROJECT NO. 391017 PREPARED FOR LAWRENCE RADIATION LAB, TID-12321-PT-2, AUG 12, 1960. A DESCRIPTION OF 21 SYMPOSIA HELD IN EUROPE AND THE U.S. ON (1) ROCK PRESSURE, (2) GROUND MOVEMENT, (3) ROCK MECHANICS MINING RESEARCH, (4) DRILLING AND BLASTING, AND (4) WAVE PROPAGATION. SPONSORS, LOCATIONS, AUTHORS OF PAPERS ARE LISTED. A BRIEF ABSTRACT OF EACH PAPER IS GIVEN. 126 PAGES.

03-61-01001 SOURCES OF INFORMATION ON ROCK PHYSICS - PART III (BIBLIOGRAPHY PHYSICAL-PROPERTIES WAVE-PROPAGATION ROCK-MECHANICE)
BURGIN, L & COLO SCHOOL OF MINES GOLDEN COLO
COLO SCHOOL OF MINES RES FOUND INC-PROJECT NO. 391017 PREPARED FOR LAWRENCE RADIATION LAB, TID-12321-PT-3, JAN 20, 1961. A LIST (BY AUTHORS NAME) OF REFERENCES ON (1) PHYSICAL-PROPERTIES OF ROCK (2) WAVE-PROPAGATION (3) ROCK-MECHANICS AND RELATED SUBJECTS TAKEN FROM PUBLICATIONS APPEARING SEPT-DEC 1960 PLUS A FEW OLDER ARTICLES BECOMING AVAILABLE ONLY AT THAT TIME. SOME ARE ABSTRACTED, MOST ARE NOT. 447 REFS.

03-61-02001 SOURCES OF INFORMATION ON ROCK PHYSICS - PART IV CURRENT LITERATURE JAN 1961 (BIBLIOGRAPHY)
BURGIN, L. & COLO SCHOOL OF MINES GOLDEN COLO
COLO SCHOOL OF MINES RES FOUND INC-PROJECT NO. 391017 PREPARED FOR LAWRENCE RADIATION LAB, TID-123321-PT-4, FEB 28, 1961. AN AUTHOR INDEX OF SOME 800 TO 900 ARTICLES WHICH RELATE TO PHYSICAL PROPERTIES OF ROCK, ROCK MECHANICS, WAVE PROPAGATION FROM DEC 1960 AND JAN 1961 JOURNALS AND INDEXES PLUS FOREIGN EXCHANGE LITERATURE RECEIVED BY COLO

SCHOOL OF MINES.

03-63-07001 DEEP EXCAVATION TECHNIQUES FOR SHELTERS IN URBAN AREAS (TUNNELS TECHNIQUES EQUIPMENT PLANNING COST-FACTORS GEOLOGICAL-CONDITIONS WATER-CONTROL)
DELEUW CATHER AND CO CONSULTING ENGINEERS PREPARED UNDER CONTRACT WITH THE CHIEF OF ENGRS U.S. ARMY FOR THE OFFICE OF CIVIL DEFENSE U.S. DEPT OF DEFENSE CONTRACT N DA-49-129-ENG-507, JULY 1963. A DISCUSSION OF SUBSURFACE CONDITIONS, EXCAVATING TECHNIQUES AND COST FOR EXCAVATION IN OPEN CUT AND TUNNELS IN EARTH AND ROCK. PRESENTED ARE FINDINGS, EVALUATIONS AND ANALYSES DEVELOPED FROM ENGINEERING STUDIES OF DEEP EXCAVATION TECHNIQUES SUITABLE FOR SHELTERS IN URBAN AREAS. THE STUDIES BROADLY ILLUSTRATE APPLICATION OF APPROPRIATE TECHNIQUES OF EXCAVATION TO GENERAL SUBSURFACE CONDITIONS WHICH OCCUR IN THE CONTINENTAL U.S. SPECIFIC SUBSURFACE CONDITIONS FOR OPEN CUT EXCAVATIONS AND GENERAL PARAMETERS FOR TUNNEL EXCAVATIONS ARE ESTABLISHED TO PROVIDE A PRACTICABLE RANGE OF STUDY RESULTS. THESE CONDITIONS ARE ANALYZED INDIVIDUALLY FOR THE TYPE AND GEOMETRY OF THE EXCAVATION FOR EVALUATION OF AN EFFECTIVE AND ECONOMICAL TECHNIQUE AND FROM THAT EVALUATION, THE DETERMINATION OF RELATED COST FACTORS. SUMMATION OF THESE COST FACTORS AND FURTHER ANALYSIS IS PRESENTED. THE RESULTS OF REVIEW OF THE GENERAL FIELD OF EXCAVATION ARE ALSO PRESENTED. THESE INCLUDE DESCRIPTION AND EVALUATION OF MATERIALS AND EQUIPMENT THAT ARE IN COMMON USE, GENERAL WAYS

THAT HAVE PROVED TO BE OF ECONOMIC VALUES TECHNIQUES UNDER DEVELOPMENT, AND SOME UNDEVELOPED TECHNIQUES WHICH ARE PROMISING AND APPROPRIATE FOR CONSIDERATION FOR EXCAVATION. 44 SKETCHES, PHOTOGRAPHS, TABLES AND GRAPHS.

03-63-08001 URBAN UNDERGROUND HIGHWAYS AND PARKING FACILITIES (TUNNELS COSTS VENTILATING ROCK-REMOVAL LININGS ROADWAYS)
HOFFMAN, G. A. & RAND DEV CORP CLEVELAND
THE RAND CORPORATION MEMORANDUM RM-3680, CLEARINGHOUSE FOR FEDERAL SCIENTIFIC AND TECHNICAL INFORMATION, AD-601782, AUG 1963. AN EXAMINATION OF THE POSSIBILITIES FOR HIGH-VOLUME AUTOMOTIVE TRANSPORTATION IN THE CENTRAL CITY BY DEEP UNDERGROUND TUNNELS AND PARKING AREAS. COSTS OF CONVENTIONAL URBAN HIGHWAYS BUILT NEAR DENSELY POPULATED AREAS ARE DESCRIBED IN TERMS OF CONSTRUCTION, RIGHT-OF-WAY ACQUISITION, AND SOME SELECTED OPERATING COSTS. CONSTRUCTION AND VENTILATING COSTS FOR VEHICULAR TUNNELS ARE PRESENTED TO PERMIT A COMPARISON WITH THE HIGHWAY COSTS. IF EXISTING TRENDS CONTINUE, IT MIGHT BE CHEAPER BEFORE THE TURN OF THE CENTURY TO MOVE AND PARK PASSENGER CARS UNDERGROUND. ASSUMING THIS ADVANTAGE OF VEHICULAR TUNNELS, SOME DESIGN AND OPERATING FEATURES OF UNDERGROUND CONSTRUCTION AND TRAVEL ARE NEXT CONSIDERED, INCLUDING TUNNELLING MACHINES, ROCK REMOVAL, PREFABRICATED LININGS AND ROADWAYS, PROVISIONS FOR MASS TRANSIT VEHICLES, LAND RECLAMATION, EXCAVATED MATERIALS, TRAFFIC PATROL AND SURVEILLANCE AND OBSTACLE REMOVAL. EXAMPLES ARE GIVEN OF WHAT MAY BE NEEDED IF ALL MASS-TRANSIT RIDERS TRANSFERRED TO PASSENGER CARS IN LOS ANGELES, CHICAGO, AND MANHATTAN WITH SUGGESTIONS FOR FUTURE STUDY AND TECHNICAL DEVELOPMENT OF THE UNDERGROUND-HIGHWAY CONCEPT. 46 PAGES.

03-64-00001 GEOLOGICAL CONSIDERATIONS IN EXCAVATION (ROCK-TYPES RESEARCH-STUDIES)
WOOD, L. E. & ARMY RESEARCH OFFICE
SCIENTIFIC & TECHNICAL APPLICATIONS FORECAST ON EXCAVATION - 1964, 1.1.1 - 1.1.8; 2.1.1 - 2.1.3; 3.1.1 - 3.1.5, 1964. STATE OF THE ART - A DISCUSSION OF THE ARTS THREE TYPES OF ROCK; IGNEOUS, SEDIMENTARY, AND METAMORPHIC IS PRESENTED. EMPHASIS IS PLACED ON FACTORS WHICH MAY HAVE A BEARING ON THE CHOICE OF SITE OR TYPE OF EQUIPMENT TO BE USED IN THE EXCAVATION. KNOWLEDGE OF THE PHYSICAL AND MECHANICAL CHARACTERISTICS OF THE ROCK IS ALSO NECESSARY. OF PRIMARY IMPORTANCE IN STATIC RESPONSE ARE ULTIMATE STRENGTH, DENSITY, PERMEABILITY, AND ELASTIC VISCO-ELASTIC MODULE. DYNAMIC FORCE FACTORS ARE NOT WELL KNOWN. A GREAT PROBLEM IS APPLYING TEST RESULTS OF LABORATORY SAMPLES INTO LARGE SIZE SITE OPERATIONS. TECHNOLOGICAL FORECAST WITHIN TWENTY YEARS OF NORMAL PROGRESS OR 5 YEARS WITH AN ACCELERATED RESEARCH PROGRAM, WE SHOULD BE ABLE TO MAKE TUNNEL DRIVING MACHINE PERFORMANCE FORECASTS WITH 85% RELIABILITY, TO MAKE USEFUL PREDICTIONS ON OPTIMUM MACHINE FOR ROCK BORING BASED ON KNOWLEDGE OF HOW ROCK BREAKS AND TO DEVISE METHODS OF ENVIRONMENTAL CONTROL TO REDUCE SUCH HAZARDS AS ROOF FAILURES, FLOODING AND EXCESSIVE DUST. RESEARCH PLAN - RESEARCH IS NEEDED TO DETERMINE ROCK FAILURE PRINCIPLES AND THEIR EFFECT ON TOOL PERFORMANCE WHEN ATTACKING ROCK FACES IN LARGE EXCAVATIONS. THE IMPROVEMENT IN CUTTERS BY THE PRESENCE OF OTHER CUTTERS WORKING AT THE SAME TIME NEEDS TO BE STUDIED. MULTIPLE FLAME JETS MAY ALSO SHOW SIMILAR IMPROVEMENT. AN EXPENDITURE OF $1 MILLION OVER A 3 TO 5 YEAR PERIOD SHOULD MAKE THE TWENTY YEAR IMPROVEMENTS AVAILABLE IN TEN YEARS. (REF. 01-64-00001)

03-64-00002 ROTARY DRILLING (METHODS DEVICES MACHINES BITS RESEARCH)
MORLAN, E. A. & HUGHES TOOL CO HOUSTON TEX
SCIENTIFIC & TECHNICAL APPLICATION FORECAST ON EXCAVATION-1964, 1.2.1-1.2.44; 2.2.1; 3.2.1-3.3.2, 1964. STATE OF THE ART - VARIOUS SECTIONS COVER SEPARATELY ROLLING CUTTER, ROCK BITS, DIAMOND BITS, DRAG BITS, AUGERS, TURBO DRILLS, AND ELECTRO-DRILLS, WITH ANALYSIS OF CAPABILITIES AND LIMITATIONS INCLUDING PERFORMANCE ESTIMATING PROCEDURES. IN ANY OF THE VARIOUS ROTARY DRILLING METHODS, ENOUGH LOAD MUST BE APPLIED TO CAUSE THE CUTTING STRUCTURE TO PENETRATE THE FORMATION AND SUFFICIENT TORQUE MUST BE AVAILABLE TO ROTATE THE BIT. TECHNICAL FORECAST - ENGINEERING AND RESEARCH SHOULD GIVE A 20% IMPROVEMENT TO PENETRATION RATE AND TOOL LIFE BECAUSE OF THE HIGHLY COMPETITIVE MARKET. IN 20 YEARS RESEARCH WILL PROVIDE BETTER MATERIALS, NEW ANTIFRICTION BEARING CONCEPTS, NEW MEANS OF SEATING BEARINGS, NEW METHODS FOR DIRECTIONAL CONTROL THAT DOES NOT PENALIZE PERFORMANCE, KNOWLEDGE FROM ROCK MECHANICS ON EFFECTS OF ENVIRONMENT. RESEARCH PLAN THE AMOUNT OF MONEY SPENT FOR ROTARY DRILLING AND THE MANUFACTURE OF TOOLS FOR IT EXCEEDS ONE BILLION DOLLARS PER YEAR. THIS PROVIDES SUFFICIENT INCENTIVE TO COMMIT MILLIONS OF DOLLARS FOR RESEARCH AND ENGINEERING EACH YEAR ALMOST ENTIRELY WITHIN THE PETROLEUM INDUSTRY. NO GOVERNMENT SUBSIDY IS NEEDED IN THIS AREA. HOWEVER, THE CONSTRUCTION INDUSTRY SHOULD DO MORE RESEARCH IN SUPPORT OF ITS PARTICULAR NEEDS. (REF. 01-64-00001)

03-64-00003 PERCUSSION DRILLING (DRILLING-METHODS EQUIPMENT NEW-METHODS RESEARCH)
KELLY, J. L., JR. & HUGHES TOOL CO HOUSTON TEX
SCIENTIFIC & TECHNICAL APPLICATION FORECAST ON EXCAVATION-1964, 1.3.1-1.3.42; 2.3.1-2.3.3; 3.3.1-3.3.2, 1964. STATE OF THE ART - CHARACTERIZED BY THE REPEATED APPLICATIONS OF HIGH INTENSITY, SHORT DURATION FORCES (PULSES) TO FRACTURE OR CRUSH THE FORMATION, PERCUSSION DRILLING EMPLOYS THREE MECHANICAL DRILLING SYSTEMS; THE CHURN DRILL OR CABLE TOOL, THE HAMMER DRILL, AND THE VIBRATORY DRILL. THE FIRST TWO SYSTEMS HAVE BEEN USED COMMERCIALLY FOR MANY YEARS. THE LAST IS STILL ESSENTIALLY IN THE RESEARCH STAGE. COMPLETE DESCRIPTION OF EACH OF THESE SYSTEMS IS GIVEN WITH SPECIFICATIONS AND OPERATING PRACTICES. DETAILED DIAGRAMS AND PHOTOGRAPHS ARE INCLUDED. TECHNICAL FORECAST - PERCUSSION DRILLING IS ONE OF THE MOST ADVANCED TECHNOLOGIES IN DRILLING. IMPROVEMENTS WILL BE SLOW AND GRADUAL. CHURN DRILLS WILL PROBABLY DISAPPEAR COMPLETELY FROM ALL LARGE SCALE DRILLING JOBS. SURFACE HAMMERS WILL REMAIN THE STANDARD FOR 3" AND SMALLER HOLES AND WILL INCREASE IN PRODUCTIVITY BY AT LEAST 100% IN THE NEXT TWENTY YEARS. RESEARCH - THE INDUSTRY USING THESE TOOLS HAS AN ANNUAL INCOME OF MORE THAN $100 MILLION. RESEARCH WILL BE MOST PROFITABLE IN THE AREAS OF: BETTER UNDERSTANDING OF ROCK BREAKING PHENOMENA; NEW MECHANICAL PERCUSSIVE DEVICES TO GIVE MORE POWER TO THE TOOL; USE OF HIGHER AIR OR GAS PRESSURE; RESEARCH IN MATERIALS. (REF. 01-64-00001)

03-64-00004 LARGE HOLE DRILLING (DRILLING-METHODS SHAFT-SINKING TUNNELING RESEARCH)
BREDTHAUER, R. O. & HUGHES TOOL CO HOUSTON TEX
SCIENTIFIC AND TECHNICAL APPLICATIONS FORECASTS ON EXCAVATION-1964, 1.4.1-1.4.79; 2.4.1-2.4.6; 3.4.1-3.4.6, 1964. STATE OF THE ART - LARGE HOLE DRILLING IS DISCUSSED UNDER SHAFT SINKING, TUNNELING, AND RAISE DRIVING. FOR THE MAJOR PART SHAFTS ARE USED AS MINE ESCAPEWAY, MINE OPERATING OR VENTILATION SHAFTS, TUNNEL ACCESS SHAFTS, OR FOUNDATION PIER HOLES. DEPENDING UPON ULTIMATE USE OR CONVENIENCE DURING CONSTRUCTION, SHAFTS MAY BE MADE WITH SQUARE, RECTANGULAR, CIRCULAR OR ELLIPTICAL CROSS SECTIONS. THE ROTARY METHOD OF DRILLING IS DISCUSSED ALONG WITH SHAFT SINKING BY THE SINKING STAGE METHOD. TUNNELING METHODS FALL INTO TWO BASIC CATEGORIES, DRILL AND BLAST, AND MECHANICAL MOLES OR TUNNELING MACHINES. VARIOUS TYPES AND MODELS OF ROTARY MACHINES ARE DESCRIBED ALONG WITH A DISCUSSION OF RAISE DRIVING PROCEDURES, WITH MECHANICAL PLATFORMS AND BORING MACHINES. TECHNOLOGICAL FORECAST - IMPROVEMENTS IN LARGE HOLE ROTARY SHAFT DRILLING WILL GRADUALLY GAIN WIDER ACCEPTANCE FOR SHAFT SINKING OPERATIONS. SHAFT SINKING SPEED SHOULD INCREASE FROM 2 TO 5 FEET PER HOUR TO 10 TO 20 FEET PER HOUR IN 20 YEARS. OTHER METHODS OF SHAFT SINKING MAY EMERGE FROM THE LABORATORY (JET DRILLING THERMO-ELECTRIC BREAKING, JET PLASMA METHODS AND FLAME JET PIERCING ARE CANDIDATES). TUNNELING BY DRILL AND BLAST CAN BE IMPROVED 100% IN 20 YEARS. RATE OF DEVELOPMENT WILL BE BASED ON RESEARCH EFFORT APPLIED. TUNNELING BY ROTARY MACHINE METHOD MAY BE ABLE TO CUT HARDER ROCK AND MOVE FASTER DEPENDING UPON HOW MUCH DEVELOPMENT EFFORT IS INVESTED. RESEARCH PLAN - A DETAILED LIST OF RESEARCH SUBJECTS IS PRESENTED. 78 REFS. (REF. 01-64-00001)

03-64-00005 NUCLEAR EXCAVATION (ROCK-DRILLING-METHOD ROCK-DISINTEGRATION-METHODS RESEARCH)
WILLIAMSON, T. N. & HUGHES TOOL CO HOUSTON TEX
SCIENTIFIC AND TECHNICAL APPLICATION FORECAST ON EXCAVATION-1964, 1.5.1 - 1.5.20; 2.5.1 - 2.5.2; 3.5.1 - 3.5.2, 1964. STATE OF THE ART - NUCLEAR EXPLOSIONS CAN BE USED TO PRODUCE LARGE CRATERS AND UNDERGROUND CAVITIES IN THE EARTH. DATA IS PRESENTED FROM THE "PLOWSHARE" PROGRAM OF THE ATOMIC ENERGY COMMISSION. COMPARISONS ARE MADE BETWEEN CHEMICAL EXPLOSIVES AND NUCLEAR EXPLOSIONS. THUS FAR NUCLEAR WORK HAS BEEN DONE IN FIVE ROCK TYPES, ALLUVIUM, TUFF, GRANODIORITE, BASALT, AND SALT, VARYING IN COMPRESSIVE STRENGTH FROM LESS THAN 5,000 PSI FOR SALT AND ALLUVIUM, TO BETWEEN 5,000 - 10,000 PSI FOR TUFF, AND TO 30,000 PSI FOR THE GRANODIORITE AND BASALT AT THE NEVADA TEST SITE. THE

VOLUME OF MATERIAL REMOVED IN A NUCLEAR EXPLOSION VARIES ONLY ABOUT 20% FROM WEAKEST TO STRONGEST ROCK. THE SIZE OF NUCLEAR FORMED CAVITIES CAN BE ESTIMATED WITHIN AN ACCURACY OF 10% IF ROCK MATERIAL, SIZE EXPLOSIVE, AND DEPTH OF PLACEMENT ARE KNOWN. SPECIFIC HEAT AND MOISTURE CONTENT CAN AFFECT THE RESULTS OF A NUCLEAR EXPLOSION. VARIOUS CHARACTERISTICS OF UNDERGROUND NUCLEAR FORMED CAVITIES ARE DISCUSSED. PARTICULAR TEST SITES INVESTIGATED INVOLVE THE RANIER SHOT, PROJECT HARDHAT, AND PROJECT GNOME. A BRIEF DESCRIPTION IS GIVEN OF THE HAZARDS OF NUCLEAR EXPLOSIVES. DIAGRAMS AND PHOTOGRAPHS ARE INCLUDED. FURTHER SECTIONS DISCUSS FORECASTS OF NEW TECHNICAL APPLICATIONS BASED UPON KNOWN PHENOMENA AND PLANS FOR RESEARCH WHICH MUST BE CONDUCTED TO FULFILL THE FORECAST. 41 REFS. (REF. 01-64-00001)

03-64-00006 THERMAL ROCK REMOVAL (ROCK-DISINTEGRATIONS-METHOD RESEARCH-DEVELOPMENT)
SCALES, S. R. & HUGHES TOOL CO HOUSTON TEX
SCIENTIFIC AND TECHNICAL APPLICATION FORECAST ON EXCAVATION-1964, 1.6.1 - 1.6.53; 2.6.1 - 2.6.8; 3.6.1 - 3.6.8, 1964. STATE OF THE ART - FRACTURING, MELTING, AND VAPORIZING ARE THE THREE MECHANISMS USED TO REMOVE ROCK BY THE FOLLOWING THERMAL MEANS: CHEMICAL, ELECTRICAL, RADIANT, NUCLEAR, FRICTIONAL, AND USE OF A LIQUID HEAT CARRIER. JET-PIERCING, CHEMICAL HEATING, OXIDANT-FUEL, COMBUSTION TORCH METHOD, ARE THE COMMERCIALLY SUCCESSFUL MEANS OF PRIMARY THERMAL ROCK REMOVAL. A TORCH WITH A HIGHER TEMPERATURE "FLAME" THAN THE OXIDANT-FUEL JET-PIERCER MIGHT BE CAPABLE OF THERMALLY REMOVING A WIDER VARIETY OF ROCKS. SUCH METHODS AS HYDROGEN PLASMA AND HIGH-FREQUENCY ELECTRICAL CONTACT RESISTANCE HEATING MAY BE ATTRACTIVE FOR MAJOR RESEARCH FOR UNDERGROUND EXCAVATION. THERMAL REMOVAL OF ROCK BY ELECTRON BEAMS AND LASER BEAMS IS NOT ATTRACTIVE FOR RESEARCH BECAUSE OF THEIR LIMITATION TO VERY SMALL HOLES. THERMAL METHODS LOOK VERY ATTRACTIVE FOR UNDERGROUND EXCAVATION IN ICE. AN OXIDANT-FUEL TORCH OR A NUCLEAR HEATING DEVICE SHOULD BE INCLUDED IN FUTURE ICE REMOVAL RESEARCH PROGRAMS. VARIOUS PHOTOGRAPHS AND DIAGRAMS ACCOMPANY THE ARTICLE. FORECASTS OF NEW TECHNICAL APPLICATION ARE GIVEN, BASED UPON KNOWN PHENOMENA. PLANS FOR RESEARCH WHICH MUST BE CONDUCTED TO FULFILL THE FORECAST. 61 REFS. (REF. 01-64-00001)

03-64-00007 OTHER DRILLING DEVICES (NEW-DRILLING-METHODS MACHINES RESEARCH)
KELLY, J. L., JR. & HUGHES TOOL CO HOUSTON TEX
SCIENTIFIC AND TECHNICAL APPLICATIONS FORECAST ON EXCAVATION-1964, 1.7.1 - 1.7.4; 2.7.1 - 2.7.2; 3.7.1, 1964. DRILLING DEVICES WHICH HAVE NEVER BEEN DEVELOPED TO A PRACTICABLE STATE OR TO THE EXTENT THAT THEY ARE COMPETITIVE WITH CONVENTIONAL METHODS FOR EXCAVATION. ONLY BRIEF DESCRIPTIONS AND AN UNANNOTATED BIBLIOGRAPHY ARE PRESENTED. MOST OF THE MATERIAL IS FROM LEDGEWOODS ARTICLE (24-60-12001). THE RESEARCH DEVICES ARE A PELLET IMPACT DRILL WHICH IMPACTS ON THE ROCK TO CAUSE FAILURE, A SHOCK WAVE DRILL WHICH INVOLVES SHOCK WAVES WHICH TRAVEL THROUGH LIQUID TO FRACTURE ROCK, AN EXPLOSIVE DRILL EMPLOYING SHAPED EXPLOSIVE CHARGES TO DISINTEGRATE THE ROCK, AND A HYDRAULIC IMPINGEMENT DRILL UTILIZING HIGH VELOCITY WATER JETS. EXPERIMENTS IN COAL BY THE U.S. BUREAU OF MINES HAVE BEEN ENCOURAGING FOR THE HYDRAULIC IMPINGEMENT DRILL METHODS, SOME RESULTS ARE GIVEN. FORECASTS OF NEW TECHNICAL APPLICATION BASED UPON KNOWN PHENOMENA ARE GIVEN AS WELL AS PLANS FOR RESEARCH WHICH MUST BE CONDUCTED TO FULFILL THE THE FORECAST. (REF. 01-64-00001)

03-65-10001 BIBLIOGRAPHY OF EXPERIMENTAL ROCK DEFORMATION SECOND EDITION
RIECKER, R. E. + COOK, H. L. + PENDLETON, D. L.
AIR FORCE CAMBRIDGE RES LABS L. G. HANSCON FIELD BEDFORD MASS, AFCRL-65-740 AD 627 002, OCT 1965. A BIBLIOGRAPHY OF OVER 1000 ROCK DEFORMATION RESEARCH ARTICLES PUBLISHED IN SCIENTIFIC JOURNALS AND BOOKS IS PRESENTED WITH BOTH SUBJECT AND AUTHOR ENTRIES. THE CROSS-REFERENCE SUBJECT LISTINGS INCLUDE THE FOLLOWING MAJOR CATEGORIES: APPARATUS, BRITTLE BEHAVIOR, CALCITE, CALIBRATION, CONDUCTIVITY, CREEP, DISLOCATIONS, DOLOMITE, DUCTILE BEHAVIOR, ELASTIC BEHAVIOR AND ELASTIC CONSTANTS, FABRIC, FRICTION, GENERAL, ICE, MARBLE, OLIVINE, PHASE STUDIES, QUARTZ, RECRYSTALLIZATION, RESISTANCE, SAFETY, SEDIMENTARY ROCKS, SEISMIC VELOCITIES, SHEAR, SHOCK, STRAIN RATE, SURVEYS, VISCOSITY, X-RAY.

03-67-04001 TUNNEL MECHANICS (ROCK-MECHANICS SUPPORTS INELASTIC-CONTROLS ELASTIC-RESPONSE GEOLOGY BOREHOLE)
ABEL, J. F., JR. & UNIV ARIZ
QUARTERLY OF THE COLO SCHOOL OF MINES BASED ON DOCTORAL THESIS SUBMITTED IN 1966, PRINTED IN APR 1967. THIS THESIS IS BASED ON DATA ACCUMULATED AT THE STRAIGHT CREEK TUNNEL PILOT BORE OF THE COLO DEPT OF HIGHWAYS NEAR GOLDEN. THE STUDY EMPLOYS NEW TECHNIQUES AND CONCEPTS TO EXPLAIN THE MECHANICS OF TUNNELING. THE THESIS DEMONSTRATES THAT THE MEASUREMENTS OF ROCK LOADS AND STRAINS, MEASUREMENT OF CONSTRUCTION VARIABLES, AND THE DETERMINATION AND QUANTIFICATION OF THE INELASTIC GEOLOGIC PARAMETERS PRESENT IN ANY ROCK MASS MAKE IT POSSIBLE TO DESCRIBE AND TO PREDICT TUNNELING CONDITIONS. THIS DESCRIPTION OF ANY TUNNELING CONDITION IS IN THE FORM OF A STATISTICAL MODEL. THIS MODEL DESCRIBES THE CONDITION IN TERMS OF THE CONTROLLING GEOLOGIC AND CONSTRUCTION FACTORS. STATISTICAL MODELS FOR TWO TUNNEL CONDITIONS WERE CONSTRUCTED FROM DATA OBTAINED AT STRAIGHT CREEK. ONE DESCRIBES THE STEEL TUNNEL SUPPORT REQUIREMENTS IN RELATION TO GEOLOGIC AND CONSTRUCTION FACTORS. THE OTHER DESCRIBES STATISTICALLY THE VARIOUS FACTORS WHICH DETERMINE THE ELAPSED TIME BETWEEN EXCAVATION OF A TUNNEL SECTION AND INITIAL STABILIZATION OF THE ROCK MASS AT THAT SECTION. 88 PAGES, 34 FIGURES, PHOTOGRAPHS AND CURVES, 15 TABLES.

03-67-09001 PROJECTION OF APPLICATIONS AND NATIONAL BENEFITS OF A NEW RAPID EXCAVATION TECHNOLOGY (COSTS SYSTEMS-APPROACH SUBSURFACE TRANSPORTATION MINING TUNNELS)
LAGO, A. + WILLIAMS, P. D. + NISSELSON, H. & KUSHMER, H. D. & OPERATIONS RESEARCH INC
OPERATIONS RESEARCH, INC., TR NO. 446, PREPARED UNDER CONTRACT 14-09-0070-399 FOR THE BUREAU OF MINES, U.S. DEPT. OF INTERIOR, SEPT 8, 1967. THIS REPORT PRESENTS THE RESULTS OF A STUDY OF RAPID EXCAVATION TECHNOLOGY PAST, PRESENT, AND CONTEMPLATED WITH PROJECTIONS OF REQUIREMENTS FOR EXCAVATION OVER THE YEARS 1968-1969 AND ESTIMATES OF BENEFITS EXPECTED FROM EXCAVATION TECHNOLOGY DEVELOPED TO MEET THOSE REQUIREMENTS. THE STUDY USED INFORMATION FROM A SURVEY OF 19 AGENCIES IN 8 DEPARTMENTS OF THE FEDERAL GOVERNMENT IN 17 TYPES OF APPLICATIONS. COST DATA WAS TAKEN FROM AGENCY REPLIES AND PUBLISHED REPORTS OF INDIVIDUAL PROJECTS. A SYSTEMS APPROACH IS DEVELOPED AND USED TO IDENTIFY RELEVANT COMPONENTS OF COSTS. EXCAVATION SYSTEMS COST REDUCTIONS ARE BASED ON THE SOURCE INFORMATION AND ON PROJECTIONS BY THE BUREAU OF MINES OF THE MAGNITUDE AND DATA OF AVAILABILITY OF COST REDUCTIONS ACHIEVED BY A RAPID EXCAVATION TECHNOLOGY R & D PROGRAM. MOST MODES OF EXCAVATION AND THEIR COMPONENT FUNCTIONS ARE DISCUSSED. TECHNOLOGY IS THE PRIMARY ELEMENT FOR COMPARISON. BENEFITS ARE IN 4 CATEGORIES: DIRECT COST SAVINGS, PRESERVED SURFACE LAND VALUES, REDUCED SURFACE ACTIVITY DISRUPTION COSTS, AND AESTHETIC BENEFITS TO THE SURFACE ENVIRONMENT. COST BENEFITS ESTIMATED ON THE PROJECTION OF URBAN TRANSPORTATION, INTERCITY TRANSPORT, WATER-GAS-OIL SUPPLY, AND MINING AMOUNT TO $235 BILLION BY 1990. 185-PAGES, 9 FIGURES AND 53 TABLES.

03-67-12001 MINING METHODS AND EQUIPMENT ILLUSTRATED (TECHNIQUES ORE WASTES STOPES SHAFTS CAVING DRILLING BLASTING)
STOUT, K. S. & MONT COL MINERAL SCI AND TECH
STATE OF MONT BUR OF MINES AND GEOLOGY BULL., N 63, DEC 1967. THIS REPORT PROVIDES AN ILLUSTRATED DISCUSSION OF MINING METHODS AND EQUIPMENT USED IN MONT. SKETCHES AND SPECIAL TECHNIQUES ARE USED TO ILLUSTRATE THREE-DIMENSIONAL EFFECTS. THE FIRST PART DESCRIBES MAP AND SKETCH READING USED TO DESCRIBE THE MINING TECHNIQUES. THE SECOND PART ILLUSTRATES AND DESCRIBES THE SHAPE AND TYPE OF ORE BODIES WHICH INFLUENCE THE MINING METHODS CHOSEN. PICTURES OF MINE METHODS ARE USED THROUGHOUT IN CONJUNCTION WITH SKETCHES TO ENHANCE THE 3-DIMENSIONAL EFFECTS. THE THIRD PART DISCUSSES AND DESCRIBES OPERATIONS IN MINING AND SOME OF THE VARIOUS TECHNIQUES USED IN THESE OPERATIONS. THE FOURTH PART DISCUSSES DEVELOPMENT, THE WORK THAT PREPARES THE ORE FOR MINING. SINCE MINING IS LOGICALLY DIVIDED INTO SURFACE METHODS AND UNDERGROUND METHODS, THE FIFTH PART DESCRIBES SURFACE METHODS INCLUDING PLACER, OPEN PIT AND SHIPPING; AND THE SIXTH PART DESCRIBES UNDERGROUND METHODS. THE REPORT IS OF VALUE TO THOSE WHO ARE UNFAMILIAR WITH MINING OPERATIONS AND WISH TO BECOME FAMILIAR WITH THE METHODS IN GENERAL.

03-68-00001 TUNNELING TECHNOLOGY - ITS PAST AND PRESENT
NASIATKA, T. M. & U.S. BUR MINES WASH D.C.
BUREAU OF MINES, U. S. DEPT. OF THE INTERIOR, INFORMATION CIRCULAR 8375, 1968. THIS REPORT BRIEFLY DESCRIBES THE PRESENT STATE OF THE ART AND THE TECHNOLOGICAL HIGHLIGHTS OF TUNNELING FROM ITS INCEPTION TO THE PRESENT. THE

DISCUSSION IS CONCERNED PRIMARILY WITH TUNNELS DRIVEN THROUGH RELATIVELY COMPETENT ROCK FOR MINE DEVELOPMENT AND VARIOUS CIVIL PURPOSES. IN ADDITION TO PINPOINTING THE MAJOR TECHNOLOGICAL BREAK-THROUGHS IN TUNNELING THIS REPORT INDICATES THEIR GENERAL EFFECT ON THE SPEED OF TUNNELING. THE TUNNELING SPEEDS ARE BASED UPON DATA FROM APPROXIMATELY 80 TUNNELS LISTED IN THE APPENDIX. THESE DATA INCLUDE LENGTH, CROSS SECTION SHAPE AND DIMENSION, TYPE OF ROCK, TUNNELING METHOD, METHOD OF BREAKING, LOADING, AND TRANSPORTING THE ROCK, AVERAGE LINEAR PROGRESS RATE, AND COST IN VALUES DURING THE PERIOD OF CONSTRUCTION. MOST OF THE TUNNELS DESCRIBED HAVE DIAMETERS OF 15 TO 30 FEET. 75 REFS. 10 PAGES.

03-68-01001 TUNNELING THE STATE OF THE ART (COSTS MOLES SHIELDS ROCK-TUNNELS)
MAYO, R. S. & ROBERT S. MAYO ASSOCIATES
U.S. DEPT. OF HOUSING AND URBAN DEVELOPMENT, 263 PAGES, JAN 1968. A REVIEW AND EVALUATION OF THE STATE OF THE ART OF TUNNELING. RECENT DEVELOPMENTS ARE REPORTED FROM PERSONAL INSPECTION OF TUNNEL PROJECTS IN U.S.,CANADA, EUROPE,& JAPAN. REPORT ALSO CONTAINS THE RESULTS OF A LITERATURE SEARCH OF ENGINEERING PUBLICATIONS. CHAPTER 3 COMPARES ROCK TUNNELING WITH MECHANICAL EXCAVATORS WITH CONVENTIONAL DRILL & BLAST. COMPARATIVE COST REPORTS BASED ON CALIFORNIA STATE DEPT OF WATER RESOURCES BULLETIN NO 78 HAVE BEEN ESCALATED TO 1967 PRICE INDEX. SOFT GROUND AND SUBAQUEOUS TUNNELING IS EXTENSIVELY COVERED AND THE RANGE OF COST AS A FUNCTION OF METHOD OF ATTACK AND SOIL CONDITION IS EXTENSIVELY ILLUSTRATED. RECOMMENDATIONS FOR SPECIFIC RESEARCH, DEVELOPMENT AND DEMONSTRATION PROJECTS ARE GIVEN.

03-68-03001 HIGH SPEED GROUND TRANSPORTATION TUNNEL DESIGN AND COST DATA (UNDERGROUND-TRANSPORTATION-SYSTEMS)
HARZA ENGR CO TRW GROUP
HARZA ENGINEERING CO. FOR THE OFFICES OF HIGH SPEED GROUND TRANSPORTATION, MARCH 1968. THIS RESEARCH DEVELOPS BASIC ENGINEERING DATA AND COST FACTORS FOR VARIOUS TUNNEL SYSTEM CONFIGURATIONS, ALIGNMENTS, AND DEPTHS, FOR POSSIBLE USE BY A HIGH SPEED GROUND TRANSPORTATION SYSTEM IN THE NORTHEAST CORRIDOR. FIVE IMPORTANT COMPONENTS OF COSTS OF TUNNELING, SHAFTING, AND TERMINAL CONSTRUCTION WERE IDENTIFIED AS, EXCAVATION; MUCK LOADING, TRANSPORTATION AND DISPOSAL; TUNNEL SUPPORTS; TUNNEL LINING; AND INTERFACE LOAD SUPPORTS. FIVE CHARACTERISTICS OF THE HSGT SYSTEM AND THREE GROUPS OF THE GEOLOGIC SITE CONDITIONS THAT MATERIALLY AFFECT TOTAL COSTS WERE IDENTIFIED AS, TUNNEL AND SHAFT DIA; TERMINAL SIZE; DEPTH; SHAFT SPACING; INTERFACE LOADS; AND ROCK TYPES GROUPED ACCORDING TO THEIR EXCAVATION, SUPPORTING, AND WATER TRANSMISSION CHARACTERISTICS. A STUDY OF THE UNIT COSTS OF WORK WAS MADE FOR EACH COST COMPONENT, BEASED ON BID PRICES OF SIMILAR COMPONENTS IN RECENT CONSTRUCTION PROJECTS AND ON SYNTHETIC CALCULATIONS OF COST OF WORK FORCES CAPABLE OF ACCOMPLISHING THE WORK. THE COST DATA WAS APPLIED TO DETERMINE THE COST OF AN ARBITRARY TUNNEL SYSTEM, BY USE OF COST CURVES. IT WAS FOUND THAT THE TOTAL COST OF THE ARBITRARY 413 MILE SYSTEM WAS NEARLY $1.6 BILLION, WITH THE TUNNELS COMPRISING OVER 95% OF THE TOTAL COST. FOR THE ARBITRARY EXAMPLE TOTAL COSTS RANGED FROM $200 TO $4500 PER LINEAR FT.

03-68-04001 THE SEIKAN UNDERSEA TUNNEL (RAILWAY GEOLOGICAL-SURVEY VOLCANIC-ROCK WATER-LAKES CONCRETE-SPRAYING BORING-MACHINE MOLE)
NOKOYAMA, A. & JAPAN RWY CONSTR CORP TOKYO
JAPAN RAILWAY CONSTRUCTION PUBLIC CORPORATION, APRIL 1968. THIS REPORT GIVES AN ACCOUNT OF INVESTIGATIVE STUDIES MADE IN PREPARATION FOR DRIVING THE SEIKAN RAILWAY TUNNEL UNDER THE TSUGARU STRAIT BETWEEN CAPE TAPPI ON THE ISLAND OF HONSHU AND YOSHIOKA ON HAKKAIDO. A NEW RAILWAY ROUTE INCLUDING THE TUNNEL WILL START NEAR MIUMAYA, THE ENDPOINT OF THE TSUGARU LINE, GO INTO THE SEA-BED AT CAPE TAPPI, CROSS THE STRAIT, EMERGE AND CONNECT TO THE MATSUMAE LINE NEAR FUKUSHIMA. THE TOTAL LENGTH OF THE TUNNEL WILL BE ABOUT 36.4 KM WITH 22 KM ABOUT 240 M BELOW THE SEA LEVEL. WHEN INVESTIGATIONS HAVE BEEN COMPLETED IT WILL BE DETERMINED WHETHER 2 SINGLE TRACK TUNNELS OR ONE DOUBLE TRACK TUNNEL WILL BE BUILT. TOPOLOGICAL AND GEOLOGICAL SURVEYS OF THE ROUTE WERE INITIATED IN 1946 AND CONTINUED TO 1962. DATA FROM THESE SURVEYS ARE GIVEN IN TABLES AND CROSS-SECTIONAL SKETCHES. THE SEA-BED CONSISTS OF VOLCANIC AND MIOCENE ROCKS AND CONTAINS MANY FAULTS AND FISSURES. THE INVESTIGATION STILL CONTINUING INCLUDED THE DRIVING OF INCLINED SHAFTS AT BOTH ENDS OF THE TUNNEL AND BORING OF A PILOT TUNNEL PARALLEL TO THE MAIN TUNNEL. CHEMICAL AND CEMENT GROUTS ARE USED AHEAD OF EXCAVATIONS TO EXCLUDE WATER LEAKAGE WHEN DETECTED BY PILOT HOLES DRILLED AHEAD OF THE ADVANCES. SPRAYED CONCRETE LINING HAS BEEN TESTED AND APPRECIATION TECHNIQUES DEVELOPED FOR USE IN BOTH THE INVESTIGATIVE TUNNELS AND THE MAIN TUNNEL. ROCK PROPERTIES, WATER ENCOUNTERED, GROUT AND CONCRETE PROPERTIES ARE ALL TABULATED AND INCLUDED WITH OTHER DESCRIPTIVE DATA MAPS, AND SKETCHES IN THIS 32 PAGE REPORT.

03-68-09001 HORIZONTAL BORING TECHNOLOGY - A STATE-OF-THE-ART STUDY (TRENCHING AUGERING EARTH-REAMER JACKING MECHANICAL-MOLE VIBRATING-DRILL ROLLING-CUTTER DRAG-BIT PERCUSSIVE-DRILLING DIRECTIONAL-DRILLING)
PAONE, J. + BRUCE, W. E. + MORRELL, R. J. & U.S. BUR MINES TWIN CITIES
U.S. BUREAU OF MINES INFORMATION CIRCULAR 8392, SEPT 1968. THIS PAPER DESCRIBES THE DIFFERENT MACHINES AND METHODS USED IN AUGERING, IMPACTING, PUSHING, DRILLING, AND MACHINE TUNNELING HORIZONTAL HOLES THROUGH SOIL AND ROCK. A REVIEW OF THE BOREHOLE SURVEY AND GUIDANCE TOOLS AND TECHNIQUES APPLICABLE TO THESE METHODS IS ALSO GIVEN. NONBORING METHODS USED FOR EMPLACEMENT OF POWER DISTRIBUTION AND TRANSMISSION LINES ARE BRIEFLY DISCUSSED. OBSTACLE DETECTION AND GUIDANCE SYSTEMS FOR DIRECTING BOREHOLES TO SPECIFIED TARGETS NEED MAJOR IMPROVEMENTS TO MEET THE REQUIREMENTS OF THE POWER INDUSTRY FOR UNDERGROUND BURIAL OF DISTRIBUTION AND TRANSMISSION LINES.

03-68-09002 RAPID EXCAVATION, SIGNIFICANCE, NEEDS, OPPORTUNITIES (HISTORY COST RESEARCH NEW-METHODS)
COMMITTEE ON RAPID EXCAVATION & NATIONAL RES COUNCIL
NAT'L ACAD OF SCI PUBLICATION 1690, 1-48, SEPT 1968. EMPHASIS IS ON THE NEED TO REDUCE THE REAL COST OF UNDERGROUND EXCAVATION AND INCREASE THE RATES OF ADVANCE. THE MINIMUM MARKET FOR UNDERGROUND EXCAVATION WILL BE $69 BILLION IN THE PERIOD 1970-1990. OF THIS MARKET $35 BILLION WILL BE CONSTRUCTION-ORIENTED IN THE PUBLIC-WORKS SECTOR, AND $34 BILLION WILL BE MINING-ORIENTED. THE CURRENT RATE OF IMPROVEMENT IN UNDERGROUND TECHNOLOGY IS CONSTRAINED BY INADEQUATE TECHNICAL KNOWLEDGE AND INSUFFICIENT INDUSTRIAL INCENTIVE TO CHANGE CURRENT PRACTICE RADICALLY. RAPID EXCAVATION IS NEEDED BECAUSE OF URBANIZATION AND NATURAL RESOURCE CONSERVATION. THE TECHNOLOGY DEVELOPMENT NEEDED TO ACCOMPLISH MORE RAPID EXCAVATION IS DIVIDED INTO: (1) DETERMINATION OF GEOLOGICAL CONDITIONS AND ROCK PROPERTIES; (2) DISINTEGRATION OF IN SITU MATERIAL; (3) TRANSPORTATION OF DISINTEGRATED MATERIAL FROM THE EXCAVATION; (4) SUPPORT AND LINING OF THE EXCAVATION; (5) PROVISION OF A SAFE WORKING ENVIRONMENT AND IN OVER-ALL SYNCHRONIZATION OF THE PROCESSES; (6) MANY OPPORTUNITIES EXIST FOR RAPID EXCAVATION OF INDUSTRIES WILL SUPPORT VARIOUS PROJECTS.

03-68-09003 COMMITTEE REPORT ON EXCAVATION REQUIREMENTS (RESEARCH-STUDIES INDUSTRY-APPLICATIONS)
MCNEE, R. & UNIV CINN CINN OHIO
PANEL REPORTS OF THE COMMITTEE ON RAPID EXCAVATION REPORT TO THE BUREAU OF MINES, U.S. DEPT OF THE INTERIOR, 1-38, SEPT. 1968. THE COMMITTEE IS CONCERNED WITH TWO QUESTIONS, WHAT MIGHT BE THE MARKET FOR UNDERGROUND EXCAVATION TECHNOLOGY IN THE YEARS 1970 TO 1990 AND WHAT MIGHT BE THE BENEFITS FROM A RESEARCH PROGRAM WHOSE OBJECTIVE IS TO SIGNIFICANTLY ACCELERATE THE DEVELOPMENT OF SUCH TECHNOLOGY. SUCH ASPECTS AS URBANIZATION, CONSERVATION OF RESOURCES, ENVIRONMENT QUALITY, AND ECONOMIC-SOCIOLOGICAL CONSTRAINTS, ARE DESCRIBED AND REVIEWED. VARIOUS CHARTS GIVE ESTIMATES OF CONSTRUCTION DEMAND, MINERAL INDUSTRY DEMAND, UNDERGROUND EXCAVATION DEMAND AND DISCOUNTED SAVINGS FROM PROPOSED RESEARCH PROGRAMS. THE ESTIMATED CUMULATIVE UNDERGROUND EXCAVATION FOR 1970-79 IS $13 BILLION FOR CONSTRUCTION ORIENTED AND $16 BILLION FOR MINING ORIENTED. FOR THE DECADE 1980-89 THE ESTIMATE IS $22 BILLION FOR CONSTRUCTION, $18 BILLION FOR MINING. AN INVESTMENT OF $200 MILLION FOR RESEARCH OVER 10 YEARS SHOULD PRODUCE SAVINGS OF MORE THAN 12 TIMES ITS COST IN THE CONSTRUCTION FIELD ALONE. ASSUMING THE PROGRAM IS GOVERNMENT FINANCED NO CREDIT WAS TAKEN FOR SPINOFF SAVINGS ACCRUING TO THE MINING INDUSTRY. CONCLUSIONS INCLUDE: THE RATE OF TECHNICAL CHANGE IN OIL DRILLING, COAL MINING AND SURFACE EXCAVATION ARE ADEQUATE; THE RATE OF ADVANCE OF TECHNOLOGY FOR UNDERGROUND EXCAVATION ESPECIALLY FOR PUBLIC WORKS TUNNELING IS INADEQUATE. A TEN YEAR $200 MILLION UNDERGROUND EXCAVATION R AND D PROGRAM WILL PAY OFF VERY WELL; FURTHER STUDY IS NEEDED TO FIND WHY PRIVATE RESEARCH AND CONSTRUCTION FAILS TO TAKE THE NECESSARY STEPS TO REAP THESE BENEFITS. OTHER MEMBERS OF THE COMMITTEE WERE R. T. NEWCOMB - PENN STATE AND E. P. PELEIDER - UNIVERSITY MINNESOTA.

03-68-09004 COMMITTEE REPORT ON GEOLOGY (ROCK-GEOLOGY COSTS RESEARCH-STUDIES)
UNDERWOOD, L. B. & U.S. CORPS OF ENGRS
PANEL REPORTS OF THE COMMITTEE ON RAPID EXCAVATION, 39-43, SEPT 1968. GEOLOGICAL CONDITIONS DETERMINE THE DEGREE OF DIFFICULTY AND COSTS OF EXCAVATING AND SUPPORTING UNDERGROUND OPENINGS. GEOLOGICAL RESEARCH REQUIREMENTS FOR IMPROVED EXCAVATION TECHNOLOGY WERE STUDIED. CURRENT EXPLORATORY TECHNIQUES ARE TOO IMPRECISE FOR ENGINEERING PURPOSES, INVOLVE EXPENSIVE AND TIME CONSUMING PROCESSES. RESEARCH IS NEEDED TO PROVIDE NEW OR IMPROVED TECHNIQUES FOR REMOTE SENSING, CORE-BORING, GEOPHYSICAL MEASUREMENT, EXPLORING AHEAD OF THE TUNNEL FACE (PROBES), DETERMINING OR PREDICTING GROUNDWATER CONDITIONS. A STANDARDIZED ENGINEERING CLASSIFICATION FOR ROCK AND ROCK MASSES NEEDS TO BE DEVELOPED AND ADOPTED TO IMPROVE COMMUNICATION BETWEEN OWNER, GEOLOGIST, ENGINEER, CONTRACTOR, MINER AND EQUIPMENT MANUFACTURER, OTHER MEMBERS OF THE PANEL WERE D. V. DEERE - UNIV. OF ILL., W. C. MAURER - ESSO PROD. RES. AND L. OBERT - U. S. BU. MINES.

03-68-09005 COMMITTEE REPORT ON ROCK MECHANICS (STRENGTHS STRESSES RESEARCH)
OBERT, L. & U.S. BUR MINES CONSULTANT
PANEL REPORTS OF THE COMMITTEE ON RAPID EXCAVATION, 45-57, SEPT 1968. ROCK MECHANICS PROVIDES THE QUANTITATIVE BASIS FOR APPRAISING THE VARIOUS ASPECTS OF THE EXCAVATION PROCESS. PROCEDURES FOR MEASURING ROCK STRENGTHS, ELASTIC PROPERTIES, CREEP RATES, AND STRESS FIELDS AND CONCENTRATIONS ARE REVIEWED. FURTHER RESEARCH IS NEEDED FOR MEASURING THE MECHANICAL PROPERTIES OF ROCK MASSES, THE DETERMINATION OF SUBSURFACE STATE-OF-STRESS, ACQUISITION OF MECHANICAL PROPERTY DATA FOR ROCK MASSES, DEVELOPMENT OF METHODS FOR DETERMINING STATES-OF-STRESS, CORRELATION OF INTACT ROCK MECHANICAL DATA, AND DEVELOPMENT OR REFINEMENT OF TEST PROCEDURES FOR DETERMINING THE MECHANICAL THERMAL OR ELECTRICAL PROPERTIES OF ROCK. OTHER MEMBERS OF THE PANEL WERE D. V. DEERE - UNIV. OF ILL., W. C. MAURER - ESSO PROD. RES., AND L. B. UNDERWOOD - USCE.

03-68-09006 COMMITTEE REPORT ON ROCK DISINTEGRATION (RESEARCH COSTS SIGNIFICANCE)
WILLIAMSON, T. N. & JACOBS ASSOCIATES
PANEL REPORTS OF THE COMMITTEE ON RAPID EXCAVATION, 51-56, SEPT 1968. ROCK DISINTEGRATION IS THE KEY ELEMENT IN EXCAVATION AND DETERMINES THE REQUIREMENTS OF ALL OTHER SUBSYSTEMS. MATERIAL IMPROVEMENT IN COST AND PRODUCTIVITY IN TUNNELING FOCUSES ON THE ROCK DISINTEGRATION PROCESS. RESEARCH NEEDS TO EMBRACE TWO IMPORTANT ELEMENTS: THE MODE AND TECHNOLOGY OF BREAKING THE ROCK, AND THE MACHINE OR TOOLS FOR ACCOMPLISHING IT. PRIORITIES FOR ROCK DISINTEGRATION RESEARCH ARE PRESENTED IN TABLE FORM. THE HIGHEST PRIORITIES WERE ASSIGNED TO SOME SPECIALIZED IMPROVEMENTS IN THE PRESENT DRILL AND BLAST METHODS, TO IMPROVEMENT OF PERFORMANCE OF PRESENT MOLES AND TO DEVELOPMENT OF TWO NEW METHODS - MECHANICAL EROSION AND PLASMA JET. THE COMMITTEE RECOMMENDED THE ESTABLISHMENT OF A FIELD TESTING STATION WITH AN ACCOMPANYING LABORATORY. THE TEST STATION WOULD HAVE AVAILABLE IN SITU VARIOUS ROCK TYPES TO BE USED FOR TESTING OF DEVICES AND METHODS OF ROCK BREAKING. FACILITIES SHOULD BE PROVIDED FOR FULL SCALE DEMONSTRATIONS OF NEW TUNNELING MACHINES. LOGISTICAL AND ENGINEERING SUPPORT WOULD BE AVAILABLE FOR CONTRACTORS, INVENTORS, MANUFACTURERS AS REQUIRED. OTHER MEMBERS OF THE PANEL WERE: T. F. ADAMS - BROWN AND ROOT, AND W. C. MAURER - ESSO PROD. RES.

03-68-09007 COMMITTEE REPORT ON MATERIALS HANDLING (MUCK-HANDLING TRANSPORTATION OBJECTIVES COST RESEARCH-STUDIES)
ADAMS, T. F. & BROWN AND ROOT CO INC
PANEL REPORT OF THE COMMITTEE ON RAPID EXCAVATION, 57-64, SEPT 1968. MATERIALS HANDLING MUST PROVIDE THE HANDLING OF MUCK PRODUCTION AT PEAK EXCAVATION RATES, MINIMUM SPACE OCCUPATION, OPERATION AROUND CORNERS OR CURVES, SIMPLICITY, EASY OPERATION, FREEDOM FROM CONTAMINATING FUMES, AND AMENABLE TO AUTOMATION. RESEARCH OBJECTIVES ARE RECOMMENDED FOR MATERIAL HANDLING LOGISTICS, CONVEYOR SYSTEMS, PIPELINE STUDIES, MORE EFFICIENT MUCK TRANSPORTATION, AND GENERAL EXPLORATION FOR NEW AND BETTER METHODS OF MATERIAL HANDLING. OTHER MEMBERS OF THE COMMITTEE WERE: E. JONES - ST. JOSEPH LEAD CO AND W. C. MAURER - ESSO PROD. RES. CO.

03-68-09008 COMMITTEE REPORT ON GROUND CONTROL (UNDERGROUND EXCAVATION RESEARCH)
LANE, K. S. & U.S. CORPS OF ENGRS MO RIV DIV
PANEL REPORTS OF THE COMMITTEE ON RAPID EXCAVATION, 65-74, SEPT 1968. PRESENT SUPPORT SYSTEMS WERE DEVELOPED FOR TUNNELS PROGRESSING AT RATES OF 15 TO 60 FT PER DAY. MOLES OPERATING AT TWICE TO 4 TIMES THAT SPEED OVERLOAD EXISTING TECHNOLOGY OF INSTALLING SUPPORTS. THE PROJECTED ADVANCE RATES OF 10 TIMES PRESENT ONES WILL NOT BE POSSIBLE WITHOUT MAJOR IMPROVEMENTS. THE MOST URGENT RESEARCH NEEDS IN THIS FIELD ARE: (1) DEVELOPMENT OF MORE RATIONAL DESIGN METHODS FOR TEMPORARY AND PERMANENT LININGS, (2) DEVELOPMENT OF NEW SYSTEMS OF SUPPORT AND LINING SYSTEMS CAPABLE OF FASTER INSTALLATION, (3) DEVELOPMENT OF METHODS FOR DESIGNING ROCK SLOPES IN SURFACE EXCAVATION (4) DEVELOPMENT OF TECHNIQUES OF SOUND-WALL BLASTING, AND (5) IMPROVE METHODS OF SOLIDIFYING GROUND. OTHER MEMBERS OF THE PANEL WERE: K. COX - DRAVO CORP., D. V. DEERE - UNIV OF ILL., L. OBERT - U.S. BU MINES.

03-68-09009 COMMITTEE REPORT ON ENVIRONMENTAL CONTROL AND SAFETY (SURFACE-EXCAVATION UNDERGROUND-EXCAVATION RESEARCH-AND- DEVELOPMENT)
HARTMAN, H. L. & SACRAMENTO STATE COLLEGE
PANEL REPORTS OF THE COMMITTEE ON RAPID EXCAVATION, 75-84, SEPT 1968. THIS SECTION ASSESSES THE NATURE AND EXTENT OF THE ENVIRONMENTAL HAZARDS AND CONTROL PRACTICES ENCOUNTERED IN EXCAVATIONS TODAY AND TO EXTRAPOLATE THESE TO THE RAPID EXCAVATION TECHNOLOGY ANTICIPATED TOMORROW. BOTH SURFACE AND UNDERGROUND EXCAVATION ARE CONSIDERED, BUT THE EMPHASIS IS ON UNDERGROUND EXCAVATION-PARTICULARLY IN THE HARDER ROCKS. PRESENT LEVELS OF RESEARCH AND DEVELOPMENT ARE DEEMED INADEQUATE. RESEARCH EFFORTS IN THE NEAR FUTURE SHOULD CONCENTRATE ON IMPROVING PRESENT TECHNIQUES. FOR THE LONGER RANGE IMAGINATIVE EFFORTS SHOULD BE LAUNCHED TO DEVISE NEW AND BETTER METHODS OF ENVIRONMENTAL CONTROL, WITH A SPECIAL EMPHASIS ON SUPPORTING NEW METHODS. OTHER MEMBERS OF THE PANEL WERE: J. D. JACOBS - JACOBS ASSOCIATES AND T. N. WILLIAMSON - JACOBS ASSOCIATES.

03-68-09010 COMMITTEE REPORT ON SYSTEMS EVALUATION (LOGISTICS ROCK-DISINTEGRATION UNDERGROUND-EXCAVATION GROUND-CONTROL)
BLEDSOE, J. D. & BROWN AND ROOT CO INC
PANEL REPORTS OF THE COMMITTEE ON RAPID EXCAVATION, 85-92, SEPT 1968. THE PURPOSE OF THIS OVERVIEW WAS TO BRING TO LIGHT DEFICIENCIES, SHORTCOMINGS, LIMITATIONS THAT HAD A SIGNIFICANT EFFECT ON THE SYSTEM COST OR PRODUCTIVITY AND INDICATE WHERE AND HOW RESEARCH MAY BE DIRECTED MOST PROFITABLY IN SUCH AREAS AS DIFFERENTIATED FROM RESEARCH ON PROCESS ELEMENTS THEMSELVES. THE FOUR MAJOR COMPONENTS OF THE UNDERGROUND EXCAVATION PROCESS ARE DESCRIBED; ROCK DISINTEGRATION, LOGISTICS OF MUCK AND SUPPLY TRANSPORT, GROUND CONTROL AND EXCAVATION LINING, AND GEOLOGICAL PREDICTION. THE DEVELOPMENT OF SYSTEMS EVALUATION MATRICES IS DISCUSSED. IN DESCENDING ORDER OF PRIORITY ARE: (1) PROCESS AND EQUIPMENT FOR DISINTEGRATION OF STRONG ABRASIVE ROCK, (2) MUCK AND MATERIALS TRANSFER TECHNOLOGY FOR LONG TUNNELS, (3) DETAILED GEOLOGICAL AND/OR GEOPHYSICAL PREDICTIONS FOR LONG, DEEP, HORIZONTAL MINE DRIFTS AND TUNNELS, (4) GROUND CONTROL TECHNIQUES FOR LONG TUNNELS IN WET CRUSHED OR UNCONSOLIDATED MATERIAL (5) SYSTEM DESIGNS COMBINING FUNCTIONS OF ONE OR MORE SUBSYSTEMS, (6) ENVIRONMENTAL CONTROL FOR LONG TUNNELS. A SPECIAL RECOMMENDATION WAS MADE TO DESIGN, BUILD, AND USE FOR FULL RESEARCH AN EXPERIMENTAL SYSTEM TO GATHER DATA AND IMPROVE PERFORMANCE AND RELIABILITY OF TUNNEL BORING MACHINES. OTHER MEMBERS OF THE PANEL WERE B. P. BELLPORT - BU REC, K COX - DRAVO CORP, J. D. JACOBS - JACOBS ASSOCIATES.

03-69-03001 PUBLISHED REPORTS (BIBLIOGRAPHY)
OFFICE OF HIGH SPEED GROUND TRANSPORTATION AND NORTHEAST CORRIDOR TRANSPORTATION PROJECT DEPT OF TRANSPORTATION, MARCH 1969. THIS BIBLIOGRAPHY LISTS AND ABSTRACTS 134 MAJOR RESEARCH REPORTS PUBLISHED BY OHSGT AND NECTP WHICH PRESENT RESULTS OF CONTRACTED RESEARCH AND DEVELOPMENT SYSTEMS ENGINEERING, TRANSPORTATION SURVEYS, AND MODEL DEVELOPMENT.

FIELD 04 ARTICLES

04-50-04001 TUNNEL RECORDS BROKEN AT OWENS RIVER GORGE (PNEUMATIC-DRILL JUMBO MUCKING)
MASON, W. C. & LOS ANGELES CAL
CIVIL ENGINEERING, (20) N 4, 22-24, APR 1950. OWENS RIVER GORGE TUNNELS ARE 10 FT. ID TUNNELS FOR LOS ANGELES DEPT. OF WATER AND POWER. THERE ARE THREE TUNNELS, ONE TO POWER HOUSE NO. 1, THE OTHER TWO CONNECT THE TAIL RACE OF POWER HOUSE 1 AN OF 2 WITH THE PENSTOCKS OF POWERHOUSES 2 AND 3 RESPECTFULLY BORING AND LINING 11.85 MI OF PRESSURE AND PENSTOCK TUNNELS AND CONSTRUCTING THREE SURGE CHAMBERS AT THE GOERGE WAS $8,947,520. TUNNELING THROUGH THYOLITE TUFF AND HARD RHYOLITE A RECORD ADVANCE OF 2,332 FT IN 31 DAYS IN RHYOLITE TUFF WAS SET BETWEEN OCT. 24 AND DEC. 2, WORKING 3 8-HR SHIFTS A DAY. TRACK MOUNTED JUMBO HAS FIVE I-R DA 35 PNEUMATIC DRIFTER DRILLS OF 3-1/2 IN. BORE, WET STYLE LIDDICOAT THROW-AWAY BITS ARE USED. MUCKING IS DONE WITH MUCKING MACHINE, TWO ELECTRIC LOCOMOTIVES AND SIDE DUMP CARS. DOUBLE TRACK SECTIONS, 200 FT LONG ARE INSTALLED AT HALF-MILE INTERVALS. DETAILED ACCOUNT IS GIVEN OF AN 8-HR SHIFT AND FOR THE CAR PASSING PROCEDURE. PREVIOUS RECORD ON SIMILAR DIAM WAS 1,879 FT IN 31 DAYS ON CARLTON TUNNEL, CRIPPLE CREEK, COLO. IN 1940.

04-58-11001 DRIVING THE CLEAR CREEK TUNNEL (JUMBO MUCKING EXPLOSIVES SUPPORTS TUNNELING-RATE)
BEHME, R. L. & LOS ANGELES CAL
THE EXPLOSIVES ENGR, 173-178, NOV-DEC, 1958. CLEAR CREEK TUNNEL WILL BE 20 FT IN DIAM AND 11 MI LONG. IT WAS DRIVEN FROM EITHER END AND FROM TWO ADITS 2-1/2 MI FROM EACH END. IT WILL HAVE A MINIMAL 9 IN. CONCRETE LINING AND CONVEYS WATER FOR POWER AND IRRIGATION. GEOLOGICAL SURVEYS WERE UNABLE TO ACCURATELY FORECAST EXACT TUNNEL CONDITIONS. IN SOME BAD ROCK A TOP HEADING AND SOLID BREAST BOARDING WAS REQUIRED. A GANTRY JUMBO ON SPECIAL RAILS EQUIPPED WITH CHERRY PICKERS AND SEVEN GARDNER-DENVER MODEL 93 WATERLINERS WITH HYDRAULIC JIBS USING FOG 1-1/4 IN. ROUND DRILL STEEL AND 1-3/4 OR 1-7/8 IN. DETACHABLE CORMANT BITS DRILLS HOLES AT 4 TO 8 FT DEPTHS ON 2 FT CENTERS. AN EXPLOSIVE CAR CHARGES THE 60 PERCENT GELATIN DYNAMITE AND GELAMITE 2 WITH 60 PERCENT GELATIN FOR PRIMERS. THREE POUNDS OF EXPLOSIVE IS USED PER CU. YD. THIS SYSTEM PULVERIZES ROCK SUFFICIENTLY FOR IMMEDIATE MUCKING WITH A CONWAY MUCKER AND A LINE OF 10 YD DUMP CARS. THE JUMBO LIFTS FILLED CARS SO THE DIESEL ENGINE CAN PUSH THE NEXT EMPTY CAR TO THE MUCKER. NEW RAILS ARE LAID BEFORE THE JUMBO CAN RETURN TO THE HEADING. WORK IS THREE SHIFTS A DAY, SIX DAYS A WEEK AT A RATE OF 32 FT PER DAY. TIGHTLY SPACED SUPPORTS ON 2 OR 3 FT CENTERS WERE NEEDED IN A BADLY FAULTED 400 FT SECTION. CLEAR CREEK TUNNEL WILL AID IN CONVEYING WATER FROM NORTHERN CALIFORNIA TO IRRIGATION LAND SOUTH OF SACRAMENTO.

04-60-02001 UNDERGROUND MINING DEVELOPMENTS (SHAFT-SINKING RAISING COMPRESSED-AIR DRILL-AND-BLAST TUNNEL-DRIVING)
BORCHERDT, E. R. & BORCHERDT AND SMITH
MINING CONGRESS JOURNAL, 52, FEB 1960. A NOTED MINES RESEARCH ENGINEER, NOW CONSULTANT, REVIEWS RECENT DEVELOPMENTS, AROUND THE WORLD, IN SHAFT SINKING AND RAISING AND TUNNEL DRIVING. WHILE DEVELOPMENTS TOOLS, EQUIPMENT AND METHODS ARE TREATED IN GENERAL NEWS ITEM STYLE, MORE DESCRIPTION IS GIVEN TO A RECORD SHAFT-SINKING IN SOUTH AFRICA OF 1000 FT 26 FT DIA SHAFT IN ONE CALENDAR MONTH AND TO THE ALIMAK SHAFT-RAISING SYSTEM AND ITS APPLICATION TO RAISE UP TO 400 FT OR MORE.

04-61-01001 CONSTRUCTING A SOFT-GROUND TUNNEL UNDER BOSTON HARBOR (SHIELD-METHOD CUTTING-EDGE EXCAVATION LINING COMPRESSED-AIR)
RICHARDSON, C. A. & PERINI CORP SPRING LAKE NJ
CIVIL ENGINEERING, JAN 1961. FROM A PAPER PRESENTED AT THE ASCE BOSTON CONVENTION SESSION OF THE CONSTRUCTION DIVISION. THE LT. WILLIAM F. CALLAHAN, JR. TUNNEL UNDER BOSTON HARBOR IS BEING CONSTRUCTED FOR THE MASS. TURNPIKE AUTHORITY TO CONNECT BOSTON TO EAST BOSTON. THE TUNNEL IS SCHEDULED TO OPEN IN NOVEMBER 1961. CONSTRUCTION IS BY MEANS OF THE SHIELD METHOD WITH A SHIELD 19 FEET 6 INCHES LONG BY 31 FEET 4 INCHES OUTSIDE DIAMETER AND WITH A TAILSKIN OF 30 FEET 10 INCHES INSIDE DIAMETER. PROGRESS OF THE WORK, METHODS, AND EQUIPMENT UTILIZED AND JOB CONDITIONS ARE DESCRIBED IN THE WORK TO DATE.

04-61-04001 NEW TUNNELS NEAR POTTERS BAR IN EASTERN REGION OF BRITISH RAILWAYS (SHIELD)
TERRIS, A. K. + MORGAN, H. D.
PROCEEDING OF INSTITUTION CIVIL ENGRS, (18) PAPER 6511, 289-304, APR.1961. DRY JOINTS BETWEEN PRECAST CONCRETE BLOCKS WITH NO BREAKS IN THE JOINTS ARE BEING USED TO LINE THE 3 SHIELD DRIVEN TUNNELS IN LONDON CLAY NEAR POTTERS BAR. THE BLOCKS WERE MANUFACTURED IN A SPECIAL UNIT LOCATED OVER TOP OF ONE OF THE TUNNELS.

04-61-08001 DEVELOPMENT IN LARGE BOREHOLE DRILLING (VENTILATION ACCESS SHAFTS CHURN-DRILL CALYX-METHOD ROTARY-DRILLING)
MAUCK, L. E. + RIDENOUR, D. C. & FREEMAN COAL MINING CORP
MINING CONGRESS JOURNAL, 61, AUG 1961. THE ARTICLE OUTLINES EXPERIENCE IN DEVELOPING LARGE BOREHOLE DRILLING TECHNIQUES FOR VENTILATION AND ACCESS SHAFTS TO COAL MINES OF THE OLGA COAL CO. DESCRIPTION OF TOOLS, METHODS AND ECONOMICS ARE OUTLINED FOR CHURN DRILL, CALYX METHOD AND ROTARY DRILL.

04-62-09001 SUBWAY CONSTRUCTION IN THE SOVIET UNION
KRUPINSKI, H. J. + WAGNER, H. & HAMBURG W. GERMANY
BAUTECHNIK, (39) NO 9 299-306, SEPT 1962. THE REPORT OF A DELEGATION SENT TO LENINGRAD & MOSCOW BY HAMBURG CITY OFFICIALS TO STUDY SOVIET SUBWAY PROJECTS.

04-63-10001 THE ROCK - NORAD COC (BLASTING CAVERN GRANITE EXCAVATION DRILL-RIGS ROCK-BOLTS JUMBOS)
NORVELL, J. M. & MILITARY ENGINEER
THE MILITARY ENGINEER, (55) NO. 367, SEPT-OCT 1963. THE ARTICLE DESCRIBES THE NEW NORTH AMERICAN AIR DEFENSE COMMAND (NORAD) COMBAT OPERATIONAL CENTER (COC) BEING BUILT DEEP WITHIN A COLORADO MOUNTAIN. APPROXIMATELY 450,000 CUBIC YARDS OF ROCK, MOSTLY GRANITE HAS BEEN REMOVED AND THE BASIC EXCAVATION WAS COMPLETED IN DECEMBER 1962. EXCAVATION WAS MAINLY BY DRILLING, BLASTING AND SLABBING. ROCK BOLTS UP TO 20 FEET LONG ON A 4 FOOT SQUARE PATTERN REINFORCE WALLS AND THE DOME SHAPED CEILINGS. THE CENTER CONSISTS OF A NETWORK OF INTERSECTING CHAMBERS 32 AND 45 FEET WIDE AND UP TO 60 FEET HIGH FORMING A PATTERN 300 FEET BY 120 FEET. CHAMBERS ARE SEPARATED BY BUFFER SECTIONS OF GRANITE. SELECTED PICTURES AND OUTLINE DRAWINGS ILLUSTRATE THE PROJECT.

04-63-12001 TUNNELLING IN GIBRALTAR (MATERIAL-HANDLING SHAFT-RAISING VENTILATION)
LAUDER, J. G. & ROYAL ENGRS 1ST FORTRESS SQUAD
ROYAL ENGINEERS, (77) NO. 4, 339-369, DEC 1963. ON THE GIBRALTAR TUNNEL PROJECT FROM LITTLE BAY TO EUROPA SIX 315 CFM COMPRESSORS WERE INSTALLED WITH AN INITIAL PLANNED MAXIMUM LOAD OF 1000 CU. FT. OF FREE AIR PER MINUTE. THE BASIC TECHNIQUE IN HARD-ROCK TUNNELLING IS THE MODERN DRILL AND BLAST METHOD. THE ROCK IS LOADED INTO DECAUVILLE WAGONS, OR SKIPS, AND TOWED OUT BY LOCOMOTIVE. PROGRESS WAS LIMITED BECAUSE THE PORTAL WAS ESTABLISHED ON A FAULT FILLED WITH CLAY, CONGLOMERATE AND FRIABLE ROCK WHICH CAUSED ROCK DRILLS TO JAM; SOFT GROUND MACHINERY CANNOT BE USED BECAUSE OF THE HARD ROCK EMBEDDED. WHEN A HOLE HAS BEEN DRILLED IN CONGLOMERATE AND FRIABLE ROCK, THE DRILL STEEL PROBABLY CANNOT BE WITHDRAWN OR WHEN WITHDRAWN, THE HOLE WILL COLLAPSE. THERE WAS MUCKING OUT PROBLEM AT GIBRALTAR BECAUSE THE LOCOMOTIVES COULD NOT NEGOTIATE THE STEEP GRADIENT. THIS LED TO A CRUDE SOLUTION BY MEANS OF A RAMP, OR "CHINAMAN" WHICH WAS SATISFACTORY FOR THE PILOT HEADING. THIS 1320 OF 14 FT. HEADING WAS COMPLETED IN 50 WEEKS OF TUNNELLING, AN AVERAGE OF 26.4 FT. PER 4 1/2 DAY WEEK. THE ENLARGEMENT OF THE PILOT HEADING TO THE REQUIRED 26 FT. NECESSITATED THE MUCKING OUT OF 20,000 CU. YDS. OF SPOIL, CAUSING THE DEVELOPMENT OF A MOBILE SPOIL ELEVATOR AND TRACKLESS MINING. THIS ELEVATOR, SERVING AS A GIANT CHINAMAN, WAS LOADED AND THEN LIFTED THE SPOIL HIGH ENOUGH TO DEPOSIT IT IN THE DUMPERS. ALL THE DRILLING AND BLASTING WAS DONE IN ONE OPERATION, AND THE SPOIL LEFT IN SITU FOR FIVE MONTHS. IN SIX MONTHS, USING TRACKLESS MINING, THE 20,000 CU. YDS. OF SPOIL WERE MUCKED OUT AT ABOUT 200-250 CU. YDS. PER DAY (2 SHIFTS). AN 8-FT. PILOT WAS DESIGNED FOR THE SECOND TUNNEL FROM CAMP BAY TO NORTH GEORGE SINCE IT WENT THROUGH SEVERELY FAULTED

GROUND OF BROKEN CLAY AND ROCK. A TIMBER LINING WAS USED AND INSERTED AS SOON AS POSSIBLE. THE ENLARGEMENT PROCESS REQUIRED THAT THE POOR GROUND BE LINED WITH STEEL SETS AS THE WORK PROCEEDS TO PREVENT THE COLLAPSE OF THE ENTIRE ROOF. STEEL "BOLING BOARDS" COULD BE USED TO HOLD THE RODE STEADY SO THAT WORK COULD CONTINUE SAFELY UNDERNEATH. DAMAGE TO THE STEEL SETS FROM BLASTING WOULD NOT BE GREAT, AND THE CAVITY CUT FOR THE POLLING BOARDS REDUCES THE TRANSMISSION OF SHOCK WAVES TO THE ROOF.

04-64-00001 CONSTRUCTION OF TUNNELS OF NEW TOKAIDO LINE (GENERAL)
SAKAMOTO, S. & JAPANESE NATIONAL RAILWAYS
PERMANENT WAY SOCIETY, 7, 1-22, 1964. THERE ARE 67 TUNNELS OF WIDTH OF 9.6 METERS AND HEIGHT 7.8 METERS ON THE NEW TOKAIDO LINE. MOST OF THE GROUND WAS SOFT ROCK WITH MANY FAULTS AND MUCH TUNNEL WATER. STEEL ARCH SUPPORTS WERE USED. THE H BEAMS HAVE BREAKING LOADS OF 145 TONS TO 618 TONS. MOST OF THE TUNNEL WAS LINED WITH 50-70 CM THICKNESS OF CONCRETE. GROUTING COST CAN BE LOWERED BY USING A SMALLER PROPORTION OF CEMENT. IN GROUND WHERE UNEXPECTED TUNNEL WATER MIGHT ARISE AND THE GEOLOGY IS VARIED BOTTOM HEADING METHOD IS PREFERRED. DIFFERENT METHODS OF WORKING WERE PERFORMED ACCORDING TO GROUND CONDITIONS. IN THE OBORA TUNNEL GROUND CONDITIONS WERE SO BAD THAT A " WELL POINT " PROCESS WAS ADOPTED. THE TANNA TUNNEL TOOK 53 MONTHS AND COST 525 YEN PER METER.

04-64-01001 SINKING VERTICAL MINE-SHAFT AT RATE OF 290.5 METERS PER MONTH
ZORI, A. S.
GORNYI ZHURNAL, N 1, 40-44, JAN 1964. SINKING OF NOVOBUTOVKA SHAFT IN DONETS BASIN USING SINKING EQUIPMENT WITH REMOTE CONTROL OF 1 CU-M CACTUS GRAB AND FACILITIES FOR INSTALLING LINING. GENERAL CHARACTERISTIC OF EQUIPMENT AND ORGANIZATION OF OPERATIONS. (IN RUSSIAN)

04-64-02001 THE DRIVING OF THE MONT BLANC TUNNEL
WIDEGREN, G. & ATLAS COPCO ITALIA
THE MINING ENGINEER, PAPER NO. 4003, 281-293, FEB 1964. THE HISTORY OF THE IDEA FOR A MONT BLANC TUNNEL IS REVIEWED. THE AGREEMENT BETWEEN FRENCH AND ITALIAN GOVERNMENT WAS REACHED IN 1958. THE TUNNEL WAS BORED FROM THE NORTH BY THE FRENCH, FROM THE SOUTH BY THE ITALIANS. THE TUNNEL IS HORSESHOE SHAPED WITH A HEIGHT OF 31 FT. AND A SHOULDER WIDTH OF 29 FT. DRILLING AND BLASTING WAS USED. SEVERAL BAD ROCK FALLS DELAYED THE ITALIAN CONSTRUCTION. METHODS OF OVERCOMING THE DIFFICULTIES ARE DESCRIBED. BREAKTHROUGH WAS ACHIEVED ON 14 AUGUST 1962. THE TUNNEL WAS EXPECTED TO BE OPEN TO TRAFFIC BY END OF 1964.

04-64-03001 THE DRIVING OF 10 MILE LONG CANYON POWER TUNNEL IN THE U.S.A. (WATER-TUNNEL ANFO FAST-TUNNELING)
MACKINTOSH, I. B. & TAYLOR WOODROW OVERSEAS LTD
CIVIL ENGINEERING AND PUBLIC WORKS REVIEW, 325-331, MARCH 1964. THE POWER TUNNEL CONTRACT WAS AWARDED TO CLANCY O'DELL CONSTRUCTION CO. FOR $11,169,895 IN JANUARY 1962. THE TUNNEL IS THROUGH GRANITE AND IS UNLINED EXCEPT IN BAD GROUND. HORSESHOE SHAPED 14 FT. X 14 1/2 FT. AN 11 FT. ROUND IS USED DRILLING 12 FT. HOLES. THE DRILL JUMBO CARRIES A BIG DRIFTER WHICH DRILLS TWO 5 IN. DIA BURN HOLES, PLUS SIX HYDRA BOOM DRILLS. A CONWAY 101 ELECTRIC LOADER LOADS 10 CU. YD. GRANBY-TYPE CARS. A FERTILIZER GRADE AMMONIUM NITRATE IS MIXED WITH FUEL OIL AND LOADED PNEUMATICALLY. AVERAGE PROGRESS 60 TO 76 FT/DAY. CYCLE TIME AVERAGES 3 HRS 40 MIN.

04-64-04001 DRIVING THE HOMESTAKE TUNNEL (WATER-TUNNEL DRILL-AND-BLAST)
WESTERN CONSTRUCTION, 55-69, APRIL 1964. A 5 1/2 MILE TUNNEL, FIRST PHASE OF A 125 MILE LONG SERIES OF TUNNELS, LAKES, RESERVOIRS AND PIPELINES FOR BRINGING WATER ACROSS THE CONTINENTAL DIVIDE TO COLORADO SPRINGS AND AURORA COLORADO IS BEING DRIVEN AT A RATE OF 44 FT/DAY BY QUAD CONSTRUCTION, INC. AND W. A. SMITH CONTRACTING CO. JOINT VENTURE. THREE MORE HOMESTAKE PROJECTS WILL BE BID IN APRIL 1964.

04-64-04002 TUNNEL WORK DURING ELECTRIFICATION OF RAILROAD LINES (LINING SPRAYED-MORTAR PLASTIC-SEALERS GLASS-FIBER-LININGS DRAINS)
SPANG, J. & FEDERAL RAILWAY MUNICH GER
DIE BAUTECHNIK, (4) 41,18-124, APRIL 1964. A SUMMARY OF THE RENOVATION OF THE 57 GERMAN FEDERAL RAILWAY SYSTEM TUNNELS IN CONNECTION WITH THE ELECTRIFICATION OF THE SYSTEM. PROBLEMS MAINLY WERE IN CONNECTION WITH LINING AND DRAINAGE. NEW CONSTRUCTION MATERIALS REDUCED OVERALL COST. SPRAYED MORTAR AND SPRAYED CONCRETE WAS PRACTICAL IN MANY CASES. USE OF SULFATE RESISTANT CEMENT REDUCED NEED FOR SPECIAL SEALING MATERIALS. MANY NEW PLASTIC SEALERS ARE AVAILABLE.

04-64-05001 SPECIAL METHODS IN CANAL CONSTRUCTION (PIPE-DRIVING SEWERS)
KUNTZE, E.
GAS - UND WASSERFACH, (105) NO. 20, 533-539, MAY 15, 1964. THE DRIVING OF SEWER PIPES CAN BE CONSIDERED ONE OF THE MOST IMPORTANT AND EXTENSIVELY DEVELOPED PROCESSES FOR THE UNDERGROUND CONSTRUCTION OF SEWER SYSTEMS. DRIVING IS DONE ONLY WHEN ANY OPEN EXCAVATION METHOD IS ECONOMICALLY OR TECHNICALLY IMPOSSIBLE. A PECULIARITY OF THE PROCESS IS THE ELASTICITY OF THE PIPE. SHORT BYPASSES ARE NOT POSSIBLE. THE LEVEL OF GROUND WATER IS ALSO IMPORTANT; ALL CONSTRUCTION ELEMENTS SHOULD HAVE THE SAME LIFE. CONCRETE AND STEEL PIPES HAVE THE DISADVANTAGE THAT IT IS DIFFICULT TO PROTECT THEM FROM CORROSION. DIFFICULTIES ARE ALSO ENCOUNTERED IN THE FORMATION OF WELDING SEAMS. DRIVING OF CONCRETE PIPES APPEARS TO BE MORE SUITABLE. DURING PASSAGE THROUGH HIGHLY UNFIXED SOIL, THE INSTALLATION OF HORIZONTAL OR SLIGHTLY TILTED BAFFLES IN THE CUTTER SLEEVE WAS FOUND ADVANTAGEOUS. IT IS OF ADVANTAGE TO INSTALL THEM RIGIDLY. FOR THE TRANSPORT OF SOIL WITHIN THE DRIVE PIPELINE, THE USE OF MONORAIL RAILROADS WITH A LATERAL GUIDANCE BY PNEUMATICALLY TIRED ROLLERS WAS FOUND ADVANTAGEOUS. WHEN THE POSSIBILITY OF AN ENCOUNTER WITH QUICKSAND EXISTS, THE POSSIBILITY OF THE INSTALLATION OF A PRESSURE CHAMBER MUST BE PROVIDED IMMEDIATELY DURING THE CONSTRUCTION OF THE CUTTER SLEEVES.

04-64-06001 THE SCHOOL OF MINES AT WEST VIRGINIA UNIV (RESEARCH EDUCATION)
HOLLAND, C. T. & UNIV WEST VA
MINING CONGRESS JOURNAL, (50) N 6, 36-40, JUNE 1964. MINERAL ENGINEERING EDUCATION AND RESEARCH IN W. VA. ARE CENTERED IN THE SCHOOL OF MINES AT W. VA. UNIV. IN MORGANTOWN. THE SCHOOL OFFERS TWO UNDERGRADUATE CURRICULA: MINING ENGINEERING AND PETROLEUM ENGINEERING. RESEARCH IS DIRECTED TOWARD: 1) COAL UTILIZATION RESEARCH, 2) MINING RESEARCH, AND 3) PETROLEUM AND NATURAL GAS PRODUCTION AND RECOVERY RESEARCH. THE BUREAU OF RESEARCH IS MAINLY CONCERNED WITH LOOKING TOWARDS NEW MARKETS AND NEW USES FOR W. VA. COAL. PETROLEUM PRODUCTION RESEARCH HAS ALSO BEEN FEATURED. COURSES OFFERED IN THE SCHOOL EXTENSION INCLUDE: MINE GASES, MINE VENTILATION, MINE FIRES AND EXPLOSIONS, HAULAGE, DRAINAGE, EXPLOSIVES, AND OTHERS. EXPANSION OF THE SCHOOL'S PROGRAM IS NEEDED. CURRICULA ARE BEING DEVELOPED IN SEVERAL MINERAL AREAS, SUCH AS BENEFICIATION, GEOPHYSICS, AND FUEL TECHNOLOGY.

04-64-07001 ROTARY AND PERCUSSION DRILLS (BLASTING-EQUIPMENT)
WESTERN CONSTRUCTION, 66-69, JULY 1964. A CONCISE COMPARISON BETWEEN THE TWO TYPES OF DRILLS. PERCUSSION DRILLS ARE MORE OFTEN USED FOR SURFACE DRILLS. ROTARY DRILLS ARE MORE OFTEN USED FOR DEEP WELL DRILLING.

04-64-08001 AZOTEA TUNNEL DRIVING BEGINS (MOLE WATER TUNNELS GEOLOGIC-EXPLORATION)
BELLPORT, B. P. & U.S. BUR RECL DENVER COLO
WESTERN CONSTRUCTION, 64-66, AUG 1964. A 12.7 MI WATER TUNNEL IN NORTHERN NEW MEXICO WILL BE BORED BY A TUNNELING MACHINE TO BE PURCHASED BY THE CONTRACTING JOINT VENTURE FIRM OF GIBBONS AND REED CO, BOYLES BROS. DRILLING CO, AND DUGAN GRAHAM CO. THE TUNNEL WILL BE CIRCULAR IN SECTION WITH FINISHED DIAMETER OF 10 FT. 11 IN. LINED WITH 9 IN. OF CONCRETE. THE BUREAU UNDERTOOK AN EXTENSIVE GEOLOGIC EXPLORATION PROGRAM--CONVENTIONAL CORE DRILLING, AIRBORNE MAGNETOMETER SURVEYS, GROUND MAGNETOMETER, AND GRAVIMETER SURVEYS, SEISMIC REFLECTION AND REFRACTION

DETERMINATIONS. BIDDERS WERE ALLOWED OPTION OF BIDDING ON CIRCULAR OR HORSESHOE SECTIONS. WHERE ROCK BOLTS ARE REQUIRED THEY MUST BE INSTALLED WITHIN 8 HRS. AFTER BLASTING (OR CUTTING) OF THE HEADING.

04-64-08002 COLLEGE OF MINERAL INDUSTRIES PENN STATE UNIV: MINING ENGINEERING (EDUCATION RESEARCH)
STEFANKO, R. & PENN STATE UNIV
MINING CONGRESS JOURNAL, (50) N 8, 88-91, AUG 1964. WITHIN A RADIUS OF 125 MI OF THE UNIVERSITY, MINES ARE LOCATED WHICH REPRESENT VARIOUS TYPES OF MINING. NO SPECIALIZATION IS ATTEMPTED AT THE UNDERGRADUATE LEVEL. APPROXIMATELY ONE-THIRD OF THE GRADUATE STUDENTS WORK IN THE OPERATIONS RESEARCH AREA. PLANS ARE UNDERWAY TO DEVELOP A GRADUATE UNIT DEVOTED TO MINE MANAGEMENT AND ECONOMICS. TODAY, ONLY FIVE OF THE 70 STUDENTS ENROLLED ARE REGULAR FOUR-YEAR STUDENTS, THE REST CHOOSING THE "CO-OP" PROGRAM. BENEFITS OF THE "CO-OP" PROGRAM INCLUDE: 1) PRACTICAL EXPERIENCE (TOTALING TWO YEARS), 2) ALTERNATE WORK AND SCHOOL QUARTERS, 3) EARNING OF MONEY, 4) CHANCES WITH CERTAIN COMPANY AFTER GRADUATION. PRESENT RESEARCH CONTRACTS INCLUDE: 1) INVESTIGATION OF EFFECTIVE MEASURES TO COMBAT MINE DISASTERS, 2) OPTIMIZATION OF COAL MINE SYSTEMS FOR LOW-COST MINING, 3) INVESTIGATION OF THE TECHNICAL ASPECTS IN THE CONTROL AND DISPOSAL OF MINE WATER TO MINIMIZE STREAM POLLUTION, 4) IMPROVEMENTS OF BLASTING TECHNIQUES IN SURFACE MINING, 5) UNDERGROUND STRESS INSTRUMENTATION, 6) STRIP MINE LAND RECLAMATION, 7) INVESTIGATION OF FAILURE PHENOMENA DURING DRILLING.

04-64-08003 COLLEGE OF MINERAL INDUSTRIES PENN STATE UNIV: MINING PREPARATION (RESEARCH EDUCATION)
LOVELL, H. L. & PENN STATE UNIV
MINING CONGRESS JOURNAL, (50) N 8, 89-92, AUG. 1964. THE RESEARCH PROGRAM IS ONE OF THE LARGEST ACADEMIC ENTERPRISES OF ITS NATURE IN THE COUNTRY. THE OBJECTIVE OF THE CURRICULUM HAS BEEN TO FURNISH THE STUDENT WITH A SOLID BASIS OF THE SCIENCES, THE COMMUNICATION MEDIA, THE ENGINEERING FUNDAMENTALS, AND THE DESIRABLE ENGINEERING SPECIALTIES UPON WHICH TO DEVELOP A BASIC PHILOSOPHY AND TECHNIQUE. THE CURRICULUM INCLUDES COMPUTER PROGRAMMING AND INSTRUMENTAL ANALYSIS. THE COURSES IN MINERAL PREPARATION ENGINEERING INCLUDE LABORATORY TECHNIQUES, UNIT OPERATIONS, COAL PREPARATION, FLOW SHEETS AND FIELD TRIPS. THE CURRENT RESEARCH PROGRAM INCLUDES NUMEROUS COAL-ORIENTED STUDIES INCLUDING PROBLEMS ASSOCIATED WITH THE CULM REFUSE BANKS, FINE COAL CLEANING, COAL GRINDABILITY, AND ELECTROKINETIC STUDIES.

04-64-08004 COLLEGE OF MINERAL INDUSTRIES PENN STATE UNIV: MINERAL ECONOMICS (EDUCATION RESEARCH)
RIDGE, J. D.
MINING CONGRESS JOURNAL, (50) N 8, 89-94, AUG. 1964. THE UNDERGRADUATE CURRICULUM IN MINERAL ECONOMICS AT PENN STATE IS DESIGNED TO TRAIN STUDENTS TO GO INTO THE MANAGEMENT PHASE OF THE MINERAL INDUSTRIES. IT COMBINES THE STUDY OF THE FUNDAMENTALS OF THE VARIOUS FIELDS THAT MAKE UP THE MINERAL SCIENCES AND TECHNOLOGIES WITH ECONOMICS AND MANAGEMENT. DURING THE SENIOR YEAR, A SEMINAR AND A MINING FIELD TRIP ARE OFFERED TO THE STUDENT. RESEARCH PROJECTS VARY WIDELY; FOR EXAMPLE, WORK IS BEING DONE IN INVESTIGATING THE NONFUEL USES OF CARBON. ALSO INVESTIGATED IS THE APPLICATION OF OPERATIONS RESEARCH TECHNIQUES TO PROBLEMS OF MINERAL SOURCE DEVELOPMENT.

04-64-11001 DRIVING 1245 M OF DRIFT PER MONTH USING PK-3 TUNNELING MACHINE
ABRAMOV, A. N. + KOLOMIN, G. A.
UGOL, N 11, 24-27, 1964. DATA ON PERFORMANCE OF TUNNELING MACHINE PK-3 IN POLYSAEVSKAYA 2 COAL MINE IN KUZNETSK BASIN. LAYOUT OF EQUIPMENT AND ORGANIZATION OF LABOR DESCRIBED. (IN RUSSIAN)

04-64-12001 PLANNING AND REALIZATION OF LARGE CROSS-SECTION TUNNEL CONSTRUCTIONS (HIGHWAY-TUNNELS RAILROAD-TUNNELS BLASTING COST-COMPARISON SWITZERLAND SWEDEN LININGS)
HERRMANN, H. V. & LOSINGER CO BERN
SCHWEIZERISCHE BAUZEITUNG (SWISS BUILDING JOURNAL), (82) N 50, 873-881, DEC. 10, 1964. LECTURE GIVEN DURING BLASTING COURSE FOR ENGINEERS IN OCTOBER 1963. SWEDISH EXPERIENCE IN TUNNEL CONSTRUCTION FOR FORTIFICATION AND POWER PLANTS AGREES WITH CONCLUSIONS FROM SWISS WORK. EXCAVATION OF FULL SECTION ON TUNNELS 70 TO 130 SQ. METERS IS MOST ECONOMICAL WHERE GEOLOGY PERMITS USE. NOMOGRAPHS SHOW RELATIONSHIP OF COSTS. MECHANIZATION AND AUTOMATION ARE NECESSARY BECAUSE OF SHORTAGE OF LABOR AND HIGH INVESTMENT COST OF MACHINES. TABLES SHOW IMPROVEMENT IN PRODUCTIVITY DUE TO INCREASING DEPTH OF ROUND UP TO 5 METERS. DETAILED TRAINING OF MINERS BECOMES NECESSARY BECAUSE OF DIVISION OF LABOR NEEDED IN LARGE BORES. COMPARISON MADE OF TYPES OF CUTS. DISCUSSES PROBLEMS OF FAULTY SHOT HOLE DRILLING.

04-64-12002 CONSTRUCTION OF RAILROAD TUNNELS IN THEORY AND PRACTICE (GERMAN-METHOD)
POTTHAST H. & DORMUND GERMANY
TIEFBAU, (6) N 12, 1003-1011, 1964. THE AUTHOR DISCUSSES THE CONSTRUCTION OF RAILROAD TUNNELS IN TWO PARTS; PART I IS PUBLISHED HERE. THE AUTHOR GIVES AN OVERALL VIEW OF TODAY'S STATE OF TECHNOLOGY IN TUNNEL CONSTRUCTION. THE IMPORTANCE OF A GEOLOGICAL EVAUATION OF THE MOUNTAIN RANGE AND THE SURVEY IS STRESSED. THE CONSTRUCTION METHODS CUSTOMARY IN GERMAN RAILROAD TUNNEL CONSTRUCTION AS WELL AS THE TEMPORARY AND FINAL LINING PROCESSES ARE DISCUSSED IN DETAIL. THE IMPORTANCE OF DRAINAGE, VENTILATION, AND SAFETY NICHES IS STRESSED.

04-64-12003 RAPID DRIVING OF INCLINE BY PK-3M TUNNELING MACHINE (SHAFT-SINKING)
BYLYNKA, G. K. + BARULIN, V. T.
UGOL, N 18, 11-13, DEC 1964. DURING A 31 DAY PERIOD 1205.6 M OF INCLINES WERE DRILLED IN NO. 27 COAL MINE OF VORKUTA. THE ANGLE OF THE INCLINES WAS 8 DEGREES TO 9 DEGREES. EQUIPMENT USED AND ORGANIZATION OF MANPOWER IS DESCRIBED. (IN RUSSIAN)

04-64-12004 TUNNEL DRIVING METHODS (SHIELDS LININGS PREFABRICATED-SECTIONS)
NOSKIEWICZ, T. M. + RAMSAY, J. A. & W. S. ATHINS AND ASSO TORONTO
ENGINEERING AND CONTRACT RECORD, 49-57, DEC 1964. GREATHEAD SHIELDS ARE NORMALLY USED ON ALL TUNNELS IN SOFT GROUND. ROTARY DIGGER SHIELDS ARE FASTER BUT UNECONOMICAL ON SHORT TUNNELS. PRESSURE WORK (COMPRESSED AIR) FOR UNDERWATER CROSSINGS HAS BECOME SAFER AND FASTER. CONCRETE AND CAST IRON LININGS ARE THE MOST POPULAR. RECENT TESTS INDICATE THAT CAST IRON LININGS IN LONDON ARE AS STRONG TODAY AS THEY WERE WHEN PLACED 80 YEARS AGO. PREFABRICATED STEEL OR CONCRETE TUNNEL SECTIONS WHICH CAN BE FLOATED TO THE JOB AND SUNK INTO POSITION ARE INCREASINGLY POPULAR FOR UNDERWATER TUNNELING. COST COMPARISON BETWEEN SHIELDS AND SUNKEN TUBES IS DIFFICULT.

04-65-01001 THE CONSTRUCTION OF RAILROAD TUNNELS IN THEORY AND PRACTICE (LININGS POWER-EQUIPMENT MUCKING-MACHINERY SPRAY-CONCRETE BLASTING AIR-DUCTS SEALING WATER-DRAINAGE)
POTTHAST, H.
TIEFBAU, (7) 27-40, JAN 1965. PART II THE AUTHOR GIVES A FEW PRACTICAL EXAMPLES OF MODERN TUNNEL CONSTRUCTION. THE THREE TUNNELS DISCUSSED BECAME NECESSARY BY THE NEW LOCATION OF THE RAILROAD IN THE AREA OF THE BIGGE DAM (SAUERLAND) UNDER CONSTRUCTION. WORK IN THE ERBSCHEID TUNNEL OF ABOUT 1000 M LENGTH IS DESCRIBED IN PARTICULAR DETAIL: DRIVING OF THE TUNNELS, EXCAVATION OF THE ENTIRE TUNNEL PROFILE, CONCRETE WORK, SEALING AND DRAINAGE, AS WELL AS THE SHAPE OF THE PORTALS. DATA ON THE MATERIAL CONSUMPTION AND CAPACITIES. (IN GERMAN).

04-65-03001 CLYDE TUNNEL: CONSTRUCTIONAL PROBLEMS (SUBAQUEOUS)
HAXTON, A. F. + WHYTE, H. E. & CHAS BRAND AND SON LTD
INST. OF CIVIL ENGINEERS, 323-346, MARCH 1965. THE CLYDE TUNNEL IS 29 FEET 6 INCHES IN INTERNAL DIAMETER. THE

PROGRESS OF THE WORK WAS HURT BY THE VARIABLE STRATA ENCOUNTERED WHICH NECESSITATED ADVANCE GROUND TREATMENT. THE TUNNEL WAS DUG USING SHIELDS AND COMPRESSED-AIR WORKING CONDITIONS. THE REQUIREMENT FOR LOW-PRESSURE AIR WAS MINIMUM CAPACITY OF 24,000 CUBIC FT/MIN OF FREE AIR WITH AN INDEPENDENTLY-POWERED STANDBY OF 5,000 CUBIC FT/MIN. THE SHIELDS WERE 32 FEET 4 INCHES IN EXTERNAL DIAMETER, 14 FEET 4 INCHES LONG AT THE SOFFIT AND 11 FEET 4 INCHES LONG AT INVERT. WHEN THEY KNEW THAT THE SHIELD WOULD RUN OUT OF A FULL FACE OF ROCK THE PLUG AND FEATHER METHOD WAS USED. THE SUCCESS OF THIS METHOD IS THE RESULT OF BEING ABLE TO MINE EASILY INTO THE TOP OF THE FACE SO THAT THE LOWER LAYERS COULD BE BROKEN OFF FROM ABOVE BY HAND QUARRYING.

04-65-06001 HIGHWAY TUNNELS (COST ROCK-BREAKING GEOLOGIC-EXPLORATION LIGHTING VENTILATION)
FOSSHEIM, S. J. & MINISTER OF TUNNELS NORWAY
TEKNISK UKEBLAD, (25) 112, 533-40, JUNE 24, 1965. DESIGN AND CONSTRUCTION OF HIGHWAY TUNNELS WITH SPECIAL REFERENCE TO NORWEGIAN CONDITIONS. TUNNEL CONSTRUCTION HAS INCREASED CONSIDERABLY DURING RECENT YEARS DUE TO A HIGHER DEMAND FOR BETTER ROAD CURVATURE AND SAFE ALL-YEAR ROADS IN THE MOUNTAINS. GREAT PROGRESS IN ROCK BLASTING TECHNIQUES HAS CONTRIBUTED FURTHER TO THIS DEVELOPMENT. THE MECHANICAL PROPERTIES OF THE ROCK IN THE INTERIOR OF THE MOUNTAINS MAY STILL BE REGARDED AS THE MOST DUBIOUS FACTOR INVOLVED IN TUNNEL CONSTRUCTION. HOWEVER, IMPROVED METHODS OF GEOLOGICAL INVESTIGATION HAVE TO A LARGE EXTENT REDUCED THE RISK OF MEETING UNEXPECTED WORKING CONDITIONS. LIGHTING AND VENTILATING PROBLEMS ARE DEALT WITH AT LENGTH. (IN NORWEGIAN)

04-65-07001 HIGHWAY TUNNELS (DRAINAGE SUPPORTS GROUND-WATER SEALING COSTS)
FOSSHEIM, S. J. & MINISTER OF TUNNELS NORWAY
TEKNISK UKEBLAD, (26) 112, 561-65, JULY 1, 1965. IN A PRECEDING ARTICLE THE AUTHOR DISCUSSED GENERAL PRINCIPLES OF TUNNEL DESIGN AND CONSTRUCTION. THIS ARTICLE DISCUSSES MORE DETAILED TECHNICAL PROBLEMS IN TUNNEL CONSTRUCTION INCLUDING DRAINING AND SEALING PROBLEMS. ITEMIZED UP-TO-DATE COST DATA ARE GIVEN FOR TUNNELS IN NORWAY AND--FOR COMPARISON--CORRESPONDING DATA FROM SWITZERLAND WHICH, QUITE NATURALLY, IS A LEADING COUNTRY IN TUNNEL TECHNIQUES. (IN NORWEGIAN)

04-65-08001 HIGH-SPEED TUBE TRANSPORTATION (NORTHEAST CORRIDOR)
EDWARDS, L. K.
SCIENTIFIC AMERICAN, 30-40, AUG 1965. THE PAPER DISCUSSES THE POSSIBILITY OF HAVING A TUBE TRAIN FROM BOSTON TO WASHINGTON. THE PAPER DISCUSSES THE ADVANTAGES OF SUCH A SYSTEM. TECHNOLOGY IS PRESENT TODAY FOR ITS CONSTRUCTION. IT WOULD WORK ON THE PRINCIPLE OF PNEUMATIC PRESSURE. WHAT IS NEEDED IS A FASTER MEANS OF TUNNELING.

04-65-09001 MODERN LIGHTING SYSTEM DESIGN FOR THE HOLLAND TUNNEL
FISHMAN, I.
IEEE TRANSACTION ON INDUSTRY AND GENERAL APPLICATIONS, (IGA-1) N 5, 339-342, SEPT 1965. IN 1927 THE LIGHTING SYSTEM CONSISTED OF INCANDESCENT LAMP. IN 1960 IT WAS DECIDED TO MODERNIZE THIS SYSTEM. THIS PAPER DESCRIBES THE DEVELOPMENT OF THIS PROJECT FROM ITS INCEPTION TO ITS COMPLETION.

04-65-11001 THE "SILENT" DRILLS WHERE THEY STAND NOW (NOISE SAFETY)
DALY, J. J.
ROCK PRODUCTS, (68) 62-63, NOV 1965. DESIGN CHANGES HAVE ELIMINATED THE EFFICIENCY LOSS OF THE EARLIER SILENCED DRILLS, AND FUTURE MODELS MAY EVEN SURPASS CONVENTIONAL UNSILENCED MACHINES.

04-66-09001 THE SEERTHRUST SYSTEM (PIPE-JACKING PEDESTRIAN-TUNNELS)
STEWART, J. & WM F REES (CONSTR) SURREY ENGL
THE AUSTRALASIAN ENGR., 43-44, SEPT. 1966. A PIPE-JACKING SYSTEM DEVELOPED IN BRITAIN ALLOWS FULL SIZE RECTANGULAR SECTION PEDESTRIAN TUNNELS TO BE CONSTRUCTED WITHOUT USING CUT AND COVER METHODS. PIPES UP TO 7 FT X 8 FT CAN BE USED. LENGTHS UP TO 1000 FT HAVE BEEN COMPLETED BY USING INTERMEDIATE JACKING STATIONS.

04-66-12001 BART TRANS-BAY TUBE (UNDERWATER-TUNNEL)
MURPHY, G. J. + TANNER, D. N.
CIV ENG (NY), (36) N 18, 51-5, DEC. 1966. UNDERWATER SECTION (3.6 MI) OF SAN FRANCISCO BAY AREA RAPID TRANSIT SYSTEM IS NOW BEING INSTALLED AS 57 BINOCULAR-SHAPED TUBES EACH 273 TO 366 FT LONG, 47 FT WIDE AND 24 FT HIGH SECTIONS ARE FABRICATED AND LAUNCHED ON SLIDING WAYS BY BETHLEHEM STEEL, THEN OUTFITTED, TOWED TO POSITION AND SUNK TO ABOUT 125 FT DEPTH UNDER SAN FRANCISCO BAY; SPECIAL PROVISION IS MADE TO ACCOMMODATE DISPLACEMENTS DUE TO EARTHQUAKES; SPECIALLY DEVELOPED RUBBER JOINT PROVIDES FOR 2 IN. VERTICAL AND 4 IN. HORIZONTAL OR LONGITUDINAL MOVEMENT OF TUBE AT FIXED VENTILATION BUILDINGS.

04-67-03001 WHERE DRILLING RESEARCH STANDS TODAY (RIG-AUTOMATION DIRECTIONAL-DRILLING CEMENTING)
HUTCHISON, S. O. & STANDARD OIL CO CAL
THE OIL AND GAS JOURNAL, (65) 84, MAR 27, 1967. THE SURVEY REPORT MADE BY THE STANDARD OIL COMPANY OF CALIFORNIA OF DRILLING RESEARCH WAS ADAPTED FROM A PAPER PRESENTED 17 FEBRUARY 1967 AT THE AAODC ROTARY DRILLING CONFERENCE IN HOUSTON ENTITLED "PRESENT STATUS OF DRILLING RESEARCH." THE REPORT SUMMARIZES THE STATE OF THE ART. TWO TABLES PRESENT DATA ON EXPENDITURES AND BUDGETS RELATED TO DRILLING RESEARCH.

04-67-04001 ANALYSIS OF PEDESTRIAN CIRCULATION THROUGH TUNNEL NETWORK (CANADA)
HAAS, G. + MORRALL, J. F.
TRAFFIC QUARTERLY, (81) N 8, 229-35, APR 1967. CARLETON UNIVERITY, OTTAWA, ONT. STARTED CONSTRUCTING PEDESTRIAN TUNNELS BETWEEN ALL MAJOR BUILDINGS AND PARKING LOTS ABOUT 7 YR AGO; ORIGINALLY, STANDARD DESIGN WAS USED AND SEVEN BUILDINGS AND ONE LARGE PARKING LOT HAVE BEEN CONSTRUCTED; RAPIDLY INCREASING ENROLLMENT AND UNIVERSITY EXPANSION HAVE LED TO CONGESTION PROBLEMS IN SEVERAL PORTIONS OF SYSTEM; STUDY FOR DESIGN OF TUNNEL SYSTEM AND BUILDING ADDITIONS CONSIDERING BOTH PEDESTRIAN CIRCULATION PATTERNS AND TUNNEL CAPACITY, WITH ADDED CONSTRAINT OF 10-MIN INTERCHANGE TIME BETWEEN ANY TWO POINTS; TABLES AND CHARTS SHOW RESULTS OF STUDY.

04-67-06001 THE WATERPROOF SLIDING REINFORCED CONCRETE RING LINING OF THE FROZEN AUGUSTE VICTORIA 8 SHAFT (SHAFT-SINKING QUICK-SAND FREEZING-SOIL)
LUTGENDORF, H. O.
GLUECKAUF, (103) 12, 553-560, JUNE 1967. SINCE 1901, THE SHAFTS OF THE AUGUSTE VICTORIA BITUMINOUS COAL MINES WERE ALL SUNK THROUGH A QUICKSAND-BEARING OVERBURDEN BY A FREEZING METHOD. THE FREEZING DEPTHS VARY FROM 121 M TO 227 M AND THE THICKNESS OF THE FROZEN LINING INCREASES PROPORTIONATELY. SHAFT NO. 8 PROBLEMS AND DESIGN DESCRIBED IN DETAIL.

04-67-06002 STATE OF UNDERGROUND AUTOMATION IN THE GERMAN COAL MINING INDUSTRY (AUTOMATIC-MINES CONVEYORS)
OLAF, J.
GLUECKAUF, (103) 13, 631-635, JUNE 1967. AUTOMATION OF THE GERMAN COAL MINES WAS UNDERTAKEN TO REDUCE THE NUMBER OF PERSONS IN THE MINES, HANDLE JOBS WHICH OVERTAXED THE PHYSICAL AND MENTAL RESOURCES OF THE WORKER, AND TO MAINTAIN THE SPEED OF THE FAST TUNNELING-MACHINES. SAFETY OF PERSONNEL STILL WITHIN THE MINES HAS BEEN GREATLY IMPROVED.

04-67-06003 MINE SYSTEMS DESIGN: THE NEXT EFFORT WILL FOCUS ON TUNNELING (MOLES ROCK-DISINTEGRATION GROUND-CONTROL MATERIALS-CONTROL ENVIRONMENTAL-CONTROL GEOLOGY)
HOWARD, T. E. & U.S. BUR MINES WASH D.C.
ENGINEERING AND MINING JOURNAL, 158-163, JUNE 1967. TUNNELING NEEDS OF THE NATION FOR ESSENTIALLY CONVENTIONAL PURPOSES WILL GROW AT A RAPID RATE BUT THE TECHNOLOGY OF TUNNELING IS NOT ADVANCING RAPIDLY ENOUGH TO KEEP PACE. RESEARCH AND DEVELOPMENT MUST BE UNDERTAKEN TO SPEED UP TUNNELING TECHNOLOGY. THE PROBLEMS ARE INTERDISCIPLINARY AND

MUST INVOLVE MANY TYPES OF ENGINEERS, SCIENTISTS, MANUFACTURERS AND CONTRACTORS TO FIND NEW AND FASTER, ECONOMICAL WAYS OF BREAKING ROCK, TRANSPORTING MATERIALS, CONTROL THE GROUND AND THE ENVIRONMENT.

04-67-07001 PRACTICAL APPLICATION OF OPERATIONS RESEARCH IN MINE PLANNING (SYSTEMS-ANALYSIS)
DORSTEWITZ, G.
GLUECKAUF, (103) 14, 663-669, JULY 1967. THE NATURE AND LIMITATIONS OF OPERATIONS RESEARCH ARE GIVEN FOLLOWED BY TWO EXAMPLES: PLANNING OF A NEW HORIZON INCLUDING VENTILATION, TUNNEL SHAPE AND VERTICAL HOISTING AND THAT OF A MAIN HAULAGE ROAD IN THE EWALD-KOHL AG. ON THE BASIS OF THE TWO EXAMPLES, USEFULNESS OF OPERATIONS RESEARCH WAS DEMONSTRATED. MAJOR ADVANTAGES DUE TO RELIABLE COST DATA FOR MANAGEMENT DECISION.

04-67-07002 THE MINING SUPPLY INDUSTRY AT THE HANOVER FAIR IN 1967 (TUNNELING-MACHINE TRUCKING DRILLING FORMS LINING CONVEYORS)
BACHSTROEM, R. H.
GLUECKAUF, 713-731, JULY 1967. THE OUTSTANDING EQUIPMENT PERTAINING TO MINING EXHIBITED AT THE MINING SUPPLY INDUSTRY FAIR AT HANOVER, GERMANY WERE TUNNELING MACHINES ONE WEIGHING 33 TONS WITH A TOOTHED ROLLER BIT, DRILLING 1.98 TO 2.30 METER DIAMETER HOLE AT 15 METERS PER TWO SHIFT DAY IN 800 TO 2000 KG PER SQ. CM LIMESTONE HAVING 220 KV POWER AND ANOTHER WITH 30 CARBIDE TIPPED TOOLS ON A ROTATABLE AND DISPLACEABLE ROCKING SHAFT HAVING 50 TO 90 KW POWER, CUTS 11 TO 17 SQ METER CROSS SECTIONS AT 3.5 METERS PER SHIFT IN ROCK VARYING FROM 350 TO 600 KP PER SQ. CM; A NEW CATERPILLAR TREAD CUTTER AND LOADER INCREASED OUTPUT 60 PERCENT OVER DRIVING WITH BLASTING; A SIDE DUMPING LOADER HAVING COMPRESSED AIR PISTON MOTOR DRIVES ON EACH CATERPILLAR TREAD AND A HYDRAULIC SHOVEL; A NEW LINE OF DIESEL AIR COOLED SHOVELS, TRUCKS AND PASSENGER VEHICLES FOR SALT OR POTASH MINES AS TRACKLESS VEHICLES ARE BECOMING MORE POPULAR; A CONCRETE SPRAYING AND INJECTION UNIT OPERATING AT 5 TO 60 KG PER SQ. CM, SIMPLE AND EASILY ALIGNED ALUMINUM FORMS FOR STOPES AND TUNNELS; A ONE METER DIAMETER CORE DRILL WITH 6-TOOTHED ROLLER DRILLS AT 1.5 M/H IN SLATE AND 0.4 M/H IN COMPACT GRAYWACKE; A HAMMER DRILL WITH ELECTRIC FEED AND ROTATION AND PNEUMATIC HAMMERING DRILLS 15 M/H IN MODERATELY HARD ROCK 10 M/HR IN HARD ROCK; CONE SHAPED ROLLER BITS IN 75 MM TO 3.3 METER SIZES HAVE INCREASED DRILLING SPUDS; A LOW SPEED HYDRAULIC MOTOR HAS 5600 KPM TORQUE AT 0-40 RPM, 2600 RPM AT 0-80 RPM.

04-67-09001 DEEP-SEA DRILLING PROJECT - JOINT OCEANOGRAPHIC INSTITUTIONS DEEP EARTH SAMPLING - JOIDES (SEDIMENTS WELL-LOGGING)
THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGIST BULLETIN, (51) 1787-1802, SEPT 1967. JOIDES (JOINT OCEANOGRAPHIC INSTITUTION DEEP EARTH SAMPLING) WAS FORMED BY FOUR OF THE MAJOR OCEANOGRAPHIC INSTITUTIONS TO FOSTER DEEP-SEA DRILLING PROJECTS. THE BLAKE PLATEAU PROJECT WAS SUCCESSFULLY COMPLETED IN 1965. THIS CONSISTED OF THE DRILLING OF SIX HOLES FROM 25 TO 1,032 M IN DEPTH WITH AN AVERAGE CORE RECOVERY OF 36 PERCENT. LAMONT GEOLOGICAL OBSERVATORY CONDUCTED THE OPERATIONS UNDER A GRANT FROM THE NATIONAL SCIENCE FOUNDATION. SCRIPPS INSTITUTION OF OCEANOGRAPHY WAS AWARDED A CONTRACT BY THE NATIONAL SCIENCE FOUNDATION FOR MORE EXTENSIVE DRILLING OPERATIONS IN THE ATLANTIC AND PACIFIC OCEANS; SEA OPERATIONS WERE EXPECTED TO BEGIN LATE IN 1968. PRELIMINARY DRILLING SITES HAVE BEEN RECOMMENCED BY THE ATLANTIC AND PACIFIC ADVISORY PANELS (PANELS WHICH WERE FORMED BY THE RECOMMENDATION OF JOIDES). THESE PLANS ARE SUBJECT TO REVISION UNTIL ACTUAL DRILLING BEGINS AS MORE DATA BECOMES AVAILABLE. THE PRIMARY OBJECTIVES OF THE DEEP SEA DRILLING ARE THE DETERMINATION OF AGE AND THE PROCESSES OF DEVELOPMENT OF THE OCEAN BASINS. THE PRESENT STATUS OF THE ATLANTIC AND PACIFIC PANEL RECOMMENDATIONS ARE SUMMARIZED WITH THEIR REASONS FOR THE CHOICES MADE.

04-67-10001 UNDERSEA DRILLING AND PRODUCTION SITES FOR PETROLEUM (TUNNEL MACHINE-BORING SHAFT-DRILLING BEDROCK)
AUSTIN, C. F. & NAV WPNS CTR - CHINA LAKE CALIF
JOURNAL OF PETROLEUM TECHNOLOGY OF THE SOCIETY OF PETROLEUM ENGINEERS, 1309-1316, OCT. 1967. PROPOSAL TO ESTABLISH PERMANENT MANNED INSTALLATIONS WITHIN THE SEA FLOOR FOR USE IN WELL DRILLING AND INITIAL PETROLEUM FLUID PROCESSING. PAST AND PRESENT PERMANENT IN-THE-SEA-FLOOR MINING INDUSTRY IS REVIEWED. METHODS NOW PRACTICAL FOR DIRECT ACCESS TO AND FROM PERMANENT IN-THE-SEA-FLOOR DRILLING AND PRODUCTION SITES ARE OUTLINED. SUCH AN OPERATING SITE IS PRESENTLY ESTIMATED TO COST APPROXIMATELY $50 MILLION.

04-67-10002 SCHEME FIRST PLANNED 30 YEARS AGO NEAR COMPLETION (TYNE-TUNNEL)
CONSULTING ENGR (LOND), (31) N 10, 46-7, 49-53, 55, 57, OCT. 1967. DESIGN PARTICULARS AND CONSTRUCTION TECHNIQUES OF TUNNEL UNDER RIVER TYNE, GREAT BRITAIN, WHICH IS FURTHEST DOWNSTREAM AND FIRST TUNNEL FOR VEHICULAR USE; ROAD TUNNEL HAS 31 FT 3 IN. ID AND IS 5500 FT LONG DESCENDING AT GRADIENT OF ONE IN 20 TO MAXIMUM DEPTH 100 FT BENEATH RIVER AND ALMOST IMMEDIATELY RISING AGAIN AT SAME GRADIENT; TUNNEL IS LINED WITH CAST IRON SEGMENTS BOLTED TOGETHER AND CALKED WITH STRIP CAPABLE OF KEEPING OUT WATER AT 45 PSI; VENTILATION IS ON SYSTEM OF UPWARD SEMITRANSVERSE; FEATURE OF VENTILATING EQUIPMENT IS USE OF MOVABLE FANS; SERVICE AND STANDBY FANSARE MOUNTED ON RAILS.

04-67-10003 OROVILLE DAM DIVERSION TUNNEL (SHAPE LINING)
LANNING, C. C. & CAL WATER RESOURCES DEPT
PROC. ASCE POWER DIV J PO 2 PAPER 5506, 51-68, OCT. 1968. NO CONSTRUCTION DETAILS FOR THE TWO 35 FT DIAM OROVILLE DAM DIVERSION TUNNELS NORTH OF SACRAMENTO, CAL. ARE GIVEN. THEIR HYDRAULIC FLOW CONDITIONS AND OPERATION DURING A FLOOD ARE DISCUSSED. A CIRCULAR SHAPE RATHER THAN HORSESHOE WAS SELECTED FOR STRUCTURAL AND CONSTRUCTION REASONS. THE CONCRETE LINING THICKNESS WAS DETERMINED BY COMBINING INTERIOR TUNNEL FLOW PRESSURE COMPUTED FROM MAXIMUM HYDRAULIC GRADE LINES WITH EXTERIOR LOADS BASED ON GROUND WATER AND TUNNEL OVERBURDEN.

04-67-11001 RAPID EXCAVATION (CONTINUOUS TUNNELLERS MOLES)
HOWARD, T. E. & U.S. BUR MINES WASH D.C.
SCIENTIFIC AMERICAN, 74-85, NOV 1967. A GREAT DEAL OF EXCAVATION TECHNOLOGY IS NEEDED. SUCH AS IN UNDERGROUND HAULAGE, VENTILATING, PREVENTING OR REMOVING THE INFLOW OF WATER AND GAS. THE PROBLEM OF DRILLING THROUGH WATER-FILLED FISSURES, EXPLOSIVE GAS AND HIGH ROCK TEMPERATURE MUST BE SOLVED. VERTICAL AND INCLINED SHAFTS TO PROVIDE ACCESS WAYS MUST BE DRIVEN AND HOLES MUST BE DRILLED FOR VENTILATION AND FOR POWER CABLES. THE TECHNOLOGY FOR THESE PROBLEMS MUST BE DEVELOPED. THERE ARE FOUR STEPS IN EARTH EXCAVATION (1) THE ROCK MUST BE BROKEN (2) THE BROKEN ROCK MUST BE REMOVED (3) THE LINING OF THE TUNNELS MUST STAY INTACT (4) THE ENVIRONMENT WITHIN THE HOLE MUST BE CONTROLLED. THE TECHNOLOGY HAS CHANGED LITTLE SINCE DRILLING AND BLASTING WITH GUNPOWDER WAS INTRODUCED EARLY IN THE 17TH CENTURY. GREAT IMPROVEMENT HAS OCCURRED IN THE HIGH EXPLOSIVES AND COMPRESSED-AIR TECHNIQUES, BUT THE SEQUENCE OF ACTS HAS BEEN LITTLE AFFECTED IN THE PAST 300 YEARS. IN SMALL TUNNELS AND IN SOME LARGE ONES THE MUCK MUST BE COMPLETELY REMOVED. SEVERAL PROBLEMS ARISE FROM HAULING THE BROKEN ROCK. THE SIZE OF THE RAILCARS OR TRUCKS IS LIMITED. IN LONG TUNNELS CARS MUST BE ABLE TO PASS ONE ANOTHER. THE GANTRY DRILL JUMBO IS A NEW TECHNIQUE WHICH ALLOWS AT LEAST PARTIALLY CONCURRENT DRILLING AND MUCKING OR CAR CHANGERS OR MOVABLE DOUBLE-CROSSOVER WHICH PERMITS QUICK EXCHANGE OF AN EMPTY RAILCAR FOR A LOADED ONE. THE ORG. RATE FOR ROCK TUNNELING WITH A DRILL-BLAST SYSTEM HAS INCREASED TENFOLD IN THE 100 YEARS SINCE MECHANICAL ROCK DRILLS WERE INTRODUCED. THE CONTINUOUS TUNNEL BORER HAS HAD PENETRATION RATES OF UP TO 20 FT/HR FOR SHORT PERIODS OF TIME.

04-67-11002 MOLE ACHIEVERS AROUND THE WORLD
ENGINEERING NEWS-RECORD, (175) 25, NOV 2, 1967. ANNOUNCEMENT OF PRESENTATION OF 1968 MOLES AWARD FOR OUTSTANDING ACHIEVEMENT IN CONSTRUCTION AT THE 28TH ANNUAL AWARD DINNER ON JANUARY 24.

04-68-01001 REVOLUTION IN TUNNELING TECHNIQUES (UNDERGROUND-TRANSPORTATION ROCK-FRACTURE)
WARD, E. J. + LUCKE, W. N. & U.S. DEPT OF TRANS
MINING CONGRESS JOURNAL, 46-49, JAN 1968. UNDERGROUND MASS TRANSPORTATION REQUIRES DEVELOPMENT OF NEW TUNNELING TECHNIQUES. CONTINUOUS EXCAVATION MUST BE DEVELOPED BEFORE SIGNIFICANT ADVANCEMENT CAN BE MADE IN ROCK TUNNELING. FLAME JET, CHEMICAL SURFACTANTS, AND HIGH-PRESSURE FLUIDS ARE EXPERIMENTAL METHODS OF FAST ROCK FRACTURE.

04-68-02001 EFFICIENCY AND SPEED - THE KEYS TO MINING TECHNOLOGY - UNDERGROUND MINING (BORING-MACHINES DRILLING-AND BLASTING NUCLEAR-EXPERIMENTS GROUND-SUPPORT MATERIALS-HANDLING SURVEYING BASIC-RESEARCH)
SCOTT, J. J. & UNIV MO ROLLA MO
MINING ENGINEERING, SOCIETY OF MINING ENGINEER, 77-80, FEB 1968. SUMMARY OF ADVANCES IN TUNNELING TECHNOLOGY DURING 1967.

04-68-02002 THE PRODUCTIVITY CHALLENGE IN MINING (ROCK-MECHANICS EXPLOSIVES)
BRESSENDEN, W. G. & NORANDO MINES LTD TORONTO
THE CANADIAN MINING AND METALLURGICAL BULLETIN, 202-208, FEB 1968. A NEW IDEA IN MINING TECHNOLOGY IS THE BORING OF LARGE- DIAMETER HOLES, UP TO 8 FEET IN DIAMETER, FOR SHAFT-SINKING, TUNNELLING, AND RAISE DRIVING. THIS ELIMINATES THE DRILLING, BLASTING, AND LOADING CYCLES OF THESE OPERATIONS, IN SOME TRIAL CASES IT HAS BEEN CHEAPER. SUPPORT PROBLEMS ARE REDUCED, IT IS SAFER AND MAY BE FASTER, AND IT OFFERS A CONTINUOUS METHOD WHICH MAY BE ADAPTABLE TO PRODUCTION MINING. AN ATTEMPT IS BEING MADE TO INCREASE PRODUCTIVITY OF LOADING-OUT OPERATIONS IN CUT-AND-FILL STOPES BY USING HIGH PRODUCTION LOAD-HAUL UNITS WHERE STOPES CAN BE INTERCONNECTED AND AN ADEQUATE NUMBER OF FACES PROVIDED TO KEEP EQUIPMENT BUSY. INCREASED PRODUCTIVITY IN THE LOADING-OUT CYCLE LEADS TO INCREASED PRODUCTIVITY IN THE DRILLING-BLASTING CYCLE AND LEADS TO LOWER COSTS ELSEWHERE. OTHER DEVELOPMENTS INCLUDE RAISING BY LONG-HOLE DRILLING, MORE HIGHLY MECHANIZED DRILLING UNITS, AND THE MORE FREQUENT USE OF TRACKLESS EQUIPMENT AND /OR CONVEYORS FOR UNDERGROUND HAULAGE. IN OPEN-PIT MINING EXPLOSIVES, SLURRY MIX TRUCKS, WHICH PREPARE THE PROPER MIXTURE FROM THE RAW MATERIALS AS THE EXPLOSIVE IS CHARGED INTO THE BORE HOLES, ARE BEING USED AND WILL LEAD TO INCREASED USE OF SLURRIES AS OPPOSED TO AN-FO.

04-68-02003 NEW TOOLS, TECHNIQUES USED IN ALASKA BIG HOLES (ABRASIVE-DRILLING)
STEWART, C. R. + KEMNITZ, G. E. & PARCO INC LAS VEGAS
WORLD OIL, 66-68, FEB 1, 1968. ONE CONVENTIONAL AND THREE BIG-HOLE TYPE DRILLING RIGS ARE BEING USED TO DRILL 60-IN AND 90-IN DIA HOLES TO DEPTHS UP TO 6,200 FT ON AMCHITKA ISLAND. TWO BIG-HOLE RIGS ARE EQUIPPED WITH 3,000 HP DRAWWORKS AND 1,330,000 LB GROSS NOMINAL CAPACITY DERRICK. DRILLING IS DONE WITH 108-IN AND 90-IN OD MULTIPLE-CUTTER BITS. BIT WEIGHTS UP TO 80,000 LBS WERE USED. AN AIR-ASSISTED REVERSED CIRCULATION SYSTEM IS USED FOR BETTER CLEANING OF CUTTINGS FROM THE WELL BORE.

04-68-02004 TYNE TUNNEL-1, 2 (GREAT-BRITAIN ROAD-TUNNEL)
PROSSER, J. R. + GRANT, P. A. + FALKINER, R. H. & TOUGH, S. G.
INSTN CIV ENGRS - PROC. (39) 193-234, PT. 1, FEB. 1968. PART OF ROAD SYSTEM AT NEWCASTLE, GREAT BRITAIN, CONSTRUCTED BETWEEN 1961 AND 1967, COMPRISES TUNNEL OVER MILE LONG BETWEEN PORTALS AND PROVIDING 24 FT WIDE ROADWAY, ENTRANCE WORKS IN URBAN AREAS BORDERING RIVER, AND APPROACH ROADS WITH DUAL 24 FT WIDE ROADWAYS EXTENDING 3 MI SOUTHWARD AND 1 1/2 MI NORTHWARD FROM ENTRANCE WORKS; PAPER OUTLINES NATURE AND GEOLOGY OF SITE AND PLANNING AND DEVELOPMENT OF WORKS, DEALS WITH DESIGN OF ROAD TUNNEL AND ITS IMMEDIATE APPROACHES AND THEIR EQUIPMENT AND SERVICES, AND GIVES ACCOUNT OF ARRANGEMENT AND CONSTRUCTION OF APPROACH ROADS. PT 2. CAST-IRON LINED TUNNEL OF 31 FT 3 IN. INTERNAL DIAM, APPROXIMATELY 5400 FT IN LENGTH, WAS CONSTRUCTED IN GLACIAL DEPOSITS AND COAL MEASURED ROCKS USING HAND DRIVING AND SHIELD DRIVING METHODS; WORK NECESSITATED CONSTRUCTION OF PILOT TUNNELS AND UTILIZATION OF VARIOUS GROUND INJECTION PROCESSES; TUNNELING OPERATIONS WERE CARRIED OUT IN WATER-BEARING SANDS AND GRAVELS AND IN CLOSE PROXIMITY TO RIVER SILTS AND REQUIRED EXTENSIVE USE OF COMPRESSED AIR IN WORKING CHAMBERS; WORK INCLUDED CONSTRUCTION OF REINFORCED CONCRETE SHIELD ERECTION PITS.

04-68-03001 TWO SORTS OF TUNNELING (SHIELDS TUNNELING-MACHINES UNDER-WATER-TUNNEL)
MUIR, A. M. + PEQUIGNOT, C. A.
NEW SCIENTIST, MAR. 1968. TWO METHODS OF MAKING UNDERWATER TUNNELS - TUNNELING THROUGH THE EARTH AND SINKING THROUGH THE WATER. A BIG HELP IN TUNNEL DESIGN IS THE USE OF THE COMPUTER. ONE OF THE LARGEST MACHINES FOR TUNNELING IS AT WORK ON THE MERSEY TUNNEL, CUTTING THROUGH ROCK WITH COMPRESSIVE STRENGTHS UP TO 45,000 LB FT/SQ. IN. IT IS OFTEN NECESSARY TO STIFFEN THE GROUND AT THE TUNNEL FACE. MOST ECONOMIC IS THE USE OF COMPRESSED AIR. FOR LININGS SUBJECTED TO HIGH STRESS RINGS OF FABRICATED STELL SEGMENTS ARE USED. GROUND TREATMENT HAS REDUCED COST BY USING SUCH MATERIALS AS THIXOTROPIC MUDS, CEMENT GROUTS, INORGANIC AND ORGANIC CHEMICALS. FREEZING CAN ALSO BE USED FOR SOLUTION OF THE WATER PROBLEM.

04-68-03002 RAISE BORING (COST WHIPSTOCKING REAMING)
STEVENS, V. L. + HENDRICKS, R. S. + FARRELL, P. F. & BOYLES BROS DRILL CO SALT LAKE
MINING CONGRESS JOURNAL, 48-56, MAR 1968. THE ADVANTAGES OF RAISE BORING ARE: ELIMINATION OF HAZARDS MINERS ENCOUNTERED IN CONVENTIONAL RAISE DRIVING, SMOOTH WALLS, TIME (APPROX. 4 FT OF ADVANCEMENT PER MANSHIFT), SMALL OPERATING SPACE (USUALLY 12 X 12 X 12 FT), LESS OVERALL COST. SECURITY ENGINEERING, JAMES S. ROBINSON CO AND LAWRENCE MANUFACTURING ARE THE THREE COMPANIES THAT PRODUCE A TRUE UNDERGROUND RAISE BORER. THE MACHINES THAT ARE USED DRILL RAISES THAT RANGE FROM 4 TO 8 FT IN DIA AND FROM 300 TO 1200 FT IN LENGTH. THE BEST RESULTS WERE OBTAINED BY THE DRILL DOWN REAM UP METHOD. RAISES SUCCESSFULLY BORED AT ANGLES OF 31 TO 84 DEG FROM THE HORIZONTAL DEMONSTRATE THEIR VERSATILITY. THE AVERAGE FIXED COST FOR THE RAISE DRILL (FIXED COST INCLUDES SITE PREPARATION AND BETWEEN-HOLE TRANSPORTATION) IS $2800. CUTTER COST, THE MOST EXPENSIVE SINGLE ITEM IN RAISE BORING EQUIPMENT, AND OPERATING LABOR MAKE UP THE DIRECT COST PER FT; THEREFORE, TOTAL COST = $2825 + $23.83 (LENGTH OF HOLE). THIS DOES NOT INCLUDE EXPENSES SUCH AS POWER, COMPRESSED AIR, ENGINEERING AND MACHINE WRITE-OFF. IT IS ESTIMATED THAT DRILLED RAISES CAN BE COMPLETED IN 1/3 THE TIME AND 50 PERCENT OF THE COST OF CONVENTIONALLY DRIVEN RAISE.

04-68-08001 THE DEVELOPMENT OF MECHANICAL MINING AT GASPE COPPER MINES LTD. (COMPUTERS AUTOMATION MATERIALS-HANDLING)
WHITE, J. C. & GASPE COPPER MINES QUEBEC CAN
CANADIAN INSTITUTE OF MINING AND METALLURGY BULLETIN, 939-949, AUG 1968. THE DEVELOPMENT OF TRACKLESS MINING AT GASPE IS DESCRIBED, SHOWING CHANGE IN MINING METHOD AND THE PART PLAYED BY THE MOBILE EQUIPMENT IN THIS HIGHLY MECHANIZED OPERATION. COMPARISON OF LOADING AND HAULING MACHINES IS GIVEN. PREDICTIONS ARE MADE ON FUTURE DEVELOPMENTS.

04-68-10001 SOUTH COVE TUNNEL PROJECT, BOSTON MASS (SUBWAY)
STACHO, Z. A.
JOURNAL OF THE BOSTON SOCIETY OF CIVIL ENGINEERS, (55) NO 4, 253-83, OCT. 1968. DESIGN FEATURES OF THE NEW SUBWAY STRUCTURE IN DOWNTOWN BOSTON ARE DESCRIBED. METHODS OF CONSTRUCTION TO BE EMPLOYED ARE DISCUSSED.

04-68-10006 SUBMERGED TUNNEL IN ANTWERP (BELGIUM HIGHWAY)
INDIAN CONCRETE, (42) NO 10, 428-29, OCT. 1968. A SUBMERGED TUBE TUNNEL IS BEING BUILT ACROSS THE SCHELDE RIVER IN ANTWERP BELGIUM. THE TUNNEL HAS 2 THREE LANE HIGHWAYS, A 13 FT WIDE BICYCLE-MOTORCYCLE LANE AND 2 ELECTRIC RAILROAD TRACKS.

04-68-12001 UNDERGROUND RAILWAY-TUNNEL WORKS AT NEW SCHIPHOL AIRPORT (NETHERLANDS DIAPHRAGM-WALLS)
DENIE, F. C.
INGENIEUR, (80) N 52, BT 51-64, DEC. 27, 1968. EXPLORATION OF TERRAIN AND PREPARATION OF PLANS FOR BUILDING RAILWAY LINE TO CONNECT SCHIPHOL AIRPORT DIRECTLY WITH AMSTERDAM AND THE HAGUE; SOIL CONDITIONS; TUNNEL DESIGN REQUIREMENTS; ADVANTAGES OF DIAPHRAGM SYSTEM EMPLOYED FOR MAKING TUNNEL WALLS; AS COMPROMISE SOLUTION, TWO CONSTRUCTION METHODS FOR BOTTOM-SLAB, SO-CALLED 'OPEN' AND 'CLOSED' ONES, WERE USED; THEIR ADVANTAGES AND DISADVANTAGES; DETAILS ARE GIVEN OF 330-M TUNNEL SECTION CONSTRUCTED BY OPEN METHOD AND 190-M TUNNEL SECTION BUILT BY CLOSED METHOD.

04-69-00001 RAPID EXCAVATION SIGNIFICANCE NEEDS OPPORTUNITIES A TECHNICAL REPORT ANALYSIS (TUNNELING RESEARCH-PROGRAMS MOLES BLAST-SHELTERS TRANSPORTATION)
SELF, M. W. & SURVIVE MAGAZINE
SURVIVE, (2) N. 1, 14-15, JAN-FEB 1969. A SOLUTION TO THE URBAN EXPANSION PROBLEM IS VERTICAL EXPANSION. SUB-SURFACE EXCAVATION HAS BEEN IGNORED. DESPITE THE FACT THAT IT COSTS MORE PER CU-YD, THE SOCIAL COSTS AND BENEFITS COULD OUTWEIGH THIS FACTOR. IT HAS BEEN CONCLUDED THAT PRESENT EXCAVATION IS INSUFFICIENT AND A TEN-YEAR, $200 MILLION, FEDERALLY FUNDED RESEARCH PROGRAM HAS BEEN PROPOSED. IN EXPERIMENTAL EXCAVATIONS, A MECHANICAL MOLE IS BEING EMPLOYED AT ONE SITE IN THE SAN FRANCISCO BAY AREA. ABOUT 20 MILES OF THE 75-MILE SYSTEM WILL BE UNDERGROUND WITH 64,000 FT OF 18-FT DIA SOFT GROUND TUNNELS. TUNNEL VENTILATION WILL BE PROVIDED BY THE PISTON ACTION OF TRAINS MOVING. AIR ESCAPE SHAFTS ARE BEING BUILT AT EACH END AND AT 1,500 TO 2,500 FT INTERVALS. IN NEVADA, A MECHANICAL MOLE IS BEING USED TO DRIVE 12 FT DIA HARD-ROCK TUNNELS. STEEL DISCS CUTTERS ARE BEING USED TO BORE THROUGH IGNEOUS FORMATIONS. CIVIL DEFENSE COULD ALSO BENEFIT BY BEING CONSIDERED IN EARLY PLANNING OF SUCH PROJECTS.

04-69-01001 STRAIGHT CREEK TUNNEL (HIGHWAY DENVER COLORADO)
SCHILLING, K. J.
COMPRESSED AIR MAG., (74) NO 1, 6-10, JAN. 1969. COMPRESSED AIR MAG., (74) NO 2, 12-16, FEB. 1969. THE STRAIGHT CREEK TUNNEL 60 MILES WEST OF DENVER ON U.S. 6 IN THE ROCKY MOUNTAINS HAS A 42 FT DIAMETER BORE AND IS 11,000 FT ABOVE SEA LEVEL. CONTRACTOR IS USING A 2 DECK 14 DRILL JUMBO ON RAILS SPACED 30 FT APART FOR DRILLING THE WEST TOP HEADING. DECKS ARE RAISED AND LOWERED BY PNEUMATIC HOISTS.

04-69-03001 BART SUBWAY CONSTRUCTION - PLANNING AND COST (CUT-AND COVER)
KUESEL, T. R.
CIVIL ENGINEERING (NY), (39) NO 3, 60-65, MAR. 1969. SAN FRANCISCO BAY AREA RAPID TRANSIT COSTS ARE LISTED FOR CUT-AND COVER TUNNELS. PROJECT MANAGEMENT CONTROLS ARE DESCRIBED.

04-69-03002 CONSTRUCTION ADVANCES RAPIDLY ON MELBOURNE TRUNK SEWER (AUSTRALIA MOLES SHAFTS ROBBINS)
NEYLAND, A. J. & MELBOURNE METRO BOARD OF WORKS
AUSTRALIAN CIV ENGR, (10) NO 3, 30-33, MAR. 1969. A REPORT ON PROGRESS ON SHAFT CONSTRUCTION AND TUNNEL DRIVING ON THE SOUTH-EASTERN TRUNK SEWER FOR MELBOURNE METROPOLITAN BOARD OF WORKS, 11 SHAFTS HAVE BEEN BUILT IN THE 10 1/2 MILE ROCK TUNNEL SECTION. A ROBBINS MOLE WITH A 12 FT 8 IN DIA HEAD WAS USED TO BORE THREE DIFFERENT DIAMETERS UP TO 14 FT 5 IN. STEEL SUPPORTS WITH 4X3 STEEL RIBS ON 3 1/2 FT CENTERS AND WELDED MESH LAGGING WAS USED. RIBS EXPANDED INTO ROCK CONTACT BY 20 TON JACKS.

04-69-04001 THE CHICAGO AREA DEEP TUNNEL PROJECT (COST SEWAGE-TUNNELS)
KOELZER, V. A. + BAUER, W. J. + DALTON, F. E. & HARZA ENGR CO CHICAGO
JOURNAL WATER POLLUTION CONTROL FEDERATION, 515-534, APR. 1969. CHICAGO MUST IMPROVE HER SEWAGE SYSTEM RADICALLY TO STOP POLLUTION OF LAKE MICHIGAN. A HISTORY OF THE DEVELOPMENT OF THE PROBLEM AND FOUR POSSIBLE SOLUTIONS ARE PRESENTED. SEPARATION OF THE DUAL SYSTEM BY BUILDING A COMPLETELY NEW STORN SEWER OR A NEW SANITARY SEWER SYSTEM WAS RULED OUT BECAUSE IT WAS TOO COSTLY AND ONLY 80% EFFECTIVE. STORAGE IN HOLDING TANKS WAS A COMPLETE SOLUTION BUT MUCH MORE EXPENSIVE THAN THE DEEP TUNNEL SYSTEM. THE UNDERFLOW SYSTEM IS ONLY PARTIALLY EFFECTIVE BUT CAN BE USED AS AN INITIAL STEP IN EMPLOYING THE CHEAPEST COMPLETE SOLUTION, THE DEEP TUNNEL PLAN. A NETWORK OF 31 MILES OF TUNNELS FROM 6 FT TO 22 FT DIA WILL CARRY FLOW TO THE MINED STORAGE AREA. TUNNELS WILL BE IN DOLOMITE OR SHALE. IF BORED, NO LINING REQUIRED. MINED RESERVOIR WILL BE A GRID OF GALLERIES 25 FT WIDE X 70 FT HIGH WITH 185 FT SEPARATION, LOCATED 930 FT BELOW GROUND. THE SYSTEM WILL HAVE A PUMPED STORAGE GENERATING CAPABILITY.

04-69-04002 KIESBERG TUNNEL AT WUPPERTAL-ELBERFELD (GERMANY BELGIAN-METHOD)
BERGER, H.
BAUTECHNIK, (46) NO 4, 109-19, APR. 1969. BAUTECHNIK, (46) NO 5, 166-74, MAY 1969. BAUTECHNIK, (46) NO 6, 191-97, JUNE 1969. 900 M LONG TUNNEL WAS DRIVEN WITH TWO ONE WAY BORES, ONE ABOVE THE OTHER. LOWER LEVEL HAS RECTANGULAR CROSS SECTION, UPPER LEVEL IS VAULTED. THE BELGIAN METHOD WAS USED FOR CONSTRUCTION. DETAILS OF VENTILATION, LIGHTING, ROADWAY ARE GIVEN. (IN GERMAN)

04-69-04003 PLANNING AND CONSTRUCTION OF ENAYAMA TUNNEL (JAPAN HIGHWAY)
EZAKI, K. + NAGATOMO, N.
JOURNAL OF JAPANESE SOCIETY CIVIL ENGRS, (54) NO 4, 2-9, APR 1969. CONSTRUCTION HAS STARTED ON THE AUXILIARY TUNNEL TO BE USED FOR VENTILATING THE 8.5 KM ENAYAMA TUNNEL FOR THE CHUO EXPRESSWAY TO CROSS THE KISO MOUNTAIN SYSTEM. CONSTRUCTION IS SCHEDULED TO START SOON ON THE MAIN TUNNEL. PROBLEMS CAUSED BY BAD GROUND AND NEED FOR LARGE SCALE VENTILATION FOR THE ROAD TRAFFIC ARE DISCUSSED. (IN JAPANESE)

04-69-07001 SELECTIVE BIBLIOGRAPHY ON IMMERSED TUBES
PEQIGNOT, C. A. & RICHARD COSTAIN LTD LONDON
TUNNELS AND TUNNELLING, (1) NO. 2, 74-76, JULY 1969. IMMERSED TUBE TUNNELING PROVIDES A FEASIBLE DRY WATER CROSSING WHERE EITHER BRIDGE OR TUNNEL HAS BEEN TOO COSTLY BECAUSE OF GROUND CONDITIONS. A BIBLIOGRAPHIC INDEX OF 63 REFERENCES SELECTED TO SHOW EVERY KIND OF IMMERSED TUBE TUNNEL STARTED OR COMPLETED AND OF EVERY TECHNIQUE EMPLOYED.

04-69-70002 MECHANIZED DRIFTING BY FULL-FACE METHOD (MOLES SHAFT-SINKING SHIELDS)
BARENDSEN, P. & ATLAS COPCO AB STOCKHOLM
TUNNELS AND TUNNELLING, (1) NO 2, 89-93, JULY-AUG 1969; NO 3, 141-4, SEPT-OCT 1969. SHAFT SINKING AND RAISE DRIVING BY BORING TECHNIQUES ARE REVIEWED. TECHNIQUES AND TOOLS FOR DRIVING TUNNELS IN SOIL AND LOOSE ROCK WITH SHIELD MACHINES AND IN FULL FACE BORING IN ROCK ARE EXAMINED. ADVANTAGES AND DISADVANTAGES OF FULL-FACE TUNNELING ARE DISCUSSED.

04-70-01001 THE ORANGE-FISH TUNNEL, SOUTH AFRICA - A REVIEW OF PROGRESS (DRILL-BLAST)
COOPER, W. H. & SIR WM HALCROW & PRTNRS LONDON
TUNNELS AND TUNNELING, (2) NO 1, 31-35, JAN. 1970. THE 51 MILE LONG, 20 FT DIA ORANGE-FISH TUNNEL IS UNDER CONSTRUCTION IN THE CAPE PROVINCE OF THE REPUBLIC OF SOUTH AFRICA. THREE TUNNELING CONTRACTS TOTAL 32 MILLION POUNDS. WORKING SHAFTS ARE APPROX 7 MILES APART. THE BEST WEEK TO DATE IS 435 FT. ALL CONSTRUCTION IS BY CONVENTIONAL DRILL AND BLAST SINCE THE LARGE NUMBER OF DOLERITE SILLS AND DYKES KNOWN TO INTERSECT THE TUNNEL DISCOURAGED ALL SUCCESSFUL BIDDERS FROM USING A TUNNEL BORING MACHINE.

04-70-01002 TUNNELING ON H-E POWER PLANT EL NIHUIL NO. 3 IN ARGENTINA (DRILL-BLAST)
PEIRANO, C. & CONEVIAL SA. ARGENTINA
TUNNELS AND TUNNELING, (2) NO 1, 37-38, JAN. 1970. CONEVIAL SA. IS CONSTRUCTING A 4.7 KM (2.92 MI) HORSESHOE SHAPED TUNNEL OF 4.8 M (15.8 FT) DIA AND A PRESSURE TUNNEL LINED WITH STEEL PIPE OF 4.7 M (15 FT 6 IN) DIA AND 155 M (508 FT) LONG. THE GROUND IS OF VOLCANIC ORIGIN AND IN GENERAL IS VERY BAD WITH MIXED AND FISSURED ROCKS AND SUBJECT TO INFLUX OF GROUNDWATER. DESCRIPTION OF EQUIPMENT USED AND A SUMMARY OF QUANTITIES OF ROCK MOVED ARE GIVEN.

04-70-01003 CONSTRUCTION OF THE LAIONG TUNNEL IN MALAYSIA (DRILL-BLAST COSTS SUPPORTS)
GOSSCHALK, F. M. + BOSTON, A. G. & SIR WM HALCROW & PARTN LONDON
TUNNELS AND TUNNELING, (2) NO 1, 41-44, JAN. 1970. A DISCRIPTION OF THE METHODS OF SURVEY, DESIGN AND CONSTRUCTION OF THE 4 1/8 MILE 15 FT DIA HORSESHOE SHAPED WATER TUNNEL FOR MALAYSIA. A DISCUSSION OF METHODS USED IN TRAVERSING DIFFICULT STRATA AND COPING WITH HEAVY WATER INFLOWS AND DATA FOR REFERENCE, INCLUDING COSTS, ARE GIVEN.

04-70-03001 PLANNING 63 ST. EAST RIVER TUNNEL FOR NEW YORK (SUBWAY TRENCH BIDS SUBAQUEOUS)
MAEVIS, A. C. & NYC TRANSIT AUTHORITY
TUNNELS AND TUNNELING, (2) NO 2, 73-77, MAR. 1970. THE 63RD ST. TUNNEL IS THE FIRST STEP OF A $1.3 BILLION PROGRAM OF SUBWAY IMPROVEMENT BEING UNDERTAKEN BY THE METROPOLITAN TRANSP. AUTH. AND NYC TRANSIT AUTH. TO PROVIDE NEW HIGH SPEED ROUTES FROM THE BRONX, QUEENS, AND BROOKLYN TO DOWNTOWN MANHATTAN. THE TUNNEL WILL HAVE TWO UPPER TRACKS FOR SUBWAY TRAINS AND TWO LOWER LEVEL TRACKS FOR LONG ISLAND R.R. TRAINS. THE JOB WAS BID IN 1965 BASED TWIN SINGLE TRACK TUBES USING SHIELDS AND COMPRESSED AIR. THE SINGLE BID WAS TOO HIGH SO THE TUNNEL WAS REDESIGNED AND REBID, ALLOWING EITHER COMPRESSED AIR OR TRENCH TO BE BID. THE LOW BID WAS $69,480,920 FOR A TRENCH METHOD SUBMITTED BY A JOINT VENTURE OF PETER KIEWIT SONS CO, SLATTERY ASSOC. AND MORRISON-KNUDSEN CO. CONTRACT WAS AWARDED OCT 24, 1969 WITH A CONTRACT TIME OF 39 MONTHS.

04-70-03002 PRECONTRACT PLANNING FOR THE LIVERPOOL - WALLASEY ROAD TUNNEL (MERSEY-TUNNEL ENGLAND)
TORPEY, K. W. & MOTT HAY AND ANDERSON
TUNNELS AND TUNNELING, (2) NO 2, 79-85, MAR. 1970. THIS ARTICLE DESCRIBES THE PRE-CONTRACT PLANNING LEADING UP TO THE CONSTRUCTION OF THE SECOND MERSEY TUNNEL. THE NEED FOR AN ADDITIONAL CROSSING, THE SELECTION OF THE LOCATION FOR THE TUNNELS (AND CHOICE OF TUNNELS OVER BRIDGE), SITE INVESTIGATION, SCHEDULING, CONSTRUCTION OF A PILOT TUNNEL BY CONVENTIONAL BLASTING, DECISIONS FOR CHOICE OF TUNNEL LININGS AND THE TYPE OF VENTILATION SELECTED ARE ALL REVIEWED. IN APRIL 1967 A CONTRACT WAS LET TO A CONSORTIUM OF NUTTALL ATKINSON & CO FOR THE TUNNEL AND SIR ALFRED MCALPINE & CO FOR THE WALLASEY APPROACH ROAD. THE EXCAVATED ROCK FROM THE TUNNEL WAS USED FOR THE APPROACH.

04-70-03003 TUNNEL CONSTRUCTION AND MAINTENANCE ON THE AUSTRIAN FEDERAL RAILWAY SYSTEM PART I (SHOTCRETE AUSTRIAN-METHOD)
ZIERMANN, R. & AUSTRIAN FED RWS VIENNA
TUNNELS AND TUNNELING, (2) NO 2, 87-91, MAR. 1970. PRIOR TO WORLD WAR I A TREMENDOUS NUMBER OF RAILROAD TUNNELS WERE BUILT FOR RAILROADS IN THE MOUNTAINS OF AUSTRIA. DURING THIS PERIOD THE SO CALLED AUSTRIAN METHOD WAS DEVELOPED. THE PERIOD AFTER WW II BROUGHT A RESURGENCE IN TUNNELING FOR HYDROELECTRIC PLANTS AND LED TO A TRANSFORMATION OF THE ART. THE HISTORY OF THIS DEVELOPMENT IS RECITED AND DETAILS OF THE METHOD ARE GIVEN. FIRST PART OF A 2 PART ARTICLE (SEE 04700501).

04-70-05002 BRITAINS MAJOR ROAD TUNNELS: A REVIEW (CLYDE DARTFORD MERSEY TYNE BLACKWALL-AND-ROTHERHITHE)
FERRIER, F. G. + MILLNS, F. L. + JONES, ST. & ALLENBY, H.
TUNNELS AND TUNNELING, (2) NO 3, 157-165, MAY 1970. DATA ON THE MAJOR ROAD TUNNELS IN BRITAIN TO INCLUDE A DISCRIPTION OF THE FACILITIES, COST OF ORIGINAL TUNNEL AND METHOD OF DRIVING, VENTILATION, LIGHTING TRAFFIC SUPERVISION AND MAINTENANCE.

04-70-05003 TUNNELS ON FRANCE'S RESEAU EXPRESS REGIONAL (MOLES ROBBINS)
BOIS, A. & REGIE AUTO DES TRANSP PARISIENS
TUNNELS AND TUNNELING, (2) NO 3, 165-169, MAY 1970. THE LINE FROM ST GERMAIN-EN-LAYE TO BOISSY-ST-LEGES WILL BE 46 KM LONG AND HAVE 15 KM OF VARIOUS TYPES OF UNDERGROUND LINE FROM OPEN CUT TO DEEP TUNNELING.

04-70-05004 EXPERIENCES GATHERED IN DRILLING AN INCLINED GALLERY THROUGH HARD ROCK (WIRTH MOLE)
HAMBACH, P. & BAUUNTERNEHMUNG MURER AG
TUNNELS AND TUNNELING, (2) NO 3, 171-176, MAY 1970. A WIRTH DRILLING MACHINE WAS USED TO DRILL A 3 M DIA 1140 M LONG GALLERY AT A 33 DEGREE INCLINE THROUGH GRANITE HAVING A COMPRESSIVE STRENGTH OF 2400 KG/CU CM. THE MAXIMUM ADVANCE RATE WAS 15.75 M/DAY.

04-70-05005 TUNNEL CONSTRUCTION ON THE AUSTRIAN FEDERAL RAILWAY SYSTEM PART 2 (SHOTCRETE)
ZIERMANN, R. & AUSTRIAN FED RWS VIENNA
TUNNELS AND TUNNELING, (2) NO 2, 179-181, MAY 1970. A DESCRIPTION OF INDIVIDUAL TUNNELS IN AUSTRIA, SOME USING THE OLDER BELGIAN METHOD, SOME THE NEW AUSTRIAN METHOD. PART 2 OF A TWO PART ARTICLE (SEE 04-70-03003).

FIELD 05 NEWS ITEMS

05-51-03001 THE WASHBURN TUNNEL, TEXAS (TRENCH-TYPE DOUBLE-SHELLED-STEEL-TUBES BULKHEADS CONCRETE)
THE ENGINEER, 390, MARCH 23, 1951. THE OPENING TO TRAFFIC OF THE WASHBURN TUNNEL UNDER THE HOUSTON SHIP CHANNEL AT PASADENA, TEXAS IS ANNOUNCED. THE TRENCH-TYPE TUNNEL AND ITS CONSTRUCTION ARE DESCRIBED IN SOME DETAIL. THE TUNNEL IS 3791 FEET IN OVERALL LENGTH AND PROVIDES IN THE TUBE INTERIOR A ROADWAY WIDTH OF 22 FT FOR TWO LANES OF TRAFFIC, A WALKWAY AND A FRESH AIR DELIVERY DUCT UNDERNEATH THE ROADWAY. PREFABRICATED TUBES WERE FLOATED INTO POSITION OVER THE DREDGE CHANNEL AND SUNK IN PLACE. FINAL PLACEMENT OF CONCRETE WAS POURED BY TREMIE. THE ENCASED TUNNEL WAS COVERED BY HYDRAULIC BACKFILL.

05-55-09001 SWEDES MAKE ROCK TUNNEL HISTORY (GEOLOGY DRILL-BIT JUMBO BLASTING ADVANCE SIZE MUCKING)
BOWMAN, W. G.
ENGINEERING NEWS-RECORD, (155) N 9, 34-36, 40-44, SEPT. 1, 1955 TUNNELS ARE IN GRANITE. DRILLS ARE PNEUMATIC, PUSHER-MOUNTED LIGHT-WEIGHT ONE-MAN. BITS ARE 7/8 IN. ALLOY STEEL TUNGSTEN CARBIDE CHISEL TIPPED, 63 IN. INCREMENTS. THEY DRILL HOLES FOR 20 TO 24 FT ADVANCE IN EACH OF 3 SHIFTS PER DAY. TANDEM JUMBOS ARE CARRIED TO FACE OF HEADING ON TRUCKS. EXPLOSIVE CONSUMPTION IS 1.56 LBS, 50 PERCENT NITRO GLYCERINE PER CU-YD. AVERAGE SHIFT TAKES THESE HOURLY TIMES. SET-UP 1.5, DRILLING 3.5, CHARGING 1.5, VENTILATION 0.5, MOVING SHOVEL IN 0.5. THREE LARGE TUNNELS HAVE BEEN CONSTRUCTED BY THIS METHOD: HARRESELE HYDROELECTRIC 2,691-SQ.-FT SECTION WITH 1,410-SQ.-FT-TOP HEADING AND TWO BENCHES IN THE 59-FT. HEIGHT, 49-FT. WIDTH. STORNORRFORS HYDROELECTRIC 3,875-SQ.-FT SECTION WITH 1,740-SQ.-FT TOP HEADING AND TWO BENCHES IN THE 77-FT HEIGHT, 53-FT WIDTH. STOCKHOLM UNDERGROUND PARKING FACILITY TO SERVE ALSO AS AIR RAID SHELTER 33-FT HEIGHT, 42-FT WIDTH. ALL PROJECTS HAVE LARGE UNDERGROUND EXCAVATIONS FOR TURBINES AND GENERATORS IN HYDROELECTRIC INSTALLATIONS AND WATER RESERVOIRS, SANITATION, KITCHEN, VENTILATION, AND EMERGENCY POWER IN STOCKHOLM PROJECT.

05-56-06001 CANADIAN TUNNELERS CLAIM RECORD (BORE DRILL-CARRIAGE BLASTED-MATERIAL HEADING)
COMPRESSED AIR MAGAZINE, 174, JUNE 1956. THE ARTICLE DESCRIBES THE PROJECT, TUNNELING METHOD AND EQUIPMENT USED IN SETTING A RECORD FOR HEADING ADVANCE OF 397 FT IN 6 DAYS FOR AN 18 X 18 FT TUNNEL. THE 6.7 MI TUNNEL IS ON THE CHEAKAMUS RIVER PROJECT 50 MI NORTH OF VANCOUVER. IT IS BEING DRIVEN BY THE DRILL, BLAST AND MUCK METHOD.

05-58-03001 TUNNELING WITH ROTARY DRILLS AND MILLISECOND DELAY BLASTING (GEOLOGY DRILLING BLASTING JUMBO MUCKING CONCRETE)
BLASCNGAME, R. + LAW, W. P. & GRAFE-TECON-MITTRY-DRAKE CHICAGO
CIVIL ENGINEERING, (28) N 3, 54-57, MAR. 1958. FOUR COMPANIES OPERATING AS GRAFE-TECON-MITTRY-DRAKE CONSTRUCTED A 17-FT WIDE, 18-FT HIGH, HORSESHOE-SHAPED WATER-SUPPLY TUNNEL IN DOLOMITE LIMESTONE, 250 FT BELOW CHICAGO'S GOLD COAST. 1 5/8 IN. HOLES ARE DRILLED 11 FT DEEP ON A 58 TO 64 HOLE PATTERN USING FOUR HYDRAULIC ROTARY ROCK DRILLS EACH POWERED WITH A 30 HP PUMP. CENTER BURN IS 15 IN. WITH KA-MO DRILL. JUMBO IS STEEL FRAME MOUNTED ON RAILS 10.5 FT CENTER TO CENTER, THE OUTSIDE RAILS OF TWO 3.5 FT GAGE TRACKS. POWDER FACTOR IS 4 LB PER CU-YD WITH PRIMER AMMONIA GELATIN. GIANT GELATIN IN 1 1/4 X 8 IN. CARTRIDGES AND BASIC POWDER SEMI-GELATIN, ATLAS GELODYN NO. 1 IN 1 1/4 X 16 IN. CARTRIDGES. MILLISECOND DELAY BLASTING WITH AN ENTIRE SERIES OF DELAYS GIVES 6 ADVANTAGES OVER STANDARD DELAY: LOOSER

MUCK PILE, BETTER FRAGMENTATION, FEWER NOXIOUS FUMES, CLEANER CUT, LOWER POWDER FACTOR, FEWER VIBRATION COMPLAINTS. VENTILATION IS WITH A 24 IN. SUCTION LINE AT 20,000 CFM. MUCKING IS WITH A CONWAY 100-1 LOADING 22 CARS OF 10 CU-YD CAPACITY. MUCK CARS ARE SHIFTED WITH A CHERRY PICKER. MUCK IS SKIPPED TO THE SURFACE IN 12 CU-YD SKIP ON 5 1/3 MIN ROUND-TRIP SCHEDULE. 2 CYCLES OF DRILLING, BLASTING, AND MUCKING ARE DONE ON EACH OF 3 SHIFTS. CONCRETING IS WITH READY MIXED CONCRETE HAULED IN 7 1/2 CU-YD AGITATOR CARS FOR THE CURB AND PUMPED IN BACK OF A 350-FT TELESCOPING FORM FOR THE ARCH. 32,000 FT OF TUNNELING IS BEING DONE UNDER A $12,700,000 CONTRACT.

05-58-04001 ORGANIZED SPEED KEY TO SUCCESSFUL TUNNEL RESULTS (GEOLOGY DRILLING JUMBO CHARGING VENTILATION MUCKING SUPPORT)
ADAMS, T. F. + MORSE, D. P. & BLUE RIV CONSTR DILLON COLO
MINING ENGINEERING, (10) N 4, 473-475, APR 1958. BLUE RIVER CONSTR ARE DIGGING THE 23 MI HAROLD D. ROBERTS TUNNEL FROM 4 HEADINGS FOR $45 MILLION FOR THE CITY AND COUNTY OF DENVER. ADVANCE GEOLOGICAL STUDY IS USED BUT EXPERIENCE AND PREDICTION ARE MORE IMPORTANT AS CLASS AND INTENSITY OF ROCK DEFECTS ARE VITAL. PULL IS 11 FT IN GOOD FORMATION 3 FT IN BAD AS FOOTAGE ADVANCE IS REDUCED TO PREVENT OVERBREAK. DRILL JUMBO IS PLACED BY HYDRAULIC JIBS AND HAS A FOLD UP PLATFORM FOR 4 DRILLS. MACHINES ARE 3 1/2 IN WITH 5 FT SHELLS. FEELER HOLES DETECT WATER AHEAD OF FACE. BITS ARE 1 1/4 IN HOLLOW CARBON DRILL STEEL WITH 1 5/8 IN CARBIDE BIT. BURN CUT IS MADE IN UNIFORM ROCK. VENTILATION IS REVERSED FOR BLASTING. CHARGES ARE 1 1/4 X 8 AND 1 1/4 X 16. ELECTRIC BLASTING CAPS WITH 1 TO 10 DELAYS ARE USED. MUCKING IS WITH 15 CARS WITH 5 CU-YD CAPACITY. CALIF SWITCHING SHUNTS EMPTY CARS TO THE HEADING AND REMOVES LOADED. STEEL SUPPORTS WITH WOOD BLOCKING ARE USUALLY AT 4 FT INTERVALS. VARIOUS OPERATIONS ARE DRILLING 1 HR LOADING 20 MIN MUCKING 1 1/2 HRS. HEADING CREW IS 25 EACH OF 3 SHIFTS UNDERGROUND. 18 SURFACE WORKERS, 12 SUPERVISORS. CONTRACTORS HAVE NEITHER TIME NOR FINANCES FOR R AND D WORK.

05-58-06001 TWO CONTRACTORS PROVED OUT NEW HARD ROCK TUNNELING METHOD (WORLD-TUNNELING-RECORD BURNCUT DRILLING-PATTERN BLASTING JUMBO)
ENGINEERING NEWS-RECORD, (160) 28, JUNE 26, 1958. A DAILY ADVANCE RECORD OF 83 FT AVERAGE OVER A WEEK HAS BEEN SET BY ONE CONTRACTOR AND THE WORLD RECORD EQUALED BY ANOTHER AT 80 FT PER DAY ON THE N.Y. CITY 44 MI WEST DELAWARE TUNNEL. THE TUNNEL 13 1/2 FT IN DIA IS BEING BORED FROM BOTH ENTRIES AND 7 SHAFTS THROUGH CATSKILL MOUNTAIN GREY SANDSTONE AND SHALE. THE BURN CUT METHOD OF DRILLING FOR BLASTING AND MINING TECHNIQUES OF THE CONTRACTOR COMBINES ARE DESCRIBED. THE TUNNEL IS BEING CONCRETE LINED TO AN 11 FT 4 IN FINISHED DIA.

05-59-10001 TUNNELING 23 MILES THROUGH ROCKIES (HARD-ROCK DRILL BLAST MUCK JUMBO HEADING VENTILATION CONCRETE-LINING GROUT)
ENGINEERING NEWS-RECORD, (163) 32, OCT 29, 1959. A SIX COMPANY COMBINE IS PIERCING THE CONTINENTAL DIVIDE UNDER THE ROCKIES WITH A 23 MI TUNNEL TO BRING WESTERN SLOPE WATER TO DENVER. ABOUT 2.5 MI OF 13 FT X 13 FT HORSESHOE TUNNEL REMAINS TO BE DRIVEN. FOUR HEADINGS ARE USED IN DRIVING THE TUNNEL; ONE AT EACH END AND TWO FROM A 916 FT DEEP ACCESS SHAFT 9 MI EAST OF DILLON. THE TUNNEL WILL BE CONCRETE LINED TO A 10 FT 3 IN I.D. A TWO-DECK JUMBO IS USED AT EACH FACE FOR DRILLING 42 TO 52 HOLES 7 FT DEEP FOR BLASTING. THE ARTICLE OUTLINES THE OVERALL WATER PROJECT TUNNELING EQUIPMENT, MATERIALS, TECHNIQUES AND PROGRESS OF THE TUNNELING WORK.

05-59-12001 AUSTRALIANS USE BURN CUT FOR RECORD (JUMBOS BIOTITE-GRANITE TUNNELS ROOF-BOLTS DYNAMITE DRILLING-EQUIPMENT)
ENGINEERING AND MINING JOURNAL, 100, DEC 1959. A TUNNELING RECORD ONLY MONTHS AFTER STARTING WITH A GREEN CREW HAS BEEN SET BY AN AUSTRALIAN FIRM IN CONSTRUCTION OF THE 9 MILE TOOMA-TUMUT WATER DIVERSION TUNNEL IN THE SNOWY MOUNTAIN PROJECT. IN 6 DAYS THE 12.5 X 12.5 FEET, HORSESHOE SHAPED TUNNEL WAS ADVANCED 526 FEET AT AN AVERAGE SPEED OF 87.7 FEET PER DAY. THE ARTICLE OUTLINES THE COMBINATION POWER-WATER DIVERSION PROJECT AND ITS PROGRESS AND DESCRIBES THE EQUIPMENT USED. APPLICATION OF THE BURN-CUT METHOD IS DESCRIBED INCLUDING THE DRILLING PATTERN DEVELOPED FOR EACH BLASTING ROUND.

05-61-03001 TUNNELING IN LONDON CLAY (SHIELD VICTORIA-LINE EXPERIMENT LININGS)
ENGINEER, (211) NO 5486, 422-25, MAR. 17, 1961. ENGINEERING, (191) NO 4953, 414-15, MAR. 24, 1961. DRIVING THE 1 MILE LONG TWIN TUNNELS FOR LONDON TRANSPORT AT FINSBURY PARK IS A FULL SCALE TRIAL OF THE METHODS OF CONSTRUCTION SELECTED FOR THE PROPOSED VICTORIA UNDERGROUND LINE. DIGGER SHIELDS ARE BEING USED IN BOTH TUNNELS AND THE LININGS ARE EITHER UNBOLTED CAST IRON OR BOLTED PRECAST CONCRETE SECTIONS.

05-61-0401 TUNNELING UNDER THAMES (LONDON)
IRON AND COAL TRADES REVIEW, (182) NO 4839, 799-801, APR. 14, 1961. CONSTRUCTION OF THE 28 FT DIA TUNNEL UNDER THE THAMES RIVER IN EAST LONDON WILL BE COMPLETED IN 2 STAGES. FIRST PHASE IS SINKING ACCESS SHAFTS, DRIVING 2 7 FT DIA PILOT TUNNELS. SECOND PHASE WILL BE DRIVING FULL SIZE TUNNEL.

05-61-09001 PROGRESS AT THE GREAT ST. BERNHARD TUNNEL (VENTILATING-SHAFTS BRITTLE-ROCK QUARTZ CARBIDE-TIPPED-DRILLS EXPLOSIVE)
THE ENGINEER, 383, SEPT 1961. THE 5.8 KILOMETER GREAT ST. BERNHARD TUNNEL HAS BEEN DRIVEN FULL SECTION FOR 2500 M AS OF AUG ON THE SWISS SIDE WHILE THE ITALIANS HAVE HAD DIFFICULTIES WITH THE ROCK AND HAVE ADVANCED ONLY 1200 M. TWO VENTILATING SHAFTS ARE ON THE SWISS SIDE. THE EXCAVATION, GEOLOGICAL FORMATIONS ENCOUNTERED, EXCAVATION METHODS, TUNNEL LINING AND EQUIPMENT USED ARE OUTLINED.

05-61-09002 MONT CENIS TUNNEL (MACHINE COMPRESSED-AIR DRILLS WORKING-FACE)
THE ENGINEER, 505, SEPT 29, 1961. A REPRINT OF AN ARTICLE PRINTED ORIGINALLY IN SEPT 1861 DESCRIBING USE OF M. SOMMELIER'S APPARATUS FOR DRIVING THE MONT CENIS TUNNEL. THE ARTICLE DESCRIBES THE HYDRAULIC COMPRESSION OF AIR AND USE OF THAT AIR TO OPERATE PERCUSSION DRILLS ON BOTH FACES IN DRIVING THE TUNNEL. OPERATION OF 8 DRILLS IS DESCRIBED AS THEY ADVANCE 3 FT IN DEPTH AND FROM 8 TO 11 HOLES IN 6 HRS.

05-62-01001 FASTER MINING METHODS FOR AUSTRALIA (TUNNEL DRILLING BLASTING CAGE-RISING)
ENGINEERING CONSTRUCTION, SECTION 10, JAN 5, 1962. A METHOD OF DRIVING A CONNECTING SHAFT UPWARD FROM A LOWER TUNNEL TO A HIGHER ONE, CALLED CAGE RISING, HAS BEEN DEVISED IN AUSTRALIA. THE METHOD ELIMINATES THE NEED FOR TIMBER AND REDUCES TIME SPENT IN TRAVELING AND HAULING GEAR. IT CONSISTS OF A TWO-DECK CAGE HOISTED UP OR DOWN THE SHAFT AS BLASTING PROCEEDES THROUGH A PREDRILLED CABLE HOLE ON THE SHAFT CENTERLINE FROM WHICH THE MINERS WORK.

05-62-01002 MULTIPLE HYDRO-ELECTRIC POWER PROJECTS IN SWEDEN (ROCK-EXCAVATION PENSTOCKS TAILRACE TUNNEL DIVERSION)
ENGINEERING CONSTRUCTION, SECTION 10, JAN 5, 1962. THE ARTICLE OUTLINES THE SWEDISH POWER PROJECT OF FOUR POWER STATIONS AT MESSAURE, POTSI, LAXIDE, AND LETSI ON THE RIVER LULE. WORK INCLUDES ROCK EXCAVATION OF 294,000 CM FOR TAILRACE AND DIVERSION TUNNELS.

05-62-05001 MONT BLANC - ONE TUNNEL, TWO JOBS (GEOLOGY FRANCE ITALY)
ENGR NEWS-RECORD (168) 56-63, MAY 31, 1962. THE GEOLOGY OF MONT BLANC POSES FAR DIFFERENT PROBLEMS FOR ITALIAN AND FRENCH MINERS. THE FRENCH HEADINGS ARE RELATIVELY DRY BUT HOT. THE ITALIANS GET FLOODED FREQUENTLY BUT HAVE SOME LOWER TEMPERATURES. COST HAS RISEN FROM $30 TO $40 MILLION. 13 LIVES HAVE BEEN LOST.

05-63-05001 HARDROCK TUNNEL SAVES 50% ON EXPLOSIVES (AN-FO SAN-FRANCISCO WATER-SUPPLY)
ENGR NEWS-RECORD, (170) 50-55, MAY 23, 1963. CLANCY O'DELL CONSTR CO PRESIDENT SAYS THAT AN-FO IS CHEAPER AND BETTER THAN DYNAMITE FOR TUNNEL DRIVING. HIS COMPANY IS SAVING 50% OF THE COST OF EXPLOSIVES FOR THE CANYON TUNNEL OF THE HETCH HETCHY WATER SUPPLY PROJECT FOR SAN FRANCISCO. DETAILS OF THE BLASTING PROCEDURES ARE GIVEN.

05-64-02001 TWO CITIES TUNNEL THROUGH THE CONTINENTAL DIVIDE FOR WATER
ENGINEERING NEWS-RECORD, 34-35, FEB 27, 1964. COLORADO SPRINGS AND AURORA AWARDED A $4 MILLION CONTRACT IN JULY 1963 FOR CONSTRUCTION OF A 5.5 MILE TUNNEL TO BRING WATER FROM HOMESTAKES DAM WEST OF THE DIVIDE. THE 9.5 FT. UNLINED HORSESHOE SHAPED TUNNEL IS BEING CONSTRUCTED BY W. A. SMITH CO. AND THE QUAD CONSTRUCTION CO. AS A JOINT VENTURE. CONSTRUCTION STARTED IN JULY 1963 SCHEDULED FOR COMPLETION IN JUNE 1966.

05-64-03001 HUGE SEWER MAKES EXCAVATION HEADACHE (CUT-AND-COVER)
HALMOS, E. E.
EXCAVATING ENGINEER, (58) N 3, 16-19, MAR 1964. THE 43 MILE, $28 MILLION INTERCEPTOR SEWER INVOLVED 5 MAJOR TUNNELS UP TO 13,000 FT. LONG, TWO OPEN CUT TRENCHES ACROSS THE BED OF THE POTOMAC RIVER.

05-64-03002 OPENING OF GREAT ST. BERNHARD ROAD TUNNEL
THE ENGINEER, 588-591, MARCH 27, 1964. THE 5.85 KM HIGHWAY TUNNEL UNDER THE GREAT ST. BERNHARD PASS WAS OPENED TO TRAFFIC MARCH 19, 1964. TUNNEL WORK BEGAN IN 1959. USE OF COVERED APPROACH ROADS OF 5.5 KM ON THE NORTH SIDE AND 10.3 KM ON THE SOUTH ALLOW YEAR ROUND USE OF THE TUNNEL.

05-64-12001 CONTRACTOR GOES THROUGH SAND FOR MINNEAPOLIS STORM DRAIN TUNNEL (COSTS)
ENGINEERING NEWS-RECORD, (173) 68, DEC 10, 1964. ASHBACH CONSTRUCTION COMPANY OF ST. PAUL, MINNEAPOLIS, WAS AWARDED A $945,807 CONTRACT FOR A MINNEAPOLIS STORM SEWER PROJECT. THE JOB INCLUDES 2/5 MILE OF REINFORCED CONCRETE PIPE 102 INCHES IN DIAMETER 22 TO 30 FEET DEEP, 1/5 MILE OF 102 INCH DIAMETER MONOLITHIC STORM SEWER 20 TO 38 FEET DEEP, AND 443 FEET OF 72 INCH DIAMETER PIPE 10 FEET DEEP. THE TUNNEL CONSTRUCTION WAS BID AT $272 PER FOOT. DETAILED BREAKDOWN OF BID GIVEN.

05-64-12002 PILOT BORE HOLED THROUGH ROCKIES (HIGHWAY-TUNNEL)
ENGINEERING NEWS-RECORD, (173) DEC 17, 1964. A PILOT HOLE 11 FEET 4 INCHES WIDE AND 10 FEET 8 INCHES HIGH AND 282 FEET LONG WAS DRILLED IN THE ROCKY MOUNTAINS NEAR LOVELAND PASS IN COLORADO AT A COST OF $1.3 MILLIONS. THE PILOT HOLE'S PURPOSE IS TO GAIN MORE INFORMATION FOR DESIGNING THE LINING AND SUPPORTS OF THE VEHICULAR TUNNELS. A $55,000 CONTRACT PROVIDED INSTRUMENTATION TO STUDY EFFECTS ON SURROUNDING ROCK OF A BLAST IN THE TUNNEL, HOW LOADS VARY IN RELATION TO THE HEADING.

05-64-12003 ROAD TUNNEL TO PIERCE PYRENEES
ENGINEERING NEWS-RECORD, (173) 30, DEC 10, 1964. PLANS ARE BEING MADE FOR A TUNNEL UNDER THE PYRENEES, 8,840 FT. LONG, 27 FT. WIDE, 14 FT. HIGH THROUGH HARD QUARTZ AND GRANITE.

05-65-02001 TUNNEL BIDS HAVE $17 MILLION SPREAD (SUBAQUEOUS-TUNNEL)
ENGINEERING NEWS-RECORD, (174) FEB 4, 1965. THE LOW BID WAS $31 MILLION TO CONSTRUCT A TWIN TUNNEL ON 100 FT. CENTERS AND 3.2 MILES LONG BENEATH THE BAY BETWEEN SAN FRANCISCO AND OAKLAND, CALIFORNIA. THE ROUGH BASE OF THE HORSESHOE SHAPED TUNNEL WILL BE 20 FEET IN DIAMETER, AND THE FINISHED DIAMETER WILL BE 17 1/2 FEET. THIS TUNNEL WILL CARRY HIGH-SPEED CARS ON A 5 1/2 FEET WIDE TRACK FOR THE BAY AREA RAPID TRANSIT DISTRICT (BARTD). THE CONTRACTORS WILL ENCOUNTER MANY SOIL AND ROCK FORMATIONS, INCLUDING A MAJOR SEISMIC DISLOCATION. AS LIMITED AMOUNTS OF GAS AND WATER ARE EXPECTED TO BE FOUND.

05-65-04001 HIGHWAY BRIDGE MEN BUILD A TUNNEL - FOR WATER (STORM-DRAIN CONSTRUCTION DRILL-PATTERNS MUCKING)
ENGINEERING NEWS-RECORD, (174) 34, APRIL 15, 1965. THE LONGEST BORED TUNNEL IN NEW YORK - 4.29 MILES, IS BEING BUILT FOR A TRUNK STORM DRAIN FOR INTERSTATE ROUTE 280, ON EAST-WEST FREEWAY THAT IS DEPRESSED THRU THE CITIES OF NEWARK, EAST ORANGE AND ORANGE. IT IS COSTING $2 MILLION MORE THAN TWICE THE NATIONAL AVERAGE FOR THE COST OF A MILE OF COMPLETED INTERSTATE HIGHWAY. THE TUNNEL IS 8 FEET IN DIAMETER WITH WALLS OF 1 FOOT THICK CAST-IN-PLACE CONCRETE AND IS BEING DUG FROM SEVEN SHAFTS 2940 FEET TO 3970 FEET APART AND ALL ABOUT 14 FEET DIAMETER. EXCAVATION OF THE ROCK, SANDSTONE AND JERSEY SHALE IS BY THE DRILL, SHOOT AND MUCK METHOD. THE ARTICLE DESCRIBES THE PROJECT, WORK CONDITIONS AND WORK METHODS.

05-65-07001 SNAKE RIVER DIVERSION TUNNEL DRIES SITE FOR HELLS CANYON DAM (LINING)
ENGINEERING NEWS-RECORD, (175) 26-8, JULY 1965. CONCRETE LINED TUNNEL 1800 FT LONG 40-FT HIGH HORSESHOE SHAPED. KEEWIT SANS CO. OF OMAHA, NEB. DROVE THE TUNNEL UNDER A $4.9 MILLION CONTRACT WHICH INCLUDED EXCAVATION FOR THE DAM ABUTMENTS, BUILDING TEMPORARY FISH TRAPS AND A PERMANENT ACCESS ROAD. A DRILL-JUMBO WAS USED ON A 22-TON END DUMP TRUCK FOR THE TOP HALF. THE BOTTOM HALF WAS EXCAVATED USING FOUR WAGON DRILLS. IT WAS LINED USING A 50 FT RAIL MOUNTED FORM. THE FORM IS COLLAPSIBLE AND MADE OF TWO 25-FT SECTIONS.

05-65-08001 SOLE TUNNEL BID TOPS ESTIMATE BY 101 PERCENT (COST)
ENGINEERING NEWS-RECORD, (175) 48, AUG 1965. NEW YORK CITY WANTS TO BUILD A SUBWAY TUNNEL, BUT THE ONLY BID WAS 101 PERCENT ABOVE 28.1 MILLION PROJECTED COST.

05-65-10001 NAVAJO INDIAN IRRIGATION TUNNEL (UNIT-COSTS)
ENGR NEWS-RECORD, (175) 195, OCT. 14, 1965. A JOINT VENTURE OF J.F. SHEA CO HENRY J. KAISER CO AND MACCO CORP SUBMITTED THE $8.6 MILLION LOW BID FOR CONSTRUCTING THE 5 MILE NAVAJO TUNNEL NO 2 FOR THE U.S. BUREAU OF RECLAMATION. UNIT PRICE BID WAS $240/LIN FT BY THE CONVENTIONAL DRILL AND BLAST METHOD.

05-65-12001 GREENBRIAR JOINT MEETING - W. VA. COAL MINING INSTITUTE AND CENTRAL APPALACHIAN SECTION AIME (MAINTENANCE COMPUTERS MATERIALS-HANDLING RESEARCH)
COAL AGE, 115-116, DEC 1965. JOINT MEETING AT THE GREENBRIAR, WHITE SULFUR SPRINGS W. VA. ON NOVEMBER 5-6, 1965, DISCUSSED CONTINUOUS FACE HAULAGE, UNDERGROUND MAINTENANCE, CONVENTIONAL MINING WITH COMPUTERS, MATERIALS HANDLING WITH TRACTOR TRAILERS, RECRUITING MEN FOR MINING BARRIER, PILLAR DESIGN, AND COAL STORAGE IN BINS.

05-65-12002 MONT BLANC ROAD TUNNEL IS WORLD'S LONGEST (SUBTERRANEAN-HIGHWAY GRANITE CONSTRUCTION SAVINGS BORING)
THE OAK RIDGER, DEC 27, 1965. NEWS ITEM ON THE OPENING OF THE WORLDS LONGEST SUBTERRANEAN TUNNEL 7400 FEET UNDER THE PEAK OF MONT BLANC BETWEEN CHAMONIX, FRANCE AND COURMAYEUR, ITALY. THE TUNNEL, 7.2 MILES LONG, WAS OPENED IN JULY 1965 AND TOOK 6 YEARS, 17 LIVES AND $70 MILLION TO BUILD, BUT WILL CUT AS MUCH AS 20 HOURS WINTER DRIVING TIME BETWEEN ROME AND PARIS. THE TUNNEL WILL HANDLE UP TO 600 VEHICLES AN HOUR DURING PEAK PERIODS. FRESH AIR FORCED THROUGH DUCTS AT A RATE OF 5800 FT PER SECOND WILL REMOVE CARBON MONOXIDE. MOTORING FACILITIES IN THE TUNNEL AND DIFFICULTIES DURING CONSTRUCTION ARE ALSO OUTLINED.

05-66-02001 NORAD (TUNNELS SOLID-GRANITE BLASTING MUCK-WAGONS CRAWLER-LOADER EXCAVATION ROCK-BOLTS)
ENGINEERING OPPORTUNITIES, 19, FEB 1966. THIS ILLUSTRATED ARTICLE GIVES A CONCISE HISTORY OF THE NORAD, NORTH AMERICAN AIR DEFENSE COMMANDS COMMAND OPERATIONS CENTER (COC), FROM CONCEPTION TO ACCEPTANCE LAST MONTH. THE CENTER IS EQUIVALENT TO A CITY LOCATED IN VAST CATHEDRAL-LIKE CHAMBERS BLASTED OUT OF THE SOLID GRANITE 1200 TO 1400 FEET DEEP IN CHEYENNE MOUNTAIN NEAR COLO. SPRINGS AND PIKE'S PEAK. THREE HORSESHOE SHAPED TUNNELS PROVIDE ACCESS FOR TRANSPORT, PEDESTRIANS, AIR SUPPLY AND AIR EXHAUST. THE NORTH TUNNEL IS 1416 FEET LONG, 29 FEET WIDE AND 22.5 FT HIGH. THE SOUTH TUNNEL IS 2,668 FEET LONG, 15 FEET WIDE AND 17.5 FEET HIGH. THE CENTRAL TUNNEL IS 591 FEET LONG, 45 FEET WIDE AND 25 FEET HIGH. THE MAIN EXCAVATION CONSISTS OF 3 CHAMBERS 45 FT WIDE, 60.5 FEET HIGH AND 588 FEET LONG, CROSSED BY 3 OTHER CHAMBERS 32 FEET WIDE, 56 FEET HIGH AND 335 FEET LONG. EXCAVATION WAS BY BLASTING WITH THE BROKEN GRANITE LOADED ONTO MUCK WAGONS BY CRAWLER LOADERS AND THEN DUMPED IN A CANYON TO FORM A PARKING LOT. ROCK BOLTS REINFORCED CEILINGS OF THE CHAMBERS IN A FOUR FOOT SQUARE PATTERN. WIRE MESH WAS INSTALLED ON WALLS AND CROWNS TO STOP FALLING LOOSE ROCK. THE CENTER IS HOUSED IN 11 ALL STEEL BUILDINGS -- STEEL PLATE SHELLS AND STEEL STRUCTURES, TO ATTENUATE

ELECTROMAGNETIC PULSES CAUSED BY NUCLEAR BLASTS. ALL BUILDINGS ARE MOUNTED ON 47 INCH HIGH 3 INCH DIAMETER WIRE WOUND INTO SPRINGS TO PROTECT DELICATE EQUIPMENT IN THE BUILDINGS FROM SHOCK OF EARTHQUAKE OR NEARBY THERMONUCLEAR BLAST. BLAST DOORS AND WALLS ARE PROVIDED AT THE PORTALS.

05-66-02002 AROUND THE WORLD - GRAND SCHEME (PLANS RAIL-SYSTEM RAPID-TRANSIT)
ENGINEERING NEWS-RECORD, (176) 19, FEB 24, 1966. WEST BAY RAPID TRANSIT AUTHORITY OF SAN MATEO ORDERED PREPARATION OF A MASTER PLAN FOR INTEGRATION OF EXISTING BUS FACILITIES AND MAY RECOMMEND A RAIL SYSTEM TO JOIN THE BARTD NETWORK.

05-66-04001 UNDERGROUND ROADS COST PLENTY (TUNNEL URBAN-HIGHWAY UNDERPINNING ELEVATED-STRUCTURES)
ENGINEERING NEWS-RECORD, (176) 28, APRIL 1966. EDITORIAL ON CHOOSING UNDERGROUND HIGHWAYS OVER DEPRESSED, AT-GRADE OR ELEVATED EXPRESSWAYS IN URBAN AREAS AND THE NEED TO CONSIDER TUNNEL COSTS CITED BY JOSEPH BARNETT OF THE BUREAU OF ROADS.

05-66-05001 TRAIN COMING CLOSE THE DOOR (RAILROAD-TUNNEL VENTILATION CONSTRUCTION)
ENGINEERING NEWS-RECORD, (176) 23, MAY 12, 1966. THE SECOND LONGEST RAILROAD TUNNEL IN THE U.S., THE 7 MILE BORE SOON TO BE DRIVEN THROUGH ELK MOUNTAIN NEAR LIBBY MONT. WILL HAVE NO VENTILATION SHAFTS BUT A GREAT STEEL DOOR AT ITS UPPER END. THE TUNNEL IS PART OF THE RAILWAY RELOCATION TO ALLOW CONSTRUCTION OF LIBBY DAM. THE TUNNEL WILL BE STRAIGHT WITH A 0.5% GRADE. TO PREVENT THE AIR WHICH SUPPLIES OXYGEN FOR ENGINE COMBUSTION FROM BEING DRIVEN AHEAD AND OUT THE END OF THE TUNNEL A STEEL DOOR AT THE HIGHER END WILL BE INSTALLED TO REMAIN CLOSED UNTIL THE TRAIN APPROACHES THEN BE OPENED BY ELECTRONIC SIGNALS. EXIT OF THE TRAIN ACTUATES A SYSTEM OF FANS THAT FLUSH AIR THROUGH THE TUNNEL IN 15 MINUTES. DOWNHILL TRAINS WITH IDLING ENGINES WILL NOT REQUIRE THIS ARRANGEMENT, SO NO DOOR IS PLANNED FOR THE LOWER END.

05-66-06001 CALIFORNIA VOTES HUGE WATER BOND ISSUE (TUNNELS FEEDER-CONSTRUCTION)
ENGINEERING NEWS-RECORD, (176) 73, JUNE 16, 1966. AN $850 MILLION BOND ISSUE WAS VOTED, ADVANCING CALIFORNIA'S CONSTRUCTION IN ITS MWD $2 BILLION WATER PROJECT. THE CONSTRUCTION PROGRAM FEATURES 4 MAJOR FEEDERS - FOOTHILL, SEPULVEDA, INLAND AND SECOND LOWER FEEDER. FOOTHILL RUNNING 94 MILES CONSISTS MAINLY OF TUNNELS, SOME 20 1/2 FEET DIAMETER AND SOME MORE THAN 7 MILES LONG. THE GLENDORA TUNNEL IS A 15 1/2 FOOT DIAMETER CONCRETE LINED SECTION 6 1/2 MILES LONG. A 3 1/2 MILE TUNNEL NEAR NEWHALL IS 20 1/2 FEET DIAMETER.

05-66-06002 SHAFT SINKING (MUCKING WINZE SKIP-BUCKET JUMBO GALLOWAY-STAGE TUBBING GROUTING FREEZING HOISTING)
ENGINEERING AND MINING JOURNAL, 437-441, JUNE 1966. A FIELD SURVEY OF SHAFT SINKING METHODS WAS MADE. AN AVERAGE RATE OF NEARLY 1 FOOT PER HOUR FOR SHAFT SINKING WAS ACHIEVED BY USING A MULTI-DECK "GALLOWAY" STAGE WITH A CRYDERMAN HYDRAULIC MUCKING MACHINE HANGING FROM THE DECK. CONCRETE IS POURED BY THE STAGE CREW WHILE THE CREW ON THE BOTTOM MUCKS OR DRILLS. A COMBINATION OF FREEZING, TUBBING, AND GROUTING WAS SUCCESSFULLY USED TO COMPLETE A SHAFT WHICH RESISTED ALL ATTEMPTS TO GROUT AND FREEZE IN THE NORMAL FASHION. A 3 SHAFT JUMBO WAS USED TO INCREASE THE RATE OF PROGRESS IN A "HARD-ROCK" MINE SHAFT. A CIRCULAR CROSS SECTION SHAFT WAS SUNK WHICH IS A GOOD EXAMPLE OF EFFICIENCY COMPARED TO OVAL AND RECTANGULAR SECTIONS.

05-66-07001 CHANNEL GETS GREEN LIGHT (FINANCE)
ENGINEERING NEWS-RECORD, (177) 9, JULY 14, 1966. CONSTRUCTION WEEK COLUMN REPORTS APPROVAL BY BRITISH AND FRENCH GOVERNMENTS TO CONSTRUCT THE 21 MILE RAILWAY TUNNEL BENEATH THE ENGLISH CHANNEL, BUT NO AGREEMENT HAS BEEN REACHED ON FINANCING THE PROJECT.

05-66-08001 TUNNEL UNDER CANAL IS BUILT IN THE DRY (CUT-AND-COVER TWO-TUBE-VEHICULAR-TUNNEL)
ENGINEERING NEWS-RECORD, (177) 97, AUG 11, 1966. CONSTRUCTION OF PORTIONS OF A TWO-TUBE, CUT AND COVER TUNNEL UNDER THE WELLAND CANAL AT THORALD, ONT., WILL TAKE PLACE DURING WINTER MONTHS WHILE THE CANAL IS CLOSED AND DEWATERED FOR MAINTENANCE. THE PROJECT AND CONSTRUCTION STEPS ARE DESCRIBED.

05-66-08002 SECURITY IS A BIG HEADACHE ON A TUNNEL DEMOLITION JOB
ENGINEERING NEWS-RECORD, (177) 84, AUG 11, 1966. DEMOLITION OF A 4 TRACK 400 FOOT LONG RAILWAY TUNNEL UNDER THE GROUNDS OF SING SING PRISON WAS AN EXPENSIVE PART OF THE NEW YORK CENTRAL RAILROAD PROGRAM OF INCREASING OVERHEAD CLEARANCES ON ITS HUDSON RIVER LINE BETWEEN TARRYTOWN AND ALBANY. UNUSUAL SECURITY REQUIREMENTS MADE IT COMPLICATED AND EXPENSIVE. THE ARTICLE DESCRIBES THE PROJECT, PROBLEMS AND CONSTRUCTION METHODS USED.

05-66-08003 TUNNEL FOR THIRSTY CITY (WATER-FEEDER-TUNNEL)
ENGINEERING NEWS-RECORD, (177) 7, AUG 4, 1966. CONSTRUCTION WEEK ITEM ON NEW YORK CITY BOARD OF WATER SUPPLY PLANS FOR A THIRD FEEDER TUNNEL FROM YONKERS INTO MANHATTAN AND QUEENS.

05-66-08004 REBOUCAS TUNNEL IN RIO NEARS COMPLETION AFTER YEARS DELAY (LIGHTING VENTILATION EXCAVATION OPEN-CUT JUMBO)
ENGINEERING NEWS-RECORD, (177) 28, AUG 4, 1966. THE REBOUCAS TUNNEL A FOUR LANE TWIN TUBE 1 1/2 MILE ROCK TUNNEL SCHEDULED FOR COMPLETION IN 1965 WILL OPEN TO HALF CAPACITY LATE 1966 AFTER BEING PLAGUED WITH CONSTRUCTION AND FINANCIAL TROUBLE. THE TWO TUBES RUN THROUGH TWO ROCK SPINES THAT DIVIDE RIO - CUTTING A 36 MINUTE DRIVE TO 6 MINUTES. PRINCIPAL FACTOR IN DELAY IS THE PROJECTED $8 MILLION COST OF LIGHTING AND VENTILATION. OVERBURDEN IN SHORTER SECTIONS FORCED REMOVAL OF A LARGER VOLUME IN OPEN CUT EXCAVATION THAN FROM THE TUNNEL ITSELF. UNSOUND ROCK AND FELDSPAR RUBBLE IN CRACKS AND CREVICES CREATED DRILLING HAZARDS. SIXTEEN 60 POUND AIR DRILLS WITH 7/8 INCH DIAMETER DRILLS WERE OPERATED FROM A THREE PLATFORM JUMBO.

05-66-09001 TRAFFIC GOES UP AS TUNNEL GOES DOWN (CUT-AND-COVER EXPRESSWAY)
ENGINEERING NEWS-RECORD, (177) 43, DEC 22, 1966. WORK HAS STARTED ON A 3135 LONG CUT AND COVER HIGHWAY TUNNEL, PART OF THE 14 MILE PARIS RIGHT BANK EXPRESSWAY. THE EXPRESSWAY AND TUNNEL WILL CARRY ONE-WAY EAST-BOUND THRU TRAFFIC THAT NOW HELPS TO CLOG LOCAL STREETS IN THE AREA.

05-66-10001 HALF A CENTURY OF DRILLING AND BLASTING (MATERIAL HANDLING PROCESS-EQUIPMENT)
PIT AND QUARRY, 228-31, OCT 1960. IN AN INTERVIEW G. T. ERRICKSON IMPLIES THAT THE GROWTH IN THE TUNNELING INDUSTRY IS UNEQUALLED. A DETERGENT IS USED TO CONTROL THE DUST. ANFO AND SLURRIES MAKE TUNNELING A LOT SAFER. IT WAS NOT UNTIL 1945 THAT MILLISECOND-DELAY ELECTRIC BLASTING CAPS WERE INTRODUCED. ANFO WOULD NOT HAVE BEEN USED IF THE COST OF TUNNELING HAD NOT DECREASED.

05-66-10002 FIVE DIE IN SWISS TUNNEL BLAST
ENGINEERING NEWS-RECORD, (177) 18, OCT 27, 1966. FIVE TUNNEL WORKERS DIED IN A METHANE GAS EXPLOSION AT THE HONGRIN DAM SITE ON THE EASTERN TIP OF SWITZERLANDS LAKE GENEVA. THE EXPLOSION OCCURRED IN A 7 FOOT DIAMETER 1.2 MILE LONG WATER DIVERSION TUNNEL.

05-66-11001 TROUBLE HITS JAPANESE TUNNELERS; KILLS SEVEN (DRILLING-CREWS GANTRY-TYPE-JUMBO BURN-CUT-METHOD)
ENGINEERING NEWS-RECORD, (177) 88, NOV 17, 1966. THREE DRILLING CREWS WORKING FOUR HEADINGS ON THE 8.4 MILE LONG SHIMIZU RAILWAY TUNNEL IN JAPAN HAVE RUN HEAD-ON INTO A PACK OF TROUBLE. THEY HAVE BEEN SCALDED BY HOT SPRINGS, HIT BY SPALLING ROCK, DRIVEN BACK BY 215 PSI WATER JETS AND INTIMIDATED BY ELECTRICITY LEAKING INTO THE TUNNEL ALL AT A COST OF SEVEN LIVES. THE ARTICLE DESCRIBES THE PROJECT, HISTORY, TUNNELING METHODS, MACHINES USED AND THE TROUBLES THAT WERE ENCOUNTERED.

05-66-11002 VARIETY OF METHODS DOUBLE BARREL PENNSYLVANIA TURNPIKE TUNNELS
ENGR NEWS-RECORD, (177) 78-79, NOV. 17, 1966. 2 CONTRACTORS ARE BUILDING 3 TUNNELS FROM 4 HEADINGS WITH A VARIETY

OF TECHNIQUES TO ELIMINATE THE LAST OF THE TWO WAY TRAFFIC TUNNELS WHICH BOTTLENECK THE PENN TURNPIKE. PETER KIEWIT IS TOP HEADING A 5000 FT BORE THROUGH TUSCURORA MOUNTAIN FROM BOTH SIDES USING RUBBER TIRED JUMBOS, SIDE-DUMP LOADERS FOR MUCKING AND RUBBER-TIRED REAR-DUMP TRUCKS FOR HAULING AN-FO FOR BLASTING. C. J. LANGENFELDER IS WORKING TWO TUNNELS SIMULTANEOUSLY FULL FACE IN KITTATINNY MOUNTAIN AND BLUE MOUNTAIN - BUT ONLY FROM ONE END. LANGENFELDER IS USING DYNAMITE AND CARRIES THE DRILLS ON RAIL MOUNTED JUMBOS. ON KITTATINNY HE IS MUCKING WITH BUCKET CONVEYORS AND HAULING ON RAIL MOUNTED NINE CARS. AT BLUE BOUNTAIN HE IS USING TRACK MOUNTED SIDE-LOADERS AND HAULING WITH RUBBER TIRED REAR DUMPS.

05-66-12001 JOBS ABROAD (TUNNELS)
ENGINEERING NEWS-RECORD, PULSE, DEC 15, 1966. MEXICO - ANNOUNCEMENT OF PREQUALIFYING FOR CONSTRUCTION OF MAJOR SEWAGE PROJECT TO REPLACE THE GRAND CANAL IN MEXICO CITY. PROJECT INCLUDES 3 MAJOR TUNNELS 50-KM LONG AND 2 INTERCEPTING TUNNELS OF 20-KM EACH.

05-66-12002 DIG WE MUST (TUNNEL FEASIBILITY-STUDY)
ENGINEERING NEWS-RECORD, (177) 57, DEC 15, 1966. THE NEW YORK GOVERNOR REQUESTED THAT THE TRISTATE TRANSPORTATION COMMISSION CONSIDER A TUNNEL CONNECTION ALONG WITH SEVERAL BRIDGE PROPOSALS FOR JOINING LONG ISLAND WITH WESTCHESTER COUNTY, N. Y. OR CONNECTICUT.

05-66-12003 ARCHITECTS PROTEST TUNNEL PLANS (CUT-AND-FILL)
ENGINEERING NEWS-RECORD, (177) 62, DEC 15, 1966. A PLAN FOR A CUT AND FILL EIGHT LANE TUNNEL APPROACH TO A FLOATING BRIDGE FOR INTERSTATE 90 ACROSS LAKE WASHINGTON FROM SEATTLE TO MERCER ISLAND WAS PROTESTED BY LOCAL ARCHITECTS. THE PROTEST CHARGES THAT THE RESIDENTIAL DISTRICT OF MOUNT BAKER WOULD BE WIPED OUT AND IT WOULD NEVER GROW BACK. THE STATE HIGHWAY DIRECTOR ESTIMATED THE METHOD WOULD COST $33 MILLION LESS THAN BORING WHICH WOULD RUIN THE PROPERTY ABOVE THE TUNNEL ANYWAY.

05-66-12004 SIX MILE TUNNEL JOB RENEGOTIATED (POWERHOUSE-TAILRACE)
ENGINEERING NEWS-RECORD, (177) DEC 15, 1966. THE CONTRACT FOR CONSTRUCTING THE 6 MILE NEW ZEALAND MANIPOURI TAILRACE TUNNEL HAS BEEN CHANGED FROM FIXED PRICE TO COST PLUS A VARIABLE FEE BASED ON WHETHER ACTUAL COSTS ARE LESS OR EXCEED A TARGET ESTIMATE. UNEXPECTED CONDITIONS INCLUDED BADLY FRACTURED ROCK THAT PERMITTED EXCESSIVE INFLOWS OF WATER UNDER HIGH PRESSURES.

05-66-12005 CALIFORNIA AWARDS CONTRACTS FOR STATE WATER TUNNELS (COSTS)
CIVIL ENGINEERING, 83, DEC 1966. THE SEVEN MILE ANGLES TUNNEL CONTRACT FOR $95,039,650 WAS AWARDED TO A JOINT VENTURE--SHEA, KAISER, LOCKWOOD, HEALY.

05-66-12006 FERRY RIDER'S MISERY LEADS TO ENGLISH TUNNEL ATTEMPT (SIZE COST FINANCING)
EDWARDS, P.
WASHINGTON POST, K-1, DEC 18, 1966. TECHNICAL STUDIES INC IS AN ORGANIZATION PLANNING TO FINANCE TWIN 21 FT TUBES FOR TRAINS TO CARRY PEOPLE, CARS, AND FREIGHT 44 MI FROM FOLKSTONE, BRITAIN TO CALAIS, FRANCE. ALL TRAFFIC PROJECTIONS SEEM ADEQUATE TO SUPPORT THE $600 MILLION-PLUS TUNNEL. UNDER THE FINANCING PLAN 20 TO 25 PERCENT WILL BE RAISED FROM PRIVATE CAPITAL AND THE REMAINDER BONDS GUARANTEED BY FRANCE AND BRITAIN. PRESENT BOAT TOLLS CAN BE REDUCED 5 PERCENT FOR PASSENGERS, 30 PERCENT FOR CARS AND 50 PERCENT FOR FREIGHT.

05-67-01001 TUNNEL TRANSPORTATION
LUCKE, W. N. & OFFICE OF HSGT
MECHANICAL ENGINEERING, 56-57, APR 1967. THE ARTICLE DISCUSSES THE FEASIBILITY OF A HIGH-SPEED UNDERGROUND TRANSIT SYSTEM. TECHNOLOGY IS LAGGING IN THE AREA OF TUNNELING. ALSO IMPROVEMENTS ARE NEEDED IN GEOPHYSICAL TESTING TECHNIQUES. THE ECONOMICS OF THE SYSTEM COULD BETTER BE CONTROLLED THROUGH MULTIPLE USE OF THE PROGRAM.

05-67-03001 TUNNEL TO UNSNARL RIO TRAFFIC (TWO-STAGE-TUNNEL)
THE WASHINGTON POST, MAR 22, 1967. A TWO-STAGE TUNNEL IS BEING COMPLETED IN RIO DE JANEIRO IN AN EFFORT TO UNSNARL TRAFFIC IN THIS CITY BY THE BAY. EXPECTED COST OF THE TUNNEL IS TO BE ABOUT $18 MILLION. THE LIGHT, VENTILATION, AND TRAFFIC CONTROL SYSTEMS AS WELL AS PART OF THE PAVEMENT ARE LACKING. URBANIZATION WORK IS BEING CARRIED OUT IN FRONT OF THE TUNNEL'S FOUR MOUTHS.

05-67-04001 THE SCHELDT TUNNEL AT ANTWERP (HIGHWAY-RAILWAY-TUNNEL IMMERSED-TUBE)
THE ENGINEER, 604-606, APR 1967. AN IMMERSED-TUBE TUNNEL 500 METERS IN LENGTH IS BEING CONSTRUCTED TO PROVIDE ROAD AND RAIL CROSSINGS OF THE SCHELDT RIVER AT ANTWERP. THE CROSSING WILL CONSIST OF FIVE FLOATING ELEMENTS, EACH ABOUT 100 METERS IN LENGTH, 50 METERS IN WIDTH AND 10 METERS IN DEPTH, AND EACH WEIGHING ABOUT 47,000 TONS. THESE ELEMENTS ARE TO BE SUNK INTO A SUB-AQUEOUS TRENCH ABOUT 30 METERS BELOW HIGH TIDE IN THE ESTUARY. THE ELEMENTS ARE BEING PREPARED, PRIOR TO FLOATING AND SINKING, IN A LARGE DEEP DOCK AREA.

05-67-04002 WHAT TO DO WITH SEWAGE WHEN IT RAINS HARD (DEEP-TUNNEL-SYSTEM COMBINED-SEWERS)
ENGINEERING NEWS-RECORD, (178) 31, APRIL 20, 1967. A RESUME OF ACTIVITY REGARDING STORM WATER PROBLEMS ON COMBINED SEWER SYSTEMS SPARKED BY FEDERAL WATER POLLUTION CONTROL ADMINISTRATION (FWPCA) GRANTS. FEATURED IS THE CHICAGO DEEP TUNNEL OVERFLOW HOLDING SYSTEM AND AN OUTLINE OF THE AREAS TO BE STUDIED UNDER FWPCA GRANTS.

05-67-05001 TEST EXCAVATION FOR SEIKAN UNDERSEA TUNNEL (JAPANESE-RAILWAYS)
CONSULTING ENGR (LOND), (31) 57-80, MAY 1967. DESIGN AND CONSTRUCTION PROBLEMS OF UNDERSEA TUNNEL, TO BE BUILT FOR JAPANESE NATIONAL RAILWAYS, TO CONNECT ISLAND OF HONSHU, ARE INDICATED BY INITIAL RESULTS FROM TEST EXCAVATIONS UNDERTAKEN DURING CONSTRUCTION OF PILOT TUNNEL; TUNNEL SUPPORT IS 125X125 MM H-SHAPED STEEL AND CONCRETE SPRAYED TO DEPTH OF 10 CM; UNSTABLE SECTIONS ARE PREHARDENED BY CEMENT GROUTING; IN MOST SECTIONS DISPLACEMENT OF CROWN HEADS IS 1.5 MM AFTER 150 DAYS OF EXCAVATION, AND LOAD, WHICH ACTS ON TENSIOMETER, IS ABOUT 3 TONS/SQ M; GROUNDWATER TOGETHER WITH DRILLING WATER IS PUMPED UP AT SITES 100 M APART.

05-67-05002 TUNNELING THROUGH GARLOCK FAULT (CALIFORNIA WATER-TUNNEL)
WESTERN CONSTRUCTION, (42) N 5, 54-60, MAY 1967. TWO SHIELDS WERE USED IN DRIVING 5 MI LONG WATER SUPPLY TUNNEL THROUGH TEHACHAPI MOUNTAINS IN SOUTHERN CALIFORNIA; LASER BEAM WAS USED FOR TUNNEL ALIGNMENT; 24-FT 4 IN. DIAM STEEL SHIELDS ARE FORCED FORWARD WITH RING OF HYDRAULIC JACKS MOUNTED AT THEIR REAR ENDS; EACH ONE HAS THRUST OF 250 TONS FOR TOTAL OF 11,500,000 LB.

05-67-06001 CHANNEL MONEY FROM THE U.S.A. (ENGLISH-CHANNEL TUNNEL FINANCING)
ENGINEERING NEWS-RECORD, CONSTRUCTION WEEK, (178) 7, JUNE 1, 1967. THREE INTERNATIONAL FINANCING TEAMS VIE FOR UNDER-WRITING BUSINESS ON THE ENGLISH CHANNEL TUNNEL. REFERS TO ENGINEERING NEWS-RECORD ARTICLE, MARCH 3, 1967.

05-67-06002 MANAPOURI: WHERE NEW ZEALAND IS MINING FOR 700,000 KW (TUNNEL TAILRACE ACCESS-ADITS DRAFT-TUBES PENSTOCKS JUMBOS)
BOWMAN, W. G. & ENGR NEWS-RECORD NEW YORK
ENGINEERING NEWS-RECORD, (178) 26, JUNE 1967. AN UNDERGROUND 700,000 KW POWER PLANT IS BEING CONSTRUCTED AT LAKE MANAPOURI NEW ZEALAND 600 FEET BELOW THE LAKE. SEVEN TURBINES WILL DISCHARGE 515 FEET NET HEAD THROUGH A 30 FOOT HORSESHOE SECTION LINED TAILRACE TUNNEL INTO DOUBTFUL SOUND OF THE TASMAN SEA. EQUIPMENT USED INCLUDED A LARGE HORSESHOE SECTION DRIVEN FULL FACE, A 3 TIER DRILLING JUMBO, TWO MUCK LOADERS AND AN EXTENSIVE MUCK-CAR RAIL SYSTEM TERMINATING IN A JACOBS SLIDING FLOOR AT THE FACE. THE MOUNTAINS THE TUNNEL PENETRATES ARE LARGELY GNEISS AND

QUARTZITE EXCELLENT FOR TUNNELING BUT FAULT CRACKS DISCHARGED HUGE QUANTITIES OF WATER REQUIRING PUMPING, GROUTING, SHORING AND ROCK BOLTING. EXCAVATION INCLUDED THE 364 FEET BY 59 FEET BY 127.5 FEET DEEP MACHINE HALL, A 36 FEET HIGH BY 33 FEET WIDE SURGE CHAMBER FOR A LENGTH OVER 3800 FEET, 7 PENSTOCK SHAFTS 570 FEET DEEP AND NUMEROUS ACCESS ADITS, DRAFT TUBES AND DRAFT MANIFOLD.

05-67-06003 AEC DIGS DEEP FOR BIG BLAST (UNDERGROUND NUCLEAR-EXPLOSIVES)
BUSINESS WEEK, 140, SEPT 16, 1967. AEC IS SPENDING $27.2 MILLION TO BUILD A NEW DEEP UNDERGROUND NUCLEAR WEAPONS TESTING FACILITY ON AMCHITKA ISLAND IN THE ALEUTIAN CHAIN. A 6000 FOOT DEEP L-SHAPE HOLE IS BEING PUNCHED INTO THE FLINT-LIKE ROCK. THE CONTRACTOR HOLDS A CONTRACT TO CUT 3 IMPLACEMENT HOLES TO LESS THAN 6000 FEET AND 5 EXPLORATORY HOLES DOWN TO 8000 FEET.

05-67-07001 TUNNELERS MAY SWARM ANYWAY (PREQUALIFICATION COST BIDS)
ENGINEERING NEWS-RECORD, 9, JULY 27, 1967. ON 1.7 MILE STRAIGHT CREEK HIGHWAY TUNNEL THE HIGHWAY DEPARTMENT SET UP STIFF PREQUALIFICATION REQUIREMENTS. BIDDERS MUST HAVE HAD AT LEAST 5 YEARS TUNNELING EXPERIENCE, COMPLETED A CONTRACT OF AT LEAST 10 MILLION DOLLARS AND BUILT AT LEAST 10,000 FEET OF TUNNEL. UNDAUNTED 23 CONTRACTORS HAD BOUGHT PLANS ON THE 35 MILLION DOLLAR PROJECT.

05-67-08001 CUSTOM RIGS SPEED 1,500-FT-LONG TUNNEL TO COMPLETION (JUMBO GROUTING-RIG)
CONSTRUCTION METHODS, 92-94, AUG 1967. FENIX AND SCISSON INC OF TULSA OKLA CONTRACTED A TUNNEL JOB IN KY FOR $2.7 MILLION. THEY FABRICATED A NUMBER OF UNIQUE RIGS. THE RIGS INCLUDE A DRILLING JUMBO MOUNTED ON AN OLD EUC TRUCK CHASSIS WITH AN UPPER DECK THAT CAN BE RAISED OR LOWERED TO MEET THE REQUIREMENTS OF DIFFERENT TUNNEL DIA, A HOME MADE GROUTING RIG, A SPECIAL JIG FOR ASSEMBLING AND WELDING CONTINUOUS REBAR RINGS, AND A CONCRETE BUCKET GIVEN LONGER LEGS TO MAKE ROOM FOR AN ELEPHANT-TRUNK TUNNEL BENEATH THE DISCHARGE SPOUT. A 600 FT LONG 17 FT DIA SECTION IS USED ONLY FOR DIVERSION, THE REMAINING 900 FT, 19 FT DIA WILL LATER BE USED AS A POWER TUNNEL. THE POWER TUNNEL IS STEEL LINED FOR 567 FT AND CONCRETE LINED FOR THE REMAINING 333 FT. MOST OF THE CONCRETE WAS PLACED WITH A 200 DOUBLE REX PUMP-CRETE UNIT. SOME 23,000 YD OF SHALE AND SANDSTONE WAS EXCAVATED BY BLASTING ON THE 19 FT DIA HOLE.

05-67-08002 REPAIRS TO BEGIN ON SEAWAYS EISENHOWER LOCK (HIGHWAY TUNNEL CONCRETE DETERIORATION)
ENGINEERING NEWS-RECORD, (179) 42, AUG 1967. AWARD OF THE FIRST CONTRACTS IS PLANNED FOR REPAIRS TO THE ST. LAWRENCE SEAWAY EISENHOWER LOCK THAT COULD BE A FIVE YEAR $11-MILLION PROJECT. MANY STUDIES WERE MADE BUT CAUSES FOR THE EXTENSIVE DETERIORATION OF CONCRETE SURFACES HAVE NOT BEEN IDENTIFIED. A TWO-LANE VEHICULAR TUNNEL FOR A HIGHWAY UNDER THE LOCK WILL HAVE A STEEL FRAME AND PLATE LINER INSTALLED.

05-67-10001 WORK BEGUN ON $200 MILLION MEXICO CITY SUBWAY (EARTHQUAKE SUBSIDENCE)
THE WASHINGTON POST, A7, OCT 24, 1967. A SUBWAY TUNNEL IS GOING TO BE BUILT UNDER MEXICO CITY WHICH WILL EVENTUALLY BE ABLE TO ACCOMMODATE 1,000,000 PASSENGERS. THEY ARE EXPERIENCING PROBLEMS WITH EARTHQUAKES AND SUBSIDENCE.

05-67-11001 STRAIGHT CREEK TUNNEL AWARD (BID ESTIMATE VENTILATION)
ENGINEERING NEWS-RECORD, 55, NOV 9, 1967. DELETING FANS AND MOTORS FOR THE VENTILATING SYSTEM LOPPED 5 MILLION DOLLARS FROM THE 49.6 MILLION DOLLAR CONTRACT FOR THE 1.7 MILE STRAIGHT CREEK HIGHWAY TUNNEL BUT THIS WAS STILL 25 PERCENT ABOVE THE ENGINEER'S ESTIMATE.

05-67-11002 SIX-LANE TUNNEL SITS ON SACKS OF GROUT (SUNKEN-TUBE SUBAQUEOUS-TUNNEL WOODPILES GROUTCUSHION)
ENGINEERING NEWS-RECORD, (179) 104-105, NOV 9, 1967. THE TINGSTAD TUNNEL IS TO BE BUILT IN FIVE SECTIONS BY THE SUNKEN-TUBE METHOD IN GOTHENBURG, SWEDEN. IT COULD BE THE WORLD'S FIRST DOUBLED-BARRELED SUBAQUEOUS TUNNEL BOASTING THREE-LANE ROADWAYS. THE ORIGINAL INTENT WAS TO FLOAT THE TUNNEL ON THE DEEP CLAY OF THE RIVER BOTTOM, BUT SILT ON TOP OF THE CLAY WAS FOUND TOO UNSTABLE, THEREFORE PILES HAD TO BE DRIVEN. TO TRANSFER THE TUNNEL LOADS TO THE PILES, THE GROUT CUSHION METHOD WAS PATENTED. GROUT CUSHIONS ARE HUGE NYLON SACKS PUMPED FULL OF GROUT TO A FORM-FIT BETWEEN THE TUNNEL BOTTOM AND THE TOPS OF THE PILES. THE COMPLETED TUNNEL JOINT IS MUCH LIKE OTHER TUNNEL JOINTS, BUT THIS GROUT CUSHION IDEA IS A NEW CONCEPT.

05-67-11003 ITALY EXPORTS ITS BUILDING KNOWHOW
BUSINESS WEEK, 92-94, NOV 18, 1967. ITALIAN COMPANIES ARE BORING TUNNELS IN NEW ZEALAND, AND THEY ALSO HAVE BUILT 19 BRIDGES OR TUNNELS ON A 56-MILE STRETCH OF ONE HIGHWAY PROJECT.

05-67-12001 ANDORRA EXPECTS TUNNEL BENEFITS (TOURISM WEATHER)
LOWELL, G.
THE WASHINGTON POST, DEC 13, 1967. ANDORRA, SPAIN WILL BUILD A TUNNEL UNDER THE PYRENEES MOUNTAINS WHICH WILL LINK THEM WITH FRANCE YEAR ROUND.

05-67-12002 YUBA RIVER JOB RACES THE RAINS (WINTER-RAINS SPOIL-DISPOSAL)
ENGINEERING NEWS-RECORD, 31, 34, DEC 7, 1967. THE YUBA RIVER BASIN DEVELOPMENT PROJECT IN NORTHERN CALIFORNIA CONSISTING OF THE CONSTRUCTION OF SEVERAL TUNNELS, DAMS, AND POWER PLANTS IS CONFRONTED WITH THE PROBLEM OF HEAVY RAINS AND OF SPOIL DISPOSAL. CONTRACTOR HAD TO COMPLETE ENOUGH OF THE 120-FEET-HIGH INTAKE STRUCTURE FOR THE PROJECT'S NEW NARROWS POWER TUNNEL TO PERMIT GATE INSTALLATION BEFORE THE WINTER RAINS SET IN, OTHERWISE TUNNEL COMPLETION WOULD HAVE BEEN IMPOSSIBLE THAT WINTER. SPOIL DISPOSAL PROBLEM WAS ENCOUNTERED IN THE CONSTRUCTION OF ONE OF THE OTHER TUNNELS INVOLVED IN THE PROJECT. THE SPOIL HAD TO BE CARRIED ACROSS OREGON CREEK AND THROUGH THE CAMPTONVILLE TUNNEL AND DUMPED IN A FUTURE RESERVOIR AREA. THIS EXCAVATION PROCEDURE CAUSED A DELAY ON THE COMPLETION OF THE CAMPTONVILLE TUNNEL.

05-68-01001 WORLD'S LARGEST SEAPORT GETS SMALLEST 'METRO' TUBE (COST)
RIJKERS, J.
THE WASHINGTON POST, JAN 20, 1968. A TUNNEL BUILT FOR A SUBWAY WHICH IS AT A DEPTH OF 53 FEET UNDER THE RIVER, 20 FEET BELOW THE RIVER BED. MAAS TUNNEL TOOK SEVEN YEARS TO BUILD AT A COST OF $56 MILLION. IT IS A 3.75 MILE TWIN TRACK.

05-68-01002 FRANCE ENDS TUNNEL PROJECT
THE WASHINGTON POST, JAN 16, 1968. BRITISH TRANSPORT MINISTER ANNOUNCED BRITAIN'S WITHDRAWAL FROM THE ANGLO-FRENCH ENGLISH CHANNEL TUNNEL.

05-68-01003 WHAT SHOULD BE THE LONG-RANGE RESEARCH MISSION FOR THE MINERALS INDUSTRIES (GEOLOGY RESEARCH COMPUTERS MINING)
MINING ENGINEERING, (20) N 1, 54-66, JAN 1968. MINING SHOWS HEAVY RELIANCE ON OTHER INDUSTRIES RESEARCH. MINING OFFICIALS ARE AWARE THAT INTRA-METALS AND INTER-MATERIALS COMPETITION WILL REQUIRE RESEARCH. 9 MINING MEN PROPOSE IDEAS ON "WHAT SHOULD BE THE LONG-RANGE RESEARCH MISSION FOR THE MINERALS INDUSTRY. THE 9 ARTICLES ARE REFERENCED SEPARATELY. SEE 05-68-01004, 05-68-01005, 05-68-01006, 05-68-01007, 05-68-01008, 05-68-01009, 05-68-01010, 05-68-01011, 05-68-01012.

05-68-01004 CHANGING TOOLS FOR THE GEOLOGIST (PHOTOGEOLOGY PETROGRAPHICS)
WORTHINGTON, J. E. & CYPRUS MINES CORP
MINING ENGINEERING, (20) N 1, 54-56, JAN 1968. ADVANCES IN PHOTOGEOLOGY USING COLOR FILM, INFRARED AND RADAR IMAGERY, MORE SOPHISTICATED AND SENSITIVE FILM TYPES AND OPTICAL PETROGRAPHIC OBSERVATIONS OF OUTCROPS WILL ASSIST IN DETERMINING STRUCTURE AT THE TUNNEL LEVEL.

05-68-01005 GEOPHYSICS TO BENEFIT FROM SPACE TECHNOLOGY (SPACE-DATA FORCE-FIELDS)
SCHARON, L. & WASH UNIV ST. LOUIS MO
MINING ENGINEERING, (20) N 1, 56-57, JAN 1968. GEOPHYSICAL EARTH EXPLORATION FROM SPACE AND IMPROVED DIRECT MEASUREMENTS OF INDUCED AND NATURAL FORCE FIELDS WILL MAKE MORE ACCURATE FUTURE DETERMINATIONS OF EARTH STRUCTURE.

05-68-01006 MINING HOLDS PROMISING AREAS FOR R. AND D. (FRAGMENTATION AIR-CONDITIONING REMOTE-CONTROL COMPUTERS)
FAIRHURST, C. & UNIV MINN MINNEAPOLIS MINN
MINING ENGINEERING, (20) N 1, 57-58, JAN 1968. MINING SHOULD DEVELOP METHODS OF CONTINUOUS FRAGMENTATION RATHER THAN THE CYCLICAL, INDIVIDUAL AIR CONDITIONED ENVIRONMENTS RATHER THAN AREAS, TOTAL REMOTE CONTROL OPERATION, SYSTEMS ANALYSIS AND EXCAVATION SEQUENCES SELECTION BY PROGRAMMING AND STRUCTURAL STABILITY DETERMINATION BY ANALOG AND DIGITAL COMPUTER MODELLING. ALL THESE DEVELOPMENTS CAN BE BENEFICIAL TO TUNNELING.

05-68-01007 ENERGY AND TIME FACTORS MAY CHANGE FOR MINING (FRACTURING MELTING DISSOLVING MOLECULAR-CRACKING)
BEEN, W. & MICH TECH UNIV
MINING ENGINEERING, (20) N 1, 58-59, JAN 1968. MINING MAY BE FEASIBLE BY DIRECT THERMAL SHOCK FRACTURING, DIRECT MELT, HIGH TEMPERATURE SOLVENTS, OR MOLECULAR CRACKING. THE HARVESTING OF MINERALS CONCENTRATED BY ORGANISMS MAY BE A POSSIBILITY.

05-68-01008 FINDING NEW WAYS TO WIN METALS (LEACHING ELECTROSTATIC PHYSICAL-FORM)
BROWN, J. H. & QUEEN'S UNIV ONT CAN
MINING ENGINEERING, (20) N 1, 59-60, JAN 1968. STANDARD BENEFICIATION PRACTICES CAN BE IMPROVED WITH SULFIDE DEPOSIT LEACHING, ELECTROSTATIC AND HIGH TENSION SEPARATION TECHNIQUES AND EVALUATING PHYSICAL FORM TO DETERMINE PROCESSING.

05-68-01009 MULTIFOLD POSSIBILITIES FACE BENEFICIATION ENGR (COMPUTERS ENVIRONMENT GEOLOGY LASER HIGH-PRESSURE-WATER)
HARRIS, C. C. & COLUMBIA UNIV
MINING ENGINEERING, (20) N 1, 60-63, JAN 1968. POLYMERS MAY BE THE FUTURE CONSTRUCTION MATERIALS BUT THERE WILL BE ENORMOUS MARKETS FOR METALS IN THEIR PRESENT FORM AND AS NEW ALLOYS, POWDERS, FIBER DISPERSIONS AND COMPOSITES. GEOPHYSICAL, GEOCHEMICAL AND GEOBOTANICAL SURVEYS WILL EVENTUALLY PREDICT OREBODY GRADE BEFORE MINING. DATA FROM LASER BEAM OR HIGH PRESSURE WATER BORING WILL ACCURATELY DETERMINE GEOLOGY. COMPUTER CONTROL MAY BE USED TO INTERPRET ON-LINE INFORMATION THROUGH FEED FORWARD AND FEED BACK LOOPS INTO APPROPRIATE CONTROL DEVICES. UNDERSEA MINING MUST NOT INTERFERE WITH SEA FARMING REQUIRING THAT DEPOSITS MAY BE MINED BY TUNNELING. ENGINEERS, SCIENTISTS, AND ADMINISTRATORS WILL BECOME INCREASINGLY AWARE OF ENVIRONMENT, OUR EFFECT ON IT AND ITS EFFECT ON US.

05-68-01010 CRUSHING AND GRINDING - THERE SHOULD BE A BETTER WAY (FRACTURE MOLECULAR-ACTIVATION)
BOND, F. C. & ALLIS-CHALMERS MFG CO
MINING ENGINEERING, (20) N 1, 63-64, JAN 1968. THE OLD METHOD OF APPLICATION OF PRESSURE TO CRUSH MATERIALS IS INEFFICIENT. THIS SHOULD BE REPLACED BY PROCESSES SUCH AS CENTRIFUGAL FORCE, INDUCED VIBRATION, HIGH VOLTAGE DISCHARGE, INDUCTION HEATING OR PENETRATION BY SUFFICIENTLY HARD MATERIAL. ANY PROCESS WHICH COULD SELECTIVELY ACTIVATE THE INTERNAL CONTACT ATOMS HOLDS PROMISE OF RESULTING IN ROCK DISINTEGRATION.

05-68-03001 HISTORIC OPENING OF TUNNEL IS RECREATED
PASSENGER TRANSPORT, MARCH 4, 1968. IN 1918 MAYOR ROLPH OPENED THE TWIN PEAKS TUNNEL WHICH CONNECTED DOWNTOWN BUSINESS IN SAN FRANCISCO TO 4000 ACRES OF DESIRABLE HOME SITES.

05-68-07001 TUNNEL AND SHAFT CONFERENCE SPOTLIGHTS WIDER ACCEPTANCE OF BORING METHODS (MOLES ROCK-BOLTS DUST-CONTROL STATE-OF-THE-ART SYSTEMS SHAFT-SINKING GEOLOGY MATERIALS-HANDLING)
BEALL, J. V.
MINING ENGINEERING, 139-143, JULY 1968. A TOTAL OF 500 PERSONS ATTENDED THE TUNNEL AND SHAFT CONFERENCE AT THE UNIVERSITY OF MINN. MAY 15-17, 1968. THE CONFERENCE COVERED: CONVENTIONAL AND BORED SHAFTS AND TUNNELS, RAISE BORING, AND GROUND SUPPORT. STATE OF THE ART OF TUNNELING WAS REVIEWED. NEW METHODS AND TECHNIQUES WERE MENTIONED IN SEVERAL REPORTS. GEOLOGIC EXPLORATION WAS STRESSED.

05-68-08001 BOLIDEN LIKES BIG HOLE RAISE BORING BUT QUESTIONS COST AS "INEXPENSIVE" (SWEDEN DRILLING)
ANDO, S.
WORLD MIN, (4) N 9, 20-1, AUG 1968. RESULTS OF EXPERIMENTAL DRIVING BY BORING METHOD OF FIVE 48 IN. ID, TOTALING 650 FT RAISES IN MINES OF BOLIDEN CO. IN SWEDEN SHOW THAT DRILLING RATE AND COST ARE INFLUENCED BY COMPRESSIVE STRENGTH OF DRILLED ROCKS; TEST DATA INCLUSIVE OF TOTAL COST OF DRILLED RAISES IS TABULATED.

05-68-08002 NEW RAISE DRILLING TOOL TESTED IN CANADA
CAN MIN JOURNAL, (89) N. 8, 61, AUG 1968. DESCRIPTION OF RAISE DRILLING RIG, DEVELOPED BY SECURITY DIV. OF DRESSER INDUSTRIES, INC, BEING TESTED IN CANADA; MODEL 480 RAISE DRILL IS CAPABLE OF DRILLING 4 TO 6 FT OPENINGS TO DEPTHS OF 350 TO 1000 FT AT INCLINES OF 90 TO 45 DEGREES FROM VERTICAL, THROUGH MOST DIFFICULT TYPE OF GROUND; AT CUPRA MINES IN QUEBEC MACHINE DRILLED SIX 4-FT RAISES IN 83 DAYS, INCLUDING MOVING, PILOT HOLE DRILLING AND REAMING AT AVERAGE OUTPUT OF 19 FT PER THREE-SHIFT WORKING DAY; IT IS HYDRAULICALLY OPERATED AND REQUIRES TWO-MAN CREW; ITS COMPONENTS CAN BE MOVED IN CAGES NO LARGER THAN 43X36 IN., LONGEST SEGMENT MEASURING 10 FT; AREA 9 FT WIDE AND 18 FT HIGH IS REQUIRED FOR OPERATION.

05-68-09001 BAY BRIDGE, TUNNEL PACTS SIGNED IN MARYLAND
HOMAN, R.
THE WASHINGTON POST, B2, SEPT 13, 1968. A SECOND BALTIMORE HARBOR TUNNEL AND A PARALLEL CHESAPEAKE BAY BRIDGE TUNNEL WERE APPROVED BY MARYLAND OFFICIALS.

05-68-10001 HEATHROW AIRPORT - LONDON CARGO TRANSPORT LINK (SHIELD CONCRETE-LINING)
INDIAN CONCRETE JOURNAL, (42) N 10, 436-8, OCT. 1968. DESIGN AND CONSTRUCTION DETAILS ARE GIVEN FOR HALF-MILE UNDERGROUND SECTION OF CARGO TRANSPORT LINK BETWEEN CENTRAL TERMINAL AREA AND NEW CARGO COMPLEX IN SOUTHWEST CORNER OF HEATHROW AIRPORT IN LONDON; TUNNEL WAS SHIELD DRIVEN IN SOFT GROUND; HIGH PRECISION CONCRETE LINING SEGMENTS WERE ERECTED IN RINGS WITHOUT ATTACHMENT BETWEEN UNITS, AND STRESSED DIRECTLY AGAINST GROUND IMMEDIATELY BEHIND TUNNEL SHIELD; DESIGN COMBINES ECONOMY WITH MINIMUM GROUND MOVEMENT ABOVE AND AROUND TUNNEL.

05-68-10002 MALABAR HILL TUNNEL IN BOMBAY (FREEWAY-TUNNEL STRUCTURAL-DESIGN)
ANDHARE, N. M. + BORKAR, A. G.
INDIAN CONCRETE JOURNAL, (48) N 10, 413-17, OCT. 1968. FEATURES OF PROPOSED MALABAR HILL TUNNEL IN BOMBAY, INDIA WHICH FORMS PART OF WEST ISLAND FREEWAY CONNECTING SOUTHERN END OF BUSINESS DISTRICT OF CITY WITH NORTHERN SUBURBS; GEOLOGICAL INVESTIGATIONS CONDUCTED AND STRUCTURAL DESIGN OF TUNNELS ARE DISCUSSED.

05-68-10003 SUBWAY, BUT NOT FOR TRAINS (WATER-TUNNEL)
ENGINEERING NEWS-RECORD, 23, OCT 17, 1968. NEW YORK CITY HAS ANNOUNCED THE START OF CONSTRUCTION ON A 15-MI WATER TUNNEL. THE 20 TO 27 FT DIA BORE WILL RUN FROM A RESERVOIR IN YONKERS UNDER THE BOROUGHS OF THE BRONX AND MANHATTAN, ULTIMATELY TO THE BOROUGH OF QUEENS. ESTIMATED COST - $238 MILLION. IT IS THE BEGINNING OF A PROPOSED 63-MI TUNNEL NETWORK.

05-68-10004 NEW SPUR FOR MINING (RESEARCH)
INDUSTRIAL RESEARCH, 25, OCT 1968. NEW TECHNOLOGY IS NEEDED (1) INCREASING URBANIZATION REQUIRES BETTER (AND CHEAPER) TECHNIQUES FOR BUILDING SUBWAYS, SEWERS, AND OTHER UNDERGROUND SERVICE FACILITIES. (2) DEPLETION OF U.S. MINERAL RESOURCES JEOPARDIZES NATIONAL SECURITY AND THE BALANCE OF PAYMENTS AND MAKES IT DIFFICULT TO HOLD DOWN FOREIGN PRICE LEVELS. A 10-YEAR $200 MILLION FEDERAL R AND D PROGRAM AIMED AT IMPROVING EXCAVATION EFFICIENCY BY 300 PERCENT AND CUTTING THE COST BY 30 TO 50 PERCENT HAS BEEN PROPOSED.

05-68-10005 REPORT CALLS FOR REVOLUTION IN METHODS OF UNDERGROUND EXCAVATION (RESEARCH)
ENGINEERING MINING JOURNAL, 109, OCT 1968. NEEDED RESEARCH IN UNDERGROUND EXCAVATION. A TEN-YEAR RESEARCH EFFORT RECOMMENDED BY THE NATIONAL ACADEMIES OF SCIENCE AND ENGINEERING WOULD AIM AT MAKING UNDERGROUND EXCAVATION THREE TIMES FASTER AND 30 PERCENT CHEAPER THAN IT IS TODAY.

05-68-11001 WHEELS OF GOVERNMENT (SAFETY-STANDARDS HEALTH-RISKS ENVIRONMENT)
OWORSHAK, H.
MINING CONGRESS JOURNAL, (54) N 11, 94-100, NOV 1968. PROPOSED STANDARDS UNDER THE FEDERAL METAL AND NONMETALLIC MINE SAFETY ACT ARE EXPECTED TO BE PUBLISHED BEFORE DECEMBER 31, 1968. H. N. DOYLE OF HEW HAS BEEN ASSIGNED THE TASK OF ASSISTING BU MINES EXPAND ITS HEALTH PROGRAM. FIRST TASK RELATES TO PNEUMOCONIOSIS. PROF. LEDBETTER OF U. OF TEXAS REPORTS THAT A RECENT SURVEY SHOWED THAT ALTHOUGH MOST PEOPLE WANT AIR POLLUTION STOPPED, THEY ARE NOT WILLING TO PAY AS LITTLE AS $15/YEAR TO CLEAN IT UP. A MINE ENVIRONMENT SHORT COURSE IS OFFERED AT UNIV. OF MISSOURI AT ROLLA, APRIL 16-18, 1969.

05-69-01001 TWELVE-DRILL JUMBO SPEEDS TUNNELING CYCLE (DRILL-BLAST RECORD)
CONSTRUCTION METHODS & EQUIPMENT (51) N. 1, 56-62, JAN 1969. HOW MINERS PUNCHED BIG HORSESHOE TUNNEL THROUGH MILE AND A HALF OF SOLID MOUNTAIN IN COLORADO ROCKIES 60 MI WEST OF DENVER; FOUR DRILLS WORKED ON TOP AND BOTTOM DECKS AND ADDITIONAL FOUR SIDE MOUNTED ON JUMBO RIDING RAILS INTO 8148 FT LONG TUNNEL; TOP RIB SECTIONS, WEIGHING 211 LB/FT WERE SET WITH HYDRAULIC EQUIPMENT.

05-69-01002 FIRST SECTION OF BUDAPEST UNDERGROUND NOW NEARING COMPLETION (HUNGARY DANUBE)
RAILWAY GAZETTE, (125) NO 1, 19-24, JAN. 3, 1969. AFTER TWENTY YEARS TUNNELING IS COMPLETE ON THE EAST-WEST LINE OF BUDAPESTS SUBWAY LINE. METHODS OF CONSTRUCTION USE ARE DESCRIBED. FIVE OVERLAPPING TUBES ARE INVOLVED FOR BUSY STATIONS.

05-69-02001 MINING AND EXPLORATION TECHNOLOGY - INNOVATION SETS PACE IN 1968
MINING ENGINEER, (21) N 2, 63-73, FEB. 1969. REVIEW AND METHODS AND EQUIPMENT DEVELOPED IN 1968 IN AREAS OF OPEN PIT-, UNDERGROUND-, AND SOLUTION-MINING; INCREASING PART PLAYED IN MINING INDUSTRY BY OPERATIONS RESEARCH AND USE OF COMPUTERS IS REPORTED. 33 REFS.

05-69-03001 MEXICO'S METRO-CONSTRUCTION MIRACLE. (SUBWAY)
WORLD CONSTRUCTION, (22) NO 3, 27-29, MAR. 1969. CONSTRUCTION PROBLEMS ENCOUNTERED IN DRIVING THE 35 KM MEXICO CITY SUBWAY NETWORK IN THE OLD LAKE BED ARE DESCRIBED. THE SYSTEM HAS 3 LINES WHICH INTERSECT IN THE CITY CENTER. THE STRATA IS A SOFT, SOGGY CLAY WHICH IS 85% WATER.

05-69-05001 FOUR BARREL TUNNEL SET FOR BIDS (NYC-SUBWAY LIRR SHIELD SUNKEN-TUBE)
ENGR. NEWS-RECORD, (182) 52, MAY 22, 1969. THE N.Y. METROPOLITAN TRANSPORTATION AUTHORITY WILL TAKE BIDS ON TWO ALTERNATE METHODS OF CONSTRUCTION FOR THE FOUR LANE DOUBLE DECK TRANSIT TUNNEL UNDER THE EAST RIVER. THE ESTIMATED $75 MILLION TUNNEL WILL CARRY TWO LANES OF THE LONG ISLAND RR ON THE LOWER DECK, TWO SUBWAY TRACKS ON THE UPPER DECK. THE CONTRACTORS MAY BID EITHER A BORED TUBE UNDER THE RIVER OR A PRECAST SUNKEN TUBE IN THE RIVER BED.

05-69-05002 LOW BID ON TUNNEL UNDER WELLAND CANAL REALLY LOW (ST-LAWRENCE-SEAWAY)
ENGR. NEWS-RECORD, (182) 56, MAY 22, 1969. SIMARD BEAUDRY INC. WAS APPARENT LOW BIDDER WITH $26.6 BID FOR THE CONSTRUCTION OF A COMBINATION HIGHWAY-RAILWAY TUNNEL UNDER A SECTION OF THE WELLAND CANAL AT WELLAND ONT.

05-69-05003 BIG DIXIE TUBE (MOBILE-RIVER SUNKEN-TUBE)
ENGR. NEWS-RECORD, (182) 7, MAY 29, 1969. ALABAMA HAS CALLED FOR BIDS JULY 29 FOR THE 3000 FT FOUR LANE SUNKEN-TUBE TUNNEL UNDER THE MOBILE RIVER WHICH IS ESTIMATED AT $34 MILLION TO $38 MILLION.

05-69-05004 BART'S GIANT CAISSON (TRANS-BAY-TUNNEL)
WESTERN CONSTRUCTION, 57-69, MAY 1968. THE VENTILATION STRUCTURE FOR THE SAN FRANCISCO END OF BART'S TRANSBAY TUBE IS A 122 FT LONG 68 FT WIDE AND 108 1/2 FT HIGH CAISSON. METHOD OF CONSTRUCTION AND INSTALLATION ARE GIVEN.

05-69-05005 NEW MEDICAL CENTER FOR SAND HOGS (COMPRESSED-AIR BARTD-SUBWAY)
WESTERN CONSTRUCTION, 64-69, MAY 1968. THREE SPECIALLY DESIGNED DOUBLE MEDICAL LOCKS AND SUPPORT SYSTEM AND AN AROUND-THE-CLOCK MEDICAL STAFF OF THE NEW COMPRESSED AIR MEDICAL FACILITY IN SAN FRANCISCO BACK-UP SAND HOGS ON ALL BART SUBWAY TUNNELS BEING DRIVEN UNDER COMPRESSED AIR.

05-69-05006 STATE OFFERS TWO TUNNELS FOR ONE (VIRGINIA HIGHWAY HAMPTON-ROADS)
ENGR. NEWS-RECORD, (182) 15, MAY 8, 1969. THE VIRGINIA HIGHWAY DEPT OFFERS AN ALTERNATE PLAN FOR THE INTERSTATE I-64 LINK AT NORFOLK AND HAMPTON ROADS. THE STATE WOULD PAY TOTAL COST FOR THE 11.3 MILE LAND CONNECTION IF THE INTERSTATE SYSTEM WOULD BUILD THE TWO TUNNELS.

05-69-05007 WHICH DESIGN FOR RECORD ROAD TUNNEL UNDER SWITZERLAND'S ST. GOTTHARD PASS? (HIGHWAY)
ENGR. NEWS-RECORD, (182) 30-33, MAY 8, 1969. TWO ENGINEERING CONSULTING FIRMS HAVE PROPOSED ALTERNATE DESIGNS FOR THE WORLDS LONGEST HIGHWAY TUNNEL TO BE BUILT UNDER THE ST. GOTTHARD PASS. THE SWISS GOVERNMENT MUST DECIDE SOON BETWEEN THE MOTOR COLUMBUS PROPOSAL FOR TWO VENTILATING SHAFTS PLUS A VENTILATING TUNNEL PARALLEL TO THE HIGHWAY, AND THE ELECTRO-WATT PROPOSAL TO USE FOUR VENTILATING SHAFTS, WHICH HAS BEEN BID AT $38 MILLION, $4 MILLION LESS THAN MOTOR-COLUMBUS

05-69-05008 GUATERNALA DIGS 'INSTANT HEAD' (HYDRO-ELECTRIC)
ENGR. NEWS-RECORD, (182) 76-77, MAY 22, 1969. A TRANSMOUNTAIN RIVER DIVERSION IN GUATAMALA USING A TUNNEL WHICH IS AS MUCH AS 459 FT BELOW THE CREST OF INTERVENING HILLS IS CREATING 2343 FT OF USABLE HEAD. THIS ADDS 60,000 K.W. TO THE NATIONAL ELECTRIFICATION SYSTEM AND USES 100% OF THE FLOW OF THE RIO MICHATOYA.

05-69-06001 SWISS TUNNEL AWARDS (ST.-GOTTHARD HIGHWAY)
ENGR. NEWS-RECORD, (183) 67, JUNE 19, 1969. THE SWISS GOVERNMENT APPROVED TUNNEL CONSTRUCTION CONTRACTS TOTALING $39.8 MILLION FOR THE 10 1/8 MILE ST. GOTTHARD HIGHWAY TUNNEL. THE TUNNEL WILL HAVE FOUR SHAFTS FOR VENTILATION.

05-69-07001 CHUNNEL STILL CHUGGING (ENGLISH-CHANNEL)
ENGR. NEWS-RECORD, (183) 7, JULY 3, 1969. THE BRITISH MINISTRY OF TRANSPORT SAID THAT WORK ON A CHANNEL TUNNEL COULD START AS SCHEDULED IN 1971 AND FINISH BY 1976.

05-69-07002 HONG KONG TUNNEL (SUNKEN-TUBE)
ENGR. NEWS-RECORD, (183) 7, JULY 3, 1969. A CONSORTIUM INCLUDING RAYMOND INTERNATIONAL SIGNED A $45 MILLION CONTRACT TO BUILD A ONE MILE TUNNEL BETWEEN HONG KONG ISLAND AND KOWLOON. WORK BEGINS ON THE FOUR-LANE DUAL SUNKEN TUBE CROSSING IN SEPTEMBER.

05-69-07003 A SUBWAY FOR FLANDERS (BELGIUM)
ENGR NEWS-RECORD, (183) 13, JULY 10, 1969. ANTWERP WILL START A $20 MILLION RAIL TRANSIT SYSTEM THIS FALL. A THREE LEVEL STATION WILL COORDINATE SUBWAY AND VEHICULAR TUNNEL. WORK WILL START ON TWO OTHER STATIONS AND 3/4 MILE OF SUBWAY NEXT YEAR.

05-69-07004 TWIN BORE HIGHWAY TUNNEL WILL LINK TWO VIRGINIAS
ENGR. NEWS-RECORD, (183) 28, JULY 10, 1969. A $23.7 CONTRACT WAS AWARDED TO THE JOINT VENTURE OF GORDON H. BALL INC. AND S. A. HEALY CO. TO BUILD THE 5661 FT LONG TWIN TUBES ON I-77 UNDER EAST RIVER MOUNTAIN TO CONNECT BLAND CO, VA WITH MERCER CO. W.VA. COMPLETION IS SCHEDULED FOR JULY 1973.

05-69-07005 ROCKY TUNNEL IS WORLD'S HIGHEST (HIGHWAY COLORADO STRAIGHT-CREEK SHIELD)
ENGR. NEWS-RECORD, (183) 39-41, JULY 10, 1969. THE 8148 FT TUNNEL, THE FIRST BORE OF A PAIR OF TUNNELS WHICH WILL CARRY I-70 THROUGH THE CONTINENTAL DIVIDE AT AN ELEVATION OF 11000 FT WILL BE THE LONGEST HIGHWAY TUNNEL IN NORTH AMERICA AND THE HIGHEST ONE IN THE WORLD. A FOUR COMPANY VENTURE-STRAIGHT-CREEK CONTRACTORS - CONSISTING OF AL JOHNSON CONSTR CO, GIBBONS & REED CO, KEMPER CONSTR CO AND WESTERN PAVING CO, BEGAN DRIVING THE WEST PORTAL IN MARCH 1968. COMPLETION IS SCHEDULED FOR DEC 1970. A SPECIAL 25 FT LONG 450 TON SHIELD WAS ASSEMBLED IN THE MIDDLE OF THE MOUNTAIN TO BE USED IN A 1000 FT STRETCH OF BADLY FAULTED ROCK.

05-69-07006 LOW BID CALLED BACK (WELLAND-CANAL RAIL-ROAD-TUNNEL)
ENGR. NEWS-RECORD, (183) 17, 1969. THE LOW BIDDER ON THE WELLAND CANAL ROAD-RAIL TUNNEL ASKED AND RECEIVED PERMISSION TO WITHDRAW THEIR LOW BID BECAUSE OF A SERIOUS ERROR IN CALCULATION. THE SEAWAY AUTHORITY WILL REBID ON AN ENLARGED SCOPE JOB.

05-69-07007 UTILITY TRENCH AT SEA-TAC AIRPORT (SEATTLE)
WESTERN CONSTRUCTION, (44) NO. 7, 60-62, JULY 1969. A 1500 FT UTILITY TUNNEL IS BEING BUILT AS PART OF THE EXPANSION OF THE SEATTLE TACOMA AIRPORT. EXCAVATION AND CONSTRUCTION TECHNIQUES ARE DESCRIBED.

05-69-08001 VIENNA TO DIG 24-MILE SUBWAY (AUSTRIA)
ENGR NEWS-RECORD, (183) 49, AUG 7, 1969. VIENNA WILL START A $195 MILLION SUBWAY SYSTEM THIS FALL. FOUR LINES WITH 24 MILES WILL BE BUILT. ONE LINE WILL BE SHIELD SHIELD DRIVEN, ONE WILL USE SLURRY TRENCH, ONE AN EXISTING TUNNEL.

05-69-08002 OHIO SANITARY INTERCEPTOR SEWER (TUNNELING OPEN-CUT COSTS)
ENGINEERING NEWS-RECORD, (183) N. 8, 41, 72, AUG 21, 1969. CONSTRUCTION OF 42 AND 48 IN PIPE LINES WAS 22 TO 46 PERCENT LESS BY OPEN CUT THAN BY TUNNELING. BLASTING FOR OPEN CUTS CREATES A PROBLEM BECAUSE OF ITS UNDETERMINED EFFECT ON HIGH-TENSION ELECTRICAL LINES PASSING THROUGH THE AREA.

05-69-08003 BLAST PULLS THE PLUG IN ALASKA LAKE (HYDRO-PROJECT)
ENGR NEWS-RECORD, (183) 16, AUG. 14, 1969. DRAVO CORP AND S.S. MULLEN DROVE A 12 FT UNLINED TUNNEL THROUGH 800 FT OF ROCK TO A POINT NEAR THE BOTTOM OF ALASKA'S LONG LAKE. THE FINAL 9 FT THICK PLUG WAS REMOVED BY A SINGLE BLAST. THE WATER LEVEL WILL BE LOWERED 115 FT IN 3 MONTHS. THEN THE CORP OF ENGRS WILL LET A CONTRACT TO BUILD A 112 FT HIGH CONCRETE GRAVITY DAM ON TOP OF THE NATURAL ROCK DAM. A POWER TUNNEL 8200 FT LONG WILL BE ADDED LATER.

05-69-08004 THE HONG KONG CROSS-HARBOUR TUNNEL (SUB-AQUEOUS)
ROADS AND ROAD CONSTRUCTION, (47) NO. 560, 246-50, AUG. 1969. A SUBMERGED TWIN TUBE TUNNEL 6085 FT LONG WILL BE BUILT UNDER HONG KONG HARBOR. THE TUBES WILL BE 34 FT IN DIAMETER AND PROVIDE 22 FT OF ROADWAY - PROVIDING TWO LANES OF TRAFFIC IN EACH DIRECTION.

05-69-09001 ROCKFALLS IN SNOWY MOUNTAIN TUNNEL (AUSTRALIA)
ENGR. NEWS-RECORD, (183) 9, SEPT. 4, 1969. ROCKFALLS IN THE 148 MILE SNOWY-EUCUMBENE TUNNEL HAVE RESTRICTED FLOWS BY 20%.

05-69-09002 NORTHFIELD MOUNTAIN GOES UNDERGROUND TO SHAPE UP
ENGR NEWS-RECORD (183), 34-42, SEPT. 4, 1969. THE $85 MILLION NORTHFIELD MOUNTAIN 1 MILLION KW PUMPED STORAGE INSTALLATION HAS A UNIQUE DESIGN. IT HAS AN UNDERGROUND POWERHOUSE AND SURGE SHAFT COMPLEX. INVESTMENT WILL BE $85 PER KW.

05-69-09003 TUNNEL BIDS HAVE A $40-MILLION SPREAD (NYC TRANSIT TRENCH-TUNNEL)
ENGR NEWS-RECORD, (183) 90, SEPT. 18, 1969. A JOINT VENTURE OF PETER KIEWIT SON'S CO MORRISON-KNUDSON CO AND SLATTERY ASSOCIATES INC IS APPARENT LOW BIDDER ON THE FOUR TRACK 3140 FT TRANSIT TUNNEL AT 69TH ST UNDER NEW YORK CITY'S EAST RIVER. THE LOW BID WAS $69.5 MILLION, $10 MILLION LESS THAN THE SECOND LOW BID. PRECAST TUBES 38 SQ FT IN SECTION WILL BE SUNK IN TRENCHES.

05-69-09004 PYRENEES TUNNELERS DRIVE HOME (SPAIN FRANCE)
ENGR NEWS-RECORD, (183) 92, SEPT. 18, 1969. FRENCH AND SPANISH WORKERS HAVE ALMOST COMPLETED THE 9900 FT LONG TUNNEL IN THE PYRENESE MOUNTAINS BETWEEN FRANCE AND SPAIN. OPENING DATE IS EXPECTED TO BE IN SPRING 1971.

05-69-09005 ARGENTINA EXPANDS HYDRO PROJECT
ENGR NEWS-RECORD, (183) 93, SEPT. 18, 1969. ARGENTINA MOVED INTO THE SECOND PHASE OF ITS 1.6 MILLION KW CHOCON-CERROS COLORADOS HYDRO COMPLEX WITH THE OPENING OF BIDS ON THE PORTEZUELO GRANDE PROJECT.

05-69-09006 THE COMING REVOLUTION IN TRANSPORTATION (FLAME WATER-JET CHEMICALS LASER GAS-GUN MOLE)
APPEL, F. C.
NATIONAL GEOGRAPHIC, (136) N 3, 301-341, SEPT 1969. THE TRANSPORTATION REVOLUTION IS ON ITS WAY. SOCIETY CAN NO LONGER TOLERATE TRAFFIC AS IT IS: ITS HIGH DEATH TOLL, ITS CONTRIBUTION TO AIR POLLUTION, ITS NOISE, ITS FRUSTRATIONS. TECHNOLOGY HAS PRODUCED AND WILL IMPROVE MORE VERSATILE HYDRAFOILS, AIR CUSHION BOATS AND TRAINS, COMPRESSED AIR TUBE TRAINS, AUTOMATED CARS, V/STOL AIRCRAFT, SUPERSONIC TRANSPORTS, JUMBO JETS AND LINEAR INDUCTION AND CAPSULE TRANSPORT. HOWEVER, THESE INNOVATIONS WILL HAVE TO BE SUPERIMPOSED ON AN ALREADY EXISTING SYSTEM. ALL THESE NEW SYSTEMS ARE DISCUSSED. STOCKHOLM IS TAKEN AS AN EXAMPLE OF THE FUTURE CITY. HERE THE GROUND LEVEL IS ALREADY A FOUNTAIN DOTTED PLAZA AS ALL TRAFFIC IS BENEATH IT IN TUNNELS. COST IS ALL THAT PREVENTS CITY TRAFFIC FROM GOING UNDERGROUND NOW. THE NEW TUNNELING METHODS: JETS OF FLAME, HYPERVELOCITY JETS OF WATER, CHEMICALS, LASER BEAMS, PLASTIC ENCASED WATER PELLETS FIRED FROM POWERFUL GAS GUNS AND IMPROVED MOLES, ARE REDUCING THIS TUNNELING COST WHILE LAND COSTS CLIMB. WHEN CARS ARE AUTOMATED AND HIGHWAYS ARE COMPUTER CONTROLLED THE RECKLESS DRIVER AND TRAFFIC JAMS WILL BE ELIMINATED. THE NEW SYSTEMS WILL BE EFFICIENT, ECONOMICAL AND SAFE WAYS TO TRAVEL.

05-69-10001 DALLAS PLAN SEPARATES TRAFFIC, PEOPLE (TRUCK-TUNNEL PEDESTRIAN TUNNELS)
ENGR NEWS-RECORD, (183) 21, OCT. 2, 1969. MONTREAL CONSULTANTS PONTE-TRAVERS ASSOCIATES HAVE COMPLETE AN 18 MONTH $178,000 STUDY FOR DALLAS CENTRAL BUSINESS DISTRICT. IT RECOMMENDS A CONTINUOUS NETWORK OF PEDESTRIAN TUNNELS, A CONSOLIDATION OF SOME OF THE DOWNTOWN BLOCKS, A MAIN STREET TRUCK TUNNEL, AND A REGIONAL RAPID TRANSIT PLAN.

05-69-10002 THIRST QUENCHER (WATER-TUNNEL NYC)
ENGR NEWS-RECORD, (183) OCT. 23, 1969. NEW YORK CITY LAUNCHED A 20 YEAR $1 BILLION WATER SUPPLY TUNNEL PROJECT BY INVITING BIDS ON THE $360,000 FIRST STAGE - A 20 FT TO 27 FT TUNNEL 15 MILES LONG FROM YONKERS INTO MANHATTAN AND EAST INTO QUEENS.

05-69-10003 FEDERAL HELP HINTED FOR RAPID EXCAVATION RESEARCH
ENGR NEWS-RECORD, (183) 24-25, OCT. 23, 1969. HINTS OF FEDERAL SUBSIDY FOR DEVELOPMENT OF RAPID EXCAVATION TECHNIQUES WERE NOTICEABLE AT THE SECOND SYMPOSIUM ON RAPID EXCAVATION HELD AT SACREMENTO STATE COLLEGE. ACCOUNTS OF RECENT CONSTRUCTION PROJECTS INCLUDED THE WHITE PINE COPPER CO DEVELOPMENT EFFORTS, HECLA MINING CO'S SPRAY-ON CONCRETE.

05-69-11001 EQUIPMENT MAINTENANCE (MACHINES MATERIALS LABOR-RATES)
PEREZ, H. T.
CONSTRUCTION METHODS AND EQUIPMENT, (51) NO. 11, 49, NOV 1969. BECAUSE OF HIGH LABOR RATES AND EXPENSIVE MACHINERY PROPER MAINTENANCE CAN MAKE THE DIFFERENCE BETWEEN PROFIT AND LOSS. CONSTRUCTION IS A BUSINESS OF MEN, MACHINES, MATERIALS, MONEY, METHODS, MANAGEMENT AND MAINTENANCE.

05-69-11002 MAINTAIN DRILL STRINGS (BITS HANDLING-COSTS RECOMMENDED-PRACTICE)
PEREZ, H. T.
CONSTRUCTION METHODS & EQUIPMENT, (51) N. 11, 50-54, NOV 1969. ROCK BITS AND DRILL RODS LOOK RUGGED BUT THEY STILL REQUIRE CARE. HANDLE THEM LIKE THE HIGH-GRADE TOOLS THEY ARE. DON'T LET STEEL LIE IN UNDERGROUND WATER. SUCCESSFUL MAINTENANCE OF ROCK BITS AND DRILL STEEL ISN'T COMPLICATED OR DIFFICULT. IT DOES REQUIRE A NUMBER OF STEPS WHICH MUST BE CARRIED OUT ROUTINELY. SLACKEN OFF AND THE PENALTIES ARE SEVERE. FOLLOW RECOMMENDED PRACTICES AND YOU BUILD A STRONG SHIELD AGAINST LOW DRILLING PRODUCTION AND HIGH COSTS.

05-69-12001 TUNNELED TRACK (JAPAN RAILWAY)
ENGR NEWS-RECORD, (183) 9, DEC. 4, 1969. JAPAN NATIONAL RAILWAY WILL CONSTRUCT A 238 MILE HIGH-SPEED EXPRESS RAIL LINE BETWEEN OKAYAMA AND HAKATA THAT WILL INCLUDE MORE THAN 100 MILES OF TUNNEL AND AN 11 MILE BORE UNDER THE KANMON STRAIT. THE $1.3 BILLION LINE IS SCHEDULED FOR COMPLETION IN 1975.

05-69-12002 SEAWAY WEIGHS TUNNEL LOW BID (WELLAND ROAD-RAIL)
ENGR NEWS-RECORD, (183) 21, DEC. 4, 1969. A JOINT VENTURE OF C. A. PITTS CONSTR CO OF TORONTO AND DON MILLS OF ONTARIO IS APPARENT LOW BIDDER FOR THE COMBINATION HIGHWAY - RAILROAD TUNNEL UNDER THE RELOCATED SECTION OF WELLAND CANAL. THEIR BID OF $31.8 WAS ONLY $200,000 LESS THAN THE PREVIOUS LOW BIDDER SIMARD BEAUDRY.

05-69-12003 D.C. SUBWAY STARTS AFTER 20 YEARS
ENGR NEWS-RECORD, (183) 24, DEC. 11, 1969. THE WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY WILL CONDUCT A GROUND BREAKING CEREMONY AT THE SITE OF ONE OF THE STATIONS OF WASHINGTON D.C.'S METRO SYSTEM. TWO CONTRACTS HAVE BEEN LET FOR SECTIONS OF THE SUBWAY. THE FIRST 6 MILES IS EXPECTED TO OPEN THREE YEARS AFTER START OF CONSTRUCTION.

05-69-12004 PUMPED STORAGE HAS NO PUMPS (CALIFORNIA)
ENGR NEWS-RECORD, (183) 60, DEC. 18, 1969. A 4300 FT LONG 14 FT TUNNEL AND BRUSH CREEK DAM IS BEING BUILT BY DRAVO CORP UNDER A $15.9 MILLION CONTRACT. THE TUNNEL IS DESIGNED TO CARRY WATER IN EITHER DIRECTION. THIS WILL DOUBLE THE CAPACITY OF SACRAMENTO MUNICIPAL UTILITY DISTRICT'S CAMINO HYDRO STATION.

05-69-12005 TUNNEL ROOF COLLAPSE BLOCKS ROCKIES TRAFFIC (ROOF-BOLTS)
ENGR NEWS-RECORD, (183) 65, DEC. 18, 1969. MOISTURE COLLECTING UNDER THE ROOF SEALANT OF A HIGHWAY TUNNEL ON U.S. HIGHWAY 6, 12 MILES FROM DENVER, CAUSED A ROCK FALL WHICH REQUIRED CLOSING THE TUNNEL FOR SEVERAL WEEK WHILE REPAIR CREWS INSTALLED ROOF BOLTS TO PREVENT FURTHER FALLS.

05-70-01001 RIVERSIDE ROAD TUNNEL PROPOSED FOR SITE NEXT TO PALACE OF WESTMINSTER
TUNNELS AND TUNNELING, (2) NO 1, 11, JAN. 1970. THE MINISTRY OF PUBLIC BUILDINGS AND WORKS, GREATER LONDON PLANS TO REDEVELOP THE WHITEHALL AREA WITH A RIVERSIDE ROAD TUNNEL FROM NORTH OF HUNGERFORD BRIDGE TO SOUTH OF LAMBETH BRIDGE. THE SIX LANE ROAD TUNNEL WOULD COST 16 MILLION POUNDS.

05-70-01002 EDINBURGH CITY MOTORWAY INCLUDES TWIN TUNNELS
TUNNELS AND TUNNELING, (2) NO 1, 11, JAN. 1970. DESIGN HAS STARTED ON A 10 MILLION POUND PROJECT TO PROVIDE NEW DUAL THREE LANE URBAN MOTORWAY THROUGH EDINBURGH. IT WILL PASS THROUGH COTTON HILL IN TWIN ROCK TUNNELS EACH 14 METERS WIDE AND 150 METERS LONG.

05-70-01003 16284 M LONG ROAD TUNNEL THROUGH MT. ST. GOTTHARD WILL BE 4 KM LONGER THAN MT. BLANC
TUNNELS AND TUNNELING, (2) NO 1, 11, JAN. 1970. CONSTRUCTION STARTS SOON ON A ROAD TUNNEL FROM GOESCHENEN TO AIROLO WHICH WILL BE ONE OF THE WORLDS LONGEST TUNNELS. THE TWO HEADINGS ARE SITUATED ABOUT 1100 M ABOVE SEA LEVEL.

05-70-01004 TUNNELS AND SUBWAYS ON THE S.F. BART SYSTEM (MOLES COST)
THON, J. G. + AMOS, M. J. & BECHTEL CORP SAN FRANCISCO
TUNNELS AND TUNNELING, (2) NO 1, 13-17, JAN. 1970. THE COMMUNITIES AROUND THE SAN FRANCISCO BAY ARE LINKED BY LONG SUSPENSION SPANS OF THE OAKLAND BAY BRIDGE. TRANSIT BETWEEN THE COMMUNITIES IS ENTIRELY BY ROAD. BART IS THE ONLY ENTIRELY NEW SYSTEM TO BE BUILT IN A U.S. CITY IN 30 YEARS. 20 MILES OF THE 75 MILE SYSTEM ARE UNDERGROUND. 4 MILES OF THIS ARE IN A SUBMERGED TUBE ACROSS THE BAY. 4 MILES ARE IN MEDIUM SOFT ROCK. 6 MILES ARE IN SOFT GROUND. 6 MILES ARE CUT-AND-COVER CONSTRUCTION. DETAILS OF THE EXCAVATION ARE GIVEN. AVERAGE COST OF SOFT GROUND TUNNELS HAS BEEN $1850/FT OF SINGLE TRACK TUNNEL. THE BERKELEY HILLS TUNNEL IN ROCK COST $940/FT AND A SHORTER TUNNEL IN ROCK COST $1300/FT. CUT AND COVER COST $680/FT.

05-70-01005 TUNNEL UNCORKS HIGHWAY BOTTLENECKS (CUT-AND-COVER MINNEAPOLIS)
ENGR. NEWS-RECORD, (184) 18-19, JAN. 29, 1970. MINNESOTA HIGHWAY DEPT IS BUILDING AN INTERCHANGE WITH A 1500 FT TUNNEL AND ANOTHER INTERCHANGE COMPLEX ON PILES TO RELIEVE THE BOTTLENECKS IN DOWNTOWN MINNEAPOLIS. A JOINT VENTURE OF OSTER PEDERSON AND FOLEY BROS. HAVE A $7.3 MILLION CONTRACT TO BUILD THE TUNNEL AND THE SUPERSTRUCTURES OVER IT.

05-70-01006 TUNNEL GOES FOR RECORD $222.6 MILLION (BLASTING MOLES COST SCHEDULE SIZE WATER)
ENGINEERING NEWS-RECORD, (184) 13-14, JAN. 15, 1970. STAGE 1 WATER DISTRIBUTION SYSTEM FOR NEW YORK CITY INCLUDES 9 MILES OF 24 FOOT DIAMETER TUNNEL, 5 MILES OF 20 FOOT DIAMETER TUNNEL AND 3 UNDERGROUND CHAMBERS FOR CONTROL VALVES AND METERS, 15 SUPPLY RISERS AND EITHER 3 OR 4 CONSTRUCTION SHAFTS FOR THE LOW BID SUM OF 222.6 MILLION DOLLARS. THE HARD ROCK, MAINLY GNEISS AND MANHATTAN SCHIST WAS PLANNED TO BE BLASTED BUT OFFICIALS ARE NOW CONSIDERING THE POSSIBLE USE OF TUNNELING MACHINES. SCHEDULED CONSTRUCTION TIME FOR THE ENTIRE PROJECT IS 60 MONTHS. PREVIOUSLY A MOLE WAS TRIED AND FINALLY PULLED OUT OF ANOTHER DEEP TUNNEL UNDER NEW YORK BAY. THE TOUGH MANHATTAN SCHIST, RIDDLED WITH PEGMATITES STOPPED A UNIT SUPPOSEDLY DESIGNED TO HANDLE SUCH HARD ROCK.

05-70-01007 PUMPED STORAGE PROJECT IS A BAD ROCK NIGHTMARE (BELGIUM)
ENGR. NEWS-RECORD, (184) 29, JAN. 1, 1970. MIST MOUNTAIN WITH THE AMBLEVE RIVER AT ITS FOOT LOOKED LIKE A PERFECT SITE FOR BELGIUM'S NEW PUMPED STORAGE PROJECT BUT BAD ROCK IS CAUSING PROBLEMS. ROCK SLIDES THREATENED WORKERS CONSTANTLY IN THE WATER TUNNEL DESPITE USE OF STEEL AND CONCRETE REINFORCING ARCHES AND AN 8 IN THICK PRELINING.

05-70-01008 CONTRACTOR LICKS TOUGH TUNNEL JOB (VIRGINIA BIG-WALKER HIGHWAY)
ENGR. NEWS-RECORD, (184) 30-31, JAN. 1, 1970. THE CONTRACTOR - C.J. LANGENFELDER & SONS - HAS HOLED THROUGH THE SECOND BORE OF THE BIG WALKER MOUNTAIN HIGHWAY TUNNEL. MUCH OF THE TIME THE TWO TUNNELS WERE DRIVEN FULL FACE AND PROGRESS WAS GOOD - SOMETIMES AS HIGH AS 60 FT IN A 20 HR DAY. BAD ROCK SHOWED UP IN THE EAST BORE ON DEC. 23, 1968. AFTER 5 MONTHS DELAY THE WORK WAS STARTED AGAIN IN THE EAST BORE WITH CAREFUL FULL FACE OPERATIONS AND DOUBLING THE

AMOUNT OF STEEL SETS AND PUMPING GROUT TO FILL THE VOIDS. GOOD ROCK WAS FOUND SOON AND THE EAST BORE WAS COMPLETED QUICKLY. THE WEST BORE WAS MUCH WORSE. WHEN THE EAST JUJBO FINISHED IT STARTED BACK ON THE WEST BORE FROM THE NORTH END AS FAR AS THE GOOD ROCK WOULD ALLOW. THE 200 FT OF BAD ROCK WAS TUNNELED BY TOP HEADING, FOREPOLING ALL THE WAY. THE HIGHWAY DEPT HOPES TO HAVE TRAFFIC THROUGH BIG WALKER BY THE END OF THE YEAR.

05-70-01009 TUNNEL GOES FOR RECORD $222.6 MILLION (NYC WATER-SUPPLY)
ENGR NEWS-RECORD, (184) 13, JAN. 15, 1970. NEW YORK CITY'S BOARD OF WATER SUPPLY AWARDED THREE CONTRACTS FOR A SINGLE PROJECT TOTALING $222.6 MILLION TO A JOINT VENTURE OF WALSH CONSTRUCTION CO, DRAVO CORP, S. J. GROVES & SONS, ARUNDEL CORP, L. E. DIXON CO AND OSTRANDER CONSTR. THE 5 YEAR CONTRACT INVOLVES 9 MILES OF 24 FT DIA TUNNEL, 5 MILES OF 20 FT DIA TUNNEL ALL CONCRETE LINED, THREE UNDERGROUND CHAMBERS FOR CONTROL VALVES AND METERS, 15 SUPPLY RISERS, AND THREE CONSTRUCTION SHAFTS.

05-70-01010 SEAWAY TUNNEL START (WELLAND-CANAL ROAD-RAIL)
ENGR NEWS-RECORD, (184) 3, JAN. 29, 1970. THE ST LAWRENCE SEAWAY AUTHORITY AWARDED A $31.8 CONTRACT FOR THE CONSTRUCTION OF A THREE TUBE ROAD-RAIL TUNNEL UNDER THE RELOCATED WELLAND CANAL TO A CANADIAN JOINT-VENTURE OF C. A. PITTS CONSTR EASTERN AND MCNAMARA CONSTRUCTION WESTERN.

05-70-01011 LONGEST S. AFRICA ROAD TUNNEL (BLASTING)
TUNNELS AND TUNNELING, (2) NO 1, 35, JAN. 1970. THE 1880 FT DANVILLE-CLAREMONT ROAD TUNNEL IS THE LONGEST IN SOUTH AFRICA. WORK STARTED IN MARCH 1969 BY BASIL READ & GMF (EDMS) BPK. MULTIPLE BLASTS WERE PERMITTED AFTER SPECIAL TEST WERE MADE.

05-70-02001 BYPASS RUSHED AFTER ROCKFALLS PLUG TUNNEL (TURKEY DIVERSION-TUNNEL)
ENGR. NEWS RECORD, (184) 13, FEB. 12, 1970. TURKISH TUNNELERS ARE DRIVING A $1.5 MILLION BYPASS TUNNEL AT THE GOKCEKAYA DAM SITE BECAUSE REPEATED ROCKFALLS FINALLY PLUGGED THE 30 FT DIA DIVERSION TUNNEL.

05-70-02002 PARIS PREPARES TO START TICKLISH SUBWAY LINE
ENGR. NEWS-RECORD, (184) 14, FEB. 26, 1970. CONSTRUCTION OF THE CENTRAL 3-MILE SEGMENT OF THE WESTERN BRANCH OF PARIS REGIONAL RAIL TRANSIT EXPRESS LINE WILL START NEXT YEAR. IT POSES SOME EXTREMELY DIFFICULT ENGINEERING PROBLEMS. PART OF IT WILL PASS BENEATH PARIS OLD CITY HALL WHOSE FOUNDATION EXTENDS 66 FT BELOW GROUND.

05-70-02003 SNOWY TUNNEL RUBBLE TROUBLE ALMOST CLEARED. (AUSTRALIA)
ENGR. NEWS-RECORD, (184) 15, FEB 26, 1970. THE 13 MILE LAKE EUCUMBENE SNOWY TUNNEL IN AUSTRALIAS SNOWY MOUNTAIN BY DROELECTRIC SCHEME WILL BE BACK IN SERVICE IN EARLY APRIL. REPAIRS WERE DELAYED BY THE NEED TO USE THE TUNNELS TO CARRY SOME OF THE SPRING RUNOFF.

05-70-03001 IMAGINING THINGS (OECD-TUNNELING-CONFERENCE)
TUNNELS AND TUNNELING, (2) NO 2, 65, MAR. 1970. AN EDITORIAL DISCUSSION OF THE RELATION BETWEEN THE GOALS OF THE OECD TUNNELING CONFERENCE SCHEDULED FOR JUNE 22-26, 1970 IN WASHINGTON D.C. AND THE NEEDS FOR ALTERNATE PLANS FOR URBAN AREAS TO REPLACE THE PRESENT SURFACE HIGHWAY SYSTEM IN EXISTANCE AND PLANNED.

05-70-03002 OECD ADVISORY CONFERENCE ON TUNNELING (URBAN-PLANNING)
ORSKI, C. K. & SCIENTIFIC DIRECTORATE OECD
TUNNELS AND TUNNELING, (2) NO 2, 69-72, MAR. 1970. THE ADVISORY CONFERENCE ON TUNNELING ORGANIZED BY THE ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT WILL BE HELD IN WASHINGTON D.C. DURING THE WEEK JUNE 22-26 1970. THE PRIMARY OBJECTIVE IS POLICY GUIDANCE TO GOVERNMENTS PARTICULARLY IN THE RELATIONSHIP BETWEEN IMPROVING TUNNELING TECHNOLOGY AND LONG RANGE PLANNING FOR THE WORLDS URBAN AREAS.

05-70-03003 THIRD MERSEY TUNNEL STARTED (ENGLAND)
TUNNELS AND TUNNELING, (2) NO 2, 85, MAR. 1970. A THIRD ROAD TUNNEL UNDER THE MERSEY RIVER FROM LIVERPOOL TO WALLASEY HAS JUST STARTED. CONSULTING ENGRS ARE MOTT, HAY & ANDERSON OF LONDON. A 2202 YD PILOT TUNNEL 11 FT IN DIA WILL BE A MACHINE DRIVEN BORE, FOLLOWED BY A SECOND MACHINE WHICH WILL ENLARGE TO 31 FT 7 IN ID. A 3 YR 5.17 MILLION POUND CONTRACT WAS PLACED WITH EDMUND NUTTALL SONS & CO AND GUY F. ATKINSON CO WHO ARE NOW WORKING ON MERSEY NO 2.

05-70-03004 PERU CARVES A RESERVOIR IN MOUNTAIN ((RAIL-TUNNEL)

05-70-03004 SEVEN RESCUED IN NEW ZEALAND TUNNEL COLLAPSE.

05-70-05002 AUTO TUNNEL SKIMS TOPS OFF SUBWAYS (PARIS
ENGR. NEWS-RECORD, (184) 36-37, MAY 7, 1970. CONTRACTORS ARE FINISHING A TRICKY TUNNEL PROJECT TO RELIEVE TRAFFIC ON A CIRCLE THAT HANDLES 200,000 VEHICLES PER DAY. THE 1/4 MILE UNDERPASS SNUGGLES THROUGH A MAZE OF SUBWAY TUNNELS, UTILITY LINES AND PEDESTRIAN WALKWAYS UNDER PLACE DE L' ETOILE. TO CUT THROUGH THE SUBWAY ARCHES WITHOUT DISTURBING TRAFFIC CREWS HAD TO WORK BETWEEN 1 AND 5 A.M.

05-70-05003 SHIFTING ROCK SQUEEZES COLORADO ROAD TUNNEL (STRAIGHT-CREEK SUPPORTS)
ENGR. NEWS-RECORD, (184) 11, MAY 14, 1970. ROCK SHIFTS IN THE STRAIGHT CREEK TUNNEL REQUIRE ABOUT $5 MILLION OF CORRECTIVE WORK TO STRENGTHEN THE SUPPORT SYSTEM. THREE OF THE SHIFTS WERE MINOR MOVEMENTS OF A FEW INCHES OUT ONE MAJOR ONE INVOLVES MOVEMENTS OF 1.4 FT ON EACH SIDE OF THE TUNNEL. ON THE MINOR SHIFTS, REPAIR CONSISTS OF INSTALLING ROCK BOLTS. THE MAJOR SHIFT IS 50 FT LONG AND REQUIRES REPLACEMENT OF THE LINER. ON THE EAST END THE TOP HEADING HAD ADVANCED 2100 FT WHEN ROCK MOVEMENT CAUSED THE CROWN AREA TO BUCKLE AND PUNCH THROUGH THE WALL PLATES. NEARLY 1000 FT MUST BE REEXCAVATED TO REPLACE THE STEEL SUPPORT SYSTEM. THE TUNNEL WORK IS A YEAR BEHIND SCHEDULE.

05-70-05004 GUATEMALA WILL TAP HIGH MOUNTAIN LAKE FOR POWER
ENGR. NEWS RECORD, (184) 45, MAY 21, 1970. GUATEMALA WILL DEVELOP A MAJOR HYDROELECTRIC PROJECT BASED ON A DEEP VOLCANIC LAKE NEAR GUATEMALA CITY. LAKE ATITLAN AT EL. 5123 FT HAS A SURFACE 80 SQ. MILES WITH A DEPTH OF 1312 FT BUT HAS NO OUTFLOW EXCEPT SEEPAGE TO RIVERS AT LOWER ELEVATIONS. PLANS CALL FOR TUNNELS AND TWO POWERPLANTS TAPPING THE LAKE DIRECTLY. LATER FOUR RIVERS WILL BE DIVERTED THROUGH TUNNELS TO AUGMENT THE FLOW. COST OF THE PROJECT $90 MILLION.

05-70-05005 LONGER THAN LONGEST (JAPAN RAILWAY SEIKAN-TUNNEL)
ENGR. NEWS-RECORD, (184) 3, MAY 28, 1970. THE JAPAN RAILWAY CONSTRUCTION PUBLIC CORPORATION HAS REDESIGNED THE 23 MILE SEIKAN TUNNEL UNDER THE TSAGARU STRAIT AS A 32.5 MILE BORE AND SUBMITTED THE $555 MILLION PROPOSAL TO THE MINISTER OF CONSTRUCTION.

05-70-05006 CHURCHILL FALLS HYDROELECTRIC PROJECT (LABRADOR)
TUNNELS AND TUNNELING, (2) NO 3, 152-155, MAY 1970. WHEN COMPLETED THE CHURCHILL FALLS HYDROELECTRIC PROJECT IN LABORADOR WILL BE THE LARGEST OF ITS TYPE IN THE WESTERN WORLD. THE POWERHOUSE IS 1000 FT BELOW GROUND. THE POWERHOUSE WITH ANCILLARY TUNNELS REQUIRED MOVING 2 1/2 MILLION CU YDS OF ROCK. DATA ON THE ENTIRE PROJECT INCLUDED.

05-70-05007 TUNNEL FOR THAMESMEAD (ENGLAND)
TUNNELS AND TUNNELING, (2) NO 3, 155, MAY 1970. PLANS FOR A 29 MILLION POUND TUNNEL UNDER THE THAMES BETWEEN BARKING AND THAMESMEAD WILL BE 811 YARD LONG WITH APPROACH ROADS. IT WILL BE IN 4 SECTIONS EACH CARRYING A DUAL CARRIAGEWAY.

05-70-04001 TUNNEL UTILITIES WITH SUBWAYS
ENGR. NEWS-RECORD, (184) 3, APR. 2, 1970. SECRETARY OF INTERIOR HICKEL SUGGESTED THAT THE WASH. D C METRO SYSTEM PROVIDE FOR INSTALLATION OF UTILITY LINES DURING CONSTRUCTION OF RAIL TUNNELS. THE COST COULD BE RECOVERED BY LEASING THE SPACE TO USERS.

05-70-04002 MINERS DRAIN MOUNTAIN FOR RAIL TUNNEL (JAPAN NATIONAL RAILWAY)
ENGR. NEWS-RECORD, (184) 22, APR. 2, 1970. JAPAN NATIONAL RAILWAY'S ENGINEERS HAD THE CONTRACTORS FOR THE NEW SAN-YO LINE DEVELOP 3/4 MILE OF BRANCH TUNNELS AND DRILL 5 MILES OF 5 IN HOLES TO DRAIN WATER FROM THE BADLY FAULTED GRANITE TO ADVANCE ONE OF THE 11 HEADINGS ONLY 1/4 MILE.

05-70-04003 UP, UP AND AWAY (PHILADELPHIA SUBWAY)
ENGR. NEWS-RECORD, (184) 3, APR. 16, 1970. PHILADELPHIA REJECTED ALL THREE BIDS FOR THE 2 MILE SECTION OF NORTHEAST EXTENSION TO THE CITY'S MAIN NORTH-SOUTH SUBWAY LINE WHEN THE LOWEST WAS 68% ABOVE ENGINEERS ESTIMATE.

05-70-04004 BIDS CALLED ON HAMPTON ROADS TWIN CROSSING (VIRGINIA SUNKEN-TUBE)
ENGR. NEWS-RECORD, (184) 14, APR 16, 1970. VIRGINIA WILL CALL FOR BIDS ON THE FIRST MAJOR CONTRACT FOR THE SECOND TUBE OF THE 3 1/2 MILE HAMPTON ROADS BRIDGE-TUNNEL WHICH WILL DOUBLE THE TWO LANE CROSSING BETWEEN NORFOLK AND HAMPTON. THE JOB INCLUDES 7270 FT OF SUNKEN TUBE TUNNEL. BIDS ARE DUE IN JUNE AND THE CONTRACT SHOULD BE AWARDED BY MID JULY.

05-70-05001 TUNNEL TO BE SUNK IN BALTIMORE OUTER HARBOR
ENGR. NEWS-RECORD, (184) 32, MAY 7, 1970. MARYLAND HIGHWAY DEPT WILL ADVERTISE FOR BIDS ON THE MAIN CONTRACT FOR THE 6200 FT BALTIMORE HARBOR OUTER TUNNEL WHICH WILL BE PREFABRICATED IN 300 FT LONG STEEL LINED CONCRETE SECTIONS AND SUNK INTO A DREDGED TRENCH ON THE HARBOR FLOOR. THE JOB WILL COST ABOUT $81 MILLION.

05-70-06002 AMSTERDAM SUBWAY LINE
ENGR. NEWS-RECORD, (184) 3, JUNE 4, 1970. THE CITY OF AMSTERDAM WILL STAND CONSTRUCTION ON THE FIRST 12 MILE RAIL TRANSIT LINE IN ITS PLANNED 55 MILE NETWORK. THE $113 MILLION LINE IS EXPECTED TO BE COMPLETE IN 1976.

05-70-06003 IN SHIFTING GROUND (JAPAN SEIKAN RAIL-TUNNEL)
ENGR. NEWS-RECORD, (184) 3, JUNE 25, 1970. A PROFESSOR AT OSAKA UNIV WARNS THAT THE SEIKAN RAIL-TUNNEL UNDER TSUGARU STRAIT IS POTENTIALLY DANGEROUS DO TO EARTH SHIFTS. TUNNEL SURVEYORS SAY THE SHIFT IS MINUTE AND THE ENGINEERING PLANS HAVE PROVIDED TOLERANCES.

05-70-07001 CAVE-IN ADDS TO TUNNEL'S HEADACHES (NYC INTERCEPTOR-SEWER)
ENGR. NEWS-RECORD, (185) 3, JULY 2, 1970. A SECTION OF TUNNEL ON NYC NORTH RIVER POLLUTION CONTROL PROJECT CAVED IN LAST WEEK, MAKING A 20X30 HOLE AT THE SURFACE. NO ONE WAS INJURED.

05-70-07002 TUNNELING EXPERTS MEET TO ASSESS TECHNOLOGY (OECD URBAN-NEEDS)
ENGR. NEWS-RECORD, (185) 14-15, JULY 2, 1970. THE 1ST INTERNATIONAL ADVISORY CONFERENCE WAS HELD IN WASH D.C. LAST WEEK. SEE ALSO 05-70-06001 EMPHASIS WAS ON NEEDS TO REDUCE DIRECT AND INDIRECT (IE SOCIAL) COSTS IN ORDER TO GAIN SOCIAL BENEFITS IN URBAN AREAS OF THE WORLD.

05-70-07003 RIVER PUT ASIDE TO BUILD SUBWAY STATIONS (CANADA LINERS MOLE)
ENGR. NEWS-RECORD, (185) 26-27, JULY 25, 1970. A CANADIAN CONTRACTOR - H.J. O'CONNELL OF MONTREAL - HAD TO TURN BACK A RIVER TO CONSTRUCT THE SUBWAY SECTION THAT PASSES UNDER THE WEST BRANCH OF THE DON RIVER IN NORTH TOTONTO. THE STATION IS PART OF THE 5 MILE EXTENSION TO TORONTO'S SUBWAY. MOST OF THE EXTENSION IS BORED TWIN TUNNELS LINED WITH PRECAST CONCRETE SEGMENTS. WHERE THE TUNNELS ARE BELOW THE WATER TABLE CAST IRON SEGMENTS ARE USED.

05-70-07004 BURY THE PROBLEM (SAN-FRANCISCO FREEWAY)
ENGR. NEWS-RECORD, (185) 3, JULY 23, 1970. THE ASSN OF BAY AREA GOVTS IS CONSIDERING A 4 MILE TUNNEL TO LINK THE BAY BRIDGE AND THE GOLDEN GATE BRIDGE. ALSO WOULD DEMOLISH THE PARTIALLY BUILT EMBARCADERO FREEWAY.

05-70-07005 SUPER CHUNNEL PACKAGE (ENGLISH-CHANNEL)
ENGR. NEWS-RECORD, (185) 3, JULY 23, 1970. THE BRITISH AND FRENCH GOVERNMENTS RECEIVED NEW PROPOSALS FOR FINANCING THE 21 MILE ENGLISH CHANNEL TUNNEL FROM AN INTERNATIONAL COMBINE WHICH INCLUDES BRITISH FRENCH AND U.S. INTERESTS. PROJECT COST EST. $625 MILLION, TAKES TWO TO THREE YEARS STUDY AND 4 TO 5 YEARS TO BUILD.

05-70-08001 THREE METHODS COMBINE IN 2-MILE HAMBURG TUNNEL (ELBE-RIVER MOLES SHIELDS)
ENGR NEWS-RECORD, (185) 28-29, AUG. 13, 1970. 11 CONTRACTORS FORMED 3 DESIGN-CONSTRUCT VENTURES AND ARE USING 3 SEPARATE METHODS OF BUILDING THE TWO-MILE CROSSING UNDER THE ELBE RIVER. THE SIX LANE TUNNEL WILL CROSS THE DEEP CHANNEL IN SUNKEN TUBE SEGMENTS, BORE THROUGH A HIGH BANK IN TUBES BORED BY 770 TON SHIELDS THEN PASS THROUGH A CUT-AND-COVER SECTION. THE TOTAL COST WAS ESTIMATED AT $104 MILLION IN 1968.

FIELD 07 LETTERS

07-67-03001 EXCAVATION AND TUNNELING (RAPID-EXCAVATION-TECHNIQUES LOW-COST)
HAMBURGER, R. & U.S. DEPT OF INT
U. S. GOVERNMENT MEMORANDUM, JULY 1967. MEMO IMPLEMENTING THE PRESIDENT'S DIRECTIVE TO THE SECRETARY OF THE INTERIOR TO INITIATE A COOPERATIVE RESEARCH PROGRAM WITH INDUSTRY TO FIND SOLUTIONS TO TECHNICAL PROBLEMS OF RAPID TUNNELING AND TO FIND WAYS TO REDUCE COSTS OF PLACING UTILITY LINES UNDERGROUND.

FIELD 08 PATENTS

08-65-12001 METHOD OF DRIVING TUNNELS IN ROCK (NEW-INVENTIONS NEW-TUNNELLING-METHODS GROUND-CONTROL-METHODS)
BRANMSFORS, S. H. & AB SKANSKA CEMENTGJUTERIET SW
U. S. PATENT NO. 3224204, DEC 21, 1965. THIS IS A METHOD OF DRIVING TUNNELS IN ROCK BY BLASTING SALVOS, WHICH ARE REPEATED AFTER THE MUCK HAS BEEN REMOVED. PARTICULARLY USEFUL IN UNSTABLE GROUND CONDITIONS, THE INVENTION PROVIDES SUCH A METHOD OF REINFORCEMENT THAT THE DRIVING OF THE TUNNEL CAN BE EFFECTED MORE QUICKLY WHILE SAVING TIME AND MATERIAL. BASED ON THE REALIZATION THAT ACTUAL FALL OF MATERIAL AFTER BLASTING DOES NOT OCCUR UNTIL SEVERAL HOURS AFTER THE INITIAL BLAST, THE INVENTION INTRODUCES A TUNNELLING METHOD BY WHICH THE ARCHED ROOF IN THE ROCK WHICH IS FORMED AFTER A SALVO AND WHICH IS SPACED FROM THE MUCK IS STABILIZED BY BEING COATED WITH CONCRETE BEFORE MUCK IS REMOVED.

FIELD 1 GEOLOGY AND ROCK MECHANICS

FIELD 11 BOOKS

11-69-02001 FUNDAMENTALS OF ROCK MECHANICS (SOIL-MECHANICS)
JAEGER, J. C. + COOK, N. G. W.
METHUEN & CO LTD LONDON, FEB 1969. ROCK MECHANICS IS FAST BECOMING RECOGNISED AS A SIGNIFICANT ENGINEERING SCIENCE. THE RESULTS OF RESEARCH ARE SCATTERED AMONG A GREAT NUMBER OF PAPERS IN VARIOUS SCIENTIFIC AND ENGINEERING JOURNALS AND CONFERENCE PROCEEDINGS. JAEGER AND COOK HAVE PREPARED AN OVERALL ASSESSMENT AND CRITICAL EVALUATION OF THE WORK, AND THE RESULT IS A BOOK WHICH IS LIKELY TO BE A USEFUL REFERENCE ON THE SUBJECT FOR MANY YEARS, BOTH IN RESEARCH AND DESIGN. THIS BOOK SETS OUT THE MATHEMATICAL AND EXPERIMENTAL BASIS OF THE MECHANICAL BEHAVIOUR OF ROCK. IT DOES NOT ATTEMPT TO DESCRIBE PRACTICAL SOLUTIONS TO ENGINEERING PROBLEMS OF ROCK MECHANICS, MAINLY BECAUSE THE AUTHOR'S FEEL THAT MUCH OF THE KNOWLEDGE IN ROCK MECHANICS IS SO RECENT THAT THERE IS AS YET LITTLE EXPERIENCE OF ITS APPLICATION TO THE SOLUTION OF SUCH PROBLEMS. LABORATORY STUDIES OF THE MECHANICAL PROPERTIES OF ROCK AND THE MECHANISM OF, AND CRITERIA FOR, ITS FAILURE ARE DESCRIBED IN DETAIL. ON THE MORE PRACTICAL SIDE, THE PRINCIPLES OF THE METHODS FOR MEASURING STRESS AND ROCK PROPERTIES IN THE FIELD ARE DESCRIBED. THE ESTIMATION OF STRESSES AND DISPLACEMENTS AROUND EXCAVATIONS IS DISCUSSED, TOGETHER WITH THE PRINCIPLES INVOLVED IN A NUMBER OF ENGINEERING AND MINING PROBLEMS. REALISTIC SOLUTIONS TO ROCK MECHANICS PROBLEMS MUST INVOLVE A COMBINATION OF GENERAL PRINCIPLES OF MECHANICS WITH A MATURE PHYSICAL INSIGHT DEVELOPED THROUGH INTELLIGENT THE FIELD. THE BOOK IS WELL ILLUSTRATED.

FIELD 12 SYMPOSIA

12-43-01001 CLASSIFICATION AND IDENTIFICATION OF SOILS (GRAIN-SIZE)
CASAGRANDE, A. & HARVARD UNIV CAMBRIDGE MASS
AMERICAN SOC. CIVIL ENGRS. TRANS. PAPER 2351, (113) 901-99, JAN. 1943. A REVIEW AND COMPARISON OF EXISTING SOIL CLASSIFICATIONS. A NEW SOIL GROUPING WAS PROPOSED. THE FIRST SOIL CLASSIFICATIONS WERE TEXTURAL CLASSIFICATIONS USING GRAIN-SIZE. THE INADEQUACIES OF THIS CRITERION WERE DUE TO THE DIFFERENCE IN PHYSICAL CHARACTERISTICS. THE NEW GROUPING APPEARED MORE ORDERLY AND TOOK PHYSICAL PROPERTIES AND ENVIRONMENT INTO CONSIDERATION. PROCEDURES FOR FIELD-IDENTIFICATION INCLUDE: SHAKING TEST, EXAMINATION OF PLASTICITY, EXAMINATION OF DRY STRENGTH, AND OBSERVATION OF COLOR AND ODOR. THE AUTHOR DISTINGUISHED BETWEEN THE COARSE-GRAINED AND FINE-GRAINED SOIL GROUPS. SANDS AND GRAVELS COMPRISE THE FIRST GROUP, SILTS AND CLAYS, THE LATTER.

12-57-04001 BEHAVIOR OF MATERIALS AND THEORIES OF FAILURE (ROCK-MECHANICS ELASTIC-DEFORMATION FRACTURE)
SILVERMAN, I. K. & U.S. BUR RECL DENVER COLO
QUARTERLY OF THE COLO SCHOOL OF MINES SECOND SYMP ON ROCK MECHANICS, (52) 3-18, APR 1957. THERE ARE THREE TYPES OF BEHAVIOR WHICH ARE ENCOUNTERED IN UNIAXIAL TESTS ON ROCK SPECIMENS; THE ELASTIC, REVERSIBLE, BEHAVIOR LIMITED TO VERY SMALL RANGE OF STRAINS; A YIELDING RANGE IN WHICH DEFORMATIONS ARE MANY TIMES THOSE OF THE ELASTIC RANGE; AND THE FRACTURE RANGE. VARIOUS THEORIES DESCRIBED ARE: MAXIMUM STRESS, MAXIMUM STRAIN, MAXIMUM SHEAR, MAXIMUM OCTOBHEDRAL STRESS, MAXIMUM ENERGY OF DISTORTION, AND MOHR'S GENERAL THEORY OF FAILURE.

12-57-04002 THEORETICAL AND EXPERIMENTAL STRESS ANALYSIS (ROCK-MECHANICS ROCK-FAILURE)
PHILIPPE, R. R. + MELLINGER, F. N. & U.S. ARMY CE WASH D.C.
QUARTERLY OF THE COLO SCHOOL OF MINES SECOND SYMP ON ROCK MECHANICS, (52) NO 3, 19-34, APR 1959. AN OUTLINE OF SOME OF THE MORE COMMON METHODS OF STRESS ANALYSIS IS GIVEN, WITH EXAMPLES OF EXPERIMENTAL RESULTS, AN ELEMENTARY CONSIDERATION OF THE PERTINENT PHYSICAL PROPERTIES OF ROCKS AND THE SIGNIFICANCE OF CONDITIONS WHICH SURROUND THEM, AND A DISCUSSION OF THE LIMITATIONS OF THE ANALYTICAL APPROACH. THE ACCURACY OF STRUCTURAL ANALYSIS WILL BE AFFECTED BY THE PHYSICAL PROPERTIES OF ROCKS, CHANGES OF THESE ROCK PROPERTIES, OTHER INTERNAL CHANGES, AND THE COMPLEXITY OF ROCK FORCES. 21 REFS.

12-57-04003 ROCK PROPERTIES AND THE MECHANICS OF SUBSIDENCE (ROCK-MECHANICS SEISMIC-ANALYSIS ANGLE-OF-BREAK)
RELLENSMANN, O. & MINING UNIV OF CLAUSTHAL GER
QUARTERLY OF THE COLO SCHOOL OF MINES SECOND SYMP ON ROCK MECHANICS, (52) NO 3, 35-44, APR 1957. THE BEHAVIOR OF STRATA SUBJECTED TO STATIC LOADING WAS EXAMINED WITH EMPHASIS ON THE ANGLE OF BREAK OF THE STRATA LAYERS. VARIOUS FIGURES ARE GIVEN WHICH REPRESENT THE CHANGES OF ANGLE OF BREAK IN DIFFERENT OVERLYING LAYERS; THIS ANGLE IS ABOUT 80-90 DEG IN ROCKY STRATA, ABOUT 60-80 DEG IN PLASTIC STRATA, AND ABOUT 40-60 DEG IN UNCONSOLIDATED STRATA. IN LIQUIDS OR GASES THERE IS NO ANGLE OF BREAK AT ALL; IF THERE IS WATER AT THE SURFACE WE HAVE A VERY FAR REACHING INFLUENCE OF SUBSIDENCE. THE MAGNITUDE OF THE ANGLE OF BREAK DEPENDS MAINLY ON THE ELASTIC PROPERTIES OF THE LAYERS AND ON THE VALUE OF THE ELASTIC MODULUS, WHICH CAN BE DETERMINED BY EXPERIMENT IN THE LABORATORY AND ALSO DIRECTLY BY MEASURING THE SEISMIC VELOCITY OF LONGITUDINAL WAVES. THE VELOCITY IS ABOUT 4500-6000 M/SEC IN ROCKY LAYERS, 300-4500 M/SEC IN PLASTIC LAYERS, AND ABOUT 1000 TO 3000 M/SEC IN UNCONSOLIDATED LAYERS. THE DEPTH AND VELOCITY OF THE DIFFERENT LAYERS CAN BE DETERMINED BY SEISMIC REFRACTION SHOOTING.

12-57-04004 UNDERGROUND INSTRUMENTATION
POTTS, E. L. J. & KING'S COLLEGE DURHAM ENG
QUARTERLY OF COLO SCHOOL OF MINES SECOND SYMP. ON ROCK MECHANICS, (52) NO 3, 132-182, APR 1957. DEVELOPMENT OF INSTRUMENTATION FOR UNDERGROUND RESEARCH INTO PROBLEMS OF STRATA CONTROL HAS BEEN A MAJOR OBJECTIVE AT THE STRATA CONTROL RESEARCH LABORATORY AT KING'S COLLEGE. THE PRINCIPAL OBJECTIVE OF THE RESEARCH IS TO PRODUCE THE OVERALL PICTURE OF PRESSURE OR LOAD DISTRIBUTION FROM THE SOLID COAL IN ADVANCE, TO THE CONSOLIDATED WASTE BEHIND THE LONGWALL FACE. BRITISH COAL MINING DEVELOPMENT IN FACE MECHANIZATION IN LONGWALL MINING HAS INVOLVED THE USE OF SUPPORTS HAVING CONTROLLED LOAD-YIELD CHARACTERISTICS. ASSOCIATED WITH THE HYDRAULIC OR YIELDING TYPE FUNCTION PROPS, ARTICULATED, CANTILEVER ROOF BARS ARE IN USE ON PROP FILL FRONT FACES. THE NEED FOR SYSTEMATIC SURVEYS OF PROP LOADS IN VARIOUS OPERATIONAL CONDITIONS HAS LED TO THE DEVELOPMENT OF THE PROP LOAD CELL. STRESSMETERS HAVE BEEN DESIGNED FOR USE IN COAL AND THE SOFTER COAL MEASURE ROCKS AND FOR HIGH PRESSURE MEASUREMENTS IN HARD ROCK. THE USE OF STRESSMETERS IN ADVANCE OF LONGWALL FACES HAS PROVIDED A CLEAR PICTURE OF THE PRESSURE DISTRIBUTION IN THE FRONT ABUTMENT AREA, AND THE INFLUENCE OF FACE OPERATIONS ON THE TRANSFERRED LOAD CONDITIONS. THE STRESSMETER DESIGNED FOR HIGH PRESSURES HAS SUCCESSFULLY RECORDED THE GENERAL DISTRIBUTION OF THE TRANSFERRED LOAD, IN FRONT OF A STOPE FACE IN THE CHAMPION REEFS MINE, ROLAC GOLD FIELD, SOUTH INDIA, AT A DEPTH OF OVER 9,000 FT. A DEVELOPMENT WHICH IT IS HOPED WILL PROVIDE A CORROBORATIVE EVIDENCE OF THE RESULTS OF THE STRESSMETER SURVEYS IN ADVANCE OF THE COAL FACE IS THE USE OF SONICS. THE EFFECTIVE USE OF ROOF BOLTING TECHNIQUES IS BEING STUDIED USING ROOF BOLT LOAD CELLS WITH WHICH LOADS CAN BE INDIVIDUALLY INDICATED OR RECORDED OVER A PERIOD.

12-57-04005 MEASUREMENT OF RESIDUAL STRESS BY THE STRAIN RELIEF METHOD (ROCK-MECHANICS INSTRUMENTATION)
OLSEN, O. J. & U.S. BUR RECL DENVER COLO
QUARTERLY OF COLO. SCH. OF MINES, SECOND SYMP. ON ROCK MECHANICS, (52) NO 3, 183-204, 1957. THE TECHNIQUE USED IN DETERMINING STRESSES IN ROCK FORMATION OR IN STRUCTURES IS CALLED THE STRAIN RELIEF METHOD WHICH CONSISTS OF CHOOSING REPRESENTATIVE LOCATIONS, PREPARING THE SURFACE, ATTACHING AND WATERPROOFING SUITABLE GAGES, TAKING TWO SETS OF STRAIN READINGS, INITIAL AND FINAL, CORE DRILLING AROUND THE GAGES BETWEEN READINGS TO RELIEVE STRAIN, AND MEASURING THE STRESS-STRAIN RATIO OF THE MATERIAL FROM THE CORES THUS DRILLED. SR.4 ELECTRIC RESISTANCE GAGE ROSETTES WERE USED TO MEASURE THE STRAIN ON THE WALLS OF THE PROSPECT MOUNTAIN TUNNEL, A CONCRETE LINED PRESSURE TUNNEL ON THE COLORADO - BIG THOMPSON PROJECT. THE MAIN KEY TO SUCCESS IN THE USE OF SR-4 GAGES IS EFFECTIVE WATERPROOFING. ALTHOUGH THE ROCK STRESSES, WHICH WERE OF THE ORDER OF MAGNITUDE OF SEVERAL THOUSAND PSI, COULD NOT BE ACCOUNTED FOR ENTIRELY BY DEPTH OF OVERBURDEN, THE STRAINS WERE CONSIDERED RELIABLE. STANDARD ERROR WAS REDUCED FROM 535 PSI FOR THE FIRST TUNNEL TO 240 PSI FOR THE SECOND TUNNEL, AND FINALLY TO ABOUT 30 PSI FOR THE DAM.

12-57-04006 INSTRUMENTATION EXPERIMENTS IN MINES (ROCK-MECHANICS ROOF-SUPPORT)
BERNATIS, T. S. & INTERMOUNTAIN RES AND ENGR CO
QUARTERLY OF THE COLO SCHOOL OF MINES SECOND SYMP ON ROCK MECHANICS, (52) NO 3, 204-224, APR 1957. INSTRUMENTATION AND INSTRUMENTATION EXPERIMENTS HAVE BEEN CONDUCTED AT THE INTERMOUNTAIN CHEM CO MINE LOCATED IN THE SOUTHWESTERN SECTION OF THE STATE OF WYO. LARGE DEPOSITS OF TRONA, A RARE NON-METALLIC MINERAL, MAKE THIS MINE PARTICULARLY INTERESTING FOR INVESTIGATION AND EXPERIMENTS. EXPERIMENTS HAVE PRIMARILY BEEN FOR THE PURPOSE OF PROVIDING THE MINER WITH PRACTICAL MEANS OF SOLVING MINING PROBLEMS, SUCH AS ROOF SUPPORTING. VARIOUS PHOTOGRAPHS ARE INCLUDED.

12-58-05001 GEOLOGICAL TOOLS AND TECHNIQUES (SUBSURFACE HYDROLOGICAL GEOCHEMICAL GEOPHYSICAL BORE-HOLES)
CLEAVES, A. B. & WASH UNIV ST. LOUIS MO
JOURNAL OF THE SOIL MECHANICS AND FOUNDATION DIV PROC OF THE ASCE SYMP ON GEOLOGICAL FACTORS IN TUNNEL CONSTRUCTION (PAPER N 1648), (84) N S.M.2, MAY 8, 1958. THE TYPES OF GEOLOGICAL INVESTIGATIONS ESSENTIAL TO DELINEATING POTENTIAL TUNNEL PROBLEMS ARE: PRINCIPLE CATEGORIES: (A) LIBRARY RESEARCH FOR LITERATURE AND MAPS, (B) FIELD RECONNAISANCE, SURFACE AND SUBSURFACE EXPLORATIONS AND (C) LABORATORY STUDIES. NEW CORE BORING AIDS SUCH AS THE BORE HOLE CAMERA AND THE TROTTER-PAJARI COMPASS; GEOCHEMICAL TECHNIQUES, CLAY TECHNOLOGICAL AND PETROGRAPHIC METHODS ARE OUTLINED.

12-59-07001 INFLUENCE OF STRESS RATE AND OTHER FACTORS ON THE STRENGTH AND ELASTIC PROPERTIES OF ROCKS (ROCK-MECHANICS STRESS-PROPERTIES RESEARCH)
WUERKER, R. G. & UNIV ILLINOIS
QUARTERLY OF THE COLO SCHOOL OF MINES THIRD SYMP ON ROCK MECHANICS, (54) 3-32, JULY 1959. IN THE "STANDARDIZED TESTS FOR DETERMINING THE PHYSICAL PROPERTIES OF MINE ROCK" PROPOSED BY THE U.S. BUR OF MINES, THE FACTORS CONDITIONING THE PHYSICAL PROPERTIES OF ROCK ARE DISCUSSED AND SPECIFICATIONS FOR EACH PARTICULAR TEST ARE GIVEN. A STRESS RATE OF 100 PSI/SEC FOR THE STANDARD COMPRESSION TEST IS PRESCRIBED. DATA FROM TESTS WITH GREATER SPEED OF LOADING SUCH AS IMPACT AND SONIC TEST INDICATE THAT STRENGTH AND MODULUS OF ELASTICITY MIGHT INCREASE BY A FACTOR OF TWO. COMPLETE DATA HAS BEEN PUBLISHED ON CONCRETE. ONE SAMPLE HAD A COMPRESSIVE STRENGTH OF 2500 PSI ANOTHER 6500 PSI. RATES OF STRESSING RANGED FROM 1 TO 100 MILLION PSI/SEC, RATES OF STRAINING FROM 0 TO 10 IN/IN PER SEC. ABILITY TO ABSORB STRAIN ENERGY ALSO INCREASED WITH THE RATE OF APPLICATION OF LOAD. THE SIGNIFICANCE OF COMPRESSION, IMPACT AND SONIC TESTS IS LIMITED BY THE FACT THAT ROCKS IN MINERAL ENGINEERING ARE ALMOST NEVER SUBJECTED TO A SINGLE TYPE OF STRESS. FACTORS, SUCH AS COMBINED STRESSES AND CONFINEMENT WILL BE DISCUSSED BY USING AN EXPANSION OF MOHR'S THEORY FOR A RANGE WITHIN WHICH THE STRAIGHT LINE EXPANSION FOR MOHR'S ENVELOPE IS VALID. INCREASE OF COMPRESSIVE STRENGTH DUE TO CONFINING PRESSURE IS MANY TIMES HIGHER THAN THE ONE DUE TO INCREASED STRESS RATE.

12-59-07002 TIME DEPENDENT DEFORMATION AND FAILURE OF GEOLOGIC MATERIALS (ROCK-MECHANICS ROCK-FAILURE ROCK-STUDIES)
HARDY, H. R, JR. & DEPT OF MINES AND TECH SUR CAN
QUARTERLY OF THE COLO SCHOOL OF MINES, THIRD SYMP ON ROCK MECHANICS, (54) 135-176, JULY 1959. INVESTIGATION OF THE BEHAVIOR OF GEOLOGIC MATERIALS WAS CONDUCTED BY THE ROCK MECHANICS GROUP OF THE MINING RESEARCH SECTION OF THE FUELS DIVISION, MINES BRANCH, DEPT OF MINES AND TECH SUR, OTTAWA, CANADA. THE TIME-DEPENDENT BEHAVIOR OF GEOLOGIC MATERIALS UNDER CONDITIONS OF LOW AND HIGH UNIAXIAL STRESS IS IMPORTANT IN THE STUDY OF COMMINUTION AND UNDERGROUND FAILURE. UNDER LOW VALUES OF APPLIED STRESS IT IS POSTULATED THAT TIME-DEPENDENT DEFORMATION MAY BE DESCRIBED APPROXIMATELY BY A VISCOELASTIC MODEL. IN THE CASE OF HIGHER VALUES OF APPLIED STRESS, IT IS POSTULATED THAT TIME-DEPENDENT DEFORMATION AND FAILURE MAY BE DESCRIBED BY THE COMBINATION OF A VISCOELASTIC MODEL AND A MICROFRACTURE MECHANISM. A COMPREHENSIVE REVIEW OF RECENT AND PAST RESEARCH IN THIS FIELD IS GIVEN. THE DESIGN AND CALIBRATION OF LABORATORY APPARATUS TO STUDY THESE PROPERTIES IS DESCRIBED, TOGETHER WITH EXPERIMENTAL RESULTS.

12-59-07003 THE EFFECT OF PORE AND CONFINING PRESSURE ON THE FAILURE PROCESS IN SEDIMENTARY ROCK (ROCK-MECHANICS ROCK-FAILURE RESEARCH)
ROBINSON, L. H., JR. & HUMBLE OIL AND REF HOUSTON
QUARTERLY OF THE COLO SCHOOL OF MINES THIRD SYMP ON ROCK MECHANICS, (54) 177-200, JULY 1959. IN EITHER CONSOLIDATED OR UNCONSOLIDATED MATERIALS, THE STRESS BETWEEN THE GRAINS CONTROLS THE FAILURE PROPERTIES. RESEARCH WAS UNDERTAKEN TO OBTAIN QUANTITATIVE DATA ON THE YIELD STRENGTH AND MODE OF FAILURE OF LIMESTONE, SANDSTONE, AND SHALE SUBJECTED TO VARIOUS CONFINING AND PORE PRESSURES. RESULTS SHOW THAT COMMON SEDIMENTARY ROCKS WILL UNDERGO EITHER MALLEABLE OR BRITTLE FAILURE, DEPENDING UPON CONFINING PRESSURE AND INTERNAL PORE PRESSURE. ALTHOUGH SHALES, LIMESTONES, AND SANDSTONES HAVE INHERENTLY DIFFERENT STRENGTHS, BRITTLE FAILURE OCCURS WHEN THE CONFINING AND PORE PRESSURE ARE EQUAL, AND THE MODE OF FAILURE CHANGES GRADUALLY FROM BRITTLE TO MALLEABLE AS THE DIFFERENTIAL BETWEEN THE CONFINING AND PORE PRESSURE INCREASES THE TRANSITION PRESSURE DEPENDING ON THE NATURE OF THE ROCK AND THE PRESSURE LEVEL. THE YIELD STRENGTHS OF ROCK INCREASE ONLY SLIGHTLY AS THE CONFINING PRESSURE INCREASES IF THE CONFINING AND PORE PRESSURES ARE MAINTAINED EQUAL. 21 REFS.

12-59-07004 ENERGY RELEASED IN ROCKBURSTS (ROCK-MECHANICS ROCK-FAILURE ENERGY STUDIES RESEARCH)
COATES, D. F. & CARLETON UNIV OTTAWA CANADA
QUARTERLY OF THE COLO SCHOOL OF MINES, THIRD SYMP ON ROCK MECHANICS, (54) 201-206, JULY 1959. DISCUSSION OF THE MECHANISMS FOR STORING AND RELEASING THE MANIFEST ENERGY OCCURRING DURING ROCKBURSTS. THE METHOD OF CALCULATING UNIT STRAIN ENERGY STORED IN ROCKS IS DESCRIBED. MORE ATTEMPTS ARE NEEDED TO DETERMINE THE ACTUAL AMOUNT OF ENERGY RELEASED BY A SPECIFIC ROCKBURST. 4 REFS.

12-59-07005 THE ATTENUATION OF SHOCK WAVES IN SOLID MATERIALS WITH SEISMIC APPLICATIONS (ROCK-MECHANICS ROCK-FAILURE RESEARCH-STUDIES)
GRINE, D. R. + FOWLES, G. R. & STANFORD RES INST POULTER LAB
QUARTERLY OF THE COLO SCHOOL OF MINES, THIRD SYMP ON ROCK MECHANICS, (54) 253-268, JULY 1959. SHOCK WAVES IN SOLIDS ARE ATTENUATED, IN GENERAL, BY SEVERAL MECHANISMS. THOSE COMMON TO ATTENUATION IN FLUIDS INCLUDE THE OVERTAKING OF THE SHOCK BY A RAREFACTION WAVE, GEOMETRICAL DIVERGENCE, AND HEATING DUE TO IRREVERSIBLE PROCESSES OCCURRING WITHIN THE SHOCK FRONT. MECHANISMS PECULIAR TO SOLIDS INCLUDE ABSORPTION OF ENERGY IN PLASTIC DEFORMATION AND FRACTURE. APPLICATION OF EXISTING THEORY FOR FLUIDS TO SOLIDS REQUIRES KNOWLEDGE OF THE EQUATION OF STATE OF THE SOLID. THE THEORY MUST THEN BE MODIFIED TO INCLUDE PLASTIC DEFORMATION AND FRACTURE. RECENT EXPERIMENTS TO DETERMINE EQUATIONS OF STATE OF ROCKS, AND OTHER EXPERIMENTS TO DETERMINE DYNAMIC YIELD STRENGTHS AND FRACTURE ENERGIES ARE DESCRIBED. APPLICATION TO THE PROBLEM OF ENERGY TRANSFER IN A SHOT HOLE ARE DISCUSSED.

12-59-07006 MECHANICAL PROPERTIES OF ICE (ROCK-GEOLOGY ROCK-MECHANICS RESEARCH STUDIES)
BUTKOWIK, T. R. & U.S. ARMY SIPRE
QUARTERLY OF THE COLO SCHOOL OF MINES THIRD SYMP ON ROCK MECHANICS, (54) 351-359, JULY 1959. ICE SHOWS BOTH PLASTIC AND ELASTIC BEHAVIOR WHEN SUBJECTED TO STRESSES OF VARIOUS KINDS. EFFECTS OF THE PLASTIC-ELASTIC BEHAVIOR ARE DISCUSSED AND VALUES OF MECHANICAL CONSTANTS SUCH AS YOUNG'S MODULUS AND VISCOSITY COEFFICIENTS, INCLUDING RESULTS OF LABORATORY AND FIELD STUDIES, ARE PRESENTED FOR VARIOUS TYPES OF ICE. THE MECHANISM UNDERLYING THE DEFORMATION OF ICE UNDER VARIOUS CONDITIONS IS INDICATED. THE NEED FOR STANDARDIZATION OF TESTING TECHNIQUES IS STRESSED. ULTIMATE STRENGTH, MODULUS OF ELASTICITY AND VISCOSITY COEFFICIENTS AS FUNCTIONS OF TEMPERATURE, STRUCTURE, ORIENTATION AND IMPURITIES ARE REVIEWED.

12-61-03001 MOVEMENTS OF THE ROOF AND FLOOR IN ROADWAYS (MINING MEASUREMENTS SUPPORTS)
SCHWARTZ, B. & SCH OF MINES NANCY FRANCE
THE PA. STATE UNIV., BULLETIN MINERAL INDUSTRIES EXPERIMENT STATION, PROC. OF FOURTH SYMP. ON ROCK MECHANICS, 1-10, MAR. 30, 31, APR. 1, 1961. THE STUDY INVESTIGATED THE FACTORS WHICH MAINLY INFLUENCE THE MOVEMENT OF THE ROCK AND ATTEMPTS TO DEFINE THESE INFLUENCES MORE ACCURATELY. RESULTS ARE BASED ON MEASUREMENTS OF THE MOVEMENTS OF PLUGS SET

INTO ROOFS AND FLOORS AND INTO SOLID ROCK WHICH ARE ABSOLUTE WITH RESPECT TO THE FIXED BASES OR RELATIVE FROM ONE PLUG TO ANOTHER WITH PARTICULAR REFERENCE TO CONVERGENCE. CONVERGENCE IS THE APPROACH OF 2 PLUGS FIXED IN THE ROOF AND FLOOR RESPECTIVELY, PERPENDICULAR TO THE STRATIFICATION. THE STUDY PERMITS ANALYSIS OF THE INFLUENCE OF NUMEROUS FACTORS SUCH AS: THE NATURE OF THE ROCK; THE DENSITY OF THE SUPPORTS; THE RATE OF ADVANCE OF THE WORKINGS AND BRUSHING. 14 TABLES.

12-61-03002 THEORETICAL ASPECTS OF ROCK BEHAVIOR UNDER STRESS (ELASTIC DEFORMATION FRACTURE STRESSES FORCES SHEAR TENSION COMPRESSION)
PONCELET, E. F. & SRI MENLO PARK CAL
THE PA. STATE UNIV., BULLETIN OF MINERAL INDUSTRIES, EXPERIMENT STATION, PROC. OF FOURTH SYMP. ON ROCK MECHANICS, 65-72, MAR. 30, 31, APR. 1, 1961. THE SIMPLIFIED THEORY FOR FRACTURE CONCLUDES THAT WHEN THE MAJOR PRINCIPAL STRESS EXCEEDS THE COHESIVE STRENGTH OF THE BOND BETWEEN TWO ATOMS IN LINE WITH IT, THESE SEPARATE, THROWING THE LOAD ON THE NEIGHBORING BONDS CAUSING FURTHER SEPARATION OF ATOM PAIRS AND THUS A FRACTURE DEVELOPS. THE SAME THINKING IS ADVANCED FOR TRIAXIAL STRESSES. THE USE OF THIS APPROACH IS DISCUSSED FOR APPLICATION TO ROCKS AND ALSO IN APPLICATION TO EXPLOSIVE CHARGES IN BORE HOLES.

12-61-03003 TRANSITION FROM ELASTIC TO PLASTIC STATES OF ROCK UNDER TRIAXIAL COMPRESSION (UNDERGROUND STRESSES ANALYSIS EXPERIMENTAL-RESULTS THEORY)
SERATA, S. & MICH STATE UNIV
THE PA. STATE UNIV., BULLETIN OF MINERAL INDUSTRIES, EXPERIMENT STATION, PROC. OF FOURTH SYMP. ON ROCK MECHANICS, 73-82, MAR. 30, 31, APR. 1, 1961. THIS PAPER INTRODUCES A THEORY DESCRIBING THE BEHAVIOR OF ROCKS IN UNDERGROUND FORMATIONS FOR THE PURPOSE OF ANALYZING UNDERGROUND STRESS CONDITIONS. A PHENOMENON OF AN ABRUPT TRANSITION FROM ELASTIC TO PLASTIC STATES OF ROCK UNDER TRIAXIAL COMPRESSION IS ANTICIPATED FROM THE THEORY. LABORATORY EXPERIMENTS WERE CONDUCTED THAT SIMULATED CONDITIONS AND RESULTS ARE GIVEN TO VERIFY THE THEORY. A METHOD FOR DETERMINATION OF THE UNDERGROUND STRESS FIELD IS PROPOSED, BASED ON THE THEORY AND THE EXPERIMENTAL RESULTS. THE EXISTENCE OF THE PLASTIC STATE AND THE BOUNDARY OF TRANSITION IN UNDERGROUND FORMATIONS ARE PREDICTED. EIGHT DIAGRAMS.

12-61-03004 THE EFFECTS OF STRAIN RATE AND TEMPERATURE ON THE BEHAVIOR OF ROCKS SUBJECTED TO TRIAXIAL COMPRESSION (TESTS STRENGTH-CHARACTERISTICS STRESS PRESSURE DEFORMATION FLOW FRACTURE)
SERDENGECTI, S. + BOOZER, G. D. & CAL RES CORP LA HABRA CAL
THE PA. STATE UNIV., BULLETIN OF MINERAL INDUSTRIES, EXPERIMENT STATION, PROC. OF FOURTH SYMP. ON ROCK MECHANICS, 83-98, MAR. 30, 31, APR 1, 1961. THIS PAPER DESCRIBES DYNAMIC TRIAXIAL COMPRESSION TESTS PERFORMED TO DETERMINE THE STRENGTH CHARACTERISTICS OF BEREA SANDSTONE, SOLENHOFEN LIMESTONE, AND PALA GABBRO ROCKS THAT WERE SUBJECTED TO CONTROLLED STRESS, STRAIN RATE AND TEMPERATURE CONDITIONS. CONTROL OF THE STRESS WAS ESTABLISHED BY VARYING LIQUID PRESSURES WITHIN AND AROUND A RUBBER-JACKETED CYLINDRICAL ROCK SPECIMEN. LIQUID PRESSURES WERE VARIED FROM ATMOSPHERIC TO 20,000 PSI. TEMPERATURES WERE VARIED FROM ROOM TEMPERATURE TO 300 DEGREES F AND AXIAL STRAIN RATE FROM 10 TO THE MINUS 3 TO 100 PERCENT PER SECOND. DATA OBTAINED SHOWS THAT FOR A GIVEN STATE OF STRESS AND TEMPERATURE, THE AXIAL COMPRESSIVE STRESS REQUIRED TO FRACTURE THE ROCK SPECIMEN INCREASES AS THE STRAIN RATE IS INCREASED AND THE TYPE OF FAILURE OBSERVED CHANGES FROM DUCTILE TO BRITTLE. WITHIN THE ABOVE TEMPERATURE AND STRAIN RATE RANGES IT APPEARS THAT FOR A GIVEN STATE OF STRESS THE EFFECTS OF CHANGING STRAIN RATE MAY BE OBTAINED BY MERELY CHANGING THE TEST TEMPERATURE. A MECHANICAL EQUATION OF STATE IS PROPOSED FOR SOLENHOFEN LIMESTONE THAT PREDICTS COMPRESSIVE STRENGTH FOR GIVEN STRESS, STRAIN RATE, AND TEMPERATURE CONDITIONS.

12-61-03005 DEPENDENCE OF FRACTURE STRENGTH OF ROCKS ON GRAIN SIZE (BRITTLE-FRACTURE FLAWS GRIFFITH-CRACKS STRESS COMPRESSIVE-STRENGTH GRAIN-BOUNDARY INDENTATION-HARDNESS)
BRACE, W. F. & HARVARD UNIV
THE PA. STATE UNIV., BULLETIN OF MINERAL INDUSTRIES, EXPERIMENT STATION, PROC. OF FOURTH SYMP. ON ROCK MECHANICS, 99-104, MAR. 30, 31, APR. 1, 1961. THIS PAPER DISCUSSES THE GRIFFITH THEORY AS THE BASIS FOR ANALYSES OF BRITTLE FAILURE. ACCORDING TO THE THEORY, MICROSCOPIC FRACTURES START AT PRE-EXISTING FLAWS (AT SO-CALLED GRIFFITH CRACKS) WHICH ENLARGE AND SPREAD UNDER THE INFLUENCE OF APPLIED STRESS. WITH THIS MODEL THE BRITTLE STRENGTH OF A MATERIAL CAN BE CALCULATED FOR ANY SYSTEM OF LOADING USING CERTAIN KNOWN VALUES SUCH AS MATERIAL CONSTANTS, AND THE SHAPE AND SIZE OF GRIFFITH CRACKS. SOME PRELIMINARY RESULTS OF A STUDY OF THE EARLY STAGES OF ROCK FRACTURE ARE PRESENTED. THEORY IS DESCRIBED AND RELATIONSHIP OF GRIFFITH CRACKS AND GRAIN BOUNDARIES IS DESCRIBED. A COMPARISON IS MADE OF CALCULATED AND MEASURED VALUES OF SPECIFIC SURFACE ENERGIES OF VARIOUS ROCK MATERIALS. REPRESENTATIVE ROCK PROPERTIES ARE USED TO CALCULATE GRIFFITH CRACK LENGTHS WHICH ARE COMPARED TO VALUES EXPERIMENTALLY DETERMINED BY OTHERS AND RELATION OF CRACK LENGTHS TO GRAIN SIZE ESTABLISHED. SPECIMENS OF REPRESENTATIVE LIMESTONE, DOLOMITE, QUARTZITE, AND BASALT WERE HARDNESS TESTED AND ROCK HARDNESS, COMPRESSIVE STRENGTH, AND MAXIMUM GRAIN SIZE RELATIONS ARE DISCUSSED AND ILLUSTRATED. STUDIES INDICATE THAT THE LENGTH OF GRIFFITH CRACKS IS OF THE ORDER OF MAXIMUM GRAIN SIZE AND THAT GRIFFITH CRACKS MUST LIE WITHIN GRAINS OR AT GRAIN BOUNDARIES.

12-61-03006 LABORATORY MEASUREMENTS OF SOME PHYSICAL PROPERTIES OF ROCK (STRENGTH TENSILE COMPRESSIVE STATIC STRESS DYNAMIC ELASTICITY-MODULUS MEASUREMENTS TESTS SPECIMENS)
FAIRHURST, C. & UNIV MINN MINNEAPOLIS MINN
PA. STATE UNIV., BULLETIN OF MINERAL INDUSTRIES, EXPERIMENT STATION, PROC. OF THE FOURTH SYMP. ON ROCK MECHANICS, 105-118, MAR. 30, 31, APR 1 1961. THIS PAPER DISCUSSES THE CONDITIONS OF ROCK TESTING AND DIVIDES ROCK MECHANICS PROBLEMS INTO TWO CLASSES: THOSE INVOLVING STATIC OR VERY SLOWLY APPLIED STRESSES AND INVOLVING DYNAMIC OR VERY RAPIDLY APPLIED STRESSES. DETERMINATION OF STRESS CONDITIONS AROUND UNDERGROUND OPENINGS IS AN EXAMPLE OF THE FORMER AND UNDERSTANDING THE MECHANICS OF ROCK FRAGMENTATION IN BLASTING IS AN EXAMPLE OF THE LATTER.

12-61-03007 PROPAGATION VELOCITY OF LONGITUDINAL WAVES IN ROCK (STRESS-WAVES STRESS-LEVEL RESONANCE-FREQUENCY PULSE DETECTOR MEASUREMENTS MODULUS CRACKS POROSITY)
RINEHART, J. S. + FORTIN, J. P. + BURGIN, L. & COLO SCHOOL OF MINES GOLDEN COLO
THE PA. STATE UNIV., BULLETIN OF THE MINERAL INDUSTRIES EXPERIMENT STATION PROC. OF FOURTH SYMP. ON ROCK MECHANICS, 119-136, MAR. 30, 31, APR 1, 1961. PROPAGATION OF LONGITUDINAL STRESS WAVES IN ROCKS DEPENDS ON SEVERAL FACTORS: THE STATE OF STRESS, STRESS LEVEL OF THE WAVE, WATER CONTENT, POROSITY, TEMPERATURE, DIRECTION OF PROPAGATION WITH RESPECT TO STRATIFICATION OF THE ROCK AND TEXTURE OF THE ROCK. WHILE SOME OF THESE FACTORS HAVE BEEN THOROUGHLY STUDIED MANY TIMES, OTHERS, SUCH AS THE STRESS LEVEL OF THE WAVE, HAVE NOT BEEN INVESTIGATED. THIS PAPER REVIEWS AND SUMMARIZES EXISTING DATA ON PROPAGATION VELOCITY OF LONGITUDINAL STRESS WAVES WITH THE VIEW TO GENERALIZE THE RESULTS AND INDICATE AREAS OF WEAKNESS AND GAPS IN OUR KNOWLEDGE.

12-61-03008 EXCAVATION OF CONTAINED TNT EXPLOSIONS IN TUFF (BEDDED-VOLCANIC-TUFF ROCK-FRACTURE SHOT-CHAMBER EXCAVATED-VOLUME CAVITY VOID)
SHORT, N. M. & LRL LIVERMORE CAL
THE PA. STATE UNIV., BULLETIN OF MINERAL INDUSTRIES EXPERIMENT STATION, PROC. OF THE FOURTH SYMP. ON ROCK MECHANICS, 171-178, MAR. 30, 31, APR 1, 1961. THIS PAPER DESCRIBES THE FRACTURING AND RELATED PHENOMENA PRODUCED BY TWO EXPLOSIONS IN BEDDED VOLCANIC TUFF WITHIN THE RANIER MESA AT THE ATOMIC ENERGY COMMISSION'S NEVADA TEST SITE. THE PAPER IS BASED ON A STUDY OF TWO H. E. EXPERIMENTAL TEST EXPLOSIONS, NO. 11 AND 14A, OF PROJECT HOBO, A FOLLOW-ON STUDY INITIATED IN PROJECT PLOWBOY AT WINNFIELD, LOUISIANA WHERE EXPLOSIONS IN SALT WERE INVESTIGATED. STUDIES IN DETAIL WERE CONDUCTED BY MINING DIRECTLY INTO DETONATION CHAMBERS AND SURROUNDING ROCK ABOUT EACH EXPLOSION. THE TWO EXPLOSIONS REPORTED IN THIS PAPER TOOK PLACE IN A SEQUENCE OF TUFF BEDS IN UNIT 3 OF THE OAK SPRINGS FORMATION IN A DRIFT IN THE TUNNEL COMPLEX ASSOCIATED WITH THE BLANCA NUCLEAR EVENT. BOTH SHOTS WERE DETONATED IN CHAMBERS FORMED FIRST BY DRILLING A PILOT HOLE BEYOND THE DESIRED DEPTH OF EXPLOSION THEN REAMING A SEGMENT TO HOLD THE AMOUNT OF GRANULAR TNT (PELLETOL) CALCULATED TO PRODUCE A PARTICULAR YIELD. RESULTS INCLUDE MEASUREMENTS OF CAVITY, ROCK RUBBLE,

POROSITY, AND EXTENT OF FRACTURES IN SURROUNDING ROCK WALLS. RESULTS ARE DISCUSSED IN RELATION TO EARLIER EXPERIMENTAL SHOTS AND TO EFFECTS OF NUCLEAR EXPLOSIONS.

12-61-03009 LABORATORY BLASTING WITH MODELS (INCLINED-BLAST-HOLES EXPERIMENT EXPLOSIVE PLEXIGLAS-MODELS BOREHOLES BURDEN THROW)
KOCHANOWSKY, B. J. + PINTO, J., JR. & PENN STATE UNIV
THE PA. STATE UNIV., BULLETIN OF MINERAL INDUSTRIES, EXPERIMENT STATION, PROC. OF THE FOURTH SYMP. ON ROCK MECHANICS, 179-180, MAR. 30, 31, APR. 1, 1961. MODEL TEST EXPLOSIONS USING PLEXIGLAS MODELS DEMONSTRATED THE DIFFERENCE IN ACTION OF VERTICAL AND INCLINED BLAST HOLES. TESTS WERE CONDUCTED IN THE ROCK MECHANICS LABORATORY AT PA. STATE FOR PARTICIPANTS OF THE SYMPOSIUM. THE INCLINED HOLE PRODUCED A FAR BETTER BLASTING EFFECT AND MUCH LARGER THROW.

12-61-03010 METHODS FOR DETERMINING ROCK PRESSURE (MEASUREMENT STRESSES DEFORMATION ROCK-MODULUS)
PANEK, L. A. & U.S. BUR MINES
THE PA. STATE UNIV., BULLETIN OF THE MINERAL INDUSTRIES, EXPERIMENT STATION, PROC. OF THE FOURTH SYMP. ON ROCK MECHANICS, 181-184, MAR. 30, 31, APR. 1, 1961. AN OUTLINE OF PROGRESS IN MEASUREMENT OF STRESSES IN ROCK AND METHODS OF EMPLOYING SENSING DEVICES HAVING VARIOUS LOAD-DEFORMATION RESPONSE CHARACTERISTICS TO DETECT CHANGES IN STRESS OR DEFORMATION IN ROCKS. EXAMPLES OF MANY SENSING ELEMENTS, METHODS OF USE AND DETERMINATION WHICH CAN BE MADE ARE PRESENTED. NO SINGLE METHOD OR DEVICE WILL BE BEST IN ALL OR EVEN IN MOST SITUATIONS BECAUSE OF THE LARGE NUMBER OF COMBINATIONS OF FACTORS SUCH AS: INTENSITY OF ROCK STRESS, ROCK STRESS-STRAIN CHARACTERISTICS, SENSING DEVICE, REMOTENESS FROM OBSERVER. TIME TO OBTAIN INITIAL MEASUREMENTS, STABILITY OF INSTRUMENTS, TIME TO OBTAIN AND REDUCE READINGS OF MEASUREMENTS REPEATED OVER A PERIOD OF TIME.

12-61-03011 A LABORATORY INVESTIGATION OF A HIGH MODULUS BOREHOLE PLUG GAGE FOR THE MEASURES OF ROCK STRESS (EXCAVATION UNDERGROUND STABILITY STRATA STRAIN-GAGES ELASTICITY EXPERIMENT)
WILSON, A. H. & NATIONAL COAL BOARD ENGLAND
THE PA. STATE UNIV., BULLETIN OF THE MINERAL INDUSTRIES EXPERIMENT STATION PROC OF THE FOURTH SYMP ON ROCK MECHANICS, 185-196, MAR. 30, 31, APRIL 1, 1961. EXPERIMENTAL METHODS, INSTRUMENTS AND RESULTS FOR MEASUREMENT OF CHANGES IN STRESS IN ROCKS. PLUGS OF RELATIVELY HIGH MODULUS OF ELASTICITY COMPARED TO ROCK ARE DEVELOPED CONTAINING STRAIN GAGES THAT MEASURE STRAIN IN THE INSTRUMENT RATHER THAN THE SURROUNDING ROCK, SO THAT ACCURATE KNOWLEDGE OF THE ELASTICITY OF THE ROCK IS NOT NEEDED. TAPERED PLUGS WERE FITTED INTO REAMED BOREHOLES IN ROCK BLOCKS WHICH WERE LOADED IN A PRESS FOR TESTING. THE PLUGS CONTAINED CLOSELY FITTED STRAIN GAGES AND COMPENSATION FOR TEMPERATURE PROVIDED. HALVES OF PLUGS ARE CEMENTED TOGETHER WITH EPOXY RESIN AND SIMILARLY CEMENTED INTO THE BOREHOLE FROM WHICH RESISTANCE MEASUREMENTS WERE MADE DURING LOADING. BOTH BRASS AND STONE PLUGS WERE USED. RESULTS WERE FOUND TO DE SATISFACTORY AND REPRODUCIBLE. STRESS IN THE PLUGS IS RELATED TO STRESS IN THE SURROUNDING ROCK BY FORMULAE DERIVED FROM THE WORK OF A. COUTINHO.

12-61-03012 THE NATURAL ARCH, THE FRACTURE PATTERN AND THE SEQUENCE OF FAILURE IN MASSIVE ROCK SURROUNDING AN UNDERGROUND OPENING (GEOLOGIC-PROCESSES DEFORMATION STRESS ELASTIC PLASTIC REBOUND)
LIVINGSTON, C. W. & BARODYN INC GEORGETOWN COLLEGE
THE PA. STATE UNIV., BULLETIN OF THE MINERAL INDUSTRIES EXPERIMENT STATION, PROC OF THE FOURTH SYMP ON ROCK MECHANICS, 197-204, MAR. 30, 31, APRIL 1, 1961. THROUGHOUT GEOLOGIC TIME, MOUNTAIN BUILDING HAS BEEN FOLLOWED BY EROSION AND SUBSIDENCE. ROCKS OF THE EARTH'S CRUST WERE LOADED, THEN UNLOADED. DURING LOADING, ROCKS ARE DEFORMED BY FLOWAGE OR BY FRACTURE. SIMILARLY DURING UNLOADINGS, DEFORMATION BY ELASTIC REBOUND WITHIN THE ELASTIC LIMIT FRACTURE OCCURS. THE SCIENTIFIC PRINCIPLES APPLY TO THE BEHAVIOR OF ROCK SUBJECT TO EITHER THE FORCES OF NATURE OR TO FORCES OCCURRING AS A RESULT OF MAN-MADE EXCAVATIONS. FRACTURES WITHIN A ROCK MASS ARE CLASSIFIED EITHER AS OCCURRING DURING LOADING OR DURING UNLOADING AND THE ATTITUDE OF THE FRACTURE IS RELATED TO THE ORIENTATION OF THE PRINCIPAL STRAIN AXES. THE SHAPES OF NATURAL ARCHES PRODUCED BY STATIC LOADING AND UNLOADING OF SANDSTONE AS IN NATURE AND AS A RESULT OF THE DYNAMIC LOADING OF A CIRCULAR OPENING IN SANDSTONE ARE ILLUSTRATED. THE SEQUENCE IN WHICH FRACTURES ARE FORMED AROUND THE OPENING IS DESCRIBED AND THE ORIENTATION OF THE FRACTURES IS COMPARED WITH THEORETICAL ORIENTATION OF LOADING AND UNLOADING FRACTURES RELATIVE TO THE PRINCIPAL AXES OF STRAINS.

12-61-03013 RIB CONTROL OF BEDDED ROOF STRESSES (BEAM-THEORY ANALYSIS ABUTMENT-LOADS ELASTIC-FOUNDATION)
ADLER, L. & MICH COLLEGE
THE PA. STATE UNIV., BULLETIN OF THE MINERAL INDUSTRIES EXPERIMENT STATION, PROC OF THE FOURTH SYMP ON ROCK MECHANICS, 205-210, MAR. 30, 31, APRIL 1, 1961. THE ANALYSIS OF STRESSES SURROUNDING AN UNDERGROUND OPENING IN BEDDED ROCK RELIES PRIMARILY ON BEAM THEORY WITH ITS SIMPLIFYING ASSUMPTIONS. CERTAIN ASSUMPTIONS PERMIT DEALING WITH A SUFFICIENTLY SIMPLE STRUCTURE THAT EMPHASIZE THIS DEPARTURE FROM CONVENTIONAL ANALYSIS. THE SIMPLIFIED STRUCTURE CONSISTS OF THE MAIN ROOF LOADED ONLY BY ITS OWN WEIGHT AND THE RIB. STRUCTURAL AND FOUNDATION ENGINEERING ARE CONFRONTED WITH THE SAME PROBLEM OF UNCERTAIN SUPPORT CONDITIONS AND EACH HAS DEVELOPED USEFUL APPROACHES TO HANDLE IT. THE ANALYSIS PROPOSED HERE EMPLOYS THE THEORY OF "BEAMS ON ELASTIC FOUNDATIONS". THE SUPPORT OR FOUNDATION IS ASSUMED TO DEFLECT AN AMOUNT PROPORTIONAL TO ITS LOCAL LOAD TERMED THE FOUNDATION MODULUS. THIS ASSUMES A FOUNDATION COMPOSED OF ADJACENT YET INDEPENDENT, DIFFERENTIAL ELASTIC PRISMSS, ORIENTED WITH THEIR FINITE AXIS NORMAL TO THE BEAMS LONGITUDINAL AXIS. PHYSICALLY THIS IS LIKENED TO SUPPORTING A BEAM ON A BED OF CLOSELY SPACED, ALTHOUGH SEPARATED SPRINGS. ADVANTAGES AND DISADVANTAGES OF THE METHOD ARE LISTED AND RECOMMENDATIONS ARE MADE FOR A COMPREHENSIVE PROGRAM OF EXPERIMENTAL VERIFICATION AND CORRELATION.

12-61-03014 FLAT JACKS PRE-LOAD MASSIVE MINE SUPPORTS (UNDERGROUND CONCRETE MEASUREMENT PILLARS PRE-LOADING-FORCE GROUTING SLOPE-DIVERGENCE)
REED, J. J. + MANN, C. D. & COLO SCHOOL OF MINES GOLDEN COLO
THE PA. STATE UNIV., BULLETIN OF THE MINERAL INDUSTRIES EXPERIMENT STATION PROC OF THE FOURTH SYMP ON ROCK MECHANICS, 211-220, MAR. 30, 31, APRIL 1, 1961. PAST EXPERIENCE SUBSTANTIATED BY 20 YEARS OF COMPRESSION MEASUREMENTS ON PILLARS BUILT IN 1938 HAS DEMONSTRATED THAT CONCRETE PILLARS WHICH ARE NOT PRE-LOADED WILL NEVER CARRY APPRECIABLE WEIGHT BY NATURAL LOADING UNTIL THE ROOF ROCKS AND ADJACENT ROCK PILLARS ARE ALREADY FAILING. EARLY EFFORTS AT PRE-LOADING USED SCREW JACKS BETWEEN PILLAR TOPS AND ROOF BUT THE WEIGHT CARRIED WAS LITTLE MORE THAN THE PILLAR ITSELF. A MUCH MORE POWERFUL PRE-LOADING FORCE WAS CLEARLY REQUIRED. EARLY EXPERIMENTAL WORK AND KNOWLEDGE OF THE USE OF FLAT JACKS IN FRANCE LED TO THE SOLUTION DESCRIBED. TESTS ON A SERIES OF TEN PILLARS, 7 OF PRE-CAST CONCRETE AND 3 CAST IN PLACE, ARE DESCRIBED. MEASUREMENTS OF HYDRAULIC JACKING PRESSURES, JACK OPENINGS, STRENGTH OF CONCRETE, YOUNGS MODULUS, AND AVERAGE STOPE DIVERGENCE ARE TABULATED. DESCRIPTIONS ARE GIVEN OF PILLAR CONSTRUCTION, FLAT JACKS, HYDRAULIC PUMPING PROCEDURE, GROUTING, AND STRAIN MEASUREMENT. THESE METHODS PROVIDE A CONTROLLABLE FORCE FOR GROUND SUPPORT WHICH APPROACHES THE FORCE WHICH MUST BE WITHSTOOD.

12-61-03015 HYPOTHESIS FOR THE MECHANISM OF ROCK FAILURE UNDER IMPACT (DRILLING CHISEL-EDGE PENETRATION STRAIN-GAGES ANALYSIS WAVE-ACTION)
SINGH, M. M. + HARTMAN, H. L. & GULF RES AND DEV CO PITTSBURGH
THE PA. STATE UNIV., BULLETIN OF THE MINERAL INDUSTRIES EXPERIMENT STATION, PROC OF THE FOURTH SYMP ON ROCK MECHANICS, 221-228, MAR. 30, 31, APRIL 1, 1961. VARIOUS THEORIES ON THE MECHANISM OF ROCK FRACTURE AND EARLIER STUDIES OF DRILLING LEADING TO AN UNDERSTANDING OF THE MODES OF FAILURE ARE REVIEWED. THE PAPER REPORTS RESULTS OF EXPERIMENTAL STUDY OF SINGLE, ISOLATED BLOWS OF A CHISEL ON ROCK TO PROVIDE A LOGICAL BEGINNING FOR INVESTIGATIONS LEADING TO AN UNDERSTANDING OF THE PHENOMENON OF ROCK FAILURE UNDER IMPACT. TESTS WERE PERFORMED ON A SPECIAL SYNTHETIC ROCK PREPARED IN THE MANNER OF CONCRETE TO REDUCE THE EFFECTS OF INHOMOGENEITIES. A FEW CONFIRMATIONAL TESTS WERE CONDUCTED ON NATURAL ROCK (BARRE GRANITE AND SOLENHOFEN LIMESTONE) AND ON PLEXIGLAS. STRAIN GAGES WERE ATTACHED TO THE ROCK AROUND THE LINE OF BIT CONTACT. TRANSIENT-STRAIN PULSES WERE RECORDED WITH OSCILLOSCOPES AND ANALYZED. A THEORETICAL ANALYSIS OF WAVE ACTION IS DESCRIBED AND ILLUSTRATED WITH OSCILLOSCOPE TRACE PHOTOS. A HYPOTHESIS OF FAILURE IS PROPOSED FROM THE EXPERIMENTAL RESULTS AND LIMITATIONS OF THE HYPOTHESIS ARE INCLUDED.

12-61-03016 RATE OF LOADING EFFECTS IN CHISEL IMPACT (ROLLER-CONE-BITS PERCUSSIVE-DRILLING PENETRATION-TIME ANALYSIS FREQUENCY)
APPEL, F. C. + GATLEY, W. S. & KANSAS STATE U MANHATTAN KANSAS
THE PA. STATE UNIV., BULLETIN OF THE MINERAL INDUSTRIES EXPERIMENT STATION, PROC OF THE FOURTH SYMP ON ROCK MECHANICS, 229-236, MAR. 30, 31, AND APRIL 1, 1961. THIS PAPER PRESENTS A COMBINED ANALYTICAL AND EXPERIMENTAL STUDY OF CHISEL PENETRATION VS. TIME DURING CHISEL IMPACT ON ROCK, A PROBLEM OF FUNDAMENTAL IMPORTANCE IN IMPROVING PERFORMANCE OF ROLLER CONE BITS OR PERCUSSIVE-TYPE DRILLING APPARATUS. THE ROCK BEHAVIOR TO IMPACT WAS SIMULATED APPROXIMATELY BY AN EQUIVALENT LUMPED SYSTEM, OR AN EQUIVALENT MASS, SPRING, DASHPOT SYSTEM. AN ANALYTICAL SOLUTION IS DESCRIBED FOR CHISEL PENETRATION VS. TIME DUE TO A SINUSOIDAL LOAD BETWEEN CHISEL AND ROCK. CURVES ARE DRAWN OF MAXIMUM DEPTH PENETRATION VS. FREQUENCY OF SINUSOIDAL LOADING AND ENERGY TRANSFER VS. FREQUENCY. RESULTS OF THE ANALYSIS WERE USED TO PREDICT PENETRATION RATE OF ROTARY BITS VS. ROTARY SPEED. TO VERIFY THIS ANALYSIS EXPERIMENTAL APPARATUS WERE CONSTRUCTED AND TESTS WERE RUN WITH A SINUSOIDAL LOADED CHISEL IMPACT. STRAIN AND VELOCITY WERE MEASURED AND RECORDED BY PHOTOGRAPHS OF OSCILLOSCOPE TRACES SIMULTANEOUSLY. GOOD AGREEMENT WAS OBTAINED WITHIN THE FREQUENCY RANGE OF THE EXPERIMENTS BUT THE SMALL INERTIA EFFECT (PEAK PENETRATION) OCCURRED AT A FREQUENCY MUCH HIGHER THAN COULD BE OBTAINED. THUS A RATE-OF-LOADING EFFECT IS INDICATED THEORETICALLY BUT HAS NOT BEEN VERIFIED AS YET.

12-61-03017 PHOTOGRAPHIC STUDY OF ROCK FAILURE IN DRAG BIT DRILLING (SEDIMENTARY-ROCK ROCK-SAMPLES CUTTING TOOL RAKE-ANGLE CUTTING-SPEED STRAIN-GAGE FORCE-SIGNAL MOVIES)
GRAY, K. E. + GATLIN, C. & UNIV TEXAS AUSTIN TEX
THE PA. STATE UNIV., BULLETIN OF THE MINERAL INDUSTRIES EXPERIMENT STATION, PROC OF THE FOURTH SYMP ON ROCK MECHANICS 237-242, MAR. 30, 31, APRIL 1, 1961. PRELIMINARY EXPERIMENTAL RESULTS ARE PRESENTED FOR TWO DIMENSIONAL CUTTING OF SEDIMENTARY ROCKS BY A FIXED BLADE. ALL CUTS WERE HORIZONTAL; HENCE THE TRUE HELICAL PATH OF AN ACTUAL DRILL BIT WAS NOT SIMULATED. ROCK SAMPLES WERE MOUNTED ON A CONVENTIONAL STEP-TOE SHAPER RAM AND THE CUTTING TOOL ASSEMBLY WAS HELD RIGIDLY IN THE VISE ON THE SHAPER BED. MOVIES OF THE CUTTING PROCESS WERE OBTAINED AT CAMERA SPEEDS OF 5000 TO 8000 FRAMES PER SECOND WITH MAGNIFICATION OF 4 ONTO THE FILM. STRAIN GAGES ON THE HEAD OF THE CUTTING TOOL ASSEMBLY PROVIDED BOTH HORIZONTAL AND VERTICAL FORCE SIGNALS TO AMPLIFIERS THEN TO A RECORDER. TEST VARIABLES INCLUDED CUTTING TIP RAKE ANGLE, CUTTING SPEED, AND CUT DEPTHS. CURVE PLOTS ARE PROVIDED TO SHOW RELATIONSHIP AND A FILM SEQUENCE SHOWS THE CUTTING ACTION. RELATIVELY SMALL INCREASES IN TOOL FORCES ARE REQUIRED TO INCREASE CUT DEPTH IN THE CHIPPING REGION. TOOL FORCES INCREASE AT AN INCREASING RATE AS RAKE ANGLE INCREASES. HIGHER CUTTING SPEEDS REQUIRE SUBSTANTIALLY HIGHER FORCES AT A GIVEN CUT DEPTH. HOWEVER, THE VERTICAL FORCE COMPONENT INCREASES MORE THAN THE HORIZONTAL. ACTUAL CONTACT AREA BETWEEN CUTTING TIP AND ROCK WAS LITTLE AFFECTED BY CUT DEPTH OR TOOTH GEOMETRY ONCE THE CHIPPING PHASE WAS REACHED. THE CONTACT HEIGHT WAS MUCH LESS THAN THE CUT DEPTH.

12-61-03018 STRATA MOVEMENT FROM UNDERGROUND OPENINGS (SUBSIDENCE PILLARS EXTRACTION-RATE SURFACE-DAMAGE FILLING)
FALKIE, T. V. & PENN STATE UNIV
THE PA. STATE UNIV., BULLETIN OF THE MINERAL INDUSTRIES EXPERIMENT STATION, PROC OF THE FOURTH SYMP ON ROCK MECHANICS, 243-246, MAR. 30, 31, APRIL 1, 1961. A SUMMARY OF THE BUZZ SESSION (GROUP DISCUSSION) ON TITLE SUBJECT. THE EFFECTS OF SURFACE SWEREDENCE WAS DISCUSSED AND VARIOUS FORMS OF CONTROL LEGISLATION IN VARIOUS STATES ARE OUTLINED. METHODS OF CONTROL AND EFFECTS OF LACK OF CONTROL ARE ILLUSTRATED BY EXPERIENCES IN VARIOUS MINING AREAS. THE USE OF PILLARS TO MINIMIZE SURFACE SUBSIDENCE AND RESULTING FIRE HAZARDS AND STREAM POLLUTION ARE CONSIDERED. PRACTICES IN EUROPE ARE COMPARED TO THOSE IN THE UNITED STATES. LEGAL LIABILITY IS DISCUSSED ALONG WITH EUROPEAN METHODS USED TO EVALUATE DAMAGES DUE TO SUBSIDENCE AND ASSESS PAYMENTS BY MINES. DISPOSAL AND HANDLING OF GAS LIBERATED DURING COAL MINING WAS ALSO DISCUSSED. LATERAL MOVEMENTS IN OPEN CUTS AND QUARRIES DUE TO LARGE HORIZONTAL FORCES WERE DISCUSSED WITH CONCENTRATION ON CAUSE AND EFFECT.

12-61-03019 BEHAVIOR OF ROCK UNDER STATIC LOADING (GROUND-PRESSURE TECTONIC-PRESSURE FRACTURE-STRENGTH FLOW CRACK-PROPAGATION)
TANDANAND, S.
THE PA. STATE UNIV., BULLETIN OF THE MINERAL INDUSTRIES EXPERIMENT STATION, PROC OF THE FOURTH SYMP ON ROCK MECHANICS 247-248, MAR. 30, 31, APRIL 1, 1961. A SUMMARY OF THE BUZZ SESSION (GROUP DISCUSSION) ON THE TITLE SUBJECT. THE DISCUSSION CENTERED ON THE QUESTIONS OF THE BEHAVIOR OF ROCK UNDER TRIAXIAL COMPRESSION AND ON FLOW AND FRACTURE IN ROCKS.

12-61-03020 BEHAVIOR OF ROCK UNDER DYNAMIC LOADING (SOURCE-ZONE TRANSITION-ZONE SEISMIC-ZONE ROCK COMPRESSIVE-STRESS PULSE ELASTIC ABSORPTION SCABBING)
PINTO, J., JR.
NATL GYMPSUM CO BELLEF PA THE PA. STATE UNIV., BULLETIN OF THE MINERAL INDUSTRIES EXPERIMENT STATION, PROC OF THE FOURTH SYMP ON ROCK MECHANICS, 249-250, MAR. 30, 31, APRIL 1, 1961. A SUMMARY OF THE BUZZ SESSION (GROUP DISCUSSION) ON THE TITLE SUBJECT. THREE ZONES OF INTEREST WERE DISCUSSED (1) THE SOURCE ZONE, (2) THE TRANSITION ZONE, AND (3) THE SEISMIC ZONE. THE SOURCE ZONE IS CONCERNED WITH THE ORIGIN OF THE DYNAMIC LOAD DUE TO SUDDEN RELEASE OF STORED ELASTIC STRAIN ENERGY SUCH AS EXPLOSIVES. THE TRANSITION ZONE SURROUNDS THE SOURCE ZONE. EQUATIONS OF STATE FOR ROCKS ARE NEEDED BEYOND THE ELASTIC LIMIT TO DEVELOP THEORIES TO DESCRIBE THE EFFECTS IN THE SOURCE ZONE. TO DATE THERE IS NO SATISFACTORY THEORY TO ACCOUNT FOR THE VARIOUS PHENOMENA THAT OCCUR IN THE TRANSITION ZONE OR TO PREDICT THE SIZE OF THIS REGION FROM A KNOWLEDGE OF ROCK PROPERTIES AND SOURCE PROPERTIES. THE STRONG COMPRESSIVE STRESS PULSE RADIATED OUTWARD FROM THE TRANSITION ZONE IS DISCUSSED IN RELATION TO INTENSITY OF SOURCE AND PROPERTIES OF ROCK. THE SEISMIC ZONE SURROUNDS THE TRANSITION ZONE AND PROPAGATION OF THE STRESS PULSE IS NEARLY ELASTIC. SCABBING IS ALSO DISCUSSED AND PREVENTIVE METHODS ARE SUGGESTED.

12-61-03021 STRESS MEASUREMENT AND GROUND CONTROL (STRESS-RELIEF CRACK ELASTIC-MODULUS FRACTURED-ROCK)
JACKSON, I. & PENN STATE UNIV
THE PA. STATE UNIV., BULLETIN OF THE MINERAL INDUSTRIES EXPERIMENT STATION, PROC OF THE FOURTH SYMP ON ROCK MECHANICS 251, MAR. 30, 31, APRIL 1, 1961. A SUMMARY OF THE BUZZ SESSION (GROUP DISCUSSION) ON THE TITLE SUBJECT. TWO MAJOR ITEMS WERE DISCUSSED. ONE WAS THE STRESS RELIEF METHOD AND THE OTHER OF MEASURING A MINE OPENING BY INDUCING A CRACK IN THE WALL. TRANSPOSING OF STRAIN TO STRESS BY USE OF THE ELASTIC MODULUS OF ROCK MET WITH RESERVATIONS ESPECIALLY IN ROCKS THAT SHOW PLASTIC DEFORMATION. IN STRESS RELIEF ONLY ELASTIC REBOUND IS MEASURED SO THAT THE FIGURES ARRIVED AT ARE LOW. LOW MODULUS STRAIN GAGES ARE ADVISED OVER HIGH MODULUS GAGES SINCE ERRORS ARE SMALLER AND HIGH STRAIN LEVELS CAN BE HELD FOR CONSIDERABLE PERIODS. A METHOD OF MEASURING STRESS AROUND A MINE OPENING WAS SUGGESTED CONSISTING OF THE CUTTING OF A NARROW SLOT IN THE SIDE OF THE OPENING. HYDRAULIC PRESSURES APPLIED TO THE SLOT CAUSE A CRACK TO FORM WHICH CLOSES WHEN HYDRAULIC PRESSURE IS RELEASED. WHEN HYDRAULIC PRESSURE IS REAPPLIED IT IS THOUGHT THAT THE PRESSURE REQUIRED TO FORCE THE CRACK OPEN IS EQUAL TO THE ROCK STRESS PERPENDICULAR TO THE CRACK. A FORMULA IS PROPOSED BASED ON PRESSURE, STRESS, AND ROCK PROPERTIES. THE CONSENSUS OF THE GROUP WAS THAT SUCH A TECHNIQUE WAS WORTH INVESTIGATING.

12-62-05001 INVESTIGATION OF DYNAMIC FAILURE BY HIGH-SPEED PHOTOGRAPHY (DEFORMATION DRILLING IMPACT PHOTOELASTIC)
TANDANAND, S. + HARTMAN, H. L. & PENN STATE UNIV
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 1-32, MAY 1962. IMPACT TESTS WERE MADE ON THE EDGE OF 5 X 8 X 1/2 INCH PLEXIGLAS AND GLASS PLATES WITH A 90 DEGREE CHISEL EDGE ASSEMBLY WEIGHING 8.5 LBS. DROPPED FROM A TWO FOOT HEIGHT (IMPACT VELOCITY 11 FT PER SEC). PHOTOELASTIC ANALYSIS WAS MADE BY TAKING PICTURES AT 6.5 MILLIONTHS OF A SECOND INTERVALS. THE SEQUENCE OF FRACTURE EVENTS IS BELIEVED TO BE AS FOLLOWS: A ZONE OF PLASTIC DEFORMATION IS PRODUCED, THE MAJOR VERTICAL CRACK FORMS, MINOR CRACKS FORM ALONG SHEAR TRAJECTORIES, REDISTRIBUTION OF IMPULSIVE FORCE PROPAGATES RADIAL FRACTURES, PROCESS RESEMBLES STATIC FAILURE MORE THAN FAILURE UNDER IMPULSIVE FORCES OF EXTREMELY SHORT DURATION SUCH AS DETONATED EXPLOSIVES. THIS INVESTIGATION HAS SHED SOME LIGHT ON THE FRACTURE OF BRITTLE MATERIALS WHICH MAY HAVE APPLICATION IN ROCK PENETRATION AND DRILLING PROCESSES.

12-62-05002 DYNAMIC ROCK PENETRATION TESTS AT ATMOSPHERIC PRESSURE (CRATER IMPACT PENETRATION ENERGY)
VANZANT, B. W. & SHELL DEV CO HOUSTON
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 61-91, MAY 1962. PENETRATORS OF VARIOUS WEIGHTS HAVE BEEN IMPELLED AT VELOCITIES OF UP TO 2000 FT PER SEC INTO CEMENT AND MARBLE. THE CRATER DEPTHS AND VOLUMES IN EACH TARGET MATERIAL WERE ESSENTIALLY THE SAME FOR CONSTANT IMPACT ENERGY, REGARDLESS OF BULLET MASS OR VELOCITY. PENETRATION WAS LESS THAN LINEARLY RELATED TO THE INITIALLY AVAILABLE ENERGY, WHEREAS THE VOLUME OF ROCK DESTROYED WAS GREATER THAN LINEARLY PROPORTIONAL TO THE ENERGY. THE PROPORTIONALITY BETWEEN PENETRATION AND ENERGY APPEARS TO BE DETERMINED BY THE ROCK ALONE. THESE RESULTS MAY DIFFER FROM DYNAMIC TESTS WITH TARGETS UNDER PRESSURE.

12-62-05003 ESTIMATING DRILLABILITY IN THE LABORATORY (BIT-MATERIAL-LIFE PENETRATION ROTARY-BITS MICROBIT)
ROLLOW, A. G. & HUGHES TOOL CO HOUSTON TEX
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 93, MAY 1962. PENETRATION AND WEAR DATA FROM A MICROBIT MADE FROM A SIZE 0 EMERY WHEEL DRESSER (1 1/4 INCH DIAMETER) REVOLVED AT 55 RPM UNDER A 200 LB LOAD ON A SAMPLE HAVE BEEN USED TO SATISFACTORILY DETERMINE THE TYPE MATERIAL FOR 4 1/4 TO 12 1/4 INCH DIAMETER ROTARY BITS AND THE PREDICTED LIFE AND PENETRATION. BOTH BORE HOLE AND BLAST-HOLE PENETRATION PREDICTIONS CAN BE MADE.

12-62-05004 MECHANICAL PROPERTIES AND DRILLABILITY OF ROCKS (HARDNESS PLASTICITY ABRASIVITY PNEUMATIC ROTARY PROTODYAKONOV-STRENGTH-COEFFICIENT)
PROTODYAKANOV, M. M. & USSR MINING INST MOSCOW
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 103-118, MAY 1962. IN ORDER TO CHARACTERIZE THE MECHANICAL PROPERTIES OF ROCKS IN DRILLING THEIR HARDNESS, PLASTICITY AND ABRASIVITY ARE ESSENTIAL. FOR PERCUSSIVE DRILLING, HARDNESS AND PLASTICITY ARE RELEVANT, FOR ROTARY DRILLING HARDNESS AND ABRASIVITY MATTER THE MOST. DETERMINING THE PROTODYAKONOV ROCK STRENGTH COEFFICIENT AND THE ROCK HARDNESS AND ABRASIVITY BY THE PTA TECHNIQUE ARE DESCRIBED. CRITICAL IMPACT AND AXIAL FORCES EXIST FOR DIFFERENT TYPES OF DRILLING AT WHICH DRILLING SPEED INCREASES SHARPLY. AN EMPIRICAL FORMULA IS GIVEN FOR DETERMINING OPTIMAL DRILLING. THIS DEPENDS ON THE PROTODYAKONOV ROCK STRENGTH COEFFICIENT, THE HOLE DIAMETER AND THE PNEUMATIC DRILL CAPACITY. IF ACTUAL DRILLING IS NOT IN THE RANGE GIVEN BY THE EMPIRICAL FORMULA CHECK FOR ABNORMAL OPERATING CONDITIONS. IT IS PROPOSED THAT A ROCK DRILLABILITY CLASSIFICATION BE COMPILED FROM PERFORMANCE OF A GRADUATED PNEUMATIC DRILL OPERATING IN STANDARD CONDITIONS.

12-62-05005 DRILLING STRESSES ON DRY BIT CUTTING EDGES (DIAMOND-BIT DRAG-BIT ROLLER-CONE-BIT ROTARY-PERCUSSION-BIT CUTTING-EDGE-STRESS)
APPEL, F. C. + ROWLEY, D. S. & KANSAS STATE U MANHATTAN KANSAS
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 119-136, MAY 1962. ROTARY-PERCUSSION, DIAMOND AND ROLLER CONE BITS HAVE SUPPLANTED DRAG BITS IN MINING BUT IN OILWELLS DRAG BITS STILL ARE USED WHERE ROLLER CONES OR DIAMOND DRILLS ARE NOT MORE ECONOMICAL. DRAG BIT DRILLING STRESSES HAVE BEEN DETERMINED ANALYTICALLY. CALCULATED MAXIMUM DRILLING STRESSES AT THE BLADE CUTTING EDGE RANGED UP TO 320,000 PSI FOR AN EXTREME DRAG BIT DRILLING SITUATION IN A HARD FORMATION. RESULTS SHOWED STRESSES APPROACHING SINTERED TUNGSTEN CARBIDE STRENGTH WERE POSSIBLE IN HARD FORMATIONS WITH SLIGHTLY ROUNDED BLADE EDGE. LOWEST DRILLING STRESSES WERE WITH THE SHARPEST LEADING EDGES. SHARPNESS EFFECT WAS FOUND TO BE MORE IMPORTANT FOR LOW DRILLING RATE AND HARDER FORMATIONS.

12-62-05006 ENERGY & SIZE DISTRIBUTION ASPECTS OF SINGLE PARTICLE CRUSHING (FLAWS)
BERGSTROM, R. H. & ALLIS-CHALMERS MFG CO
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 155-172, MAY 1962. WHEN A SINGLE CRUSHING EVENT IS CONSIDERED THE CIRCUMSTANCES NECESSARILY APPROXIMATE THOSE OF SINGLE PARTICLE CRUSHING. CORRELATION OF COMMERCIAL DATA YIELD SATISFACTORY EQUATIONS FOR DESIGN PURPOSES BUT TO DEVELOP A COMPLETELY UNIFIED CRUSHING THEORY, SINGLE PARTICLE CRUSHING MUST BE UNDERSTOOD. FRACTURING OF SPHERICAL OR ROUNDED SPECIMENS DEPENDS ON THE AVERAGE SPACING OF ACTIVATED EDGE FLAWS.

12-62-05007 ELECTRICAL DISINTEGRATING DRILLING (CURRENT-DENSITY ELECTRIC-ARC THERMAL-STRESS)
SARAPUU, E. & ELECTROFRAC CORP KC MO
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 173-183, MAY 1962. ELECTRIC POWER HAS BEEN RECOMMENDED AND USED IN SEVERAL FORMS OF DRILLING BEFORE THIS NEW APPROACH IN WHICH A HIGH CURRENT DENSITY GENERATES STRONG ELECTRIC STRESS CONCENTRATION AT THE EDGES AND POINTS OF THE ELECTRIC DRILL BIT. THE HIGH TEMPERATURE CREATED BY ELECTRIC CURRENT FLOW COMBINED WITH CHEMICAL DECOMPOSITION AND PHYSICAL FRACTURING OF MINERAL AGGREGATES DISINTEGRATES THE ROCK UNDER THE DRILL BIT. THERMAL STRESSES ARE INCREASED BY THE COOLING EFFECT OF THE DRILL COOLING AIR. TEST RESULTS SHOW THAT PENETRATION RATES ARE GREATLY INCREASED BY THE PROPER APPLICATION OF ELECTRICITY TO A DRILL BIT.

12-62-05008 THE SECONDARY BREAKING EFFECT OF HIGH-FREQUENCY ELECTRIC ENERGY APPLIED TO ROCK FRAGMENTS (CONDENSERS FRACTURING SHIELDING)
YOUNG, F. M. & MONTANA SCHOOL OF MINES
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 185-204, MAY 1962. MECHANICAL FRACTURING OF DIELECTRIC ROCK MATERIAL PARTICULARLY LOW-GRADE DISSEMINATED COPPER ORE AND ASSOCIATED WASTE MATERIALS CAN BE ACCOMPLISHED BY USING HIGH FREQUENCY ELECTRIC ENERGY. IT WAS FOUND THAT FREQUENCIES BETWEEN 250 KC PER S AND 27 MC PER S CAUSED MECHANICAL FAILURE. UTILIZATION OF PULSE POWER FROM CAPACITOR BANKS WAS UNSUCCESSFUL. TIME FOR SWITCH-OVER FROM HIGH FREQUENCY PULSE POWER WAS SUFFICIENTLY LONG SO THAT THE RESISTANCE OF THE ROCK ROSE TO A LEVEL THAT THE VOLTAGE AVAILABLE WAS NOT ABLE TO DRIVE CURRENT THROUGH THE ROCK. SHIELDING METHODS AND SAFE WORKING PROCEDURES WILL HAVE TO BE FORMULATED WHEN A WORKING UNIT IS UTILIZED.

12-62-05009 FEASIBILITY OF MODEL STUDIES IN BLASTING RESEARCH (CRATER-BLASTING-CAPS CHARGE)
JOHNSON, J. R. & U.S. BUR MINES
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 263-271, MAY 1962. LABORATORY CRATERING EXPERIMENTS WITH A NO. 6 CAP HAVE BEEN COMPARED WITH FIELD RESULTS UTILIZING CHARGES WEIGHING FROM ONE TO 32 LBS. HIGH-SPEED MOVIES HAVE BEEN USEFUL IN DEMONSTRATING THE SIMILARITY OF THE FRACTURING AND FRAGMENT MOTION IN LARGE AND SMALL SCALE BLASTING.

12-62-05010 EXPLOSIVE PERFORMANCE AS RELATED TO BLASTING (COUPLING DENSITY-EXPLOSIVE DETONATION-VELOCITY IMPULSE THRUST)
SADWIN, L. D. + OKUBO, S. + KENNEDY, J. E. & ARMOUR FOUNDATION ILL TECH
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 307-312, MAY 1962. PERFORMANCE PARAMETERS ARE GIVEN FOR PRESSURE AND STRAIN IN TERMS OF DISTANCE FROM THE EXPLOSIVE CHARGE, EXPLOSIVE CHARGE WEIGHT AND INITIAL DENSITY, DETONATION VELOCITY AND TIME. A CIRCUMFERENTIAL AIR GAP BETWEEN EXPLOSIVE AND BORE HOLE KNOWN AS POOR COUPLING WILL CONSIDERABLY REDUCE THE EFFICIENCY OF THE STRESS TRANSMISSION. UPWARDS OF 50 PERCENT OF THE EXPLOSIVE ENERGY IS EXPENDED IN THRUST WHILE ONLY 15 PERCENT IS IN THE FORM OF SHOCK OR STRAIN ENERGY. FURTHER INVESTIGATIONS ARE WARRANTED TO UNDERSTAND THE INFLUENCE OF IMPULSE AND THRUST ENERGY IN ROCK BREAKAGE.

12-62-05011 EFFECT OF DECOUPLING ON EXPLOSION-GENERATED STRAIN PULSES IN ROCK (COUPLING DYNAMIC-FAILURE)
ATCHISON, T. C. + DUVALL, W. I. & U.S. BUR MINES WASH D.C.
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 313-329, MAY 1962. SMALL CYLINDRICAL HIGH-VELOCITY GELATIN DYNAMITE CHARGES OF SEVERAL DIAMETERS WERE DETONATED IN VARIOUSLY SIZED HOLES IN GRANITE ROCK AND THE RESULTING STRAIN PULSES WERE RECORDED AT DISTANCES RANGING FROM 5 TO 100 FEET. THE AMPLITUDE AND PERIOD OF THE STRAIN PULSES WERE STUDIED AS FUNCTIONS OF THE DECOUPLING WHICH IS THE HOLE TO CHARGE DIAMETER RATIO. ROCK STRAIN PULSE AMPLITUDE AND PERIOD DECREASE AS DECOUPLING INCREASES. DYNAMIC FAILURE STRENGTH IS SEVERAL TIMES THE LABORATORY STATIC FAILURE STRENGTH. A SATISFACTORY EXPLANATION OF THE EXPERIMENTAL RESULTS IS DERIVED FROM SIMPLE THEORETICAL CONSIDERATIONS.

12-62-05012 EFFECT OF CHARACTERISTIC IMPEDANCE ON EXPLOSION-GENERATED STRAIN PULSES IN ROCK (ACOUSTIC SHOCK)
NICHOLS, H. R. + DUVALL, W. I. & U.S. BUR MINES WASH D.C.
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 331-346, MAY 1962. THE EFFECT OF THE RATIO OF CHARACTERISTIC IMPEDANCE ON EXPLOSION-GENERATED STRAIN AMPLITUDES AND STRAIN ENERGIES HAS BEEN INVESTIGATED THEORETICALLY AND EXPERIMENTALLY. ALTHOUGH THE THEORY POSTULATED IS FOR PLANE WAVES, OBSERVED DATA AGREE WITH PREDICTIONS BASED ON SHOCK WAVE THEORY. THE EFFECT OF CHARACTERISTIC IMPEDANCE WAS SHOWN TO BE MUCH GREATER THAN ACOUSTIC THEORY PREDICTIONS. THE MEDIUM STRESS CAN BE EXPRESSED IN TERMS OF SOME CONSTANT, THE RATIO OF CHARACTERISTIC IMPEDANCE OF EXPLOSIVE TO ROCK AND THE DETONATION PRESSURE. TABLES FOR PROPERTIES AND CONSTANTS OF HIGH VELOCITY GELATIN, SEMI-GELATIN, TNT AND AMMONIUM DYNAMITE ARE GIVEN.

12-62-05013 SYNTHESIS OF SHOCK HUGONIOTS FOR ROCK MATERIAL (COMPRESSION DENSITY PRESSURE PROPAGATICN SHOCK)
CHABAI, A. J. & SANDIA CORP
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 347-366, MAY 1962. THE HUGONIOT EQUATION IS A UNIQUE RELATICNSHIP BETWEEN PRESSURE AND DENSITY FOR ANY GIVEN MEDIUM. IT REPRESENTS THE LOCUS OF THOSE THERMODYNAMIC STATES WHICH MAY BE ATTAINED IN THE MEDIUM BY MEANS OF SHOCK WAVES, STARTING WITH THE MEDIUM IN SOME INITIAL STATE. METHODS WERE PRESENTED FOR OBTAINING ESTIMATES OF THE HUGONIOT EQUATION OF STATE OF GEOLOGIC MATERIALS. FOR NONPOROUS MULTICOMPONENT SOLIDS, THE ASSUMPTION IS MADE THAT THE SHOCK PRESSURE IN THE SOLID IS EQUAL TO THE SUM OF THE PARTIAL SHOCK PRESSURES OF THE SOLIDS CONSTITUENTS. IN MANY INSTANCES GOOD APPROXIMATIONS ARE OBTAINED. FOR POROUS MULTICOMPONENT SOLIDS, HUGONIOT SYNTHESIS WAS PERFORMED BY THE METHOD OF LYAKHOV IN WHICH A SUMMATION OF COMPRESSIONS IS PERFORMED. DESPITE THE CRUDENESS OF THE METHODS, USEFUL RESULTS ARE OBTAINED FOR STUDY OF THE PROBLEM OF SHOCK WAVES PROPAGATING FROM BURIED EXPLOSIONS.

12-62-05014 CURRENT STATE OF KNOWLEDGE ON ANGLE DRILLING IN SURFACE OPERATIONS (BENCH-HEIGHT BURDEN POWDER-FACTOR)
KOCHANOWSKY, B. J. & PENN STATE UNIV
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 367-375, MAY 1962. ANGLE DRILLING UP TO 45 DEGREE INCLINATION WILL PRODUCE COST SAVINGS OF ONE PERCENT FOR EACH INCLINATION. WITH ANGLE DRILLING BENCH HEIGHTS CAN BE INCREASED, THERE IS GREATER SAFETY, POWDER FACTOR IS IMPROVED AND BETTER FRAGMENTATION IS OBTAINED. IN BLASTING IN VERTICAL BORE HOLES A GREAT AMOUNT OF EXPLOSIVES ENERGY GOES UNDERNEATH THE QUARRY LEVEL CAUSING THE LOSS OF EXPLOSIVE ENERGY. IT ALSO BREAKS COAL IN COAL STRIPPING OR FRACTURES ROCK IN QUARRIES SO THAT IT IS LATER DIFFICULT TO DRILL.

12-62-05015 THE MOOSE MOUNTAIN DRILLING AND BLASTING PROGRAM (BLAST-HOLES DRILL-BITS EXPLOSIVES)
WEBER, K. J. & MOOSE MTN MINE
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 377-383, MAY 1962. THIS IRON ORE WITH A BOND WORK INDEX OF 25 IS ONE OF THE HARDEST ORES BEING MINED. 9 7/8 INCH ROTARY TUNGSTEN CARBIDE BITS AVERAGED 5/8 FEET AND COST 1550 DOLLARS EACH. FIVE TYPES OF DRILLS, FIVE SIZES OF BITS AND FIVE DIFFERENT MAKES OF ROTARY BITS HAVE BEEN TESTED. ECONOMICS COULD NOT BE EFFECTED BY INCREASING BIT LIFE SO THE APPROACH WAS TO INCREASE YIELD PER HOLE. CRATER TESTS WERE MADE AND LIVINGSTON'S THEORY APPLIED. THIS INCREASED THE BLAST PATTERN TO 19 X 23 FEET AND THE YIELD FROM 296 TO 437 CUBIC YARDS. CONVENTIONAL EXPLOSIVES AND BLASTING AGENTS WERE USED UNTIL THE AMMONIUM NITRATE PRODUCTS BECAME POPULAR. REVIEW STUDIES LED TO INCREASED PATTERN SPACING AND A GREATER VELOCITY AND DENSITY SLURRY. NEW EXPLOSIVES ARE INITIATING ANOTHER SERIES OF TESTS.

12-62-05016 UNDERGROUND BLASTING IN SMALL HOLES WITH AMMONIUM NITRATE (CHARGING COST EXPLOSIVES FUMES)
CAMPBELL, W. C. & HOMESTAKE MINING CO
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 385-391, MAY 1962. THE PNEUMATIC LOADER DEVISED BY OPEN PIT OPERATORS FOR LOADING HORIZONTAL TOE HOLES WAS SOON ADAPTED FOR UNDERGROUND USE. IF THE AMMONIUM NITRATE AND FUEL OIL ARE PROPERLY MIXED AND DETONATED, THE FUME CHARACTERISTICS ARE AS GOOD OR BETTER THAN COMPARABLE STRENGTH DYNAMITE. THREE CHARGING MECHANISMS ARE DESCRIBED AND THE DRILL HOLE LAYOUT AND BLASTING SEQUENCE GIVEN. IT IS ESTIMATED THAT 8 CENTS OF THE 18 CENTS DYNAMITE COST PER TON OF ORE MINED WILL BE SAVED WHEN CONVERSION TO AN-FO IS COMPLETE. 1,480,000 POUNDS OF DYNAMITE WERE CONSUMED IN 1961.

12-62-05017 DEVELOPMENT AND APPLICATION OF AMMONIUM NITRATE - FUEL OIL BLASTING AGENTS TO UNDERGROUND MINING (CHARGING FUMES COST EXPLOSIVES STATIC-ELECTRICITY)
COOLEY, C. M. & SPENCER CHEMICAL CO
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 393-398, MAY 1962. AN-FO SHOULD BE MECHANICALLY MIXED TO ASSURE A UNIFORM AND ACCURATE MIXTURE. GUARD AGAINST STATIC ELECTRICITY DISCHARGES ESPECIALLY ITEMS OF SIZABLE CAPACITANCE LIKE THE HUMAN BODY. ALL EXPLOSIVES HAVE TOXIC FUMES AND CARE SHOULD BE EXERCISED. SPENCER CHEMICAL CO HAS BEEN INVOLVED IN AN-FO DEVELOPMENT AND THEIR ADVICE CAN BE OBTAINED ON EQUIPMENT, METHODS AND TECHNIQUES. PRIMERS SHOULD BE 60 PERCENT DYNAMITE. DON'T JEOPARDIZE THE AN-FO EFFECTIVENESS BY POOR PRIMING.

12-62-05018 RECENT DEVELOPMENTS OF SLURRY EXPLOSIVES UNDERGROUND (BLASTING DBA LOADING)
BAILEY, D. T. + CLAY, R. B. + COOK, M. A. & PACK, D. H. + BRECKENRIDGE, R. N. + GREIGLEY, J. H. & INTERMOUNTAIN RES AND ENGR CO
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 399-405, MAY 1962. DENSE BLASTING AGENTS DBA-3 PRESENTED PROBLEMS IN PNEUMATICALLY PUMPING INTO BOREHOLES. TO ALLEVIATE THESE PROBLEMS A NEW CARTRIDGE TYPE SLURRY DBA-12 HAS BEEN PRODUCED IN CONVENTIONAL STICK DYNAMITE SIZE HAVING THE DESIRABLE PHYSICAL CHARACTERISTICS OF DYNAMITE AND IS LOADED AND TAMPED INTO THE BOREHOLES IN THE NORMAL MANNER. ANOTHER SLURRY DBA-6 HAS BEEN USED UNDERGROUND FOR SECONDARY BLASTING. IT DEVELOPS SUFFICIENT BRISANCE TO BREAK MOST TYPES OF BOULDERS WITHOUT DRILLING OR MUD PACKING.

12-62-05019 DETONATION OF AMMONIUM NITRATE IN SMALL DRILL HOLES (AMMONIUM-NITRATE DIATOMACEOUS-EARTH FUEL-OIL GELEX PRILLS WATER)
MAURER, W. C. + RINEHART, J. S. & COLO SCHOOL OF MINES GOLDEN COLO
MINN UNIV FIFTH SYMPOSIUM ON ROCK MECHANICS, 407-418, MAY 1962. BY USING SMALL POROUS PRILLS, HIGH DETONATION VELOCITIES CAN BE OBTAINED FROM AN-FO MIXTURES IN SMALL HOLES. ADEQUATE PRIMERS AND PREVENTING AN-FO MIXTURES FROM ABSORBING WATER MAKE VERY RELIABLE AND EFFECTIVE EXPLOSIVES FOR USE IN SMALL HOLES, BEING SIMILAR IN STRENGTH TO 50 OR 60 PERCENT DYNAMITE. TESTS WERE MADE AND FIGURES DRAWN RELATING THE DETONATION VELOCITY TO: PERCENT FUEL OIL, PERCENT MOISTURE AND PERCENT DIATOMACEOUS EARTH. AMMONIUM NITRATE PRILLS ARE COATED WITH DIATOMACEOUS EARTH TO PREVENT CAKING AND TO INSURE A FREE-FLOWING PRODUCT. SEVERAL TYPES OF COMMERCIAL AND PILOT PLANT AMMONIUM NITRATE PRODUCTS WERE TESTED USING 6 PERCENT FUEL OIL MIXTURES. THE VELOCITIES OF THE DIFFERENT PRODUCTS VARIED FROM 14,300 FT/SEC FOR THE MICROPRILLS TO FAILURE FOR THE DENSE PRILLS AND GRAINS.

12-62-05020 SHEAR WAVE VELOCITY MEASUREMENTS OF SEDIMENTARY ROCK SAMPLES UNDER COMPRESSION (ELASTIC-CONSTANT SEDIMENTARY-ROCK SHEAR-VELOCITY)
GREGORY, A. R. & GULF RES AND DEV CO PITTSBURGH
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 439-471, MAY 1962. EXAMPLES ARE GIVEN INDICATING THE QUALITY OF SHEAR (S-WAVE) VELOCITY DATA TO BE EXPECTED FROM CERTAIN ULTRASONIC PULSE TECHNIQUES WHEN APPLIED TO SAMPLES OF SEDIMENTARY ROCKS UNDER SPECIFIED LABORATORY CONDITIONS. THE RELATIONSHIP OF THE DYNAMIC AND STATIC ELASTIC CONSTANTS OF DRY AND LIQUID-SATURATED SEDIMENTARY ROCKS WAS INVESTIGATED. ABSORPTION LOSSES OF ELASTIC WAVES PROPAGATED IN POROUS MEDIA ARE ALSO DISCUSSED.

12-62-05021 SOME DYNAMIC AND STATIC PROPERTIES OF ROCK (COMPRESSIVE-STRENGTH DEFORMATION RIGIDITY)
SUTHERLAND, R. B. & WITWATERSRAND UNIV SOUTH AFRICA
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 473-491, MAY 1962. ROCK PROPERTIES OF MOST VALUE IN APPLYING ELASTIC THEORY ARE THE MODULUS OF DEFORMATION, THE MODULUS OF RIGIDITY, POISSON'S RATIO AND COMPRESSIVE STRENGTH. THESE

EXPERIMENTS SHOW THAT THE MODULUS OF DEFORMATION AND MODULUS OF RIGIDITY MAY BE DETERMINED EITHER SONICALLY OR STATICALLY BUT POISSON'S RATIO AND THE COMPRESSIVE STRENGTH SHOULD ONLY BE DETERMINED STATICALLY.

12-62-05022 THE SEISMIC LOCATION OF ROCKBURSTS
COOK, N. G. W. & WITWATERSRAND UNIV SOUTH AFRICA
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 493-516, MAY 1962. IN 11,000 FT DEEP MINES STRESS CONCENTRATIONS SUFFICIENT TO CAUSE FAILURE ARISE IN THE ROCK SURROUNDING THE MINING EXCAVATION. ADDITIONAL KNOWLEDGE SEEMED NECESSARY TO EVALUATE METHODS OF REDUCING THE HAZARDS OF ROCKBURSTS. IF THE MODEL IS CORRECT, IT IS NOT POSSIBLE TO STOP ROCKBURSTS. BUT IT MAY BE POSSIBLE TO MAKE THEM OCCUR DURING BLASTING BY RELATING THE FACE ADVANCE PER BLAST AND THE INTERVAL BETWEEN BLASTS TO THE CONDITIONS IN THE STOPE. THERE APPEARS TO BE NO DIFFERENCE IN ENERGY OR LOCATION BETWEEN MAJOR FAILURES WHICH CAUSE DAMAGE TO THE STOPE AND THOSE WHICH DO NOT. IT IS SUGGESTED THAT THE ROCK CONDITIONS IMMEDIATELY AROUND THE STOPE MAY DETERMINE DAMAGE CAUSED BY FAILURE.

12-62-05023 DYNAMIC INVESTIGATION OF FOUNDATION ROCKS IN-SITU (GROUTING YOUNGS-MODULUS SOUNDNESS STRESS)
ONODERA, T. F. & INT CHRISTIAN UNIV TOKYO JAPAN
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 517-533, MAY 1962. UNDERSTANDING THE RESPONSE OF ROCK TO APPLIED STRESSES IS IMPORTANT. THE INSITU ROCK PROPERTIES ARE MORE IMPORTANT THAN THOSE FROM SAMPLES BUT BY USE OF BOTH ROCK SOUNDNESS CAN BE DETERMINED. ROCKS ARE CLASSIFIED BY THEIR CRACK COEFFICIENT WHICH IS THE RELATIONSHIP OF THE FIELD DETERMINED DYNAMIC MODULUS AND THE LABORATORY DETERMINED ELASTIC MODULUS. THIS CLASSIFICATION CAN BE USED TO JUDGE THE NEED FOR AND THE EFFICIENCY OF CONSOLIDATION GROUTING.

12-62-05024 THE DESIGN OF UNDERGROUND INSTALLATIONS TO RESIST GROUND SHOCK FROM NUCLEAR BLASTS (STRESS STRUCTURES)
COATES, D. F. & ENGINEER OTTAWA
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 535-562, MAY 1962. METHODS OF COMPUTING MAXIMUM TENSILE AND COMPRESSIVE STRESSES ON UNDERGROUND STRUCTURES FROM AIR OR GROUND ATOMIC BLASTS ARE GIVEN. THERE WILL BE AN INDEFINITE ROCK STRENGTH INCREMENT TO THE DYNAMIC LOAD. WHERE A SERIES OF OPENINGS EXIST SIDE BY SIDE THE STABILITY OF THE PILLARS MIGHT BE IMPORTANT. TNT TEST RESULTS SHOULD NOT BE USED FOR EXTRAPOLATION DUE TO RADICAL STRESS PULSE DIFFERENCE TO ATOMIC BLASTS. ROCK BOLTING IS THE BEST WAY TO STRENGTHEN AN UNDERGROUND STRUCTURE. ROCK MECHANICS ASPECTS OF DESIGNING UNDERGROUND OPENINGS TO RESIST DYNAMIC STRESS SHOULD BE USED FOR ACCESS AND SERVICE OPENINGS.

12-62-05025 BRITTLE FRACTURE OF ROCKS AND CONCRETE UNDER TRIAXIAL STRESS (GRIFFITH-CRACKS PORE-PRESSURE)
MURRELL, S. A. F. & UNIV SHEFFIELD ENGLAND
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 563-577, MAY 1962. INTERNAL STRESSES ASSOCIATED WITH CRYSTAL IMPERFECTIONS BUILD UP DURING DEFORMATION TO LEVELS SUFFICIENT TO RUPTURE ATOMIC BONDS AND FORM CRACKS. IN CRYSTALLINE GEOLOGIC MATERIALS AND CONCRETE THERE WILL BE INCREASING PLASTIC STRAIN BEFORE FRACTURE IF THERE IS CONFINING PRESSURE. BRITTLE FRACTURE CRITERIA DERIVED BY GRIFFITH HAVE BEEN EXTENDED TO TRIAXIAL STRESS CONDITIONS AND HYDROSTATIC PRESSURE. BROAD AGREEMENT EXISTS BETWEEN THE NEW CRITERION AND EXPERIMENTAL DATA FOR ROCKS AND CONCRETE.

12-62-05026 EFFECT OF PORE FLUIDS ON THE DEFORMATION BEHAVIOR OF ROCK SUBJECT TO TRIAXIAL COMPRESSION (CONFINING-PRESSURE DUCTILITY STRESS STRAIN-RATE)
BOOZER, G. D. + HILLER, K. H. + SERDENGECTI, S. & CAL RES CORP LA HABRA CAL
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 579-625, MAY 1962. TRIAXIAL COMPRESSION TESTS WERE MADE ON NAVAJO SANDSTONE AND INDIANA LIMESTONE WITH OLEIC ACID, OLEYLAMINE, DISTILLED WATER, N-HEXADECANE AND CALCIUM CARBONATE SOLUTION WITH VARIOUS STRAIN RATES, CONFINING PRESSURES AND TEMPERATURES. EFFECTS OF SURFACE-ACTIVE FLUIDS CANNOT BE EXPLAINED BY ONE SIMPLE THEORY. ADSORPTION OF LIQUIDS ON CALCITE SURFACE IS BY IONIC BONDING WHILE FOR QUARTZ IT IS HYDROGEN BONDING. EFFECTS OF SURFACE-ACTIVE FLUIDS CANNOT BE EXPLAINED BY ONE SIMPLE THEORY, THE ONLY COMMON FACT IS THEY LOWER THE FREE SURFACE ENERGY. LOWER STRAIN RATES, HIGHER TEMPERATURES AND CONFINING PRESSURES AND SATURATION FLUIDS INCREASE THE DUCTILITY OF IND LIMESTONE AND NAVAJO SANDSTONE.

12-62-05027 RESERVOIR ROCK BEHAVIOR UNDER MODERATE CONFINING PRESSURE (COMPRESSIBILITY CONFINING-PRESSURE LITHOLOGY PERMEABILITY POROSITY)
KNUTSON, D. F. + BOHOR, B. F. & CONTINENTAL OIL CO PONCA CITY
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 627-659, MAY 1962. FIFTEEN DIFFERENT ROCKS WERE TESTED IN A BOMB DEVICE FOR COMPRESSIBILITY, POROSITY, PERMEABILITY AND PERCENT RETAINED PERMEABILITY UNDER VARIOUS CONFINING PRESSURES. IT WAS SHOWN THAT FROM LITHOLOGY THE PERMEABILITY, POROSITY AND COMPRESSIBILITY OF RESERVOIR ROCK CAN BE ESTIMATED. DATA IS EVALUATED BY THE AMYX, BASS AND WHITING SCHEME.

12-62-05028 LABORATORY DEMONSTRATIONS OF THE FAILURE OF MATERIALS UNDER UNIFORM LOADS (JOINTING FOLDING)
TRUMP, R. P. + PATNODE, H. W. & GULF RES AND DEV CO PITTSBURGH
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 661-676, MAY 1962. FOUR TYPES OF TESTS WERE MADE WITH THE OBJECTIVE OF BETTER UNDERSTANDING VARIOUS ASPECTS OF THE FOLDING AND JOINTING OF SEDIMENTARY STRATA. BOUNDARY CONDITIONS AND ANISOTROPIES ARE OF PRIMARY IMPORTANCE IN FAILURE PATTERN CONTROL AND CANNOT BE EXTRAPOLATED FROM STANDARD TESTS ON ROCK.

12-64-04001 STRESSES AT TUNNEL INTERSECTIONS (MODELS TENSION COMPRESSION PHOTOELECTRICITY)
RILEY, W. F. & IIT RES INST CHICAGO ILL
PROC. AMERICAN SOC. CIVIL ENGRS., (90) N EM2, 167-179, APR. 1964. AN EXPERIMENTAL PROGRAM ON THREE COMMON TYPES OF CYLINDRICAL TUNNEL INTERSECTIONS, TEE, CROSS AND RIGHT ANGLE WERE CONDUCTED TO DETERMINE STRESS DISTRIBUTIONS. STRESSES WERE DETERMINED USING MODELS MACHINED FROM EPOXY RESIN, LOADED WITH AIR PRESSURE, STRESS FROZEN, SLICED AND EXAMINED IN A DIFFUSED LIGHT POLARISCOPE. STUDY RESULTS INDICATE THAT MAXIMUM TENSILE STRESSES IN THE REGION OF THE INTERSECTIONS ARE EQUAL TO OR SLIGHTLY LESS THAN THOSE IN THE TUNNEL AWAY FROM THE INTERSECTION. MAXIMUM COMPRESSIVE STRESSES AT INTERSECTION CORNER ARE 60 PERCENT GREATER THAN AWAY FROM IT. WITHIN A DISTANCE OF ONE DIA THIS HIGH STRESS REGION BECOMES NORMAL. MAXIMUM COMPRESSIVE WALL STRESS OPPOSITE THE CORNER OF TEES OR RIGHT ANGLES IS NOT SIGNIFICANTLY INFLUENCED BY THE INTERSECTION.

12-64-10001 ATTENUATION MEASUREMENTS ON ROCKS IN THE FREQUENCY RANGE 12 KC/S TO 51 KC/S AND IN THE TEMPERATURE RANGE 100 DEGREES K TO 1150 DEGREES K (MAGNETOSTRICTION ANELASTIC-PROPERTIES VIBRATIONS PULSE RESONANCE INTERNAL-FRICTION RETARDATION)
ATTEWELL, P. B. + BRENTNELL, D. & UNIV SHEFFIELD ENGLAND
UNIV MO AT ROLLA PROC OF THE SIXTH SYMP ON ROCK MECHANICS, 330-357, OCT 1964. A GENERAL RESEARCH PROGRAM IS UNDER WAY IN WHICH THE ANELASTIC PROPERTIES OF SELECTED ROCKS ARE EXAMINED OVER A BROAD FREQUENCY BAND RANGING FROM A FEW CYCLES PER SECOND TO SEVERAL MEGACYCLES PER SECOND. A STUDY OF ATTENUATION WITH FREQUENCY AND TEMPERATURE IS REALLY A STUDY OF INTERNAL FRICTION AND IT IS HERE THAT ROCK TAKES ITS RIGHTFUL PLACE AS A MATERIAL TO BE ASSESSED ON THE BASIS OF THE SAME PHYSICAL CRITERIA AS HAVE BEEN ALREADY APPLIED TO METALS AND POLYMERS. THE VIBRATIONAL BEHAVIOR OF SIX NATURAL ROCK TYPES CHOSEN ON THE BASIS OF PARTICULAR PETROLOGICAL CHARACTERISTICS IS DISCUSSED. THREE SEDIMENTARY, ONE METAMORPHIC, AND TWO IGNEOUS ROCKS WERE EXAMINED. USING MAGNETOSTRICTIVE METHODS THE SAMPLES WERE STUDIED AT FREQUENCIES OF 12, 17, 36 AND 51 KC/S AT TEMPERATURES RANGING FROM 100 TO 1150 DEGREES K. IN HIGH TEMPERATURE TESTS, THE SPECIMENS WERE CONFINED WITHIN A NARROW BORE ELECTRIC RESISTANCE FURNACE WHILE AT LOW TEMPERATURES COOLING PROVIDED BY LIQUID NITROGEN. ROOM TEMPERATURE ATTENUATION INCREASES LINEARLY WITH FREQUENCY BUT A PLOT OF ATTENUATION VS TEMPERATURE INDICATES SEVERAL WELL DEFINED ATTENUATION PEAKS.

12-64-10002 IN-SITU MEASUREMENT OF THE ELASTIC PROPERTIES OF ROCK (BOREHOLE COMPRESSIONAL-WAVE SHEAR-WAVE WELL-LOGGING MAGNETOSTRICTION PULSE AMPLITUDE TUBE-WAVE STONELY-WAVE)
LAWRENCE, H. W. & SEISMOGRAPH SERVICE CORP
UNIV MO AT ROLLA PROC OF THE SIXTH SYMP ON ROCK MECHANICS, 381-390, OCT 1964. EXPERTS DO NOT AGREE AS TO WHERE AND WHEN DYNAMICALLY AS OPPOSED TO STATICALLY DETERMINED ELASTIC CONSTANTS OF ROCKS SHOULD BE APPLIED. WHILE LABORATORY DETERMINED DYNAMIC CONSTANTS ARE IMPROVING IN RELIABILITY, THEY ARE STILL SUBJECT TO INACCURACIES. RECOGNIZING THE SHORTCOMINGS OF LABORATORY RESULTS, THE PROBLEM BECOMES ONE OF BETTERING THEM BY IN SITU MEASUREMENTS. THE NEED AS SEEN BY THE BINDWELL DIVISION OF SEISMOGRAPH SERVICE CORP WAS FOR A METHOD OF GENERATING AND RECORDING COMPRESSIONAL AND SHEAR WAVES SIMULTANEOUSLY AND CONTINUOUSLY. TO DO THIS THE ACOUSTIC-TYPE WELL LOGGING TOOL WAS USED. THIS TOOL MEASURES THE TRANSMISSION TIME OF COMPRESSIONAL WAVES GENERATED BY SONIC IMPULSE IN THE MEDIA SURROUNDING A BOREHOLE. IT WAS EVIDENT EARLY IN THE DEVELOPMENT THAT THERE WERE SIGNAL ARRIVALS OTHER THAN THE COMPRESSIONAL WAVE BUT THERE WAS NO MEANS OF RECORDING THEM AT THAT TIME. THIS PAPER DESCRIBES LOGGING SYSTEMS USED TO RECORD THE COMPONENTS SEPARATELY BOTH WITH REGARD TO TRANSMISSION AMPLITUDE AND VELOCITY. THE CHAIN OF EVENTS FROM IMPULSE EMISSION THROUGH VARIOUS MODES OF ENERGY ARRIVAL AT THE RECEIVER WERE PICTURED ON AN OSCILLOSCOPE. BY MODIFYING THE SIGNAL TRACE OF EACH SIGNAL EMISSION TO A VARIABLE DENSITY AMPLITUDE DISPLAY A RECORD COULD BE MADE ON PHOTOGRAPHIC FILM. THE PAPER DISCUSSES THE RELATIONSHIP WHICH EXISTS WITH RESPECT TO THE ROCK PROPERTIES AND USE OF COMPUTER ANALYSIS IN CALCULATING ELASTIC MODULI WITH RESULTS TABULATED OR SHOWN IN ANALOG FORM.

12-64-10003 DETERMINATION OF THE MODULUS OF RIGIDITY OF ROCK BY EXPANDING A CYLINDRICAL PRESSURE CELL IN A DRILLHOLE (CALIBRATION ELASTIC-THEORY HYDROSTATIC-PRESSURE LIMESTONE)
PANCK, L. A. + HARNSEY, E. E. + LAPPI, R. L. & U.S. BUR MINES COLLEGE PARK MD
UNIV MO AT ROLLA PROC OF THE SIXTH SYMP ON ROCK MECHANIC, 427-449, OCT 1964. THE MODULUS OF RIGIDITY OF ROCK CAN BE DETERMINED BY A FAIRLY SIMPLE PROCEDURE IN WHICH A CYLINDRICAL PRESSURE CELL IS FIRST CALIBRATED BY EXPANDING IT INSIDE TWO METAL TEST CYLINDERS AND THEN INSIDE A DRILLHOLE IN ROCK. THE TWO TEST CYLINDERS HAD DIFFERENT EXPANSION CHARACTERISTICS (DIFFERENT MATERIAL, AND/OR DIFFERENT WALL THICKNESS) WHICH PERMITS DETERMINATION OF TWO CALIBRATION CONSTANTS. CHANGE OF DIA OF THE PRESSURE CELL IS DETERMINED FROM THE VOLUME OF FLUID PUMPED INTO IT AT PRESSURES UP TO 10,000 PSI. RESULTS WERE INTERPRETED BY MEANS OF THE CLASSICAL THICK-WALLED CYLINDER EQUATIONS FOR AN ELASTIC BODY. THE OBJECTIVE WAS TO DEVELOP A CONVENIENT APPARATUS AND TECHNIQUE FOR MAKING ROUTINE FIELD DETERMINATION OF G IN MINE AND TUNNEL ROCKS. THE ESSENTIAL APPARATUS CONSISTED OF A CYLINDRICAL PRESSURE CELL, A BOURDON PRESSURE GAGE, A VOLUME-METERING FLUID PUMP, AND TWO TEST CYLINDERS. THE RESULTS OF BOREHOLE TESTS ARE FURTHER COMPARED TO THOSE DETERMINED BY USE OF OTHER METHODS TO SHOW THE CLOSE SIMILIARITY.

12-64-10004 ROCK MECHANIC CONSIDERATIONS IN DESIGN AND CONSTRUCTION (GEOLOGIC-CONDITIONS IN-SITU ROCK-RELAXATION ROCK-STRESSES ELASTIC-ANALYSIS LOAD DEFORMATION-CREEP ARCH-ACTION GRAVITY-EFFECT)
LANG, T. A. & BECHTEL CORP SAN FRANCISCO
UNIV MO AT ROLLA PROC OF THE SIXTH SYMP ON ROCK MECHANICS, 561-605, OCT 1964. THE APPLICATION OF UP-TO-DATE DEVELOPMENTS IN ROCK MECHANICS AND IN SITU TESTING TO CONSTRUCTION PROJECTS CONDUCTED IN ROCK. DATA FROM 32 REFERENCES ARE USED IN OUTLINING THE MEASUREMENT AND ANALYSIS TECHNIQUES THAT CAN BE UTILIZED IN PLANNING OR MONITORING THE CONSTRUCTION. THE EMPHASIS IS PLACED ON GENERAL CONSIDERATIONS AND FUNDAMENTAL PRINCIPLES RATHER THAN DETAILED PROCEDURES. HOWEVER, DURING CONSTRUCTION CARE MUST BE TAKEN TO RECORD AND UTILIZE INFORMATION AND DATA THAT CAN BE OBTAINED AS THE WORK PROCEEDS. INVESTIGATIONS BEFORE STARTING A JOB INCLUDE GEOLOGICAL CONDITIONS AT THE SITE, LABORATORY AND IN SITU TESTING. THE DETERMINATION OF ROCK STRESSES IS DISCUSSED WITH RESPECT TO VARIATIONS THROUGHOUT THE SITE. USE OF MODELS IN DETERMINING THE BEST ARRANGEMENT AND ORIENTATION OF THE WORKS IS ADVOCATED. ELASTIC ANALYSIS CAN BE SIMPLIFIED BY ADOPTING ASSUMPTIONS THAT PERMIT REDUCING TRIAXIAL ANALYSIS TO BIAXIAL ANALYSIS, BUT THIS MUST BE REVIEWED WITH THREE DIMENSIONAL PERCEPTION. LOAD AND TIME DEFORMATION CURVES ILLUSTRATE THE CONSIDERATIONS OF DEFORMATION CHARACTERISTICS BOTH STABLE AND UNSTABLE. A DETAILED TREATMENT IS GIVEN TO STRENGTH CRITERIA AND FRICTION AND SHEAR AT JOINTS. DESIGN MUST CONSIDER CONDITIONS AROUND ROCK EXCAVATIONS INCLUDING GEOLOGICAL FEATURES, ARCH ACTION, GRAVITY EFFECTS, MAGNITUDE OF OPENING SIZE, TRIAXIAL CONDITIONS AND THE CONSTRUCTION SEQUENCE AND METHODS USED. OBSERVATIONS AND MEASUREMENTS ARE RECOMMENDED FOR MONITORING CONSTRUCTION AS IT PROCEEDS.

12-64-10005 TRIAXIAL TESTING FOR STRENGTH OF ROCK JOINTS (ROCK-MASS IN-SITU FAULTS SHEAR TENSION COMPRESSION NORAD-GRANITE JOINTED-ROCK-MASS MOHR'S-ENVELOPE)
LANE, K. S. + HECK, W. J. & U.S. ARMY CORPS OF ENGR
UNIV MO ROLLA PROC OF THE SIXTH SYMP ON ROCK MECHANICS, 98-108, OCT 1964. A REPORT OF EARLY RESULTS OF LABORATORY TRIAXIAL TESTS FOR DETERMINING THE SHEAR STRENGTH OF A ROCK JOINT, BEDDING PLANE OR FAULT AND THE MATERIAL FILLING SUCH GEOLOGIC SEPARATION. TESTS INCLUDE AN EVALUATION OF GRANITE FROM THE NORAD UNDERGROUND PROJECT PLUS ITS IMPROVEMENT BY BOND GROUTING WITH EPOXY. SKETCHES SHOW ORIENTATION OF SPECIMENS AND PRINCIPLES OF TEST OPERATION. RESULTS ARE SHOWN IN THE FORM OF A STRESS-STRAIN CURVE AND SHEAR STRENGTH - NORMAL STRESS CURVES. THE AUTHORS DISCUSS THE TEST INFORMATION AS IT RELATES TO STRENGTHENING OF ROCK MASSES BY PRESTRESSING WITH ROCK BOLTING AND SUGGEST FURTHER AVENUES OF INVESTIGATION BY TRIAXIAL TESTING.

12-65-01001 STATIC AND DYNAMIC FAILURE OF ROCK UNDER CHISEL LOADS (CRATERING ENERGY IMPACT STATIC-LOADING)
SINGH, M. M. + JOHNSON, A. M. & PENN STATE UNIV
UNIV. OF TEX, SECOND CONF. ON DRILLING & ROCK MECHANICS, NO. SPE 1047, 49-53, JAN. 1965. FAILURE MECHANISM UNDER A DRILL BIT IS STILL IMPROPERLY UNDERSTOOD. THE CRATERING PROCESS UNDER STATIC LOADING IS REGARDED AS BEING SIMILAR TO THAT FROM DYNAMICALLY APPLIED IMPACT. ALTHOUGH THE SEQUENCE OF EVENTS IN THE TWO CASES APPEAR IDENTICAL AT LEAST SOME DISSIMILARITIES EXIST. CRATER CHARACTERISTICS, SUCH AS WIDTH TO DEPTH RATIO VARY TO SOME EXTENT. ENERGY CONSUMED PER UNIT VOLUME OF ROCK IS ALSO OBSERVED TO BE UNEQUAL. THE ENERGY ASPECT MAY BE EXPLAINED BY REGARDING ROCK AS A VISCOELASTIC SUBSTANCE. ESTIMATIONS BASED ON MAXWELL AND KELVIN-VOIGT MODELS HAVE BEEN MADE BUT BURGER'S MODEL WITH A PLASTIC COMPONENT SHOULD PROVIDE BETTER SIMULATION. GENERATION OF TENSILE FRACTURES BENEATH THE BIT MAY ALSO CONTRIBUTE TOWARDS INPUT ENERGY DIVERSITY. SOME EVENTS THAT OCCUR DURING CRATER FORMATION ARE DISCUSSED. POSSIBILITY OF A COMPACTED ROCK WEDGE BEING FORMED BELOW THE BIT DUE TO INTENSE SHEARING RATHER THAN CRUSHING IS SUGGESTED.

12-65-01002 AN EXPERIMENTAL STUDY OF SINGLE BIT-TOOTH PENETRATION INTO DRY ROCK AT CONFINING PRESSURES OF 0 TO 5,000 PSI (STATIC-LOAD CONFINEMENT DUCTILE BRITTLE)
CHEATHAM, J. B., JR. + GNIRK, P. F.
UNIV. OF TEX, SECOND CONF. ON DRILLING AND ROCK MECHANICS, 77-92, JAN. 1965. SINGLE BIT-TOOTH PENETRATION EXPERIMENTS UNDER STATIC LOAD HAVE BEEN MADE ON SIX ROCKS AT CONFINING PRESSURES OF 0 TO 5,000 PSI USING SHARP WEDGE-SHAPED TEETH WITH INCLUDED ANGLES RANGING FROM 30 TO 120 DEG. THE FORCE-DISPLACEMENT CURVES FOR ALL ROCKS EXHIBIT AN INCREASINGLY NONLINEAR AND DISCONTINUOUS BEHAVIOR WITH DECREASING CONFINING PRESSURE. CONFINING PRESSURE AT WHICH ROCK EXHIBITS A MACROSCOPIC TRANSITION FROM PREDOMINANTLY DUCTILE TO PREDOMINANTLY BRITTLE BEHAVIOR DURING PENETRATION VARIES FROM ABOUT 500 TO 1,000 PSI FOR THE LIMESTONES TO GREATER THAN 5,000 PSI FOR THE DOLOMITE. CORRELATION BETWEEN CALCULATED VALUES OF FORCE PER UNIT PENETRATION BASED ON PLASTICITY THEORY AND EXPERIMENTAL VALUES IS QUITE ENCOURAGING EVEN AT CONFINING PRESSURES AS LOW AS 1,000 PSI. A QUALITATIVE CORRELATION BETWEEN VOLUME OF FRAGMENTED ROCK PER UNIT ENERGY INPUT FOR A SINGLE BIT-TOOTH AND DRILLING RATE FOR MICRO-BITS APPEARS TO EXIST OVER A CONFINING PRESSURE RANGE OF 0 TO 5,000 PSI.

12-65-01003 AN EXPERIMENTAL STUDY OF DRAG-BIT DRILLING USING DIMENSIONAL ANALYSIS (ROTARY-SPEED BIT-WEIGHT DISTANCE-DRILLED BIT-CLEARANCE-ANGLE CIRCULATION-RATE WEAR TEMPERATURE PENETRATION-RATE)
KIM, Y. S. + HARTMAN, H. L. & PENN STATE UNIV
UNIV. OF TEX. SECOND CONF. ON DRILLING AND ROCK MECHANICS, NO. SPE 1053, 93-104, JAN. 1965. THIS SECOND RESEARCH INVESTIGATION AT PENN STATE ON DRAG-BIT DRILLING USED A LABORATORY DRILL PRESS, A DRAG BIT WITH ONE-HALF IN. CUTTING EDGE ON PENNSYLVINIA SLATE. DIMENSIONLESS PARAMETERS WERE DEVELOPED WHICH PERMITTED THE EFFECT AND THE INTERACTION OF

ROTARY SPEED, BIT WEIGHT, DISTANCE DRILLED, FIT CLEARANCE ANGLE, CIRCULATION RATE, BIT WEAR, BIT TEMPERATURE AND PENETRATION RATE TO BE ANALYZED. EXPERIMENTS WERE CONCERNED WITH BIT CLEARANCE ANGLES FROM 5 TO 25 DEG AND FLUID CIRCULATION RATE. PENETRATION RATE VARIES DIRECTLY WITH BIT CLEARANCE ANGLE AND THRUST AND BIT WEAR MEASURED BY WEIGHT LOSS VARIES DIRECTLY WITH CLEARANCE ANGLE AND INVERSELY WITH WIDTH OF FLAT. BIT TEMPERATURE INCREASES AS FLOW RATE DECREASES WITH AN INCREASE IN BIT WEAR AND DECREASE IN PENETRATION RATE. THIS COULD NOT BE CORRELATED WITH THE PHYSICO-THERMAL PROPERTIES OF THE BITS. FOR A GIVEN CIRCULATION RATE THE TEMPERATURE GRADIENT ACROSS THE CUTTING EDGE OF A DRAG BIT INCREASES WITH PENETRATION RATE. OBSERVATIONS ARE ALSO REPORTED ON THE NATURE OF CUTTING ACTION, ROCK FAILURE AND BIT WEAR IN DRAG-BIT DRILLING.

12-65-01004 SHEAR FAILURE OF ROCK UNDER NORMAL STRESS (FRICTION-SURFACES COMPRESSION BRITTLE-FRACTURE DUCTILE-FRACTURE)
MAURER, W. C. & JERSEY PROD RES CORP
UNIV. OF TEX. SECOND CONF. ON DRILLING AND ROCK MECHANICS, NO. SPE 1054, 105-116, JAN. 1965. A STUDY OF ROCK SHEAR FAILURE MECHANICS UNDER PRESSURE HAS BEEN MADE. TRANSITION FROM BRITTLE TO DUCTILE FAILURE OCCURS WHEN FRICTION ALONG THE FRACTURE SURFACES EXCEEDS THE ROCK SHEAR STRENGTH. A MACHINE WAS DEVELOPED FOR MEASURING BOTH THE ROCK SHEAR STRENGTH AND FRICTION ALONG FRACTURE SURFACES. IN THIS SHEAR MACHINE, FRACTURES ARE FORCED ALONG DEFINITE PLANES SO ROCK IS STRONGER THAN IN COMPRESSION TESTS WHERE FRACTURES CHOOSE THE WEAKEST PATHS THROUGH THE SPECIMENS. FRICTION IS COMPOSED OF: FORCES TO SLIDE IRREGULARITIES ON SURFACES OVER EACH OTHER, FORCES TO SHEAR SOME OF THESE IRREGULARITIES, MOLECULAR ATTRACTIONS ACROSS FRACTURES, AND FORCES REQUIRED TO BREAK BONDS RESULTING FROM MELTING AND WELDING AT TIPS OF SURFACE IRREGULARITIES. FRICTION ALONG ROCK FRACTURE SURFACES IS NOT PROPORTIONAL TO CONTACT PRESSURE AS USUALLY ASSUMED BUT INCREASES AS THE 0.4 TO 0.8 POWER OF CONTACT PRESSURE.

12-65-01005 REDUCTION OF FRACTURE PRESSURES OF ROCKS BY INTENSIVE BOREHOLE HEATING (VERTICAL-FRACTURING)
CLARK, K. K. + SOMERTON, W. H. & UNIV CAL BERKELEY CAL
UNIV. OF TEX. SECOND CONF. ON DRILLING AND ROCK MECHANICS, NO. SPE 1055, 117-121, JAN. 1965. TO INCREASE WELL PRODUCTIVITY BY FRACTURING A VERTICAL FRACTURE IS PREFERRED TO A HORIZONTAL. VERTICAL FRACTURE PRESSURE VARIES AS TWICE THE RADIAL STRESS PLUS THE MEDIUM'S TENSILE STRENGTH. HORIZONTAL FRACTURES OCCUR IN PLANES OF WEAKNESS AT PRESSURES EQUALLING OR EXCEEDING EFFECTIVE OVERBURDEN STRESS. THEREFORE, BY REDUCING THE ROCK STRENGTH VERTICAL FRACTURING WILL BE INDUCED. THREE GROUPS OF SAMPLES WERE TESTED AT CONDITIONS SIMULATING A DEPTH OF 5,000 FT. ONE SET WAS FURNACE HEATED TO 600 C, THE OTHER TWO WERE BOREHOLE HEATED TO 625 C AND 792 C. ALL WERE COOLED AND TESTED. IT WAS CONCLUDED THAT FRACTURE PRESSURES MAY BE REDUCED BY 20 TO 50 PERCENT BY INTENSIVE BOREHOLE HEATING BEFORE FRACTURING.

12-65-01006 ON THE DETERMINATION OF THE STATE OF STRESS IN ROCK MASSES (BOREHOLE-STRAIN GAUGES FLAT-JACKS HYDRAULIC-FRACTURING INSITU-ROCK-STRESS)
FAIRHURST, C. & UNIV MINN MINNEAPOLIS MINN
UNIV. OF TEX. SECOND CONF. ON DRILLING AND ROCK MECHANICS, NO. SPE 1062, 133-145, JAN. 1965. ACCURATE INFORMATION ON INSITU ROCK STRESS IS ESSENTIAL TO THE SOLUTION OF MANY ROCK MECHANICS PROBLEMS. FLAT-JACKS GIVE GOOD INFORMATION BUT CAN ONLY BE APPLIED TO AN EXCAVATION WALL. THE VARIOUS BOREHOLE DEVICES ARE DISCUSSED. NO ONE INSTRUMENT OR TECHNIQUE SHOULD BE EXPECTED TO BE APPLICABLE TO EVERY SITUATION. THEY CAN PROVIDE USEFUL INFORMATION WHEN APPLIED INTELLIGENTLY. HYDRAULIC FRACTURING APPEARS TO BE WORTHY OF FURTHER ATTENTION AS A POSITIVE METHOD OF STRESS MEASUREMENT.

12-65-06001 CEMENTED TUNGSTEN CARBIDE BEARINGLESS ROTARY ROCK DRILL BITS (HARDNESS STRENGTH)
ENGLE, E. + GOODFELLOW, R. D. & KENNAMETAL INC
PENN STATE UNIV VII SYMP ON ROCK MECHANICS, (2) 209-217, JUNE 14, 1965. TUNGSTEN CARBIDE BITS ARE ILLUSTRATED FOR WELL DRILLING, BLAST HOLE DRILLING, ROOF DRILLING, AND BORING MACHINE APPLICATIONS. CEMENTED TUNGSTEN CARBIDE HAS LARGELY REPLACED STEEL BITS. MUCH OF THE MECHANICAL EQUIPMENT FOR MINING AND DRILLING WOULD BE UNECONOMICAL TODAY IF CARBIDE CUTTING EDGE WERE NOT AVAILABLE. PHYSICAL PROPERTIES OF FIVE GRADES OF KENNAMETAL OF TUNGSTEN CARBIDE AND COBALT ARE GIVEN.

12-65-06002 DRILLING & BLASTING AT SMALLWOOD MINE (JET-DRILL ROTARY-DRILL SLURRY GRINDING-FACTOR-INDEX)
BAUER, A. + CARR, H. H. + CALDER, P. + FARRIS, G. R. & IRON ORE CO CANADA
PENN STATE UNIV SEVENTH SYMP. ON ROCK MECHANICS, (2) 218-241, JUNE 14, 1965. ROTARY AND JET PIERCING DRILLS ARE USED. THEIR DRILLING RATE CORRELATES WELL WITH THE GRINDING FACTOR INDEX, BUT IT WAS DISAPPOINTING THAT NO BASIC PHYSICAL PROPERTY WOULD TIE IN WELL WITH PIERCEABILITY. THE BEST ROTARY GROUND WAS THE WORST JET GROUND AND VICE VERSA. A DISCUSSION IS PRESENTED ON FUEL OXYGEN RATIOS FOR JET PIERCING AND ON SITE GAS SAMPLING AND ANALYSIS. FUEL HAS BEEN CUT-BACK SO THAT STOICHIOMETRIC CONDITIONS EXIST, CARBON MONOXIDE IS DRASTICALLY REDUCED AND POP-UP HOLES ELIMINATED. BLASTING PROCEDURE AND RESULTS AT THE OPEN PIT IRON ORE OPERATION USING SLURRY PUMP-MIX TRUCK IS DESCRIBED. AFTER TEST DRILLING WITH ROTARY, JET AND PERCUSSION DRILLS FOUR JPM-4 JET PIERCERS WERE OBTAINED FOR THE BULK OF PRODUCTION DRILLING. TWO 50-R, ONE 60-R AND ONE 40-R MACHINES ARE ALSO USED. BENCHES ARE 45 FT HIGH AND 50 FT HOLES ARE GENERALLY DRILLED.

12-65-06003 THERMAL FRAGMENTATION OF ROCK (BURNERS THERMAL-CONDUCTIVITY THERMAL-ENERGY THERMAL-SHOCK COEFFICIENT-OF-EXPANSION TENSILE-STRENGTH YOUNG'S-MODULUS)
MAROVELLI, P. L. + CHEM, T. + VEITH, K. F. & U.S. BUR MINES
PENN STATE UNIV SEVENTH SYMP. ON ROCK MECHANICS, (2) 253-280, JUNE 14-19, 1965. THERMAL ENERGY WAS USED FOR PRIMARY ROCK REMOVAL BEFORE BLASTING POWDERS WERE INVENTED. GASEOUS OXYGEN - OIL BURNERS GAINED ACCEPTANCE FOR DIFFICULT BLAST HOLE DRILLING AND SOME QUARRY OPERATIONS. AT PRESENT, THERE IS RENEWED INTEREST IN COMPRESSED AIR - OIL BURNER DESIGNS. AN ANALYTICAL STUDY IS MADE OF THERMAL STRESS DISTRIBUTION IN A THIN CIRCULAR DISK SUBJECTED TO A PERIPHERAL THERMAL SHOCK AT VARIOUS RATES OF HEAT TRANSFER. THE PROBLEM IS OF IMPORTANCE IN PREDICTING THERMAL SHOCK RESPONSE OF A ROCK BODY OF FINITE SIZE. THEORETICAL ANALYSIS IS BASED ON RADIAL HEAT FLOW BY CONDUCTION IN THE DISK AND HEAT EXCHANGE BY CONVECTION BETWEEN DISK AND SURROUNDINGS. THE CASE OF CONSTANT PROPERTIES AND PLANE STRESS IS TREATED. SOLUTIONS OF THE STRESS DISTRIBUTION ARE PRESENTED FOR BOTH COOLING AND HEATING SHOCKS AND AN AVERAGE STRESS THEORY IS FORMULATED. PRELIMINARY EXPERIMENTAL VERIFICATION WAS OBTAINED FROM SHOCK TEST RESULTS ON THIN ROCK DISKS INSULATED ON BOTH FLAT END FACES SO THAT HEAT EXCHANGE TOOK PLACE THROUGH THE EXPOSED PERIPHERAL SURFACE. PHYSICAL PROPERTIES VITAL TO THE ANALYSIS ARE YOUNG'S MODULUS, TENSILE STRENGTH, COEFFICIENT OF LINEAR THERMAL EXPANSION AND THERMAL CONDUCTIVITY. PLOTS OF THESE PROPERTIES ARE PRESENTED.

12-65-06004 RECENT ADVANCES IN FLAME JET WORKING OF MINERALS (TEMPERATURE-GRADIENT SPALLING FUSION ABRASIVE)
BROWNING, J. A. + HORTON, W. B. + HARTMAN, H. L. & BROWNING ENG CO
PENN STATE UNIV SEVENTH SYMP ON ROCK MECHNICS, (2) 281-313, JUNE 14, 1965. FLAME JET OPERATION THEORY AND REPRESENTATIVE MINERALS CUTTING RATES ARE GIVEN. THE NEW FLAME JET WITH ABRASIVE SUSPENSION CUTTING IS DESCRIBED AND FLAME JET WORKING OF PERMAFROST AND ICE IS MENTIONED. COMPARISONS OF ROCK SPALLABILITY AND DRILLABILITY ARE TABULATED. PRACTICAL APPLICATIONS OF FLAME JET FOR DRILLING, CHANNELING, AND WORKING OF VARIOUS MINERALS ARE PRESENTED. EARLIER FLAME JETS WERE PRODUCED BY COMBUSTION OF PURE OXYGEN AND FUEL. IT HAS BEEN FOUND THAT THIS FLAME IN MOST CASES IS MUCH TOO HOT. FOR GRANITES AND TACONITES IMPROVED REMOVAL RATES ARE OBTAINED AT LOWER FLAME TEMPERATURES BY ADDING AIR TO THE OXY-FUEL MIXTURE. A TEMPERATURE GRADIENT SUFFICIENT TO INDUCE SPALLING IS REQUIRED RATHER THAN ONE LEADING TO FUSING. SOME MINERALS ARE CUT AT MAXIMUM SPEEDS USING AIR-FUEL FLAME JETS WITH NO PURE OXYGEN NECESSARY. FOR SLATE AN EVEN FURTHER REDUCTION IN FLAME TEMPERATURE IS REQUIRED.

12-65-06005 ELECTRICAL FRACTURING AND CRUSHING OF TACONITE (THERMAL-STRESS MICROFRACTURES ELECTRODES)
SARAPUU, E. & UNIV ARIZ

PENN STATE UNIV SEVENTH SYMP ON ROCK MECHANICS, (2) 314-324, JUNE 14, 1965. FRACTURING OF TACONITE BY ELECTRICAL CONDUCTION AND ELECTRICALLY GENERATED THERMAL STRESSES HAS BEEN DEMONSTRATED. ENERGY TRANSFER IN ROCK FRACTURING WAS ACCOMPLISHED BY MULTI-CONTACT ELECTRODES AT COMPARATIVELY LOW VOLTAGE USING 60 CYCLE ALTERNATING CURRENT. DIFFERENCE IN POINT ELECTRODES VERSUS LARGE DIAMETER ELECTRODES IS DISCUSSED AND EXPERIMENTS DESCRIBED. POSSIBLE LARGE SCALE USE OF ELECTRICAL FRACTURING WITH TACONITE ORE IS BASED ON LABORATORY EXPERIMENTS, AND IS APPLICABLE TO SECONDARY BREAKING AND COARSE CRUSHING. ALSO MICROFRACTURES ARE PRODUCED WHICH AID IN CRUSHING.

12-65-06006 A POTENTIAL METHOD FOR EVALUATING THE ENERGY RELEASED FROM NON-IDEAL EXPLOSIVE REACTIONS (INITIATION-TIME-DELAY PRIMER)
ASH, R. L. + RYDLUND, P. H. + YANCIK, J. J. & UNIV MO ROLLA MO
PENN STATE UNIV SEVENTH SYMP. ON ROCK MECHANICS, (2) 325-334, JUNE 14, 1965. TESTS ON ANFO MIXTURES BY THE RESISTANCE WIRE TECHNIQUE SHOWED THAT MANY OF THE SAME PHYSICAL PARAMETERS WHICH AFFECT ITS REACTION VELOCITIES WERE RELATED TO THE INITIATION TIME DELAY. THE INITIATION TIME DELAY IS THE TIME INTERVAL BETWEEN THE ARRIVAL OF THE PRIMER'S DETONATION SHOCK WAVE AT THE PRIMER TO ANFO CHARGE INTERFACE AND FORMATION OF DETONATION SHOCK WAVE IN THE ANFO MIXTURE. PHYSICAL PARAMETERS WERE STRENGTH OF PRIMER, RATIO OF PRIMER TO CHARGE DIAMETER, CHARGE DIAMETER CONFINEMENT AND CHARGE DENSITY.

12-65-06007 THE MECHANICS OF EXPLOSIVE CAVITY FORMATION AND ENERGY DISSIPATION IN A SOLID EARTH (MOHR-COULOMB DYNAMIC-PRESSURE COUPLING)
GNIRK, P. F. + FAIRHURST, C. & S.D. SCHOOL OF MINES
PENN STATE UNIV SEVENTH SYMP ON ROCK MECHANICS, (2) 382-406, JUNE 14, 1965. MECHANICS OF SPHERICALLY-SYMMETRIC AND CYLINDRICALLY-SYMMETRIC EXPLOSIVE CAVITY FORMATION, VALID FOR LARGE ELASTIC-PLASTIC DEFORMATIONS IN AN INFINITE SOLID EARTH, ARE ANALYTICALLY DEVELOPED FOR THE CASE IN WHICH PRESSURE APPLICATION ON THE CAVITY WALL IS OF A DYNAMIC NATURE. PRESSURE IS APPLIED UNIFORMLY TO CAVITY SURFACE AND IS A KNOWN FUNCTION OF CURRENT CAVITY RADIUS THROUGHOUT THE EXPANSION PROCESS AND EARTH MATERIAL IS ELASTIC-PERFECTLY-PLASTIC AND INCOMPRESSIBLE AND OBEYS THE MOHR-COULOMB YIELD CRITERION. IT IS ASSUMED THAT MOTION OF THE CAVITY CEASES COMPLETELY AT END OF INITIAL EXPANSION PHASE. FORMULATED RESULTS PERMIT CAVITY RADIUS CALCULATION AND ENERGY PARTITION AT INITIAL WALL YIELDING AND AT EXPANSION TERMINATION. QUANTITATIVE AGREEMENT WITH AVAILABLE DATA FOR CONTAINED FULLY-COUPLED EXPLOSIONS IN SALT IS QUITE ENCOURAGING IN VIEW OF THE NUMEROUS AND RESTRICTIVE ASSUMPTIONS EMPLOYED THROUGHOUT THE ANALYSIS.

12-65-06008 DYNAMIC STRESSES INDUCED WITHIN ROCK IN CASE OF BLASTING WITH ONE FREE FACE (ELASTIC-THEORY PARTICLE-VELOCITY RADIAL-DISPLACEMENT CRACKS TENSILE-STRESS)
SUSSA, K. + LTO, I. & KYOTO UNIV JAPAN
PENN STATE UNIV SEVENTH SYMP ON ROCK MECHANICS, (2) 407-437, JUNE 14, 1965. DYNAMIC PRINCIPAL STRESS BEHAVIOR INDUCED WITHIN ROCK BY AN EXPLOSION UNDER CONFINED CONDITION WAS ANALYZED FOR BLASTING WITH ONE FREE FACE BY APPLYING MEASURED RADIAL DISPLACEMENT VALUES, PARTICLE VELOCITY TO EQUATIONS DERIVED FROM ELASTICITY THEORY. FREE FACE DYNAMIC STRESSES WERE ALSO CALCULATED FROM STRAIN MEASURED BY WIRE STRAIN GAUGES AFFIXED ON THE FREE FACE. RESULTS SHOWED: MAXIMUM FREE FACE STRESS WAS AT FREE FACE AND BURDEN INTERSECTION; ITS MAGNITUDE WAS TWICE THAT OF THE TANGENTIAL TENSILE STRESS FROM THE INCIDENT STRESS WAVE WITHIN THE RANGE RELATED TO THE BLASTING BREAKAGE; MAXIMUM COMPRESSIVE STRESS NEAR THE FREE FACE WAS DECREASED DUE TO THE FREE FACE WHILE TENSILE STRESS WAS INCREASED; MAXIMUM VALUE OF TENSILE STRENGTH IN PHI DIRECTION WAS LARGER THAN THOSE IN GAMMA THETA PLANE ON AND NEAR THE FREE FACE; TENSILE STRESS CAUSED BY THE HOPKINSON EFFECT APPEARED ONLY NEAR THE BURDEN; RADIAL CRACKS WILL BE PRODUCED IN THE ROCK MASS NEAR AN EXPLOSION POINT BUT WITH THE APPROACH OF THE FREE FACE CRACK DIRECTIONS WILL BE CURVED TO ONES PARALLEL TO THE FREE FACE; APPEARANCE OF BREAKAGE DEDUCED AGREES FAIRLY WELL WITH PRACTICAL OBSERVATIONS.

12-65-06009 BEHAVIOR OF ROCK DURING BLASTING (ROCK-PROPERTIES SHOCK-FRONT ENERGY-DISTRIBUTION EXPLOSION LOADING ALUMINIZED-SLURRY)
COOK, M. A. + COOK, V. O. + KEYES, R. T. & UDY, L. L. + CLAY, R. B. & INTERMOUNTAIN RES AND ENGR CO
PENN STATE UNIV SEVENTH SYMP ON ROCK MECHANICS, (2) 438-461, JUNE 14, 1965. BASED ON COMPRESSIBILITY AND SHOCK VELOCITY IN ROCK, INITIAL EXPLOSIVE LOADING CONDITIONS, EXPLOSIVE THERMOCHEMISTRY AND DESCRIPTION OF PRESSURE-DISTANCE RELATIONS BEHIND THE SHOCK FRONT, THE ENERGY DISTRIBUTION BETWEEN DETONATION PRODUCTS AND BURDEN ARE ESTIMATED AS A FUNCTION OF TIME FOR VARIOUS LOADING CONDITIONS INCLUDING "POWDER FACTOR," LOADING DENSITY AND THE EXPLOSIVE ITSELF. RELEASE WAVE FRACTURING, SHEAR WAVE FRACTURING, RELEASE OF LOAD FRACTURING ARE DISCUSSED IN TERMS OF THESE FINDINGS. RELEASE OF LOAD FRACTURING, ROCK BURSTING, IS CONSIDERED TO BE THE MOST IMPORTANT MEANS OF ROCK FRACTURING IN BLASTING. MEANS FOR MAXIMIZING IT ARE CONSIDERED. MAXIMUM EFFICIENCY IS ATTAINED BY USING HIGH DENSITY EXPLOSIVES AT A LOADING DENSITY OF UNITY. WAYS FOR ACHIEVING THIS CONDITION ARE DISCUSSED. BULK-HANDLED ALUMINIZED SLURRY BLASTING AGENTS ARE DESCRIBED AND SHOWN TO HAVE THE DESIRED PROPERTIES FOR ACHIEVING OPTIMUM CONDITIONS FOR HIGH BLASTING EFFICIENCY.

12-65-06010 DRILLING BY EXPLOSIVES (CAPSULES SHAPED-CHARGE GAUGING-CHARGE DRILLING REAMER) -
ROBINSON, L. H., JR. & ESSO PROD RES CO HOUSTON TEX
PENN STATE UNIV SEVENTH SYMP ON ROCK MECHANICS, (2) 462-489, JUNE 14, 1965. EXPLOSIVE DRILLING WAS PROBABLY FIRST UTILIZED BY QUARRY OPERATORS TO SPRING A HOLE. THE RUSSIANS HAVE DRILLED OVER 7600 FT OF HOLE IN DIFFERENT FORMATIONS WITH CAPSULES WHICH RESULTED IN A ROCK REMOVAL EFFICIENCY OF 20 CC OF ROCK PER GRAM OF EXPLOSIVE. THE HUMBLE TECHNIQUE VISUALIZES ALTERNATELY PUMPING 4 TO 5 FT LONG PLASTIC CAPSULES CONTAINING SHAPED AND GAUGING CHARGES DOWN TO THE BOTTOM OF A DRILL PIPE AND DETONATING THEM. THE ONLY CHANGES IN CURRENT ROTARY DRILLING EQUIPMENT WOULD BE ELIMINATION OF A DRILL BIT AND SOME DRILL COLLARS AND ADDITION OF A CAPSULE ADDING MECHANISM AND THE SPECIAL DRILLING-REAMING HEAD. INTERACTION OF SHAPED AND GAUGING CHARGES WITH ROCK ARE GIVEN. IT IS CONCLUDED THAT SEQUENTIAL FIRING OF SHAPED AND GAUGING CHARGES CAN FORM HOLES AT AN ATTRACTIVE CHARGE TO ROCK-REMOVAL RATIO; INCREASED PRESSURE INCREASES GAUGING CHARGE ROCK REMOVAL EFFICIENCY, TEMPERATURE HAS ONLY A SLIGHT EFFECT ON ROCK REMOVAL EFFICIENCY, AND GAUGING CHARGES EXPAND SHAPED-CHARGED HOLES MORE EFFECTIVELY THAN THEY DO DRILLED HOLES. SEE ALSO 22-65-01001.

12-65-06011 WILDCATTING ON THE MOON (VACUUM LUBRICATION FRICTION ADHESION IMPREGNATION)
PENN, S. H. & GRUMMAN AIRCRAFT ENGINEERING CO
PENN STATE UNIV SEVENTH SYMP ON ROCK MECHANICS, (2) 490-517, JUNE 14, 1965. PRELIMINARY EXPERIMENTAL EVIDENCE SEEMS TO PRECLUDE THE USE OF UNLUBRICATED MECHANICAL-FORCE DRILLS ON THE MOON. MEASURED VALUES OF THE COEFFICIENTS OF FRICTION AND ADHESION BETWEEN METALLIC AND NONMETALLIC SOLIDS HAVE BEEN SHOWN TO INCREASE IN AN ULTRAHIGH VACUUM ENVIRONMENT. THE PAUCITY OF REAL KNOWLEDGE AND INFLUENCE OF A HARD LUNAR VACUUM UPON INTERACTING SOLID SURFACES, RELEGATES CURRENT PROPOSALS TO SAMPLE THE MOON WITH A MECHANICAL FORCE DRILL, TO THE EQUIVALENT OF WILDCATTING ON EARTH. IT IS RECOMMENDED THAT IMPREGNATED DRILL BITS BE DEVELOPED FOR LUNAR USE.

12-65-06012 EXTRATERRESTRIAL MINING (OXYGEN WATER MINERALS PERSONNEL-SHELTER TUNNELING-MACHINE)
WILLIAMSON, T. N. & HUGHES TOOL CO HOUSTON TEX
PENN STATE UNIV VII SYMP ON ROCK MECHANICS, (2) 518-534, 518-531, JUNE 14, 1965. EXTRATERRESTRIAL MINING WILL PROVIDE PERSONAL SHELTER OXYGEN FROM MINERALS, WATER FROM HYDROUS ROCK, BUILDING MATERIALS FOR STRUCTURES AND RECOVERY OF NEW MINERALS. THE LACK OF AIR AND WATER ON THE MOON AND ITS LOWER GRAVITY WILL FACILITATE TUNNELING MACHINE OPERATION. SUCH A MACHINE WOULD EITHER BE CONSTRUCTED IN SPACE OR HAVE ITS COMPONENTS ASSEMBLED ON THE MOON. WHAT WILL BE OUR FUTURE REQUIREMENTS? IT IS NOT TOO SOON TO SPECULATE.

12-66-09001 BRITTLE FRACTURE OF ROCKS (BRAZILIAN-TEST GRIFFITH-CRITERION MOHR-ENVELOPE ROCK-STRENGTH)
JAEGER, J. C. & AUSTRALIAN NATIONAL UNIV
UNIV. OF MINN., EIGHTH SYMP ON ROCK MECHANICS, 3-57, SEPT 1966. A HISTORY OF THE BRITTLE FRACTURE OF ROCK IS GIVEN. PRACTICAL ROCK MECHANICS ENTAILS ANALYZING HIGHLY INHOMOGENEOUS STRESSES. THE INTERNAL FRICTION APPROACH IS THE

SIMPLEST CRITERION. AN ANALYSIS INVOLVING THIS AND THE MOHR ENVELOPE IS GIVEN MODIFIED BY THE GRIFFITH CRITERION FOR TWO-DIMENSION AND THREE-DIMENSION THEORY. PROBLEMS ARE PRESENTED IN UNCONFINED COMPRESSION, UNIAXIAL TENSION, BIAXIAL TENSION, THE TRIAXIAL TEST, HOLLOW CYLINDERS WITH INTERNAL OR EXTERNAL PRESSURE AND AXIAL LOAD, THE BRAZILIAN TEST WHICH IS LOADING CYLINDERS IN A DIAMETRAL PLANE, BENDING AND OTHER SYSTEMS TESTS. SEVERAL MATHEMATICAL APPROACHES TO STRESSES AND DISPLACEMENTS AROUND A CRACK ARE GIVEN. MATHEMATICAL STUDIES FOR CRACK PROPAGATION ARE ENUMERATED. 185 REFS.

12-66-09002 RECENT EXPERIMENTAL STUDIES OF BRITTLE FRACTURE OF ROCKS (COMPRESSION FRICTION EFFECTIVE-STRESS VOLUME CHANGE GRIFFITH-THEORY)
BRACE, W. F. + BYERLEE, J. D. & M.I.T. CAMBRIDGE MASS
UNIV. MINN. EIGHTH SYMP. ON ROCK MECHANICS, 58-81, SEPT. 1966. NEW EXPERIMENTAL STUDIES CONCERN VOLUME CHANGES WHICH ACCOMPANY BRITTLE FRACTURE, PROPAGATION OF CRACKS IN COMPRESSION, FRICTIONAL CHARACTERISTICS OF ROCKS AND MINERALS AT HIGH PRESSURE, AND THE LAW OF EFFECTIVE STRESS FOR CRYSTALLINE ROCK. OBSERVATIONS OF THESE EXPERIMENTS ARE GIVEN AND A DISCUSSION OF THE PROCESS OF BRITTLE FRACTURE OF ROCKS IN COMPRESSION AND THE APPLICABILITY OF GRIFFITH THEORY TO FRACTURE OF ROCK.

12-66-09003 THE INFLUENCE OF ENVIRONMENT ON THE BRITTLE FRACTURE OF ROCKS (FLUID-PRESSURE LOADING-DURATION TEMPERATURE)
HEARD, H. C. & LRL LIVERMORE CAL
UNIV. MINN. EIGHTH SYMP. ON ROCK MECHANICS, 82-93, SEPT. 1966. THE EFFECT OF THE SUPEPPOSED STRESS FIELD UPON THE LITHOSTATIC AND INTERSTITIAL FLUID PRESSURE, THE TEMPERATURE AND DURATION OF THE LOADING UPON THE FAILURE OF ROCKS EITHER BY FRACTURE OR FLOW IS EXAMINED WITH SMALL HOMOGENEOUS SAMPLES. EACH PARAMETER IS EXAMINED SINGLY WITH ALL OTHERS HELD CONSTANT. THE DATA DO NOT SEEM TO FIT THE COULOMB-MOHR, VON MISES, OR GRIFFITH CRITERIA AT PRESENT IN FAVOR.

12-66-09004 A PHOTOELASTIC TECHNIQUE FOR THE DETERMINATION OF POTENTIAL FRACTURE ZONES IN ROCK STRUCTURES
HOEK, E. & IMPERIAL COL LONDON ENG
UNIV. MINN. EIGHTH SYMP. ON ROCK MECHANICS, 94-112, SEPT. 1966. A PHOTOELASTIC TECHNIQUE FOR DETERMINATION OF POTENTIAL FRACTURE ZONES IS DESCRIBED. A PRACTICAL EXAMPLE, DESIGNING A DEEP-LEVEL MINE EXCAVATION LAYOUT, IS GIVEN. PHOTOELASTIC ISOCHROMATIC PATTERNS DO NOT CONTAIN SUFFICIENT INFORMATION FOR ROCK FRACTURE PREDICTION BUT BY SUPERIMPOSING AN ISOPACHIC PATTERN BOUNDARIES OF POTENTIAL FRACTURE ZONES CAN BE DETERMINED. THE TECHNIQUE FOR OBTAINING THE ISOPACHS BY MEANS OF THE ELECTRICAL ANALOG IS DESCRIBED. FROM SUCH STUDIES THE BEST MINE EXCAVATION LAYOUT CAN BE OBTAINED.

12-66-09005 INITIAL AND SUBSEQUENT FRACTURE CURVES FOR BIAXIAL COMPRESSION OF BRITTLE MATERIALS (FAILURE FLOW COULOMB-MOHR GRIFFITH-THEORY VON-MISES)
PAUL, B. + GANGAL, M. & INGERSOLL-RAND CO
UNIV. MINN. EIGHTH SYMP. ON ROCK MECHANICS, 113-141, SEPT. 1966. SINCE ROCK DRILLING DEPENDS ON MECHANICAL ROCK LOADING, A CRITERION IS NECESSARY WHICH DISTINGUISHES STRESS COMBINATIONS WHICH CAUSE MACROSCOPIC ROCK FAILURE FROM THOSE WHICH DO NOT. THE ORIGINAL GRIFFITH THEORY PREDICTS CRACK INITIATION AT A MICROSCOPIC LEVEL AND NOT MASSIVE OR MACROSCOPIC FAILURE. MODIFIED COULOMB-MOHR THEORY WHICH ALLOWS FOR ARBITRARY TENSION TO COMPRESSION RATIOS IS SUPERIOR TO THE INITIAL GRIFFITH THEORY BUT THE EXTENDED GRIFFITH THEORY GIVEN HERE BETTER EXPLAINS BY FRACTURE HARDENING THE EXPERIMENTAL RESULTS CONCERNING GROWTH AND FORM OF SLOWLY PROPAGATING CRACKS AND MODE OF COMPRESSION FAILURE. GRIFFITH'S ORIGINAL THEORY IS ANALOGOUS TO TRESCA AND VON MISES PLASTIC THEORY WHERE INITIAL YIELD CURVES INDICATE ONLY PLASTIC FLOW ONSET RATHER THAN GROSS MACROSCOPIC FAILURE.

12-66-09006 DISCUSSION OF BRITTLE FRACTURE OF ROCK (BRAZILIAN-TEST COMPRESSION TENSION REBOUND)
MCWILLIAMS, J. R. + PARISEAU, W. G. & HARDY, H. R., JR. + WAWERSIK, W. R. + PAUL, B. & GANGAL, M. + HUDSON, J. A.
UNIV. MINN. EIGHTH SYMP. ROCK MECHANICS, 142-164, SEPT. 1966. WRITTEN DISCUSSIONS WERE CONTRIBUTED BY SEVEN INVESTIGATORS. MCWILLIAMS BY POINT LOAD TESTS AND BRAZILIAN TESTS SHOWS THAT TENSILE STRENGTH VARIES INVERSELY WITH FREQUENCY OF DEFECT STRUCTURE OCCURRENCE. PARISEAU BY FOCUSING ATTENTION ON FRACTURE PHYSICAL FEATURES OBTAINS THEORETICALLY THROUGH EXPLOITATION OF A MINIMUM ENERGY POSTULATE ALL MAJOR FEATURES OF FAILURE. HARDY BY USING A TEFLON WAFER IN A CUP HAS OBTAINED UNIFORM END LOADING FOR COMPRESSIVE TESTS OF CYLINDRICAL SPECIMENS. WAWERSIK PERFECTLY CONTROLLED TEST MACHINE ELASTIC REBOUND BY INCORPORATING A HYDRAULIC LOADING SYSTEM IN PARALLEL WITH THE ROCK SPECIMEN. IN COMPRESSIVE TESTS CYLINDRICAL SPECIMENS GO THROUGH ELASTIC COMPRESSION, NONELASTIC COMPRESSION, NONELASTIC DEFORMATION AND NONELASTIC COMPRESSION. PAUL AND GANGAL REEMPHASIZED THE CONCLUSIONS IN THEIR ARTICLE 12-66-09005. HUDSON GIVES THE RESULTS OF 48 CENTRALLY LOADED BEAM TESTS AND SHOWS THE GOOD FIT OF THE WEIBULL DISTRIBUTION CURVE. FOR A GOOD ROCK, TENSILE STRENGTH DISTRIBUTION CAN BE PREDICTED.

12-66-09007 THE DESIGN OF UNDERGROUND EXCAVATIONS (ANALOGUES ENERGY EXCAVATIONS STRESS-ANALYSIS)
COOK, N. G. W. & JOHANNESBURG SOUTH AFRICA
UNIV. OF MINN. EIGHTH SYMP. ON ROCK MECHANICS, 167-193, SEPT 1966. TOTAL FORCE RESULTING FROM STRESSES ACROSS ANY PLANE MUST BE THE SAME BEFORE AND AFTER MAKING EXCAVATION AND ENERGY MUST BE RELEASED BY UNDERGROUND EXCAVATION. METHODS OF EVALUATING STRAIN ENERGY ACCUMULATION AND EXCESS ENERGY RELEASE WHICH RESULT FROM UNDERGROUND EXCAVATION ARE DISCUSSED. SOLUTIONS OF DISPLACEMENTS AND STRESS CONCENTRATIONS CAN BE FOUND BY APPLYING APPROPRIATE BOUNDARY CONDITIONS TO ANALOGUES PROVIDED BY ELECTRICAL CONDUCTION. THESE METHODS ARE USED TO SHOW HOW EXCAVATIONS CAN BE PLANNED TO MINIMIZE ENERGIES. PROPERTIES OF FAILED ROCK AND INTERACTION BETWEEN FAILED ROCK AND THE STRESSES APPLIED TO IT BY THE ROCK MASS AND SUPPORT MEDIA ARE EXAMINED, PARTICULARLY WITH A VIEW TO CONTROLLING ROCK FAILURE AND AVOIDING VIOLENT FAILURES.

12-66-09008 THE RELATIONSHIP BETWEEN ENERGY RELEASE RATE, DAMAGE, AND SEISMICITY IN DEEP MINES (ANALOGUE-ANALYSIS SEISMIC-RECORDINGS ROCK-BURST)
HODGSON, K. + JOHGHIN, N. C. & JOHANNESBURG SOUTH AFRICA
UNIV. MINN. EIGHTH SYMP ON ROCK MECHANICS, 194-203, SEPT. 1966. ENERGY RELEASE RATE WAS DETERMINED BY MEANS OF THE ELECTRICAL RESISTANCE ANALOGUE. THIS ASSUMES ELASTIC ROCK BEHAVIOR AND DEVIATION FROM ELASTIC BEHAVIOR RESULTS IN HIGHER ENERGY RELEASE RATES. A SEISMIC RECORDING NETWORK IN EACH OF THE TWO SOUTH AFRICAN MINES ONE AT 9,000 FT DEPTH, THE OTHER AT 5,000 FT DEPTH ENABLES THE AMOUNT OF KINETIC ENERGY RELEASED BY VIOLENT ROCK FAILURES PER UNIT AREA MINED TO BE DETERMINED. IN THIS MINING SYSTEM AN ENERGY RELEASE RATE OF LESS THAN 100 MILLION FT LBS PER SQUARE FATHOM REDUCES ROCK FAILURE PROBLEMS TO EASILY MANAGEABLE PROPORTIONS.

12-66-09009 THE EFFECT OF NONELASTIC BEHAVIOR OF ROCKS (CREEP-STRAIN DEFORMATION-GAGES STRESSMETERS PRESSURE-CELLS SALT-MINE)
MCCLAIN, W. C. & ORNL OAK RIDGE TENN
UNIV. MINN. EIGHTH SYMP. ROCK MECHANICS, 204-216, SEPT. 1966. ROCK MECHANICS PROBLEMS HAVE BEEN ANALYZED BY THE THEORY OF ELASTICITY BUT IN SALT, POTASH, AND TRONA CREEP STRAIN CAN BE SEVERAL ORDERS OF MAGNITUDE GREATER THAN INSTANTANEOUS STRAIN AND DESIGN MUST INCORPORATE PROVISION FOR THIS. THIS PROJECT WAS IN THE CAREY SALT MINE AT LYONS, KANSAS AND THE INVESTIGATION'S OBJECTIVE WAS TO PRODUCE ANY SPECIFIED CLOSURE AT ANY SPECIFIED TIME. FOUR ROOMS WERE MINED AND THE RESULTS FROM BOREHOLE DEFORMATION GAGES, BOREHOLE STRESSMETERS AND PRESSURE CELLS ARE GIVEN. FROM A LABORATORY TEST ON A MODEL PILLAR OF SALT AN EMPIRICAL FORMULA WAS GENERATED RELATING STRESS, TIME, STRAIN AND TEMPERATURE. IN THE ACTUAL WORKINGS ROOF DEFORMATION INCREASED SO RAPIDLY UPON HEATING THAT THE ENTIRE EXPERIMENTAL AREA WAS ROOF BOLTED. BY UTILIZING CREEP STRAIN PROPERTIES A BETTER CONTROL OF THE WORKINGS IS POSSIBLE. ALL ROCK HAS A CERTAIN NONELASTICITY AND ANALYSIS SIMILAR TO THIS CAN BE USEFUL.

12-66-09010 SUMMARY OF STRESS DETERMINATIONS MADE IN THE PROXIMITY OF UNDERGROUND OPENINGS (OVERCORING RIB-PILLAR ROCK-STRESS)
OBERT, L. & U.S. BUR MINES
UNIV. MINN. EIGHTH SYMP. ON ROCK MECHANICS, 217-223, SEPT. 1966. DATA FROM OVERCORING AND OTHER STRESS-MEASURING TECHNIQUES ARE DISCUSSED AND IT IS STATED THAT ALTHOUGH THESE DATA ARE MEAGER, THEY SHOULD STIMULATE SPECULATION REGARDING EARTH'S CRUST STRESS.

12-66-09011 UNDERGROUND EXCAVATION AND SUPPORT (ROCK-BOLTS GROUTING SURFACE-COATING PRELOADED-SUPPORTS INSTRUMENTATION)
REED, J. J. & COLO SCHOOL OF MINES GOLDEN COLO
UNIV. MINN. EIGHTH SYMP. ROCK MECHANICS, 224-231, SEPT. 1966. THIS IS A SUPPLEMENT TO ARTICLE 12-66-09007, "DESIGN OF UNDERGROUND EXCAVATIONS". FOR HIGHEST QUALITY EXCAVATION, CONTROLLED BLASTING MUST BE CAREFULLY DESIGNED PLUS GOOD SUPERVISION AND ATTENTION TO DETAIL. ROCK REINFORCEMENT WITH BOLTS OR OTHER MEANS IS SUPERIOR TO ROCK SUPPORT. ROCK BOLTING THEORY, GROUTING, SURFACE COATINGS, PRELOADED SUPPORTS, OPENING ORIENTATION, AND INSTRUMENTATION FOR EXCAVATION CONTROL HAVE CHANGED UNDERGROUND EXCAVATION FROM AN ART TO AN ENGINEERING SCIENCE.

12-66-09012 DISCUSSION OF DESIGN OF UNDERGROUND EXCAVATIONS IN ROCK (ANALOG ELASTIC-THEORY ROCK-BOLTS ROCK-STRENGTH FIELD-STUDIES)
PARKER, J. + FAIRHURST, C. + STARFIELD, A. M. & OBERT, L. + REED, J. J. + SALAMON, M. D. G. & COOK, N. G. W.
UNIV. MINN. EIGHTH SYMP ON ROCK MECHANICS, 232-234, SEPT. 1966. PARKER (WHITE PINE COPPER CO.) STATES THAT FOR ROOF SPANS, ASSUMING ROCK TO BEHAVE AS A GRAVITY LOADED BEAM IS OFTEN UNREALISTIC. ROOF BOLTS MAY ACT NOT ONLY TO SUPPORT GRAVITY LOADED BEAMS BUT ALSO TO PREVENT BUCKLING DUE TO LATERAL PRESSURE. NO ONE HAS INVESTIGATED THE REDUCTION OF ROCK STRENGTH FROM MOISTURE. FAIRHURST (UNIV. MINN.) SAID THAT THE ANALOG CAN BE MODIFIED TO ENABLE ITS USE FOR ROCK WITH NONLINEAR DEFORMATION BEHAVIOR. STARFIELD (UNIV. MINN.) MENTIONS THE IMPORTANCE OF GUIDING FIELD MEASUREMENTS BY THEORY. OBERT (U. S. BUR. MINES, DENVER) EMPHASIZES THE FACT THAT CURRENT THEORIES OF PLASTICITY AND VISCOELASTICITY ARE HIGHLY IDEALIZED AND OF LIMITED VALUE IN ROCK MECHANICS UNTIL CONSIDERABLY IMPROVED. BY FIELD STUDIES WE SHOULD ATTEMPT TO SOLVE THE PRESSING PRACTICAL PROBLEMS. REED (COLO. SCH. OF MINES) SUGGESTS THAT THE NEED FOR FIELD INVESTIGATIONS CAN BEST BE MET BY INDUSTRIAL ORGANIZATIONS CREATING THEIR OWN "IN-HOUSE" ROCK MECHANICS CAPABILITY. SALAMON (CHAMBER OF MINES, JOHANNESBURG) POINTS OUT THAT ROCK MECHANICS RESEARCH IN SOUTH AFRICA HAS BEEN BASED ON ELASTIC THEORY BUT ONLY AFTER FIELD EVIDENCE PROVED ITS VALIDITY FOR THEIR MINING CONDITIONS. THE ANALOG HAS BEEN HELPFUL IN COAL MINES AS WELL AS GOLD MINES WHICH ARE SEVERAL HUNDREDS OF FEET DEEPER. COOK (CHAMBER OF MINES, JOHANNESBURG) FOUND THAT THE ANALOG RESULTS WHEN INTERPRETED IN TERMS OF ENERGY CONCEPTS WERE USEFUL IN PLANNING MINE LAYOUTS.

12-66-09013 THE STATE OF ROCK MECHANICS KNOWLEDGE IN DRILLING (DRILLING-RATE EXOTIC-DRILLING PERCUSSION-DRILLING ROTARY-DRILLING ROTARY-PERCUSSIVE-DRILLING ROCK-MECHANICS)
MAURER, W. C. & ESSO PROD RES CO HOUSTON TEX
UNIV. MINN. EIGHTH SYMP. ON ROCK MECHANICS, 355-395, SEPT. 1966. SEVERAL MODELS PROPOSED TO EXPLAIN VARIOUS ASPECTS OF PERCUSSION AND ROTARY DRILLING ARE REVIEWED. DRILLING RATE EQUATIONS ARE GIVEN FOR PERCUSSION, DRAG BIT, ROLLER BIT AND DIAMOND BIT DRILLING. UNDER EXOTIC DRILLING METHODS, EIGHT MECHANICAL, SIX THERMAL SPALLING, SIX FUSION AND VAPORIZATION AND ONE CHEMICAL ARE LISTED. ALTHOUGH MANY EXOTIC DRILLS HAVE ONLY LIMITED POTENTIAL AT THIS TIME, THEY SHOULD BE REEVALUATED AS NEW TECHNOLOGY AND IMPROVED EQUIPMENT BECOME AVAILABLE.

12-66-09014 ROCK MECHANICS AND THE EVALUATION OF IMPROVED ROCK CUTTING METHODS (DRILLING EXOTIC-DRILLING)
BAILEY, J. J. + DEAN, R. C., JR. & CREARE INC HANOVER N.H.
UNIV. MINN. EIGHTH SYMP. ON ROCK MECHANICS, 396-409, SEPT. 1966. IN ROCK CUTTING THEORY A MODEL'S EFFECTIVENESS IS MEASURED IN FORCE OR WORK DONE PER VOLUME OF ROCK REMOVED. TO MAKE IMPROVEMENTS THE STRESS STATE AT OR CLOSE TO THE TOOL CONTACT AREA SHOULD BE UNDERSTOOD, KNOWLEDGE CONCERNING FRACTURE INITIATION SHOULD BE AVAILABLE AND THE FACT THAT THE BIT IS WORKING ON ROCK DAMAGED BY PREVIOUS PASSES IS IMPORTANT. THE MODELS HAVE AT BEST A VERY TENUOUS CONNECTION WITH SCIENTIFIC KNOWLEDGE OF ROCK FAILURE BUT SUCH KNOWLEDGE SHOULD POINT TO MORE MEANINGFUL MODELS. INTELLIGENCE IS SHOWN TO BE IMPORTANT IN ICE DISENGAGEMENT. DEVELOPMENT OF THE INTELLIGENT ROCK REMOVAL CONCEPT SHOULD PRODUCE SUPERIOR MACHINES. ALSO EXOTIC METHODS DIRECTED TOWARD VASTLY INCREASED POWER INPUT MAY BE EFFECTIVE.

12-66-09015 THE MECHANICS OF ROCK FAILURE ASSOCIATED WITH DRILLING AT DEPTH (DRAG-BIT ROLLER-BIT CONFINING-PRESSURE FLUID-PRESSURE LOAD-RATE BIT-PENETRATION PLASTIC-THEORY)
CHEATHAM, J. B., JR. + GNIRK, P. F. & RICE UNIV HOUSTON
UNIV. MINN. EIGHTH SYMP ON ROCK MECHANICS, 410-439, SEPT. 1966. A REVIEW OF FUNDAMENTAL MECHANICS OF ROCK TO BIT-TOOTH INTERACTION UNDER DOWNHOLE CONDITIONS. VARIOUS VARIABLES ARE FLUID PRESSURES WHICH SIMULATE BOREHOLE CONDITIONS, MECHANICAL ROCK PROPERTIES, BIT-TOOTH SHAPE AND ANGLE OF ATTACK, AND BIT-TOOTH LOAD APPLICATION RATE. IN ADDITION, EFFECTS OF DISTANCE FROM AND GEOMETRICAL SHAPE OF ADJACENT PENETRATION CRATERS ON MULTIPLE BIT-TOOTH PENETRATION IS GIVEN. EXPERIMENTAL RESULTS AND IDEALIZED THEORETICAL MODELS FOR SINGLE BIT-TOOTH PENETRATION ARE PRESENTED. APPLICABILITY OF PLASTIC THEORY TO DRILLING PHENOMENA AT DEPTH, RESULTS OF RECENT DRAG-BIT STUDIES AND SEVERAL GENERAL THEORIES OF ROLLER-BIT DRILLING ARE DISCUSSED.

12-66-09016 ROCK FRAGMENTATION BY CONCENTRATED LOADING (CRACK-PROPAGATION DEFORMATION DRILLING)
SIMON, R. & BATTELLE MEMOR INST COLUMBUS
UNIV. MINN. EIGHTH SYMP. ON ROCK MECHANICS, 440-454, SEPT. 1966. THEORETICAL DEVELOPMENTS AND EXPERIMENTAL FINDINGS SHOW THAT ALL MECHANICAL METHODS OF ROCK DRILLING COMPRISE A SEQUENCE OF INDEXED, CONCENTRATED LOADINGS ON THE HOLE BOTTOM. A CONSIDERABLE PORTION OF ROCK MECHANIC STUDIES IN DRILLING HAS INVOLVED CONCENTRATED LOADINGS. STRESS DISTRIBUTION IN THE PORTION OF THE VOLUME OF A MEDIUM IN THE VICINITY OF THE CONTACT SURFACE OF A CONCENTRATED LOADING IS EXTREMELY NONUNIFORM AND CRITICALLY DEPENDENT UPON AMOUNTS OF VARIOUS POSSIBLE DEFORMATION AND FAILURE MODES PRODUCED BY THE LOADING ITSELF AND BY PREVIOUS LOADINGS. A COMPLEX INTERACTION OCCURS AS TOOL PENETRATES ROCK BETWEEN CHANGING NONUNIFORM STRESS DISTRIBUTION AND VARIOUS MODES OF FAILURE THAT RESULT, EACH MODIFYING THE OTHER. PROPAGATION OF CRACKS THROUGH REGIONS OF HIGH STRESS GRADIENTS IS A MAJOR COMPLICATING FACTOR. GRIFFITH THEORY CAN EXPLAIN CRACK FORMATION AND MOHR-COULOMB TRAJECTORY GIVE ITS PROPAGATION. BASIC MECHANISMS OF DRILLING ARE NOT YET WELL UNDERSTOOD, NOT BECAUSE OF OUR LACK OF KNOWLEDGE OF ROCK FAILURE'S BASIC PRINCIPLES, BUT DUE TO OUR EXTREMELY LIMITED ABILITY TO APPLY THESE PRINCIPLES TO THE COMPLEX SITUATION INVOLVED IN CONCENTRATED LOADING. 15 REFS.

12-66-09017 DISCUSSION OF ROCK DRILLING (DRILLING-ENERGY DRILLING-RATE EXOTIC-DRILLING PERCUSSION-DRILLING ROTARY-DRILLING ROCK-FAILURE)
TANDANAND, S. + MAURER, W. C. + SIMON, R. & FAIRHURST, C. + HARTMAN, H. L. + BAILEY, J. J. & DEAN, R. C., JR.
UNIV. MINN. EIGHTH SYMP. ON ROCK MECHANICS, 455-460, SEPT. 1966. TANDANAND (U. S. BUR. MINES, MINN.) DESCRIBES THE U. S. BUR. OF MINES WORK IN DETERMINING THE MECHANISM OF ROCK FAILURE FROM A BIT, THE DRILLING ENERGY VERSUS VOLUME OF ROCK REMOVED, AND DRILL PENETRATION RATE. MAURER (ESSO PROD. RES., HOUSTON) SAYS DON'T RULE OUT EXOTIC DRILLING JUST BECAUSE IT TAKES A LOT OF ENERGY. POWER COST IS INSIGNIFICANT IN PETROLEUM DRILLING AND QUITE NEGLIGIBLE IN MOST MINING DRILLING. THE JET PIERCER DRILL HAS A HUNDRED TIMES AS MUCH POWER AS A ROTARY DRILL AND REQUIRES TEN TIMES THE ENERGY FOR DRILLING BUT WILL DRILL TEN TIMES AS FAST. SIMON (B.M.I.) BRINGS OUT THE FACT THAT HAVING A MACHINE TO SURVEY THE BOTTOM OF A HOLE AND COMPUTE HOW BEST TO DRILL IT WOULD GIVE A MUCH HIGHER DRILLING RATE BUT THE COST OF THE MACHINE MIGHT MAKE IT UNECONOMICAL BASED ON THE COST PER FT OF DRILLED HOLE. FAIRHURST (UNIV. MINN.) SAYS THAT FOR INTELLIGENT ROCK REMOVAL IT MAY BE NECESSARY TO DESIGN A MACHINE CAPABLE OF LOCATING ROCK WEAKNESSES. HARTMAN (PENN STATE) INDICATES THAT GREATER IMPROVEMENT IN DRILLING MAY COME FROM SUPPLYING MORE POWER TO MORE EFFICIENT BITS RATHER

THAN ROCK MECHANICS ANALYSIS. BAILEY AND DEAN (CREARE INC., HANOVER, N. H.) POINT OUT THAT CONVENTIONAL LIMITS IN DRILLING SYSTEMS' SPECIFIC ENERGY CAN BE VASTLY IMPROVED. TO ACHIEVE THESE IMPROVEMENTS WILL REQUIRE NEW DRILLING SYSTEMS.

12-66-09018 BLASTING AND DYNAMIC ROCK MECHANICS (ROCK-BREAKAGE STRESS-WAVES ELASTIC-THEORY SOLID-FRICTION CRATERING)
CLARK, G. B. & UNIV MO ROLLA MO
UNIV. MINN. EIGHTH SYMP. ON ROCK MECHANICS, 463-499, SEPT. 1966. NO SUITABLE MATHEMATICAL MODEL HAS BEEN DEVELOPED WHICH WILL DESCRIBE THE STRESS WAVES IN ROCK WHICH ARE RESPONSIBLE FOR ROCK BREAKAGE. SIGNIFICANT PROGRESS HAS BEEN AND IS BEING MADE IN DEVELOPING THEORY ON PARTITIONING OF ENERGY OF EXPLOSIVES IN ALL TYPES OF BLASTING. MODELING ELASTIC AND NONELASTIC WAVES BY ELASTIC, SOLID-FRICTION, MAXWELL, VOIGT, SPRING VOIGT AND BERGER ARE EXPLAINED. THE INVERSION OF THESE MODELS INTO THE REAL TIME PLANE THEN PROVIDES THE FINAL SOLUTION FOR EVALUATION, USUALLY BY COMPUTER TECHNIQUES. COLLINS PRESENTS AN ANALYSIS OF THE PLANE EQUATION FOR THE VOIGT MODEL. THE VOIGT SPHERICAL WAVE EQUATION AND THE MODIFIED VOIGT MODEL ARE PRESENTED. THE SOLID FRICTION MODEL IS GIVEN AND THE VOIGT MODEL SOLUTION DISCUSSED. TRUE CRATERING DATA IN TEN DIFFERENT ROCKS ARE ANALYZED. GRAVITY SCALING IS EXPLAINED.

12-66-09019 EMPIRICAL APPROACH TO PROBLEMS IN BLASTING RESEARCH (EXPLOSIVES PULSE FREQUENCY DISPLACEMENT)
DUVALL, W. I. + ATCHISON, T. C. + FOGELSON, D. E. & U.S. BUR MINES DENVER COLO
UNIV. MINN. EIGHTH SYMP. ON ROCK MECHANICS, 500-523, SEPT. 1966. NONE OF THE THEORETICAL SOLUTIONS FOR THE GENERATION OF STRESS WAVES BY APPLIED PRESSURES TO INTERIOR BOUNDARIES OF SPHERICAL OR CYLINDRICAL CAVITIES APPEAR TO BE COMPLETELY SATISFACTORY TO EXPLAIN EXPERIMENTAL DATA. THIS DOES NOT MEAN THAT THE THEORETICAL WORK IS IN ERROR BUT THAT THE APPROPRIATE DYNAMIC PROPERTIES OF ROCK HAVE NOT BEEN TAKEN INTO ACCOUNT IN THE PRESENT THEORETICAL DEVIATIONS. AN EMPIRICAL APPROACH IS USED TO ESTABLISH THE DAMAGE CRITERION FOR QUARRY BLASTING. EXPERIMENTAL RESULTS FROM EIGHT EXPLOSIVES SHOW THAT THEIR RELATIVE STRAIN PRODUCING ABILITIES AND THUS THEIR CRATER BREAKING ABILITIES CAN BE PREDICTED FROM DETONATION PRESSURES AND IMPEDANCE RATIOS. THE TYPICAL STRAIN PULSES GENERATED BY DETONATING CYLINDRICAL CHARGES IS GIVEN TOGETHER WITH SOME ANALYSIS OF THE DATA. THE SIMULATION OF LONG CYLINDRICAL CHARGES BY SUPERPOSITION OF INCREMENTAL PULSES DOES APPEAR PROMISING AND MAY PROVE VALUABLE IN UNDERSTANDING THE MECHANISM OF BREAKAGE. 23 REFS.

12-66-09020 COMPUTER CALCULATIONS OF EXPLOSION-PRODUCED CRATERS
CHERRY, J. T. & LRL LIVERMORE CAL
UNIV. MINN. EIGHTH SYMP. ON ROCK MECHANICS, 524-527, SEPT. 1966. A TECHNIQUE IS PRESENTED TO CALCULATE ADEQUATELY FROM FIRST PRINCIPLES, THE MOUND AND CAVITY GROWTH THAT OCCURS DURING NUCLEAR AND HIGH-EXPLOSIVE CRATERING EVENTS. A PRESHOT TESTING PROGRAM DETERMINES CONSOLIDATED AND CRACKED EQUATIONS OF STATE. FIELD LOGGING MUST DETERMINE DENSITY AND COMPRESSIONAL AND SHEAR VELOCITY. LABORATORY TESTS DETERMINE HYDROSTATIC COMPRESSIBILITY, TRANSAXIAL DATA, TENSILE STRENGTH, HUGONIOT ELASTIC LIMIT, AND HIGH-PRESSURE HUGONIOT DATA FOR THE ROCK NEAR THE POINT OF DETONATION. THE CALCULATED CRATER RADIUS AND EJECTA REGION AGREE QUITE WELL WITH THOSE OBSERVED POSTSHOT. 1 REF.

12-66-09021 PULSE PROPAGATION IN ROCKS (WAVES MATHEMATICAL-ANALYSIS)
GOLDSMITH, W. & UNIV CAL BERKELEY CAL
UNIV. MINN. EIGHTH SYMP. ON ROCK MECHANICS, 528-537, SEPT. 1966. DETAILED MATHEMATICAL ANALYSIS OF SPHERICAL WAVE PROPAGATION IN AN ELASTIC SUBSTANCE. A VOIGT, A MODIFIED VOIGT AND A SOLID FRICTION MODEL WERE STUDIED. PULSE INPUTS CONSIDERED COMPRISED EXPONENTIAL DECAY, A UNIT STEP AND STEADY-STATE SINUSOIDAL EXCITATION. IN ANALYZING WAVE PROPAGATION IN ROCK, MATERIAL BEHAVIOR IS ESSENTIAL. SUCH INFORMATION IS OBTAINED BY FIELD OBSERVATIONS AND LABORATORY TESTS BUT BOTH ARE BESET WITH DIFFICULTIES AND SUBJECT TO VALID CRITICISM. GRINES' INVESTIGATION OF ROCK POROSITY AND ATTENUATION IS DISCUSSED. THE RESULTS OF HOPKINSON BAR TESTS IN WHICH 845 IN. DIA. BARS ARE LONGITUDINALLY IMPACTED WITH A ONE-HALF IN. DIA. BALL AT 1600 TO 6400 IN/SEC VELOCITY ARE ANALYZED. SOLID FRICTION MODELS CORRESPOND MORE TO EXPERIMENTAL RESULTS THAN VISCOUS REPRESENTATION. A MORE CAREFUL REPRESENTATION OF CLEAVAGE AND OTHER IRREVERSIBLE OR TIME-DEPENDENT MECHANISMS OF THE MICROSCOPIC PROCESSES INVOLVED IN ROCKS DURING THE PASSAGE OF PULSES OF SIZABLE AMPLITUDE IS NEEDED. 19 REFS.

12-66-09022 STRAIN WAVE THEORY IN BLASTING (CRATERING EXPLOSIVES STRAIN-AMPLITUDE CONFIGURATION)
STARFIELD, A. M. & UNIV MINN MINNEAPOLIS MINN
UNIV. MINN EIGHTH SYMP. ON ROCK MECHANICS, 538-548, SEPT. 1966. A KNOWLEDGE OF STRAIN WAVE BEHAVIOR ENABLES ONE TO PREDICT OPTIMUM BURDENS FOR DIFFERENT WEIGHTS AND CONFIGURATIONS OF THE SAME EXPLOSIVE BUT MAKING PREDICTIONS FOR ONE EXPLOSIVE FROM A CRATERING TEST WITH ANOTHER EXPLOSIVE IN SIMILAR ROCK IS NOT RELIABLE. A PEAK STRAIN HYPOTHESIS IS PRESENTED WHICH ALLOWS ONE TO EXTRAPOLATE FROM A CRATERING EXPERIMENT TO A FULL SCALE BLAST. STRAIN WAVE MEASUREMENTS SHOULD PROVIDE THE ATTENUATION LAW AND WAVE SHAPE FOR A CONCENTRATED CHARGE. COMBINATION OF THESE WILL ALLOW COMPUTER SIMULATION FOR ANY BLASTING DESIGN. 18 REFS.

12-66-09023 DISCUSSION OF ROCK BLASTING (ATTENUATION COMPRESSIBILITY PRESPLITTING SHOCK-DAMAGE STRAIN VISCOELASTIC-MODELS)
CULVER, R. S. + FOGELSON, D. E. + DRURY, F. & FAVREAU, R. + STARFIELD, A. M. + LANE, K. S. & GOLDSMITH, W. + CHERRY, J. T. + DRAKE, J. & CLARK, G. B. + FAIRHURST, C.
UNIV. MINN. EIGHTH SYMP. ON ROCK MECHANICS, 549-553, SEPT. 1966. CULVER (COLO. SCHOOL OF MINES) REPORTS ON ROCK PRESPLITTING. A SATISFACTORY PRESPLITTING THEORY HAS NEVER BEEN OBTAINED, BUT A TENTATIVE EXPLANATION HAS EVOLVED. BY PROPER LOADING AND BUFFER CONFIGURATION FRACTURES MAY BE FORCED THROUGH ADVERSE STRESS CONDITIONS, HOLE SPACING MAY BE INCREASED OR AMOUNT OF EXPLOSIVE DECREASED THUS REDUCING DAMAGE TO ADJACENT STRUCTURES. FOGELSON POINTS OUT THAT BUILDING DAMAGE MAY CORRELATE BETTER WITH KINETIC ENERGY OF BUILDING VIBRATION RATHER THAN PARTICLE VELOCITY MEASURED IN THE GROUND. DRURY (HERCULES POWDER) MENTIONED THAT BY INCREASING THE NUMBER OF BOOSTERS THE EXPLOSIVE ROCK BREAKING ABILITY WAS ENHANCED. FAVREAU (ROYAL MIL COLLEGE, MONTREAL) SAYS THAT MAXIMIZING THE HORIZONTAL STRAIN IS NOT THE CONSIDERATION IN MOVING THE BURDEN FOR WHICH VERTICAL STRAIN IS NEEDED. STARFIELD (UNIV. MINN.) ENCOURAGES THE PRACTICAL BLASTING MAN TO TELL THE THEORETICIAN EXACTLY WHAT HE WANTS TO DO THEN DESIGN TECHNIQUES AND COMPUTER PLANNING MAY HELP. LANE (U.S. CORPS ENGR. OMAHA) WOULD LIKE TO KNOW RATE OF WAVE ATTENUATION CORRELATED WITH ROCK SATURATION. GOLDSMITH (UNIV. CAL, BERKELEY) SPECULATES THAT SATURATING ROCK WILL DECREASE AMPLITUDE MORE RAPIDLY. CHERRY (UNIV. CAL., BERKELEY) EXPLAINS THAT IN HIS CALCULATIONS THE ATTENUATION FALLS OUT AS IT IS COVERED BY THE ROCK COMPRESSIBILITY. DRAKE (COAST MFG. AND SUPPLY, LIVERMORE) SAYS THAT COMPUTER TIME ON LARGE NUCLEAR EXPLOSIONS MAY BE 40 HRS TO KEEP TRACK OF THE PARTICLES. CLARK'S (UNIV. MO.) APPROACH HAS BEEN TO ANALYZE VISCOELASTIC AND SIMILAR MODELS TO SEE IF THEY HAVE ELEMENTS APPLICABLE TO ROCK MASSES. FAIRHURST (UNIV. MINN.) MENTIONS THAT PEAK STRAIN DEVELOPED IN ROCK MAY EXPLAIN ITS REACTION TO EXPLOSIVES.

12-66-09024 RESIDUAL STRESSES IN ROCK MASSES (INSTRUMENTATION)
DENKHAUS, H.
PROC INT SOC OF ROCK MECHANICS 1ST CONGRESS, LISBON, (3) 311-383, SEPT 25-OCT 1, 1967. STATE-OF-ART INVESTIGATIONS OF RESIDUAL (LATENT) STRESSES IN ROCK MASSES WITH PARTICULAR EMPHASIS ON STRESS MEASURING TECHNIQUES, STRESS DISTRIBUTION AND THEIR RELATIONS WITH TECTONICS, DISCUSSED IN 10 PAPERS, SUBMITTED TO ABOVE CONGRESS AND AUTHORS OWN ANALYSIS; WRITTEN AND ORAL CONTRIBUTIONS BY CONGRESS MEMBERS ARE INCLUDED. 18 REFS.

12-66-09025 NATURAL AND EXCAVATED SLOPES
TER-STEPANIAN, G.
PROC INT SOC OF ROCK MECHANICS 1ST CONGRESS, LISBON, (3) 425-475, SEPT 25-OCT 1, 1967. STATE-OF-ART INVESTIGATION OF NATURAL AND EXCAVATED SLOPES WITH EMPHASIS ON STRESS DISTRIBUTIONS, STABILITY AS WELL AS STABILIZATION OF SLOPES, AND OBSERVATIONS OF THEIR BEHAVIOR, DISCUSSED IN 16 PAPERS SUBMITTED TO ABOVE CONGRESS AND AUTHORS' OWN ANALYSIS; WRITTEN AND ORAL CONTRIBUTIONS BY CONGRESS MEMBERS ARE INCLUDED.

12-66-10001 PROCEEDINGS OF FIRST CONGRESS OF INT SOC OF ROCK MECHANICS
LABORATORIO NATIONAL DE ENGENHARIA CIVIL, LISBON, PORTUGAL, (2) 1-679, OCT 1966. GROUP OF PAPERS BY 187 AUTHORS ON RESIDUAL STRESSES IN ROCKS, FAILURE OF ROCKS, STABILITY OF SLOPES, UNDERGROUND EXCAVATIONS AND DEEP BOREHOLES, AND BEHAVIOR OF ROCKS AS FOUNDATIONS. SOME INDIVIDUAL PAPERS ARE INDEXED SEPARATELY. SEE 22-66-10002.

12-66-10002 FUNDAMENTAL STUDY ON ROCK STRESS MEASUREMENT BY BOREHOLE DEFORMATION METHOD
SUZUKI, K.
PROC INT SOC OF ROCK MECHANICS 1ST CONGRESS, LISBON, (2) 35-9, OCT. 1966. MEASUREMENT OF DEFORMATION OF BOREHOLE IN ROCK SUBJECTED TO CHANGE IN APPLIED STRESS, MAKES IT POSSIBLE TO CALCULATE MAGNITUDE AND DIRECTION OF APPLIED STRESS, AS DEFORMATION - APPLIED STRESS RELATIONSHIP EXISTS; HONING DEVICES WERE USED TO GET GOOD ROUNDNESS AND SMOOTHNESS OF BOREHOLE; TO MEASURE DEFORMATION OF BOREHOLE IN ROCK SUBJECTED TO KNOWN APPLIED STRESS, CYLINDER GAGE WITH ELECTRIC MICROMETER, AIR MICROMETER AND BOREHOLE GAGE DESIGNED BY AUTHOR WERE USED.

12-66-10003 CONTRIBUTION TO THE PROBLEM OF ROCK BURSTS
KIESER, A.
PROC INT SOC OF ROCK MECHANICS 1ST CONGRESS, LISBON, (2) 221-5, OCT. 1966. CONTRIBUTION TO PROBLEM OF ROCK BURSTS IN EXCAVATIONS; ROCK BURSTS DURING CONSTRUCTION OF TUNNELS AND GALLERIES; ANALYSIS IS GIVEN OF DEFORMATION PROCESSES IN WALLS OF TUNNELS AND GALLERIES AND OF SUBSEQUENT ROCK BURSTS; ROCK BURSTS ARE CLASSIFIED ACCORDING TO CAUSE AND EFFECT, AND FINALLY INFLUENCE OF DECREASING ROCK TEMPERATURE. (IN GERMAN)

12-66-10004 ON DISTRIBUTION OF STRESSES AROUND CIRCULAR TUNNELS IN NONHOMOGENEOUS ROCKS
GOODMAN, R. E.
PROC INT SOC OF ROCK MECHANICS 1ST CONGRESS, LISBON, (2) 249-55, OCT. 1966. EFFECT OF CONSTRUCTING TUNNELS IN LAYERED ROCKS AS OPPOSED TO HOMOGENEOUS ROCKS; RESULTS REPRESENT SOLUTIONS TO PLANE STRAIN BOUNDARY VALUE PROBLEMS USING FINITE ELEMENT ANALYSIS; WHEN CIRCULAR TUNNEL IS EXCAVATED ALONG VERTICAL CONTACT BETWEEN TWO ROCK TYPES WITH DIFFERENT ELASTIC MODULI, STRESSES ARE FOUND TO INCREASE IN HARDER MATERIAL WHILE SOFTER ROCK IS RELATIVELY DESTRESSED; RESULTS SHOW CHANGES IN STRESS DISTRIBUTION AS TUNNEL IS CONSTRUCTED AT VARYING DISTANCES FROM CONTACT BETWEEN ROCK TYPES; EFFECT OF DIFFERING ORIENTATIONS OF BEDDING AND ASSUMPTIONS OF INITIAL ROCK STRESS HAVE ALSO BEEN EXPLORED.

12-66-10005 UNDERGROUND EXCAVATIONS AND DEEP BORINGS (ROCK-MECHANICS TECHNIQUES STRESS STRAIN)
TROLLOPE, D.
PROC INT SOC OF ROCK MECHANICS, 1ST CONGRESS LISBON, (3) 477-535, OCT. 1966. STATE-OF-ART OF UNDERGROUND EXCAVATIONS AND DEEP BORING TECHNIQUES WITH PARTICULAR EMPHASIS ON INVESTIGATION OF STRESS AND STRAIN DISTRIBUTION; STABILITY OF EXCAVATIONS AND BOREHOLES; LININGS; STRENGTHENING; SUPPORT AND SUBSIDENCE, DISCUSSED IN 42 PAPERS SUBMITTED TO ABOVE CONGRESS AND AUTHORS OWN ANALYSIS; WRITTEN AND ORAL CONTRIBUTIONS BY CONGRESS MEMBERS ARE INCLUDED. 16 REFS.

12-66-11001 CURVED BEAM ANALOG FOR TUNNEL DESIGN IN MASSIVE ROCK (TUNNEL DESIGN)
ADLER, L. & VA POLY INST BLACKSBURG VA
AM SOC. CIVIL ENG. PROCEEDINGS, (92) 189-209, NOV 1966. THE CURVED BEAM ANALOG CORRELATES WILL WITH THE ACCEPTED HOLE-IN-A-PLATE ANALYSIS. BECAUSE THE CURVED BEAM METHOD IS EASIER TO LEARN AND USE IT IS PROPOSED AS A SUBSITUTE FOR THE MORE RIGOROUS METHOD. THE SUGGESTED METHOD HAS GREATER POSSIBILITIES FOR ESTIMATING THE EFFECTS OF A WIDE RANGE OF PROBABLE FIELD CONDITION AND THEREFORE COULD PROVIDE GREATER VERSATILITY IN DESIGN PRACTICE.

12-67-04001 STATUS OF ROCK MECHANICS AS APPLIED TO MINING (RESEARCH THEORY)
BLACK, R. A. L. + HOCK, E. & ROYAL SCHOOL OF MINES LONDON
COLO SCHOOL OF MINES NINTH SYMP ON ROCK MECHANICS, 5-27, APR 1967. FORMERLY ROCK MECHANICS RESEARCH WAS PURELY THEORETICAL, ALSO SOME CONSULTANTS AND RESEARCHERS GAVE ROCK MECHANICS A BAD NAME BY EXTRAVAGANT CLAIMS OR BY PLUGGING SOME TECHNIQUE OR GADGET. DUE TO THIS AND THE POOR RETURN WHICH COULD BE SHOWN ON RESEARCH INVESTMENT THE MINING INDUSTRY DID LITTLE RESEARCH INTO ITS BASIC SCIENCES. NOW ROCK MECHANICS ART IS AT THE POINT WHERE IT CAN TACKLE PRACTICAL PROBLEMS PROFITABLY. ROCK MECHANICS IS WHAT HAPPENS NOT WHAT THEORY THINKS OUGHT TO HAPPEN AND SHOULD PREDICT BEHAVIOR AROUND EXCAVATIONS WITH ACCURACY. THE ELEMENTAL FORCES WHICH ACT WHEN ANCIENT EQUILIBRIUM IS DISTURBED BY MINING EXCAVATIONS MUST BE UNDERSTOOD BEFORE REAL PROGRESS IN ROCK MECHANICS APPLICATION TO MINE DESIGN CAN BE MADE. ROCK MECHANICS TOOLS WHICH ARE AVAILABLE TO ATTACK PRACTICAL MINING PROBLEMS, MINING PROBLEMS WHICH ARE AMENABLE TO STUDY AND FOUR EXAMPLES OF THE APPLICATION OF ROCK MECHANICS TECHNIQUE ARE PRESENTED. THE TIME WHEN YOU COULD SHUT UP SHOP AND LOOK FOR A RICHER ORE BODY IF BRUTE FORCE AND CASH WOULD NOT SOLVE THE PROBLEM IS PAST. NOW WE MUST LIVE WITH OUR PROBLEMS AND ENGINEER THE BEST SOLUTIONS POSSIBLE.

12-67-04002 STATUS OF ROCK MECHANICS AS APPLIED TO CIVIL ENGINEERING (DESIGN ECONOMY)
MCCLURE, C. R. & BECHTEL CORP SAN FRANCISCO
COLO SCHOOL OF MINES NINTH SYMP ON ROCK MECHANICS, 28-41, APR 1967. ROCK MECHANICS THRU SPECIFIC GRAVITY, POROSITY, ABSORPTION, COMPRESSIVE AND TENSILE STRENGTH, MODULUS OF ELASTICITY, POISSON'S RATIO AND TRIAXIAL AND DIRECT SHEAR STRENGTH COMBINED WITH GEOLOGIC INVESTIGATION RESULTS IN SAFE AND ECONOMICAL UNDERGROUND STRUCTURE DESIGN. TEST DATA MUST BE PROPERLY EVALUATED. IMPROVEMENT CAN COME FROM BETTER AND MORE ECONOMICAL TEST METHODS AND STANDARDIZATION OF TEST PROCEDURES AND REPORTING METHODS AND PERSONAL EXCHANGE OF IDEAS.

12-67-04003 ANALYSIS OF ACCURACY IN THE DETERMINATION OF THE GROUND-STRESS-TENSOR BY MEANS OF BOREHOLE DEVICES (COMPUTER-SOLUTIONS LEAST-SQUARES STRESS-FORMULAS TENSORS TEST-HOLE-ORIENTATION)
GRAY, W. M. + TOEWS, N. A. & DEPT MINES OTTOWA CAN
COLO SCHOOL OF MINES NINTH SYMP ON ROCK MECHANICS, 45-78, APR 1967. FORMULAS BASED ON THE APPLICATION OF THE LEAST SQUARES TO SOLUTION OF EQUATIONS FOR STRESS TENSOR COMPONENTS ARE GIVEN. STRAINS OR DEFORMATION DEPENDS ONLY ON CERTAIN PARAMETERS, ON THE NUMBER OF MEASUREMENT DIRECTIONS AND ON THE GEOMETRICAL RELATIONSHIPS BETWEEN BOREHOLE AND MEASUREMENT DIRECTIONS AND COORDINATE AXES. IT IS POSSIBLE TO COMPUTE THE MULTIPLYING FACTORS FOR ANY PROPOSED MEASUREMENT SYSTEM, QUITE INDEPENDENTLY OF THE MEASUREMENTS. THIS HAS BEEN DONE BY ELECTRONIC COMPUTER FOR TWELVE SYSTEMS AND THE RESULTS TABULATED. AN ANGLE SMALLER THAN 45 DEGREES BETWEEN PAIRS OF BOREHOLES SHOULD NOT BE USED AND WORK SUGGESTS THAT 60 DEGREES MAY BE OPTIMUM. FOUR MEASUREMENT DIRECTIONS FOR BOREHOLE ARE REQUIRED FOR GREATEST AND MOST UNIFORM PRECISION IN STRESS COMPONENT DETERMINATION.

12-67-04004 SENSITIVITY ANALYSIS OF BOREHOLE DEFORMATION MEASUREMENTS OF IN SITU STRESS DETERMINATION WHEN AFFECTED BY BOREHOLE ECCENTRICITY (ROCK-STRESS)
AGARWAL, R. & COLUMBIA UNIV
COLO SCHOOL OF MINES NINTH SYMP ON ROCK MECHANICS, 79-83, APR 1967. MEASURING IN SITU STRESSES IN ROCK MASSES HAS BECOME IMPORTANT IN UNDERGROUND STRUCTURE DESIGN. STRESS RELIEF TECHNIQUES HAVE THE WIDEST ACCEPTANCE. DURING BOREHOLE DRILLING FOR DEFORMATION MEASURING DEVICE PLACEMENT BOREHOLE ECCENTRICITY CAN NOT BE RULED OUT. THEORETICAL ROCK STRESS FORMULA WILL BE MODIFIED BY HOLE ECCENTRICITY. HOWEVER, PRESENT PRACTICE IS BASED ON A FEW THOUSANDTHS OF MICRO-IN DISPLACEMENT AND MODIFICATION OF THEORETICAL FORMULA DUE TO ELLIPTICITY CREATED DURING BOREHOLE DRILLING DOES NOT APPEAR TO BE JUSTIFIED IF THE MEASURING DEVICE HAS A PRECISION OF PLUS OR MINUS 50 MICRO-INS.

12-67-04005 ESTIMATED ROCK STRESSES AT MORROW POINT UNDERGROUND POWER PLANT FROM EARTHQUAKES AND UNDERGROUND BLASTS
CAMPBELL, R. B. + DODD, J. S. & U.S. BUR RECL DENVER COLO

COLO SCHOOL OF MINES NINTH SYMP ON ROCK MECHANICS, 84-114, APR.1967. ROCK STRESSES ARE ANALYZED WHICH ARE INDUCED BY NATURAL EARTHQUAKES, NUCLEAR BLASTS OR CONSTRUCTION BLASTING. THE ALLOWABLE TENSILE STRENGTH OF 335 PSI WILL BE EXCEEDED IN A REGION IN THE ROCK ARCH LESS THAN 10 FT IN DEPTH BY AN EARTHQUAKE WAVE STRESS SUPERIMPOSED UPON THE STATIC STRESS BUT THIS WILL BE ADEQUATELY TAKEN CARE OF BY THE ROCK BOLTING SO THAT THE UNDERGROUND MORROW POINT POWER PLANT WILL EXPERIENCE NO DAMAGE FROM NATURAL SEISMIC DISTURBANCES.

12-67-04006 INDICES RELATED TO THE MECHANICAL PROPERTIES OF JOINTED ROCK (JOINT-BREAKAGE-INDEX JOINT-DISPERSION-INDEX ROCK STRENGTH)
MCMAHON, B. K. & COLO SCHOOL OF MINES GOLDEN COLO
COLO SCHOOL OF MINES NINTH SYMP ON ROCK MECHANICS, 117-133, APR 1967. THE JOINT BREAKAGE INDEX AND THE JOINT DISPERSION INDEX ARE USED TO DETERMINE THE IN SITU ROCK STRENGTH FROM LABORATORY ROCK CORE TESTS. THE JOINT BREAKAGE INDEX IS THE PERCENTAGE OF TOTAL EXPOSED SURFACE AREA THAT IS COMPOSED OF JOINT FACES. IT PROVIDES A FIRST STEP FOR ESTIMATION OF LOAD-DEFORMATION CURVES AND FRACTURE ENVELOPES FOR ANY DIRECTION IN THE ROCK MASS. THE JOINT DISPERSION INDEX IS DEFINED AS THE AREA ENCLOSED BY A GIVEN CONCENTRATION CONTOUR ON AN EQUAL AREA PROJECTION OF A JOINT PATTERN EXPRESSED AS A PERCENTAGE OF THE AREA COVERED BY THE SAME CONTOUR OF A RANDOM SAMPLE FROM A UNIFORM DISTRIBUTION OF THE SAME NUMBER OF POINTS, CONTOURED BY THE SAME METHOD. JOINT MEANS ALL NATURALLY OCCURRING ROCK FRACTURES WITH LESS THAN ONE QUARTER IN OF CLAY OR OTHER SOFT COATING MATERIAL. DISCONTINUITIES LARGER THAN JOINTS MUST BE GIVEN SPECIAL TREATMENT.

12-67-04007 POINT LOAD TESTING OF BRITTLE MATERIALS TO DETERMINE TENSILE STRENGTH AND RELATIVE BRITTLENESS (SHAPE-FACTOR)
RICHMUTH, D. R. & MONTANA STATE UNIV BOZEMAN MONT
COLO SCHOOL OF MINES NINTH SYMP ON ROCK MECHANICS, 134-160, APR 1967. AS TENSILE TESTS OF ROCK ARE DIFFICULT OR COSTLY TO MAKE, THE TENSILE STRENGTH CAN BE OBTAINED BY POINT LOADING THRU A SPHERICALLY ENDED 3/8 IN DIA ROD. THE TENSILE STRENGTH EQUALS THE APPLIED COMPRESSIVE LOAD AT FAILURE MULTIPLIED BY THE SHAPE FACTOR AND DIVIDED BY THE SQUARE OF THE DISTANCE BETWEEN LOAD POINTS PLUS THE RELATIVE BRITTLENESS INDEX OF THE MATERIAL MULTIPLIED BY THE SAME APPLIED LOAD AT FAILURE. TABLES ARE GIVEN FOR THE SHAPE FACTOR AND THE BRITTLENESS INDEX. INVESTIGATORS HAVE NOT EXPERIENCED ANY GREAT DIFFICULTY IN MASTERING THE TECHNIQUE OR OBTAINING REPRODUCIBLE RESULTS. FAILURE MECHANISM ASSUMES AN ECHELON CRACK FORMATION, THEIR SUCCESSIVE TRANSFORMATION INTO SLIP LINES BENEATH THE LOAD AND FINALLY SPONTANEOUS CRACK PROPAGATION CLEAVING THE SAMPLE.

12-67-04008 A STATISTICAL STUDY OF RELATIONSHIPS BETWEEN ROCK PROPERTIES
MUTMANSKY, J. M. + SINGH, M. M. & PENN STATE UNIV
COLO SCHOOL OF MINES NINTH SYMP ON ROCK MECHANICS, 161-177, APR 1967. FROM A FEW PROPERTIES INVOLVING MINIMAL COST AND READILY OPERABLE APPARATUS THE OTHER ROCK PROPERTIES CAN BE CALCULATED. THESE METHODS ALSO AID IN INTERPRETATION OF REGRESSION MODELS. INDUSTRY EAGERLY AWAITS STANDARDIZED PROCEDURES FOR THE SYSTEMATIC DETERMINATION OF ROCK CHARACTERISTICS. THREE SETS OF DATA ON VARIOUS ROCK CLASSES GIVE THE VARIATION THAT MAY BE OBTAINED IN TEN PROPERTY VALUES. ROCK PROPERTIES ARE GIVEN FOR FORTY-ONE DIFFERENT TYPES OF MATERIAL.

12-67-04009 MECHANICAL PROPERTIES AND IN SITU BEHAVIOR OF THE "CHINO LIMESTONE" CRESTMORE MINE RIVERSIDE CALIF (FLEXURE LABORATORY-TESTS)
HEUZE, F. E. + GOODMAN, R. E. & UNIV CAL BERKELEY CAL
COLO SCHOOL OF MINES NINTH SYMP ON ROCK MECHANICS, 181-202, APR 1967. IN SITU TESTS USING FLAT JACKS, PLATE BEARING, OVER CORING, SEISMIC VELOCITY AND BOREHOLE JACKING METHODS WERE CONDUCTED ON A PILLAR IN THE 130 FT LEVEL OF CHINO LIMESTONE MINE WHICH IS NOW OPERATING AT 750 FT. EXHAUSTIVE LABORATORY TESTS WERE MADE ON CORES DRILLED IN FOUR DIRECTIONS FROM THE MINE SITE. PRIMARY CONCERN WAS ROOF STABILITY. NO BEHAVIORAL SIMULATION HAS PROVED SATISFACTORY UNLESS FURTHER IN SITU INVESTIGATION, AS BOREHOLE CAMERA EXAMINATION TO LOCATE POSSIBLE DISCONTINUITIES, AND STRESS AND DEFORMATION MEASUREMENTS, CAN BE PERFORMED. FLEXURE IS AN APPROPRIATE TEST FOR UNSUPPORTED MINE ROOF DESIGN SPECIFICATIONS.

12-67-04010 THE APPLICATION OF BARODYNAMIC PHOTOSTRESS TECHNIQUES TO THE STUDY OF THE BEHAVIOR OF ROCK BEAMS LOADED BY THEIR OWN WEIGHT (PHOTOTYPES BENDING)
WANG, C. + BOSHKOW, S. H. + WANE, M. T. & COLUMBIA UNIV
COLO SCHOOL OF MINES NINTH SYMP ON ROCK MECHANICS, 203-221, APR 1967. BARODYNAMIC PHOTOSTRESS TECHNIQUE IS COATING OPAQUE BEAM MATERIAL WITH TRANSPARENT BIREFRINGENT PLASTIC, SUBJECTING TO LOADING AND OBSERVING SURFACE STRAINS DEVELOPED IN THE MODEL TRANSMITTED TO THE PLASTIC BY SHEAR FORCES DEVELOPED AT THE INTERFACE. PURE BENDING THEORY DOES NOT OCCUR IN TESTS AS THE NEUTRAL AXIS APPEARS AT THE TOP EDGE OF THE BEAM AND SHIFTS DOWNWARD WITH INCREASING LOAD STABILIZING WITHIN THE UPPER HALF THICKNESS. NEUTRAL SURFACE RADIUS OF CURVATURE CAN BE EVALUATED BY A SIMPLE GRAPHICAL METHOD. BASED ON PHOTOTYPE SPAN-THICKNESS RELATIONSHIPS, MINE OPENINGS CAN BE SAFELY DESIGNED SO NO ROOF BOLTING OR SUPPORTING IS NECESSARY. PHOTOGRAPHS SHOW MAJOR TENSILE STRESS CONCENTRATIONS ARE WITHIN A SMALL CENTRAL REGION. CONTRARY TO CLASSICAL BEAM THEORY, STRESS INTENSITY IN THE IMMEDIATE ROOF SUPPORT VICINITY IS SIGNIFICANTLY LOWER THAN AT THE CENTER. TWENTY-THREE BEAM TESTS WERE MADE.

12-67-04011 FRACTURING AROUND A ROCK BELT ANCHOR (PHOTOELASTIC-PLASTIC ROCK-BLOCKS)
CULVER, R. S. + JORSTAD, T. & COLO SCHOOL OF MINES GOLDEN COLO
COLO SCHOOL OF MINES NINTH SYMP ON ROCK MECHANICS, 222-234, APR 1967. HIGH STRESSES IN THE ROCK BOLT ANCHOR REGION ARE CAPABLE OF GENERATING ROCK FRACTURES. PHOTOELASTIC PLASTIC TESTS AND TEST OF STANDARD WEDGE-TYPE EXPANSION SHELLS ANCHORED IN YULE MARBLE BLOCK TESTS WERE MADE TO DETERMINE ROCK BOLT ANCHOR STRESSES. WHERE ROOF FRACTURES MAY OCCUR IT IS SUGGESTED THAT BOLT LENGTHS BE STAGGERED, BOLTS SHOULD BE TENSIONED ONLY TO MAKE GOOD CONTACT AS BLASTING PRODUCES SHOCK LOADS FAR IN EXCESS OF DESIGN VALUE. IN VERTICALLY JOINTED ROCK FLAT WEDGE-TYPE ANCHORS SHOULD BE ORIENTED TO MINIMIZE THE CHANCE OF WEDGING ACTION WHICH WOULD OPEN NEW OR EXISTING FRACTURES.

12-67-04012 THE STATUS OF ROCK MECHANICS IN BLASTING (ANGLE-DRILLING CONTROL-BLASTING CRATERING DRILL-HOLES EXPLOSIVES)
BAUER, A. & QUEEN'S UNIV ONT CAN
COLO SCHOOL OF MINES NINTH SYMP ON ROCK MECHANICS, 249-262, APR 1967. BLASTING ECONOMY SHOULD CONSIDER DRILLING COST, EXPLOSIVES COST AND MUCK SIZE. A 12 1/4 IN DIA DRILL HOLE HAS PROVED MORE ECONOMICAL THAN A 10 IN, AND 15 IN DIA HOLES ON THE 12 1/4 PATTERN SHOULD BE EVEN MORE ECONOMICAL BY USING CHEAPER LOWER ENERGY PER LB SLURRY. ANGLE DRILLING HAS NOT BEEN USED BECAUSE OF REDUCED BIT LIFE, REDUCED PENETRATION RATE AND NO APPARENT DECREASE IN EXPLOSIVE CONSUMPTION. IN RATING EXPLOSIVES ROCK THROW AND MOVEMENT AFFECT THE TOTAL ENERGY AS WELL AS THE STRESS WAVE MEASUREMENTS. USING CRATERING AS AN EXPLOSIVE RATING IS NOT ONLY COSTLY BUT SUBJECT TO ERRORS FROM ROCK DISCONTINUITIES. EXPLOSIVE TESTS IN WATER GIVE RESULTS AGREEING WELL WITH THEORETICAL ENERGY. CONTROL BLASTING HAS NOT BEEN USED IN PITS AS LITTLE IS TO BE CONTROLLED EXCEPT WATER AND SMALL BLASTHOLE SPACINGS ARE NOT ECONOMICALLY COMPETITIVE WITH LARGE HOLES.

12-67-04013 THE ROLE OF STRESS WAVE AND GAS PRESSURE IN PRESPLITTING (LUCITE-MODELS EXPLOSION-WAVE GAS-STRESS)
KUTTER, H. K. + FAIRHURST, C. & IMPERIAL COL LONDON ENG
COLO SCHOOL OF MINES NINTH SYMP ON ROCK MECHANICS, 265-284, APR 1967. WHEN AN EXPLOSIVE CHARGE IS DETONATED IN A BOREHOLE PRESPLITTING MAY BE CAUSED BY EITHER OR BOTH THE EXPLOSION WAVE AND THE EXPANDING GAS. A SERIES OF TESTS WERE RUN ON HOLES IN LUCITE PLATES WITH THE STRESS WAVE GENERATED BY AN UNDERWATER SPARK DISCHARGE AND THE PRESSURE SIMULATED BY PRESSURIZED OIL. AN EXPLOSION IN ONE HOLE MAY CAUSE CRACKING IN AN ADJACENT HOLE AND SIMULTANEOUS OR SHORT DELAY DETONATION IN MULTIPLE HOLES INCREASES THE CRACK PROPAGATION. IN FIELD CONDITIONS THE STATIC FIELD STRESS MAY CAUSE EXCESSIVE WALL DAMAGE OR REQUIRE UNECONOMICALLY NARROW HOLE SPACING.

12-67-04014 PRESSURE-TIME MEASUREMENTS IN ROCK (CHARGE-GEOMETRY CHARGE-WEIGHT DETONATION-VELOCITY SEISMIC-WAVE)
NOREN, C. H. & E. I. DUPONT DENEMOURS
COLO SCHOOL OF MINES NINTH SYMP ON ROCK MECHANICS, 285-296, APR 1967. EFFECT OF EXPLOSIVES HAS BEEN STUDIED BY STRAIN MEASUREMENTS FROM GAGES CEMENTED IN BOREHOLES. THESE MEASUREMENTS DID NOT GIVE THE EFFECT OF EXPLOSIVES IN THE ZONE WHERE FRACTURE MIGHT OCCUR. THIS STUDY ADOPTED A SYSTEM OF PRESSURE GAGES IN WATER FILLED BOREHOLES. GAGE HOLES THAT WILL NOT RETAIN WATER INDICATE FRACTURED ROCK AND ARE NOT USED. BARIUM TITANATE GAGES WERE DEVELOPED FOR THE PROGRAM. NOW PURCHASED TOURMALINE PRESSURE GAGES ARE USED. PRESSURE PULSE IN ROCK, INTENSITY AND SHAPE ARE DEPENDENT ON CHARGE WEIGHT, CHARGE GEOMETRY, DETONATION VELOCITY AND SEISMIC WAVE VELOCITY. FOR NEAR-SPHERICAL CHARGES GOOD PREDICTIONS CAN BE MADE OF PULSE SHAPE AND PEAK PRESSURE IN ROCK. THE VARIABLES MENTIONED ABOVE AFFECT THE INTENSITY AND SHAPE FOR COLUMNAR CHARGES. ONLY ONE ROCK MEDIUM WAS INVESTIGATED. ADDITIONAL TESTING IS REQUIRED BEFORE A FULL UNDERSTANDING OF ROCK BREAKAGE MECHANISM CAN BE OBTAINED.

12-67-04015 MECHANISM OF ROCK FAILURE UNDER THE ACTION OF EXPLOSIVES (LOW-EXPLOSIVES PHOTOGRAPHY MECHANICAL-TESTS)
SALUJA, S. S. & BANARAS HINDU UNIV
COLO SCHOOL OF MINES NINTH SYMP ON ROCK MECHANICS, 297-320, APR 1967. A COMPREHENSIVE REVIEW OF WORK ON THE MECHANISM OF ROCK FAILURE UNDER THE ACTION OF AN EXPLOSIVE CHARGE IS GIVEN. IN 1909 THE DAWS BROTHERS PUBLISHED A TREATISE ON ROCK BLASTING WHICH HELPED IMPROVE BLASTING. THE DAWS FORMULA HAS BEEN USED IN PRACTICE QUITE SUCCESSFULLY FOR A LONG TIME. TESTS WERE MADE WITH SMOKELESS GUNPOWDER AS A LOW EXPLOSIVE AND PENTAETHYRITETETRANITRATE WITH LEAD AZIDE AS INITIATOR AND BUILT IN ALUMINUM SHELLS WITH A BOTTOM CHARGE OF PETN AND A TOP CHARGE OF LEAD AZIDE AS HIGH EXPLOSIVES. MECHANICAL TESTS IN HOLES DRILLED IN BLOCKS WERE MADE TO COMPARE WITH EXPLOSIVE TESTS. TESTS WERE STUDIED WITH HIGH SPEED PHOTOGRAPHY. FOR LOW EXPLOSIVES ALL THE WORK OF FRACTURING IS DONE BY EXPANDING GASEOUS PRODUCTS. IN HIGH EXPLOSIVES CRUSHING AND SCABBING IS CAUSED BY THE COMPRESSIVE WAVE AND FAILURE OCCURS AS THE GASEOUS PRODUCTS ASSIST THIS WAVE. A NEW EMPIRICAL EQUATION IS GIVEN TO REPLACE THE DAWS EQUATION.

12-67-04016 ON THE CORRELATION BETWEEN EXPLOSIVE CRATER FORMATION AND ROCK PROPERTIES (PHYSICAL-CHARACTERISTICS)
GNIRK, P. F. + PFLEIDER, E. P. & S.D. SCHOOL OF MINES
COLO SCHOOL OF MINES NINTH SYMP ON ROCK MECHANICS, 321-346, APR 1967. THIRTY-THREE CRATERING EXPERIMENTS IN FIVE TACONITE ROCK LOCATIONS IN THE EASTERN MESABI DISTRICT OF MINN WERE MADE USING EIGHTEEN LB CYLINDER SHAPED CHARGES OF GELEX 2 EXPLOSIVE AT VARIOUS DEPTHS. FROM SIX OR MORE TESTS THE UNCONFINED TENSILE AND UNCONFINED COMPRESSIVE STRENGTH, THE MODULUS OF ELASTICITY, LONGITUDINAL WAVE VELOCITY AND DENSITY WERE OBTAINED. OPTIMUM CHARGE DEPTH WAS FOUR TO FIVE FT BUT BEST FRAGMENTATION WAS AT 75 TO 80 PERCENT OF THIS. NONUNIFORM CRATER VOLUME BEHAVIOR IS PROBABLY DUE TO PHYSICAL CHARACTERISTICS RATHER THAN MECHANICAL PROPERTIES. THEREFORE, EMPIRICAL RELATIONSHIP BETWEEN OPTIMUM CRATER DIMENSIONS AND MECHANICAL AND PHYSICAL ROCK PROPERTIES MUST AWAIT ADDITIONAL CRATERING EXPERIMENTS.

12-67-04017 DRILLING AND BLASTING TECHNIQUES FOR MORROW POINT POWER PLANT (DRILL-PATTERN CHARGE EXPLOSIVE ROCK-PROPERTIES)
HANSEN, D. W. & U.S. BUR RECL DENVER COLO
COLO SCHOOL OF MINES NINTH SYMP ON ROCK MECHANICS, 347-360, APR 1967. DETAILS OF PLANNING, DRILLING, CHARGE COMPUTATION, EXPLOSIVE PROPERTIES, AND INFLUENCE OF ROCK STRUCTURE AND PROPERTIES ARE GIVEN FOR BOTH BENCH TYPE AND ARCH EXCAVATIONS. MORROW POINT POWER PLANT WAS RECLAMATIONS' FIRST UNDERGROUND POWER PLANT AND SITE INVESTIGATION, SAMPLING, TESTING AND DELIBERATION PRECEDED CONSTRUCTION. PRINCIPLES AND EQUATIONS GIVEN IN LANGEFORS AND KIHLSTROM'S "THE MODERN TECHNIQUE OF ROCK BLASTING" WERE APPLIED. FIVE TYPES OF ROCK WITH COMPRESSIVE STRENGTHS FROM 3,170 PSI TO 28,820 WERE ENCOUNTERED. THE METHODS USED FOR STABILIZATION ARE NOT GIVEN BUT CAN BE OBTAINED FROM THE RECLAMATION BUREAU. THE CHAMBER IS 206 FT LONG 57 FT WIDE WITH A ROOF ARCH RISE OF 16 FT. HEIGHT FROM FOUNDATION TO ROOF SPRING LINE IS 51 FT IN THE SERVICE BAY AND 120 FT IN THE CONTROL BAY.

12-67-04018 ON A SOLID FRICTION ATTENUATION SCHEME FOR DRY BRITTLE ROCK (QUALITY-FACTOR)
BRADY, B. T. & COLO SCHOOL OF MINES GOLDEN COLO
COLO SCHOOL OF MINES NINTH SYMP ON ROCK MECHANICS, 361-373, APR 1967. TABLES OF QUALITY FACTORS ARE GIVEN FOR VARIOUS MATERIALS AND GRANITE, LIMESTONE, SANDSTONE, AND SHALE. FOR LARGE QUALITY FACTORS, A BRITTLE ROCK IS QUASI-LINEAR AND A SOLID FRICTION SCHEME CAN EXPLAIN MANY OBSERVABLE CHARACTERISTICS GOVERNING LOW AMPLITUDE WAVE PROPAGATION.

12-67-04019 ON THE PERFORMANCE OF PERCUSSIVE DRILLS (DRILLING-SPEED PISTON-GEOMETRY BIT-LIFE)
BAILEY, J. J. & INGERSOLL-RAND CO
COLO SCHOOL OF MINES NINTH SYMP ON ROCK MECHANICS, 377-400, APR 1967. A BROAD EXAMINATION OF CONVENTIONAL PERCUSSIVE DRILLING SYSTEMS IS GIVEN. A LARGE NUMBER OF PARAMETERS CAN BE VARIED. BECAUSE UNFAVORABLE STRESSES CAN OCCUR FROM THE UNHAPPY COINCIDENCES OF STRESS WAVES, SMALL CHANGES CAN RESULT IN LARGE PERFORMANCE VARIATIONS. PISTON LIFE AND BIT LIFE ARE CONSIDERATIONS IN MAXIMIZING DRILLING SPEED. STRESS WAVE SOLUTION, ROCK CHARACTERISTICS AND CLASSIC FORMULA ARE COMBINED INTO A FORM COMPATIBLE WITH THE COMPUTER. BASIC HAMMER AND BIT PROPORTIONS ARE OPTIMIZED FOR HIGHEST PERFORMANCE AND LOWEST STRESS LEVELS. A REGULAR 9 IN. DOWN-HOLE OPERATION WAS CONSIDERED. A TABLE OF POTENTIAL IMPROVEMENT IN DRILLING SPEED WITH CHANGES IN PISTON GEOMETRY IS GIVEN. WE MAY BE PAYING A HEAVY PRICE FOR OUR UNCERTAINTY AS TO WHICH SYSTEM STRESSES ARE LIMITING.

12-67-04020 SOME ROCK MECHANICS ASPECTS OF PETROLEUM ENGINEERING (COMPRESSIVE-STRENGTH MODULUS-OF-ELASTICITY WAVE-PROPAGATION MICROBIT IMPACT DRAG-BIT)
GRAY, K. E. & UNIV TEXAS AUSTIN TEX
COLO SCHOOL OF MINES NINTH SYMP ON ROCK MECHANICS, 405-433, APR 1967. ROCK MECHANICS STUDIES OF INTEREST TO PETROLEUM ENGINEERS ARE DISCUSSED FOR WELL BORES, RESERVOIR DESCRIPTION AND BEHAVIOR AND DRILLING IMPROVEMENT THRU MICROBIT STUDIES, BIT TOOTH INDENTATION TESTS AND DRAG BIT STUDIES. ROCK MECHANICS IS BASIC TO THE PETROLEUM INDUSTRY AND SOLVING ROCK MECHANICS PROBLEMS HAS TREMENDOUS ECONOMIC IMPLICATIONS. EST DESCRIPTIONS AND RESULTS ARE GIVEN FOR VARIOUS EXTERNAL CONFINING AND PORE PRESSURE. TESTS FOR COMPRESSIVE LOAD, MODULUS OF ELASTICITY AND WAVE PROPAGATION, FOR MICROBIT TESTS, FOR IMPACT TESTS AT SIMULATED WELL BORE STRESS STATE, ARE SUMMARIZED.

12-67-04021 A LABORATORY STUDY OF THE FRACTURING OF ROCKS BY HYDRAULIC PRESSURE (PHOTOELASTIC-STUDY PREFERRED-SHEAR-PLANE)
PEGLER, A. V. & QUEEN'S UNIV ONT CAN
COLO SCHOOL OF MINES NINTH SYMP ON ROCK MECHANICS, 437-460, APR 1967. SAMPLES WERE TRIMMED FROM CORES OBTAINED WITH A 6 IN DIA THIN-WALLED DIAMOND DRILL BIT ON A 3 FT CORE BARREL THE FOUR SIDES WERE VERTICALLY ORIENTED. FRESHLY CUT FLAT PLANES WERE INSTRUMENTED WITH PHOTOELASTIC MATERIAL USING AN EPOXY BONDING CEMENT CONTAINING A REFLECTIVE MEDIUM. AS ENERGY RELAXATION OCCURRED STRAINS WERE PRODUCED IN THE PHOTOELASTIC MATERIAL IN SUCH A PATTERN THAT PRINCIPAL STRAIN DIRECTIONS AND PLANES OF PREFERRED SHEAR WERE IDENTIFIABLE. LOADING WAS HYDROSTATIC THROUGH PERFORATIONS IN A STEEL CASING BONDED IN A HOLE IN THE SAMPLE. UPON LOADING SAMPLES THE AZIMUTH IN WHICH STRAIN PROPAGATED WAS RECORDED. USUALLY FRACTURING OCCURRED CLOSE TO PREFRACTURE DETERMINATIONS OF PREFERRED SHEAR PLANES OR CLOSE TO STRIKES OF A COMPLEX OF SHEAR PLANES. TEN SAMPLES OF POTSDAM SANDSTONE AND NINE SAMPLES OF LYNDHURST MARBLE WERE TESTED. PREDICTING PLANES OF POTENTIAL FRACTURE IS DIRECTLY PROPORTIONAL TO THE MAGNITUDES OF SHEAR STRAIN DETERMINED IN RELAXATION. SHEAR PLANES MUST BE TAKEN INTO ACCOUNT WHEN MAKING A CONVENTIONAL MINING DESIGN OR IN DETERMINING CORRECT HYDRAULIC FRACTURE PROPAGATION.

12-67-04022 ORIENTATION OF HYDRAULICALLY INDUCED FRACTURES (FRACTURE-ORIENTATION MOHR-DIAGRAM)
PAULDING, B. W., JR. & COLO SCHOOL OF MINES GOLDEN COLO
COLO SCHOOL OF MINES NINTH SYMP ON ROCK MECHANICS, 461-489, APR 1967. BY CONSIDERING THE ROCK FORMATION WHICH IS SUBJECTED TO HYDRAULIC PRESSURE AS A THICK WALLED HOLLOW CYLINDER AN ELASTIC SOLUTION OF THE STRESS STATE CAN BE

OBTAINED. IF THE MATERIAL IS PERMEABLE ALONG ANY HORIZONTAL PLANE AN INCREASE IN PORE PRESSURE WILL DECREASE THE AXIAL AND RADIAL EFFECTIVE STRESSES. THERE ARE TWO CASES ONE IN WHICH THE HORIZONTAL PRINCIPAL STRESS IS LESS THAN HALF THE VERTICAL PRINCIPAL STRESS AND THE OTHER WHERE IT IS GREATER THAN THE VERTICAL PRINCIPAL STRESS. FRACTURE WILL OCCUR WHEN THE STRESS BECOMES TENSILE. ORIENTATION OF FRACTURE PLANES RELATIVE TO THE WELL BORE ARE GIVEN FOR THESE TWO CASES AND ANALYZED BY MOHR DIAGRAMS. IT IS CONCLUDED THAT HYDRAULICALLY INDUCED FRACTURES ARE NOT NECESSARILY PERPENDICULAR TO THE LAST COMPRESSIONAL STRESS, NO UNIQUE RELATIONSHIP EXISTS BETWEEN FRACTURE ORIENTATION AND FLUID PRESSURE MAGNITUDE AT FAILURE AND NO UNIQUE RELATIONSHIP EXISTS BETWEEN IN SITU STRESS STATE AND FLUID PRESSURE AT FAILURE WHICH SUGGESTS THAT IN SITU STRESS STATE CANNOT BE DETERMINED FROM HYDRAULIC FRACTURING DATA.

12-70-00001 TUNNEL SITE INVESTIGATIONS - A REVIEW (GEOLOGY CORE-BORING SURVEYS INSTRUMENTS)
GARDNER, W. I. & U.S. BUR RECL DENVER COLO
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 2. SITE INVESTIGATION MUST DETERMINE GEOLOGIC CONDITIONS AFFECTING CONSTRUCTION METHODS AND EQUIPMENT, THE QUANTITIES OF WATER AND GAS TO BE ENCOUNTERED, AND THE STRENGTH AND STABILITY OF THE ENVIRONMENT OF THE PROPOSED TUNNEL. DATA IS OBTAINED FROM MAPS, GEOLOGICAL SURVEYS, AERIAL PHOTOS, CORE BORINGS, GEO PHYSICAL SURVEYS, GEOLOGICAL MAPPING, MAGNETOMETER SURVEYS PILOT TUNNELS AND TRENCHES, PETROGRAPHIC ANALYSIS, ROCK DRILLABILITY TESTS. ACCURACY AND EXTENT OF KNOWLEDGE IS USUALLY SEVERELY LIMITED BECAUSE OF SHORTAGE OF TIME AND FUNDS.

12-70-00002 FUTURE NEEDS IN SITE STUDY (REMOTE-SENSING ROCK-CLASSIFICATION GOPHER)
UNDERWOOD, L. B. & U.S. CORPS OF ENGR
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 3. AERIAL RECONNAISSANCE BY REMOTE SENSING DEVICES SHOULD BE IMPROVED MATERIALLY AND USED TO SUPPLEMENT THE PRESENT METHODS OF SITE EXPLORATION. NEW RAPID-CUTTING ACCURATELY CONTROLLED DRILLING EQUIPMENT IS NEEDED FOR EXPLORATORY DRILLING, HORIZONTALLY AS WELL AS VERTICALLY. WE NEED TO DEVELOP BETTER GEOPHYSICAL MEASURING TECHNIQUES PARTICULARLY SUITED TO DETERMINE LOCATION, EXTENT AND CHARACTER OF DISCONTINUITES IN ROCK. A STANDARDIZED ENGINEERING CLASSIFICATION FOR ROCK IS NEEDED. BETTER METHODS OF EXPLORING AHEAD OF THE FACE MUST BE FOUND.

12-70-00003 INDEXING ROCK FOR MACHINE TUNNELING (MOLE HARDNESS RQD-INDEX)
DEERE, D. U. & UNIV ILLINOIS
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 4. A SYSTEM OF MODIFIED CORE RECOVERY CALLED RQD (ROCK QUALITY DESIGNATION) WAS DEVELOPED TO GIVE A UNIFORM CLASSIFICATION OF QUALITY OF THE ROCK MASS. RQD OF 25% OR LESS IS VERY POOR; 25% TO 50% IS POOR; 50% TO 75% IS FAIR; 75 TO 90% IS GOOD; 90% TO 100% EXCELLENT. A NUMBER OF DIFFERENT METHODS OF MEASURING AND EVALUATING ROCK HARDNESS EXIST, NONE ARE UNIVERSALLY ACCEPTABLE, RESEARCH IS CONTINUING TO TRY TO DEVELOP ONE THAT WILL BE USEFUL FOR CLASSIFYING ROCK FOR MACHINE TUNNELING.

12-70-00004 ANALYSIS OF HARD-ROCK CUTTABILITY FOR MACHINES (MOLES SOUTH-AFRICA PROFILE-CUTTING)
COOK, N. G. W. & SO AFRICA CHAMBER OF MINES
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 5. THIS PAPER PRESENTS A SIMPLIFIED ANALYSIS OF ROCK-BREAKING BY MECHANICAL LOADING (CHISEL BITS). FROM THIS ANALYSIS CRITERIA ARE OBTAINED FOR THE DESIGN AND PERFORMANCE OF HARD-ROCK TUNNELING MACHINES. SOME PERFORMANCE CHARACTERISTICS OF EXISTING MOLES ARE SUMMARIZED TO COMPARE WITH THE ANALYSIS. THE CONCEPT FOR A TUNNEL PROFILE CUTTING MACHINE IS OUTLINED. TO CUT A PROFILE FOR A 6 FT. DIA TUNNEL AT 5 FT/HR A FORCE OF 40 TONS IS REQUIRED. THIS CAN BE PRODUCED BY 50 HORSEPOWER UNIT.

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13-55-01001 CLASSIFICATION OF ROCKS (IGNEOUS SEDIMENTARY METAMORPHIC TEXTURE STRUCTURE MINERALOGY)
TRAVIS, R. B. & COLO SCHOOL OF MINES GOLDEN COLO
COLORADO SCHOOL OF MINES, QUARTERLY, (50) NO. 1, JAN 1955. THIS QUARTERLY PRESENTS IN COMPACT FORM THE GENERALLY ACCEPTED CONVENTIONS FOR NAMING ROCKS ON THE BASIS OF MINERALOGY AND TEXTURE. NOMENCLATURE ESPECIALLY IN SEDIMENTARY ROCKS IS IN NEED OF STANDARDIZATION AND IT WAS HOPED TO EXERT INFLUENCE IN THAT DIRECTION BY THIS REPORT. THE CONVENTIONS AND TERMS PRESENTED ARE THOSE RECOMMENDED BY A MAJORITY OF AUTHORITIES AS DETERMINED BY GEOLOGICAL LITERATURE RESEARCH. A PETROGRAPHIC BASIS IS USED RATHER THAN GENESIS EXCEPT FOR THE USE OF A PRIMARY GENETIC DIVISION BUT THEREAFTER THE PRINCIPLE IS FOLLOWED OF NAMING ROCKS ON THE BASIS OF VISIBLE FEATURES AND NOT ON A BASIS OF INFERENCE. THE PRIMARY DIVISION OF CLASSIFICATION CONSIDERS ROCK AS IGNEOUS, SEDIMENTARY OR METAMORPHIC. DESCRIPTIONS OF EACH AND VARIATIONS THEREFROM ARE PROVIDED. A FOLD-OUT CLASSIFICATION CHART IS PROVIDED FOR EACH OF THE THREE CLASSES AND ILLUSTRATIONS INCLUDE FOUR SKETCHES, 45 PHOTO PLATES, AND 20 PHOTOMICROGRAPHS TO DEPICT THE METHOD OF CLASSIFICATION ADVOCATED.

13-64-00001 GEOLOGIC RESEARCH AT THE STRAIGHT CREEK TUNNEL SITE COLORADO (CORE-HOLES RESISTIVITY RADIOACTIVITY DENSITY SEISMIC-PROFILES FUTURE-HOLES CONSOLIDATION)
ROBINSON, C. S. + LEE, F. T. & U.S. GEOL SURVEY DENVER
NATIONAL RESEARCH COUNCIL, HIGHWAY RESEARCH BOARD, RESEARCH RECORD, NO. 57, 18-34, 1964. PRECONSTRUCTION GEOLOGIC, GEOPHYSICAL AND LABORATORY INVESTIGATIONS THAT WERE MADE AND ENGINEERING INTERPRETATION AND PREDICTION OF RESULTS ARE DESCRIBED. GEOLOGIC INVESTIGATIONS CONSISTED OF GEOLOGIC MAPPING OF SIX SQUARE MILES IN THE TUNNEL SITE'S VICINITY AND GEOLOGIC LOGGING OF TWO CORE HOLES. GEOPHYSICAL INVESTIGATION CONSISTED OF RESISTIVITY, RADIOACTIVITY, AND GAMMA-RAY DENSITY LOGGING OF DRILL HOLES AND SEISMIC PROFILES AT THE SURFACE AND AT RIGHT ANGLES TO THE PROPOSED TUNNEL LINE. NEW INSTRUMENTS AND TECHNIQUES FOR DETERMINING ROCK ENGINEERING PROPERTIES IN SITU AND OBTAINING SUPPLEMENTAL DATA FOR GEOLOGIC INTERPRETATIONS WERE USED. LABORATORY INVESTIGATIONS WERE MADE ON SURFACE AND DRILL-CORE SAMPLES WITH THE HOPE THAT CORRELATION OF GEOLOGIC ANALYSES WITH PHYSICAL AND ENGINEERING PROPERTIES WILL IN THE FUTURE ALLOW TRANSLATION OF LABORATORY DATA TO FIELD CONDITIONS AND CORRELATION OF LABORATORY RESULTS WITH IN-SITU MEASUREMENTS. DATA COMPILED FROM THE GEOLOGIC, GEOPHYSICAL AND LABORATORY INVESTIGATIONS WERE USED TO CONSTRUCT A PREDICTED SECTION ALONG THE PROPOSED TUNNEL LINE. LOCATIONS WHERE ROCK WAS EXPECTED TO BE BADLY BROKEN OR CRUSHED AND FILLED WITH WATER WERE SHOWN AND FEELER HOLES WERE DRILLED IN THREE LOCATIONS TO DETERMINE THE NECESSITY OF SEALING OFF THE WATER OR CONSOLIDATING THE ROCK.

13-66-00001 DYNAMIC PROPERTIES OF ROCKS (HUGONIOT TRANSITION SHOCK-INDUCED)
AHRENS, T. J. + ROSENBERG, J. T. + RUDRMAN, M. H. & STANFORD RES INST
DEFENSE ATOMIC SUPPORT AGENCY, DASA 1868, SEPT. 1966. HUGONIOT EQUATION OF STATE MEASUREMENTS USING STREAK CAMERA TECHNIQUES WERE PERFORMED ON SIX MINERALS WHICH ARE CONSTITUENTS OF COMMON CRYSTAL ROCK. AT PRESSURES ABOVE THE HUGONIOT ELASTIC LIMITS THE MINERALS INDICATED EITHER BY CUSPS OR BY ANOMALOUSLY HIGH COMPRESSION FOLLOWED BY A MARKED INCREASE IN INCOMPRESSIBILITY THAT ONE OR MORE SHOCK-INDUCED TRANSITIONS TO HIGH PRESSURE POLYMORPHOUS FORMS OCCUR. RELEASE ADIABATS OF POLYCRYSTALLINE QUARTZ AND ANORTHOSITE DESCENDING FROM VARIOUS STATES ON THEIR HUGONIOTS AT PRESSURES UP TO 380 AND 420 K BAR RESPECTIVELY WERE MEASURED BY TWO NEW TECHNIQUES. STRESS RELAXATION OF ELASTIC SHOCK WAVES IN POLYCRYSTALLINE QUARTZ ROCK WAS INVESTIGATED EXPERIMENTALLY AND THEORETICALLY. A RELATION WAS DERIVED BETWEEN STATIC BRITTLE FAILURE STRENGTH, MATERIALS POISSON RATIO, AND HUGONIOT ELASTIC LIMIT BY APPLYING BRACE-MCCLINTOCK MODIFICATION OF GRIFFITH THEORY. RELATIONSHIP BETWEEN FREE SURFACE VELOCITY AND POSTSHOCK ZERO PRESSURE VOLUME WERE DISCUSSED. ELASTIC WAVE PROPAGATION IN PYROXENE CRYSTALS WAS DISCUSSED AND EQUATIONS WERE DERIVED INDICATING THE EXISTENCE OF, AND GIVING THE DIRECTION COSINES FOR, PROPAGATION DIRECTIONS FOR WHICH PURE LONGITUDINAL AND TRANSVERSE WAVES MAY TRAVEL PERPENDICULAR TO THE UNIQUE AXIS IN THESE CRYSTALS.

13-67-00001 RESULTS OF GEOLOGIC RESEARCH AT THE STRAIGHT CREEK TUNNEL PILOT BORE, COLORADO (ROCK-MECHANICS GEOPHYSICS PREDICTIONS HIGHWAY-TUNNEL GROUND-WATER INSTRUMENTATION)
ROBINSON, C. S. + LEE, F. T. & U.S. GEOL SURVEY DENVER
NATIONAL RESEARCH COUNCIL - HIGHWAY RESEARCH BOARD - RESEARCH RECORD, (1) NO. 185, 9-19, 1967. U. S. GEOL. SURVEY, COOPERATING WITH COLORADO DEPT. OF HIGHWAYS, CONDUCTED A RESEARCH PROJECT IN ENGINEERING GEOLOGY AT THE STRAIGHT CREEK TUNNEL SITE, COLORADO, FROM 1962 TO 1966. A TABLE IS GIVEN COMPARING PREDICTIONS MADE FROM THE GEOLOGIC MEASUREMENTS DURING THE PILOT BORE AND THE FINDINGS MADE DURING ACTUAL CONSTRUCTION OF THE 42-FT DIAMETER 8300-FT LONG TWIN BORES.

13-67-00002 NONUNIFORM RADIAL LOADS APPLIED TO BOUNDARY OF CIRCULAR HOLE IN INFINITE PLATE (MOLE TUNNELING-MACHINE-STRESS)
DUVALL, W. I. + BLAKE, W.
U. S. BUR MINES REPT INVESTIGATIONS 7030, 1-16, 1967. THEORETICAL SOLUTION IS PRESENTED FOR STRESSES AND DISPLACEMENTS IN INFINITE ELASTIC PLATE CONTAINING CIRCULAR HOLE WITH BOUNDARY LOADED BY APPLIED RADIAL STRESSES OVER FOUR SEPARATED ARCS; PROBLEM SOLVED IS TWO-DIMENSIONAL APPROXIMATION OF STRESSES AND DISPLACEMENTS DEVELOPED BY LARGE TUNNEL-BORING MACHINE ANCHORED IN CIRCULAR TUNNEL; ANALYSIS OF SOLUTION SHOWS THAT TANGENTIAL TENSILE STRESSES INDUCED ON BOUNDARY OF CIRCULAR OPENING CAN BE MINIMIZED IN ROOF AND MAXIMIZED IN FLOOR OF OPENING BY PROPER SPACING AND LOADING OF FOUR ARCS. SEE ALSO 13-68-11001.

13-67-00003 RESULTS OF GEOLOGIC RESEARCH AT THE STRAIGHT CREEK PILOT BORE, COLORADO (PREDICTIONS ESTIMATES COST FAULT FOLIATION FRACTURE WATER SUPPORT FEELER-HOLE)
ROBINSON, C. S. + LEE, F. T. & U.S. GEOL SURVEY DENVER
NATIONAL RESEARCH COUNCIL, HIGHWAY RESEARCH BOARD RESEARCH RECORD, NO 185, 9-19, 1967. IN STRAIGHT CREEK TUNNEL PILOT BORE RESEARCH PROJECT A STATISTICAL STUDY OF SURFACE AND DRILL HOLE FEATURES GAVE GOOD PREDICTIONS OF KINDS OF CONDITIONS AND THEIR EXTENT, BUT NOT THEIR EXACT LOCATION, THAT COULD BE EXPECTED AT TUNNEL LEVEL. SUCCESSFUL PREDICTIONS WERE MADE REGARDING PERCENTAGES OF ROCK TYPES, LINEAR FEET OF FAULTED AND SHEARED ROCK AND ATTITUDES OF FOLIATION AND FRACTURES, INCLUDING FAULTS AND JOINTS. PREDICTED ROCK LOADS AND FINAL SWELL PRESSURES IN GANGUE AND ALTERED ROCK AGREED WELL WITH ACTUAL MEASUREMENTS. GROUNDWATER FLOWS OCCURRED IN EXPECTED AMOUNTS, BUT CRITERIA FOR ESTIMATIONS PROVED UNSOUND. ESTIMATES OF AMOUNT OF TEMPORARY SUPPORT, FOOTAGE OF FEELER HOLES, AND AMOUNT OF GROUTING PROVIDED ENGINEERS WITH A SOUND BASIS FOR ESTIMATES OF TUNNEL COSTS.

13-67-07001 MECHANICAL PROPERTIES OF ROCKS AT HIGH TEMPERATURES AND PRESSURES (DATA PROPERTIES TESTING EXCAVATED MINING DRILLING TECTONIC GEOLOGY WALL-STABILITY)
BAIDYUK, B. V. & INST OF GEOLOGY MOSCOW
CONSULTANTS BUREAU - TRANSLATED FROM 1963 PUB OF THE INST OF GEOLOGY AND DEV OF MINERAL RESOURCES, 66, JULY 12, 1967. THIS BOOK PROVIDES A SUMMATION OF CRITICAL DATA ON ROCK PROPERTIES AND INCLUDES A COMPREHENSIVE BIBLIOGRAPHY ON ROCK PROPERTIES, ROCK TESTING AND RELATED FIELDS IN RUSSIAN AND OTHER LANGUAGES. ITS INTENT IS TO PROVIDE MEANS TO BETTER UNDERSTAND CRUSTAL BEHAVIOR DURING OPERATION OF TECTONIC STRESSES AND AS AN AID IN PREDICTING BEHAVIOR OF ROCKS IN MASS WHEN THEY ARE BEING EXCAVATED DURING MINING OR DEEP DRILLING. THE BOOK FURNISHES DATA ON RECENTLY USED METHODS OF TESTING ROCK FOR MECHANICAL PROPERTIES AT HIGH TEMPERATURE AND PRESSURES. DESCRIBED ARE TESTS ON ROCKS UNDER CONDITIONS OF SHEAR CUTTING, BENDING, TORSION, TENSION AND COMPRESSION WITH BOTH DIRECTED AND 3-DIMENSIONAL PRESSURES AT DIFFERENT DURATIONS AND LOADING RATES. TEST EQUIPMENT IS DESCRIBED IN DETAIL AND RESULTS ARE GIVEN IN NUMEROUS SKETCHES, DIAGRAMS, TABLES AND CURVES. DISCUSSIONS COVER MARBLE, LIMESTONE, DOLOMITE, ROCK SALT, ANHYDRITE, CLAY, SANDSTONE, AND SILTSTONE. TECHNIQUES ARE COMPARED AND RECOMMENDATIONS MADE CONCERNING BEHAVIOR OF THE DIFFERENT ROCK TYPES UNDER DIFFERING CONDITIONS. THE DATA IS REVIEWED FOR APPLICABILITY TO ACTUAL GEOLOGIC PROBLEMS. THEY ARE CONSIDERED IN RELATION TO LARGE AND SMALL SCALE STRUCTURES THAT DEVELOP DURING TECTONIC MOVEMENTS AND THE RELATIONSHIP BETWEEN STRUCTURE AND MOVEMENTS IS CONSIDERED. SIGNIFICANCE OF THE DATA FOR DEEP DRILLING AND WALL STABILITY IS DISCUSSED AT LENGTH.

13-68-00001 SOLID-INCLUSION BOREHOLE PROBE TO DETERMINE THREE-DIMENSIONAL STRESS CHANGES AT POINT IN ROCK MASS (STRAIN-GAUGE)
NICHOLS, T. C., JR. + ABEL, J. F., JR. + LEE, F. T.
U. S. GEOL SURVEY - BUL 1258-C, 1-28, 1968. IN ORDER TO RELATE CHANGING STRESS CONDITIONS WITHIN ROCK MASSES TO GEOLOGIC FACTORS, WELDED HIGH-MODULUS SOLID-INCLUSION BOREHOLE PROBE TO DETERMINE THREE-DIMENSIONAL STRESS CHANGES AT POINT IN ROCK MASS WAS DEVELOPED AND TESTED; PROBE CONSISTS OF 1 IN. DIAM CHROME ALLOY STEEL BALL, MOUNTED WITH THREE STRAIN-GAGE ROSETTES, AND IS ENCAPSULATED IN FILLED WATERPROOF EPOXY; RELIABILITY OF PROBE WAS ESTABLISHED BY CONDUCTING SERIES OF TESTS IN WHICH PROBE WAS SUBJECTED TO CHANGING HYDROSTATIC AND TRIAXIAL STRESS FIELDS; IN ALL THESE TESTS PROBE RESPONDED AS PREDICTED BY ELASTIC THEORY.

13-68-01001 PIEZOELECTRIC PULSING EQUIPMENT FOR SHEAR WAVE VELOCITY MEASUREMENTS IN ROCK SAMPLES
CANNADAY, F. X.
U. S. BUR. MINES REPORT INVESTIGATIONS 7065, 25, JAN. 1968. EQUIPMENT AND TECHNIQUES WERE DEVELOPED FOR MEASUREMENT IN LABORATORY OF SONIC SHEAR WAVE VELOCITY. VARIOUSLY SHAPED ROCK SPECIMENS IN WIDE RANGE OF SIZES; VARIETY OF ROCK TYPES WERE TESTED; SHEAR WAVE FRONT WAS PRODUCED BY ELECTRONICALLY EXCITED, PIEZOELECTRIC CERAMIC, DISK-SHAPED TRANSDUCERS; TRANSMITTER AND RECEIVER ARE INTERCHANGEABLE; EQUIPMENT PERMITS QUICK MEASUREMENT OF SHEAR WAVE VELOCITY ON VARIOUSLY SHAPED SPECIMENS WITH MINIMUM OF SPECIMEN PREPARATION.

13-68-07001 DYNAMIC PROPERTIES OF ROCKS (SHOCK-WAVE-TECHNIQUES ROCK-MECHANICS GEOLOGY)
ROSENBERG, J. T. + AHRENS, T. J. + PETERSON, C. F. & STANFORD RES INST
FINAL REPORT FOR DEFENSE ATOMIC SUPPORT AGENCY WASH D.C., 1-75, JULY 1968. HIGH STRAIN RATE RELEASE ADIABATS AND THE PRINCIPAL HUGONIOTS OF WATER-SATURATED TUFF AND OF FUSED QUARTZ WERE MEASURED AT STRESSES BELOW 500 KBAR IN ONE-DIMENSIONAL SHOCK-WAVE EXPERIMENTS USING EXPLOSIVELY ACCELERATED FLYER PLATES. RESULTS SUGGEST THAT BOTH MATERIALS UNDERGO SHOCK-INDUCED TRANSFORMATIONS WHICH ARE AT LEAST PARTIALLY IRREVERSIBLE ON THE TIME SCALE OF THE EXPERIMENTS. A THERMODYNAMIC DISCUSSION OF THE KINETIC CONDITIONS FOR WHICH A TWO-PHASE REACTING SYSTEM MAY RELEASE ISENTROPICALLY FROM A SHOCK STATE IS PRESENTED AND RELATED TO PRESENT SATURATED TUFF EXPERIMENTS TO EXPLORE THE VALIDITY OF APPLYING THE RIEMANN INTEGRAL TO THE PRESENT DATA.

13-68-08001 EFFECT OF END CONDITIONS ON DETERMINING COMPRESSIVE STRENGTH OF ROCK SAMPLES
HOSKINS, J. R. + HORINO, F. G.
U. S. BUR MINES REPORT INVESTIGATIONS 717, 22, AUG 1968. REPORT ON INVESTIGATION TO MORE EXACTLY DEFINE INFLUENCE OF SOME END CONDITIONS ON LABORATORY-DETERMINED UNIAXIAL COMPRESSIVE STRENGTH OF ROCK SAMPLES; FOUR VARIABLES WERE STUDIED - NONPARALLELISM AND SURFACE TEXTURE OF SPECIMEN ENDS WERE SPECIMEN VARIABLES, END PLATEN SIZE AND ADJUSTABLE OR SPHERICAL HEAD FRICTION WERE MACHINE VARIABLES; MEASURED COMPRESSIVE STRENGTH OF SPECIMENS PREPARED WITH TOLERANCES, WILL BE STATISTICALLY SAME WITH ANY DIA OR THICKNESS OF PLATEN AND ANY DEGREE OF HEAD FRICTION. 22 REFS.

13-68-09001 MODELING A JOINTED ROCK MASS (ROCK-MECHANICS ROCK-BREAKING)
NELSON, R. A. + HIRSCHFELD, R. C. & M.I.T. CAMBRIDGE MASS
M.I.T. RESEARCH REPORT, R 68-70, DSR 76112, PREPARED FOR U.S. DEPT. OF TRANSPORTATION, SEPT. 1968. AN OVERALL STUDY IS BEING MADE OF JOINTED ROCK TO PROVIDE FUNDAMENTAL UNDERSTANDING OF THE MECHANICS OF JOINTED ROCK, WHICH IS A CRUCIAL PART OF HARD-ROCK TUNNEL DESIGN OF THE TYPE THAT MIGHT BE REQUIRED FOR UNDERGROUND HIGH-SPEED TRANSPORT SYSTEMS. THE JOINTED-ROCK MODELING MATERIAL WAS A MIXTURE OF HYDROCAL B-11 (A VARIETY OF GYPSUM), WATER, AND DIATOMACEOUS EARTH, IN THE RATIO 144:32:1. A UNIVERSAL MOLD WAS DESIGNED FOR MANUFACTURING SPECIMENS HAVING DIFFERENT JOINT SPACINGS AND ORIENTATIONS. STRENGTH TESTS WERE PERFORMED ON THE MODELS IN A TRIAXIAL CELL. THE

FOLLOWING CONCLUSIONS HAVE BEEN REACHED TO DATE: (1) THE MOHR ENVELOPE FOR RUPTURE THROUGH THE INTACT MODEL MATERIAL IS CURVED AND BECOMES ALMOST HORIZONTAL AT HIGH NORMAL STRESS; (2) THE SLIDING FRICTION ENVELOPE, DERIVED FROM BOTH DIRECT SHEAR TESTS AND FROM TRIAXIAL TESTS ON JOINTED SPECIMENS, WAS LINEAR OVER THE RANGE OF STRESSES TESTED; AND (3) THE MOHR ENVELOPE FOR RUPTURE-THROUGH-INTACT-MATERIAL OF A SPECIMEN WITH MULTIPLE JOINTING PERPENDICULAR TO THE MAJOR PRINCIPAL DIRECTION FELL BELOW THE ENVELOPE FOR AN UNJOINTED SAMPLE.

13-68-11001 STRESSES AND DISPLACEMENTS INDUCED IN ROCK BY TUNNEL BORING MACHINE PROPS
DUVALL, W. I. + BLAKE, W.
U. S. BUR MINES REPORT INVESTIGATIONS 7200, 29, NOV. 1968. BUREAU OF MINES PRESENTS THEORETICAL SOLUTION FOR STRESSES AND DISPLACEMENTS IN INFINITE ELASTIC PLATE CONTAINING CIRCULAR HOLE WHOSE BOUNDARY IS SUBJECTED TO APPLIED SHEAR LOADS OVER FOUR SEPARATED ARCS; ANALYSIS OF VARIOUS SOLUTIONS SHOWS THAT TANGENTIAL TENSILE STRESSES INDUCED ON BOUNDARY TUNNEL BY APPLIED RADIAL LOADS CAN BE MINIMIZED IN ROOF AND FLOOR OF TUNNEL BY APPLICATION OF APPROPRIATE SHEAR LOADS TO EACH OF FOUR PROPS. 4 REFS.

13-69-02001 ROCK MECHANICS--A BIBLIOGRAPHY (GEOLOGY STRUCTURAL-PROPERTIES FRACTURE DRILLING DEFORMATION)
BURT, C. R. & GENERAL MOTORS WARREN MICHIGAN
GENERAL MOTORS TECHNICAL CENTER, WARREN MICHIGAN, MATERIALS AND STRUCTURES JOB REPORT NO. MSL-68-48, 145, FEB. 1969. A BIBLIOGRAPHY ON ROCK MECHANICS OVER THE 1957 TO 1966 PERIOD CONTAINS OVER 1200 REFERENCES TO BOOKS, ARTICLES AND REPORTS. REFERENCES ARE ALPHABETICALLY BY AUTHOR IN EACH OF THE THREE CATEGORIES.

13-69-02002 NEAR SURFACE HORIZONTAL STRESSES INCLUDING EFFECTS OF ROCK ANISOTROPY (ROCK-MECHANICS COMPUTER-TECHNIQUES)
HOOKER, V. E. + JOHNSON, C. F. & U.S. BUR MINES
U.S. BUR MINES REPORT INVESTIGATIONS 7224, 29, FEB 1969. IN SITU STRESSES, BASED ON ISOTROPIC RELATIONS, WERE EVALUATED USING COMPUTER TECHNIQUES FROM OVERCORING DATA OBTAINED IN DIMENSION STONE QUARRIES ALONG APPALACHIAN, PIEDMONT, OZARK UPLIFT, AND OUACHITA TECTONIC BELT; STRESSES IN HORIZONTAL PLANE NEAR SURFACE ARE COMPRESSIVE AND RANGE FROM 100 TO 4500 PSI; DIRECTION OF MAXIMUM COMPRESSIVE STRESS SEEMS TO BE ALIGNED WITH GENERAL TECTONIC STRUCTURE FOR MOST OF DETERMINATION; COMPUTER PROGRAM USED FOR ISOTROPIC CALCULATION OF STRESSES IS INCLUDED. 9 REFS.

FIELD 14 ARTICLES

14-43-00001 EARTH PRESSURE ON TUNNELS (PRESSURE-RESEARCH-STUDIES)
HOUSEL, W. S. & U.S.N. NORFOLK VA
ASCE TRANS., (108) 1037-58, 1943. GOLDBECK PRESSURE CELLS WERE INSTALLED IN TUNNELS, SHAFTS AND RETAINING WALLS IN DETROIT, MICH., IN 1930 TO DETERMINE EARTH PRESSURE ON TUNNELS. IN THIS INVESTIGATION THE SOIL INVOLVED WAS ASSUMED TO BE A PURELY COHESIVE MATERIAL (PLASTIC CLAY). THE RESULTS OF THE 10-YEAR TEST PERIOD SHOWED THAT FINAL EQUILIBRIUM WAS ACHIEVED 5 YEARS AFTER TUNNEL CONSTRUCTION. PRESSURE DECREASES FOR 3 MONTHS, THEN INCREASES UNTIL EQUILIBRIUM IS REACHED. AT FINAL EQUILIBRIUM VERTICAL PRESSURES WERE ABOUT EQUAL TO THE STATIC HEAD. LATERAL PRESSURE VARIED LITTLE AND WAS SUBSTANTIALLY LESS THAN THE STATIC HEAD. A METHOD OF COMPUTING THE EARTH PRESSURE WAS DEVISED.

14-54-03001 A PHYSICAL EXPLANATION OF THE EMPIRICAL LAWS OF COMMINUTIONS (GRINDING-CHARACTERISTICS)
WALKER, D. R. + SHAW, M. C. & M.I.T. CAMBRIDGE MASS
MINING ENGINEERING, 6, 313-320, MARCH 1954. THE EMPIRICAL LAWS OF COMMINUTION ARE MORE CORRECTLY BASED ON PARTICLE SIZE THAN THE SURFACE AREA. THE TENDENCY OF BRITTLE MATERIALS TO FOLLOW THE SAME ENERGY LAWS AS MACHINE GRINDING OF METALS INDICATES THAT COMMINUTION OF BRITTLE MATERIALS IS SIMILAR TO MACHINE GRINDING OF METALS. APPRECIABLE PLASTIC DEFORMATION IS ASSOCIATED WITH THE GRINDING OF ORDINARILY BRITTLE MATERIALS, THUS THE MACHINE GRINDING TECHNIQUE IS A PRECISE METHOD FOR EVALUATING THE GRINDING CHARACTERISTICS OF VARIOUS MATERIALS.

14-57-01001 EXPERIMENTAL DEFORMATION OF SEDIMENTARY ROCKS UNDER CONFINING PRESSURES: TESTS AT ROOM TEMPERATURE ON DRY SAMPLES (ROCK-MECHANICS STUDIES RESEARCH)
HANDIN, J. + HAGER, R. V., JR. & SHELL DEV CO HOUSTON
BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS, 1-50, JAN 1957. THE MECHANICAL PROPERTIES OF VARIOUS SEDIMENTARY ROCKS WERE STUDIED IN A SIMULATED NATURAL ENVIRONMENT OF HIGH PRESSURE, TEMP, AND HYDROTHERMAL SOLUTIONS. RESULTS ARE RECORDED OF TRIAXIAL COMPRESSION TESTS ON 23 DRY ROCKS AT ROOM TEMP, AND AT VARIOUS CONFINING PRESSURES FROM 0-2000 ATM. STRESS-STRAIN CURVES AND CURVES FOR ULTIMATE STRENGTH AND DUCTILITY AS FUNCTIONS OF CONFINING PRESSURE ARE GIVEN FOR EACH ROCK TYPE INVESTIGATED: SILTSTONE, SHALE, SANDSTONE, LIMESTONE, DOLOMITE ROCK, AND ANHYDRITE. MARKED INCREASES IN STRENGTH AND ABILITY TO DEFORM PERMANENTLY WITHOUT FRACTURING WERE FOUND. AN EXTENSIVE REFERENCE LIST IS GIVEN.

14-58-12001 EXPERIMENTAL DEFORMATION OF SEDIMENTARY ROCKS UNDER CONFINING PRESSURE: TESTS AT HIGH TEMPERATURE (ROCK-MECHANICS STUDIES RESEARCH)
HANDIN, J. + HAGER, R. V., JR. & SHELL DEV CO HOUSTON
BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS, 2892-2934, DEC 1958. SHORT TIME TRIAXIAL COMPRESSION TESTS OF DRY ANHYDRITE, DOLOMITE ROCK, LIMESTONE, SANDSTONE, SHALE, SILTSTONE, SLATE, AND HALITE CRYSTALS UNDER PRESSURE-TEMP CONDITIONS SIMULATING DEPTHS DOWN TO 30,000 FT REVEAL: AN INCREASE OF PRESSURE AT CONSTANT TEMP INCREASES YIELD STRESS, BUT AN INCREASE OF TEMP AT CONSTANT PRESSURES REDUCES IT. INCREASED PRESSURE AT CONSTANT TEMP ENHANCES ULTIMATE STRENGTH; HOWEVER, HEATING AT CONSTANT PRESSURE MAY RAISE STRENGTH BY INCREASING THE DUCTILITY OF WORK-HARDENING ROCKS. HEATING USUALLY LOWERS STRENGTH BY ELIMINATING WORK-HARDENING. EXCEPT FOR HALITE, ULTIMATE STRENGTH AT ANY SIMULATED DEPTH EXCEEDS THE CRUSHING STRENGTH AT ATMOSPHERIC CONDITIONS. THE STRENGTH OF LIMESTONE, SHALE, AND SILTSTONE AT ROOM TEMP EXCEEDS THAT AT 300 DEG C BY ABOUT 50%, AND OF HALITE NEARLY 7 TIMES, THE EFFECT ON OTHER MATERIALS TESTED IS SMALL. WORK IN PROCESS WILL MORE REALISTICALLY SIMULATE THE NATURAL ENVIRONMENT OF DEEPLY BURIED ROCKS BY USE OF AN INDEPENDENTLY CONTROLLED FLUID PORE PRESSURE.

14-62-08001 IN SITU DETERMINATION OF STRESS IN ROCK (ROCK-MECHANICS RESEARCH STUDIES)
OBERT, L. & U.S. BUR MINES APL PHYS RES LAB
MINING ENGINEERING, (18) NO. 8, 51-58, AUG. 1962. TO DETERMINE THE ABSOLUTE STRESS IN ROCKS IT WAS NECESSARY TO MEASURE THE DEFORMATION OF A BOREHOLE BEFORE AND AFTER THE ROCK WAS STRESS-RELIEVED. ALL MEASUREMENTS WERE MADE WITH A USBM BOREHOLE DEFORMATION GAUGE. OVERCORING A 1-1/2-IN DIAM GAUGE HOLE WITH A 6-IN O.D. BIT ALLOWED STRESS-RELIEF MEASUREMENTS TO BE MADE AT DEPTHS UP TO 20 FT. FORMULAS FOR CALCULATION OF MAXIMUM AND MINIMUM STRESSES WERE GIVEN. STRESS DETERMINATIONS OF GRANITE, TRONA, LIMESTONE AND TUFF WERE PRESENTED IN DETAIL. THESE DETERMINATIONS WERE SUFFICIENTLY ACCURATE FOR ENGINEERING PURPOSES; HOWEVER THE STRESS DETERMINATION FOR SALT WAS NOT.

14-64-01001 GEOLOGIC RESEARCH AT THE STRAIGHT CREEK TUNNEL SITE, COLORADO (GEOLOGY GEOPHYSICS STATISTICAL-MODEL CONSTRUCTION-PROCEDURE)
ROBINSON, C. S. + LEE, F. T. & U.S. GEOL SURVEY DENVER
NATIONAL RESEARCH COUNCIL - HIGHWAY RES. BOARD, RES. RECORD 57, 18-34, JAN 1964. A RESEARCH PROJECT AT STRAIGHT CREEK TUNNEL SITE ON I-70 IS TO APPLY AND EVALUATE IDEAS IN THE USE OF GEOLOGY AND GEOPHYSICS FOR PREDICTION OF GEOLOGIC CONDITIONS TO REDUCE CONSTRUCTION COST. SURFACE OUTCROPS IN THE TUNNEL VICINITY WERE MAPPED IN DETAIL. TWO CORE HOLES WERE DRILLED AND LOGGED. THIS WAS SUPPORTED BY GEOPHYSICAL LOGGING OF THE DRILL HOLES. SEISMIC PROFILES WERE RUN PARALLEL AND AT ANGLES TO THE TUNNEL. LABORATORY MEASUREMENTS WERE MADE OF PHYSICAL AND ENGINEERING PROPERTIES OF SAMPLES, A STATISTICAL MODEL OF TUNNEL GEOLOGY WAS CONSTRUCTED AND TUNNELING PROCEDURE DETERMINED. CONSTRUCTION HAS STARTED AND PREDICTIONS ARE BEING CHECKED IN THE HOPE THAT EVEN BETTER GEOLOGY FORECASTS CAN BE MADE FOR FUTURE TUNNELS.

14-64-02001 FUNDAMENTAL QUESTIONS IN THE FIELD OF GEOMECHANICS (ROCK-MECHANICS)
HACKETT, P.
MINE AND QUARRY ENGINEERING, (30) NO. 2, 75-77, FEB. 1964. AN IMPORTANT PART IS PLAYED BY JOINT FAULTS AND STRATIGRAPHICAL LINES OF WEAKNESS WHEN ROCKS ARE SUBJECTED TO STRESS. THE SHEAR STRENGTH OF THE ROCK MASS COULD THEN BE BASED UPON THE SHEAR STRENGTH OF THE JOINT SYSTEM AND NOT ON THE STRENGTH OF THE SOLID ROCK MATRIX. TYPES OF JOINTS CONSIDERED INCLUDE CLAY AND PEAT. WHEN EXPERIMENTING IN LARGE ROCK MASSES WITH INDIVIDUALLY THICK STRATA AND LITTLE TECTONIC DISLOCATION, A FEW RESULTS OF FLAT-JACK TESTS OFTEN GIVE A FAIRLY GOOD INDICATION OF THE MODULUS OF DEFORMATION. WHEN EXPERIMENTING IN CLOSELY STRATIFIED AND BADLY BROKEN ROCK MASSES IT WAS FOUND THAT LARGE NUMBERS OF TESTS ARE REQUIRED TO BRING OUT THE EFFECTS OF LOCAL DISCONTINUITIES; THE STATISTICALLY DETERMINED VALUES FOR THE MODULI MAY HAVE SUCH HIGH DEVIATIONS THAT RESULTS MAY BE ALMOST USELESS. THE USE OF A TRANSVERSELY ISOTROPIC ELASTIC MODEL FOR ANALYZING ROCK MOVEMENTS DUE TO MINING WAS INTRODUCED. THE PREDICTIONS OF STRAIN AND DISPLACEMENT WERE SHOWN TO BE COMPATIBLE WITH MEASURED DATA. THE FIELD OF THEORETICAL STUDIES IS NOW ADVANCING TO THE STAGE WHEN FORECASTS OF BEHAVIOR OF THE MAIN ROCK MASS MAY BE MADE.

14-66-00001 EQUIPMENT FOR MEASURING PORE PRESSURE IN ROCK SPECIMENS UNDER TRIAXIAL LOAD (ROCK-MECHANICS)
NEFF, T. L. & U.S. CORPS OF ENGRS
TESTING TECHNIQUES FOR ROCK MECHANICS, ASTM STP 402, AM. SOC. TESTING MATS., 3-18, 1966. THIS PAPER DEALS WITH EQUIPMENT DEVELOPMENT, PROCEDURAL DETAILS, AND PILOT TESTS OF LARGER SPECIMENS OF INTERMEDIATE QUALITY ROCK, AND ROCK CONTAINING JOINT SYSTEMS AND WEAKNESS PLANES. THE EFFECT OF PORE-PRESSURE BUILDUP DURING LOADING AND ITS GRAPHICAL REPRESENTATION, THAT IS, THE VECTOR CURVE AS EMPLOYED IN SOIL MECHANICS, IS CONSIDERED. WORK TO DATE INDICATES THAT IN AN UNDRAINED TRIAXIAL TEST THE PORE PRESSURE RISES TO A PEAK VALUE AT "YIELDING" OF THE SPECIMEN AND THEN FALLS OFF TO SOME LOWER VALUE AT FAILURE. PEAK VALUES AND FINAL VALUES VARY WIDELY FOR DIFFERENT ROCK TYPES. THE VECTOR CURVE DEPICTS QUITE CLEARLY THE RESULTS OF THE UNDRAINED TRIAXIAL TEST.

14-66-00002 PLATE-LOAD TESTING ON ROCK FOR DEFORMATION AND STRENGTH PROPERTIES (ROCK-MECHANICS SHEAR-STRENGTH SPECIFICATIONS)
COATES, D. F. + GYENGE, M. & DEPT MINES OTTAWA CAN
TESTING TECHNIQUES FOR ROCK MECHANICS, ASTM STP 402, AM. SOC. TESTING MATS., 19-40, 1966. PLATE-LOAD TESTS WERE CONDUCTED UNDERGROUND ON ROCK TO DETERMINE IN SITU STRENGTH AND DEFORMATION PROPERTIES. THE PLATE-LOAD TEST PROVIDES INFORMATION ON THE ROCK MASS PROPERTIES AS OPPOSED TO THE STRENGTH OF THE ROCK SUBSTANCE. WHEN A PLATE IS PLACED ON THE SURFACE OF THE MATERIAL TO BE TESTED AND THE CONTACT PRESSURE INCREASED, THE PLATE DEFLECTS AS THE MATERIAL DEFORMS, AND SHEAR FAILURE OF THE MATERIAL ULTIMATELY OCCURS. TESTS WERE CONDUCTED ON THREE DIFFERENT MATERIALS: IRON ORE, PAINT ROCK, AND ASH ROCK. THE RESULTS WERE COMPARED, IN OTHER CASES, WITH THE RESULTS OF ANALYZING FAILURES OF THE ROCK MASS. MODERATELY GOOD AGREEMENT WAS OBTAINED BETWEEN THESE INDEPENDENT METHODS OF DETERMINING THE MATERIAL PROPERTIES. HOWEVER, THE PRINCIPAL ASPECT THAT EMERGES IS THE DISPERSION OF STRENGTH VALUES THAT MUST BE EXPECTED IN TESTING GEOLOGICAL MATERIALS. SUGGESTED SPECIFICATIONS ARE GIVEN FOR PLATE-LOAD TESTING, CONVENTIONAL UNIAXIAL COMPRESSION TESTING, AND CLASSIFICATION UNIAXIAL COMPRESSION TESTING.

14-66-00003 A TRIAXIAL PRESSURE APPARATUS FOR TESTING OF CONSOLIDATED OR UNCONSOLIDATED MATERIALS SUBJECTED TO PORE PRESSURE (ROCK-MECHANICS COMPACTION CREEP-TEST)
DONATH, F. A. & COLUMBIA UNIV
TESTING TECHNIQUES FOR ROCK MECHANICS, ASTM STP 402, AM. SOC. TESTING MATS., 41-51, 1966. TO DETERMINE THE EFFECTS OF DIFFERENT STRESS STATES AND PORE PRESSURE ON THE COMPACTION OF SEDIMENT AND ON THE DEFORMATIONAL BEHAVIOR OF ROCK, A TRIAXIAL APPARATUS WAS DEVELOPED THAT PERMITS CONTROL OF PORE PRESSURE DURING TRIAXIAL TESTING OF MATERIALS UNDER HIGH CONFINING PRESSURE. THE APPARATUS IS DESIGNED FOR USE WITH 1-IN. DIAMETER BY 2-IN. LENGTH SPECIMENS SUBJECTED TO CONFINING PRESSURES AND PORE PRESSURES UP TO 30,000 PSI AND AXIAL STRESS UP TO 130,000 PSI. THE AXIAL LOAD CAN BE HELD CONSTANT OR VARIED CONTINUOUSLY DURING TESTING. THE COMPACT NATURE OF THE APPARATUS PERMITS MOBILITY THAT MAKES THE APPARATUS PARTICULARLY DESIRABLE WHERE FIELD TESTING IS NECESSARY.

14-66-00004 MEASUREMENT AND ANALYSIS OF ROCK PHYSICAL PROPERTIES ON THE DEZ PROJECT, IRAN (CONGLOMERATE-ROCKS ROCK-MECHANICS)
DODDS, R. K. & FOUNDATION SCI CO ASTORIA ORE
TESTING TECHNIQUES FOR ROCK MECHANICS, ASTM STP 402, AM. SOC. TESTING MATS., 52-72, 1966. THE FOUNDATION ROCK FOR THE DEZ PROJECT IS A PLIOCENE LIMESTONE-COBBLE CONGLOMERATE. THE CONSTRUCTION OF A THIN-ARCH DAM ON THIS YOUNG, HETEROGENEOUS MATERIAL REQUIRED A THOROUGH UNDERSTANDING OF ITS PHYSICAL PROPERTIES. THE TESTING PROGRAM INCLUDED: 257 PLATE BEARING TESTS, 85 IN SITU MEASUREMENTS OF RESIDUAL STRESS USING THE FLAT JACK METHOD, 2 LARGE HYDROSTATIC PRESSURE CHAMBERS, AND LABORATORY TESTS ON 887 SIX-IN.-DIAMETER ROCK CORES. THE APPLICATION OF THE PRINCIPLES OF ROCK MECHANICS RESULTED IN CONSIDERABLE SAVINGS IN TIME AND MONEY ON THE DEZ PROJECT.

14-66-00005 TECHNIQUES USED IN STUDYING THE FRACTURE MECHANICS OF ROCK (CRACK-PROPAGATION COMPRESSION TESTS)
PAULDING, B. W., JR. & IIT RES INST CHICAGO ILL
TESTING TECHNIQUES FOR ROCK MECHANICS, ASTM STP 402, AM. SOC. TESTING MATS., 73-86, 1966. PARTIALLY BROKEN MATERIAL WAS OBTAINED TO STUDY THE GROWTH OF CRACKS DURING BRITTLE FRACTURE. IN UNIAXIAL COMPRESSION THIS WAS ACCOMPLISHED BY PLACING A SIMPLY SUPPORTED BEAM IN PARALLEL WITH THE ROCK SPECIMEN TO LIMIT THE ADVANCE OF THE RAM WHEN THE LOAD-CARRYING ABILITY OF THE SPECIMEN DECREASED. UNCERTAINTIES ASSOCIATED WITH STRAIGHT CYLINDRICAL SPECIMENS WERE AVOIDED BY USING CYLINDERS WITH A REDUCED CENTRAL SECTION. VOLUMETRIC STRAIN WAS COMPUTED FROM TWO PERPENDICULAR STRAIN GAGES. THE ONSET OF CRACK GROWTH AND THE WORK EXPENDED AGAINST CONFINING PRESSURE WERE FOUND WITH THE AID OF PLOTS OF VOLUMETRIC STRAIN VERSUS STRESS. MEASUREMENTS OF LINEAR COMPRESSIBILITY INDICATED THE PREDOMINANT DIRECTION OF CRACK GROWTH AND THE INCREASE IN POROSITY.

14-66-00006 CAPABILITIES OF PHOTOELASTIC COATINGS FOR THE STUDY OF STRAIN IN ROCKS (ROCK-MECHANICS PHOTOELASTICITY)
PINCUS, H. J. & OHIO STATE UNIV
TESTING TECHNIQUES FOR ROCK MECHANICS, ASTM STP 402, AM. SOC. TESTING MATS., 87-105, 1966. ROCK STRAIN CAN BE STUDIED UTILIZING CONTINUOUSLY AND PERIPHERALLY CEMENTED PHOTOELASTIC SHEETS AND FROZEN-STRESS RING PHOTOELASTIC GAGES IN INTEGRATING MOUNTS. STANDARD ERRORS OF ESTIMATE OF STRAIN DIFFERENCES, AS CALCULATED FROM NORMAL INCIDENCE, RANGE UP TO 20 MICROINCH/IN. STANDARD ERRORS OF ESTIMATE OF PRINCIPAL STRAINS TAKEN SEPARATELY RANGE UP TO ABOUT 30 MICROINCH/IN. STRAIN LEVELS AS LOW AS SEVERAL TENS OF MICROINCH/IN CAN BE MEASURED WITH CONFIDENCE. STRAIN LEVELS CALCULATED FROM PHOTOELASTIC OBSERVATIONS AND ELASTICITY THEORY TYPICALLY DIFFER FROM EACH OTHER BY 10 PER CENT. RESULTS ARE CONSISTENT AMONG CONTINUOUSLY BONDED AND INTEGRATING MOUNTS, RECTANGULAR AND CIRCULAR SHEETS, DIFFERENT LOADING SCHEMES, AND DIFFERENT LIGHTING AND VIEWING ARRANGEMENTS. FROZEN RING PHOTOELASTIC GAGES ARE RELATIVELY EASILY READ AND INDICATE DIRECTIONS OF PRINCIPAL STRAINS. WORK WITH ROCK SPECIMENS GIVES RESULTS IN ACCORD WITH THOSE OBTAINED FROM WORK WITH ALUMINUM BARS. PHOTOELASTIC COATINGS ARE VERY SENSITIVE INDICATORS OF FRACTURES AND OTHER TYPES OF ANISOTROPHY. THIS METHOD IS APPLICABLE TO MANY TYPES OF INVESTIGATION.

14-66-00007 CALCULATION OF THE AVERAGE GROUND-STRESS COMPONENTS FROM MEASUREMENTS OF THE DIAMETRAL DEFORMATION OF A DRILL HOLE (ROCK-MECHANICS CORE-TEST)
PANEK, L. A. & U.S. BUR MINES COLLEGE PARK MD
TESTING TECHNIQUES FOR ROCK MECHANICS, ASTM STP 402, AM. SOC. TESTING MATS., 106-132, 1966. DETERMINING THE CHANGE OF STRESS IN ROCK BASED ON MEASUREMENTS OF THE DEFORMATION OF A DRILL HOLE IS A PROCEDURE THAT IS INCREASING IN POPULARITY. A CLOSELY RELATED PROCEDURE INVOLVES THE APPLICATION OF THIS PRINCIPLE TO DETERMINE THE EXISTING STRESSES IN A ROCK MEDIUM BY CUTTING FREE (CORE DRILLING) AN ANNULUS CONTAINING THE DRILL HOLE. IN THIS REPORT, EXPRESSIONS ARE DERIVED FROM WHICH ONE CAN CALCULATE THE STRESS ELLIPSOID-THE THREE-DIMENSIONAL CHANGE OF STRESS OR THE EXISTING THREE-DIMENSIONAL STRESS FIELD, AS THE CASE MAY BE. STUDY OF THESE EQUATIONS SHOWS THAT THE STRESS COMPONENTS

IN THREE DIMENSIONS CAN BE DETERMINED BY MEASUREMENTS IN ONLY TWO DRILL HOLES AND YIELDS GENERAL PRINCIPLES THAT ARE USEFUL IN PLANNING AN EFFICIENT PROGRAM OF DRILLING AND MEASUREMENT. THE NEED FOR SOME METHOD OF AVERAGING THE MEASUREMENTS ARISES EVEN IN THE SIMPLEST SITUATION, BECAUSE ONE USUALLY HAS AVAILABLE SEVERAL SETS OF MEASUREMENTS AND WISHES TO COMBINE THEM INTO A SINGLE SET OF AVERAGE STRESS COMPONENTS. PROCEDURES, THEREFORE, ARE GIVEN FOR CALCULATING THE LEAST SQUARES ESTIMATES OF THE STRESS COMPONENTS AND THEIR STANDARD ERRORS, AND FOR EVALUATING OR COMPARING CALCULATED VALUES BY MEANS OF STANDARD STATISTICAL INFERENCES.

14-66-00008 DEFORMATION MODULI OF ROCKS (ROCK-MECHANICS)
CLARK, G. B. & UNIV MO ROLLA MO
TESTING TECHNIQUES FOR ROCK MECHANICS, ASTM STP 402, AM. SOC. TESTING MATS., 133-174, 1966. THERE IS A REAL NEED FOR MORE PRECISE DEFINITIONS OF PHYSICAL PROPERTIES OF ROCKS, PARTICULARLY THE DEFORMATION MODULI OF BOTH LABORATORY SPECIMENS AND ROCK MASSES IN SITU. A VITAL INITIAL STEP IN ESTABLISHING STANDARDS IS TO RECOGNIZE EXISTING PROBLEMS OF ENGINEERING APPLICATIONS. ONE OF THE PRIME PURPOSES OF THIS PAPER IS TO FURNISH BACKGROUND INFORMATION ON DEFORMATION MODULI SO THAT FURTHER STEPS IN SETTING UP STANDARDS CAN BE TAKEN. MORE BASIC AND APPLIED RESEARCH WILL BE REQUIRED BEFORE SATISFACTORY STANDARDS CAN BE ESTABLISHED.

14-66-00009 THE ROLE OF MICROSTRUCTURE IN THE PHYSICAL PROPERTIES OF ROCK (ROCK-MECHANICS)
MCWILLIAMS, J. R. & U.S. BUR MINES
TESTING TECHNIQUES FOR ROCK MECHANICS, ASTM STP 402, AM. SOC. TESTING MATS., 175-189, 1966. THE PAPER DESCRIBES AN APPROACH TO UNDERSTANDING ROCK PROPERTIES THROUGH STUDY OF THEIR RELATION TO THE MICROSTRUCTURE OF THE ROCK. PETROFABRIC ANALYSES OF ROCK SPECIMENS, SUBJECTED TO VARIOUS PHYSICAL PROPERTY TESTS, HAVE SHOWN A STRONG CORRELATION AMONG SEVERAL PROPERTIES AND SOME OF THE MICROSTRUCTURAL FEATURES. THE EQUIPMENT AND TECHNIQUES BEING USED IN THESE ROCK PHYSICS STUDIES ARE DISCUSSED. AS AN EXAMPLE OF THIS WORK, THE RESULTS OF AN EXPERIMENTAL STUDY OF ANISOTROPISM IN SALISBURY GRANITE ARE GIVEN. ORIENTED DRILL CORES WERE CUT IN THREE MUTUALLY PERPENDICULAR DIRECTIONS FROM LARGE BLOCKS OF THE ROCK. AXIAL AND DIAMETRIC PULSE VELOCITY MEASUREMENTS WERE MADE ON THE CORES TO DETERMINE THE DIRECTION AND MAGNITUDE OF ELASTIC ANISOTROPISM. THE CORES WERE CUT INTO DISKS AND SUBJECTED TO AXIAL (POINT-LOAD) AND DIAMETRIC (LINE-LOAD) TENSION TESTS TO DETERMINE DIRECTION AND MAGNITUDE OF STRENGTH ANISOTROPISM. THE BROKEN SPECIMENS WERE RECONSTRUCTED, BUT INTO THEN SECTIONS, AND EXAMINED PETROGRAPHICALLY. THERE WAS A STRONG CORRELATION AMONG THE DIRECTION OF MAXIMUM AND MINIMUM SONIC VELOCITY, PREFERRED DIRECTION OF FAILURE, AND A NUMBER OF MICROSTRUCTURAL FEATURES, SUCH AS DEFECT STRUCTURES AND GRAIN ORIENTATION.

14-66-00010 INFLUENCE OF ROCK ANISOTROPY AND TIME-DEPENDENT DEFORMATION ON THE STRESS-RELIEF AND HIGH-MODULUS INCLUSION TECHNIQUES OF IN SITU STRESS DETERMINATION
BERRY, D. S. + FAIRHURST, C. & UNIV MINN MINNEAPOLIS MINN
TESTING TECHNIQUES FOR ROCK MECHANICS, ASTM STP 402, AM. SOC. TESTING MATS., 190-206, 1966. TWO OF THE MOST POPULAR TECHNIQUES USED IN THE DETERMINATION OF IN SITU ROCK STRESSES ARE THE STRESS-RELIEF AND HIGH-MODULUS INCLUSION METHODS. DEFORMATIONS AND STRAINS OBSERVED IN THE MEASURING INSTRUMENTS ARE USUALLY INTERPRETED ON THE ASSUMPTION THAT THE ROCK BEHAVES AS A HOMOGENEOUS, ISOTROPIC, LINEARLY ELASTIC MEDIUM, A SITUATION WHICH IS NOT EVEN APPROXIMATELY CORRECT IN SOME PRACTICAL CASES. THIS PAPER PRESENTS A THEORETICAL ANALYSIS OF THE INFLUENCE OF: (A) ROCK ANISOTROPY, OF THE TRANSVERSELY ISOTROPIC KIND, ON THE ACCURACY OF VALUES OF IN SITU STRESSES DETERMINED FROM THE USUAL ISOTROPIC ANALYSIS AND (B) TIME-DEPENDENT ROCK DEFORMATION, REPRESENTED AS LINEAR, ISOTROPIC, VISCOELASTIC CREEP, ON THE STRESSES DEVELOPED IN HIGH-MODULUS PLUGS. IT IS SHOWN THAT SIGNIFICANT ERRORS (OVER 50 PER CENT FOR ONE STRESS-RELIEF EXAMPLE CHOSEN) MAY BE INTRODUCED BY NEGLECTING THESE FACTORS.

14-66-00011 LABORATORY TESTING OF ROCK STRENGTH
MAZANTI, B. B. + SOWERS, G. F. & GA INST TECH ATLANTA
TESTING TECHNIQUES FOR ROCK MECHANICS, ASTM STP 402, AM. SOC. TESTING MATS., 207-231, 1966. NEW EQUIPMENT AND TESTING TECHNIQUES HAVE BEEN DEVELOPED TO INVESTIGATE THE BASIC STRENGTH OF ROCK. THE EFFECT OF VARYING THE INTERMEDIATE PRINCIPAL STRESS ON THE STRENGTH APPEARS APPRECIABLE IN THE CASE OF CRYSTALLINE ROCKS SUCH AS GRANITE. FAILURE OF HOLLOW CYLINDERS OF ROCK UNDER CONDITIONS OF HIGH RATIOS OF THE INTERMEDIATE TO THE MAJOR PRINCIPAL STRESS APPEARS TO BE INITIATED AS A "SPALLING" FAILURE. ALTHOUGH SIMPLE TESTS FOR THE DETERMINATION OF THE STRENGTH OF INTACT ROCK CAN FURNISH RELIABLE DATA FOR CERTAIN DESIGN SITUATIONS, THE BEHAVIOR OF DISCONTINUOUS ROCK MASSES MUST BE EVALUATED BY MEANS OF SUITABLE MODEL STUDIES AND ANALYTICAL PROCEDURES. WHILE THE RESULTS WILL STILL BE ONLY APPROXIMATIONS OF THE MASS PROPERTIES, THERE ARE DEFINITE BENEFITS IN TERMS OF PLANNING AND INTERPRETING FIELD TESTS.

14-66-00012 A LOADING SYSTEM FOR THE INVESTIGATION OF THE INELASTIC PROPERTIES OF GEOLOGIC MATERIALS (ROCK-MECHANICS)
HARDY, H. R., JR. & PENN STATE UNIV
TESTING TECHNIQUES FOR ROCK MECHANICS, ASTM STP 402, AM. SOC. TESTING MATS., 232-271, 1966. THIS PAPER DESCRIBES THE THEORY AND DEVELOPMENT OF A LOADING SYSTEM FOR THE LABORATORY INVESTIGATION OF THE INELASTIC PROPERTIES OF SMALL ROCK AND MINERAL SPECIMENS UNDER A VARIETY OF LOADING MODES, INCLUDING CONSTANT LOAD, INCREMENTAL LOADING, AND CONSTANT RATE OF LOADING. THE APPLICATION OF BASIC FEEDBACK CONTROL THEORY TO THE DESIGN OF THE CONTROL SYSTEM IS OUTLINED, ALONG WITH DETAILS OF THE CONSTRUCTION AND TESTING OF THE COMPLETED SYSTEM. THE PROBLEM OF OBTAINING UNIFORM LOADING OF CYLINDRICAL TEST SPECIMENS UNDER COMPRESSIVE LOAD IS DISCUSSED, AND DETAILS OF A SPECIAL SPECIMEN LOADING JIG DEVELOPED FOR THIS PURPOSE ARE DESCRIBED.

14-66-00013 FOUNDATION TESTING TECHNIQUES FOR ARCH DAMS AND UNDERGROUND POWERPLANTS
WALLACE, G. B. + OLSEN, O. J. & U.S. BUR RECL DENVER COLO
TESTING TECHNIQUES FOR ROCK MECHANICS, ASTM STP 402, AM. SOC. TESTING MATS., 272, 1966. TO ENSURE THAT FOUNDATION TESTS ARE PERFORMED ON REPRESENTATIVE SPECIMENS AND FIELD SITES, GEOLOGISTS TAKE ADVANTAGE OF REGIONAL SURVEYS, VICINITY SURFACE MAPPING, AND SUBSURFACE CONDITIONS AT THE SITE AS REVEALED FROM BORINGS AND BOREHOLE CAMERA STUDIES. FOLLOWING THIS, THE PHYSICAL PROPERTIES OF THE ROCK ARE DETERMINED FROM DRILL CORES. DEFORMATION OF THE ROCK, FOR COMPUTATION OF ARCH REACTIONS AND DEFLECTIONS, IS DETERMINED BY NUMEROUS LABORATORY TESTS OF SOUND ROCK SPECIMENS AND BY JACKING AND SEISMIC TESTS IN THE FIELD THAT SHOW THE INFLUENCE OF CRACKS AND OTHER INHERENT WEAKNESSES. THE SHEAR STRENGTH OF THE ROCK IS DETERMINED TRIAXIALLY IN THE LABORATORY WITH SPECIMENS FROM HOLES ORIENTED AT VARIOUS ANGLES TO THE FOLIATION PLANE. IN THE FIELD, LARGE BLOCKS OF ROCK ARE TESTED TO OBTAIN THE INFLUENCE OF JOINT SYSTEMS ON SHEAR STRENGTH AND RESISTANCE TO SLIDING UNDER VARIOUS NORMAL LOADS. STRAIN RELIEF TECHNIQUES ARE USED TO OBTAIN IN SITU STRESSES ON THE WALLS AND ROOF OF AN EXPLORATORY TUNNEL AND WITHIN THE ROCK MASS BY MEANS OF DEEP DRILL HOLES. ROCK DEFORMATION CAUSED BY EXCAVATION OF A MACHINE HALL CHAMBER IS MEASURED BY THE USE OF MULTIPLE BOREHOLE EXTENSOMETERS AND CONVERGENCE GAGE POINTS. WHEN JOINTED ROCK IS BOLTED TOGETHER AND USED AS A STRUCTURAL MATERIAL, TESTS ARE MADE TO DETERMINE THE TORQUE-TENSION RELATIONSHIP FOR BOLTS TO BE SURE THAT THE ANCHORS WILL HOLD AND NOT RELAX THEIR GRIP WITH TIME. AS A SAFETY MEASURE AND TO CHECK DESIGN ASSUMPTIONS, DEFORMATION METERS ARE INSTALLED BETWEEN THE BASE OF THE DAM AND THE FOUNDATION ROCK AT VARIOUS DEPTHS BELOW THE STRUCTURE.

14-66-02001 ROCK MECHANICS STUDY DETERMINES DESIGN (LINING SUPPORTS INSTRUMENTATION)
DUTCO, H. B. & TERRAMETRICS GOLDEN COLO
CIVIL ENGINEERING, 60-62, FEB 1966. THE REDISTRIBUTION OF LOAD TO ADJACENT ROCK TAKES TIME. IT USUALLY INVOLVES A GRADUAL ADJUSTMENT IN THE JOINT OR BEDDING SYSTEMS NEAR THE WALL AREA. THE INITIAL SUPPORT SYSTEM GENERALLY CONSISTS OF STEEL RIB SUPPORTS AND WOOD OR STEEL LAGGING. THE FINAL SUPPORT SYSTEM IS FORMED CONCRETE, EITHER WITH OR WITHOUT REINFORCEMENT. THE SUPPORT SYSTEM SHOULD BE STRONG ENOUGH TO RESIST APPRECIABLE DAMAGE YET FLEXIBLE ENOUGH TO YIELD SLIGHTLY IN ORDER TO INITIATE DISTRIBUTION ADJUSTMENTS DURING PERIODS OF PEAK LOADS. THE FINAL SUPPORT SYSTEM SHOULD SUPPORT THE LIMITING ROCK LOAD. FOUR TESTING STATIONS POINTED OUT THAT A CONTINUOUS INITIAL SUPPORT TO MEET STRUCTURAL REQUIREMENTS AND TO PROVIDE PROTECTION FROM ROCK FALLS WAS NEEDED UNTIL THE TUNNEL WAS LINED. INTERIM RESULTS REDUCED THE OVERALL COST OF THE INITIAL SUPPORT SYSTEM BY 24.7 PERCENT.

14-66-05001 CERTAIN INVERSE PROBLEM IN THEORY OF ELASTICITY (ROCK-MECHANICS)
CHEREPANOV, G. P.
INZHENERNYI ZHURNAL, N 3, 119-122, MAY-JUNE 1966. TWO DIMENSIONAL PROBLEM OF EQUAL STRENGTH PROFILES IS CONSIDERED FOR CASE OF TUNNEL DRIVES IN HALF-SPACE ASSUMED TO HAVE PROPERTIES OF UNIFORM, ISOTROPIC, ELASTIC BODY. TUNNEL AXIS IS PARALLEL TO SURFACE OF HALF-SPACE, AND WALL OF TUNNEL IS SUBJECTED TO CONSTANT NORMAL LOAD, AND TANGENTIAL LOAD EQUAL TO ZERO. SOLUTIONS TO BOUNDARY VALUE PROBLEMS ARE FOUND TO BE FAMILY OF SIMILAR ELLIPSES. (IN RUSSIAN)

14-66-11001 CURVED BEAM ANALOG FOR TUNNEL DESIGN IN MASSIVE ROCK (ROCK-MECHANICS)
ADLER, L. & VA POLY INST BLACKSBURG VA
PROC. AM. SOC. OF CIVIL ENGINEERS; JOURNAL OF SOIL MECHANICS AND FOUNDATIONS DIV., 189-209, NOV. 1966. INSTEAD OF USING THE THEORY OF ELASTICITY OR OF AN EXPERIMENTAL STRESS ANALYSIS TECHNIQUE IN DESIGNING TUNNELS, THE CURVED BEAM ANALOG IS BEING USED. THE THEORY'S ABILITY TO SYNTHESIZE AND LUMP INTO A SIMPLE MECHANISM THE ACTUALLY-OCCURRING STRESS INTERACTIONS GIVES IT AN IMPORTANT ADVANTAGE FOR ESTIMATING THE EFFECTS OF A WIDE RANGE OF PROBABLE FIELD CONDITIONS. BEAM THEORY REQUIRES A DOMINANT MOMENT ON TRANSVERSE PLANES AND THE NONWARPING ROTATIONAL RESPONSES OF THESE PLANES. IF SIMPLE BEAM THEORY IS TO BE AT LEAST 10 PERCENT ACCURATE, A SPAN-TO-DEPTH RATIO OF GREATER THAN 2 IS REQUIRED FOR STRAIGHT BEAMS. STRESS MAPS ARE DELINEATED BY OBTAINING THE CRITICAL PROFILE ALONG THE INNER BOUNDARY, THEN BY LOCATING THE ZERO STRESS POINT ALONG THE VERTICAL AXIS OF SYMMETRY. IN PLOTTING THE STRESS TRAJECTORIES, LOCATION OF THE SINGULAR POINT IS CRITICAL. RECOGNITION OF BEAM ACTION HAS LED TO THE RECENT FORMULATION OF A GENERAL STABILITY CRITERION FOR UNDERGROUND OPENINGS. IT IS ALSO POSSIBLE TO EXTEND CURVED BEAM ANALOG TO OTHER PHASES.

14-66-12001 FIRST INTERNATIONAL CONGRESS ON ROCK MECHANICS (EXPLORATION DESCRIPTION-OF-ROCK-MASSES PROPERTIES-OF-ROCK RESIDUAL-STRESS-IN-ROCK-MASSES COMMINUTION EXCAVATED SLOPES TUNNELS)
FELD, J.
CIVIL ENGINEERING, ASCE, 58-60, DEC 1966. THE FIRST INTERNATIONAL CONFERENCE ON ROCK MECHANICS WAS HELD IN LISBON, PORTUGAL. ABOUT 850 PERSONS ATTENDED. 241 PAPERS WERE PRESENTED FROM 31 COUNTRIES. SEE 12-66-10001.

14-67-00001 DETERMINATION OF STRESS IN ROCK STATE-OF-ART REPORT
OBERT, L. & U.S. BUR MINES DENVER COLO
ASTM, PHILADELPHIA, PA. SPECIAL TECH PUBL 429, 56, 1967. PAPER BEFORE SYMPOSIUM ON ROCK MECHANICS (ATLANTIC CITY, 1966) REVIEWS VARIOUS METHODS THAT HAVE BEEN REPORTED, INCLUDING APPROPRIATE THEORY AND SOME EXPERIMENTAL CHECKS USED TO ESTABLISH THEIR VALIDITY AND ACCURACY; RESULTS FROM FIELD INVESTIGATIONS INDICATE QUALITY OF DATA THAT CAN BE OBTAINED; THEY ALSO SHED SOME LIGHT ON NATURE OF STRESS IN ROCK AND STRESS DISTRIBUTIONS THAT OCCUR AROUND UNDERGROUND OPENINGS; IT IS SUGGESTED THAT RECOMMENDATIONS BE MADE GOVERNING SPECIFICATIONS AND CALIBRATION OF THIS CLASS OF EQUIPMENT AND METHODS ARE NOTED.

14-67-01001 GEOLOGY OF THE HAROLD D. ROBERTS TUNNEL, COLORADO; STATION 468 + 49 TO EAST PORTAL (WATER-DIVERSION)
WARNER, L. A. + ROBINSON, C. S. & UNIV COLORADO BOULDER COLO
GEOLOGICAL SOCIETY OF AMERICA BULLETIN, (78) 57-120, JAN. 1967. THE HAROLD D. ROBERTS TUNNEL IS A 23.3 MILE WATER DIVERSION TUNNEL THAT EXTENDS THROUGH THE WESTERN PART OF THE FRONT RANGE BETWEEN GRANT AND DILLON COLORADO. THIS REPORT CONCERNS THE GEOLOGY OF THE SOUTHEASTERN SEGMENT OF THE TUNNEL WHICH IS PARTLY IN MONTEGUMA STOCK-A LARAMIDE QUARTZ MONZONITE PLUTON-BUT IS MAINLY IN PRECAMBRIAN BASEMENT ROCKS. 13 FIGURES, 2 PLATES, 50 REFERENCES.

14-67-01002 COST AND VALUE OF DRILL HOLE INFORMATION (WELL-LOGGING CORE-DRILLING)
PETERS, W. C. & UNIV ARIZ MIN AND GEOL ENGR
MINING CONGRESS, (53) N 1, 56-59, JAN 1967. NEW METHODS OF OBTAINING ADDITIONAL INFORMATION AND UTILIZATION OF NON CORE DRILLING INCREASES ACCURACY OF GEOLOGIC EXPLORATIONS. WIDER USE OF HOLE SURVEYING IS RECOMMENDED. NORMAL COSTS RUN ABOUT $15/FOOT FOR HOLES LESS THAN 3000 FEET DEEP ADVANCES RAPIDLY TO ABOUT $25/FOOT AT 5000 FT.

14-67-01003 SURFACE & UNDERGROUND GEOPHYSICAL STUDIES AT STRAIGHT CREEK TUNNEL SITE, COLORADO (RESISTIVITY SEISMIC-VELOCITY ROCK-QUALITY GEOPHONES)
SCOTT J. H. + CARROLL, R. D. & U.S. GEOL SURVEY DENVER
NATIONAL RESEARCH COUNCIL - HIGHWAY RESEARCH BOARD, RES. RECORD, (1) N 185, 20-35, 1967. STRAIGHT CREEK TUNNEL PILOT BORE WAS A 13 FT DIA TUNNEL 8,300 FT LONG EXCAVATED BY BLASTING TO OBTAIN GEOLOGIC AND ENGINEERING INFORMATION REQUIRED FOR EFFICIENT CONSTRUCTION OF A TWIN BORE HIGHWAY TUNNEL TO BE PART OF I-70. PREDICTIONS WERE ACCURATELY MADE BASED ON GEOPHYSICAL MEASUREMENTS MADE ON THE SURFACE ABOVE THE TUNNEL AND BY PROBES CONTAINING GEOPHONES LOWERED INTO AND FASTENED TO THE WALLS OF DRILL HOLES AT DEPTHS OF 712 AND 526 FT WHEN DETONATING 25 AND 50 LBS DYNAMITE CHARGES. GEOPHYSICAL MEASUREMENTS MADE IN LONG FEELER HOLES DRILLED AHEAD OF THE WORKING FACE COULD BE USED TO PREDICT ENGINEERING AND ECONOMIC PARAMETERS AHEAD OF CONSTRUCTION BUT INSTRUMENTATION FOR SUCH MEASUREMENTS NEEDS IMPROVEMENT IF THEY ARE TO BE TAKEN IN A ROUTINE MANNER. RESISTIVITY AND SEISMIC VELOCITY RESULTS TAKEN IN THE TUNNEL WALL CORRELATE WELL WITH ROCK QUALITY BUT WOULD NOT BE APPLICABLE TO A TUNNEL DRIVEN IN A DIFFERENT ENVIRONMENT OR TO ONE OF A DIFFERENT SIZE DRIVEN IN THE SAME ENVIRONMENT.

14-68-00001 SIMPLE TRIAXIAL CELL FOR FIELD OR LABORATORY TESTING OF ROCK
HOEK, E. + FRANKLIN, J. A.
INSTITUTION MIN & MET TRANS, (77) SECTION A 22 - A 26, 1968. ONE OF MOST IMPORTANT CHARACTERISTICS OF ROCK, FROM DESIGN ENGINEER'S POINT OF VIEW, IS SIGNIFICANT INCREASE IN STRENGTH WITH INCREASING CONFINING PRESSURE; ADEQUATE DESCRIPTION OF THIS STRENGTH BEHAVIOR REQUIRES NUMBER OF TRIAXIAL TESTS OVER RANGE OF CONFINING PRESSURES; SIMPLE AND INEXPENSIVE TRIAXIAL CELL FOR TESTING ROCK CORE SPECIMENS AT CONFINING PRESSURES UP TO 10,000 LB-FT/SQ IN. IS DESCRIBED; CELL WEIGHS ONLY 10 LB AND EMPLOYS SELF-SEALING RUBBER SLEEVE; TRIAXIAL TESTING IS RAPID AND CONVENIENT SINCE NEITHER DRAINING OF HYDRAULIC FLUID NOR DISMANTLING OF CELL BETWEEN TESTS IS NECESSARY.

14-68-01001 DEVELOPMENT OF A PETROFABRIC-PHOTOELASTIC TECHNIQUE IN ROCK MECHANICS (GEOLOGICAL STRUCTURE SUPPORTS STRAIN RELIEF)
RANA, D. H. + BULLOCK, W. D. & QUEEN'S UNIV ONT CAN
CAN MIN & MET BULL, 61, 89-92, JAN 1968. ANY METHOD FOR DETERMINING THE STATE OF STRESS EXISTING IN ANY GIVEN ROCK MASS HAS CERTAIN DRAWBACKS. PHOTOELASTICITY IS NOT EXPENSIVE TO USE BUT RESULTS SO FAR HAVE NOT BEEN GOOD. PETROFABRICS CAN COMPLETELY DEFINE THE STRESS ELLIPSOID IN QUALITATIVE TERMS. THE ANALYSIS OF PETROFABRIC DATA IS TO DEVELOP A TECHNIQUE WHICH WILL BE DIRECTLY APPLICABLE TO FIELD USE IN THE DESIGN OF STABLE STRUCTURES, TO COMPARE THE ATTITUDES OF EXISTING JOINT SETS WITH PREFERRED PLANES OF SHEAR.

14-68-02001 DEVELOPMENTS IN REMOTE SENSING APPLICABLE TO AIRBORNE ENGINEERING SURVEYS OF SOILS AND ROCKS (ROCK-MECHANICS GEOLOGY INFRARED MICROWAVE-SENSORS RADIO-SENSORS LASER)
PARKER, D. C. & UNIV MICHIGAN
MATERIALS RESEARCH AND STANDARDS, (8) NO 2, 22-30, FEB 1968. USES OF VARIOUS AIRBORNE SENSORS IN ENGINEERING SURVEYS OF SOILS AND ROCKS. THE SENSORS INCLUDE CAMERAS, INFRARED AND PASSIVE MICROWAVE MAPPERS, RADAR, SPECTROMETERS, LASER, RADIO FREQUENCY, AND INDUCTION DEVICES. THE APPLICATIONS INCLUDE IDENTIFYING AND DELIMITING SOIL AND ROCK UNITS AND LOCATING SOIL AND ROCK MATERIALS SUITABLE FOR ENGINEERING PURPOSES. THE DATA ALSO PROVIDE ANSWERS ABOUT SURFACE AND SUBSURFACE CONDITIONS THAT WOULD AFFECT EASE OF EXCAVATION, SLOPE STABILITY, OR SUITABILITY FOR SUBGRADE, FOUNDATION, OR FILL MATERIALS. MANY POTENTIALLY VALUABLE SENSORS ARE NOT BEING EXPLOITED OR CONSIDERED. A BIG PROBLEM RELATING TO THEIR EXPLOITATION IN ENGINEERING SURVEYS IS THAT OF ECONOMICALLY CONVERTING DEVELOPMENTS IN SENSOR TECHNOLOGY AND DATA INTERPRETATION INTO ROUTINE ENGINEERING PRACTICE. ALTHOUGH SENSOR TECHNOLOGY IMPOSES LIMITS, CAPABILITY COULD BE ADVANCED BY SOLVING PROBLEMS THAT OVERSHADOW IT-THE MOST IMPORTANT OF WHICH IS LEARNING TO ACCURATELY AND ROUTINELY INTERPRET THE DATA IN TERMS OF ENGINEERING PARAMETERS.

14-68-04001 SHAFT AND TUNNEL BREAK-THROUGH - BASIC FUNCTIONS AND MODERN SURVEYING TECHNIQUES
FALTER, A.
CAN MIN & MET BULL, 544-552, APRIL 1968. PRECISION SURVEYS AND ADEQUATE CALCULATION PROCEDURES ARE REQUIRED FOR A PRECISE SHAFT OR TUNNEL BREAKTHROUGH. SURVEYING UNDERGROUND IS DIFFICULT AND THE UTMOST CARE MUST BE EXERCISED. USE OF A GYRO-THEODOLITE FOR ORIENTING BASE LINES AND A TELLUROMETER OR GEODIMETER FOR DISTANCE MEASUREMENT IS RECOMMENDED.

14-68-05001 SWELLING CHARACTERISTICS OF ROCK (ROCK-MECHANICS WATER-ABSORPTION)
DUNCAN, N. + DUNNE, M. H. + PETTY, S.
WATER POWER, (20) N 1, 85-92, MAY 1968. PROBLEM OF SWELLING IN ROCK MASSES TO WHICH WATER HAS HAD ACCESS AND RELATIONSHIP BETWEEN ROCK PROPERTIES AFFECTING SWELLABILITY ARE DISCUSSED. EFFECTS OF WATER ON ROCK MATERIALS AND STRESS HISTORY OF SEDIMENTARY ROCKS; TESTS TO DETERMINE EXTENT TO WHICH VARIOUS ROCK MATERIALS DILATED WHILE ABSORBING WATER; SWELLING WAS MEASURED IN DIRECTION NORMAL TO BEDDING OR MAJOR JOINT SYSTEM.

14-68-06001 THEORY OF IN-SITU ROCK TESTS FOR UNDERGROUND WORKS
TANDON, G. N. + VARSHNEY, R. S.
INDIAN J POWER & RIVER VALLEY DEVELOPMENT, (18) N 6, 240-5, JUNE 6, 1968. A THEORETICAL PRESENTATION OF INSITUD ROCK TESTS TO DETERMINE COHESION AND SHEAR RESISTANCE OF ROCK DEFORMATION MODULUS, MODULUS OF ELASTICITY AND POISSON'S RATIO, INITIAL STRESS FIELD IN DIFFERENT DIRECTIONS, ROCK PERMEABILITY AND DEFORMATIONS WITH SPECIAL REFERENCE TO FLAT JACK TESTS METHOD, PLATE BEARING METHOD, TUNNEL DEFORMATION, AND INSITU SHEAR TESTS.

14-68-07001 DETERMINATION OF STRESS IN ROCK UNAFFECTED BY BOREHOLES OR DRIFTS FROM MEASURED STRAIN OR DEFORMATION (DESIGN-DATA ROCK-MECHANICS)
HIRAMATSU, Y. + OKA, Y.
INT J ROCK MECHANICS & MIN SCIENCES, (5) N 4, 337-53, JULY 1968. PROBLEMS REGARDING DETERMINATION OF STRESSES IN ROCK UNAFFECTED BY BOREHOLES OR DRIFTS FROM MEASUREMENTS MADE IN THEM ARE DISCUSSED. DIAMETER OF BOREHOLE, STRAINS ON BOTTOM OR WALL SURFACE OF BOREHOLES AND STRAINS ON WALL SURFACE OF BOREHOLES AND STRAINS ON WALL SURFACE OF DRIFTS OR SHAFTS ARE CONSIDERED AS PARAMETERS. PRACTICAL FORMULAS FOR DETERMINATION OF STRESSES IN ROCK FROM MEASUREMENTS ARE PRESENTED AND THEIR APPLICATIONS ARE DISCUSSED. 10 REFS.

14-68-07002 SOME ASPECTS OF ROCK PRESSURE MODELLING ON EQUIVALENT MATERIALS (ROCK-MECHANICS)
THAKUR, D. N.
INT J ROCK MECHANICS & MIN SCIENCES, (5) N 4, 355-69, JULY 1968. FUNDAMENTALS OF THEORY OF ROCK PRESSURE MODELING ON EQUIVALENT MATERIALS ARE DISCUSSED. SCALE FACTORS HAVE BEEN DERIVED USING THEORY OF DIMENSIONAL ANALYSIS, SPECIAL EMPHASIS HAVING BEEN LAID ON TIME SCALE FACTOR. CORRECTION FACTOR HAS BEEN INTRODUCED IN MODULUS OF ELASTICITY OF EQUIVALENT MATERIALS OF PLANE MODELS TO SIMULATE TRIAXIAL LOADING CONDITIONS EXISTING IN MINE. FOR MODELING DEEPER DEPOSITS NEW TECHNIQUE WITH COMPENSATED LOAD IS SUGGESTED. 8 REFS.

14-68-08001 SOIL MECHANICS, ROCK MECHANICS AND MINING
ROBERTS, A. F.
MINING ENGINEERING, N 95, 621-31, AUG. 1968. REVIEW OF PRINCIPLES AND SCOPE OF SOIL, AND ROCK MECHANICS AND DISCUSSION OF THEIR APPLICATIONS TO MINING TECHNOLOGY. FIRST SECTION OF PAPER DEALS WITH CONVENTIONAL SOIL MECHANICS PROBLEMS SUCH AS CONSTRUCTION OF WASTE PILES, STABILITY OF EARTH SLOPES, FLOW OF BULK SOLIDS IN BLOCK CAVING AND SHRINKAGE SLOPING, ORE PASSES AND VARIOUS TRANSPORT SYSTEMS. SECOND SECTION OF PAPER DISCUSSES ROCK MECHANICS AS APPLIED TO STRATA CONTROL, ROOF SUPPORTS, DRILLING AND BLASTING TECHNIQUES, SUBSIDENCE ROCK AND GAS BURSTS. 56 REFS.

14-68-09001 DESIGN AND CONSTRUCTION OF TRIAXIAL AND POLYAXIAL CELL FOR TESTING ROCK SPECIMENS
HOJEM, J. P. M. + COOK, N. G. W.
SOUTH AFRICA MECH. ENGR., (18) N 2, 57-61, SEPT. 1968. STRENGTH OF ROCK AND MANY OTHER BRITTLE MATERIALS IS MARKEDLY AFFECTED BY SYSTEM STRESSES TO WHICH THEY ARE SUBJECTED. DESIGN OF SIMPLE TRIAXIAL CELL FOR SUCH EXPERIMENTS IS DESCRIBED. FEW INVESTIGATIONS OF POLYAXIAL STRENGTH HAVE BEEN MADE BECAUSE OF EXPERIMENTAL DIFFICULTIES OF ACHIEVING CONDITIONS OF TRUE HOMOGENEOUS POLYAXIAL STRESS. PAPER DESCRIBES POLYAXIAL CELL IN WHICH VIRTUALLY HOMOGENEOUS STRESSES ARE APPLIED TO OPPOSITE SIDES OF RECTANGULAR PRISMATIC SPECIMEN BY THIN COPPER FLAT-JACKS, AND AXIAL STRESS IS APPLIED BY STEEL END-PIECES AS IN TYPICAL TRIAXIAL TEST. 7 REFS.

14-68-09002 PERFORATED BEAM TEST FOR DETERMINING TENSILE STRENGTH OF ROCK
LADANYI, B. + NGUYEN, D.
J OF MATLS, (3) N. 3, 483-495, SEPT. 1968. FOUR-POINT BENDING TESTS TO FRACTURE WERE CARRIED OUT WITH LIMESTONE BEAMS HAVING SAME OVERALL DIMENSIONS BUT WITH CENTRAL TRANSVERSE HOLES OF VARYING DIAMETER. RESULTS ARE INTERPRETED BY TAKING INTO ACCOUNT STRESS CONCENTRATION EFFECTS AS FOUND BY THEORY AND PHOTOELASTIC ANALYSIS. IT IS CONCLUDED THAT THIS TYPE OF TEST HAS CERTAIN ADVANTAGES OVER OTHER INDIRECT METHODS BUT IT CANNOT PROVIDE UNIQUE INFORMATION ON TENSILE STRENGTH OF ROCK WITHOUT DETAILED KNOWLEDGE ON STRESS-STRAIN BEHAVIOR OF MATERIAL UP TO FRACTURE. 23 REFS.

14-68-09003 UNIQUE DESCRIPTION OF FAILURE OF BRITTLE MATERIAL
CHERRY, J. T. + LARSON, D. B. + RAPP, E. G.
INT J ROCK MECHANICS & MIN SCIENCES, (5) N 5, 455-63, SEPT. 1968. FAILURE LAW IS PRESENTED WHICH COMBINES BOTH 'SHEAR' AND 'TENSION' FAILURE INTO SINGLE INVARIANT EXPRESSION, AND EXPRESSED IN MATHEMATICAL FORMULA. THIS EXPRESSION IS ABLE TO DESCRIBE CONSISTENTLY MATERIAL FAILURE PRODUCED BY COMPRESSION, EXTENSION AND HOLLOW TORSION LABORATORY TESTS. EXTENSION OF FAILURE SURFACE BACK TO ZERO MEAN STRESS IS NOW POSSIBLE. FAILURE LAW HAS BEEN USED TO CALCULATE EXTENT OF CRACKING FROM THREE NUCLEAR EXPERIMENTS. PRELIMINARY OBSERVATION SUGGESTS THAT CHIMNEY HEIGHT IS RELATED TO CRACK RADIUS. 5 REFS.

14-68-09004 ON PENETRATION OF ROCK BY THREE-DIMENSIONAL INDENTORS
MILLER, M. H. + SIKARSKIE, D. L.
INT J ROCK MECHANICS & MIN SCIENCES, (5) N 5, 375-98, SEPT 5, 1968. EXPERIMENTAL AND THEORETICAL INVESTIGATION WAS UNDERTAKEN OF ROCK-PENETRATING CHARACTERISTICS OF FIVE STATICALLY LOADED, THREE-DIMENSIONAL INDENTORS; TWO CONES, TWO SPHERES AND PYRAMID; TWO ROCK TYPES WERE USED IN STUDY, BARRE GRANITE AND INDIANA LIMESTONE; INDENTORS ARE COMPARED ON BASIS OF FORCES NECESSARY TO PENETRATE TO GIVEN DISTANCE BY CRUSHING, STRESS REQUIRED TO CAUSE CHIPPING, AND AMOUNT OF ENERGY REQUIRED TO FRACTURE UNIT VOLUME OF ROCK; IN ADDITION INDENTOR RESULTS ARE COMPARED TO SOME WEDGE RESULTS OBTAINED UNDER IDENTICAL CONDITIONS. 5 REFS.

14-68-09005 STRENGTH OF ROCK-LIKE MATERIALS
LUNDBORG, N.
INT J ROCK MECHANICS & MIN SCIENCE, (5) N 5, 427-54, SEPT 1968. PAPER DEALS WITH STRENGTH OF ROCK-LIKE MATERIALS UNDER TRIAXIAL STRESS CONDITIONS; MOST COMMON THEORIES OF BRITTLE FRACTURE ARE REVIEWED; SOME METHODS OF TRIAXIAL STRENGTH DETERMINATION ARE DESCRIBED AND RESULTS COMPARED; STRENGTH DEPENDENCE OF LATERAL PRESSURE, PORE PRESSURE AND SIZE OF TEST SAMPLE IS DESCRIBED; SOME STANDARD TESTS ARE SUGGESTED; METHOD FOR DETERMINING SHEAR STRENGTH AT HIGH NORMAL PRESSURE HAS BEEN USED AS MEASURE OF STRENGTH OF NUMBER OF SWEDISH ROCKS AND ORES. 31 REFS.

14-68-09006 TEST OF LAW OF EFFECTIVE STRESS FOR CRYSTALLINE ROCKS OF LOW POROSITY
BRACE, W. F. + MARTIN, R. J.
INT J ROCK MECHANICS & MIN SCIENCE, (5) N 5, 415-26, SEPT 1968. VARIETY OF CRYSTALLINE SILICATE ROCKS OF LOW POROSITY (0.001-0.03) WERE FRACTURED IN TRIAXIAL EXPERIMENTS AT STRAIN RATES FROM ABOUT 10-3 TO 10-8; COMPARISON OF

FRACTURE STRENGTHS AT DIFFERENT PORE PRESSURES PROVIDED TEST OF LAW OF EFFECTIVE STRESS FOR THESE BRITTLE ROCKS. TEST REVEALED THAT LAW HELD FOR THESE ROCKS ONLY WHEN LOADING RATE WAS LESS THAN SOME CRITICAL VALUE WHICH DEPENDED ON PERMEABILITY OF ROCK, VISCOSITY OF PORE FLUID AND SAMPLE GEOMETRY. 18 REFS.

14-68-10001 A RECOMMENDED ROCK CLASSIFICATION FOR ROCK MECHANICS PURPOSES (GEOLOGY EXPLORATION PHYSICAL-PROPERTY)
POTCHING, T. H. + COATES, D. E. & UNIV ALBERTA
CAN MIN & MET BULL, 1195-1197, OCT. 1968. THE SUBCOMMITTEE ON ROCK CLASSIFICATION, CANADIAN ADVISORY COMMITTEE ON ROCK MECHANICS HAS DEVELOPED A USEFUL SYSTEM OF CLASSIFICATION OF ROCKS. THIS CLASSIFICATION IS IN 2 STAGES AND CONTAINS 5 CATEGORIES. I. ROCK SUBSTANCE (1) THE GEOLOGICAL NAME OF THE ROCK. (2) (A.) STRENGTH DRY BASED ON UNIAXIAL COMPRESSIVE LOADING TO FAILURE OF A CYLINDER WITH A L/D RATIO OF APPROXIMATELY 2. THE RANGES ARE: VERY HIGH (32,000 PSI), HIGH (16-32,000 PSI), MEDIUM (8-16,000 PSI), LOW (4-8,000 PSI) AND VERY LOW (4,000 PSI). (3) DEFORMATION - ELASTIC IF THE RELATIVE PERMANENT STRAIN AT THE ULTIMATE COMPRESSIVE LEVEL IS LESS THAN 25% OR IF ROCK SHOWS A CREEP-RATE OF LESS THAN 2 MICRO INCHES PER INCH PER HOUR WHEN LOADED TO HALF OF THE ULTIMATE STRENGTH; IF THESE VALUES ARE EXCEEDED, THE ROCK IS CLASSIFIED YIELDING. II. ROCK MASS: (4) GROSS HOMOGENEITY, MASSIVE OR LAYERED. (5) CONTINUITY OF FORMATION: (A) SOLID IF JOINT SPACING GREATER THAN 6 FT; SLABBY IF 3-IN. TO 6 FT. BUT CLOSER IN ONE DIAMETER THAN ANOTHER; BROKEN IF CLOSER THAN 3 INS. (B) LOOSE OR TIGHT.

14-68-10002 NEW METHOD FOR SAMPLING DIAMOND-DRILL CORE - FILLET-CUTTING
BONSALL, E. + GRAHAM, A. R. + BRUMMER, J. J.
CAN MIN & MET BUL, (61) N 678, 1207-10, OCT 1968. METHOD AND DEVICE ARE DESCRIBED FOR SAMPLING DIAMOND-DRILL CORE BY CUTTING CONTINUOUS FILLET OF CONSTANT CROSS SECTION FROM CYLINDRICAL SURFACE OF CORE THROUGHOUT APPROPRIATE SAMPLE LENGTHS; APPARATUS EMPLOYS TAPERED, ABRASIVE-SET, CUTTING WHEEL, CONICAL CUTTING SURFACE OF WHICH PROJECTS SLIGHTLY INTO RECTANGULAR CORE-GUIDING TROUGH SET PARALLEL TO AXIS OF ROTATION; CUTTINGS WHICH FORM SAMPLE ARE NORMALLY COLLECTED IN TRAY BELOW CUTTING WHEEL AND APPEAR AT ABOUT 80% - 100 MESH; THEY REQUIRE LITTLE OR NO FURTHER TREATMENT OR COMMINUTION BEFORE ANALYSIS.

14-68-10003 RECOMMENDED CLASSIFICATION FOR ROCK MECHANICS PURPOSES
PATCHING, T. H. + COATES, D. F.
CAN MIN & MET BUL, (61) N. 678, 1195-1197, OCT. 1968. SUB-COMMITTEE ON ROCK CLASSIFICATION, CANADIAN ADVISORY COMMITTEE ON ROCK MECHANICS, HAS EVOLVED CLASSIFICATION OF ROCK MECHANICS; CONSIDERED IN TWO STAGES, ACTUAL ROCK SUBSTANCE AND ROCK MASS, FIVE-POINT CLASSIFICATION INVOLVES GEOLOGICAL NAME OF ROCK, ROCK STRENGTH AND ROCK DEFORMATION, AND, IN SECOND STAGE, GROSS HOMOGENEITY OF ROCK MASS AND FORMATION CONTINUITY. 10 REFS.

14-68-10004 DETERMINATION OF PRESSURE ACTING ON FLEXIBLE SUPPORT OF ROCK EXCAVATIONS
NUDNYI, I. P.
PRIKLADNAYA MEKHANIKA, (4) N 10, 113-20, OCT. 1968. PROBLEM IS EXAMINED FOR CASE OF CIRCULAR FLEXIBLE SUPPORT WITH SEVERAL FLEXIBLE JOINT CONNECTIONS, WITH ALLOWANCE FOR CREEP OF OVERBURDEN. STRESS STATE OF PLANE WITH REINFORCED OPENING IS DETERMINED, PLANE BEING ACTED UPON BY BIAXIAL COMPRESSION AND HAVING PROPERTIES OF ELASTOVISCOUS MEDIUM. ACTUAL SUPPORT IS SIMULATED BY RING SEGMENTS JOINED BY SPRINGS OF GIVEN RIGIDITY. THIS MODEL ALLOWS ACCOUNTING FOR EFFECT OF MUTUAL RIGID DISPLACEMENT OF SEGMENTS ON MAGNITUDE OF PRESSURE TAKEN UP BY SUPPORT. (IN RUSSIAN)

14-68-10005 REVIEW OF ROCK MECHANICS APPLICATIONS IN CANADIAN BEDDED DEPOSITS (GROUND-CONTROL)
IGNATIEFF, A.
CAN MIN & MET BUL, (61) N 678, 1180-4, OCT. 1968. PRACTICAL PICTURE OF EFFECTS OF STRESS AND OF STRUCTURAL ENVIRONMENT IN EXTRACTION AREA IN BEDDED DEPOSIT IS DESCRIBED, AND MAIN FACTORS OF GROUND CONTROL WHERE PRINCIPLES OF ROCK MECHANICS CAN BE APPLIED ARE DISCUSSED; MANY OF BEDDED DEPOSITS, SUCH AS COALS AND EVAPORITES, HAVE PRONOUNCED DEFORMATION PROPERTIES, AND THERE ARE LIMITATIONS IN MAKING STRESS MEASUREMENTS WITHIN SHORT DISTANCES OF MINE OPENINGS OR EXTRACTION AREAS; ON OTHER HAND, MEASUREMENT OF MOVEMENT OF HANGING WALL (ROOF) AND FOOTWALL (FLOOR) OF ROADWAYS AND EXTRACTION FACES AS WELL AS SIDES OF PILLARS, PROVIDES MOST USEFUL TOOL IN ASSESSING GROUND STABILITY. 22 REFS.

14-68-11001 STRAIN ROSETTE RELIEF MEASUREMENTS IN HEMISPHERICALLY ENDED BOREHOLES
HOSKINS, E. R.
INT J ROCK MECHANICS & MIN SCIENCES, (5) N 6, 551-9, NOV 1968. FULL-SCALE LABORATORY EXPERIMENTS HAVE BEEN PERFORMED TO DETERMINE EFFECTIVENESS OF STRAIN ROSETTE RELIEF TECHNIQUES IN HEMISPHERICALLY ENDED BOREHOLES; STRAINS MEASURED DURING THESE TESTS AGREE WITH THOSE INFERRED FROM WELL-KNOWN SOLUTION FOR STRESSES SURROUNDING SPHERICAL CAVITY IN ELASTIC MEDIUM; UNDER SPECIFIC CONDITIONS, DISCUSSED IN PAPER, STRAIN RELIEF IN HEMISPHERICALLY ENDED BOREHOLES APPEARS TO BE PROMISING TECHNIQUE FOR MEASURING ROCK STRESS. 16 REFS.

14-68-12001 ENERGY CRITERION FOR STRENGTH OF ROCK IN POLYAXIAL COMPRESSION (ROCK-MECHANICS)
WIEBOLS, G. A. + COOK, N. G. W.
INT J ROCK MECHANICS AND MIN SCIENCE, (5) N 6, 529-549, NOV 1968. IT IS GENERALLY ACCEPTED THAT STRENGTH OF ROCK IS DETERMINED BY PRESENCE OF FLAWS, USUALLY KNOWN AS GRIFFITH CRACKS; HOWEVER, VARIOUS CRITERIA BASED ON THIS AND OTHER CONCEPTS FAIL TO DESCRIBE ADEQUATELY STRENGTH OF ROCK UNDER GENERAL SYSTEM OF POLYAXIAL COMPRESSIVE STRESSES; IN THIS PAPER A NEW CRITERION IS PROPOSED, BASED ON ADDITIONAL ENERGY STORED AROUND GRIFFITH CRACKS DUE TO SLIDING OF CRACK SURFACES OVER EACH OTHER; PREDICTIONS OF STRENGTH BASED ON THIS CONCEPT ARE IN GENERAL AGREEMENT WITH KNOWN BEHAVIOR OF ROCK UNDER UNIAXIAL AND TRIAXIAL STRESS. 14 REFS.

14-68-12002 BRITTLE ROCK FAILURE UNDER TRIAXIAL STRESS
GIARDINI, A. A.
ASME - PAPER 68-WA/PT-3, 4, DEC. 1-5, 1968. EXPERIMENTALLY DETERMINED FAILURE DATA ARE GIVEN FOR NORMAL AND FOR MODERATELY AND SEVERELY PRESHOCKED GRANITIC ROCK UNDER TRIAXIAL COMPRESSIVE STRESS. AT OR NEAR ATMOSPHERIC CONFINING PRESSURE MODE OF FAILURE RANGED FROM BRITTLE SHEAR FOR NORMAL ROCK TO CRUMBLING FOR SEVERELY PRESHOCKED MATERIAL. UNDER CONFINING PRESSURE, FAILURES TYPICALLY WERE BY SINGLE SHEAR SURFACE INCLINED ABOUT 30 DEGREES TO LONGITUDINAL AXIS OF CYLINDRICAL TEST SPECIMEN. NO INDICATION OF PLASTIC DEFORMATION WAS OBSERVED. SLIP MODE OF FAILURE WAS FOUND TO PERSIST AS LONG AS TOTAL BULK COULOMB STRENGTH OF STRESSED MATERIAL REMAINED LESS THAN ITS COULOMB FUNDAMENTAL COHESIVE STRENGTH. 7 REFS.

14-69-01001 MICROSTRUCTURAL TECHNIQUES IN STUDY OF PHYSICAL PROPERTIES OF ROCK (ROCK-MECHANICS)
WILLARD, R. J. + MCWILLIAMS, J. R.
INT J ROCK MECHANICS & MIN SCIENCES, (6) N 1, 1-12, JAN 1969. TECHNIQUES HAVE BEEN DEVELOPED TO FURTHER UNDERSTANDING OF ROCK BEHAVIOR IN TERMS OF ITS MICROSTRUCTURE; TECHNIQUES MEASURE CERTAIN FABRIC PARAMETERS ON ROCK DISKS AND IN THIN SECTIONS WITH PETROGRAPHIC MICROSCOPE FOR CORRELATION WITH PHYSICAL PROPERTY LABORATORY TESTS. THEY INCLUDE DIAMETRIC MINERALOGICAL ANALYSIS, DEFECT ANALYSIS, GRAIN ELONGATION ANALYSIS, MACRO-GRID ANALYSIS. TRANSGRANULAR-INTERGRANULAR ANALYSIS. PULSE VELOCITIES AND BREAKING STRENGTHS IN SAMPLES OF GRANITE AND LIMESTONE ARE COMPARED WITH THEIR FABRIC PROPERTIES OBTAINED THROUGH THESE TECHNIQUES. 21 REFS.

14-69-01002 STATISTICAL THEORY OF BRITTLE FRACTURE FOR ROCK MATERIALS
BRADY, B. T.
INT J ROCK MECHANICS & MIN SCIENCES, (6) N 1, 21-42, JAN. 1969. BRITTLE FAILURE UNDER HOMOGENEOUS AXISYMMETRIC STATES OF STRESS; CRITERION OF BRITTLE FRACTURE IS FORMULATED FOR ROCK MATERIALS DISPLAYING TIGHT PORE STRUCTURE; IT IS ASSUMED THAT TOTAL FRACTURE OCCURS WHEN AVERAGE VALUE OF TOTAL VOLUMETRIC MICROCRACK STRAIN ATTAINS CRITICAL VALUE; RESULTS AND CONCLUSIONS OF ANALYSIS ARE COMPARED WITH EXISTING THEORIES OF BRITTLE FRACTURE. 20 REFS.

14-69-03001 NONLINEAR STRESS-STRAIN RELATIONS FOR HOMOGENEOUS SANDSTONE (POROSITY WETTING)
MORGENSTERN, N. R. + TAMULY PHUKAN, A. L.
INT J ROCK MECHANICS & MIN SCIENCE (6) N 2, 127-142, MAR 2, 1969. TRIAXIAL COMPRESSION TESTS HAVE BEEN CARRIED OUT ON SPECIMENS OF BUNTER SANDSTONE AT CONFINING PRESSURES OF 0, 150, AND 500 PSI; AS IS COMMONLY FOUND WITH POROUS AND CRACKED ROCK WHEN LOADED AT STRESS LEVELS OF INTEREST IN CIVIL ENGINEERING, SPECIMENS DEFORMED IN NONLINEAR MANNER AND DISPLAYED HYSTERESIS ON CYCLIC LOADING AND IRRECOVERABLE STRAIN ON COMPLETE UNLOADING; THESE FEATURES WERE INCREASED BY INCREASE IN POROSITY AND BY WETTING. 15 REFS.

14-69-03002 ELASTIC BEHAVIOR OF SOME INDIAN ROCKS UNDER CONFINED PRESSURE
RAMANA, Y. V.
INT J ROCK MECHANICS & MIN SCIENCES, (6) 191-201, MAR 2, 1969. EXPERIMENT WAS CONDUCTED IN WHICH HYDROSTATIC PRESSURES OF ORDER OF 2 KBARS WERE FOR FIRST TIME ATTAINED IN INDIA AND ULTRASONIC WAVE VELOCITY AND ATTENUATION MEASUREMENTS WERE MADE AT DIFFERENT PRESSURES STARTING FROM ROOM CONDITIONS, IN STUDY OF FIVE INDIAN ROCK TYPES; SAMPLES INVESTIGATED INCLUDED SHALE, GRANITE, QUARTZITE, SERPENTINITE AND SANDSTONE; INVESTIGATIONS COVERED STUDY OF EFFECT OF CYCLICAL LOADING ALSO.

14-69-03003 NONLINEAR MECHANICAL BEHAVIOR OF BRITTLE ROCK-1
BRADY, B. T.
INT J ROCK MECHANICS & MIN SCIENCES, (6) N 2, 211-25, MAR 1969. RESULTS OF THEORETICAL STUDY DESCRIBING LOADING AND UNLOADING STRESS-STRAIN BEHAVIOR DURING REGIONS I AND II OF HOMOGENEOUS BRITTLE ROCK MATERIALS DISPLAYING TIGHT PORE STRUCTURE ARE PRESENTED; IT IS ASSUMED THAT ROCK CAN BE MODELED BY ELASTIC, ISOTROPIC CONTINUUM CONTAINING LARGE NUMBER OF ELLIPSOIDAL CRACKS WHICH ARE COLLECTIVELY CHARACTERIZED BY DISTRIBUTION FUNCTION P (C, BETA, PHI) (C EQUALS CRACK HALF-LENGTH, BETA EQUALS INCLINATION OF MAJOR AXIS TO DIRECTION OF MAXIMUM PRINCIPAL STRESS, AND PHI EQUALS ANGLE BETWEEN PROJECTED CRACK NORMAL AND X2 AXIS); CRACK INTERACTION EFFECTS ARE NEGLECTED IN THIS STUDY. 20 REFS.

14-70-01001 THE INFLUENCE OF ROCK CHARACTERISTICS ON THE STABILITY OF ROCK CAVITIES PART 1 (ROCK-MECHANICS)
LOMBARDI, G. & MINUSIO, SWITZERLAND
TUNNELS AND TUNNELING, (2) NO 1, 19-22, JAN. 1970. THE FIRST OF TWO PART ARTICLE WHICH ATTEMPTS TO PRESENT A REPORT ON THE PRESENT STATE OF KNOWLEDGE IN THE NEW SCIENCE, ROCK MECHANICS. SEE 14-70-03001.

14-70-02001 COMPRESSIVE STRENGTH OF CEMENTED CARBIDE - FAILURE MECHANICS & TESTING METHODS (END-EFFECTS)
LUETH, R. C. & HALE, T. E. & GENERAL ELECTRIC CO
ASTM MATERIALS RESEARCH & STANDARDS, (10) NO. 2, 23-28, FEB 1970. STUDY OF FAILURE MECHANICS OF CYLINDRICAL CEMENTED CARBIDE SPECIMENS LOADED IN COMPRESSION INDICATED THAT FAILURE ORIGINATES IN SPECIMEN END REGIONS DUE TO END FRICTIONAL INTERACTIONS WITH LOADING PLATES. NATURE OF END EFFECTS AND THEIR DETRIMENTAL INFLUENCE UPON MEASURED ULTIMATE COMPRESSION STRENGTH WERE DETERMINED. RESULTS OF TESTS ON SEVEN DIFFERENT GRADES OF CARBOLOY ARE GIVEN. IT IS SHOWN THAT A TRUER ULTIMATE COMPRESSIVE STRENGTH CAN BE OBTAINED BY INTERPOSING THIN SHIMS OF STEEL BETWEEN CEMENTED CARBIDE SPECIMEN AND CEMENTED CARBIDE LOADING PLATES.

14-70-03001 THE INFLUENCE OF ROCK CHARACTERISTICS ON THE STABILITY OF ROCK CAVITIES PART 2 (ROCK-MECHANICS)
LOMBARDI, G. & MINUSIO, SWITZERLAND
TUNNELS AND TUNNELING, (2) NO 2, 104-109, MAR. 1970. THE FORMATION PRESSURE EXERTED ON A TUNNEL LINING IS A FUNCTION OF THE EXISTING STRESS CONDITION IN THE FORMATION, OF ROCK PROPERTIES, OF CONSTRUCTION METHODS, AND OF THE TYPE OF LINING. IN ORDER TO DETERMINE THE FORMATION PRESSURE A KNOWLEDGE OF THESE VALUES IS ESSENTIAL: (1) EXPERIMENTAL DETERMINATION OF STRESS CONDITIONS BEFORE CONSTRUCTION BEGINS, ESP HORIZONTAL AND VERTICAL COMPONENTS; (2) DETERMINATION OF THE STRENGTH OF THE FISSURE SYSTEM, ESP. COHESION AND FRICTION; (3) VOLUME INCREASE DUE TO FAILURE. ALL CASES CAN BE ANALYZED IF THE BASIC PARAMETERS ARE ESTABLISHED AND A MATHEMATICAL FORMULATION IS KNOWN. PART I IS 14-70-01001

FIELD 15 NEWS ITEMS

15-64-08001 PILOT BORE IS LABORATORY FOR TWIN ROAD TUNNELS (INSTRUMENTATION ROCK-MECHANICS STRUCTURAL-SUPPORT)
ENGINEERING NEWS-RECORD, (173) 38-39, AUG 13, 1964. THE COLORADO DEPT. OF HIGHWAYS IS INVESTING OVER $1 MILLION IN A PILOT TUNNEL BENEATH LOVELAND PASS TO ANSWER A NUMBER OF DESIGN QUESTIONS. MID VALLEY INC. OF HOUSTON, TEXAS IS DRIVING A $1.3 MILLION 8,282 FT. LONG 11 FT. 4 IN. WIDE BY 10 FT. 8 IN. HIGH PILOT TUNNEL. TERRAMETRICS DIVISION OF PATRICK HARRISON, INC. OF GOLDEN COLORADO IS DOING $55,000 WORTH OF INSTRUMENTATION.

15-65-01001 ROCK MECHANICS (STRENGTHENING STRESSES TUNNEL BOREHOLE BOLTING GROUTING CUTTINGS ROCKFALL)
CIVIL ENGINEERING AND PUBLIC WORKS REVIEW, JANUARY 1965 DATA SHEETS, REFERENCE NO. 06.03 THRU 06.16, JULY 1965.
HAND NOTED DATA SHEETS CONTAIN TEST METHODS, SOME CALCULATION METHODS, SOME DATA AND DISCUSSIONS COVERING THE FOLLOWING SUBJECT AREAS: GENERAL ROCK MECHANICS, ROCK STRENGTHENING, MEASUREMENT OF "IN SITU" ROCK STRESSES, ROCK PERMEABILITY, PRESSURE TUNNELS IN ROCK, ROCK CUTTINGS, AND ROCK EMBANKMENTS.

15-65-06001 CORE BORING FOR A SUBWAY TUNNEL (GEOLOGY NEW-YORK-CITY)
ENGINEERING NEWS-RECORD, (174) 29, JUNE 10, 1965. RAYMOND CONCRETE PILE DIVISION OF RAYMOND INTERNATIONAL WILL MAKE 22 CORE BORINGS 50 TO 100 FT. APART ALONG THE TRACE OF A PLANNED 2/3 MILES SUBWAY TUNNEL FROM MIDTOWN MANHATTAN TO QUEENS UNDER THE EAST RIVER. THE TUNNEL WILL TAKE SIX YEARS TO BUILD.

15-66-05001 ROCK MECHANICS IN MINE DESIGN THEME OF W.V.U. SYMP (SUPPORT-LOADS STRESSES FRICTION EXCAVATION COAL-PILLARS)
COAL AGE, 100-101, MAY 1966. ROCK MECHANICS APPLICATIONS IN COAL MINE WAS THE THEME OF A SYMP AT MORGANTOWN, W. VA APR 14-15, 1966 UNDER THE SPONSORSHIP OF THE MONONGAHELA VALLEY COAL MINING INSTITUTE IN COOPERATION WITH W. VA UNIV SCHOOL OF MINES. MAJOR TOPICS DISCUSSED WERE MEASUREMENT OF SUPPORT LOADS, DETERMINATION OF STRESSES IN ROCKS AROUND OPENINGS AND FACTORS AFFECTING STRENGTH AND DESIGN OF COAL MINE PILLARS. THIS ARTICLE OUTLINES GENERALLY THE MATERIAL COVERED BY DISCUSSIONS.

15-67-10001 ROCK MECHANICS (BLASTING ROCK-FAILURE ROCK-STRESS)
CHEATHAM, J. B., JR. & RICE UNIV HOUSTON
APPLIED MECHANICS REVIEWS, (20) N 10, 923-927, OCT. 1967. UNDERSTANDING ROCK MECHANICS IS IMPORTANT IN PREVENTING PREMATURE COLLAPSE OF UNDERGROUND EXCAVATION. CURRENTLY NO RELIABLE THEORETICAL METHOD FOR PREDICTING ROCK STRESSES IS AVAILABLE. AN ESTIMATE OF ROCK STRESSES CAN BE OBTAINED BY BOREHOLE GAGE MEASUREMENTS OF A SMALL PILOT HOLE RELIEVED BY OVERCORING OR A SLOT MAY BE CUT INTO A ROCK SURFACE AND THE HYDRAULIC PRESSURE ON A FLAT JACK MEASURED WHEN THE ROCK AROUND THE SLOT HAS BEEN FORCED TO RETURN TO ITS ORIGINAL POSITION. VERY SHORT DURATIONS OF INTENSE LOADING OCCUR IN ROCK SURROUNDING CHEMICAL OR NUCLEAR EXPLOSION. RESEARCH EFFORTS ARE BEING DIRECTED TOWARDS DEVISING APPROPRIATE THEORETICAL METHODS FOR PREDICTING BLASTING RESULTS. MICROSEISMIC DETECTION METHODS CAN PREDICT ROCK BURSTS BUT HAVE THE DISADVANTAGE OF PREDICTING BURSTS THAT DO NOT ACTUALLY OCCUR. FUTURE IMPROVEMENTS IN ROCK MECHANICS PROBLEMS ANALYSIS MUST BE SUPPLEMENTED BY IMPROVED LABORATORY AND FIELD MEASUREMENTS.

15-68-04001 SANDIA CORP DEVELOPS PROJECTILE FOR USE IN SUB-SURFACE EXPLORATION (GEOLOGY MINING TERRADYNAMICS)
ENGINEERING AND MINING JOURNAL, 102, 109, APRIL 1968. A HIGH SPEED PROJECTILE DROPPED FROM AIRCRAFT OR PROPELLED BY ROCKETS IS USED TO MEASURE PENETRATION RESISTANCE OF SOIL AND ROCK TO GIVE GEOLOGIC DATA. THE DECELERATION PROFILE IS MEASURED BY INSTRUMENTS LOCATED IN THE HEAD OF THE PROJECTILE. THE MISSILES IMPACT AT 800 MPH AND HAVE PENETRATED MORE THAN 200 FT.

15-70-01001 CONTRACTOR LICKS TOUGH TUNNEL JOB (ADVANCE JUMBO EXPLOSIVE COST BAD-GROUND)
ENGINEERING NEWS-RECORD, (184) 30-31, JAN 1, 1970. TUNNELLING THROUGH BIG WALKER MOUNTAIN ON I-77 BAD GROUND WAS UNEXPECTEDLY ENCOUNTERED. BECAUSE OF VENTILLATION THE WEST TUNNEL HAS 2 FT 5 IN FLATTER ARCH OVER THE 36 FT SPAN THAN THE EAST TUNNEL. THIS REQUIRED A TOP HEADING TO THE SPRING LINE, SETTING THE ARCH RINGS AND THEN REMOVING ENOUGH MATERIAL TO SET THE PLUMB POSTS ONE AT A TIME. THE TUNNELS ARE 4,229 FT LONG AND THE BAD GROUND WAS ENCOUNTERED AFTER 2,500 FT OF ADVANCE IN THE EAST TUNNEL WHICH WAS 80 FT AHEAD OF WEST TUNNEL ADVANCE. THESE TUNNELS WERE DRIVEN WITH JUMBOS EACH MOUNTING 9 DRIFTERS. TUNNELERS WERE V CUTTING 12 FT. ROUNDS ON A FULL FACE AND USING UP TO 950 LB OF 40 PERCENT GEL PER ROUND. ADVANCE WAS AS GOOD AS 60 FT. A DAY WITH TWO 10 HOUR SHIFTS AND AVERAGE WAS BETTER THAN 30 FT. IT TOOK 5 MONTHS DELAY FOR THE CONTRACTOR, HIGHWAY DEPARTMENT AND TUNNEL DESIGNER TO EVOLVE A BAD GROUND PROCEDURE. THE EAST TUNNEL WAS FIRST DRIVEN THRU THE BAD GROUND BEFORE WORK ON THE WEST TUNNEL WAS RESTARTED. THE EAST TUNNELING THEN PROCEEDED TO THE NORTH PORTAL, TURNED AROUND, AND RETURNED TO THE WEST TUNNEL BAD GROUND BEFORE THE WEST TUNNEL ADVANCED THRU ITS BAD GROUND. $22.6 MILLION WAS THE CONTRACT FOR THE TWO TUNNELS BUT THE BAD GROUND WILL INCREASE THIS.

FIELD 16 COMPANY BROCHURES

16-64-02001 NORAD COMBAT OPERATIONS CENTER (NUCLEAR-WEAPON DETONATION L-SHAPED-TUNNEL MAJOR-JOINT-SYSTEM
PARSONS, BRINKERHOFF, QUADE AND DOUGLAS, (12) N 2, 1-7, 1963-64. A DISCUSSION OF THE DESIGN AND CONSTRUCTION OF THE NORAD COMBAT OPERATIONS CENTER AT COLORADO SPRINGS, COLORADO. MANY PROBLEMS INVOLVING UNORTHODOX DESIGN AND CONSTRUCTION METHODS WERE ENCOUNTERED. THE INSTALLATION WAS BUILT TO PROTECT IT AGAINST ALL EFFECTS OF A CLOSE-IN NUCLEAR WEAPON DETONATION. THE COMMAND CENTER IS TO BE BUILT IN EXCAVATED CHAMBERS WITH AN L-SHAPED TUNNEL AS A MEANS OF ACCESS TO THE SURFACE. MANY DESIGN PROBLEMS WERE CAUSED BY UNEXPECTED AND UNPREDICTABLE ROCK CONDITIONS ENCOUNTERED DURING EXCAVATION. ONE SUCH PROBLEM AROSE WHEN IT WAS OBSERVED THAT CHAMBER EXCAVATION WAS GOING TO RUN PARALLEL TO A MAJOR JOINT SYSTEM. A VERY EXPENSIVE STRUCTURAL COVERING HAD TO BE USED AT ONE OF THE TUNNEL INTERSECTIONS DUE TO VERY POOR ROCK CONDITIONS. THE BUILDINGS HAD TO BE SHOCK MOUNTED WITH A NEWLY DEVELOPED SPRING SYSTEM TO WITHSTAND THE EXPECTED NUCLEAR BLAST EFFECTS. SOME OF THE ELECTRONIC EQUIPMENT HAD TO BE INSULATED TO PROTECT IT FROM THE ELECTROMAGNETIC FIELD CAUSED BY A NUCLEAR BLAST. THE ENVIRONMENT TO WHICH THE NORAD C.O.C. MIGHT BE SUBJECTED DURING A NUCLEAR ATTACK, REQUIRED CAREFUL STUDY OF MANY CONSTRUCTION FEATURES TO ASSURE THAT THE FACILITY WOULD SURVIVE AN ATTACK AND PROPERLY FUNCTION THEREAFTER.

FIELD 19 DISSERTATION

19-67-00001 OBLIQUE INCIDENCE OF PLANE STRESS WAVES ON A CIRCULAR TUNNEL (ROCK-MECHANICS NUMERICAL-SOLUTIONS)
AKBARIAN, M. A. & UNIV ILLINOIS
DISSERTATION FOR PH.D. AT UNIV ILLINOIS, 1967. A METHOD IS PRESENTED FOR COMPUTING STRESSES AND DISPLACEMENTS IN THE VICINITY OF A LONG CYLINDRICAL CAVITY IN AN INFINITE ELASTIC MEDIUM SUBJECTED TO A PLANE DILATATIONAL WAVE TRAVELING OBLIQUELY WITH RESPECT TO THE AXIS OF THE TUNNEL. HOOP, LONGITUDINAL AND SHEAR STRESSES DUE TO A PLANE STEP WAVE OF DILATATION ARE COMPUTED ON THE BOUNDARY OF THE OPENING. THE EFFECTS OF VARIOUS PARAMETERS INVOLVED ARE STUDIED FOR A STEP WAVE. FINALLY, A DUHAMEL INTEGRAL IS USED TO FIND STRESSES DUE TO A REALISTIC TYPE OF WAVE FORM. THE PROBLEM IS TREATED AS A STEADY-STATE CASE. THE STEADY-STATE ASSUMPTION RESTRICTS THE INVESTIGATION TO LONG TUNNELS AND INCIDENT DILATATIONAL WAVES. INCIDENT SHEAR WAVES MAY ALSO BE TREATED FOR A RESTRICTED RANGE OF ANGLE OF INCIDENCE. THE METHOD OF SOLUTION INVOLVES EXPANSION OF THE STRESS FIELD IN FOURIER SERIES AROUND THE CAVITY, WHICH LEADS TO SEPARATE EQUATIONS FOR EACH TERM OF THE SERIES. FOR EACH TERM, THE HYPERBOLIC PARTIAL DIFFERENTIAL EQUATIONS WITH TWO INDEPENDENT VARIABLES ARE SOLVED BY SETTING UP INTEGRAL EQUATIONS FOR THE UNKNOWN POTENTIAL FUNCTIONS. NUMERICAL VALUES OF THE UNKNOWN FUNCTIONS ARE CALCULATED AND FINALLY THE VALUES OF STRESSES AT POINTS ON THE BOUNDARY OR IN THE MEDIUM ARE OBTAINED THE NUMERICAL SOLUTIONS ARE CHECKED IN THE FAR FIELD WITH STATIC VALUES. THEY ALSO AGREE WITH SERIES EXPANSION OF THE POTENTIAL FUNCTIONS AT POINTS CLOSE BEHIND THE WAVE FRONT.

FIELD 2 ROCK DISINTEGRATION METHODS

FIELD 21 BOOKS

21-60-00001 DEEP HOLE DRILLING WITH EXPLOSIVES (ROLLER-CUTTERS DIAMONDS)
OSTROVSKII, A. P.
CONSULTANTS BUREAU ENTERPRISES INC TRANSLATION FROM ORIGINAL PUBLISHED IN MOSCOW, 1960. DRILLING DEEP HOLES IS A COMPLEX PROBLEM AND MAY BE MOST ECONOMICALLY ACCOMPLISHED BY THIS NEW EXPLOSIVE METHOD OF SHATTERING ROCK. THE NEW TREND IN WORLDWIDE APPLICATION OF EXPOLSIVES IN TECHNOLOGY AND THE NATIONAL ECONOMY ARE DISCUSSED. EXPERIMENTAL DATA ON THE EFFECT OF EXPLOSIONS IN SOLID MEDIA ARE PRESENTED. MANY PHENOMENA DISCUSSED STILL AWAIT EXPLANATION BUT THE FACT THAT THESE PHENOMENA HAVE BEEN SUBJECTED TO EXPERIMENTAL STUDY ADDS TO OUR KNOWLEDGE OF A MOST MEAGERLY INVESTIGATED AREA, THAT OF THE SHATTERING EFFECT OF EXPLOSIONS ON SOLID MEDIA. DURING EXPLOSIVE DRILLING, CHARGES OF LIQUID EXPLOSIVE MIXTURE ARE PREPARED AUTOMATICALLY IMMEDIATELY NEXT TO THE HOLE BOTTOM FROM CHEMICAL COMPONENTS THAT ARE NOT EXPLOSIVE IN THEIR INITIAL STATE. THE SHATTERED ROCK IS REMOVED FROM THE HOLE BY FLUSHING. DURING EXPLOSIVE DRILLING THE HOLE DIAMETER MAY BE REGULATED WITHIN BROAD LIMITS PERMITTING DRILLING DEEP OIL AND GAS WELLS OF THE MINIMUM DIAMETER PERMISSIBLE. ROLLER CUTTER BITS, DIAMOND BITS AND EXPLOSIVES ARE NOT MUTUALLY EXCLUSIVE MEANS OF DRILLING AND A CORRECT COMBINATION MAY LEAD TO MORE EFFECTIVE DRILLING.

21-67-03001 THE MODERN TECHNIQUE OF ROCK BLASTING (BURDEN HOLE SPACING CRATERING IGNITION FRAGMENTATION)
LANGEFORS, U. + KIHLSTROM, B. & STOCKHOLM
JOHN WILEY & SONS, INC., MAR 1967. WITHIN SOME THOUSANDTHS OF A SECOND AFTER EXPLOSIVE INITIATION, THE EXPLOSIVE CHEMICAL ENERGY IS LIBERATED AND CAN EXCEED 100,000 ATMOSPHERES. THERE IS AN OUTGOING SHOCK WAVE WHICH GIVES A LATERAL POSITIVE PRESSURE WHEN THE SHOCK WAVE ARRIVES AND THEN FALLS RAPIDLY TO NEGATIVE VALUES. CRACK FORMATION IN BLASTING ONE ROW OR MORE OF DRILL HOLES WILL DEPEND UPON RELATION BETWEEN BURDEN AND DISTANCE BETWEEN HOLES AND ALSO IF IGNITION IS SIMULTANEOUS OR DELAYED. WITH DELAYED IGNITION THROW IS REDUCED BUT FRAGMENTATION IMPROVED. CONTROL TESTS SHOULD BE MADE ON A FULL SCALE BEFORE DECIDING THE FINAL BLASTING PATTERN. THERE MAY STILL BE A POSSIBILITY OF DEVELOPING MORE EFFECTIVE BLASTING METHODS.

21-68-00001 NOVEL DRILLING TECHNIQUES (ROCK-BREAKING WATER-JETS THERMAL-METHODS CHEMICAL-METHODS ELECTRICAL-METHODS PLASMA ELECTRON-BEAM EXPLOSIVE-CAPSULES)
MAURER, W. C. & ESSO PROD RES CO HOUSTON TEX
PERGAMON PRESS, NEW YORK, NY, 114, 1968. ANALYSIS OF BASIC ROCK DESTRUCTION MECHANISMS BY MECHANICALLY, AND THERMALLY INDUCED STRESSES, FUSION AND VAPORIZATION OR CHEMICAL REACTIONS IS MADE AND THEORETICAL CONSIDERATIONS ARE PRESENTED; DESCRIPTION OF ALL KNOWN TYPES OF ROCK DRILLS, BASED ON ABOVE CATEGORIES OF ACTION, IS MADE AND THEIR CHARACTERISTICS AS WELL AS LIMITATIONS OF THEIR APPLICATION ARE DISCUSSED. DRILLING PERFORMANCE DATA IN VARIOUS ROCKS AND TOTAL ENERGY CONSUMPTION ARE TABULATED. 111 REFS.

FIELD 22 SYMPOSIA

22-56-04001 FUNDAMENTAL CONCEPTS OF ROCK FAILURE (ROCK-LOADS STRESS ROCK-MECHANICS)
LIVINGSTON, C. W. & COLO SCHOOL OF MINES GOLDEN COLO

QUARTERLY OF THE COLO SCHOOL OF MINES FIRST SYMP ON ROCK MECHANICS, (51) N 3, 1-11, JULY 1956. AN HYPOTHESIS IS ADVANCED THAT FAILURE OF SOLIDS IS DEPENDENT UPON ENERGY TRANSFER, AND THAT FUNDAMENTALS OF ENERGY TRANSFER DO NOT DIFFER GREATLY FOR SOLIDS, LIQUIDS AND GASES. IT IS PROPOSED THAT FAILURE CRITERIA SHOULD BE INTERPRETED RELATIVE TO MASS, ENERGY, AND TIME OF UNKNOWN PRINCIPLES OF ENERGY. EXPERIMENTS REVEAL THAT IN BLASTING, THE ENERGY OF AN EXPLOSIVE IS PROPORTIONAL TO THE WEIGHT OF THE EXPLOSIVE. AS THE DEPTH OF A CHARGE IS DECREASED AT CONSTANT WEIGHT OR AS THE WEIGHT OF CHARGE IS INCREASED AT CONSTANT DEPTH, RANGES OF BEHAVIOR OF SOLIDS INVOLVE; THE STRAIN ENERGY RANGE REPRESENTED BY THE STRAIN ENERGY EQUATION, THE SHOCK RANGE, THE FRAGMENTATION RANGE, AND THE AIR BLAST RANGE.

22-56-04002 A NOTE CONCERNING THE MECHANISM OF ARTIFICIAL AND NATURAL HYDRAULIC FRACTURE SYSTEMS (HYDROFRAC DRILLING CRACK-ORIENTATION)
ODE, H. & SHELL DEV CO HOUSTON
QUARTERLY OF THE COLO SCHOOL OF MINES FIRST SYMP ON ROCK MECHANICS, (51) N 3, 21-29, JULY 1956. A DISCUSSION OF THE ORIENTATION OF THE CRACKS IN THE FORMATION DUE TO HYDRAULIC PRESSURE. WHAT HAPPENS AROUND A WELL BORE MAY BE DUPLICATED ON A MUCH LARGER SCALE AROUND VOLCANIC PLUGS. MEASUREMENTS OF PRESSURE WHICH SHOW THAT THE PRESSURE AT WHICH THE FLUID DISAPPEARS INTO THE FORMATION IS IN MANY CASES LOWER THAN THE OVERBURDEN PRESSURE, WERE MADE IN THE STUDY OF THREE PHENOMENA KNOWN BEFORE THE ADVENT OF THE VARIOUS FRACTURE TECHNIQUES: PRESSURE BREAKTHROUGH, LOST CIRCULATION, AND SQUEEZE-CEMENTING. THERE ARE TWO WAYS IN WHICH A SEPARATION INTO TWO OR MORE PARTS OF A MATERIAL CAN BE ACHIEVED, BY CLEAVAGE OR BY SHEAR. MECHANISMS OF EACH ARE DISCUSSED.

22-56-04003 HORIZONTAL SUPPORT OF MINE OPENINGS (ROCK-MECHANICS STRESS-PATTERNS)
VAN POOLLEN, H. K. & COLO SCHOOL OF MINES GOLDEN COLO
QUARTERLY OF THE COLO SCHOOL OF MINES FIRST SYMP ON ROCK MECHANICS, (51) N. 3, 101-122, JULY 1956. IMPORTANCE OF HORIZONTAL SUPPORT OF MINE OPENINGS IS EMPHASIZED. THIS WAS THE CONCLUSION OF A PHOTOELASTIC INVESTIGATION, WHICH WAS PERFORMED AT THE COLO SCHOOL OF MINES DURING 1954-1955. THE PRIMARY PURPOSE OF THE PHOTOELASTIC INVESTIGATION WAS TO DETERMINE THE RELATION BETWEEN STRESSES AROUND UNDERGROUND MINE OPENINGS AND THE FAILURE RESULTING THEREFROM. MODELS WERE MADE OF 1/4 IN PLATES OF COLUMBIA RESIN CR-39. THE OPENINGS STUDIED WERE: A RECTANGULAR, HORIZONTAL OPENING WITH SHARP CORNERS; A CIRCULAR OPENING; AND A TRIANGULAR OPENING. FROM THE STRESS PATTERNS OBTAINED, THE EXTENT OF FAILURE WAS CALCULATED FOR FOUR DIFFERENT MATERIAL CONDITIONS: CASE I - ZERO TENSILE STRENGTH AND INFINITE SHEAR STRENGTH, CASE II - ZERO TENSILE STRENGTH AND 1600 PSI SHEAR STRENGTH, CASE III - ZERO TENSILE STRENGTH AND 1200 PSI SHEAR STRENGTH, AND CASE IV - ZERO TENSILE STRENGTH AND 800 PSI SHEAR STRENGTH. EACH MODEL WAS SUBJECTED TO A VERTICAL LOAD, AND THE STRESS PATTERN RECORDED. FROM THE STRESS PATTERN THE CRITICAL STRESSES WERE OBTAINED. THIS PROCEDURE WAS REPEATED FOR A SERIES OF MODELS THUS INDICATING THE EXTENT OF FAILURE. IT WAS THUS CONCLUDED THAT HORIZONTAL SUPPORT IS AS IMPORTANT OR MORE IMPORTANT THAN, VERTICAL SUPPORT.

22-56-04004 FUNDAMENTAL CONSIDERATIONS IN BLOCK CAVING
BUCKY, P. B. & COLUMBIA UNIV
QUARTERLY OF THE COLO SCHOOL OF MINES FIRST SYMP ON ROCK MECHANICS, (51) N 3, 129-143, JULY 1956. BLOCK CAVING USES GRAVITATIONAL FORCES TO STRESS PARTS OF THE FORMATION TO PRODUCE FRAGMENTS OF A SIZE SUITABLE FOR HANDLING AND TO TRANSPORT IT ECONOMICALLY TO THE BASE OF A SHAFT. IMPORTANT ADVANCES DEVELOPED AT CLIMAX, DELETED THE TRANSFER RAISES, INTRODUCED THE IDEA OF BLASTING BOULDERS ON A SOLID (SLUSHER) DRIFT BOTTOM, AND USED THE DRIFT FOR THE OPERATION OF A SLUSHER WHICH IS ABLE TO TRANSPORT AND LOAD LARGE PARTICLES INTO CARS ON A LOWERED HAULAGEWAY. IN ADDITION THE IDEA OF CONCRETE SUPPORTED DRIFTS AND FINGERS INCREASES THE CROSS SECTIONAL DIMENSIONS OF BOTH. TWO DIAMETRICALLY OPPOSED PROBLEMS IN BLOCK CAVE MINING ARE; THAT OF DESIGNING A PROCEDURE WHEREBY THE EARTH FORCES SHALL FRAGMENT OR CAUSE AN OREBODY TO FAIL, AND THAT OF DESIGNING A SERIES OF OPENINGS IN THE SAME OREBODY WHICH SHALL CONVEY THE ORE AND ALLOW MEN AND LARGE EQUIPMENT TO WORK EFFICIENTLY, COMFORTABLY, AND SAFELY. THE ABILITY OF A BLOCK TO CAVE OR FRAGMENT IS A FUNCTION OF ITS STRENGTH IN TENSION SHEAR AND THE VALUE OF OF THE FORCES THAT ACT THEREON WHICH ARE MAINLY COMPRESSIVE. DETAILS OF THE BLOCK CAVING PROCEDURES AND THE THEORETICAL CALCULATIONS UPON WHICH THEY ARE BASED ARE PRESENTED FOR THE JEFFREY OREBODY OF THE JOHNS MANVILLE CO AT ASBESTOS, QUEBEC.

22-56-04005 BASIC PERFORMANCE PROPERTIES OF BLASTING EXPLOSIVES (ROCK-MECHANICS)
BROWN, F. W. & U.S. BUR MINES
QUARTERLY OF THE COLO SCHOOL OF MINES FIRST SYMP ON ROCK MECHANICS, (51) N 3, 171-188, JULY 1956. AN INVESTIGATION OF THE CONDITIONS WITHIN THE EXPLODING CHARGE IN A BLASTING OPERATION. THE IMPORTANT EFFECTS OF AN EXPLODING CHARGE ON A MEDIUM ARE THOSE DUE TO SHOCK AND EXPANSION OF THE BUBBLE OF DETONATION GASES. THE SHOCK EFFECTS FOR LARGE CONFINED CHARGES ARE LARGELY DETERMINED BY THE DETONATION PRESSURE, WHILE SUCH EFFECTS FOR SMALLER UNCONFINED CHARGES DEPEND ON THE IMPULSE. EXPANSION EFFECTS DEPEND ON THE ENERGY CONTENT OF THE EXPLOSION GASES AND THE LAW GOVERNING THEIR EXPANSION. METHODS OF COMPUTING DETONATION VELOCITY, PRESSURE AND ENERGY AND EXPANSION PROPERTIES OF THE GASES ARE OUTLINED AND CALCULATIONS FOR SEVERAL EXPLOSIVES ARE PRESENTED. THE DEVIATIONS FROM IDEAL DETONATION ARE CONSIDERED IN SOME DETAIL. A TENTATIVE DISCUSSION OF ACOUSTIC IMPEDANCE AND ITS IMPORTANCE IS PRESENTED. MOST OF THE CURRENT METHODS OF MEASURING PERFORMANCE AND DETONATION PROPERTIES ARE DISCUSSED. 20 REFS.

22-56-04006 FRAGMENTATION OF ROCK THROUGH BLASTING
HINO, K.
QUARTERLY OF THE COLO SCHOOL OF MINES FIRST SYMP ON ROCK MECHANICS, (51) N 3, 191-209, JULY 1956. THE SHOCK-WAVE THEORY OF ROCK FAILURE IN BLASTING HAS BEEN EARLIER PROPOSED AND IS NOW USED TO FURTHER DEFINE THE GEOMETRY OF CRATER FORMATION. THE FUNDAMENTAL PRINCIPLE OF THE THEORY HOLDS THAT MAJOR ROCK FAILURE IS CAUSED BY REFLECTION IN TENSION OF THE PRIMARY SHOCK WAVE. MATHEMATICAL EXPRESSIONS FOR THE INTENSITY OF THE SHOCK WAVE AT ANY DISTANCE FROM A CHARGE, THE RELATION OF ROCK STRENGTH TO THE PRESSURE INTENSITY OF THE SHOCK WAVE, AND THE RELATION BETWEEN WEIGHT OF CHARGE TO DEPTH OF OVERBURDEN HAVE BEEN DERIVED PREVIOUSLY. EXPERIMENTAL WORK DESCRIBED HAS NOW PERMITTED THE EXTENSION OF THE THEORY TO DESCRIBE MORE FULLY THE SHAPES AND INTENSITIES OF THE SHOCK WAVE IN DIFFERENT ROCKS USING DIFFERENT EXPLOSIVES. BLASTABILITY COEFFICIENT, THE RATIO OF THE COMPRESSIVE AND TENSILE STRENGTHS OF ROCK IS PROPOSED AS CONTROLLING THE MAXIMUM NUMBER OF SLABS FORMED IN A BLAST. THE DISTANCE OF THROW OF FRAGMENTS IN BLASTING IS SHOWN TO BE A FUNCTION OF THE SHAPE OF THE SHOCK WAVE. 14 REFS.

22-56-04007 BLASTING EXPERIENCE IN GRANITE ROCK (ROCK-BREAKING)
NOREN, C. H. & DUPONT EASTERN LABS
QUARTERLY OF THE COLO SCHOOL OF MINES FIRST SYMP ON ROCK MECHANICS, (51) N. 3, 213-225, APRIL 1956. DESCRIPTION OF TESTS MADE AT THE DU PONT EXPERIMENTAL TUNNEL, POMPTON LAKES N.J. THE INVESTIGATIONS DESCRIBED WERE CARRIED OUT TO DETERMINE THE EFFECT OF THE AMOUNT OF BURDEN ON ROCK MOVEMENT OPPOSITE A BOREHOLE OF CONSTANT SIZE (1 1/2 IN DIA) WITH A CONSTANT (1 1/4 IN DIA) POWDER CHARGE. THE DATA WERE THEN USED TO DERIVE FORCE-DISTANCE CURVES FOR THE EXPLOSIVE TESTED. DATA INDICATES THAT AT A CONSTANT EXPLOSIVE LOAD, THE TIME REQUIRED FOR INITIAL MOVEMENT OF THE ROCK IS NORMALLY APPROXIMATELY PROPORTIONAL TO THE BURDEN AND THAT THE TERMINAL VELOCITY OF THE ROCK IS NORMALLY INVERSELY PROPORTIONAL TO THE SQUARE ROOT OF THE ROCK WEIGHT. INDICATIONS ARE THAT FURTHER REFINEMENTS IN INSTRUMENTATION MAY NOT BE WARRANTED IN THE STUDY OF ROCK MOVEMENT BECAUSE OF THE EFFECT OF PHYSICAL CHARACTERISTICS OF NORMAL ROCK ON ROCK BREAKAGE. IN NORMAL BLASTING, FRACTURE PLANES, BEDDING PLANES, AND UNBURDENING BY ADJACENT HOLES WILL BE VERY IMPORTANT FACTORS THAT INFLUENCE THE RESULTANT ROCK MOVEMENT. 6 REFS.

22-58-00001 NEW IDEAS AND TECHNIQUES IN DRILLING AND BLASTING (ROTARY-DRILLING FLAME-JET VIBRATORY-DRILLING)
ANTONIDES, L. E.
PROC OF THE 8TH ANNUAL DRILLING AND BLASTING SYMP, 100-112, 1958. THE ROTARY DRILLING SYSTEM HAS PROVED MORE CONDUCIVE TO COARSE CHIP FORMATION AND HENCE IS MORE EFFICIENT. THE "NO-CUT" OR "CONCENTRATED EXPLOSIVE" DRIFT ROUND DEVELOPED BY HINO IN JAPAN IS A RADICAL ONE. THE RESULTING CRATER IS CLAIMED TO REQUIRE FEWER HOLES, NEED LESS EXPLOSIVE AND GIVE DEEPER PULL THAN OTHER ROUNDS. THE FAST ROTARY-PERCUSSION DRIFTER HAS NOT BEEN RAPIDLY

ACCEPTED; HIGH THRUST AND HIGH AIR CONSUMPTION ARE COMPLAINTS. THE POCKET CHURN DRILL MIGHT OFFER SOME ADVANTAGES UNDERGROUND FOR LARGE VERTICAL HOLES. THE SIMPLICITY AND LOW POWER CONSUMPTION ARE ASSETS. FLAME-JET PIERCING CONTINUES TO GAIN ADVOCATES IN HIGHLY ABRASIVE SILICA-BEARING AND NEPHELINE-BEARING ROCKS. IT IS THE ONLY BLAST-HOLE DRILLING SCHEME IN USE THAT DOES NOT EMPLOY THE CONTACT OF A MECHANICAL ELEMENT TO BREAK ROCK. AUGERS ARE OF NOTE; THEY REQUIRE NO FLUSHING MEDIUM. SONIC VIBRATION IS AN INTERESTING FUTURE POSSIBILITY. AT THE DRILL-BIT'S CUTTING EDGE AND GAGING SURFACE THERE IS ALWAYS NEED FOR HARDER MATERIAL. CURRENT WORK IS DONE ON CERAMIC-METALLIC MATERIALS; ALSO INTERESTING IS BORON NITRIDE. THE TUNGSTEN CARBIDE INSERTED ROLLER-CONE BIT HAS SHOWN MUCH SUCCESS IN HARD ROCKS, ESPECIALLY TACONITE. IN SWEDEN, KIRUNA'S "IMATREX" - A CAST CYLINDER OF POTASSIUM CHLORATE SOAKED IN KEROSENE - IS A LOCALLY COMPOUNDED EXPLOSIVE DRAWING ATTENTION FOR ITS LACK OF TOXIC FUMES, HIGH DENSITY, ITS NONDETERIORATING QUALITY AND ITS INSENSITIVITY TO TEMPERATURE.

22-59-07001 BLASTING PRACTICE IN SHAFT SINKING AND TUNNELING (DRILLING ROCK-BREAKAGE)
FISH, B. G. + WESTWARTER, R. & NATIONAL COAL BOARD ENGLAND
PROC OF THE SYMP ON SHAFT SINKING AND TUNNELING, 421-438, JULY 1959 (THE INSTITUTION OF MINING ENGINEERS, 1960). DISCUSSION OF BRITISH METHODS IN THE BLASTING OF SHAFTS AND TUNNELS, WITH EMPHASIS ON COAL MINING. ALL ASPECTS OF BLASTING METHODS ARE DESCRIBED, INCLUDING TYPES OF EXPLOSIVES AND SHOTFIRING TECHNIQUES. PARALLEL ELECTRIC SHOTFIRING IS BECOMING POPULAR. IN TUNNEL BLASTING, SHORT WEDGE OR BURN CUT ROUNDS ARE EFFICIENT IN SMALL TUNNELS, WHERE AIR-LEG MOUNTED PERCUSSIVE DRILLS ARE USED, AND LONG BURN CUT ROUNDS ARE PREFERRED IN LARGER TUNNELS, WHERE DRILLING CARRIAGES ARE USED. ALTHOUGH BRITISH MINES ARE VERY STRICT, HIGH RATES OF ADVANCE ARE MADE IN BOTH SHAFT AND TUNNEL DRIVING. SEVERAL MAJOR TUNNELS REPORT ADVANCES OF 50-60 YD PER WEEK, WITH ONE INSTANCE OF 75 YDS DRIVEN IN ONE WEEK.

22-59-07002 STUDIES OF THE ENERGY REQUIREMENTS FOR CRUSHING (ROCK-MECHANICS ROCK-FAILURE RESEARCH)
ZELENY, R. + PIRET, E. L. & MICH STATE UNIV
QUARTERLY OF THE COLO SCHOOL OF MINES THIRD SYMP ON ROCK MECHANICS, (54) 33-42, JULY 1959. THE WORK "INPUT - NEW AREA-SURFACE ENERGY - HEAT PRODUCED" RELATIONSHIPS IN THE CRUSHING OF SINGLE AND MULTIPLE PARTICLES OF GLASS AND QUARTZ IN SIMPLE DEVICES WERE PRESENTED. IT WAS SHOWN THAT APPRECIABLE QUANTITIES OF ENERGY COULD BE LOST TO PLASTIC DEFORMATION OF THE CRUSHING DEVICE. FUTURE INVESTIGATIONS COULD WELL BE POINTED TOWARD A STUDY OF THE TRANSITION OF THE WORK INPUT TO THE FINAL ENERGY FORMS AND A STUDY OF THE ENERGY LOSS TO PLASTIC DEFORMATION OF METAL CRUSHER SURFACES. 8 REFS.

22-59-07003 THE ROLE OF STRESS WAVES IN COMMINUTION (ROCK-MECHANICS ROCK-FAILURE RESEARCH-STUDIES)
RINEHART, J. S. & COLO SCHOOL OF MINES GOLDEN COLO
QUARTERLY OF THE COLO SCHOOL OF MINES THIRD SYMP ON ROCK MECHANICS, (54) 61-76, JULY 1959. A SERIES OF TESTS SHOW THE INFLUENCE OF STRESS WAVES AS A RESULT OF ROCK BLASTS. THESE TESTS RESOLVE INTO THE GEOMETRICAL PROBLEM OF TRACING THE PEREGRINATIONS OF THESE DISTURBANCES THROUGH THE ROCK SPECIMEN OF INTEREST, WITH RESPECT TO MUTUAL INTERACTION OF INCIDENT AND REFLECTED STRESS 2 WAVES. RESULTS SUGGEST THAT COMMINUATION MAY TO A LARGE MEASURE BE CONTROLLED BY THE INTERFERENCES OF STRESS WAVES.

22-59-07004 THE WORK INDEX IN BLASTING (ROCK-MECHANICS ROCK-FAILURE RESEARCH)
BOND, F. C. + WHITNEY, B. B. & ALLIS-CHALMERS MFG CO
QUARTERLY OF THE COLO SCHOOL OF MINES THIRD SYMP ON ROCK MECHANICS, (54) 77-82, JULY 1959. AN EVALUATION OF WORK INDEX FOR VARIOUS BLASTING TECHNIQUES. THREE CAREFULLY CONTROLLED BLASTS IN STOPES WERE MADE IN THE UNDERGROUND CHRISTMAS MINE OF THE INSPIRATION COPPER CO IN ARIZ. COMPLETE SIZE ANALYSES EXTENDING DOWN TO 3/4 IN WERE MADE ON THE ENTIRE LOTS OF BROKEN ROCK. THE HOLES WERE 1.5 IN DIA SPACED 3 FT APART AND 6 TO 10 FT DEEP WITH EIGHT OR NINE HOLES PER BLAST. THIRD THEORY PLOTS OF THE SIZE DISTRIBUTION OF THE THREE BLAST PRODUCTS ARE GIVEN. THESE TESTS REVEALED THAT THE THIRD THEORY WORK INDEX CAN BE APPLIED TO BLASTING AS WELL AS TO CRUSHING AND GRINDING. 4 REFS.

22-59-07005 PROPAGATION OF PEAK STRAIN AND STRAIN ENERGY FOR EXPLOSION-GENERATED STRAIN PULSES IN ROCK (ROCK-MECHANICS ROCK-FAILURE RESEARCH-STUDIES)
FOGELSON, D. E. + ATCHISON, T. C. + DUVALL, W. I. & U.S. BUR MINES COLLEGE PARK MD
QUARTERLY OF COLO SCHOOL OF MINES THIRD SYMP ON ROCK MECHANICS, (54) 274-279, JULY 1959. THE RESULTS OF A SERIES OF LINEAR ARRAY STRAIN TESTS ARRANGED BY THE BUR OF MINES DESIGNED TO DETERMINE THE STRAIN PRODUCING ABILITIES OF SIX EXPLOSIVES WHEN DETONATED IN A GRANITE GNEISS. BOTH PEAK STRAIN AND STRAIN ENERGY WERE FOUND TO PROPAGATE THROUGH THE ROCK ACCORDING TO AN EXPONENTIAL DECAY LAW. THE AMOUNT OF STRAIN PRODUCED IN THE ROCK BY THE EXPLOSIVES WAS FOUND TO CORRELATE WITH THE CALCULATED DETONATION PRESSURE. THE AMOUNT OF STRAIN ENERGY TRANSFERRED TO THE ROCK, DIVIDED BY THE CALCULATED ENERGY OF THE EXPLOSIVE, WAS FOUND TO CORRELATE WITH THE CHARACTERISTIC IMPEDANCE OF THE EXPLOSIVE. FIVE TO NINE PERCENT OF THE TOTAL ENERGY RELEASED BY THE EXPLOSIVE WAS TRANSFERRED TO THE ROCK AS STRAIN ENERGY.

22-59-07006 COMPARISON OF GRIFFITHS THEORY WITH MOHR'S FAILURE CRITERIA (FAILURE-THEORY ROCK-MECHANICS RESEARCH STUDIES)
CLAUSING, D. P. & INGERSOLL-RAND CO
QUARTERLY OF THE COLO SCHOOL OF MINES THIRD SYMP ON ROCK MECHANICS, (54) 285-297, JULY 1967. GRIFFITH'S CRACK PROPAGATION THEORY AND MOHR'S THEORY ARE MATHEMATICALLY RELATED. EXPERIMENTAL DATA QUALITATIVELY STRONGLY SUPPORTS GRIFFITH'S CONCEPT OF FAILURE. GRIFFITH'S CRITERIA CAN BE PLOTTED AS A MOHR'S ENVELOPE, AND ALL OF THE MATHEMATICAL RELATIONSHIPS ASSOCIATED WITH MOHR'S ENVELOPE ARE VALID. HOWEVER, GRIFFITH'S THEORY AND EXPERIMENT REFUTE MOHR'S CONCEPT OF FAILURE. 5 REFS.

22-59-07007 RECENT EUROPEAN RESEARCH WORK IN EXPLOSIVES (BLAST-THEORIES RESEARCH)
JOHENSSON, C. H. & PHYS RES DEPT OF NITROGLYCERIN
QUARTERLY OF THE COLO SCHOOL OF MINES THIRD SYMP ON ROCK MECHANICS (54) 299-303, JULY 1959. VARIOUS EUROPEAN WORKS INDICATE THE NATURE AND CHARACTERISTICS OF EXPLOSIVES ARE RELATED. THIS SUMMARY IS DIVIDED INTO THREE MAJOR SECTIONS; CONGRESSES, MONOGRAPHS, AND INVESTIGATIONS. THE LAST SECTION IS FURTHER SUBDIVIDED INTO 5 SECTIONS; INITIATION BY HEAT, IMPACT OR SHOCK, DETONATION CONDITIONS, PERMITTED EXPLOSIVES, NEW EXPLOSIVES, AND CHARGING OF EXPLOSIVES.

22-59-07008 MINERAL RESOURCE DEVELOPMENT BY USE OF NUCLEAR EXPLOSIONS (NUCLEAR-BLASTS RESEARCH STUDIES BLASTING-METHODS)
JOHNSON, G. W. & LRL LIVERMORE CAL
QUARTERLY OF THE COLO SCHOOL OF MINES THIRD SYMP ON ROCK MECHANICS, (54) 321-330, JULY 1959. THE RESULTS OF NUCLEAR EXPLOSIVES THAT ARE PRESENTLY AVAILABLE AND HOW THEY MIGHT BE EMPLOYED TO PROBLEMS OF MINERAL EXPLOITATION ARE DISCUSSED. TEST EXPLOSIONS EXTENDING FROM A FEW TENS OF TONS TO A FEW MILLIONS OF TONS OF EQUIVALENT TNT ENERGY RELEASE HAVE BEEN CONDUCTED IN THE AIR, ON THE SURFACE, AND UNDERGROUND. INDICATIONS ARE THAT EXCAVATION CAN BE ACCOMPLISHED AT ABOUT 100,000 CU-YDS/KT, AND THAT THE AIR BLAST, RADIOACTIVITY AND FLASH EFFECTS CAN BE CONTROLLED. THE THEORY OF EXPLOSION SEQUENCE IS BRIEFLY DISCUSSED, WITH REFS TO 4 TIME PHASES OF PHENOMENA; NUCLEAR PHASE, HYDRO-DYNAMIC, QUASI-STATIC, AND LONG-TERM. A DESCRIPTION OF THE MOUNT RAINIER TEST BLAST IS GIVEN. VARIOUS APPLICATIONS FOR NUCLEAR EXCAVATION ARE GIVEN SUCH AS, RECOVERY OF OIL FROM OIL SHALES, LOW GRADE ORE BREAKAGE, AND EXTRACTION OF OIL FROM THE ATHABASCA TAR SANDS. 20 REFS.

22-59-07009 EXCAVATION WITH NUCLEAR EXPLOSIVES (BLASTING METHODS RESEARCH STUDIES)
HARRISON, M. A. + KELLER, H. B. & UNIV CAL LIVERMORE
QUARTERLY OF THE COLO SCHOOL OF MINES THIRD SYMP ON ROCK MECHANICS, (54) 336-345, JULY 1959. THE APPLICATION OF NUCLEAR EXPLOSIVES TO LARGE SCALE EXCAVATION PROJECTS IS DISCUSSED. CRATERING IS SUGGESTED AS A POSSIBLE MEANS OF EXCAVATION. FROM DATA GATHERED FROM VARIOUS TESTS IT HAS BEEN CONCLUDED THAT CRATER DIA. IS PROPORTIONAL TO THE CUBE ROOT OF ENERGY RELEASE AND THAT THE DEPTH OF THE CRATER IS PROPORTIONAL TO THE FOURTH ROOT AT HIGH YIELDS. THE PROBLEM

OF FALLOUT AND ENERGY BLAST WAVES ARE DISCUSSED WITH DEEP UNDERGROUND PLACEMENTS GIVEN AS A POSSIBLE SATISFYING SOLUTION. THE FIRST SERIOUS LARGE SCALE NUCLEAR EXCAVATION, THE CHARIOT PROJECT UNDER THE PLOWSHARE PROGRAM IS DISCUSSED. TOTAL COST FOR THESE TYPE PROGRAMS IS EXTIMATED AT $3.5 MILLION, WITH COST PER CU-YD OF EXCAVATED MATERIAL AROUND 55 CENTS. NUCLEAR EXCAVATION IS DETERMINED VERY PRACTICAL.

22-62-05001 ESTIMATING DRILLABILITY IN LABORATORY (ROCK BREAKING)
ROLLOW, A. G. & HUGHES TOOL CO HOUSTON TEX
FIFTH SYMP ON ROCK MECHANICS, MINN. UNIV. SCHOOL OF MINES AND METALLURGY, 93-102, MAY 1962. HUGHES TOOL CO. HAS DEVELOPED AND USED FOR SEVERAL YEARS A LABORATORY TEST TO PREDICT THE DRILLABILITY OF ROCK FORMATIONS FROM RELATIVELY SMALL SAMPLES USING A 1 1/4 INCH MICROBIT. TESTS HAVE PROVEN TO BE FAIRLY ACCURATE WHEN COMPARED WITH FIELD CONDITIONS.

22-62-05002 DEVELOPMENT AND APPLICATION OF AMMONIUM NITRATE - FUEL OIL BLASTING AGENTS TO UNDERGROUND MINING (AN-FO MIXED-EXPLOSIVES INITIATION)
COOLEY, C. M.
FIFTH SYMP ON ROCK MECHANICS, MINN. UNIV. SCHOOL OF MINES AND METALLURGY, 393-398, MAY 1962. THE USE OF AN-FO IN UNDERGROUND BLASTING REQUIRES THAT MORE CONSIDERATION BE GIVEN TO THE PREPARATION OF THE PRODUCT THAN IN OPEN-PIT WORK. THIS IS PRIMARILY BECAUSE OF THE EFFECT FUEL DISTRIBUTION HAS UPON PRODUCTION OF TOXIC FUMES FROM DETONATION. OXIDES OF NITROGEN PRODUCED BY AN-FO MIXTURES INCREASE RAPIDLY AS THE FUEL OIL CONTENT DROPS BELOW STOICHIOMETRIC. AN-FO SHOULD BE MECHANICALLY MIXED TO ASSURE A UNIFORM AND ACCURATE MIXTURE. PRIMING SHOULD BE WITH 100 PERCENT DYNAMITE SO AS TO ASSURE PROPER INITIATION. THE PRIMER SHOULD BE PLACED FIRMLY AND TIGHTLY AGAINST THE CHARGE. STATIC ELECTRICITY IS A COMMON OCCURRENCE IN CONVEYING EQUIPMENT, PARTICULARLY PNEUMATIC SYSTEMS. THE GENERATION OF A STATIC CHARGE ITSELF IS NOT THE BASIC HAZARD, BUT RATHER THE ACCUMULATION OF THE CHARGE IN SUFFICIENT QUANTITIES TO CAUSE A SIGNIFICANT DISCHARGE TO A LOWER POTENTIAL THROUGH THE CAP WIRES.

22-62-05003 RECENT DEVELOPMENTS OF SLURRY EXPLOSIVES UNDERGROUND (COSTS)
BAILEY, D. T. + CLAY, R. B. + COOK, M. A. & PACK, D. H. & INTERMOUNTAIN RES AND ENGR CO
FIFTH SYMP ON ROCK MECHANICS, MINN. UNIV. SCHOOL OF MINES & METALLURGY, 399-405, MAY 1962. CENTENNIAL DEVELOPMENT CO. HAS BEEN USING "DBA-3" (A COMPOSITION B/AN/WATER SLURRY) SINCE 1961. ADVANTAGES, DISADVANTAGES, AND IMPROVEMENTS IN USE OF THE SLURRY ARE DISCUSSED. THE TWO PRINCIPAL DISADVANTAGES OF COMPOSITION B SLURRY WERE: NEED FOR BOOSTER, AND NEED FOR PNEUMATIC MACHINE FOR LOADING HOLES. THE ADVANTAGES WERE: HIGHER LOADING DENSITY; LOWER SENSITIVITY TO BURNING AND DETONATION BY SHOCK; HIGHER DETONATION PRESSURE; LOWER HANDLING TOXICITY; AND LOWER COST. EXPLOSIVE SLURRIES TEND TO BE INSENSITIVE TO SHOCK. RELIABLE BOOSTERING REQUIRES A HIGH BRISANCE EXPLOSIVE; THE COST IS MINOR. THE MAJOR PROBLEM IS TO DEVELOP LOW COST PACKAGING TECHNIQUES. DBA-6 WAS DEVELOPED FOR USE IN BREAKING HANGUPS IN FINGER RAISES FOR BLOCK CAVING OPERATIONS AND FOR SECONDARY BLASTING WITHOUT BLOCKHOLDING OR MUDCAPPING.

22-62-05004 ELECTRIC DISINTEGRATION DRILLING (ELECTRIC-ARC ROCK-DRILLS)
SARAPUU, E. & ELECTROFRAC CORP KC MO
FIFTH SYMP ON ROCK MECHANICS, MINN UNIV SCHOOL OF MINES AND METALLURGY, 173-83, MAY 1962. THE ELECTRIC ARC DRILLING IDEA HAS BEEN ADVANCED BY DRILLING RESEARCH, INC. THIS DRILLING DEVICE CONSISTS OF TWO ELECTRODES SPACED APPROXIMATELY 1 IN APART. IN THIS CASE, ELECTRIC ARC SUBSTITUTES FOR COMBUSTION AS THE ENERGY SOURCE. ELECTRIC ARC DRILLING MIGHT BE COMPARED WITH JET PIERCING DRILLING. THE IDEA ADVANCED AND TESTED BY ELECTROFRAC CORPORATION USING THE HIGH CURRENT DENSITY EFFECT OF GROUND ELECTRODE (ELECTRIC DRILL BIT) IS DIFFERENT FROM THE ABOVE DESCRIBED METHODS. THE HIGH TEMPERATURE CREATED BY ELECTRIC CURRENT FLOW COMBINED WITH CHEMICAL DECOMPOSITION AND PHYSICAL FRACTURING OF MINERAL AGGREGATES DISINTEGRATES THE ROCK UNDER THE DRILL BIT. THE DIFFERENTIAL IN THERMAL STRESSES IS INCREASED BY THE SUDDEN COOLING EFFECT OF THE ELECTRICALLY HEATED ZONE. DRILLING FLUID (AIR) HAS BEEN USED AS A COOLING MEDIUM. IN ROTATING THE ELECTRIC DRILL BIT, IT HAS BEEN POSSIBLE TO DEVELOP AN OSCILLATING HEATING AND COOLING CYCLE AND REGULATE IT WITH THE ROTATION AND ELECTRIC LOAD TO OBTAIN MAXIMUM PENETRATION RATES. EXPERIMENTS TO DRILL CONCRETE BLOCKS AND TACONITE HAVE BEEN CONDUCTED IN THE LABORATORY WITH A 10 KVA A.C. TRANSFORMER. THE DATA OF PENETRATION RATES IN DRILLING CONCRETE AT VARIABLE ELECTRIC LOADS WITH 1 AND 2 IN. DRILL BITS IS AVAILABLE. THE MAXIMUM RATE OF DRILLING HAS BEEN 126.3 FT/HR WITH 10.1 KW LOAD. FIELD EXPERIMENTS HAVE BEEN PERFORMED WITH A REICHDRILL, MANUFACTURED BY THE REICHDRILL DIVISION OF CHICAGO PNEUMATIC TOOL COMPANY. SHALLOW DRILLING OF TOP SOIL AND LIMESTONE HAS BEEN ACCOMPLISHED WITH ELECTRIC DRILLING. ELECTRIC POWER EQUIPMENT CAPABLE OF DELIVERING UP TO 1200 KVA HAS BEEN AVAILABLE. IN DRILLING 4 7/8 IN. HOLES, UP TO 150 KVA LOAD HAS BEEN USED.

22-63-00001 HYDRAULIC COAL MINING IN THE UNITED STATES
PALOWITCH, E. R. & U.S. BUR MINES PITTSBURGH PA
INT CONFERENCE ON RAPID ADVANCE OF WORKINGS IN COAL MINES, 361-7, 1963. EXPERIMENTAL WORK WAS CONDUCTED IN COAL MINES IN PENNSYLVANIA AND WASHINGTON. FLAT LYING PITTSBURGH COALBED WAS MINED HYDRAULICALLY FROM SOLID FACE AT RATE OF ABOUT 1.6 TONS/MIN USING 3.8 IN. DIAMETER TAPERED NOZZLE (340 GPM AT 4000 PSI), PILLARS IN PITCHING ROSLYN NO. 5 COALBED WAS MINED HYDRAULICALLY FROM SOLID FACE AT AVERAGE RATE OF 0.74 TON/MIN. USING 0.50 IN. DIAMETER NOZZLE (38.5 GPM AT 3500 PSI), PRODUCTIVITY WAS 50 PERCENT HIGHER THAN THAT ACHIEVED BY CONVENTIONAL METHODS, TAPERED NOZZLES WERE SUPERIOR TO ANY OF NOZZLES TESTED. CUTTING RATE INCREASED DIRECTLY WITH JET TRAVERSING SPEED, INVERSELY WITH DISTANCE FROM JET TO FACE.

22-63-00002 HYDRAULIC MINING OF ANTHRACITE
BUCH, J. W. & U.S. BUR MINES ANTH RES CENTER
INT CONFERENCE ON RAPID ADVANCE OF WORKINGS IN COAL MINES, 368-77, 1963. EXPERIMENTAL STUDY WAS CONDUCTED AT PENNSYLVANIA MINE. HYDRAULIC JUMBO WAS DESIGNED FOR THICK COALBED (10 FT 6 INCHES TO 15 FEET) AND FOR PITCHES OF 0 TO 20 DEGREES. CHARACTERISTICS OF H-P PUMP WERE SET AT 4000 PSI AND 300 GPM. FLOW OF H-P WATER IS CONTROLLED BY FACE OPERATOR WITHOUT STOPPING PUMP. MINING-OUT RATE EXCEEDED 1 TON/MIN FOR RELATIVELY EXTENSIVE PERIODS. HOWEVER, OVERALL MINING-OUT RATE FOR 7400 TONS OF MATERIAL MINED IS 0.800 TON/MIN. NET POWER REQUIREMENT IS 14.125 KWH/TON.

22-64-00001 THE EXPERIENCE OF OLD BEN COAL CORPORATION WITH GOODMAN CONTINUOUS MINING MACHINES
MCDANIEL, O. D., JR. & OLD BEN COAL CORP
COAL MINING INSTITUTE OF AMERICA PROCEEDING OF 78TH, 54-62, 1964. DETAILED DISCRIPTION OF THE INSTALLATION TESTING AND THE CHARACTERISTICS OF THE GOODMAN MINERS INSTALLED IN OLD BEN MINES SINCE 1954.

22-65-01001 DRILLING WITH EXPLOSIVES (SHAPED-CHARGE GAUGING-CHARGE PRIMACORD DETONATION)
ROBINSON, L. H., JR. & ESSO PROD RES CO HOUSTON TEX
UNIV TEX SECOND CONF ON DRILLING ROCK MECHANICS, PAPER NO. SPE 1001, 3-9, JAN 1965. A PROPOSED DRILLING METHOD UTILIZES SEQUENTIAL DETONATION OF TWO EXPLOSIVE CHARGE TYPES DELIVERED TO THE HOLE BY CONVENTIONAL DRILLING FLUID THROUGH PIPE. FIRST, A SHAPED CHARGE PRODUCES A LONG THIN HOLE. THEN A GAUGING CHARGE PUMPED INTO THIS HOLE EXPLODES AND ENLARGES IT TO FULL GAUGE. ONE CONFIGURATION IS TO CONTAIN THE EXPLOSIVE IN FOUR TO FIVE FT LONG CYLINDRICAL CAPSULES. UPON PUMPING A CAPSULE TO THE BOTTOM PRESSURE INSIDE THE DRILL PIPE INCREASES AND DIFFERENTIAL PRESSURE DETONATES THE EXPLOSIVE. PRIMACORD DISINTEGRATES THE CAPSULE. DRILLING FLUID CIRCULATES DEBRIS OUT OF THE HOLE. EXPERIMENTS WERE CONDUCTED IN BEREA SANDSTONE AND CALAVERAS, METAMORPHIC LIMESTONE. IN THE SANDSTONE 190 GRAMS OF ROCK WERE REMOVED FOR EACH GRAM OF EXPLOSIVE DETONATED. IN THE LIMESTONE EXTENSIVE FRACTURING PREVENTED A VOLUME ESTIMATE. SEE ALSO 12-65-06010.

22-65-06001 FRAGMENTATION IN ROCK BLASTING (ROCK-MECHANICS DISINTEGRATION-THEORY)
LANGEFORS, U. & SWEDISH DETONIC RES FOUND

PENN STATE UNIV VII SYMP ON ROCK MECHANICS, (1) 1-21, JUNE 1965. THE FACTORS WHICH DETERMINE ROCK FRAGMENTATION ARE THE QUALITY OF THE ROCK, SPECIFIC CHARGE, DISTRIBUTION OF THE CHARGE, BURDEN, SPACING, DRILLING AND IGNITION PATTERN, AND THE DEVIATION IN DRILLING. EXPERIMENTS WERE CARRIED OUT IN PERSPEX LUCITE PLATES 25 MM THICK WITH 1.5 MM DIA. HOLES AND CHARGE Q=100 MG/HOLE. EXPERIMENTS WERE CARRIED OUT IN MATERIAL WITH AND WITHOUT CRACKS, MULTIPLE-ROW ROUNDS IN HOLES STRAIGHT AND ALTERNATE, AND WITH INSTANTANEOUS AND DELAYED IGNITION. COLLISION EFFECTS WERE NOT STUDIED. IT WAS CONCLUDED THAT DELAY IGNITION IS SUPERIOR TO INSTANTANEOUS, BOULDER SIZE INCREASES WITH INCREASED SPACING, AND ALTERNATING ROWS WITH DELAY IGNITION GIVE THE BEST RESULTS. BY EXPRESSING THE LIMIT CHARGE AS A FUNCTION OF THE BURDEN THE SIZE OF THE LARGEST BOULDERS CAN BE THEORETICALLY CALCULATED. DIAGRAMS DESCRIBE THE EXPERIMENTAL RESULTS IN DETAIL. 1 REF.

22-65-06002 THEORETICAL CONSIDERATIONS AND PRACTICAL APPLICATIONS OF SMOOTHWALL BLASTING (MINING-METHODS TECHNIQUES)
SMITH, A. F. + BARNETT, R. M. & CLIMAX MOLYBDENUM CO CLIMAX COLO
PENN STATE UNIV VII SYMP ON ROCK MECHANICS, (1) 68-58, JUNE 1965. WITH PROPER PROCEDURES, NOT ONLY IS THE OVERBREAK REDUCED BY SMOOTHWALL BLASTING, BUT GROUND SUPPORT COSTS ARE LESS, BARRING TIME IS REDUCED, MUCKING TIME IS SHORTENED, AND A SAFER WORKING SPACE IS PROVIDED. IF THE GROUND WILL NOT SUPPORT ITSELF, SMOOTHWALL BLASTING WILL NOT ELIMINATE THE NEED FOR SUPPORT, BUT WILL REDUCE THE AMOUNT OF SUPPORT ORDINARILY REQUIRED. WITH THE USE OF THE LIVINGSTON CRATER THEORY, DESIGNING ROUNDS AND SMOOTHWALL BLASTS HAVE BEEN ATTEMPTED AT THE CLIMAX MINES. ALTHOUGH GROUND CONDITIONS AND ROCK VARY, IT IS BELIEVED THIS THEORY, WHEN TEMPERED WITH PRACTICAL EXPERIENCES CAN BE USED AS A BASIS FOR ROUND DESIGN. 12 REFS.

22-65-06003 A PRELIMINARY THEORY OF STATIC PENETRATION BY A RIGID WEDGE INTO A BRITTLE MATERIAL (ROCK-DISINTEGRATION-THEORY ROCK-MECHANICS)
PAUL, B. + SIKARSKIE, D. L. & INGERSOLL-RAND CO
PENN STATE UNIV VII SYMP ON ROCK MECHANICS, (1) 119-148, JUNE 1965. A THEORY IS PRESENTED FOR THE STATIC PENETRATION OF A SINGLE RIGID WEDGE INTO A BRITTLE MATERIAL. THE MATERIAL CONSIDERED IS ONE WHICH EXHIBITS BOTH CRUSHING AND CHIPPING PHASES IN THE PENETRATION PROCESS. IF THE WEDGE ANGLE AND THREE PARAMETERS ARE SPECIFIED, THE THEORY PREDICTS FORCES AND ASSOCIATED PENETRATIONS DURING BOTH THE CRUSHING AND CHIPPING PHASES. FOR CERTAIN RANGES OF THE PARAMETERS, AGREEMENT WITH THE LIMITED EXPERIMENTAL DATA IS PROMISING EXCEPT FOR THE INITIAL PHASE OF THE PENETRATION PROCESS WHERE REFINEMENTS ON THE THEORY ARE REQUIRED. THE PROPOSED THEORY ALSO PREDICTS THAT FOR CERTAIN VALUES OF THE WEDGE ANGLE AND OTHER KNOWN PARAMETERS, THE CHIPPING PROCESS DOES NOT OCCUR AND PENETRATION IS DUE ENTIRELY TO CRUSHING. IT WAS FOUND THAT FOR THE VELOCITIES ENCOUNTERED IN PERCUSSION DRILLING A STATIC ANALYSIS ADEQUATELY DESCRIBES THE PENETRATION PROCESS. VARIOUS SECTIONS DISCUSS THE MATHEMATICAL MODEL AND THE ANALYSIS ITSELF, THE VOLUME OF ROCK REMOVED WITH CORRESPONDING ENERGIES DETERMINED, COMPARISON OF THE THEORETICAL RESULTS WITH SOME LIMITED EXPERIMENTAL DATA GIVEN BY REICHMUTH ON CHARCOAL GREY GRANITE. DISCREPANCIES WITH EXPERIMENTAL RESULTS ARE POINTED OUT AND ANALYZED, AND CONCLUSIONS DRAWN.

22-65-06004 INELASTIC DEFORMATION OF ROCK UNDER A HEMISPHERICAL DRILL BIT (DISINTEGRATION-THEORY ROCK-MECHANICS)
PAONE, J. + TANDANAND, S. & U.S. BUR MINES TWIN CITIES
PENN STATE UNIV VII SYMP ON ROCK MECHANICS, (1) 149-174, JUNE 1965. A STUDY OF THE BEHAVIOR OF ROCK AT THE INITIAL STATE OF CRATER FORMATION RESULTING FROM STRESSES CREATED UNDER A DRILL BIT WAS MADE TO DETERMINE RELEVANT PARAMETERS RELATED TO MECHANICAL PROPERTIES OF ROCK IN ROCK FRAGMENTATION BY DRILLING. MAX. YIELD STRENGTH OR HARDNESS OF ROCK IS APPARENTLY A PARAMETER OF DRILLABILITY OF ROCK. THE STRENGTHS OF ROCK WERE CONSIDERED FROM THE MOHR-COULOMB CRITERION FROM WHICH THE SURFACE OF FAILURE WAS CONSTRUCTED. THE RESULTS FROM PREVIOUS TRIAXIAL TESTS ON SOLENHOFEN LIMESTONE WERE ADOPTED IN ESTABLISHING A LIMIT OF FAILURE. INELASTIC BEHAVIOR OF SOLENHOFEN LIMESTONE WAS OBSERVED UNDER A LOW VELOCITY IMPACT OF A HEMISPHERICAL BIT AND UNDER STATIC INDENTATION WITH A SIMILAR BIT. PERMANENT SET AT LOW APPLIED LOADS IN THE INDENTED AREA WAS DISCERNIBLE WITH THE AID OF AN INTERFEROMETRIC TECHNIQUE. A QUANTITATIVE DETERMINATION OF STRENGTHS OF THE ROCK WAS MADE UNDER STATIC INDENTATION. THE MAXIMUM YIELD STRENGTH ESTIMATED FROM THE AVERAGE STRESS AT FULL PLASTIC DEFORMATION OVER THE CONTACT AREA WAS SUGGESTED AS THE CRUSHING STRENGTH OF ROCK UNDER A DRILL BIT. 20 REFS.

22-65-06005 INDEXING ANALYSIS FOR PLASTIC ROCK (ROCK-MECHANICS GEOLOGY METHODS THEORY)
CHEATHAM, J. B., JR. & RICE UNIV HOUSTON
PENN STATE UNIV VII SYMP ON ROCK MECHANICS, (1) 175-186, JUNE 1965. DISCUSSION OF APPLICATION OF PLASTICITY THEORY TO THE ANALYSIS OF INDEXING FOR PLASTIC ROCK. A METHOD IS INDICATED FOR COMPUTING THE DEPENDENCE OF CHIP SIZE AND SHAPE AS WELL AS FORCE ON THE TOOTH FOR VARIOUS TOOTH SHAPES AS A FUNCTION OF CRATER CONFIGURATION AND DISTANCE TO THE PREVIOUS CRATER. PRESSURE ON THE TOOTH IS FOUND TO VARY WITH DEPTH OF PENETRATION AFTER A CRITICAL DEPTH HAS BEEN REACHED. DAMP SAND MODEL EXPERIMENTS INDICATE THAT SIMPLE SOLUTIONS USING LINEAR AND LOGARITHMIC SPIRAL SLIP-LINE FIELDS FOR COULOMB PLASTIC MATERIALS GIVE REASONABLE APPROXIMATIONS TO THE FAILURE PATTERNS. BOTH IDEALIZED ROLLER CONE BITS AND FIXED BLADE OR DRAG BITS ARE CONSIDERED, AND METHODS ARE PRESENTED FOR APPROXIMATING THE FORCE ON THE BIT AND THE CHIP VOLUME WHEN THE ROCK IS SUBJECTED TO SUFFICIENTLY HIGH PRESSURE TO BEHAVE PLASTICALLY. DISCONTINUOUS STRESS FIELDS ARE PROPOSED FOR DRAG BIT DRILLING BASED UPON THE SOIL MECHANICS ANALYSIS OF SHIELDS. 12 REFS.

22-65-06006 THE DEVELOPMENT OF A ROCK DRILLABILITY INDEX (ROCK-MECHANICS)
WHITE, C. G. & COLO SCHOOL OF MINES GOLDEN COLO
PENN STATE UNIV VII SYMP ON ROCK MECHANICS, (1) 187-204, JUNE 1965. A SYSTEM IS PROPOSED FOR DETERMINING THE DRILLABILITY INDEX OF A ROCK TYPE THAT COVERS THE COMPLETE RANGE OF ROCK TYPES AND INCLUDES THE THREE MAJOR DRILLING SYSTEMS, ROTARY, PERCUSSIVE, AND ROTARY-PERCUSSIVE. AN ABRASIVE INDEX OF A ROCK TYPE BASED ON THE 3 MAJOR DRILLING SYSTEMS IS ALSO PROPOSED. THE TEST MACHINE EMPLOYS A HYDRAULIC PISTON FOR VARIABLE THRUST, A HYDRAULIC GEAR SYSTEM FOR VARIED ROTATIONAL SPEED, AND A STANDARD GARDNER-DENVER CH3A MODEL CHIPPING HAMMER. TESTS INDICATE THAT THERE IS NO DIRECT RELATIONSHIP BETWEEN DRILLABILITY AND THE SCHMIDT HAMMER VALUE OR THE SHORE SCLEROSCOPE HARDNESS NUMBER.

22-65-06007 DYNAMIC FRACTURE STRENGTHS OF ROCKS (ROCK-MECHANICS DISINTEGRATION-THEORY)
RINEHART, J. S. & COLO SCHOOL OF MINES GOLDEN COLO
PENN STATE UNIV VII SYMP ON ROCK MECHANICS, (1) 205-208, JUNE 1965. A SERIES OF EXPERIMENTS WERE PERFORMED IN WHICH THE DYNAMIC FRACTURE STRENGTHS OF SEVERAL ROCKS WERE MEASURED. THE RESULTS OBTAINED ARE COMPARED WITH STATIC TENSILE STRENGTH DATA ON THE SAME ROCKS. ROCKS HAVING A WIDE RANGE OF MECHANICAL PROPERTIES WERE SELECTED FOR THE EXPERIMENTS; BEDFORD LIMESTONE, YULE MARBLE, MEASUREMENTS BEING MADE BOTH PARALLEL AND PERPENDICULAR TO BEDDING, PINK GRANITE, AND TACONITE. THE EXPERIMENTAL METHOD INVOLVED THE RINEHART PELLET TECHNIQUE. THE RESULTS INDICATE THAT UNDER IMPULSIVE LOADS SUCH AS ARE GENERATED BY HIGH-SPEED IMPACTS AND EXPLOSIONS, THE FRACTURE STRENGTH OF ROCKS IS MANY TIMES, IN THE CASE OF TACONITE, NEARLY 13, THAT OF ITS RESPECTIVE STATIC FRACTURE STRENGTH. 5 REFS.

22-65-12001 BIT-TOOTH PENETRATION UNDER SIMULATED BOREHOLE CONDITIONS (DEEP-WELL-DRILLING)
MAURER, W. C. & ESSO PROD RES CO HOUSTON TEX
JOURNAL OF PETROLEUM TECHNOLOGY, 1433-1442, DEC 1965. A STUDY OF BIT-TOOTH PENETRATION, OR CRATER FORMATION, UNDER SIMULATED BOREHOLE CONDITIONS WAS MADE. PRESSURE CONDITIONS EXISTING WHEN DRILLING WITH AIR, WATER, AND MUD HAVE BEEN SIMULATED FOR DEPTHS OF 0 TO 20,000 FT. THESE CRATER TESTS SHOWED THAT A THRESHOLD BIT-TOOTH FORCE MUST BE EXCEEDED BEFORE A CRATER IS FORMED. THIS THRESHOLD FORCE INCREASED WITH BOTH TOOTH DULLNESS AND DIFFERENTIAL PRESSURE BETWEEN THE BOREHOLE AND FORMATION FLUIDS. AT LOW DIFFERENTIAL PRESSURES, THE CRATERS FORMED IN A BRITTLE MANNER AND THE CUTTINGS WERE EASILY REMOVED. AT HIGH DIFFERENTIAL PRESSURES, THE CUTTINGS WERE FIRMLY HELD IN THE CRATERS AND THE CRATERS WERE FORMED BY A PSEUDOPLASTIC MECHANISM. WITH CONSTANT FORCE OF 6,500 LB APPLIED TO THE BIT TEETH, AN INCREASE IN DIFFERENTIAL PRESSURE (SIMULATED MUD DRILLING) FROM 0 TO 5,000 PSI REDUCED THE CRATER VOLUMES BY 90 PERCENT. A COMPARABLE INCREASE IN HYDROSTATIC FLUID PRESSURE (SIMULATED WATER DRILLING) PRODUCED ONLY A 50 PERCENT

DECREASE IN VOLUME WHILE CHANGES IN OVERBURDEN PRESSURE (SIMULATED AIR DRILLING) HAD NO DETECTABLE EFFECT ON CRATER VOLUME. CRATER TESTS IN UNCONSOLIDATED SAND SUBJECTED TO DIFFERENTIAL PRESSURE SHOWED THAT HIGH FRICTION WAS PRESENT IN THE SAND AT HIGH PRESSURES. SIMILAR FRICTION BETWEEN THE CUTTINGS IN CRATERS PRODUCES THE TRANSITION FROM BRITTLE TO PSEUDOPLASTIC CRATERS.

22-66-06001 DETERMINATION OF STRESS IN ROCK - A STATE-OF-THE-ART REPORT (ROCK-MECHANICS STRESS-ANALYSIS STRAIN-MEASUREMENT STRESS-RELIEF BOREHOLE-DEFORMATION FLATJACKS IN-SITU-ROCK-STRESSES)
OBERT, L. & U.S. BUR MINES DENVER COLO
SYMPOSIUM PRESENTED AT MEETING OF ASTM ATLANTIC CITY, N.J., JUNE 26-JULY 1, 1966. VARIOUS PROCEDURES AND ASSOCIATED INSTRUMENTATION THAT HAVE BEEN USED TO MEASURE THE ABSOLUTE OR CHANGE IN STRAIN, DEFORMATION, AND STRESS IN ROCK ARE REVIEWED. THE MERITS, LIMITATIONS, AND UNDESIRABLE FEATURES IN EACH PROCEDURE ARE DISCUSSED. THE RESULTS OF A NUMBER OF IN SITU INVESTIGATIONS IN VARIOUS ROCK TYPES ARE PRESENTED, TOGETHER WITH AN APPRAISAL OF THE STATE OF STRESS THAT GENERALLY EXISTS AROUND UNDERGROUND OPENINGS IN VARIOUS TYPES OF ROCK. THE REPORT GIVES RECOMMENDATIONS FOR SPECIFYING THE PERFORMANCE AND CHARACTERISTICS OF THIS CLASS OF EQUIPMENT. (THIS SAME PAPER WAS PUBLISHED BY ASTM - SEE 14-67-00002)

22-66-09001 COMMINUTION
CHEATHAM, J. B., JR.
PROC INT SOC OF ROCK MECHANICS 1ST CONGRESS, LISBON, (3) 385-423, SEPT 25-OCT 1, 1966. STATE-OF-ART ON INVESTIGATIONS OF COMMINUTION OF ROCKS WITH PARTICULAR EMPHASIS ON PHYSICAL PHASES OF COMMINUTION, BREAKING, DRILLING, BLASTING, CRUSHING, GRINDING AND ABRASION, DISCUSSED IN 11 PAPERS, SUBMITTED TO ABOVE CONGRESS AND AUTHORS' OWN ANALYSIS; WRITTEN AND ORAL CONTRIBUTIONS BY CONGRESS MEMBERS ARE INCLUDED. 12 REFS. PART ARE ABSTRACTED SEPARATELY. SEE 22-66-10001.

22-66-10001 ELECTROMAGNETIC-THERMAL CRUSHING OF ROCKS (DRILLS EXOTIC-DRILLING)
MATTHAEI, H. W.
PROC INT SOC OF ROCK MECHANICS 1ST CONGRESS, LISBON, (2) 87-91, OCT. 1966. AN ELECTROMAGNETIC METHOD OF CRUSHING ROCK HAS BEEN DEVELOPED AS A SUBSTITUTE FOR MECHANICAL ROCK DRILLS IN ABRASIVE ROCKS. ROCKS ABSORB ELECTROMAGNETIC ENERGY FROM THE FIELD AND CONVERT IT TO BEAT WHICH LEADS TO THERMAL STRESS WHICH BREAKS THE ROCK. (IN GERMAN)

22-66-10002 PLASTIC LIMIT ANALYSIS APPLIED TO SIMPLIFIED DRILLING PROBLEM (CHIP-FORMATION)
CHEATHAM, J. B., JR. + PITMAN, R. W.
PROC INT SOC OF ROCK MECHANICS 1ST CONGRESS, LISBON, (2) 93-7, OCT. 1966. PROBLEM OF ROCK FAILURE DURING DRILLING IS IDEALIZED TO REQUIRE ONLY CALCULATION OF UPPER AND LOWER BOUNDS FOR CHIP FORMATION FORCE AND APPROXIMATION FOR RESULTING CHIP SIZE AND SHAPE WHEN HORIZONTAL ROCK SURFACE IS LOADED BY RIGID FLAT-PUNCH NEAR TWO-DIMENSIONAL CRATER; IT IS POSTULATED THAT CHIP SIZE AND SHAPE ARE APPROXIMATED BY THAT VELOCITY FIELD WHICH REQUIRES LEAST POWER OF DISSIPATION; THIS METHOD IS ALSO USED TO PREDICT CRITICAL INDEXING DISTANCE BEYOND WHICH CHIPPING OCCURS TO HORIZONTAL SURFACE RATHER THAN TO SURFACE OF ADJACENT CRATER.

22-66-10003 ROCK PENETRATION AT OBLIQUE INCIDENCE BY YAWED BIT TOOTH (DRILLING)
BERRY, P. M.
PROC INT SOC OF ROCK MECHANICS 1ST CONGRESS, LISBON, (2) 115-18, OCT. 1966. IDEALIZING ROCK TO BE PLASTIC, TWO DIMENSIONAL PLANE STRAIN PROBLEM OF INDENTATION BY RIGID YAWED WEDGE AT OBLIQUE INCIDENCE IS SOLVED USING HILL-TYPE SOLUTION; YIELD IS GOVERNED BY MOHR COULOMB CRITERIA; THEORY TAKES INTO ACCOUNT LIP FORMED AROUND TOOTH DURING INDENTATION AND PREDICTS WEDGE-SHAPED CAP OF DEAD ROCK UNDER BIT TOOTH FOR SUFFICIENTLY LARGE WEDGE ANGLES AND SUFFICIENTLY LARGE COEFFICIENT OF FRICTION.

22-66-10004 EXPERIMENTAL STUDY OF INDEXED SINGLE BIT-TOOTH PENETRATION INTO DRY ROCK AT CONFINING PRESSURES OF 0 TO 7500 PSI (DRILLING)
GNIRK, P. F.
PROC INT SOC OF ROCK MECHANICS 1ST CONGRESS, LISBON, (2) 121-9, OCT. 1966. EXPERIMENTAL CONSIDERATION IS GIVEN TO MECHANISM OF ROCK FAILURE AND CHIP GENERATION ASSOCIATED WITH PENETRATION OF SINGLE SHARP, WEDGE-SHAPED BIT-TOOTH INTO ROCK SURFACE AT PRESCRIBED DISTANCE, KNOWN AS INDEXING DISTANCE FROM PREVIOUS PENETRATION CRATER; RESULTS SHOW THAT PHYSICAL MODE OF CHIP GENERATION IS STRONGLY INFLUENCED BY MAGNITUDE OF FLUID CONFINING PRESSURE AND FAILURE STRENGTH OF ROCK; EXPERIMENTAL DATA OBTAINED AT CONFINING PRESSURES ABOVE 1000 TO 3000 PSI COMPARE FAVORABLY WITH PREVIOUS THEORETICAL RESULTS FOR SINGLE BIT-TOOTH PENETRATION IN DUCTILE ROCK.

22-67-00001 BASIC THEORIES OF DEFLECTION IN DIAMOND DRILLING
GAUTHIER, G.
SCI & TECH OF INDUSTRIAL DIAMONDS PROC INT. INDUSTRIAL DIAMONDS CONF. OXFORD 1966, (2) 135-41, 1967. LATERALLY STABLE AND ISOTROPIC TOOL WILL DEFLECT ON COMPACT ANISOTROPIC GROUND WHILE TRANSITION FROM SOFT TO HARD GROUND TENDS TO BRING TOGETHER DRILLING AXIS AND PERPENDICULAR TO LAYERS; ALL OTHER THINGS BEING EQUAL, LATERALLY UNSTABLE TOOL HAS, OF COURSE, MUCH GREATER TENDENCY TO DEVIATE THAN LATERALLY STABLE TOOL AND STILL MORE SO, IF ITS INDEX OF LATERAL INSTABILITY IS HIGH ONE; UNLIKE CASE OF ROCK-BITS OF CONVENTIONAL TYPE, IT IS IMPOSSIBLE TO ESTABLISH GENERAL THEORY FOR DIAMOND TOOLS APPLICABLE TO DEVIATION IN DRILLING.

22-67-01001 OPTIMUM BLASTING
MACKENZIE, A. & UNIV MINN MINNEAPOLIS MINN
SCHOOL MIN & MET ENG - MIN SYMP. 28TH, 181-8, JAN. 16-18, 1967. OPTIMUM BLASTING IS DEFINED AS THAT BLASTING PRACTICE WHICH GIVES DEGREE OF FRAGMENTATION NECESSARY TO OBTAIN LOWEST UNIT COST OF COMBINED OPERATIONS OF DRILLING, BLASTING, LOADING, HAULING, AND CRUSHING; PAPER DISCUSSES METHOD OF EVALUATING OPTIMUM BLASTING AND PRESENTS OPERATING DATA TO ILLUSTRATE ITS USE AND EFFECTIVENESS; PARTICULAR MENTION IS MADE OF THOSE ITEMS WHICH HAVE BEEN MOST IMPORTANT TO QUEBEC CARTIER MINING CO.

22-67-01002 FIELD CONDITIONS AND THEIR RELATIONSHIPS TO BLASTING DESIGN
ASH, R. L.
MINN. UNIV. SCH MIN & MET ENG - MIN SYMP, 28TH, 189-96, JAN. 16-18, 1967. PAPER DISCUSSES BASIC FIELD VARIABLES AND THEIR RELATIONSHIP TO OPEN-CUT BENCH BLASTING. MOST OF THE SIGNIFICANT FACTORS, IMPORTANT TO DESIGN, INCLUDE BENCH GEOMETRY, MATERIAL'S PROPERTIES, EQUIPMENT OPERATING SPECIFICATIONS, AND EXPLOSIVE'S INITIATION AND ENERGY RELEASE CHARACTERISTICS; EFFECTS OF THOSE FACTORS ON SELECTION OF APPROPRIATE BLAST DESIGN ARE DESCRIBED.

22-67-01003 VALUE OF THEORY IN BLASTING DESIGN
STARFIELD, A. M.
MINN. UNIV. SCH MIN & MET ENG - MIN SYMP, 28TH, 197-202, JAN. 16-18, 1967. THEORY AND PRACTICE OF CRATERING IS EXAMINED AND ITS APPLICATION TO LONG EXPLOSIVE CHARGES USED IN BENCH BLASTING IS CRITIZED; RELATIVE ROLES OF STRAIN WAVE AND GAS PRESSURE IN ROCK BREAKAGE ARE DISCUSSED AND IT IS SUGGESTED HOW COMPUTER MODEL MIGHT ULTIMATELY BE USED FOR COMPARING DIFFERENT DESIGNS IN BRITTLE ROCK; EXAMPLES ARE GIVEN OF COMPUTED RESULTS FOR DRILL-HOLE LOADED AND INITIATED IN NUMBER OF DIFFERENT WAYS AND WITH DIFFERENT TYPES OF EXPLOSIVES.

22-67-07001 RESEARCH IN IMPROVED METHODS OF ROCK BREAKAGE (NEW-DRILLING-METHODS)
GELLER, L. B. & CANADA DEPT ENERGY OTTAWA CANADA
INSTITUTION OF MINING AND METALLURGY, JULY 1967. THE AMOUNT OF SPECIFIC ENERGY WHICH A ROCK MASS CAN BE FORCED TO ACCEPT DETERMINES THE VOLUME OF BROKEN ROCK. TWO MAJOR METHODS FOR BREAKING ROCK ARE MECHANICAL AND THERMAL. MORE RESEARCH IS NEEDED TO DEVELOP ECONOMICAL EQUIPMENT FOR BETTER ROCK BREAKAGE. 182 REFS.

22-68-01001 NFS ADVANCED SCIENCE SEMINAR IN ROCK MECHANICS FOR COLLEGE TEACHERS OF STRUCTURAL GEOLOGY VOLUME 1 (STRESS STRAIN MOHR-CIRCLE BUCKLING FRACTURES ELASTICITY)
BOMBOLAKIS, E. G. + RIECKER, R. E. & BOSTON COLLEGE
SPECIAL REPORT PUBLISHED BY TERRESTRIAL SCIENCES LABORATORY, AIR FORCE CAMBRIDGE RESEARCH LABORATORIES, BEDFORD, MASS., JAN 1968. THE SEMINAR WAS CONDUCTED DURING JUNE AND JULY 1967 UNDER AUSPICES OF THE AMERICAN GEOLOGICAL INSTITUTE AS A SPECIAL COURSE IN ROCK MECHANICS FOR COLLEGE TEACHERS OF STRUCTURAL GEOLOGY. VOLUME 1 CONTAINS PAPERS ON MATHEMATICAL TOOLS NEEDED FOR THE COURSE, MOHR CIRCLE ANALYSES, RELATIONS BETWEEN STRESS AND STRAIN, ELASTIC PROPERTIES, MEASUREMENT OF IN SITU STRESS AND STRAINS IN ROCK. AUTHORS ARE RIECKER, R. E.; BOMBOLAKIS, E. G.; BRACE, W. F.; STEAMS, D. W.; MERRILL, R. H.; CHAPPLE, W.M.

22-68-01002 NFS ADVANCED SCIENCE SEMINAR IN ROCK MECHANICS VOLUME 2 (PORE-WATER-PRESSURE DUCTILITY HOMOGENEOUS-STRAIN ROCK-DEFORMATION)
BOMBOLAKIS, E. G. + RIECKER, R. E. & BOSTON COLLEGE
SPECIAL REPORT PUBLISHED BY TERRESTRIAL SCIENCE LABORATORY, AIR FORCE CAMBRIDGE RESEARCH LABORATORIES, BEDFORD, MASS., JAN 1968. VOLUME TWO CONTAINS PAPERS ON HOMOGENEOUS STRAIN IN ROCKS, EFFECTS OF PORE WATER PRESSURE ON STRENGTH AND DUCTILITY OF ROCKS AND EXPERIMENTAL ROCK DEFORMATION. AUTHORS: HANDIN, J.; CHAPPLE, W. M.; DONATH, F. A.; HEARD, H. C.; CARTER, N. L.

22-68-12001 REACTION OF ANFO EXPLOSIVES WITH MINERAL SULPHIDES (SAFETY)
LUKASZEWSKI, G. M.
PROC AUSTRALASIAN INST. MIN & MET, N. 228, 61-70, DEC. 1968. AMMONIUM NITRATE - FUEL OIL (ANFO) EXPLOSIVES ARE UNSTABLE IN HOT, REACTIVE SULFIDE-RICH GROUND AT MOUNT ISA; UNDER CERTAIN CONDITIONS ASSOCIATED WITH BACKGROUND HEAT, MOISTURE, AND CHEMICAL IMPURITIES FROM NATURAL OXIDATION, ANFO COMPOSITES IN CONTACT WITH HOT GROUND DISPROPORTIONATE AND AMMONIUM NITRATE CAN UNDERGO RAPID EXOTHERMIC REACTIONS WITH SULFIDE; PARTIAL INTERACTION CAN RESULT IN MISFIRES OR PREMATURE DETONATION; THERMAL ANALYSIS WAS USED TO DEFINE CRITICAL CONDITIONS FOR ANFO SULFIDE INTERACTION AND SULFIDE COMBUSTION AGENTS AND CONTROL METHODS HAVE BEEN DEVELOPED TO PREVENT ANFO-INDUCED OXIDATION AND COMBUSTION. 14 REFS.

22-69-01001 HYDRAULIC JET DRILLING (WATER-JETS TUNNELING RESEARCH)
MAURER, W. C. + HEILHECKER, J. K. & ESSO PROD RES CO HOUSTON TEX
FOURTH CONFERENCE ON DRILLING AND ROCK MECHANICS, AMERICAN INSTITUTE OF MINING, METALLURGICAL AND PETROLEUM ENGINEERS, 213-17, JAN 1969. A THRESHOLD NOZZLE PRESSURE MUST BE EXCEEDED BEFORE HYDRAULIC JETS WILL DRILL ROCKS. WATER JETS OF 0.2 TO 1.0 IN DIA. DRILLED HOLES WITH DIA. RANGING FROM 0.8 TO 4 IN. IN SANDSTONE AND LIMESTONE. THESE HOLES WERE 1 TO 3 IN. DEEP AND WERE DRILLED IN 0.02 TO 0.2 SEC. A 2-IN. DIA. DRILL DRILLED AT PRESSURES OF UP TO 13,500 PSI. IN CARTHAGE MARBLE IT HAD A DRILLING RATE OF 180 FT/HR, INDIANA LIMESTONE 280 FT/HR. BEREH SANDSTONE AT 300 FT/HR. A HYDRAULIC JET DRILL (3,000 HP) SHOULD DRILL 8-IN. DIA. HOLES IN AVERAGE-STRENGTH SEDIMENTARY ROCKS AT RATES OF 200 TO 300 FT/HR.

22-69-10001 PRINCIPLES OF ROCK CUTTING APPLIED TO MECHANICAL BORING MACHINES (EFFICIENCY PENETRATION ENERGY)
BRUCE, W. E. + MORRELL, R. D. & U.S. BUR MINES
SACRAMENTO STATE COLLEGE, CAL. SECOND SYMP. ON RAPID EXCAVATION, 3-1 - 3-43, OCT 16, 1969. BUREAU OF MINES, TWIN CITIES MINING RESEARCH CENTERS MECHANICAL FRAGMENTATION LABORATORY IS CONDUCTING RESEARCH TOWARD MORE EFFICIENT TUNNELING WITH BORING MACHINES BY BETTER UNDERSTANDING OF DESIGN PARAMETERS. THEIR MULTIPURPOSE BORING UNIT EQUIPPED WITH TUNNELING MACHINE CUTTERS TO SIMULATE SHAFT-DRILLING OR TUNNEL BORING IS DESCRIBED. OPERATION OF THEIR LINEAR-CUTTER APPARATUS IS GIVEN AND RESULTS USING 60 DEG AND 90 DEG CUTTERS TABULATED. 60 DEG CUTTERS WERE SUPERIOR TO 90 DEG IN PENETRATION AND ENERGY REQUIREMENTS. PEAK HORIZONTAL CUTTER FORCE CAN BE AS MUCH AS 80 PERCENT HIGHER THAN AVERAGE. IN ACTUAL PRACTICE CUTTERS NEAR THE CUTTING HEAD CENTER MAY REQUIRE SUBSTANTIALLY GREATER FORCE THAN THAT SHOWN FOR A LINEAR CUTTER.

22-69-10002 NOVEL METHODS OF ROCK BREAKAGE (WATER JET CAVITATION PELLET-IMPACT THERMAL-SHOCK FLAME-JET ELECTRON-BEAM LASER CHEMICAL-ACTION SPECIFIC-ENERGY ECONOMY)
SINGH, M. M. & IIT RES INST CHICAGO ILL
SACRAMENTO STATE COLLEGE, CAL. SECOND SYMP. ON RAPID EXCAVATION, 4-1 - 4-27, OCT. 16, 1969. URGENT NEED FOR MORE RAPID FUTURE EXCAVATION HAS BROUGHT INCREASED ATTENTION TO UNCONVENTIONAL ROCK BREAKAGE METHODS. DURING THE LAST FIVE YEARS SIGNIFICANT PROGRESS HAS BEEN MADE IN UNDERSTANDING AND DEVELOPING THESE TECHNIQUES BUT FURTHER WORK IS OBVIOUSLY REQUIRED. BRIEFLY DISCUSSED ARE: HIGH-SPEED WATER JET EROSION, CAVITATION, PELLET IMPACT, THERMAL SHOCK, FLAME JET, ELECTRON BEAM, LASER, AND CHEMICAL ACTION. SPECIFIC ENERGY IS A USEFUL MEASURE OF BREAKAGE EFFECTIVENESS BUT RECOMMENDED PROCEDURES FOR ITS DETERMINATION WOULD BE HELPFUL. ALSO OPTIMIZATION OF A METHOD BASED ON ENERGY MAY NOT PROVE ECONOMICALLY BEST AS ENERGY IS CHEAP COMPARED TO LABOR.

22-69-10003 HECLA MINING COMPANY CASE STUDY (RAISES SHOTCRETE SUPPORT TUNNEL-MACHINE CUTTERS)
HENDRICKS, R. S. & HECLA MINING CO
SACRAMENTO STATE COLLEGE, CAL. SECOND SYMP. ON RAPID EXCAVATION, 7-1 - 7-38, OCT 16, 1969. HECLA MINING EXPERIENCE INDICATES THAT 48 IN. DIA. DRILLED RAISES CAN BE COMPLETED IN APPROXIMATELY ONE-THIRD THE TIME AND AT 50 PERCENT OF CONVENTIONAL DRIVEN RAISE ON A COST PER FOOT BASIS. ON A COST PER UNIT VOLUME OF ROCK CONVENTIONAL METHODS WOULD BE FAVORED. HOWEVER, COST PER LINEAL FOOT COMPARISON IS MORE VALID AS SIZE IS OFTEN DICTATED BY DRIVING METHOD RATHER THAN SPECIFIC FUNCTION. WET AND DRY SHOTCRETE PROCESSES ARE DESCRIBED AND IT WAS DECIDED THAT THE DRY PROCESS MOST FULLY MET THE REQUIREMENTS. SHOTCRETE OFFERS GREATER OPPORTUNITY FOR MECHANIZATION THAN ROCK BOLTING, TIMBERING OR STEEL SUPPORT. BEING A CONTINUOUS PROCESS SHOTCRETE HAS A POTENTIAL FOR INCORPORATION INTO THE TOTAL RAPID EXCAVATION SYSTEM. DURING A TWO MONTH OPERATION PERIOD OF A 9 FOOT DIAMETER JARVA TUNNEL MACHINE THE CUTTER PERFORMANCE AND PENETRATION RATE WERE SUFFICIENTLY GOOD TO MAKE THE MACHINE POTENTIALLY ECONOMIC FOR MINING IN COMPARISON TO ALTERNATIVE METHODS. A COOPERATIVE PROGRAM BETWEEN JARVA, REED AND HECLA HAS REDESIGNED AND MODIFIED THE EQUIPMENT WHICH IS READY FOR REUSE.

22-69-10004 DEVELOPMENT MINING AT WHITE PINE (BORING-MACHINES PENETRATION-RATE JUMBOS GUIDANCE EXCTIC-BORING CUTTERS)
THOMPSON, R. J. + SCHULZE, W. H. & GARFIELD, L. A. & WHITE PINE COPPER CO
SACRAMENTO STATE COLLEGE, CAL. SECOND SYMP ON RAPID EXCAVATION, 8-1 - 8-22, OCT 16, 1969. WHITE PINE COPPER CO EXPERIMENTED WITH A 7 FT DIA HUGHES TOOL CO BORING MACHINE IN 15,000 TO 30,000 PSI COMPRESSIVE STRENGTH SHALE. A PENETRATION RATE OF 10 FT. PER HOUR WAS ATTAINED IN SHALE WHICH WAS REDUCED TO 5 FT PER HOUR IN SANDSTONE. TO DRILL AN 18 FT DIA TUNNEL AT A SPECIFIED MINIMUM OF 3 FT PER HOUR, TWO SHIFTS A DAY A JAMES S. ROBBINS MACHINE WAS PURCHASED. THIS MACHINE HAS BORED A MAXIMUM OF OVER 5 FT PER HOUR FOR SUSTAINED PERIODS. BASIC MACHINE DESIGN CHANGES HAVE IMPROVED PERFORMANCE WITH INCREASED SAFETY. THE MACHINE MANUFACTURER HAS DESIGNED AND FABRICATED CUTTERS WHICH HAVE IMPROVED LIFE AND THIS PROGRESS WILL CONTINUE UNTIL CUTTERS ARE REPLACED BY SOME MORE EXOTIC METHOD. A SECOND MECHANICAL ROCK BORER, AN ATLAS COPCO MACHINE, WITH TWO BORING HEADS WILL EXCAVATE AN 8-1/2 FT BY 16 FT HEADING AT 5 FT PER HOUR. IT INCLUDES A PNEUMATIC DRILL FOR ROOF BOLTING, A WET TYPE DUST COLLECTOR AND A LASER BEAM GUIDANCE SYSTEM. MUCKING IS WITH A 36 IN WIDE BELT. A BURN-ROUND JUMBO WEIGHING 22 TONS IS BEING TESTED TO REPLACE THE MORE MOBILE AND MANUVERABLE V CUT JUMBOS. ALL RADICALLY NEW CONCEPTS OF ROCK DISINTEGRATION, LASER BEAMS, ELECTRON BEAMS, MICROWAVES, INFRARED GENERATORS, HIGH PRESSURE WATER AND SURFACTANTS ARE UNDER INVESTIGATION.

22-69-10005 DOT AND THE UNDERGROUND - SOME HIGHLIGHTS (TRANSPORTATION BORING-MACHINES GEOLOGY FLUID-JETS EXOTIC-BORING)

BROWNE, S. D. & U.S. DEPT OF TRANS
SACRAMENTO STATE COLLEGE, CAL. SECOND SYMP ON RAPID EXCAVATION, 9-1 - 9-4, OCT 16, 1969. UNDERGROUND TUNNELING IS A KEY TO FUTURE SUCCESSFUL TRANSPORTATION. THE DEPARTMENT OF TRANSPORTATION IS DEEPLY INVOLVED IN TRYING TO FIND MORE EFFICIENT AND ECONOMICAL METHODS OF EXCAVATION. THE LAST DECADE'S MOST PROMISING DEVICE IS THE FULL-FACE BORING MACHINE. HOWEVER IN HARDER FORMATIONS THE COST OF REPLACEMENT CUTTERS AND BEARINGS BECOMES PROHIBITIVELY HIGH. WE MUST GET A SHARPER KNIFE OR TENDERIZE THE STEAK WITH CHEMICALS OR A LASER BEAM OR OTHER HEAT SOURCE TO WEAKEN THE ROCK AHEAD OF THE CUTTER BLADES. FRACTURING ROCK WITH HYPER- VELOCITY FLUID JETS IS AN APPROACH. TECHNIQUES FOR IMPROVING PREDICTIONS OF GEOLOGICAL FORMATIONS ARE HELPING TO REDUCE TUNNEL COSTS.

22-70-00001 SOME EUROPEAN DEVELOPMENTS IN SMOOTHWALL BLASTING (PRESPLITTING CANADA)
OLROG, T. & SWEDISH STATE PWR BD STOCKHOLM
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL ANC SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 26. ECONOMICS OF SMOOTHWALL BLASTING ARE NOT ALWAYS CLEAR. HIGHER COSTS OF DRILLING, INCREASED TIME FOR CHARGING, MORE EXPLOSIVE MAY BE OFFSET BY GREATER STABILITY, LESS MAINTENANCE. CANADIANS DEVELOPED PRESPLITTING WHICH MAKES A CRACK IN THE CONTOUR LINE AS A SEPARATE OPERATION PRECEDING THE MAIN BLAST. SWEDISH PRACTICE IS TO USE SMOOTHWALL BLASTING FOR COMMUNICATION TUNNELS BUT PRESPLITTING FOR CANALS OPEN CUTS, TUNNEL PORTALS AND UNDERGROUND CHAMBERS. TECHNICAL PROBLEMS OF BLASTING HAVE BEEN VERY WELL SOLVED BUT ADMINISTRATIVE PROBLEMS HAVE NOT.

FIELD 23 GOVERNMENT REPORTS

23-62-06001 NEW METHODS OF CRUSHING OF ROCKS (DRILLING ELECTROHYDRAULIC THERMAL PNEUMATIC-PERCUSSION PERCUSSION-ROTATION ULTRASONICS WATER-JET DETONATION-DRILLING JET-BURNER ELECTROPHYSICAL)
EPSHTEYN, Y. F. + ARSH, E. I. + VITORT, G. K. & GOSTOPTEKHIZDAT
CLEARINGHOUSE FOR FEDERAL SCIENTIFIC AND TECHNICAL INFORMATION OF THE U.S. DEPARTMENT OF COMMERCE, UNABRIDGED TRANSLATION FROM RUSSIAN, FTD-TT 62-122/1+2, 131 PAGES, JUNE 19, 1962. THIS IS A SUMMARY REVIEW OF THE STATE OF RESEARCH INTO NEW METHODS OF CRUSHING ROCK AND DRILLING VARIOUS TYPES OF ROCK FORMATION UP TO AND INTO 1959. DATA IS PRESENTED FROM 84 RESEARCH PAPERS AND REPORTS PREDOMINATELY OF RUSSIAN ORIGIN. NUMEROUS DATA TABLES, CURVES, DIAGRAMS, SKETCHES AND A FEW PHOTOGRAPHS ILLUSTRATE THE TEXT. CRUSHING OF ROCK FOR SINKING DRILLHOLES, SECONDARY GRINDING AND FOR DEVELOPMENT OF COAL AND ORE DEPOSITS IS CONSIDERED ON THE BASIS OF MECHANICAL METHODS, ELECTROHYDRAULIC, THERMAL AND ELECTROPHYSICAL METHODS. THE RESULTS OF INDUSTRIAL AND LABORATORY TESTS OF VARIOUS INSTALLATIONS ARE DESCRIBED. DRILLING BY PNEUMATIC-PERCUSSION, PERCUSSION-ROTATION, ULTRASONICS, WATER JET AND DETONATIONS ARE DISCUSSED IN DETAIL IN THE MECHANICAL CRUSHING METHODS DESCRIPTION. THESE ARE DISCUSSED IN TERMS OF MECHANICAL PROPERTIES OF ROCK, QUANTITATIVE RELATIONSHIPS AND EXPERIENCE IN DRILLING. ELECTROHYDRAULIC CRUSHING BY ELECTRICAL DISCHARGE IN WATER IS DISCUSSED IN TERMS OF AN INVESTIGATION WITH PRACTICAL RECOMMENDATIONS OFFERED. DISCUSSION OF THERMAL CRUSHING INCLUDES JET-BURNER DRILLING, MECHANISM OF ROCK CRUSHING BY THERMAL DRILLING AND DESCRIPTION OF CRUSHING BY MEANS OF THERMITE. ELECTROPHYSICAL METHODS DISCUSSIONS COVER ELECTRICAL AND MAGNETIC PROPERTIES OF ROCK, RAPIDLY CHANGING MAGNETIC FIELDS AND CRUSHING BY PUNCTURING WITH AN ELECTRICAL CURRENT. 84 REFS.

23-63-10001 A NEW APPROACH TO BIT DESIGN - THE DIAMOND DRAG BIT (MOLES CORES DRILLING)
PETERS, R. I. & CHRISTENSON DIAMOND PROD CO
QUARTERLY OF THE COLORADO SCHOOL OF MINES, (58) N 4, 153-61, OCT 1963. A NEW DRILLING TOOL HAS BEEN INTRODUCED INTO THE OILFIELD AND WILL HAVE APPLICATION IN RAPID TUNNELING MACHINES. THE BIT HAS A HARD-FACING MATERIAL COMBINING A HIGH DEGREE OF HARDNESS AND TOUGHNESS WHICH PRODUCES LONG FOOTAGES AND HIGH PENETRATION RATES COMPARED TO OTHER DRAGBITS OR ROLLER TYPE BITS. DIAMONDS ARE CAST INTO THE HARD SURFACING MATERIAL. THIS MATERIAL IS A FURNACED, METALLURGICALLY CONTROLLED PRODUCT CONTAINING A HARD, TOUGH GRADE OF CEMENTED TUNGSTEN CARBIDES.

23-63-10002 THE MECHANISM OF THERMAL SPALLING IN ROCKS (RAPID-EXCAVATION FLAME-JET)
FREEMAN, D. C. + SAWDYE, J. A. + MUMPTON, F. A. & LINDE DIV UNION CARBIDE
QUARTERLY OF THE COLORADO SCHOOL OF MINES, (58) N 4, 225-52, OCT 1963. THE PHYSICAL AND PETROLOGICAL PROPERTIES OF ROCKS PERTINENT TO THERMAL SPALLING HAVE BEEN DETERMINED. THERMAL EXPANSIVITY, THERMAL DIFFUSIVITY AND STRENGTH DATA HAVE BEEN OBTAINED FOR A NUMBER OF ROCKS FROM ROOM TEMPERATURE TO THE MELTING POINTS. THE EFFECTS OF THESE PARAMETERS ALONG WITH THOSE OF GRAIN SIZE AND GRAIN CONFIGURATION ON THE ROCK SPALLABILITY IS DISCUSSED.

23-64-03001 SOME RESULTS OF THE DESTRUCTION OF ROCKS BY MEANS OF A PULSED WATER JET (WATER-CANNON)
VOYTSEKHOVSKIY, B. V.
JOINT PUB RES SERVICE (JPRS 23,719) OFFICE OF TECHNICAL SERVICE OTS 64-21809 U.S. DEPT OF COMMERCE, MAR 17, 1964. BASED ON EARLIER THEORETICAL AND EXPERIMENTAL INVESTIGATIONS, THE DIV OF RAPIDLY OCCURING PROCESSES OF THE HYDRODYNAMICS INSTITUTE OF THE SIBERIAN DEPT OF THE ACADEMY OF SCIENCES USSR CREATED IN 1961 THE IV-4 PULSED WATER JET WHICH CAN BE EMPLOYED BY THE MINING INDUSTRY FOR THE DESTRUCTION OF ROCKS. THIS WATER JET WAS TESTED AND DEVELOPED A DYNAMIC PRESSURE OF APPROXIMATELY 5,000 KILOGRAMS PER SQ CM IT CAN SUCCESSFULLY BE APPLIED FOR THE DESTRUCTION OF ROCKS CONTAINING CRACKS AND HAVING A STRENGTH FACTOR OF F = 5-6. THIS PAPER DISCUSSES THE TEST PROCEDURES, THEORY INVOLVED, AND THE SIGNIFICANCE OF THE RESULTS. 8 PAGES. 3 REFS.

23-65-00001 HYDRAULIC COAL MINING RESEARCH (MONITORING SAFETY WATER-JETS)
PRICE, G. C. + BADDA, F. & U.S. BUR MINES
U.S. BUR OF MINES - REPORT INVESTIGATIONS 6685, 16, 1965. A BUREAU-DEVELOPED HYDRAULIC MINING MACHINE WAS USED SUCCESSFULLY IN THE PITCHING COALBED. IT CONSISTED OF A REMOTELY CONTROLLED MONITOR MOUNTED ON A SELF-ADVANCING ROOF SUPPORT UNIT OF THE TYPE COMMONLY USED FOR ROOF SUPPORT IN LONGWALL MINING SYSTEMS. PROJECT WAS TERMINATED BY OWNER BEFORE BUREAU PERSONNEL HAD ACHIEVED OPTIMUM DESIGN. THE COAL CUTTING RATES AVERAGED 0.73 AND 0.54 TON PER MINUTE IN RAISE AND ROOM MINING, RESPECTIVELY, WHILE USING WATER VOLUMES UP TO 230 GPM AT A PRESSURE OF 4,000 PSIG. PRODUCTIVITY AVERAGED 4.7 AND 5.2 TONS PER MAN-SHIFT FOR RAISE AND ROOM MINING, RESPECTIVELY, COMPARED WITH 7.5 AND 8.5 TONS PER MAN-SHIFT, RESPECTIVELY, BY CONVENTIONAL HAND MINING METHODS.

23-65-00002 HYDRAULIC MINING OF ANTHRACITE: ENGINEERING DEVELOPMENT STUDIES (WATER-JETS SAFETY)
BURCH, J. W. & U.S. BUR MINES
U.S. BUR OF MINES - REPORT INVESTIGATIONS 6610, 34, 1965. THE BUREAU ESTABLISHED A FULL SCALE EXPERIMENT OF HYDRAULIC MINING OF ANTHRACITE IN A PA MINE. OPERATING CONDITIONS OF 5000 PSI AND 300 GPM (1000 HP) WERE SELECTED FROM EXPERIMENTAL DATA. A HYDRAULIC JUMBO WAS DESIGNED FOR HANDLING THE MONITOR. THE COAL WAS 10 1/2 TO 15 FT THICK WITH A PITCH VARYING FROM 0 DEG. TO 20 DEG. PRODUCTION OF 7400 TONS OF COAL AVERAGED 0.8 TON PER MIN WITH AVERAGE POWER REQMT OF 14.125 KW-HRS/TON.

23-65-10001 HARD-ROCK TUNNELING INVESTIGATION (MACHINES MOLES DRILLING-AND-BLASTING COST RATE-OF-TUNNELING FEASIBILITY CONSTRUCTION ESTIMATES)
HIRSCHFELD, R. C. & M.I.T. CAMBRIDGE MASS
MASS INST OF TECH FOR THE U.S. DEPT OF COMMERCE UNDER CONTRACT C-85-65, OCT 15, 1965. THIS 56 PAGE REPORT SURVEYS THE TECHNOLOGY OF HARD-ROCK TUNNELING, WITH EMPHASIS ON TUNNELING MACHINES AND IS PART OF THE OVERALL STUDY TO ESTABLISH THE RELATIVE FEASIBILITY OF TUNNEL, SURFACE, AND ELEVATED ROUTES FOR A HIGH SPEED GROUND TRANSPORT (HSGT) SYSTEM. DRILLING AND BLASTING IS THE CONVENTIONAL METHOD FOR HARD-ROCK TUNNEL EXCAVATION BUT THE REPORT POINTS OUT THAT, DESPITE MANY TECHNOLOGICAL IMPROVEMENTS IN RECENT YEARS, THE COST OF THIS METHOD APPEARS TO BE RISING. COST AND RATE-OF-TUNNELING FIGURES THAT MIGHT BE USED FOR FEASIBILITY STUDIES HAVE BEEN ABSTRACTED FROM CALIF. DEPT OF WATER RESOURCES AND ARE PRESENTED. CAUTION IS ADVISED IN USING THE FIGURES THEREIN SINCE THE NUMBER OF TUNNEL CONSTRUCTION

RECORDS ON WHICH THEY ARE BASED IS STATISTICALLY SMALL AND THE PARTICULAR GEOLOGIC CONDITIONS AT EACH NEW TUNNEL SITE HAVE AN IMPORTANT INFLUENCE ON BOTH COST AND RATE OF TUNNELING. TUNNELING MACHINES ARE DISCUSSED IN THEIR USE ON 20 PROJECTS OVER THE LAST 10 YRS. ON SOME PROJECTS THE MACHINES HAVE TUNNELED FASTER AND CHEAPER THAN CONVENTIONAL DRILLING AND BLASTING, BUT MOSTLY IN SOFTER ROCK. EXPECTATIONS ARE THAT THE MACHINES WILL EVENTUALLY BE IMPROVED TO WHERE THEY CAN TUNNEL THROUGH HARDER ROCK AND UNDER MORE UNFAVORABLE CONDITIONS. A PROGRAM FOR SUCH DEVELOPMENT WORK IS PROPOSED. THE REPORT ALSO BRIEFLY DISCUSSES OTHER HARD ROCK TUNNELING METHODS INCLUDING NUCLEAR, THERMAL AND HYDRAULIC. TWELVE TABLES, GRAPHS AND PHOTOS.

23-66-00001 INELASTIC DEFORMATION OF ROCK UNDER A HEMISPHERICAL DRILL BIT (ABRASIVE-DRILLING
ROCK-DISINTEGRATION-METHODS <
PACNE, J. + TANDANAND, S. & U.S. BUR MINES
U.S. BUR OF MINES - REPORT INVESTIGATIONS 6838, 24, 1966. STUDIES WERE MADE TO DETERMINE THE BEHAVIOR OF ROCKS AT THE INITIAL STATE OF CRATER FORMATION RESULTING FROM THE STRESSES CREATED UNDER A DRILL BIT TO DETERMINE WHICH MECHANICAL PROPERTIES OF ROCK ARE IMPORTANT IN ROCK FRAGMENTATION BY DRILLING. MAXIMUM YIELD STRENGTH OF ROCK IS APPARENTLY A PARAMETER OF DRILLABILITY OF ROCK. THE STRENGTHS OF ROCK WERE CONSIDERED FROM THE MOHR-COULOMB CRITERION FROM WHICH THE SURFACE OF FAILURE WAS CONSTRUCTED. RESULTS FROM PREVIOUS TRIAXIAL TESTS ON SOLENHOFEN LIMESTONE WERE USED TO VERIFY THE CRITERION OF FAILURE. INELASTIC BEHAVIOR OF SOME ROCK TYPES WAS OBSERVED UNDER A LOW-VELOCITY IMPACT OF A HEMISPHERICAL BIT AND UNDER STATIC INDENTATION WITH A SIMILAR BIT. PERMANENT SET AT LOW APPLIED LOADS IN THE INDENTED AREA WAS MEASURED WITH AN INTERFEROMETRIC TECHNIQUE. QUANTITATIVE DETERMINATIONS OF STRENGTHS OF SOLENHOFEN LIMESTONE, IND LIMESTONE, AND TENN MARBLE WERE MADE UNDER STATIC INDENTATION. THE MAXIMUM YIELD STRENGTH ESTIMATED FROM THE AVERAGE STRESS OVER THE INDENTED AREA WAS USED AS THE CRUSHING STRENGTH OF ROCK UNDER A DRILL BIT. 18 REFS.

23-67-00001 ZETA POTENTIAL AND PENDULUM SCLEROMETER STUDIES OF GRANITE IN SOLUTION ENVIRONMENT (CHEMICAL-SOFTENING)
ENGELMANN, W. H. + TERICHOW, A. + SELIM, A.
U.S. BUR MINES - REPORT INVESTIGATIONS 7048, 1-16, 1967. ELECTROKINETIC (ZETA) POTENTIALS OF CHARCOAL GRANITE IN ALUMINUM CHLORIDE (ALCL3) SOLUTION AND IN OLEYLAMMONIUM ACETATE SOLUTION HAVE BEEN CORRELATED WITH SPECIFIC DAMPING VALUES AS MEASURED BY PENDULUM SCLEROMETER. THIS INVESTIGATION SHOWS THAT PENDULUM SPECIFIC DAMPING ATTAINS MINIMUM AT ISOELECTRIC POINT FOR CHARCOAL GRANITE - ALUMINUM CHLORIDE AND CHARCOAL GRANITE - OLEYLAMMONIUM ACETATE SYSTEMS, AND THUS INDICATES THAT PENETRATION OF DIAMOND POINTS IS MAXIMUM AT ISOELECTRIC POINT.

23-67-12001 A STUDY OF EXTERNALLY AUGMENTATION OF THE VELOCITY OF FLUID JETS (TUNNELING WATER-JET SHOCK-WAVES
ROCK-FRACTURE HYPERVELOCITY SHAPED-CHARGE)
BOWES ENGINEERING CORP., UNDER CONTRACT 7-35380 FOR THE U.S. DEPARTMENT OF TRANSPORTATION, DEC 12, 1967. THIS 23 PAGE REPORT PRESENTS RESULTS OF A STUDY OF A METHOD OF EXTERNAL AUGMENTATION OF FLUID JETS AND INCLUDES A DISCUSSION OF BACKGROUND APPLICATIONS OF WATER JETS FOR ROCK FRACTURE, ANALYSES OF THE AUGMENTATION METHOD AND TEST DATA CORROBORATION OF ANALYTICAL RESULTS. THE TEXT IS SUPPLEMENTED BY 21 FIGURES, CURVES, AND PHOTOGRAPHS. TO MAKE TUNNELING OPERATIONS MORE ECONOMICALLY FEASIBLE FOR FUTURE TRANSPORTATION SYSTEMS A NEED WAS RECOGNIZED FOR A NEW TECHNIQUE OF TUNNELING. WATER JET TECHNIQUES ARE INVESTIGATED TO OVERCOME THE INHERENT SLOWNESS OF CONVENTIONAL TUNNELING SINCE PREVIOUS WORK INDICATED THAT HIGH VELOCITY WATER JETS PRODUCE MUCH THE SAME EFFECT ON ROCK AS EXPLOSIVES. THE PROBLEM OF HIGH VELOCITY JETS CENTERS AROUND THE FACT THAT THE VELOCITY NEEDED TO FRACTURE ROCK IS VERY HIGH. IN A DIRECT CONVERSION OF PRESSURE HEAD TO VELOCITY HEAD IN THE CONVENTIONAL NOZZLE, EXCESSIVE PRESSURE IS REQUIRED SUCH AS 174,000 PSI FOR A JET VELOCITY OF 5,000 FEET PER SECOND. HOWEVER, BY THE VELOCITY AUGMENTATION METHOD, TWO SLUGS OF WATER WITH EQUAL LOW VELOCITY FROM SEPARATE NOZZLES COLLIDING AT EQUAL ACUTE ANGLES ALONG A CENTERLINE WILL PRODUCE A RESULTANT SMALLER SLUG WITH A VELOCITY AUGMENTED BY A FACTOR OF 11.4 TIMES THE ORIGINATING VELOCITY. IN THE CASE CONSIDERED, AT A PRESSURE OF 280 PSI A FAST JET VELOCITY OF 2,700 FEET PER SECOND RESULTED WHICH ORDINARILY WOULD HAVE REQUIRED A PRESSURE HEAD OF 50,000 PSI. A MATHEMATICAL DEVELOPMENT OF THE METHOD IS PRESENTED AND A DESCRIPTION IS GIVEN OF LABORATORY TEST THAT VERIFIED THE ANALYTICAL RESULTS.

23-68-02001 DESIGN STUDIES OF HIGH VELOCITY LIQUID JET EQUIPMENT (WATER-CANNON ROCK-FRACTURE)
YOUNGQUIST, R. + CLIPP, L. + COOLEY, W. C. & EXOTECH INC ROCKVILLE MD
EXOTECH, INC. REPORT, TR-RD-021, FINAL TECHNICAL REPORT, FOR THE DEPT. OF ARMY, (11) 1-32, FEB 1968. THE OBJECTIVE OF THE STUDY WAS TO ANALYZE HIGH PRESSURE WATER JET EQUIPMENT IN THE FOLLOWING SITUATIONS: 1) ROCK FRAGMENTATION, 2) RAPID EXCAVATION, 3) BREACHING OF INLAND ROCK AND CONCRETE BARRIERS, 4) BREACHING OF SHORE-LINE ROCK OR CONCRETE BARRIERS. THE HIGH PRESSURE (PULSED) LIQUID JETS TRAVEL AT PEAK VELOCITIES OF 3,600 TO 5,100 FT/SEC OR HIGHER. THE PNEUMATIC POWERED WATER CANNON CONSISTS OF HIGH PRESSURE JET HEAD ASSEMBLY DRIVEN BY A PNEUMATIC HAMMER ASSEMBLY. LONG TERM WATER CANNON DEVELOPMENTS WILL BE AIMED AT HIGHER SYSTEM EFFICIENCIES AND LOWER SYSTEM WEIGHTS. THE WATER CANNON EQUIPMENT DESCRIBED HERE IS ABLE TO SPLIT OR QUARRY MORE ROCK PER HOUR BY A FACTOR OF TWO TO TEN. IT IS BELIEVED THAT THE ADVANTAGES OF THE WATER JET DRILLING WILL YIELD A COST EFFECTIVENESS RATIO SEVERAL TIMES BETTER THAN OTHER METHODS. THE ADVANTAGES FOR WATER CANNON EQUIPMENT INCLUDE SPEED AND ADAPTABILITY. IT WAS CONCLUDED THAT WATER CANNON EQUIPMENT WHICH CAN REPETITIVELY FIRE JETS OF WATER AT PRESSURE ABOVE 50,000 PSI OFFER ADVANTAGES OVER PRESENT METHODS FOR BARRIER BREACHING, RAPID EXCAVATION, AND ROCK QUARRYING.

23-68-03001 HYDRAULIC COAL MINING RESEARCH - ASSESSMENT OF PARAMETERS AFFECTING CUTTING RATE OF BITUMINOUS COAL
FOWKES, R. S. + WALLACE, J. J.
U.S. BUR MINES - REPORT INVESTIGATIONS 7090, 23, MAR. 1968. JETSTREAM PRESSURE DISTRIBUTIONS AND COAL CUTTING RATES WERE DETERMINED FOR A NUMBER OF NOZZLES AND UNDER DIFFERENT OPERATING CONDITIONS. JETSTREAM PRESSURE DISTRIBUTION DATA WERE FITTED TO ASSUMED CURVILINEAR EQUATION BY UTILIZATION OF NUMERICAL LEASTSQUARES TECHNIQUE WITH AID OF DIGITAL COMPUTER. SUBSEQUENT MANIPULATION OF APPROXIMATION EQUATION SHOWED THAT TOTAL FORCE OF JETSTREAM, RATHER THAN ITS MAXIMUM PRESSURE OR TOTAL KINETIC ENERGY PER UNIT TIME, WAS MOST SIGNIFICANT QUANTITY AFFECTING COAL CUTTING RATE.

23-68-04001 JET DELIVERY OPTIMIZATION (FLUID-PROPERTIES POLYMERS WATER-VELOCITY SLUGS IMPACT ROCK-TUNNELLING NOZZLE
FLUIDIC-CONTROL)
BOWLES ENGINEERING CORPORATION, CONTRACT NO. 7-35381, FOR U.S. DEPARTMENT OF TRANSPORTATION APRIL 23, 1968. THIS REPORT PROVIDES RESULTS OF STUDIES OF SEVERAL CONCEPTS FOR IMPROVING WATER JET DELIVERY TO INCREASE THE EFFICIENCY OF HYDRAULIC TUNNELING AND MINING. THREE OF 5 CONCEPTS CONCERN REDUCTION OF WATER JET VELOCITY DECAY BY SUPPRESSING PRESSURE DISTURBANCES AND TURBULENCE WHICH CAUSE JET BREAKUP, THROUGH USE OF TURBULENCE SUPPRESSING LONG CHAIN POLYMER CHEMICAL ADDITIVES, DESIGN OF A MINIMUM TRANSVERSE TURBULENCE NOZZLE, AND SUPPRESSION OF AIR SHEAR OF THE JET BY USE OF A MOVING AIR SHEATH. A STUDY WAS ALSO MADE OF THE USE OF A FLUIDIC JET MODULATOR TO GENERATE LIQUID SLUGS TO PRODUCE HIGH PRESSURE IMPULSIVE SHOCKS TO A ROCK FACE. LABORATORY TESTS OF THE CONCEPTS WERE PERFORMED. PRINCIPLES OF ROCK FRACTURE BY WATER JETS ARE EXAMINED AND THE STUDIED CONCEPTS EVALUATED FOR APPLICATION IN AN OPTIMUM SYSTEM FOR A PROPOSED TUNNELLING MOLE. GENERAL CONCLUSIONS ARE THAT CHEMICAL ADDITIVES SHOW PROMISE BUT FURTHER TESTING IS RECOMMENDED, THAT FURTHER ANALYSIS IS NEEDED IN OPTIMIZING NOZZLE DESIGN BY TRADE OFF BETWEEN CONTRACTION RATIO AND MINIMUM TRANSVERSE TURBULENCE AT THE EXIT, THAT FLUID MODULATION OF THE JET TO BREAK IT INTO COHERENT SLUGS AND USE OF A MOVING AIR SHEATH AROUND A LIQUID JET ARE NEITHER TECHNICALLY NOR ECONOMICALLY FEASIBLE. HOWEVER, FURTHER STUDY AND DEVELOPMENT OF A PROPOSED HIGH PRESSURE JET TUNNELLING SYSTEM IS RECOMMENDED. 108 PAGES, 42 FIGURES, 5 TABLES, 16 REFS.

23-68-04002 HYPERVELOCITY JET DRIVER STUDY FINAL REPORT (ROCK-DISINTEGRATION-METHODS WATER-JETS LIQUID-JETS)
NERADAKA, V. + WALSTON, W. + TUREK, R. & BOWLES ENGR CORP
BOWLES ENGINEERING CORP. FLUIDIC SYSTEMS, FOR THE U.S. DEPT OF TRANSPORTATION UNDER CONTACT 3-0055, 1-59, APRIL 1968. THIS STUDY INVESTIGATES ANALYTICALLY A CONCEPT FOR ACCELERATING LIQUID SLUGS TO HIGH VELOCITY BY THE USE OF SUPERSONIC GAS NOZZLES. THESE HIGH VELOCITIES ARE ACHIEVED BY A HYPERVELOCITY GUN COMPRISING OF A CONSTANT AREA SECTION TUBE FOR ACCELERATING THE SLUG TO SONIC SPEED AND A DIVERGING AREA TUBE FOR FURTHER ACCELERATING THE SLUG TO

SUPERSONIC GAS SPEEDS. ANALYSES ARE PERFORMED TO EVALUATE THE LENGTHS AND ACCELERATION TIMES FOR BOTH SECTIONS OF THE GUN UNDER DIFFERENT CONDITIONS OF SUPPLY PRESSURE AND TEMPERATURE AND SLUG SIZES. THE RESULTS ARE PRESENTED GRAPHICALLY TO SHOW THESE PARAMETRIC RELATIONSHIPS. THE ANALYSES INDICATED THAT SLUG VELOCITIES EXCEEDING 3000 FT/SEC CAN BE ACHIEVED USING AIR AS THE DRIVING GAS AND WITH REASONABLE GUN LENGTHS IN THE RANGE OF 5 TO 15 FT. AND OPERATING AT MODERATE TEMPERATURE AND PRESSURE, 1000 DEGREES R AND 500 TO 1500 PSI, RESPECTIVELY. INDICATIONS ARE THAT INCREASING THE GAS TEMPERATURES YIELDS A SIGNIFICANT INCREASE IN THE SLUG EXIT VELOCITY. THE CONCEPT REQUIRES THE HYPERVELOCITY JET DRIVER TO BE CONTROLLED RESPECTIVELY AT A CONTROLLED FREQUENCY AND SLUG SIZE. 6 REFS.

23-68-04003 ROCK DRILLABILITY FOR MILITARY APPLICATIONS (ROTARY-DRILLS PERCUSSIVE-DRILLS PENETRATION-RATE ROCK-STRENGTH)
PAONE, J. + UNGER, H. F. + TANDANAND, S. & U.S. BUR MINES TWIN CITIES
U.S. DEPT OF INTERIOR, BUREAU OF MINES, REPORT NO. AD671, APR 1967. REPORT DESCRIBES DRILLING SYSTEMS AND THEIR DRILLABILITY IN VARIOUS ROCKS. DRILLABILITY EQUATIONS FOR ROTARY AND PERCUSSIVE DRILLING SYSTEMS AND ROCK STRENGTH CHARACTERISTICS ARE DERIVED AS A GUIDE FOR PREDICTING DRILLING IN MILITARY APPLICATIONS. DRILLING RATE EQUATIONS CAN BE FORMULATED IF THE FUNCTIONS OF THE PARAMETERS ARE KNOWN. FLUSHING MEDIUM AND BIT SIZE EFFECTS ON DRILLABILITY ARE EVALUATED.

23-68-04004 TURBODRILL FOR DRILLING LARGE-DIAMETER HOLES
VYSOTSKIY, V. A. + LIBERMAN, V. I.
U.S. DEPT. OF COMMERCE, 1-16, APRIL 8, 1968. THE JET-TURBINE TECHNIQUE WAS TESTED AND SUBSEQUENT IMPROVEMENTS MADE. THE FIRST TEST MODELS WERE FROM DRILLING SETS OF TYPES RTB3-588, RTB3-722 AND RTB3-920. TRANSLATED FROM "WORKS OF THE ALL-UNION SCIENTIFIC-RESEARCH INSTITUTE FOR DRILLING TECHNOLOGY, RUSSIAN 1967, NO. 18, 50-63.

23-68-05001 CRACK INITIATION AND PROPAGATION IN ROCK (ROCK-BREAKING HEAT-TREATMENT LASER)
FOROOTAN-RAD, P. + MOAVENZADEH, F. & M.I.T. CAMBRIDGE MASS
M.I.T. RESEARCH REPORT, R 68-29, PREPARED FOR U.S. DEPT OF TRANSPORTATION, MAY 1968. THEORIES OF CRACK INITIATION, PROPAGATION AND BIFURCATION IN PERFECT SOLIDS BASED ON ENERGY EQUILIBRIUM CRITERIA, ELASTICITY THEORY CONSIDERATIONS AND PARTICULATE BODY MECHANICS ARE REVIEWED. MODIFICATIONS OF THESE AND THEIR APPLICABILITY TO ROCK ARE DISCUSSED. DIFFERENT TESTING METHODS USED TO STUDY THE FRACTURE CHARACTERISTICS OF ROCK ARE REVIEWED; A BENDING METHOD WAS CHOSEN AS MOST SUITABLE FOR THE PURPOSE. A LITERATURE REVIEW ON THE EFFECT OF HEAT TREATMENTS ON ROCK WEAKENING ARE DISCUSSED. THE PRINCIPLES OF A CONTINUOUS DUTY, HIGH POWERED GAS LASER AS A HEAT SOURCE ARE DESCRIBED. THE VALUES OF THE FRACTURE SURFACE ENERGY WERE DETERMINED FOR FOUR DIFFERENT GEOMETRIES OF A GRANITE SPECIMEN. THE RESULTS SHOW THAT IF A STABLE FRACTURE IS OBTAINED, THE VALUE IS INDEPENDENT OF GEOMETRY. RESULTS OF THE HEAT TREATMENT AND LASER TREATMENT STUDIES ON MARBLE AND GRANITE SHOW THE THERMAL EXPOSURE CAUSES A DECREASE IN THE VALUE OF ULTIMATE FLEXURAL STRENGTH BECAUSE OF INTERGRANULAR AND TRANSGRANULAR CRACKS INDUCED IN THE SPECIMEN.

23-68-05002 THIN DISK TECHNIQUE FOR ANALYZING ROCK FRACTURES INDUCED BY LASER IRRADIATION (NOVEL DRILLING LASER)
MOAVENZADEH, F. + WILLIAMSON, R. B. + MCGANY, F. J. & M.I.T. CAMBRIDGE MASS
DEPT OF C.E., MASS. INST. OF TECH. RESEARCH REPORT R68-21 FOR U.S. DEPT. OF TRANSPORTATION, 81, MAY 1968. MECHANISM BY WHICH A LASER BREAKS A MATERIAL DEPENDS ON THE TYPE OF LASER AND THE ABSORPTION OF RADIATION (AS HEAT) BY THE MATERIAL. HEAT IS THE PRIME DAMAGING FACTOR WITH ROCKS. THE FAILURES OF THE MATERIAL WAS CAUSED BY THERMALLY INDUCED TENSILE STRESSES WHICH EXCEEDED THE STRENGTH OF THE MATERIAL. AS THE POWER LEVEL WAS DECREASED, THE TIME TO FAILURE INCREASED. THE MAXIMUM CALCULATED STRESSES IN THE THREE TESTS WERE 5140, 5510 AND 4700 PSI.

23-68-05003 HYDRAULIC MINING OF ANTHRACITE
MALENKA, W. T. & U.S. BUR MINES
U.S. BUR MINES REPORT INVESTIGATIONS 7120, APR 1968. OPERATING CONDITIONS IN HYDRAULIC MINING OF ANTHRACITE WERE INVESTIGATED USING MODIFIED FACTORIAL EXPERIMENTS. THE MOST IMPORTANT VARIABLES WERE FOUND TO BE PRESSURE-VOLUME RATIO PATTERN OF CUTS AND TRAVERSING SPEED OF THE NOZZLES. A COMPUTER PROGRAM WAS PREPARED FOR MINING PROGRAMMING. A PREDICTION EQUATION WAS OBTAINED BASED ON COMPUTER PRINT OUT, OPERATING PARAMETERS, AND PROPERTIES OF ANTHRACITE. 19 PAGES.

23-68-06001 ROCK TUNNELING WITH HIGH SPEED WATER JETS UTILIZING CAVITATION DAMAGE (EROSION VELOCITY DRILLING COMPRESSIVE-STRENGTH BUBBLE-COLLAPSE)
KOHL, R. E. & HYDRONICS INC
HYDRONICS, INC., TECHNICAL REPORT NO. 713.1, CONTRACT NO. 735-088 FOR THE U. S. DEPT OF TRANSPORTATION, OFFICE OF HIGH SPEED GROUND TRANSPORTATION, JUNE 1968. THIS REPORT PROVIDES ILLUSTRATED RESULTS OF TESTS PERFORMED AS PART OF A PROGRAM TO DETERMINE THE FEASIBILITY OF DRILLING ROCK WITH CAVITATING WATER JETS AND TO DEVELOP FASTER, CHEAPER AND SAFER METHODS OF TUNNELING. THE EFFORT IS RELATED TO THE PLACEMENT OF FUTURE LONG DISTANCE, HIGH SPEED TRANSPORTATION SYSTEMS UNDERGROUND. LABORATORY TESTS WERE DESIGNED STUDYING EFFECTS OF 1/4 AND 1/8 INCH JETS ON VARIOUS MATERIALS WITH VELOCITIES UP TO 500 FT./SEC WITH VARYING NOZZLE DESIGNS, NOZZLE TO TARGET DISTANCE, SOURCE PRESSURE, ROTATION OF TARGET. THE INVESTIGATION CENTERS AROUND EROSION INTENSITY OF THE JET ON TARGET MATERIALS, WHERE EROSION INTENSITY IS DEFINED AS THE POWER ABSORBED BY A UNIT AREA OF THE ERODED PORTION OF THE MATERIAL. MEANS OF INDUCING CAVITATION IN THE JET INCLUDE USE OF TURNING VANES AND CAVITY INDUCING INSERTS IN THE JET NOZZLES. THE TESTS ALSO INVESTIGATED THE RELATIONSHIP OF EROSION INTENSITY TO ROCK COMPRESSIVE STRENGTH AND HEATING OF ROCK TO REDUCE ITS STRENGTH AND INCREASE EROSION RATES. EROSION INTENSITY VALUES WERE DEVELOPED FROM AN INITIAL 37 WATTS/SQ.M. AT THE START OF THESE TESTS UP TO 670 WATTS/SQ.M. 46 PAGES, 20 SKETCHES, PHOTOGRAPHS, TABLES AND GRAPHS.

23-68-06002 REVIEW OF EFFECTS OF HYPER-VELOCITY JETS AND PROJECTILES ON ROCK (THEORY WATER-JETS EXPLOSIVES)
CLARK, G. B. + HAAS, C. J. + BROWN, J. W. & MUIR, C. D. & UNIV MO ROLLA MO
UNIV OF MO AT ROLLA FOR OFFICE OF HIGH SPEED GROUND TRANSPORTATION-FINAL REPORT, JUNE 1968. A STUDY OF THE THEORY OF HYPERVELOCITY TECHNIQUES TO ASSESS THE APPLICABILITY OF USING HIGH SPEED WATER JETS, METALLIC JETS AND PROJECTILES FOR CUTTING AND BREAKING ROCK PARTICULARLY FOR TUNNELING APPLICATIONS. SHAPED CHARGES AND HYPERVELOCITY JETS ARE DISCUSSED AT LENGTH. IT IS SHOWN THAT UNSTEADY FLOW PROCESSES OF HYPERVELOCITY PHENOMENA INCLUDE MOVEMENT IN SOLIDS LIQUIDS AND GASES AS WELL AS SHOCK WAVES IN ALL THREE. EQUATIONS OF STATE ARE GIVEN FOR NUMERICAL SOLUTION OF THE EQUATIONS OF MOTION. 411 PAGES. 147 REFS.

23-68-08001 SOME RELATIONSHIPS BETWEEN POWER LEVEL, EXPOSURE TIME, SAMPLE SIZE AND WEAKENING IN LASER-ASSISTED ROCK FRACTURE
WILLIAMSON, R. B. + MOAVENZADEH, F. + MCGARRY, F. J. & M.I.T. CAMBRIDGE MASS
M.I.T. RESEARCH REPORT, R 68-30, PREPARED FOR U.S. DEPT. OF TRANSPORTATION, AUG 1968. DIFFERENT SIZE FLEXURAL SAMPLES OF MARBLE AND GRANITE WERE STRENGTH-TESTED BEFORE AND AFTER EXPOSURE TO THE 10.6 MICRON INFRARED RADIATION FROM CO2-N2-HE GAS LASERS. THE LASER OUTPUT POWER VARIED BETWEEN 100 - 5000 WATTS AND TOTAL DOSAGE VARIED BETWEEN 1000-30,000 JOULES. LOSSES OF FLEXURAL STRENGTH WERE PRODUCED BY A FEW THOUSAND JOULES RADIATION, AND THE LOSSES INCREASED AS THE DOSAGES INCREASED. THE DEGREE OF ROCK DAMAGE APPEARED TO BE DIRECTLY PROPORTIONAL TO THE TOTAL DOSAGE IMPOSED. WITHIN THE LIMITS STUDIED, THE DAMAGE WAS INDEPENDENT OF THE RADIANT ENERGY INPUT RATE. AS THE ROCK SAMPLE VOLUME INCREASED, THE AMOUNT OF ENERGY REQUIRED TO PRODUCE THE SAME DEGREE OF ROCK DAMAGE INCREASED PROPORTIONATELY.

23-68-09001 HYDRAULIC JET TESTING WITH CLEAR WATER, SECOND TEST SERIES (EXCAVATING CAVITY DRILLED-SHAFT NOZZLES ROCK-SURFACE)
ASH, J. L. & FENIX AND SCISSON INC TULSA OKLA
FENIX AND SCISSON, INC., TULSA AND PETROLEUM CONSULTANTS, HOUSTON FOR THE U. S. ATOMIC ENERGY COMMISSION, SEPT 1968. THIS STUDY IS A PART OF A LARGER STUDY 'CONSTRUCTION OF A CAVITY BY ACID SOLUTIONS AND BY WATER AND/OR ACID

JETTING' FOR ENGINEERING AND LOGISTICS, NEVADA OPERATIONS OFFICE, U. S. ATOMIC ENERGY COMMISSION, R & D WORK AUTHORIZATION NO. 3105-021. THE REPORT COVERS A SECOND SERIES OF TESTS FOR FEASIBILITY OF EXCAVATING WITH HIGH VELOCITY JETS OF CLEAR WATER. THE TESTS WERE CONDUCTED AT THE NEVADA TEST SITE OF THE U. S. ATOMIC ENERGY COMMISSION ON JULY 9 AND 10, 1968 ON AN OUTCROPPING OF WELDED TUFF. TWO TESTS WERE CONDUCTED ON A BOULDER FROM THE SAME OUTCROP PLACED UNDERWATER IN AN OPEN TANK. EXCEPT FOR THE JET NOZZLES, COMMERCIAL EQUIPMENT THAT IS PRESENTLY AVAILABLE WAS USED TO MAKE ALL TESTS. TEST PRESSURES ACROSS THE NOZZLE RANGED UP TO 15000 PSI. NOZZLES WERE MOUNTED ON THE END OF A BOOM ON A BACKHOE AND WERE SUPPLIED WITH WATER FROM PUMPER TRUCKS. 65 PAGES.

23-68-11001 ELECTRON BEAMS A NEW TOOL FOR CUTTING & BREAKING ROCK (SCATTER-GUN SHIELD POWER HARD-ROCK)
SCHUMACHER, B. W.
WESTINGHOUSE RESEARCH LABORATORIES SCIENTIFIC PAPER, 68-IC2-EWELD-P2, NOV 25, 1968. IN WELDING, ELECTRON BEAM SHOWED ADVANTAGES OVER OLDER METHODS BECAUSE OF EXCEPTIONAL HIGH POWER CONCENTRATION COMBINED HIGH TOTAL POWER OF NEWER ELECTRON BEAM MACHINES. IN CUTTING AND DISINTEGRATING ROCK IT IS OBVIOUS THAT IT CANNOT BE DONE IN A VACUUM. IN WESTINGHOUSE'S NEW ATMOSPHERIC ELECTRON GUN THE BEAM IS STILL FORMED IN A HIGH VACUUM BUT THEN BROUGHT TO ATMOSPHERE THRU A SERIES OF DIFFERENTIALLY PUMPED CHAMBERS. A SCHEMATIC DIAGRAM OF THIS GUN IS SHOWN. ELECTRON BEAMS TRAVEL AT ABOUT HALF THE SPEED OF LIGHT AND THIS ENERGY MUST BE DISSIPATED IN A SHORT DISTANCE. TO GET NARROW CUTS OR PIERCING EFFECTS IN ROCK THE GUN MUST BE CLOSE AS AIR MOLECULES SCATTER THE BEAM. IF THE POWER IS SUFFICIENT VERY RAPID MATERIAL REMOVAL OCCURS DUE TO VAPORIZATION. OPERATOR SHIELDING BY 1/4 IN. OF LEAD SHOULD BE SUFFICIENT AND THERE IS NO PERMANENT ACTIVATION. ROCK HARDNESS MEANS NOTHING TO ELECTRON BEAMS. FOR ROCK BREAKAGE IT IS CRUCIAL THAT THE POWER BE RELEASED DEEP BELOW THE SURFACE. TEST RESULTS WITH 9 KW BEAM ON VARIOUS ROCKS ARE GIVEN. ELECTRON BEAM SHOULD BE ESPECIALLY APPLICABLE IN TUNNELING IN HARD ROCK.

23-69-01001 INFLUENCE OF SPHERICAL HEAD SIZE AND SPECIMEN DIAMETERS ON UNIAXIAL COMPRESSIVE STRENGTH OF ROCKS (ROCK-MECHANICS LABORATORY-TESTS)
HOSKINS, J. R. + HORINO, F. G. & U.S. BUR MINES
U.S. BUR MINES-REPORT INVESTIGATIONS 7334, JAN 16, 1969. UNIAXIAL COMPRESSIVE STRENGTH OF ROCK IS USUALLY DETERMINED IN LABORATORY FROM CYLINDRICAL SAMPLES THAT VARY IN DIA FROM 5/8 TO 8 IN USING SPHERICALLY SEATED COMPRESSION HEAD OF UNSPECIFIED SIZE. BUREAU OF MINES CONDUCTED SERIES OF TESTS TO DETERMINE INFLUENCE OF SPHERICAL HEAD SIZES AND SPECIMEN DIA THEMSELVES ON UNIAXIAL COMPRESSIVE STRENGTH. ANALYSIS OF DATA SHOWS THAT SPHERICAL HEAD SIZE DOES NOT SIGNIFICANTLY AFFECT UNIAXIAL COMPRESSIVE STRENGTH OF CYLINDRICAL ROCK SAMPLES BUT DIAMETER OF ROCK SPECIMENS DOES. 16 REFS.

23-69-01002 ROCK BREAKAGE BY LIGHT-GAS GUN PROJECTILES (SHOCK HYPERVELOCITY)
GREGSON, V. G., JR. + SINGH, M. M. & IIT RES INST CHICAGO ILL
FINAL REPORT NO. D6000-06 ILLINOIS INSTITUTE OF TECHNOLOGY RESEARCH INSTITUTE OFFICE OF HIGH SPEED GROUND TRANSPORTATION JAN 22, 1969. THIS REPORT DISCUSSES HYPERVELOCITY IMPACT ON ROCK TARGETS USING A LIGHT-GAS GUN WITH ZELUX PROJECTILES (SOLID AND WATER-FILLED). THE SPECIFIC ENERGIES FOR ROCK BREAKAGE RANGE FROM 120 TO 260 JOULES/CC (1,400 TO 3,200 FT-LB/CU IN.) FOR INDIANA LIMESTONE, AND FROM 80 TO 120 JOULES/CC (900 TO 1,500 FT-LB/CU IN.) FOR MILFORD PINK GRANITE. ROCK DESCRIPTIONS AND STRENGTH PROPERTIES ARE INCLUDED. PREVIOUS WORK ON BASALT BY GAULT (NASA) AND MOORE (USGS) IS INCLUDED. THE SPECIFIC ENERGIES COMPARED TO SPECIFIC ENERGIES INCURRED BY OTHER POTENTIAL DRILLING TECHNIQUES INDICATE THAT HIGH VELOCITY SOLID IMPACT IS A POTENTIAL METHOD TO INCREASE DRILLING RATES. A POTENTIAL METHOD IS DEVELOPED TO CALCULATE HYDRODYNAMIC CRATER VOLUMES FOR GIVEN IMPACT ENERGIES. THE GENERAL PROBLEM IS OUTLINED WHEREBY THE STRONG SHOCKS GENERATING THE HYDRODYNAMIC CRATER CAN BE EXTENDED TO INCLUDE SPALL AND FRACTURE EFFECTS.

23-69-04001 EXPERIMENTAL OBSERVATIONS OF ROCK FAILURE DUE TO LASER RADIATION (SPALLING THERMAL-BREAKING)
FARRA, G. + NELSON, C. R. + MOAVENZADEH, F. & M.I.T. CAMBRIDGE MASS
MASS INST TECH DEPT OF CIVIL ENGR R 69-16 FOR U.S. DEPT OF COMMERCE, APR 1969. A REPORT OF EXPERIMENTS ON THERMAL AND MECHANICAL RESPONSES OF ROCK TO LASER RADIATION. TEMPERATURE MEASUREMENTS WERE MADE ON THIN DISCS SUBJECTED TO LASER RADIATION. STRAIN MEASUREMENTS WERE MADE ON THIN DISCS SUBJECTED TO LASER RADIATION. CRACKING AND SPALLING PHENOMENA WERE OBSERVED AND EVALUATED FOR BOTH CONSTRAINED AND UNCONSTRAINED THIN DISCS SUBJECTED TO LASER RADIATION. A HEAT FLOW ANALYSIS AND A STRESS ANALYSIS PROGRAM WERE DEVELOPED FOR THE PROJECT. GOOD CORRELATIONS WERE OBTAINED BETWEEN THEORETICALLY PREDICTED RESPONSES AND ACTUAL OBSERVED RESPONSES TO LASER RADIATION. 30 REFS. 98 PAGES.

23-70-10001 EXAMINATION OF HIGH PRESSURE WATER JETS FOR MOLES (MOLES)
MCCLAIN, W. C. + CRISTY, G. A. & ORNL OAK RIDGE TENN
ORNL-HUD1 UC-38 ENGR. & EQUIP., JAN 1970. NOZZLES OF 2, 3, 4, AND 6 MM DIAMETER WERE USED TO PRODUCE HIGH VELOCITY WATER JETS WITH PRESSURES UP TO 11,000 PSI. THE JETS WERE TRAVERSED ACROSS SANDSTONE, LIMESTONE, AND GRANITE ROCK SPECIMENS (18 IN X 18 IN X 24 IN) AT RELATIVE VELOCITIES (ROCK TO JET) RANGING FROM 30 TO 90 CM PER SEC. THE THRESHOLD CUTTING PRESSURE FOR SANDSTONE WAS 2,000 PSI; FOR LIMESTONE - 3,500 PSI; FOR GRANITE - 6,000 PSI. SPECIFIC ENERGY OF CUTTING WAS INVERSELY PROPORTIONAL TO THE SQUARE ROOT OF THE TRAVERSING VELOCITY. FOR SINGLE CUTS IN SANDSTONE, SPECIFIC ENERGY AS A FUNCTION OF WATER JET PRESSURE DECREASED RAPIDLY FROM A VERY HIGH VALUE AT THE THRESHOLD PRESSURE TO A MINIMUM AT A TRANSITION REGION APPROXIMATELY 3 TIMES THE THRESHOLD PRESSURE, THEN GRADUALLY INCREASED. THE MINIMUM VALUES OBTAINED FOR SANDSTONE SINGLE CUTS WERE APPROXIMATELY 500 JOULES/CM3. THE LOWEST VALUES OBTAINED FOR SINGLE CUTS IN LIMESTONE AND GRANITE (2,000 AND 5,000 JOULES/CM3 RESPECTIVELY) WERE LOCATED ON THE DESCENDING PORTION OF AN ENERGY-PRESSURE CURVE. MINIMUM VALUES OF THE CURVE WERE PROBABLY NOT REACHED. EXPERIMENTS INVOLVING CUTS CLOSE ENOUGH TOGETHER TO PRODUCE INTERACTION BETWEEN SUCCESSIVE KERFS (FOR THIS REASON CALLED "KERFING" CUTS) GAVE A SPECIFIC ENERGY REQUIREMENT OF ABOUT ONE-HALF THAT FOR SINGLE CUTS. AT FLUID PRESSURES LESS THAN THE TRANSITION REGION, THERE WAS A MARKED DIFFERENCE IN SPECIFIC ENERGY DEPENDING UPON ORIENTATION OF THE CUT TO THE BEDDING PLANES OF THE SEDIMENTARY ROCKS OR TO THE FOLIATION OF GRANITE. BASED ON THE RESULTS OF THIS PRELIMINARY STUDY, A MECHANICAL MOLE USING WATER JETS AS CUTTING DEVICES APPEARS TO BE FEASIBLE AND FURTHER RESEARCH WHICH COULD LEAD TO THE DEVELOPMENT OF SUCH A MOLE IS RECOMMENDED.

FIELD 24 ARTICLES

24-57-01001 SEARCHING FOR NEW METHODS OF BREAKING HARD ROCK (ULTRASONICS INFRASONICS ELECTRO-HYDRAULIC HIGH-FREQUENCY-HEATING)
KRAUCHENKO, V. S.
GORNYI ZHURNAL, (132) NO 1, 36-43, JAN 1957. EXPERIMENTS WERE CONDUCTED ON NEW METHODS OF BREAKING HARD ROCKS INCLUDING: ULTRASONICS, INFRASONICS, HIGH FREQUENCY HEATING, AND ELECTROHYDRAULIC DRILLING. (IN RUSSIAN)

24-58-03001 HOW TO GET THE MOST HOLE FOR YOUR MONEY (PENETRATION BIT-WEIGHT ROTATION HYDRAULICS BIT JETS WEAR)
SPUR, J. W. & SHELL OIL CO
THE OIL & GAS JOURNAL, 90-96, MAR 31, 1958 & 148-156 APR 7, 1958. THIS IS A SIMPLE METHOD FOR DETERMINING COMBINATION OF BIT WEIGHT, ROTARY SPEED AND HYDRAULIC HORSEPOWER WHICH PORDUCES MIMINUM DRILLING COST. EMPERICAL RELATIONSHIPS ARE DEVELOPED TO SHOW INFLUENCE ON PENETRATION RATE OF WEIGHT ON BIT, ROTARY SPEED AND HYDRAULIC HORSEPOWER. PENETRATION RATE IS ONLY ONE OF FIVE FACTORS INFLUENCING FOOTAGE COST. OTHERS ARE: BIT LIFE, TIME REQUIRED TO PUT A NEW BIT ON BOTTOM, BIT COST, AND HOURLY RIG COST. WEIGHT WHICH RESULTS IN MINIMUN COST REFERRED TO AS OPTIMUM WEIGHT CANNOT BE ATTAINED IN SOME HARD FORMATIONS BECAUSE OF BIT FAILURE. IN IN DEVIATION PROBLEMS MAY RESTRICT WEIGHT. BECAUSE WEIGHT ON BIT HAS MORE EFFECT ON PENETRATION RATE THAN SPEED OF ROTATION AND SINCE SPEED OF ROTATION IS REDUCED AS WEIGHT IS INCREASED, AN OPTIMUM CURVE HAS BEEN CONSTRUCTED FOR THESE TWO PARAMETERS. THERE IS A CRITICAL HYDRAULIC HORSEPOWER FOR EACH WEIGHT ON IT IN A SPECIFIC FORMATION TO REMOVE CUTTING FROM HOLE BOTTOM, CARRY THEM TO THE SURFACE AND TO CLEAN THE BIT. SEVERAL TESTS OF WEIGHT VERSUS PENETRATION RATE WERE MADE TO ESTABLISH APPROPRIATE DRILLING INDEXES. A PROBLEM IS SOLVED TO DETERMINE OPTIMUM DRILLING TECHNIQUES FOR AVAILABLE RIG AND ALSO TO DETERMINE PUMP CAPACITY FOR OPTIMUM DRILLING.

24-58-10001 FIVE FACTORS THAT AFFECT DRILLING RATE (HYDRAULICS BIT-WEIGHT ROTARY-SHIELD HARD PRESSURE)
MOORE, P. L. & UNIV OKLAHOMA
THE OIL & GAS JOURNAL, 141-156, 160-170, OCT 6, 1958. FIVE FACTORS: HYDROSTATIO PRESSURE, BIT WEIGHT & ROTARY SPEED, MUD PROPERTIES, HYDRAULICS AND ECONOMICS, THAT EFFECT DRILLING RATE ARE DISCUSSED. INCREASES IN DRILLING RATE DUE TO HIGHER BIT WEIGHT AND ROTARY SPEED DEPEND ON PROPER USE OF HYDRAULIC HORSEPOWER. THIS MEANS THERE MUST BE ENOUGH HYDRAULIC HORSEPOWER THROUGH BIT TO REMOVE FORMATION CUTTINGS AS THEY ARE GENERATED SO THAT NO REGRINDING OCCURS. AT A GIVEN BIT WEIGHT AND ROTARY SPEED, DRILLING RATE INCREASES WITH HYDRAULIC HORSEPOWER UNTIL THERE IS COMPLETE CLEANING BELOW THE BIT. ABOVE THIS INCREASING HYDRAULIC HORSEPOWER HAS NO EFFECT ON DRILLING RATE. EFFECT OF FLUID PROPERTIES DOES NOT VERY DIRECTLY WITH HYDRAULICS HORSEPOWER. HOWEVER, WHEN IT IS NECESSARY TO INCREASE MUD WEIGHT, VISCOSITY OR SOLIDS CONTENT DRILLING RATE DECREASES. THIS DECREASE MAY BE MINIMIZED BY USING MORE HYDRAULIC HORSEPOWER AT BIT. LABORATORY TESTS SHOWED THERE WAS NO REGRINDING OF PARTICLES AT WATER FLOW RATE OF 3 GPM BUT REGRINDING STILL OCCURS AT 11 GPM WITH MUD. TO GET HIGH PENETRATION RATES AT LOWEST COST USE MIMINUM POSSIBLE MUD WEIGHT. VISCOSITY AND SOLIDS CONTENT AND MAXIMUM FILTRATION RATE. STEPS TO GET OPTIMUM DRILLING CONDITIONS ARE: CORRECT MUD PROPERTIES TO GIVE MAXIMUM DRILLING RATE, OPTIMISE BIT WEIGHT AND ROTARY SPEED, MAXIMIZE BIT HORSEPOWER WITH OPTIMUM CIRCULATING RATE. CHECK SURFACE HORSEPOWER TO SEE IF DRILLING RATE DROPS AT LOWER HORSEPOWER.

24-59-05001 SMOOTH BLASTING (DETONATION CRACKS CHARGE GUIDE-HOLES BURDEN PLANNING SUPERVISION)
LANGEFORS, U. & NITROGLYCERIN AB
WATER POWER, 189-195, MAY 1959. IN MODERN ROCK BLASTING IT IS POSSIBLE TO MAKE FINAL CONTOUR AS IF IT WERE CUT OUT OF ROCK AND LEAVE REMAINING MATERIAL PRACTICALLY UNDAMAGED. HOLE PLACEMENT AND DETONATION SEQUENCE MUST BE CHOSEN SO ROCK IS BLASTED AWAY SUCCESSIVELY WITH BREAKAGE TOWARDS FREE SURFACES. FOR CONTOUR HOLES CORRECT SIZE AND CONCENTRATION OF CHARGE IS IMPORTANT. CRACKS CAN BE GUIDED IN DEFINITE DIRECTIONS BY SPECIAL UNLOADED GUIDE HOLES. RATIO OF DISTANCE BETWEEN HOLES AND BURDEN SHOULD BE EQUAL TO OR LESS THAN EIGHT TENTHS. A SPECIAL HOLE CHARGE FOR SMOOTH BLASTING IS AVAILABLE ON THE MARKET. A DIAGRAM SHOWS AVERAGE UNEVENNESS OF FACE IN RELATION TO DISTANCE BETWEEN HOLES, BURDEN AND CHARGE SIZE. SKILLFUL PLANNING AND CAREFUL SUPERVISION ARE REQUIRED FOR SMOOTH BLASTING.

24-60-07001 IMPACT CRATER FORMATION IN ROCK (ROCK-BREAKING DRILLING RESEARCH)
MAURER, W. C. + RINEHART, J. S. & COLO SCHOOL OF MINES GOLDEN COLO
JOURNAL OF APPLIED PHYSICS, (31) NO 7, 1247-52, JULY 1960. CRATERS WERE PRODUCED BY FIRING 3/16 AND 3/32 INCH DIA STEEL PROJECTILES INTO SANDSTONE AND GRANITE AT VELOCITIES FROM 300 TO 6000 FT/SEC. IMPACT ANGLES OF 30, 60 AND 90 DEG WERE USED FOR SANDSTONE, 90 DEG FOR GRANITE. CRATERS FORMED BY TWO MECHANISMS (1) CRUSHING OF MATERIAL IN FRONT OF PROJECTILE (2) FRACTURING OCCURRING STEP WISE ALONG SPIRALS OF MAX SHEAR. VOLUME OF MATERIAL REMOVED AND DEPTH OF PENETRATION VARY LINEARLY WITH IMPACT VELOCITY AND INVERSELY WITH THE SPECIFIC ACOUSTIC RESISTANGE OF THE TARGET.

24-61-00001 EROSION BY LIQUID IMPACT (JET-DRILLING CAVITATION THRESHOLD)
DE CORSO, S. M. + KOTHMANN, R. E. & WESTINGHOUSE ELEC CORP
ASTM SPECIAL TECHNICAL PUBLICATION, N 307, 32-45, 1961. THE JET IMPACT MACHINE, DEVELOPED BY WESTINGHOUSE, DRIVES A LEAD PELLET INTO A LIQUID RESERVOIR THUS FORCING LIQUID OUT OF A NOZZLE AT VELOCITIES UP TO 4500 FT/SEC. THE JET CYLINDER REMAINS WELL DEFINED FOR AS MUCH AS TWO INCHES FROM THE NOZZLE. JET DIAMETERS OF 0.020, 0.040, AND 0.060 INCHES WERE USED. IMPACT TESTS WERE MADE ON A NUMBER OF METALS AND THE METALS RANKED ACCORDING TO THEIR RESISTANCE TO DAMAGE. NO INCREASE IN DAMAGE WAS NOTED WHEN SURFACE IRREGULARITIES WERE PRESENT. UNDER CERTAIN CONDITIONS LIGHT WAS EMITTED ON IMPACT. A JET HAVING AN IRREGULAR LEADING SURFACE WILL CAUSE SUBSTANTIALLY LESS DAMAGE THAN ONE OF SMOOTH SURFACE.

24-61-00002 DEFORMATION OF SOLIDS BY LIQUID IMPACT AT SUPERSONIC SPEEDS (EROSION SUPERSONIC-SPEED)
BOWDEN, F. P. + BRUNTON, J. H. & CAVENDISH LAB CAMBRIDGE MASS
ROYAL SOCIETY OF LONDON PROC VI (263A), 433-450, 1961. EXPERIMENTAL EVIDENCE SUGGESTS THAT FOR IMPACT VELOCITIES ABOVE 500 M/S A LIQUID MASS COLLIDING WITH A SOLID SURFACE BEHAVES IN A COMPRESSIBLE MANNER. AS A RESULT OF THIS, A SHORT INTENSE COMPRESSION PULSE MOVES INTO THE SOLID FROM THE REGION OF IMPACT. PART OF THE DEFORMATION PRODUCED IN THE TARGET CAN BE RELATED TO THIS COMPRESSION WAVE. IN THIS RESPECT THE LIQUID DEFORMS THE TARGET IN MUCH THE SAME WAY AS A SOLID PROJECTILE. THE MAIN DIFFERENCE IS THAT THE DURATION OF THE PRESSURE PULSE IS SHORTER IN THE CASE OF LIQUID IMPACT, AND MORE NEARLY RESEMBLES THE PULSE PRODUCED BY AN EXPLODING CHARGE. THE REMAINDER OF THE DEFORMATION CONSISTS OF A SHEARING OR TEARING OF THE SURFACE BROUGHT ABOUT BY LIQUID FLOWING AT HIGH SPEED ACROSS THE SURFACE. SURFACE FLATNESS INFLUENCES CONSIDERABLY THE EXTENT OF THIS TYPE OF DEFORMATION.

24-63-09001 THE SIMULATION OF PERCUSSION DRILLING IN THE LABORATORY BY INDEXED-BLOW STUDIES (IMPACT-DROP-TESTER)
HARTMAN, H. L. & PENN STATE UNIV
SOCIETY OF PETROLEUM ENGINEERS JOURNAL, (3) N 3, 214-26, SEPT 1963. LABORATORY TESTS HAVE BEEN CONDUCTED WITH AN IMPACT. DROP TESTER AND CHISEL-SHAPED BITS TO STUDY ASPECTS OF PERCUSSION DRILLING. BEDFORD LIMESTONE WAS EMPLOYED. THE VOLUME OF INDEXED CRATERS ON A FRESH OR DAMAGED SURFACE ALWAYS EXCEEDS THAT OF SINGLE-BLOW CRATERS. FOR ANY SHAPE OF CHISEL AND SURFACE CONDITION AT CONSTANT BLOW ENERGY THERE EXISTS AN OPTIMUM INDEX DISTANCE FOR WHICH CORRESPONDING CRATER VOLUME IS A MAXIMUM. OPTIMUM INDEX DISTANCE IS ALWAYS GREATER FOR BOTH BIT SHAPES ON A DAMAGED SURFACE THAN ON A FRESH ONE. VALUES OF THE OPTIMUM INDEX DISTANCE AND MAX. CRATER VOLUME VARY DIRECTLY WITH BLOW ENERGY FOR EITHER BIT OR SURFACE CONDITION. WITH DIES, THE OPTIMUM INDEX DISTANCE AND MAXIMUM CRATER VOLUME VARY INVERSELY AS THE WIDTH OF FLAT, WITH WEDGES, THE OPTIMUM INDEX DISTANCE VARIES WITH THE INCLUDED ANGLE; BUT MAXIMUM CRATER VOLUME DOES NOT FOLLOW A DISCERNIBLE TREND. THE LARGEST INDEXED CRATERS ARE FORMED BY DIES RATHER THAN WEDGES. DIFFERENCES IN STRAIN-TIME HISTORIES WERE OBSERVED BETWEEN SINGLE-BLOW AND INDEXED CRATERS. NO RELATIONSHIP EXISTS BETWEEN THE MAXIMUM CRATER VOLUME OF INDEXED BLOWS AND SINGLE-BLOW VOLUME OF A BIT AT CONSTANT ENERGY. CRATERING RESULTS ON A DAMAGED SURFACE ARE NOT SUSCEPTIBLE TO THE PLOTTING OF UNIVERSAL INDEXING CURVES. THESE RESULTS WERE BASED ON PARALLEL INDEXING ONLY TWO ROWS OF BLOWS AND MID-POINT SPACING OF CRATERS IN THE SECOND ROW.

24-63-09002 HYDRAULIC MINING AND HYDRAULIC TRANSPORTATION IN COAL MINES (PIPELINES)
MAURER, H.
GLUECKAUF, (99) NO 20, 1081-1100, SEPT 25, 1963. A SUMMARY OF THE METHODS AND THE ECONOMY OF MINING AND TRANSPORTING COAL BY HYDRAULIC MEANS. EQUIPMENT USED IN GERMAN HYDRO-MINES IS DESCRIBED. LIMITS OF THE HYDRAULIC METHOD ARE INDICATED. 31 REFS. (IN GERMAN)

24-63-09003 RAISE BORING AT THE MATHER MINE (HUGHES ROTARY-DRILLING COST)
ANDELIN, A. J. & CLEVELAND CLIFFS IRON CO
MINING CONGRESS JOURNAL, (49) 24-28, SEPT. 1963. IN 1960 CLEVELAND CLIFFS IRON CO AND HUGHES TOOL CO AGREED TO DEVELOP TOOLS TO BORE RAISES IN THE HARD, ABRASIVE GRAYWACKE OF THE MATHER MINE. THE PROTOTYPE MACHINE HAS AVERAGED NEARLY 13 FT/SHIFT IN DRIVING 1100 FT OF 48 IN DIA RAISES. IT PROVIDES THE HIGHEST DEGREE OF SAFETY YET OBTAINED AND HAS MAJOR COST ADVANTAGES, ESP. IN LONG RAISES, SINCE SETTING UP THE MACHINE IS THE MAJOR COST.

24-63-12001 ROCK DRILLING PATTERN WITH EXTRA PULL (BURN-CUT)
DANECKI, M. & NATIONAL COAL BOARD ENGLAND
STEEL AND COAL, 1109-1111, DEC 6, 1963. BURN-CUT DRILLING PATTERN WITH 3 IN DIA CENTER HOLE HAS RECENTLY BEEN TRIED WITH SUCCESS. THE CENTER HOLE IS REAMED OUT TO 3 IN DIA AND 4 IN TO 6 IN DEEPER THAN THE STANDARD SHOTHOLE TO PROVIDE A SECOND FREE FACE. THE SIMPLE DISTRIBUTION OF SHOTHOLES AT THE TUNNEL FACE MAKES IT ADVANTAGEOUS. VERY GOOD FOR ARGILLACEOUS STRATA. SAVINGS OF EXPLOSIVES UP TO 20 PERCENT. GREATER ADVANCE OF TUNNEL BECAUSE OF FULL PULL. EFFECTIVE CONTROL OF MUCKPILE MATTER.

24-63-12002 ENERGY BALANCE IN ROCK DRILLING (MOLES)
SIMON, R. & BATTELLE MEMOR INST COLUMBUS
SOC. OF PETROLEUM ENGINEERS JOURNAL, (3) N 4, 298-306, DEC. 1963. A RELATIVELY HIGH VALUE OF THE ENERGY PER UNIT VOLUME REQUIRED TO DRILL A HOLE INTO ROCK COMPARED WITH THAT REQUIRED FOR FRACTURE BY UNIAXIAL COMPRESSION OF A ROCK SPECIMEN IS ATTRIBUTED TO THE FACT THAT FOR EACH BASIC ACTION OF ROCK DRILLING, A CONCENTRATED LOADING ON AN ESSENTIALLY SEMI-INFINITE MEDIUM, THE ROCK FRAGMENTS BROKEN OUT REPRESENT ONLY A SMALL PORTION OF THE ROCK VOLUME THAT MUST BE LOADED IN ORDER TO OBTAIN THE NECESSARY STRESS CONDITIONS FOR THE BREAKOUT OF A ROCK FRAGMENT OFF TO THE SIDE OF THE LOADED REGION. MOST OF THE RESULTANT ELASTIC STRAIN ENERGY IS DISSIPATED, LARGELY IN THE FORM OF STRESS WAVES RESULTING FROM THE VERY HIGH RATES OF UNLOADING ASSOCIATED WITH THE PROPAGATION OF CRACKS IN THE MEDIUM. THE EFFICIENCY OF ROCK DRILLING IS REASONABLY HIGH WHEN DEFINED IN TERMS OF A COMPARISON OF THE VOLUME OF ROCK BROKEN OUT PER UNIT ENERGY INPUT WITH THE SAME QUANTITY MEASURED BY DROP TESTS WITH CHISELS. SYSTEMATIC RESEARCH INTO ENERGY REQUIREMENTS AND MECHANISMS OF ENERGY DISSIPATION FOR DIFFERENT METHODS OF ATTACKING ROCK, SUBJECT TO THE LIMITATIONS OF DOWN-HOLE GEOMETRY, IS REQUIRED TO DETERMINE THE FEASIBILITY OF OBTAINING A SUBSTANTIAL INCREASE IN THE EFFICIENCY OF ROCK DRILLING WITH PRACTICAL DOWN-HOLE DRILLING MECHANISMS.

24-63-12003 SMALL DIAMETER AN-FO BLASTING METHODS CUT UNDERGROUND MINING COSTS (SAFETY ARGENTINA)
ROSSETTI, M. + PREISZ, G. & COMPANIA MINERA AGUILAR S.A.
ENGINEERING AND MINING JOURNAL, (164) N 12, 94-97, DEC. 1963. THE USE OF CARTRIDGED AMMONIUM NITRATE - FUEL OIL MIXTURE AS AN EXPLOSIVE IN SMALL DIA HOLES IS A NEW PRACTICE. INITIAL TESTS AT AGUILAR MINE IN ARGENTINA SHOWED THAT A CARTRIDGED AN-FO MIXTURE GAVE BLASTING RESULTS EQUAL TO THOSE OBTAINED WHEN USING CONVENTIONAL 42 PERCENT GELATIN DYNAMITE. ADVANTAGES: BLASTING COST LOWER WITHOUT AFFECTING FRAGMENTATION, BLASTING EFFICIENCY, OR THE EXPLOSIVE FACTOR; MIXTURES ARE NOT CAP-SENSITIVE UNLESS CONFINED; NO EXCESS OF NO2 OR CO GASES. DISADVANTAGES: HIGHER CAPITAL INVESTMENT IS REQUIRED; UNDERGROUND RECEIVING DEPOTS MUST BE DRY; TWO EXPLOSIVES ARE NECESSARY. THE FOLLOWING PROCEDURES WERE DEVELOPED: 1) THE BORE HOLES WERE BLOWN AND CLEANED, 2) THE CHARGE IS TAPPED NORMALLY 3) COLLAR STEMMING IS ALWAYS USED, 4) AIR-WATER JETS ARE USED, 5) A 20-MIN. WAITING PERIOD PROVIDES ADEQUATE TIME FOR VENTILATION. TESTS ARE BEING RUN ON 10 PERCENT REPLACEMENT OF AMMONIUM NITRATE WITH NANO3. GAS TESTS OF THE STOPES REVEALED THAT NEITHER NO2 NOR CO FUMES IN DANGEROUS CONCENTRATIONS EXISTED 20 MIN. AFTER THE BLAST.

24-63-12004 EXPERIMENTS WITH WATER AS A DYNAMIC PRESSURE MEDIUM (ELECTRICAL-DISCHARGE ROCK-DISINTEGRATION)
FARMER, I. W. + ATTEWELL, P. B.
MINE AND QUARRY ENGINEERING, (29) 524-530, 1963. THE INABILITY OF WATER TO SUSTAIN SHEAR FORCES MAKES IT A DESIRABLE MEDIUM FOR PROVIDING THE PRIMARY PRESSURE MEDIUM FOR THE DISINTEGRATION OF ROCKS BY IMPULSE ENERGY RELEASE. TWO LABORATORY TESTS WERE RUN. THE FIRST USED WATER JETS AS THE BREAKING MEDIUM. THE RESULTS WERE SIMILAR TO RESULTS SHOWN BY PREVIOUS WORKERS ON IMPACT OF SOLID OBJECTS OF COMPARABLE MASS AND TERMINAL VELOCITY. THE SECOND LAB TEST USED WATER AS THE CONTACT MEDIUM FOR UNDERWATER ELECTRICAL DISCHARGE. THE RESULTS SUGGEST THAT THE UNDERWATER SPARK DISCHARGE IS A RELATIVELY CONVENIENT AND CHEAP BUT INEFFICIENT MEANS OF GENERATING IMPULSIVE POWER.

24-63-12005 EXPERIMENTS WITH WATER AS A DYNAMIC PRESSURE MEDIUM (INTENSIFIER JET DIFFUSION NOZZLE SPARK DETONATOR EXPLOSIVE)
FARMER, I. W. + ATTEWELL, P. B. & UNIV SHEFFIELD ENGLAND
MINE & QUARRY ENGINEERING, 524-530, DEC 1963. INHERENT PROPERTIES OF WATER, PARTICULARLY ITS INABILITY TO SUSTAIN SHEAR, SUGGEST THAT IT MIGHT POSSES PARTICULAR ADVANTAGES AS A PRESSURE MEDIUM IN IMPULSIVE DEGREDATION OF ROCKS AND OTHER BRITTLE MATERIALS. TWO LABORATORY TESTS ARE DESCRIBED IN WHICH WATER TRANSMITS DYNAMIC ENERGY, FIRST AS A HIGH PRESSURE WATER JET AND SECOND IN CONTACT WITH AN UNDERWATER ELECTRICAL DISCHARGE. CONSIDERING A JET, THE MATERIAL DIRECTLY IN LINE IS SUBJECTED TO COMPRESSIVE FORCES WHICH USUALLY EXCEED THE DYNAMIC COMPRESSIVE STRENGTH OF THE ROCK. IMMEDIATELY ADJACENT TO ACTUAL JET CONTACT AREA, THE ROCK IS SUBJECTED TO TENSION AND SHEAR FORCES WHICH GENERALLY ADD TO THE DEGRADATION MECHANISMS. RATE OF STRAIN ADSORPTION EFFECTS ASSOCIATED WITH LIQUID JETS MIGHT BE IMPROVED BY INJECTING SMALL AMOUNTS OF CONTAMINANT INTO PRESSURIZED WATER TO IMPROVE RATE OF DIFFUSION OF THE LIQUID FOR IMMEDIATE ADSORPTION ON THE NEWLY CREATED CRACK SURFACES. IF THE ROCK BEGINS TO BEHAVE HYDRODYNAMICALLY THEN THE CRATERING PROCESS WOULD BE SIGNIFICANTLY ACCELERATED. PRESSURE INTENSIFIERS, NOZZLES AND THE UNDERWATER DISCHARGE OF EXPLOSIVES AND SPARKS ARE DISCUSSED. SPARK DISCHARGE MAY BE DEVELOPED SO THAT IT WILL BECOME A DETONATOR OF CONDENSED EXPLOSIVES AND AMMONIUM NITRATE, DIESEL OIL MIXTURES.

24-64-00001 "BIG-HOLE" DRILLING TECHNIQUES OF THE ATOMIC ENERGY COMMISSION
PRESLEY, C. K. & U.S. AEC LAS VEGAS NEV
APL DIVISION PRODUCTION-DRILLING AND PRODUCTION PRACTICE, 87-89, 1964. SEVERAL DIFFERENT DRILLING TECHNIQUES (AND VARIATIONS THEREON) HAVE BEEN UTILIZED AT THE NEV TEST SITE, AND ELSEWHERE, IN THE DRILLING OF MORE THAN 90,000 FT OF HOLES HAVING A CASED DIA OF 29 IN (DRILLED DIA 36 IN) OR GREATER. APPROXIMATELY 30,000 ADDITIONAL FT OF HOLE WITH DRILLED DIA OF 26 IN TO 36 IN HAVE ALSO BEEN COMPLETED. METHODS SUCH AS MUD DRILLING AND AIR DRILLING HAVE HAD THEIR DEFICIENCIES--IN EQUIPMENT LIMITATIONS, COST, TIME OR A COMBINATION OF THESE. CERTAIN COMBINATIONS OF DRILLING CONDITIONS EXISTING AT THE NEV TEST SITE INDICATE THAT ENTIRELY NEW EQUIPMENT AND/OR TECHNIQUES MUST BE DEVELOPED IF BIG HOLES ARE TO BE SUCCESSFULLY DRILLED WHEN THESE CONDITIONS EXIST.

24-64-01001 EQUIPMENT FOR INVESTIGATION OF TORCH OF JET DRILL BURNER (FLAME-JET)
BRICHKIN, A. V.
GORNYI ZHURNAL, N 1, 179-188, 1964. DESIGN AND TECHNICAL FEATURES OF ELECTRONIC MEASURING AMPLIFIER CONSISTING OF INTAKE DEVICE, VOLTAGE AMPLIFIER, VACUUM TUBE VOLTMETER, OSCILLOGRAPH OR MAGNETIC TAPE RECORDER, POWER AMPLIFIER CONNECTED WITH AUTOMATIC CONTROL OF DRILL ROTATION AND INDICATOR OF DISTANCE BETWEEN JET DRILL BURNER AND SURFACE OF BLAST HOLE BOTTOM. (IN RUSSIAN)

24-64-02001 SIZE OF ROCK FRAGMENTS PRODUCED DURING JET FLAME PIERCING
MOSKALEV, A. N.
GORNYI ZHURNAL, N 2, 93-99, 1964. ANALYSIS OF FRAGMENTS PRODUCED INDICATES THAT THE SIZE DECREASES WITH INCREASE OF PRESSURE AND RATE OF JET PIERCING. SIZE OF ROCK CHIPS IS AN INDICATION OF JET PIERCING CONDITION IN VARIOUS ROCKS. (IN RUSSIAN)

24-64-02002 POWER REQUIRED TO DISINTEGRATE ROCK DURING EXPLOSIVE PIERCING OF BLAST-HOLES
SHUKHMAN, V. L.
GORNYI ZHURNAL, N 2, 46-50, FEB 1964. EXPERIMENTAL DATA ON POWER REQUIRED ARE COMPARED WITH DATA ON CONVENTIONAL METHODS OF DRILLING USING AIR AND WATER-AIR AS CIRCULATING MEDIA IN ROCKS OF 9 TYPES EACH CHARACTERIZED BY SPECIFIC STRENGTH. TWO TYPES OF EXPLOSIVES WERE USED. THE HOLES DRILLED WERE APPROXIMATELY 300 MM DIA IN LIMESTONE, ABOUT 200 MM IN THE OTHER ROCKS. MINIMUM DEPTH OF BROKEN ROCK IN QUARTZITE WAS 44 MM MAXIMUM 83 MM. IN LIMESTONE MAXIMUM DEPTH PER CHARGE WAS 110 MM. FOR FERROUS QUARTZITES OF STRENGTH 16 THE SPECIFIC POWER WAS 130 KG - M PER CU-CM (1274 J/CC). RATE OF DRILLING DEPENDS ON RAPIDITY OF EXPLOSION AS WELL AS DEPTH OF PENETRATION PER EXPLOSION. FROM LIMITED EXPERIMENTAL DATA, RATE OBTAINABLE WILL BE 250-300 EXPLOSIONS PER HOUR. IN QUARTZITES OF PROTODYA KNOWN STRENGTH 16 THIS GIVES DRILLING RATES OF 10-12 M/HR.

24-64-03001 FULL-SCALE EXPERIMENTS ON JETS IN IMPERMEABLE ROCK DRILLING (JET-BIT-DRILLING)
FEENSTRA, R. + VAN LEEUWEN, J. J. M. & KONINKLISKE/SHELL NETHERLANDS
JOURNAL OF PETROLEUM TECH., 329-336 MAR 1964. USE OF JET BITS IN OIL WELL DRILLING HAS BEEN INCREASING. TO STUDY THIS EFFECT, LAB DRILLING TESTS WERE PERFORMED WITH 8 - 1/2-IN. COMMERCIAL BITS UNDER BOTTOM HOLE PRESSURES REPRESENTATIVE OF DEEP WELLS. INVESTIGATION WAS RESTRICTED TO IMPERMEABLE ROCK. TRANSPORT OF LOOSE CUTTING TOWARDS THE ANNULUS DOES NOT REQUIRE A POWERFUL JET ACTION. INDEED, WELL DRILLING, BIT PENETRATION IS HAMPERED BY THE

EXISTENCE OF A DIFFERENCE IN PRESSURE BETWEEN THE FLUID IN THE HOLE AND THAT IN THE ROCK. TWO RANGES WERE DISCERNED: 1) THAT IN WHICH THE REDUCTION FACTOR IS ALMOST INDEPENDENT OF HOLE PRESSURE, AND 2) THAT IN WHICH THE REDUCTION FACTOR IS SMALLER AND ALMOST PROPORTIONAL TO THE HOLE PRESSURE. INVARIABLY PENETRATION RATE WAS FOUND TO INCREASE WITH NOZZLE VELOCITY. CIRCULATION RATES OVER 250 GAL/MIN DID NOT INCREASE PENETRATION RATE PERCEPTIBLY. AT ELEVATED PRESSURE, BIT-BALLING IS MOST PRONOUNCED IN SOFT TO MEDIUM-HARD ROCK, SUCH AS SHALE. A HIGH FLUID VELOCITY IS REQUIRED IN FRONT OF THE TEETH. EROSION OF WHAT PLASTER THERE IS ON THE HOLE BOTTOM REDUCES THE HOLD-DOWN EVEN AT MODERATE JET INTENSITY WHEREAS HIGHLY INTENSIVE BOTTOM SCAVENGING IS REQUIRED FOR REDUCING THE BOTTOM-BALLING.

24-64-03002 AMMONIUM NITRATE FUEL OIL BLASTING AGENTS (AN-FO TUNNELING EXPLOSIVES)
SUTTON, D. T. + PUGSLEY, T. F.
MINING MAGAZINE, 156-161, MAR. 1964. IN NORTH AMERICA, 70% OF ALL PRODUCTION ROCK-BREAKING IN OPEN CAST AND UNDERGROUND OPERATIONS TOGETHER IS NOW ACHIEVED BY THE USE OF AN-FO BLASTING AGENTS. THE NON-USE OF AN-FO HAS BEEN DUE TO ECONOMIC REASONS. AN INERT MATERIAL SUCH AS DIATOMACEOUS EARTH IS USED AS A COATING FOR PRILLED NITRATE. HOWEVER, IT LOWERS THE SENSITIVITY OF THE AMMONIUM NITRATE WHEN USED IN BLASTING AGENT MIXTURES. AN-FO HAS BEEN USED SUCCESSFULLY IN DRILL HOLES AS SMALL AS 1 1/4 IN. IT IS DESIRABLE TO HAVE AN OXYGEN-BALANCED MIXTURE OF AN-FO TO OBTAIN THE MAXIMUM EFFICIENCY. THE PREPARATION OF AN AN-FO MIXTURE IS A SIMPLE OPERATION PERFORMED AT LOW COST. PREMIXED AN-FO MIXTURES IN MULTIWALLED BAGS HAVE A SHELF LIFE RANGING FROM 2 TO 7 DAYS. PRESENTLY THREE TYPES OF LOADERS ARE AVAILABLE FOR CHARGING SMALL DIA DRILL HOLES: VENTURI, PRESSURE-VESSEL LOADER, AND A COMBINATION. THE VENTURI IS USED FOR SHORT HOLES. THE SECOND TYPE FOR HEAVIER ONES. FORMATION OF STATIC ELECTRICITY ON AN-FO LOADING EQUIPMENT AND HOSES IS STILL A PROBLEM. IN THE PRESSURE VESSEL LOADER, THE SOLID COLUMN OF DRILLS TENDS TO REDUCE THE ACCUMULATION OF STATIC ELECTRICITY. THE VENTURI TENDS TO INCREASE IT. THE LOADING AREA CAN ALSO BE SPRAYED WITH WATER VAPOR. THE ONLY SEVERE LIMITATION TO THE USE OF AN-FO BLASTING AGENTS IS WHERE THE HOLES ARE SUBMERGED. INCREASED SAVINGS ARE GAINED BY USING AN AN-FO BLASTING AGENT. HOWEVER, THE EMPLOYMENT OF AN-FO SYSTEM INVOLVES THE CAPITAL AND MAINTENANCE COSTS OF LOADERS, INCREASED TRANSPORT COSTS AND AN INCREASE IN COMPRESSED AIR CONSUMPTION. IT DOES PROVIDE SAVINGS IN COST OF MATERIALS AND LABOR.

24-64-03003 INVESTIGATION OF RESULTS OF SINGLE JET BURNERS UNDER WORKING CONDITIONS (FLAME-JET)
BRICHKIN, A. V. + SYNDYUKOV, V. M.
ZORNYI ZHURNAL, N 3, 43-46, MAR 1964. PERFORMANCE OF JET PIERCING DRILL IS EVALUATED ACCORDING TO CONSUMPTION OF FUEL-GAS/SEC/UNIT OF BOTTOM HOLE SURFACE AREA. ECONOMIC EVALUATION OF FLAME JET PIERCING IS MADE ACCORDING TO SPACE VELOCITY. (IN RUSSIAN)

24-64-03004 FULL SCALE EXPERIMENTS ON JETS IN IMPERMEABLE ROCK DRILLING (HOLD-DOWN BITS BIT-BALLING BOTTOM-BALLING LOAD)
FUNSTRA, R. + VAN LEEUWEN, J. J. M. & SHELL EXPLORATIE LAB
JOURNAL OF PETROLEUM TECHNOLOGY, 329-336, MAR 1964. BIT PENETRATION EFFECT OF JETS WAS INVESTIGATED WITH A 50 TON DRILLING MACHINE AND 8 1/2 IN. COMMERCIAL JET BITS DRILLING UNDER BOTTOM HOLE CONDITIONS. CONCLUSIOUS APPLY TO DRILLING IMPERMEABLE ROCK. WITH PERMEABLE ROCK HOLD-DOWN IS OF A DIFFERENT NATURE SO THAT DIFFERENT RELATIONS MAY BE EXPECTED. PENETRATION RATE IS PRIMARILY HAMPERED BY A DIFFERENTAL PRESSURE EFFECT KNOWN AS DYNAMIC HOLD-DOWN. JET ACTION CAN REDUCE THIS SLIGHTLY. MAJOR GAIN IN PENETRATION RATE, UP TO 25 OR 50 PERCENT, IS ALREADY OBTAINED AT MEDIUM-HIGH JET POWER. AT HIGH BIT LOAD, PENETRATION BY SOFT TO MEDIUM-HARD FORMATION BITS IS HAMPERED BY BITS-BALLING. IT ALLEVIATION REQUIRES INTENSIVE TOOTH SCAVENGING WHICH IS BEST PERFORMED BY SLANTED NOZZLES WITH TRAILING, HIGH VELOCITY, HIGH-VOLUME JETS, HITTING BOTTOM IN FRONT OF TEETH. PENETRATION MAY THUS BE IMPROVED BY 100 PERCENT. AT HIGH BIT LOAD BOTTOM-BALLING MAY LIMIT PENETRATION OF INSERT-TYPE BITS. IN THIS CASE BOTTOM SCAVENGING IS REQUIRED WHICH IS MOST EFFECTIVELY PERFORMED WITH HIGH VELOCITY JETS FROM NOZZLES CLOSE TO BOTTOM. BY THIS PENETRATION MAY IMPROVE 70 PERCENT. TOOTHED HARD-FORMATION BITS SUFFER AT HIGH BID LOADS FROM BOTH BIT AND BOTTOM BALLING. SLANTED NOZZLES, POSSIBLE MUCH EXTENDED, WITH HIGH-VOLUME JETS THEN HAVE BEST-PROSPECTS.

24-64-04001 BASIC FACTORS AFFECTING ROCK DRILLING PART 1 INTRODUCTION AND PERCUSSIVE DRILLING
FISH, R. G. & INSTITUTE OF QUARRYING
QUARRY MANAGERS' JOURNAL, (48) 135-142, APR 1964. PERCUSSIVE DRILLING IN BRITTLE ROCK MAY RESULT IN SHATTERING. IN SOFT ROCK THE MACHINE MAY STALL IF ENERGY PER BLOW IS HIGH RESULTING IN TOO DEEP PENETRATION. OPTIMUM THRUST FOR MAXIMUM PENETRATION IS DEFINED. WITH THE DOWN-THE-HOLE MACHINE ENERGY LOSSES IN TRANSMISSION ARE ELIMINATED. FOR THE PNEUMATIC FLUSHING OF DEBRIS THE CRITICAL VELOCITY DEPENDS ON THE TERMINAL VELOCITY WHICH THE PARTICLE WOULD ATTAIN IF FALLING FREE IN THE STILL FLUID.

24-64-05001 JET PIERCING DRILLS WITH ANNULAR COOLING SYSTEMS
MOSKALEV, A. N. + POPOV, V. M. + FEDIN, I. A.
GORNYI ZHURNAL, NO 5, 45-46, MAY 1964. AN INVESTIGATION OF THE PROBLEM OF COOLING THE DRILLS DURING THE EXTREMELY COLD WINTERS IN THE URALS. RAISING THE TEMPERATURE OF THE WHOLE COOLING SYSTEM IS NECESSARY TO PREVENT FREEZING OF WATER IN THE SYSTEM. USE OF CIRCULATING KEROSENE AS A COOLANT IS CONSIDERED. THIS PREHEATING OF THE FUEL IMPROVES THE PERFORMANCE.

24-64-05002 TRENDS IN SHAFT DESIGN, SHAFT-SINKING METHOD & EQUIPMENT (STAGE CIRCULAR-SHAFT RECTANGULAR-SHAFT COST)
GILLINGHAM, W. & BOYLES BROS DRILL CO SALT LAKE
MINING CONGRESS JOURNAL, 45-49, MAY 1964. TOO MANY SHAFTS ARE DESIGNED WITH NO CONSIDERATION GIVEN TO SHAFT-SINKING METHODS AND EQUIPMENT AND WILL COST CONSIDERABLE MORE THAN IT SHOULD. CONSULTATION WITH REPUTABLE SHAFT CONTRACTORS PRIOR TO FINAL DESIGN OFTEN WILL RESULT IN CONSIDERABLE SAVINGS. IN LARGE DEEP SHAFTS THE SOUTH AFRICAN METHOD OF SHAFT SINKING USING A MULTI-DECK GALLOWAY STAGE SUSPENDED BY ROPES ATTACHED TO AN INDEPENDENT HOISTING SYSTEM RESULTS IN THE MOST RAPID SINKING. CIRCULAR SHAFTS ARE GAINING FAVOR OVER RECTANGULAR AS THEY ARE STRONGER, REQUIRE LESS MAINTENANCE, OFFER LESS RESISTANCE TO VENTILATING AIR PASSAGE, REQUIRE LESS STEEL AND ARE FAR EASIER TO LINE. HOWEVER, TO FIT EQUIPMENT INTO A CIRCULAR SHAFT RATHER THAN RECTANGULAR IT MUST BE LARGER IN CROSS-SECTIONAL AREA AS THERE IS MORE WASTED AREA. THE CONSTRUCTION, AND SINKING RATE OF SEVERAL SHAFTS ARE GIVEN.

24-64-06001 HARDNESS REDUCTION THROUGH WETTING (CHEMICAL-SOFTENING)
HEINS, R. W. + STREET, N. & UNIV WISC AND UNIV ILL
SOCIETY OF MINING ENGINEERS, 223-224, JUNE 1964. A STUDY OF THE USEFULNESS OF THE KUZNETSOV PENDULUM AS A MEANS OF STUDYING ROCK DRILLABILITY AND OF THE EFFECTS OF VARIOUS LIQUIDS ON THE PENDULUM HARDNESS OF BAVARIAN LIMESTONE. LIQUIDS STUDIED INCLUDE GLYCERIN, WATER, ANILINE, ETHYLENE GLYCOL, NITROBENZENE, BENZALDEHYDE, BENZENE, TOLUENE, ETHYL ALCOHOL, N-BUTYL ALCOHOL.

24-64-06002 BASIC FACTORS AFFECTING ROCK DRILLING PART 2 ROTARY PERCUSSION DRILLING
FISH, R. G. & INSTITUTE OF QUARRYING
QUARRY MANAGERS' JOURNAL, (48) 219-226, JUNE 1964. IN ROTARY DRILLING A MAXIMUM PENETRATION MAY BE REACHED WHEN DRILLING DEBRIS IS BEING CREATED AT A GREATER RATE THAN IT CAN BE EVACUATED FROM THE DRILL HOLE. A ROCK OF HIGH STRENGTH BUT LOW INTRINSIC ABRASIVENESS MAY BE A FEASIBLE ROTARY DRILLING PROPOSITION. EXCEPT AT VERY HIGH PENETRATION RATE LEVELS, ROTARY-PERCUSSIVE DRILLING NEEDS ONLY HALF THE THRUST OF ROTARY DRILLING AND GIVES A PENETRATION RATE IN EXCESS OF THAT ASSOCIATED WITH PERCUSSIVE DRILLING. PRACTICAL BENCH HEIGHTS OF 50-60 FT LEAD TO A HOLE DIA OF THE ORDER OF 3 1/4 TO 4 IN. WITH A BURDEN AND SPACING OF THE ORDER OF 10 FT X 10 FT. GIVEN MODERN TYPICAL FACE CONDITIONS IT SEEMS UNLIKELY THAT A HOLE DIAMETER OF MORE THAN 4 1/2 IN. IS JUSTIFIED. INCREASING THE DIA INCREASES DISPORTIONATELY CAPITAL COST OF THE EQUIPMENT AND THE EXTENT OF THE DRILLING PROBLEMS.

24-64-06003 HYDRAULIC PITCH MINING AT VICARY CREEK (CANADA COAL-MINING)
DISKEN, J. J. + HEINER, C. P.
ROCKY MTN. COAL MINING INSTITUTE, 60TH PROC., 63-65, JUNE 28-JULY 1, 1964. EXPERIENCE WITH LONG HOLE HYDRAULIC MINING NEAR COLEMAN, ALBERTA, WITH SEAM THICKNESS OF 20 TO 40 FT SHOWS THAT IT IS PRACTICAL IN COAL SEAMS HAVING MINIMUM PITCH OF 30 DEGREES. ROOF MUST BE STRONG, AND DEPOSIT MUST HAVE CONSISTENCY. THIS METHOD ELIMINATES USE OF TIMBER IN MINING AREAS, SINCE MINERS DO NOT WORK IN CUTTING ZONES. COMPLETE HYDRAULIC MINING SYSTEM WITH HYDRAULIC TRANSPORTATION REQUIRES SMALLER NUMBER OF OPERATING AND MINING PERSONNEL AS COMPARED WITH CONVENTICNAL MINING SYSTEM.

24-64-06004 EROSION TESTS OF STEAM TURBINE BLADE MATERIALS (EROSION VELOCITY JET-PENETRATION DAMAGE THRESHOLD)
DECORSO, S. M. & WESTINGHOUSE ELEC CORP
ASTM PROC, (64) 782-796, JUNE 21-26, 1964. EROSION PRODUCED BY SINGLE SHOT WATER JET IMPINGEMENT ON MATERIALS SUITABLE FOR STEAM TURBINE BLADING WAS STUDIED. MATERIALS WERE TITANIUM ALLOYS, CHROMIUM STEEL, STELLITE AND COPPER. EROSION DAMAGE PRODUCED WAS MEASURED AND PLOTTED VERSUS JET VELOCITY. A METHOD OF RANKING THE MATERIALS FOR EROSION RESISTANCE DEPENDING ON AN UPPER TOLERANCE LIMIT OF THE EROSION DATA WAS FOUND TO BE CONSISTENT WITH TURBINE FIELD EXPERIENCE. TITANIUM ALLOY MATERIALS ARE RANKED SIGNIFICANTLY BETTER IN EROSION RESISTANCE THAN CHROME STEEL OR STELLITE. A VISIBLE VELOCITY THRESHOLD OF DAMAGE WAS DETERMINED FOR SOME MATERIALS USING LIQUID JETS OF VARYING DIAMETERS. CONCLUSIVE PROOF OF THE METHOD'S APPLICABILITY MUST AWAIT A DETERMINATION OF THE ACCURACY WITH WHICH IT PREDICTS EROSION PERFORMANCE IN SERVICE FOR NEW MATERIALS. THE APPARATUS PERMITTED SPEEDS UP TO 4600 FT/SEC.

24-64-07001 FOUNDATION-ENGINEERING PROBLEMS IN UNDERWATER TUNNEL CONSTRUCTION (OPEN-CUT CONSTRUCTICN SINKING-METHOD CAISSON-METHOD SHIELD-METHOD)
SCHENCK, W., SR.
VEREIN DEUTSCHER INGENIEURE, DUSSELDORF, (106) N 20, 853-96, JULY 1964. VARIOUS FOUNDATION-ENGINEERING PROBLEMS ENCOUNTERED IN UNDERWATER TUNNEL CONSTRUCTION ARE DISCUSSED WITH REGARD TO THEIR ECONOMIC AND STRUCTURAL ADVANTAGES AND DISADVANTAGES. FOUR METHODS FOR SOLVING THE DIFFERENT PROBLEMS WERE ENCOUNTERED. (1) CONSTRUCTION IN AN OPEN CUT, (2) THE FLOATING AND SINKING METHOD, (3) SINKING AS A CAISSON, AND (4) THE SHIELD METHOD. THE DIFFERENCE BETWEEN FLOATING UNIT CONSTRUCTION METHODS IN THE U.S. AND IN EUROPE WAS THAT THE AMERICANS USE A CIRCULAR CROSS SECTION WHEREAS THE EUROPEANS USE A RECTANGULAR CROSS SECTION WITH A COMPACT HEIGHT. EUROPEANS SAY THAT THE CIRCULAR CROSS SECTIONS REQUIRE A GREATER CONSTRUCTION HEIGHT AND THEREBY A LOWER TUNNEL LOCATION WITH LONGER RAMP SECTIONS. (IN GERMAN)

24-64-08001 DRILLING LARGE DIAMETER HOLES FOR SHAFTS (ROTARY-DRILLING BIT CIRCULATORY-SYSTEM COST SAFETY)
BROMLEY, E. C. & BAWCOM, J. W. & NORTH AMERICAN DRILLING COMPANY
MINING CONGRESS JOURNAL, 27-32, AUG 1964. SAVINGS IN SHAFT SINKING COST BY USING ROTARY DRILLING RATHER THAN CONVENTIONAL METHODS IS INFLUENCING ACCEPTANCE OF SMALLER MINING SHAFTS AND THIS EXPERIENCE WILL EXPEDITE DEVELOPMENT OF NEW ECONOMIES. DEEP HOLES OF 130 IN. DIAMETER AND SHALLOW HOLES OF 178 IN. DIA HAVE BEEN ROTARY DRILLED EITHER BY REAMING A PILOT HOLE LARGER OR BY USING A SINGLE OR MULTIPLE STAGE BIT TO DRILL IT WITH ONE PASS. SINCE ALL PERSONNEL ARE ABOVE GROUND WITH ROTARY DRILLING, IT IS SAFER THAN CONVENTIONAL SHAFT SINKING. MOST ROTARY DRILLING PROBLEMS INVOLVE EITHER BIT CUTTING ACTIONS OR CIRCULATORY SYSTEM. A COMPLETE STUDY OF DRILLING CONDITIONS AND FORMATION DRILLABILITY SHOULD BE A PREREQUISITE TO DETERMINING FEASIBILITY OF ANY DRILLING JOB. COMPONENTS OF A DRILLING PLANT ARE OUTLINED AND CUTTING REMOVAL BY AIR OR WATER, LINING REQUIREMENTS AND HOLE ALIGNMENT ARE DISCUSSED. THREE WAYS ARE GIVEN TO ACHIEVE REVERSE CIRCULATION.

24-64-09001 THE NEXT PROBLEMS OF DEVELOPMENT OF HYDRAULIC METHOD OF EXTRACTION OF COAL
KUZ'MICH, A. S.
UGOL, (9) 1-5, SEPT 1964. THE PRODUCTION OF COAL FROM THE ODESSA-KOMSOMAL HYDRO MINE NO. 2 INCREASED BY A FACTOR OF FOUR OVER THE FORMER TECHNOLOGY. PRODUCTIVITY OF LABOR IN AUG 1963 EXCEEDED 100-T PER MONTH COMPARED TO 40 T BY USUAL TECHNOLOGY. HYDROMINES HAVE ALREADY REALIZED SHARP REDUCTION TO HEALTH HAZARDS TO WORKERS. RESEARCH INDICATES THE EFFICIENCY OF CUTTING CAN BE INCREASED BY INCREASING THE PRESSURE OF THE USUAL DIA JETS FROM (80 TO 120 ATM) TO (150 TO 250 ATM) AND OF THE SMALLER DIA JETS FROM (80 TO 120) TO (250 TO 500) ATM. IMPULSE JETS WITH PRESSURES FROM 3000 UP TO 10,000 ATM ARE VERY EFFICIENT FOR THE REMOVAL OF VERY HARD COAL AND OTHER HARD ROCKS. THE MINE EFFICIENCY CAN BE IMPROVED BY DEVELOPMENT OF MORE EFFECTIVE HYDRAULIC AND MECHANICAL HYDRAULIC MACHINES WHICH CAN BE AUTOMATED. SINGLE AND TWO STAGES PUMPS ARE BEING USED SUCCESSFULLY FOR SLURRY PUMPING. SINGLE STAGE PUMPS WITH CAPACITIES UP TO 175 METERS (HEAD?) SHOW HIGH RELIABILITY AND GOOD OPERATING QUALITIES. INCREASED RELIABILITY AND LONGER LIFE OF THE MEANS OF HYDRAULIC TRANSPORT IS DESIRED. A 20 TO 30 KM EXPERIMENTAL SLURRY LINE WILL BE BUILT TO INVESTIGATE PROBLEMS OF THICK SLURRIES AND THE APPLICATION OF TRANSPORT FROM MINE TO CONSUMER. MEANS OF FILTERING THE WATER AND DEWATERING FINE COAL NEED TO BE STUDIED. ALSO METHODS OF RECOVERY OF THIN SEAM NEEDS FURTHER DEVELOPMENT. (IN RUSSIAN)

24-64-09002 HYDRAULIC MINING RESEARCH - A PROGRESS REPORT (NOZZLE COAL-MINE JETSTREAM JET-TRAVERSE FACE-LIGHTING FLUSHING)
PALOWITCH, E. R. + MALENKA, W. T. & U.S. BUR MINES PITTSBURGH PA
MINING CONGRESS JOURNAL, 66-73, SEPT 1964. MANY SIZES AND TYPES OF NOZZLES WERE TESTED IN COAL MINES. THE 3/8 IN DIA TAPERED NOZZLE HAVING A STRAIGHT SECTION 3 DIA (3D) LONG WAS THE MOST EFFICIENT BECAUSE THE PRESSURE DROP ACROSS THE NOZZLE WAS THE LOWEST. THIS NOZZLE ALSO PRODUCED THE MOST COMPACT STREAM WITH A HIGH PRESSURE CENTER HAVING AN EFFECTIVE DIA. OF 0.8 IN. AT A DISTANCE OF ONE FOOT FROM THE FACE. AT THE HIGHEST PRESSURE, TWO TONS OF COAL COULD BE CUT PER MIN AT 5000 PSI. ANTHRACITE CUTTING RATE (.4TPM) WAS 1/5 OF BITUMINOUS RATE. A HYDRAULIC MINING MACHINE WAS USED IN A MINE AT 1000 HP, 5000 PSI, 0.99 TPM AND 10.2 KWH PER TON. SEALED BEAM FACE LIGHTING WAS ESSENTIAL FOR EFFICIENT HYDRAULIC MINING. AT VERY HIGH MINING RATES THERE WAS INSUFFICIENT WATER TO MOVE THE COAL TO THE MAIN CHUTE.

24-64-09003 ROCK PENETRATION BY HIGH VELOCITY WATER JET (COMPRESSIVE-STRENGTH HEALTH NOZZLE SAFETY)
FARMER, I. W. + ATTEWELL, P. B. & UNIV SHEFFIELD ENGLAND
INT J ROCK MECHANICS MIN SCIENCE, (2) 135-153, SEPT 1964. HIGH SPEED WATER JETS WOULD NOT ONLY BE SAFER AND LESS HAZARDOUS TO HEALTH THAN ACCEPTED METHODS OF ROCK FRACTURING BUT THEY MAY BE MORE EFFICIENT. THEORY OF JET DISINTEGRATION, NOZZLE DESIGN, IMPACT AND WATER JET PENETRATION ARE GIVEN. FIVE DIFFERENT ROCKS WERE TESTED WITH WATER JETS FROM NOZZLES HAVING 1.19 MM TO 4.76 MM DIAM AND VELOCITY FROM 447 TO 1118 M PER HR. THE TWO ROCKS WITH COMPRESSIVE STRENGTH ABOVE 15,000 PSI WERE NOT EASILY PENETRATED. THE OTHER THREE WITH COMPRESSIVE STRENGTHS UNDER 9,000 PSI WERE READILY PENETRATED. EFFECTS OF WATER JET IMPACT INCREASE NOTICEABLY WITH INCREASING IMPACT VELOCITY AND AT 2,000 M/SEC (4,470 MI PER HR)-THE MAXIMUM VELOCITY WHICH WATER CAN READILY BE USED AS A PRESSURE TRANSMITTING MEDIUM-A FUNDAMENTALLY DIFFERENT MODE OF PENETRATION WILL BE RECOGNIZED. JETS OF THIS VELOCITY HAVE BEEN DEVELOPED IN U.S.S.R. AND IMPRESSIVE RESULTS ARE CLAIMED.

24-64-09004 HYDRAULIC COAL MINING IN CZECHOSLOVAKIA (INVESTMENT COST EXCAVATOR BOOSTER-PUMP CONVEYING PRODUCTION)
SURNACHEV, A. A. + SMETANA, N. YA.
UGOL, (39) NO. 9, 93-96, SEPT. 1964. IN TROITSA HYDRAULIC MINE IN CZECHOSLOVAKIA SURFACE PUMPING EQUIPMENT IS ONE BV-10, 1,585 GAL PER MINUTE AT 910 PSI AND TWO 200 CDR, 1,255 GAL PER MINUTE AT 1,280 PSI WHICH SUPPLY WATER FOR EXCAVATION AND ELEVATING. THE EXCAVATORS ARE TYPE DN-30 OPERATING AT 1,400 TO 1,470 PSI. A COMPLETE HYDRAULIC SYSTEM IS OPERATED AND GIVES A 15 PERCENT HIGHER MINER PRODUCTIVITY. TESTS ON A NEW PRESSURE BOOSTER DELIVERING WATER AT 8,230 PSI ARE NOW BEING CARRIED OUT. TO STUDY HYDRAULIC MINING UNDER CONDITIONS OF THICK SLANTING LAYERS A 4 TO 6 METER COAL LAYER IN K. GOTWALD MINE IS BEING EXPLOITED. FURTHER HYDROMECHANIZATION IS PLANNED AND IT IS FIGURED THAT AT 8 MINES WITH A DAILY OUTPUT OF 31,000 TONS THE INVESTMENT WOULD BE 212 CROWNS PER TON FOR HYDROMECHANIZATION INSTEAD OF 260 CROWNS FOR DRY TECHNIQUE WITH TOTAL COST PER TON FOR HYDRAULIC MINING OF 210 CROWNS INSTEAD OF 262 CROWNS WITH DRY TECHNIQUE.

24-64-09005 CERTAIN QUESTIONS OF IMPROVEMENT OF TECHNOLOGY OF HYDRAULIC EXTRACTION OF COAL IN HYDROMINE AT KRASNOGORSK
GOLLARND, E. B. + TEREKHIN, A. I.
UGOL, (39) N. 9, 18-22, SEPT 1964. THE MINE WAS CONSTRUCTED IN 1949. THERE ARE 6 COAL BEDS RANGING FROM 1.5 TO 8.5 M IN THICKNESS WITH AN ANTICLINE DIP OF 45-65 DEG. A SERIES OF TESTS WAS RUN TO DETERMINE THE BEST OPERATING CONDITIONS. THE SOLUTION INVOLVED HYDRAULIC UNDERCUTTING OF THE SUBLEVEL COAL WITH CONTROLLED DISCHARGE. THE EQUIPMENT USED AND THE PROVISIONS FOR ROOF CONTROL ARE DESCRIBED.

24-64-09006 AN INVESTIGATION OF THE HYDRAULIC CUTTING OF COAL BY FINE, HIGH-PRESSURE JETS (HYDROMINING)
NIKONOV, G. P. + KARACHENTSOV, V. I. & A. A. SKOCHINSKI MINING INST
UGOL, (39) N. 9, 26-28, SEPT 1964. EXPERIMENTS IN THE LABORATORY AND IN THE MINES PROVED THAT FINE, HIGH PRESSURE JETS (UP TO 500 ATMS) CAN EFFICIENTLY BREAK DOWN COAL OF VARYING STRENGTHS WITH THE MINIMUM YIELD OF THE SMALL GRADES. THE PREFERRED SYSTEM COMBINES FINE JETS AT HIGH PRESSURES WITH REGULAR JETS USING PRESSURES OF 30 TO 40 ATMS. FOR SIMULTANEOUSLY BREAKING DOWN THE BLOCKS.

24-64-09007 PLANNING A HYDRAULIC MINE WITH SEPARATE HOISTING OF ANTHRACITE AND HYDRAULIC TRANSPORT TO THE ELECTRIC POWER PLANT
ABRAMOV, YU. G.
UGOL, (39) NO 9, 82-85, SEPT 1964. TO INCREASE THE PRODUCTION OF THE HYDROMINED COAL IN THE DONETS BASIN TO 12.6 MILLION TONS/YR IT IS NECESSARY TO BUILD FOUR NEW HYDROMINES WITH ANNUAL PRODUCTIONS OF 1.8 MILLION TO 3.0 MILLION TONS OF ANTHRACITE. THE PLUS 6 MM SIZE WILL BE HOISTED IN CAGES, SKIPS AND CONVEYORS. THE FINES OF LESS THAN 6 MM DIA WILL BE HYDRAULICALLY TRANSPORTED TO THE BOILER PLANT. THE DESIGN OF THE HYDRAULIC SYSTEM AND THE METHOD OF MINING ARE DESCRIBED. (IN RUSSIAN)

24-64-09008 AUTOMATION OF TECHNOLOGICAL PROCESSES DURING HYDRO-MINING (RUSSIA COAL-MINES)
TIMOSHENKO, G. M. + GRUBA, V. I. + LOGVINOV, N. G.
UGOL, (39) N 9, 37-42, SEPT 1964. A DISCUSSION OF THE COMBINING OF THE VARIOUS TECHNOLOGICAL PROCESSES INTO COMPLETE HYDROMINING SYSTEMS, AND DESIGNING A CONTROL SYSTEM TO UTILIZE THEM EFFECTIVELY. THE SYSTEM INCLUDES A HIGH PRESSURE PUMPING STATION, PIPELINES, MONITORS, COAL SLURRY HANDLING EQUIPMENT, COAL PUMPING STATIONS, COAL LIFTS AND A COAL PREPARATION PLANT. (IN RUSSIAN)

24-64-09009 THE EXPERIMENTAL WORK ON THE PIONER HYDROMINE - DONETS BASIN, (COAL-MINES RUSSIA SLURRY-PUMPING)
SHAPOVALOV, A. D. + NEIENBURG, V. E. + GUMENNIK, YA.
UGOL, (39) NO 9, 14-18, SEPT 1964. THE PIONER HYDROMINE INCLUDES TWO UNITS (D-1 AND D-2) AND AN ENRICHING PLANT. IT WAS DESIGNED TO PRODUCE 900 THOUSAND TONS/YR BUT REACHED ONLY 54 PERCENT OF THAT IN 1963. DETAILS OF THE MINING METHODS AND THE HYDRAULIC TRANSFERS ARE GIVEN. THE LOW PRODUCTION IS BLAMED ON LACK OF WATER, LARGE QUANTITIES OF HARD LABOR REQUIRED, AND DIVERGENCE FROM THE PLANNED METHOD OF OPERATION. (IN RUSSIAN)

24-64-09010 THE ECONOMY OF ROCK USAGE IN HYDROMINES. I. THE INVESTIGATION OF ECONOMIC EFFICIENCY OF PLANS OF DISPOSITION AND THE TRANSPORTATION OF ROCK AFTER HYDRAULIC EXTRACTION
TOLKATSER, D. YA.
UGOL, (39) NO 9, 69-72, SEPT 1964. A STUDY OF VARIOUS MEANS OF DISPOSING OF UNWANTED ROCK REMOVED INCIDENTAL TO HYDROMINING OF COAL. THE FIRST ARTICLE OF A TWO PART REPORT. SEE 26-64-09007 (IN RUSSIAN)

24-64-09011 THE ECONOMY OF ROCK USAGE IN HYDROMINES II THE MEANS OF HYDRAULIC TRANSPORT AND HOISTING OF ROCKS
BORISENKO, L. D.
UGOL, (39) NO 9, 72-74, SEPT 1964. VARIOUS METHODS OF HYDRAULIC TRANSPORT AND LIFT ARE DISCUSSED AND A STUDY OF THE ECONOMIC ASPECTS OF VARIOUS SCHEMES OF STOWAGE ARE PRESENTED. PART TWO OF A TWO ARTICLE SERIES. SEE 26-64-09006 (IN RUSSIAN)

24-64-09012 IMPROVEMENT OF MINING SYSTEMS DURING HYDRAULIC MINING (RUSSIA COAL-MINES)
TEODOROVICH, B. A.
UGOL, (39) NO 9, 28-31, SEPT. 1964. DESIGNS OF 29 SYSTEMS ARE GIVEN. FOURTEEN OF THESE ARE ALREADY IN USE FOR HYDRAULIC COAL MINES. CHARACTERISTICS OF LONGWALL SYSTEM, RETREATING TO DIP, THE ROOM AND PILLAR SYSTEM AND SUBLEVEL HYDRAULIC MINING ARE GIVEN.

24-64-11001 DRY PERCUSSION DRILLING WITH DETERGENT MIST (HEALTH DUST COST)
MALMGREN, C. & GARDNER-DENVER CO CLEV OHIO
MINING CONGRESS JOURNAL, (50) 62, NOV 1964. NUISANCE AND HEALTH HAZARD OF DRY COMPRESSED AIR PERCUSSION DRILLING HAS CAUSED WIDESPREAD USAGE OF A WATER-DETERGENT MIXTURE INTRODUCED INTO THE AIR STREAM. EQUIPMENT FOR WATER-DETERGENT USE AND ITS COST AND MAINTENANCE ARE GIVEN. WHERE LAWS REQUIRE DUST COLLECTORS FOR DRY AIR DRILLING WATER-DETERGENT USE IS PARTICULARLY ECONOMICAL.

24-64-11002 NEW APPROACH TO INTERPRETING ROCK DRILLABILITY 1. NEEDED, FORMULAS FOR PREDICTING DRILLING IN THE FIELD (BIT-GEOMETRY BIT-WEIGHT ROTARY-SPEED HYDRAULICS PENETRATION GEOLOGY)
BINGHAM, M.G. & UNIV HOUSTON
THE OIL & GAS JOURNAL, (62) NO. 44, 52-57, NO 2, 1964. THESE ARTICLES WILL RELATE ROTARY DRILLING TO ROCK STRENGTH OR ROCK DRILLABILITY IN AN ATTEMPT TO PREDICT BEHAVIOR OF ONE WELL DRILLING TO THE NEXT. THIS WILL ENABLE LOWEST COST DRILLING AND FUTURE EQUIPMENT DESIGN. CONDUCTING TESTS WITH FLUID AND RIG POWER HELD FAIRLY CONSTANT OPTIMIZES PRESENT PRACTICE WHICH IS SELDOM OPTIMUM. SHORT INTERVAL TESTS OF BIT WEIGHT, ROTARY SPEED, BIT GEOMETRY AND HYDRAULICS OFFER LITTLE PROMISE FOR IMPROVING DRILLING. HOWEVER LONG INTERVAL CONTROL BY LOGGING DEPTH AGAINST ON-BOTTOM ROTATING HOURS AND CONSIDERING GEOLOGIC FORMATION PROVIDES GOOD REGIONAL CONTROL. IN SOME CASES ABRASIVENESS VARIATIONS MAY REQUIRE SETTING UP GEOLOGIC SUBGROUPS. EXTENT TO WHICH DRILLING CAN BE PREDICTED DEPENDS UPON ABILITY TO RECOGNIZE MAJOR FOCUS CHANGES IN FORMATIONS. IF DRILLING IS BELOW PREDICTIONS, CAUSE SHOULD BE DETERMINED.

24-64-11003 NEW APPROACH TO INTERPRETING ROCK DRILLABILITY 2. HOW TO MAKE THE R/N-W/D CHART & WHAT IT MEANS (PENETRATION ROTARY-SPEED BIT-WEIGHT DIAMOND-BIT DRAG-BIT ROLLER-CONE-BIT DRILLING-FLUID CIRCULATION)
BINGHAM, M. G. & UNIV HOUSTON
THE OIL & GAS JOURNAL, (62) NO. 45, 212-217, NOV 9, 1964. BY PLOTTING PENETRATION PER REVOLUTION AGAINST BIT LOAD PER FOOT OF BIT DIAMETER, GENERAL EQUATIONS DESCRIBING DESIRABLE DRILLING LIMITS CAN BE ESTABLISHED AND CONSISTENT MINING AND PETROLEUM DRILLING DATA CORRELATION IS PROVIDED. PERFORMANCE REGION, TRANSPORT LIMIT REGION AND LOWER DRILLING LIMIT ARE SHOWN ON R/N-W/D PLOTS. EFFECTS OF DRILLING FLUID OR MUD, CIRCULATION RATE, PRESSURE, ROTARY SPEED, BIT WEIGHT AND BIT TYPE, ROLLER CONE, DIAMOND OR DRAG ARE GIVEN FOR LABORATORY TESTS. BY MEANS OF THESE LABORATORY TESTS, GENERAL RELATIONSHIPS ARE ESTABLISHED. THESE ARE CHECKED AGAINST FIELD DATA AND USED AS DRILLING CRITERIA.

24-64-11004 NEW APPROACH TO INTERPRETING ROCK DRILLABILITY 3. HOW TO INTERPRET DRILLING IN THE PERFORMANCE REGION (BITS GEOLOGY MICROBIT)
BINGHAM, M. G. & UNIV HOUSTON
THE OIL & GAS JOURNAL, (62) NO. 46, 173-179, NOV 16, 1964. BY FINDING ROTARY DRILLING ULTIMATE POTENTIAL AN EXTREMELY VALUABLE BASE AGAINST WHICH TO COMPARE EACH DRILLING FACTOR IS ACQUIRED. CHARACTERISTIC PERFORMANCE CURVES CAN BE OBTAINED FOR DRILLING VARIOUS ROCK AND CAN BE EXPRESSED AS PENETRATION PER REVOLUTION EQUAL TO A CONSTANT MULTIPLIED BY THE BIT LOAD PER FT OF BIT DIAMETER TO SOME POWER. BOTH THE CONSTANT AND POWER VARY OVER WIDE RANGES. THIS CURVE CAN BE APPROXIMATED BY A STRAIGHT LINE AND SUCH STRAIGHT LINES HAVE BEEN DRAWN FOR HUGHES TOOL CO'S BIT TEST

DATA FOR ROCK HAVING 2,500 PSI TO 80,000 PSI COMPRESSIVE STRENGTH. RESULTS OF TESTS WITH SOFT AND MEDIUM-HARD FORMATIONS USING DRAG BITS ARE GIVEN. BIT DRILLABILITY INCREASES WITH DEGREE OF HORIZONTAL SCRAPING ACTION BUT THIS IS OFFSET BY INCREASED WEAR. TOOTH BREAKAGE ALSO MUST BE CONSIDERED. MICROBIT RESULTS MUST BE CAREFULLY EVALUATED TO PREVENT ERRORS DUE TO THE SCALING PARAMETERS.

24-64-11005 NEW APPROACH TO INTERPRETING ROCK DRILLABILITY 4. WHAT YOU SHOULD KNOW ABOUT BIT DESIGN & PERFORMANCE. (DEVIATION BIT-WEIGHT DRILLING-FLUID HYDRAULICS WEAR)
BINGHAM, M. G. & UNIV HOUSTON
THE OIL & GAS JOURNAL, (62) NO. 47, 77-89, NOV 23, 1964. BIT CHOICE DEPENDS NOT ONLY ON BIT CAPABILITY BUT ALSO ON TOOTH OR BLADE WEAR. DIFFERENT BITS HAVE WIDE VARIATION IN DRILLING RATES. THIS IS ILLUSTRATED BY A CHART SHOWING PERFORMANCE LINES FOR VARIOUS BITS. ALL BITS HAD A COMMON INTERCEPT BUT PERFORMANCE LINE RESPONSE CHANGED WITH BIT SKEWNESS. WHEN FIELD RESULTS ARE PLOTTED THERE IS LITTLE DATA FOR LIGHT WEIGHTS DUE TO A TREND TOWARD HIGHER WEIGHTS. HENCE THE ECONOMY OF SOFTER FORMATION BITS WITH LOWER LOADING MAY BE OVERLOOKED FOR THAT OF MEDIUM FORMATION BID WITH HIGH LOADING. UNDER MANY FIELD CONDITIONS THE BIT DOES NOT AFFECT DRILLING RATE BECAUSE SOME OTHER FACTOR, CONDITIONS OF PRESSURE, FLUID AND HYDRAULICS ARE LIMITING. TWO FIELD CASES ARE GIVEN. ROLLER BITS WERE FOUND SUPERIOR TO DRAG BECAUSE OF RAPID DRAG BIT WEAR, HIGH BIT LOADING REQUIRED AND DEVIATION PROBLEMS.

24-64-11006 NEW APPROACH TO INTERPRETING ROCK DRILLABILITY 5. HOW TO LOCATE PERFORMANCE LINE WHEN DRILLING RESPONSE IS LOW (SHARP-BIT WORN BIT)
BINGHAM, M. G. & UNIV HOUSTON
THE OIL & GAS JOURNAL, (62) NO. 48, 78-79, NOV 30, 1964. PRIMARY PERFORMANCE LINE WAS AN APPROXIMATE FIT TO THE PERFORMANCE CURVE. AT LOW PERFORMANCE RATES A SECONDARY PERFORMANCE LINE MUST BE DETERMINED TO MORE ACCURATELY FIT THE CURVE. SLOPE AND INTERCEPT OF SECONDARY PERFORMANCE LINE DEPEND ON ROCK CHARACTERISTICS. LABORATORY AND FIELD TESTS AND HUGHES TOOL CO INFORMATION ARE PLOTTED TO SHOW DATA FIT WITH PRIMARY AND SECONDARY PERFORMANCE LINES. ONCE SHARP BIT LINES ARE FITTED, LINES AND INTERCEPTS FOR WORN BITS CAN BE FOUND BY WEAR EQUATIONS.

24-64-12001 TECHNIQUE OF GEOLOGICAL SURVEY OPERATIONS: EXPERIMENTAL STUDY OF THE DEGREE OF WEAKENING OF CERTAIN ROCKS BY THE LOCAL ACTION OF HIGH TEMPERATURES (THERMAL-JET THERMOMECHANICAL)
SELEZNEV, A. P.
IZVESTIYA VYSSHIKH UCHEBNYK ZAVEDENII GEOLOGIYA I RAZVEDKA, N 12, 98-102, 1964. THE USE OF THERMAL JET DRILLING IS EFFECTIVE IN HARD ROCKS WITH LOW THERMAL CONDUCTIVITY, HIGH ELASTICITY, AND A DISTINCTLY CRYSTALLINE STRUCTURE. IT IS CLEAR THAT IT DOES NOT DESTROY ALL ROCKS. MANY INVESTIGATORS HAVE PROPOSED THE USE OF A THERMOMECHANICAL DRILLING TECHNIQUE WHICH ACCOMPLISHES PARTIAL DESTRUCTION AND WEAKENING BY TEMPERATURE AND ULTIMATE DESTRUCTION BY A MECHANICAL TECHNIQUE. RESULTS OF TESTS HAVE PROVIDED VALUABLE EVIDENCE. THE OPTIMUM DISTANCE FOR HARD ROCKS VARIES WITHIN THE 6 - 10 MM. INTERVAL. THE DEGREE OF WEAKENING INCREASES WITH AN INCREASING DURATION OF ACTION UP TO A DEFINITE OPTIMUM TIME WHICH FOR THE GIVEN SETUP WAS AN AVERAGE OF 30 SEC. THE DEGREE OF WEAKENING IS HIGHER FOR ROCKS WITH A HIGHER PLASTICITY COEFFICIENT AND LOWER HARDNESS. VERY HARD ROCKS WITH HIGH ELASTICITY DO NOT SHOW A ZONE OF WEAKENING. (IN RUSSIAN)

24-64-12002 A NEW APPROACH TO INTERPRETING ROCK DRILLABILITY 6. MULTIPLE PERFORMANCE LINE IS SPECIAL CASE BUT CAN BE USED (PENETRATION BIT-LOAD AIR-CIRCULATION WATER-CIRCULATION)
BINGHAM, M. G. & UNIV HOUSTON
THE OIL & GAS JOURNAL, (62) NO. 49, 154-168, DEC 7, 1964. ONE COMMON PERFORMANCE LINE, A PLOT OF RATE OF PENETRATION IN FT PER REVOLUTION VS THOUSANDS OF LB. LOAD PER FT OF BIT, IS THE USUAL DRILLABILITY FUNCTION FOR ANY MATERIAL. BUT FOR SOME VARIATIONS IN RPM AND CIRCULATION CONDITIONS THERE ARE MULTIPLE LINES. HOWEVER, KNOWING THESE CONDITIONS DRILLING CAN BE PREDICTED. ONCE CUTTINGS ARE PRIED OFF THE BOTTOM AND MOVED TO AN UNDER BIT POSITION THEY MUST BE CLEARED FROM UNDER BIT, MOVED INTO ANNULUS, CARRIED UP ANNULUS AND OUT OF HOLE. IF THESE TWO ACTIONS ARE INEFFICIENT THEY LIMIT DRILLING RATE. IN ACTUAL DRILLING BACK PRESSURE REDUCES THE DRILLING RATE TO THE PERFORMANCE LINE AND THERE IS NO DIFFERENCE BETWEEN RESULTS WITH REGULAR AND JET BITS. A LARGER REMOVAL FORCE IS AVAILABLE WHEN DRILLING WITH LIQUID THAN WHEN DRILLING WITH AIR BUT LIQUID SHOULD NOT INTERFERE WITH FRACTURE PROCESS, STRESS ROCK APPRECIABLY, INCREASE ROCK STRENGTH OR GUM UP CUTTINGS.

24-64-12003 A NEW APPROACH TO INTERPRATING ROCK DRILLABILITY 7. HOW ROCK PROPERTIES ARE RELATED TO DRILLING (COULOMB- MOHR CUTTINGS PRESSURE EXPERIMENTS)
BINGHAM, M. G. & UNIV HOUSTON
THE OIL & GAS JOURNAL, (62) NO. 50, 94-101, DEC 14, 1964. DRILLING SHOULD BE RELATED TO ROCK PROPERTIES TO PREDICT DRILLING, EVALUATE DRILLING PERFORMANCE AND TO EVALUATE METHODS OF IMPROVEMENT. COULOMB-MOHR CRITERIA ARE DISCUSSED AND A GENERAL ROCK STRENGTH EQUATION GIVEN. TESTS ON INDIANA LIMESTONE SHOW THAT DRILLABILITY IN ANY SINGLE SHIPMENT VARIED NO MORE THAN 12 PERCENT WHILE ROCK DRILLABILITY AND ROCK STRENGTH VARIED ABOUT 3 TO 1. AT HIGHER BIT WEIGHTS THERE IS AN INDICATION THAT A TRANSPORT LIMIT TENDS TO DEVELOP. A TABLE SHOWS THE INCREASE OF ROCKS RESISTANCE TO FAILURE WITH INCREASED PRESSURE. PRESSURE APPLIED TO TEST ROCK MAY NOT BE THE SAME AS ACTUAL EFFECTIVE PRESSURE ACHIEVED. ALSO, DRILLING IS LIMITED BY ABILITY TO REMOVE CUTTINGS. SOME MINIMUM TEST INTERVAL MUST BE DRILLED IN ORDER TO REACH AN EQUILIBRIUM OF CUTTING REMOVAL TO CONDUCT A VALID TEST.

24-64-12004 A NEW APPROACH TO INTERPRATING ROCK DRILLABILITY 8. HOW TO USE PERFORMANCE-LINE EQUATIONS (BIT ROTATION LOAD CIRCULATION GENERAL-DRILLING-EQUATION)
BINGHAM, M. G. & UNIV HOUSTON
THE OIL & GAS JOURNAL, (62) NO. 51, 80-85, DEC 21, 1964. THE EQUATION MOST FREQUENTLY USED IS BASED ON DATA OBTAINED FROM THE PERFORMANCE LINE. DATA ARE GIVEN FOR THREE STRATA. METHODS OF IMPROVING ROTODRILLABILITY ARE GIVEN. THIS IS THE LAST IN A SERIES OF ARTICLES TO DEVELOP A SET OF EQUATIONS TO PREDICT DRILLING. EQUATIONS ALONE CANNOT ANALYZE DRILLING RESULTS BUT THEY ARE IMPORTANT AND USEFUL. DERIVATION OF 27 EQUATIONS LEADING TO THE GENERAL DRILLING EQUATION ARE GIVEN.

24-65-01001 NEW METHODS OF FRACTURING ROCKS (DRILLING-METHODS ULTRASONIC-DRILLING WATER-JET PLASMA JET ELECTRICAL FRACTURE)
FARMER, I. W. & UNIV SHEFFIELD ENGLAND
MINING AND MINERALS ENGINEERING, 177-184, JAN 1965. RECENT DEVELOPMENTS IN ROCK FRACTURING INCLUDE ULTRASONIC DRILLING, WATER JET PENETRATION, THERMAL PENETRATION, PLASMA JET, AND ELECTRICAL ROCK FRACTURE. THE ULTRASONIC DRILL PRODUCES HIGH-FREQUENCY VIBRATIONS WHICH FRACTURE THE ROCK, AND IS USEFUL ONLY TO PENETRATE VERY HARD ROCKS AND ORES NOT EASILY PENETRATED OTHERWISE. WATER JET PENETRATION IS PROPORTIONAL TO IMPACT VELOCITY OF THE WATER. THIS METHOD HAS BEEN USED SUCCESSFULLY ON THICK COAL SEAMS. PRESENTLY, SIZE LIMITATIONS ARE IMPOSED DUE TO THE NECESSITY OF MECHANICAL CONTROL OF HIGH-PRESSURE DEVICES. THERMAL PENETRATION OF ROCK CONSISTS OF A HIGH-TEMPERATURE FLAME JET EJECTED AT HIGH VELOCITIES FROM SPECIALLY DESIGNED NOZZLE. PLASMA JET PENETRATION IS LIMITED BY MOLTEN ROCK WHICH OFTEN CLOGS THE JET NOZZLE. ELECTRICAL ROCK FRACTURE IS ACCOMPLISHED BY NUMEROUS ENERGY TRANSFER METHODS AND IS MOST LIKELY TO BE ECONOMICALLY APPLICABLE IN THE NEAR FUTURE.

24-65-01002 PROBLEM OF EVALUATING BREAK-DOWN OF COAL BY JET OF HYDRAULIC MONITOR (PERMEABILITY)
NIKONOV, G. P. + ISHCHOK, I. G.
UGOL, (39) N 1, 27-31, JAN 1965. EXPERIMENTS WITH COAL IN PLACE INDICATE THAT WATER-ABSORBING PROPERTIES OF COAL BED ARE GENERAL FACTOR CHARACTERIZING PHYSICAL AND MECHANICAL PROPERTIES OF COAL. DESIGN AND USE OF DEVICE FOR MEASURING PERMEABILITY OF ROCKS IN PLACE. FORMULA IS DERIVED FOR DETERMINATION OF MONITOR EFFICIENCY DEPENDING ON SPECIFIC ABSORPTION OF WATER BY COAL BED UNDER GIVEN HEAD AT NOZZLE. (IN RUSSIAN)

24-65-01003 PROBLEM OF THE RATIONAL DEPTH OF BORE HOLES IN MINING (DRILLING-ECONOMY DRILLING TOOLS)
PETROSOV, A. A. &
IZVESTIYA VYSSHIKH UCHEBNYK ZAVEDENII GEOLOGIYA I RAZVEDKA, N 1, 117-121, JAN. 1965. OPTIMUM BORE HOLE DEPTH IS DETERMINED BY SUCH A WIDE RANGE OF EQUIVALENT VALUES THAT ANALYTICAL SOLUTION OF THIS PROBLEM HAS NO PRACTICAL MEANING. 1.34 TO 1.81 IN. DIAM BORE HOLES WERE MADE WITH KTSM-4 CORE DRILLS OPERATING AT 100 TO 110 PSI AIR PRESSURE IN SILICACEOUS LIMESTONE WITH A PROTODYAKONOV STRENGTH OF F = 8 - 10, WITH DECREASING BIT DIA OPTIMUM BORE HOLE DEPTH INCREASES. MINIMUM BORE HOLE DEPTH IN THE OPTIMUM REGION DECREASES WITH INCREASING ROCK HARDNESS. DETERMINATION OF BORE HOLE DEPTH SHOULD BE RELATED TO PENETRATION RATE, PHYSICOMECHANICAL ROCK PROPERTIES AND DRILLING TOOLS EMPLOYED. (IN RUSSIAN)

24-65-01004 NEW APPROACH TO INTERPRETING ROCK DRILLABILITY 9. HOW TO FIND ROCK STRENGTH IN TYPICAL FIELD DRILLING (BITS PERFORMANCE-LINE PERMEABILITY POROSITY FRACTURE WEAR)
BINGHAM, M. G. & UNIV HOUSTON
THE OIL & GAS JOURNAL, (63) NO. 1, 100-111, JAN 4, 1965. WHEN MORE ROCK STRENGTH INFORMATION BECOMES AVAILABLE IT HELPS WHEN DRILLING IN AN UNKNOWN AREA BECAUSE DRILLING RATES ARE PREDICTABLE AND COSTS CAN BE MINIMIZED. LINEAR APPROXIMATION METHOD OF DETERMINING ROCK STRENGTH CALLS FOR LITTLE MORE INFORMATION THAN APPEARS ON RIG TOUR SHEETS. OTHER METHODS REQUIRE INFORMATION WHICH IS VIRTUALLY UNOBTAINABLE. JUDGEMENT IS NECESSARY IN EVALUATING PERFORMANCE CURVE SLOPE CHANGES AS PERMEABILITY, POROSITY, FRACTURE DEVELOPMENT, FALLING AND GUMMING WILL AFFECT PENETRATION RATE AS WELL AS ROCK HARDNESS. PROPER WORN BIT CAPABILITY CONSTANT IS EQUAL TO GENERAL PERFORMANCE SLOPE MULTIPLIED BY SQUARE ROOT OF WORN BIT INTERCEPTS. RECENT HIGH DRILLING RATES ARE ATTRIBUTED ALMOST ENTIRELY TO DRILLING WITH FLUID AS NEAR AS POSSIBLE TO CLEAR WATER. ROCK SHEAR STRENGTH IS EQUAL TO SQUARE ROOT OF BIT INTERCEPT DIVIDED BY BIT FACTOR FOR ANY TOOTH WEAR CONDITION AND THIS SHEAR CAN BE CONVERTED TO COMPRESSIVE STRENGTH. AS ROCK STRENGTH INFORMATION IS COMPILED IT SHOULD BE POSSIBLE TO PREDICT MAXIMUM BIT TOOTH OFFSET WHICH CAN BE USED WITHOUT EXCESS TOOTH BREAKAGE. DRILLING RESULTS ARE GIVEN FOR TUNGSTEN CARBIDE INSERT BUTTON BITS, HARD FORMATION TOOTH BITS, MEDIUM AND SOFT FORMATION BITS.

24-65-01005 NEW APPROACH TO INTERPRETING ROCK DRILLABILITY 10. HOW STRONG ARE ROCKS FOUND IN TODAY'S OIL FIELD DRILLING? (SHALE CARBONATE SANDSTONE FLUIDS)
BINGHAM, M. G. & UNIV HOUSTON
THE OIL & GAS JOURNAL, (63) NO. 2, 87-90, JAN 11, 1965. THE OIL INDUSTRY USUALLY DRILLS SHALE, CARBONATE OR SAND AND VARIATIONS, ESPECIALLY GUMMING UP, MUST BE CONSIDERED IN EXPLAINING DRILLING RATES. MOST ROCK HAS A GRADUAL STRENGTH INCREASE WITH DEPTH. TOUR SHEET DATA, PERFORMANCE LINE INTERCEPT AND INDICATED SHEAR STRENGTH ARE GIVEN FOR MINE MAJOR AREAS AND SEVERAL MISCELLANEOUS ONES. A TABLE IS GIVEN OF QUARRY AND MINE ROCK STRENGTH. UNTIL A BETTER UNDERSTANDING OF FLUIDS INFLUENCE ON DRILLING IS ACQUIRED, PENETRATION RATE IN DEEP HOLES IS UNLIKELY TO BE SIGNIFICANTLY IMPROVED.

24-65-01006 NEW APPROACH TO INTERPRETING ROCK DRILLABILITY 11. GREATER SPEED AWAITS MEANS TO REACH PERFORMANCE LINE (ROLLER-CONE DIAMOND LITHOLOGY)
BINGHAM, M. G. & UNIV HOUSTON
THE OIL & GAS JOURNAL, (63) NO. 3, 75-77, JAN 18, 1965. PERFORMANCE LINES FOR HALF WORN BITS DRILLING IN FORMATIONS WITH STRENGTH HAVING INTERCEPTS OF 5,000, 10,000, 20,000, 30,000 AND 40,000 LB PER FT ARE DRAWN. SPECIFIC CAPABILITY AND DRILLING CHARACTERISTICS OF DIAMOND AND ROLLER CONE BITS ARE COMPARED.

24-65-02001 ECONOMICS OF PERCUSSION VS AIR ROTARY DRILLING (BIT-LIFE ECONOMICS)
BATES, R. F. & MISSION MFG CO HOUSTON TEX
WORLD OIL, (160) N 2, 51-59, FEB. 1, 1965. PERCUSSION ROTARY DRILLING TECHNIQUE IN WHICH MAIN ENERGY SOURCE FOR FRACTURING ROCK IS OBTAINED FROM A PERCUSSION MACHINE CONNECTED DIRECTLY TO THE BIT. CIRCULATING SYSTEM DRILL STRING AND HOISTING SYSTEM ARE UNCHANGED FROM THAT USED IN CONVENTIONAL AIR ROTARY METHOD. PERCUSSION BITS ARE, MILLED TOOTH OR CARBIDE INSERT, THREE CONE ROLLER BITS STRENGTHENED TO WITHSTAND PERCUSSION BLOW. PERCUSSION MACHINE OPERATION AND KINETIC ENERGY DETERMINATION ARE DESCRIBED. PERCUSSION DRILLS HAVE LONGER BIT LIFE THAN ROTARY DRILLS AS THERE IS LONGER BEARING LIFE AND THE BIT TEETH DON'T DULL AS RAPIDLY. CHOICE BETWEEN PERCUSSION AND ROTARY DRILLING IS DETERMINED BY ECONOMIC COMPARISON. AN ECONOMICAL PERCUSSION DRILLING OMOGRAPH FACILITATES DIRECT COST COMPARISON OF THE TWO METHODS.

24-65-02002 NEW APPROACH TO INTERPRETING ROCK DRILLABILITY 12. WHAT IT MEANS WHEN DRILLING FALLS BELOW PERFORMANCE LINE (TRANSPORT-LIMIT BIT-WEIGHT CIRCULATION NOZZLE-VELOCITY FLUID)
BINGHAM, M. G. & UNIV HOUSTON
THE OIL & GAS JOURNAL, (63) NO. 5, 66-73, FEB 1, 1965. VARIOUS OIL FIELD DRILLING RESULTS ARE SHOWN. ALTHOUGH MAXIMUM PRACTICAL POTENTIAL IS ESTABLISHED BY PERFORMANCE LINE, USUAL DRILLING IS ON SOME TRANSPORT LINE. VARIATIONS WITH CIRCULATION RATES, JET NOZZLE VELOCITY AND ROTARY SPEEDS SHOW THAT FOR SHALLOW DRILLING EXTREMELY HIGH BIT WEIGHTS ARE NOT RECOMMENDED. AT DEEPER DRILLING, 11,000 FT. DRILLING RESPONSE WAS SUPPRESSED INDICATING A SEVERE CUTTINGS REMOVAL PROBLEM. SINCE FIELD DRILLING IS DIFFICULT TO EVALUATE LABORATORY TESTS ARE USED TO SHOW RELATIVE IMPORTANCE OF VARIOUS FACTORS. RESULTS DEMONSTRATE THAT NO SINGLE EQUATION CAN BE WRITTEN TO APPLY TO ALL DRILLING SITUATIONS. DISCONTINUITY REPRESENTED BY TRANSPORT LIMITS APPEAR WITH ALL BIT TYPES. MAIN FACTORS GOVERNING MAXIMUM RESPONSE ARE LEVEL OF INPUT ENERGY AND REMOVAL PROBLEM SET UP BY INTERPLAY OF FLUID, ROCK AND PRESSURE. IF CUTTING REMOVAL IS ADEQUATE, PERFORMANCE LINE RESULTS ARE OBTAINED AND ITS SLOPE IS INFLUENCE ONLY BY BIT DESIGN FOR A ROCK OF GIVEN DRILLABILITY.

24-65-02003 NEW APPROACH TO INTERPRETING ROCK DRILLABILITY 13. HOW DRILLING-FLUID FACTORS AFFECT THE TRANSPORT-LIMITS (DENSITY FLOW-VOLUME FLOW-VELOCITY AIR)
BINGHAM, M. G. & UNIV HOUSTON
THE OIL & GAS JOURNAL, (63) NO. 6, 91-93, FEB 8, 1965. MANY FACTORS AFFECT DRILLING RATE. THE EFFECTS OF DENSITY, FLOW RATE AND NOZZLE VELOCITY ARE SHOWN. WHEN PREDICTING DRILLING THE BIT AND ROCK AS WELL AS FLOW RATE MUST BE CONSIDERED. A CERTAIN FLOW RATE IS REQUIRED TO CLEAN THE BOTTOM AND A CERTAIN VELOCITY TO CLEAR AROUND HOLE BOTTOM CORNER. EXCESS BEYOND THESE VALUES CAN PROVIDE LITTLE IMPROVEMENT. TESTS WERE CONDUCTED COMPARING DRILLING WITH AIR CIRCULATED AT TWO DIFFERENT RATES AND WITH WATER INJECTED INTO THE AIR STREAM. AN INCREASE IN FLOW RATE INCREASES DRILLING RESPONSE AND PENETRATION RATE WHEN DRILLING FALLS ON A TRANSPORT LIMIT. GREATER DENSITY BROUGHT A LARGE INCREASE IN PENETRATION RATE. IN AIR DRILLING RAISING PENETRATION RATE BY ADDING WATER DEPENDS UPON ROCK, LIQUID CIRCULATED AND PNEUMATIC-HYDRAULIC POWER AVAILABLE. AIR DRILLING SUCCEEDS SOMETIMES ONLY BECAUSE DRILL PIPE SIZE RESTRICTS VOLUME OF LIQUID THAT CAN BE CIRCULATED.

24-65-02004 NEW APPROACH TO INTERPRETING ROCK DRILLABILITY 14. HOW ROTARY SPEED & BIT CONFIGURATION AFFECT TRANSPORT LIMITS (PENETRATION FLUID CIRCULATION CUTTINGS-REMOVAL)
BINGHAM, M. G. & UNIV HOUSTON
THE OIL & GAS JOURNAL, (63) NO. 7, 137-144, FEB 15, 1965. PENETRATION RATE IS EQUAL TO SOME CONSTANT MULTIPLIED BY THE QUANTITY ROTARY SPEED DIVIDED BY REFERENCE ROTARY SPEED RAISED TO SOME POWER. IF THIS POWER IS ONE, DOUBLING ROTARY SPEED DOUBLES PENETRATION RATE WHILE IF IT IS ZERO ROTARY SPEED HAS NO EFFECT ON PENETRATION RATE. WHEN DRILLING ON PERFORMANCE LINES THIS POWER IS CLOSE TO ONE BUT WHEN ON TRANSPORT LIMITS IT NORMALLY VARIES FROM 0.57 TO 0.80. IT CAN SOMETIMES DROP ZERO. HENCE DRILLING CONDITIONS MUST BE KNOWN BEFORE EFFECT OF ROTARY SPEED ON PENETRATION RATE CAN BE PREDICTED. WHEN CHANGING BIT CONFIGURATION OR JET POSITION MANY COMPLICATIONS CAN BE INTRODUCED WHICH AFFECT FLOW PATTERN ON BOTTOM AND CUTTINGS RESISTANCE. WHEN CONSIDERING EFFECT ON DRILLING RESPONSE OF TOOTH BLUNTNESS, THEIR HEIGHT AND FLATNESS MUST ALSO BE CONSIDERED AS WELL AS THE NUMBER OF CONES, CIRCULATING MEDIUM AND TYPE OF FLOW.

24-65-02005 NEW APPROACH TO INTERPRETING ROCK DRILLABILITY 15. HOW CHANGES IN ROCK & PRESSURE AFFECT THE TRANSPORT LIMITS (PERFORMANCE-LINE CHIP-REMOVAL FLUID)
BINGHAM, M. G. & UNIV HOUSTON
THE OIL & GAS JOURNAL, (63) NO. 8, 120-123, FEB 22, 1965. TRANSPORT LIMIT REPRESENTS SYSTEM ABILITY TO TRANSPORT CUTTINGS TO ANNULUS. IF LARGE CUTTINGS CANNOT BE REMOVED INTACT AND ARE REGROUND PENETRATION RATE WILL BE LOW. WHEN DRILLING FLUID IS CHANGED FROM WATER TO MUD DRILLING RESPONSE IS NOT AFFECTED IF DRILLING IS ON PERFORMANCE LINE BUT IS REDUCED IN TRANSPORT LIMIT REGION. BACK PRESSURE TREMENDOUSLY SUPPRESSES DRILLING RESPONSE BUT IF REMOVAL FORCE IS HIGH SUCH SUPPRESSION WILL NOT BE OBTAINED. ONCE PRESSURE INITALLY SUPPRESSES DRILLING RESPONSE ADDITIONAL PRESSURE HAS LITTLE FURTHER EFFECT. INCREASING PRESSURE INCREASES ROCK STRENGTH AND AS ROCK STRENGTH GOES UP, TRANSPORT LIMIT FOR A GIVEN SET OF CONDITIONS GOES DOWN.

24-65-03001 THE CONCEPT OF SPECIFIC ENERGY IN ROCK DRILLING (BORING DRILLING INDENTATION ROCK-STRENGTH)
TEALE, R. & NATIONAL COAL BOARD ENGLAND
INT. J. ROCK MECHANICS AND MIN. SCIENCES, (2) 57-73, MARCH 1965. SPECIFIC ENERGY IS THE ENERGY REQUIRED TO EXCAVATE UNIT VOLUME OF ROCK AND MAY ALSO BE AN INDEX OF THE MECHANICAL EFFICIENCY OF ROCK WORKING. SPECIFIC ENERGY CORRELATES WITH COMPRESSIVE STRENGTH. IN PRACTICE CHIPPING MAY OCCUR SO THAT THE VOLUME OF AN INDENTATION IS MUCH GREATER THAN THE VOLUME ACTUALLY DISPLACED BY THE INDENTER ITSELF. POSSIBLY BY USING SUITABLE ARRAYS OF INDENTERS TO CAUSE INDUCED STRESSES TO LINK UP, LARGE FRAGMENTS CAN BE BROKEN FROM THE SURFACE. AN UNDERSTANDING OF HOW SPECIFIC ENERGY IS GOVERNED BY THRUST AND ROTATION SPEED WILL BENEFIT TOOL DESIGN AND USE.

24-65-03002 THE WEAKENING OF COAL MASSIF - THE WAY OF INCREASING PRODUCTIVITY OF HYDROCUTTING
KUZ'MICH, I. A. + ISHCHUK, I. G. + KUZNETSOV, G.
UGOL, N 3, 34-36, MAR 1965. THE MOST EFFICIENT METHODS OF PREWEAKENING OF A COAL MASSIF FOR HYDRO-EXTRACTION ARE PRESSURIZATION OF WATER IN THE LAYER OF COAL UNDER HIGH PRESSURE AND BY BLASTING. WATER INFUSION THROUGH HOLES 25 METERS LONG INCREASED THE PRODUCTIVITY OF THE HYDROMONITOR BY 2 1/2 TO 3 TIMES AND IMPROVED THE QUALITY OF COAL BY AN INCREASE OF 10 PERCENT IN THE 25 MM AND LARGER SIZES. THE EXPLOSIVES WERE CHARGED HYDRAULICALLY UNDER PRESSURE OF 5 ATM. (IN RUSSIAN)

24-65-03003 WATER AS WINNING AND TRANSPORT MEDIUM IN HARD-COAL MINING (WATER-JET SAFETY ECONOMY HYDRAULIC-HOISTING TRANSPORT HYDROMINING DRILLING)
WUSSOW, D. & MINING ASSESSOR ESSEN GERMANY
GLUECKAUF, (101) N 5, 316-321, MAR 3, 1965. BECAUSE OF SUCCESSFUL RUSSIAN HYDROMINING THE WESTERN EUROPEAN HARD COAL ASSOCIATION EXPERIMENTED WITH A COMPLETE UNIT. WATER NOZZLE WAS RUSSIAN IMPROVED BY THE MINING SUPPLIERS AND MANNESMANN RESEARCH INSTITUTE. A 0.062 IN. DIAM NOZZLE DELIVERING 40 GAL. OF WATER A MIN. AT 3,650 LBS. PER SQ. IN. WORKED VERY SATISFACTORILY. IN THE U. S. A. A BLACK LUSTROUS ALMOST VERTICAL, ASPHALT DEPOSIT IS SUCCESSFULLY MINED WITH WATER JET AT 4,400 PSI. THE COMPLETE OPERATION WITH HYDRAULIC HOISTING IS PRESCRIBED. THE CONCLUSION WAS 9 TO 12 PERCENT SAVING CAN BE REALIZED WITH HYDROMINING INCLUDING THE INCREASED COAL DRYING COST AND WATER CLARIFICATION. AN ADDED CONSIDERATION IS ELIMINATION OF COMPANY SILICOSIS CONTRIBUTION. A .59 IN. DIAM PIPE WITH SIX HOLES IN ITS END CAP HAS SATISFACTORILY DRILLED 1-3/8 IN. DIAM HOLES AT ONE METER PER MIN. (IN GERMAN)

24-65-03004 NEW APPROACH TO INTERPRETING ROCK DRILLABILITY 16. FIELD RESULTS SUPPORT LABORATORY CONCLUSIONS ON TRANSPORT-LIMIT DRILLING (BIT-WEIGHT BIT-CONFIGURATION MICROBITS ROTATION HYDRAULICS WEAR)
BINGHAM, M. G. & UNIV HOUSTON
THE OIL & GAS JOURNAL, (63) NO. 9, 60-67, MAR 1, 1965. FIELD CONDITIONS WHERE A NUMBER OF VARIABLES ARE CHANGED SIMULTANEOUSLY MAY LEAD TO CONFUSION. SUCH WAS THE CASE WHEN DRILLING RATE IMPROVED GREATLY BY INCREASING NOT ONLY HYDRAULICS BUT ALSO BIT WEIGHT. ACTUALLY INCREASED BIT WEIGHT ONLY INCREASES DRILLING ALONG THE PERFORMANCE LINE ON TRANSPORT LIMIT CURVES. ADDITIONAL WEIGHT MAY ACTUALLY DECREASE PENETRATION RATE. IN FIELD DRILLING, EFFECT OF FLOW RATE IS USUALLY ACCOMPANIED BY GREATER NOZZLE VELOCITY AND EFFECT OF EACH SHOULD BE EVALUATED. OFTEN MICROBITS ARE USED TO EVALUATE DRILLING VARIABLES BUT THIS SHOULD BE DONE WITH CAUTION DUE TO MICROBIT CHARACTERISTICS. SOME DRILLING TAKES A PRECIPITIONS DROP AS WEIGHT INCREASES. THIS IS DUE TO GUMMING UP AND TOOTH BURIAL. A THREE CONE BIT DUE TO ITS SELF CLEANING ACTION CAN BE DEPENDED ON TO DRILL FASTER THAN A TWO CONE. INCREASING ROTARY SPEED INCREASES WEAR AND SOMETIMES CANNOT BE JUSTIFIED ECONOMICALLY. CHANGES IN BIT GEOMETRY WHICH INCREASED HYDRAULIC REMOVAL FORCE ALSO INCREASED DRILLING RESPONSE AND PENETRATION RATE.

24-65-03005 NEW APPROACH TO INTERPRETING ROCK DRILLABILITY 17. WHAT LOWER DRILLING LIMIT MEANS (DEPTH VOLUME-LIMIT PERFORMANCE-LINE)
BINGHAM, M. G. & UNIV HOUSTON
THE OIL & GAS JOURNAL, (63) NO. 10, 148-151, MAR 8, 1965. DRILLING BEHAVIOR IS LESS KNOWN AS RESULTS FALL FARTHER FROM PERFORMANCE LINE. FROM FIELD DATA DRILLING IS BETWEEN PERFORMANCE LINE AND A LINE CALLED THE LOWER DRILLING LIMIT WHICH HAS A SLOPE ONE THIRD OR ONE QUARTER THAT OF PERFORMANCE LINE. DRILLING DATA EVEN FALL BELOW LOWER DRILLING LIMIT BECAUSE OF VOLUME LIMIT WHERE FLUID CIRCULATION IS INADEQUATE TO CLEAR A SPECIFIC VOLUME OF CUTTINGS. FIGURES ARE GIVEN SHOWING LOWER DRILLING LIMIT AND TYPICAL DRILLING OF SHALLOW, MEDIUM DEPTH AND DEEP WELLS.

24-65-03006 NEW APPROACH TO INTERPRETING ROCK DRILLABILITY 18. HOW MUD REDUCES RESULTS TO LOWER DRILLING LIMITS (DRILLING-FLUID VOLUME-LIMIT TRANSPORT-LIMIT PERFORMANCE-LINE)
BINGHAM, M. G. & UNIV HOUSTON
THE OIL & GAS JOURNAL, (63) NO. 11, 106,109, MAR 15, 1965. IN LOWER DRILLING LIMIT REGION DRILLING FLUID PROPERTIES FREQUENTLY EXERT A CRITICAL EFFECT. DRILLING RESULTS ARE GIVEN FOR VARIOUS MUDS AT 5,000 TO 6,500 FT. INTERVAL IN A MONTANA FIELD. DRILLING WAS BETWEEN TRANSPORT LIMIT AND LOWER DRILLING LIMIT WITH NO CONSISTENT CORRELATION WITHIN VARIOUS TYPES OF MUD. WHEN MUD DRILLING IS COMPARED TO AIR, RESULTS FREQUENTLY SUGGEST EXISTENCE OF A LOWER DRILLING LIMIT. AIR DRILLING RESULTS SHOW THAT IT IS ON A PERFORMANCE LINE WHILE MUD DRILLING IS CONSIDERABLY BELOW THIS ON LOWER DRILLING OR VOLUME LIMIT. WATER AS A CIRCULATING MEDIUM GIVES RESULTS CLOSE TO AIR BUT IS NOT USED AS IT SOON MAKES UNSTABLE HOLE WALLS. AN EXPERIMENTAL ASPHALT MUD HAS GIVEN GOOD DRILLING RESULTS. DETERMINATION OF ITS CRITICAL FLUID PROPERTY COULD PROVIDE A SOUND BASIS FOR FORMULATING DRILLING FLUID.

24-65-03007 NEW APPROACH TO INTERPRETING ROCK DRILLABILITY 19. HOW LOWER DRILLING LIMIT APPEARS IN LABORATORY DRILLING (BIT PERFORMANCE-LINE FLUID PRESSURE)
BINGHAM, M. G. & UNIV HOUSTON
THE OIL & GAS JOURNAL, (63) NO. 12, 101-104, MAR 22, 1965. ALL DRILLING IS A BALANCE OF MECHANICAL AND HYDRAULIC INPUT ENERGIES AND THEIR EFFECTS UPON ROCK AND CUTTINGS REMOVAL SITUATION SET UP BY DRILLING FLUID, PRESSURE, AND ROCK ITSELF. SOME GENERALIZATIONS APPLY FOR FIELD DRILLING, MICROBITS AND DIAMOND BITS. CHANGING FROM WATER TO MUD AND APPLYING BACK PRESSURE GREATLY REDUCES DRILLING RESPONSE. REASON FOR SUPPRESSION OF DRILLING FROM PERFORMANCE LINE TO LOWER DRILLING LIMIT IS UNKNOWN.

24-65-03008 NEW APPROACH TO INTERPRETING ROCK DRILLABILITY 20. HOW SPEED, BITS, HYDRAULICS AFFECT LOWER-DRILLING-LIMIT RESULTS (PERFORMANCE-LINE TRANSPORT-LIMIT PRESSURE)
BINGHAM, M. G. & UNIV HOUSTON
THE OIL & GAS JOURNAL, (63) NO. 13, 144-151, MAR 29, 1965. IN EVALUATING A REVOLUTIONARY NEW BIT DESIGN ITS PERFORMANCE LINE WAS FOUND TO BE BELOW THAT FOR A SOFT FORMATION ROLLOER CONE BIT BUT ABOVE THAT FOR A HARD FORMATION. IT DID NOT PROMISE TO BE ECONOMICAL AS IT ALSO WORM FASTER THAN SOFT FORMATION BITS. UNDER SOME CONDITIONS BIT GEOMETRY MAY BE CRITICAL WHILE UNDER OTHERS IT IS NOT. THIS MAY BE IMPORTANT IN SETTING LOWER DRILLING LIMIT SLOPE. IN TESTS WITH ROLLER CONE, DIAMOND AND MICROBITS THE DRILLING WAS ON THE PERFORMANCE LINE AND TRANSPORT LIMIT WITH CLEAR WATER BUT DROPPED TO THE LOWER DRILLING LIMIT WHEN MUD WAS USED. HOWEVER WHEN ROTARY SPEED WAS SLOWED FROM 50 RPM TO 5 RPM OR WHEN THE BIT WAS CHANGED TO A JET MODEL, RESPONSE PICKED UP TRANSPORT LIMIT WITH WATER

24-65-04001 NEW-APPROACH TO INTERPRETING ROCK DRILLABILITY 21. FULL-SCALE TESTS SHOW EFFECTS OF HYDRAULICS ON LOWER DRILLING LIMIT. (DATA-INTERPRETATION FLUID)
BINGHAM, M. G. & UNIV HOUSTON
THE OIL & GAS JOURNAL, (63) NO. 14, 195-198, APR 5, 1965. INDUSTRY LITERATURE PROVIDES A WIDE RANGE OF EXPERIENCE FOR COMPARISONS WITH ANY FIELD OPERATION. IT IS USUALLY POSSIBLE TO GET DATA TO PROVE ANY CONTENTION THE INTERPRETES CARES TO MAKE. WHETHER A LABORATORY IMPROVEMENT CAN BE DUPLICATED IN THE FIELD IS THE REAL QUESTION. BY PLOTTING DATA ON DIFFERENT COORDINATES INTERPRETATION OF RESULTS MAY BE CHANGED OR IMPORTANT POINTS OBSCARED. PLOTS OF DATA WITH R/N-W/D GIVE CLEAREST INTERPRETATION. INFLUENCE OF FLOW RATE, MUD AND PRESSURE ARE GIVEN. IN MENTIONING AIR AS A CIRCULATING MEDIUM ITS LOW REMOVAL FORCE IS NOTED. LOWER DRILLING LIMIT DISCUSSIONS MAY HAVE GREATEST IMPORTANCE IN EVALUATING DRILLING FLUIDS ROLE THAN IN SETTING PENETRATION RATE. THERE IS SOME CRITICAL FLUID PROPERTY WHICH WOULD ALLOW DRILLING RATE TO CLIMB ABOVE LOWER DRILLING LIMIT AND BEGIN TO APPROACH CLEAR WATER RATES. CLEAR WATER WOULD BE USED EXCEPT FOR THE FACT THAT IS MAKES UNSTABLE HOLES

24-65-04002 ROLLER CUTTERS WITH TUNGSTEN CARBIDE TEETH (ROLLER-CUTTERS)
HUGHES, H. M. & NATIONAL COAL BOARD ENGLAND
COLLIERY GUARDIAN, 499-501, APRIL 9, 1965. BETWEEN 1956 AND 1962 CENTRAL ENGINEERING ESTABLISHMENT OF THE NATIONAL COAL BOARD (ENGLAND) DEVELOPED ROLLER CUTTERS FOR HORIZONTAL DRILLING OF LARGE DIAMETER HOLES IN HARD ROCK. THE TEETH WEAR LONGER THAN THE BEARINGS. A THRUST OF 13,000 LB. PER CUTTER IS NEEDED TO DRILL A ROCK WITH COMPRESSIVE STRENGTH OF 27,000 LB./SQ. INCH. THE RATE OF PENETRATION IS APPROXIMATELY 1 1/2 IN./MIN. IN HARD ROCK.

24-65-05001 FACTORS INFLUENCING THE DESIGN AND APPLICATION OF DOWNHOLE DRILLS (ROCK-DRILLS)
KNOX, J. & INGERSOLL-RAND CO
THE CANADIAN MIN AND MET BULL MONTREAL, 547-550, MAY 1965. AN ANALYSIS OF THE MAJOR PROBLEMS ENCOUNTERED IN THE DESIGN AND APPLICATION OF DOWNHOLE DRILLS. DESIGN FEATURES ARE GOVERNED BY: PHYSICAL SIZE LIMITATIONS; METALLURGICAL MATERIAL STANDARDS; PHYSICAL OPERATING ENVIRONMENT; RANGE OF COMMERCIAL MATERIALS TO BE DRILLED; HIGH POWER OUTPUT REQUIRED, COUPLED WITH SIMPLICITY FROM THE OPERATING AND MAINTENANCE VIEWPOINT, AND BIT DESIGN. THE HISTORY OF ATTEMPTS TO DEVELOP DOWNHOLE DRILLS IS DISCUSSED, AND REPRESENTATIVE MECHANICAL CONFIGURATIONS ARE ILLUSTRATED. THE GENERAL DESIGN AND APPLICATION ASPECTS OF THE DIFFERENT TYPES ARE COMMENTED ON. THE APPLICATION OF THIS DRILL TYPE IN VARIOUS COMMERCIAL FIELDS, SUCH AS (A) OIL-WELL DRILLING, (B) OPEN-PIT MINING AND (C) UNDERGROUND MINING, IS DISCUSSED, ALONG WITH THE LIMITATIONS PRESENTLY IMPOSED BY THE COMMERCIAL STATE OF THE ART IN THE MANUFACTURE OF ACCESSORY EQUIPMENT; E.G., DRILL RODS, AIR COMPRESSORS, MOUNTINGS, ETC. SUGGESTIONS ON THE POSSIBLE FUTURE DIRECTION OF THE DEVELOPMENT AND APPLICATION OF THIS TOOL ARE GIVEN. 3 REFS.

24-65-05002 RESULTS OF FIELD TESTING OF DIAMOND BITS OF NEW CONSTRUCTION (DRILLING)
ARTSIMOVICH, G. V. + ASYCHENKO, E. I. & VOVCHANOVSKII, I. F. + IVANOV, V. V.
RAZVEDKA I OKHRANA NEDR, N 5, 18-21, MAY 1965. MAJOR REQUIREMENTS ARE THAT DIAMONDS HAVE TO BE CONCENTRATED WITHIN ONE LAYER AND MUST HAVE A DEFINITE ORDER OF EXPOSURE. DESIGN OF AKV DIAMOND BITS AND RESULTS OF THEIR FIELD TESTS. (IN RUSSIAN)

24-65-05003 WATER AS WINNING AND TRANSPORT MEDIUM IN HARD-COAL MINING (JET PRESSURE VOLUME DUST SAFETY DRILLING)
WUSSOW, D.
GLUCKAUF, (101) NO. 5, 316-321, 1965. FIRST HYDRAULIC MINING WAS DONE BY RUSSIANS IN 1935 WITH A 4 MM DIAMETER NOZZLE, HANDLING 40 GALLONS OF WATER PER MINUTE AT 3675 PSI. RECENTLY THEY HAVE GONE TO 660 GALS PER MINUTE AT 1500 PSI. IN 1959 HYDROMINING WAS SUFFICIENTLY PROMISING THAT GERMANS IMPROVED A RUSSIAN NOZZLE AND EXPERIMENTED WITH IT. HYDROMINING HAS THESE ADVANTAGES OVER STANDARD METHODS: NO LONGER HINDERED BY TIMBER INSTALLATION AND STOWING, WORK IS MORE CONCENTRATED, GEOLOGICAL DEFORMATIONS ARE MORE EASILY HANDLED, TIMBERING LABOR IS REDUCED, EQUIPMENT COST SHOULD RISE MORE SLOWLY, NO DUST IS PRODUCED, AND ACCIDENT RISK IS REDUCED. RESULTS FROM THE EXPERIMENTAL SECTION WHERE ABOUT 5000 TONS OF COAL WERE MINED ENCOURAGED A FURTHER LARGE-SCALE TEST WHICH IS RUNNING. DESCRIPTION AND COMPARISON OF VARIOUS HYDRAULIC HOISTING SYSTEMS IS GIVEN. HYDRAULICALLY BORING HOLES IS DESCRIBED. SINCE MATERIAL COSTS INCREASE MORE SLOWLY THAN LABOR COSTS, THE COST ADVANTAGE SHOWN FOR HYDROMINING OVER STANDARD METHODS WILL INCREASE.

24-65-07001 RESULTS OF EXPERIMENTAL INVESTIGATION OF DRILLABILITY OF QUARTZITES IN PERVOURAL'SK DEPOSIT IN THERMAL JET PIERCING (FLAME-JET)
SIMANOV, V. G. + SUVOROV, B. I. + VINOGRADOV, V. S. & KRIVOSCHENKO, YU. V. + KUZHEL, S. A. + KRAUTSON, V. M.
GORNYI ZHURNAL, N 7, 92-97, JULY 1965. COST OF DRILLING WITH JET PIERCING WAS ONE-HALF OF CONVENTIONAL. PRESENCE OF SHALE PARTINGS REDUCED EFFICIENCY OF JET PIERCING. IN THIS CASE CONVENTIONAL ROCK DRILL BITS ACHIEVE BETTER PENETRATION. USE OF COMBINATION DRILL COMPREISING BOTH JET AND CONVENTIONAL BIT IS RECOMMENDED. RECOMMENDATIONS ARE MADE FOR IMPROVING THE DESIGN AND CONSTRUCTION OF THE THERMAL JET PIERCING DRILL. (IN RUSSIAN)

24-65-07002 EFFECT OF ELASTICITY OF ROCKS ON THEIR DRILLABILITY USING THERMAL JET PIERCING (FLAME-JET)
DMITRIEV, A. P. + YAMSHCHIKOV, V. S.
GORNYI ZHURNAL, N 7, 98-102, JULY 1965. ANALYSIS OF EXPERIMENTAL DATA INDICATES THAT TEMPERATURE EFFECT ON NATURE OF CHANGES IN ELASTICITY IS DIFFERENT. THIS IS CONNECTED WITH VARIOUS RELAXATION PROCESSES AT BOUNDARIES BETWEEN MINERALS. DATA WERE EVALUATED ACCORDING TO TEMPERATURE DEPENDENCE OF YOUNG'S MODULUS. (IN RUSSIAN)

24-65-07003 HYDRAULIC COAL MINING AND WASTE AREA PACKING AT KRASNOGARSKAYA (PRODUCTION PACKING SUPPORT COMBUSTION SLOPE)
YAKOVLEV, N. M. + BOLOTOV, R. P. + ZAKHVATKIN, L. N. & KAZBASSUGOL COMBINE &
UGOL, (40) NO. 7, 31-64, JULY 1965. COAL LAYERS AT KRASNOGORSKAYA IN RUSSIA ARE GAS YIELDING AND HAVE A TENDENCY TOWARD SPONTANEOUS COMBUSTION. MINING WAS BEGUN USING LAYER COLLAPSING SYSTEMS BUT BECAUSE OF FIRE EMERGENCE ON BOTH FLANKS IT WAS DECIDED TO PACK WASTE AREAS. AVERAGE THICKNESS OF 42 TO 45 DEGREE SLOPING COAL LAYERS IS 3 METERS. AT FIRST EXPLOSIVE MINING AND BELT CONVEYING WAS USED TO PRODUCE 1150 TONS PER MONTH WITH WORKER OUTPUT PER FACE OF 7.5 TONS AND MONTHLY FACE ADVANCE OF 25.5 METERS. BY USING HYDRAULIC WASHOUT AND CONVEYANCE MONTHLY PRODUCTION WAS INCREASED TO 3800 TONS AND OUTPUT PER MINER TO 13.5 TONS. DETAILS OF THE SUPPORT SYSTEM AND HYDRAULIC PACKING ARE GIVEN. DETAILS OF HYDRAULIC WASHOUT AND COAL CONVEYING ARE NOT GIVEN.

24-65-07004 THE FAILURE OF ROCK (BREAKAGE NON-ELASTIC GRIFFITH-CRACK)
COOK, N. G. W. & CHAMBER OF MINES JOHANNESBURG
INTERNATIONAL JOURNAL OF ROCK MECHANICS AND MINING SCIENCES, (2) 389-403, JULY 1965. AN ANALYSIS OF THE ENERGY CHANGES ASSOCIATED WITH THE EXTENSION OF GRIFFITH CRACKS IN TENSION AND COMPRESSION IS MADE, WHICH SHOWS THAT THE NON-ELASTIC BEHAVIOR CAN BE DESCRIBED BY A CURVED GRIFFITH LOCUS IN THE STRESS - STRAIN PLANE. ONLY WHEN THE SLOPE IS POSITIVE IS A MATERIAL INTRINSICALLY BRITTLE AND LIABLE TO SPONTANEOUS FRACTURE. WHEN THE LOCUS IS NEGATIVE CRACK EXTENSION CAN PROCEED BY UNSTABLE FRACTURE OR STABLE FRACTURE DEPENDING ON THE AMOUNT OF ENERGY SUPPLIED. TRIAXIAL CONFINEMENT REDUCES THE NEGATIVE SLOPE AND MAKES MATERIAL MORE DUCTILE. EXPERIMENTAL DATA ON TENNESSEE MARBLE AND ST. CLOUD GRANITE IS SHOWN TO BE IN ACCORD WITH THE ANALYTICAL PREDICTIONS.

24-65-10001 ON DETERMINATION OF PERFORMANCE OF NOZZLE OF HYDRAULIC MINING DEVICE (WATER-JET)
YOSHIZAWA, Y. + KAWASHIMA, T. + YANAIDA, K.
JOURNAL OF MIN AND MET INST JAPAN, (81) N 830, 29-34, OCT 1965. FOR DETERMINING PERFORMANCE OF NOZZLE, FLOW CHARACTERISTICS OF WATER JET ARE STUDIED MATHEMATICALLY CORRELATING DIVERGENCE COEFFICIENT OF JET, PROFILE OF JET, AND DYNAMIC PRESSURE DISTRIBUTION ALONG CENTER LINE AND RADIAL AXIS OF JET. (IN JAPANESE)

24-65-10002 ON PARAMETERS OF MONITOR JET AND STRESS DISTRIBUTION IN COAL SEAMS IN HYDRAULIC CRUSHING
HOKAO, Z.
JOURNAL OF MIN AND MET INST JAPAN, (81) N 830, 23-28, OCT 1965. PROBLEMS ASSOCIATED WITH PARAMETERS OF HIGH-PRESSURE WATER JET DIRECTED AGAINST FACE, AND STRESS DISTRIBUTION IN COAL SEAMS IN HYDRAULIC CRUSHING ARE DERIVED MATHEMATICALLY SHOWING RELATIONSHIP BETWEEN PARAMETERS RELATED TO DISTANCE BETWEEN FACE AND NOZZLE. (IN JAPANESE)

24-65-10003 PRINCIPAL HYDRAULIC JET PARAMETERS AND STRESS DISTRIBUTION IN COAL SEAMS DURING HYDRAULIC CRUSHING (NOZZLE PRODUCTION)
HOKAO, Z. & TOKYO UNIV
NIPPON KOGYO KAISHI, (81) N 930, 23-28, OCT. 1965. SINCE HYDROMINING WAS INTRODUCED TO JAPAN MANY LABORATORY AND COLLIERY EXPERIMENTS HAVE BEEN CARRIED OUT. MANY GOOD RESULTS WERE REPORTED AND SOME COAL MINES HAVE ACHIEVED VERY HIGH PRODUCTIVITY. DEVELOPMENT OF THIS TECHNIQUE REQUIRES THEORETICAL ANALYSIS AS WELL AS EXPERIMENTAL WORK ON PARAMETERS OF HIGH PRESSURE JET DIRECTED AGAINST THE FACE, AND STRESS DISTRIBUTION IN COAL SEAMS IN HYDRAULIC CRUSHING. A THEORETICAL AND MATHEMATICAL ANALYSIS OF THESE PROBLEMS IS GIVEN. RESULTS ACQUIRED SHOW RELATIONS BETWEEN PARAMETERS OF JET AND STRESS DISTRIBUTION IN COAL SEAMS RELATED TO DISTANCE BETWEEN FACE AND NOZZLE.

24-65-10004 DETERMINATION OF HYDRAULIC MINING DEVICE NOZZLE PERFORMANCE (SLOPE-ANGLE NOZZLE-LENGTH PRESSURE FLOW FRACTURING KOBAYASHI-FORMULA)
YOSHIZAWA, Y. + KAWASHIMA, T. + YANAIDA, K. & TOHOKU UNIV
NIPPON KOGYO KAISHI, (81) 29-34, OCT. 1965. PREVIOUS NOZZLE DESIGN FROM VELOCITY DISTRIBUTION CALCULATIONS OR EXPERIMENTATION WITH VARIOUS CONFIGURATIONS WAS INADEQUATE. FROM THE KOBAYASHI EQUATIONS A TABLE OF NOZZLE EXIT SLOPE ANGLE, NOZZLE LENGTH AND PRESSURE. NOZZLE LENGTH EQUAL TO FOUR TIMES THE JET DIAMETER WAS FOUND TO GIVE BEST PERFORMANCE. THE GREAT EFFECT OF NOZZLE OUTLET SLOPE ANGLE ON PERFORMANCE IS SHOWN. A SLOPE ANGLE OF 80 DEGREES WAS FOUND TO GIVE GOOD PERFORMANCE. WORK IS NOW UNDERWAY TO DETERMINE THE EFFECT OF NOZZLE DIAMETER AND NOZZLE INLET WIDTH ON NOZZLE PERFORMANCE, ESTABLISHMENT OF CONE SHAPED NOZZLE PERFORMANCE FOR EASIER FABRICATION, HIGH PRESSURE PERFORMANCE AS COMPARED TO THESE LOW PRESSURE DATA, AND ELUCIDATION OF JET FLOW CHARACTERISTICS AND FRACTURING BEHAVIOR.

24-65-11001 WHEN SHOULD YOU REPLACE A ROCK DRILL (INSPECTION MAINTENANCE REPAIR RECORDS)
POHS, H. A. & GARDNER-DENVER CO CLEV OHIO
ROCK PRODUCTS, 65, NOV. 1965. MAINTENANCE OF THE MODERN ROCK DRILL AND ITS INDIVIDUAL PARTS HAS BECOME A PROBLEM OF SIMPLE, INDIVIDUAL INSPECTION AND BALANCING OF REMAINING USEFUL LIFE OF PARTS AGAINST THEIR REPLACEMENT OR REPAIR COST. KEEP A CARD FILE FOR EACH DRILL AND RECORD BEGINNING DATE OF SERVICE, DATE OF EACH OVERHAUL OR SHIP REPAIR, PART NAME AND COST OF PARTS REPAIRED AND DRILLING FOOTAGE RENDERED BY EACH PART. SUCH RECORDS PROVIDE ACCURATE COST PER FOOT DRILLED OR PER HOLE DRILLED AND WILL VERIFY MAINTENANCE TECHNIQUES. FURTHER ANALYSIS WILL GIVE ACCURATE COST RECORDS OF OVERALL DRILLING OPERATIONS AND CAN PINPOINT AREAS WHERE IMPROVEMENT MAY BE ACHIEVED.

24-65-11002 ROCK DRILL MAINTENANCE MADE EASY (LUBRICATION AIR INSPECTION EFFICIENCY)
REINKER, N. W. + LEAR, E. B. + POHS, H. A. & WESTINGHOUSE AIR BRAKE
ROCK PRODUCTS, 66-70, NOV 1965. THE THREE MOST IMPORTANT FACTORS IN ROCK DRILL OPERATION ARE: GOOD LUBRICATION PRACTICE, IMMEDIATE PROPER REPLACEMENT OF WORN PARTS, AND CLEAN COMPRESSED AIR. WESTINGHOUSE'S ROCK DRILL TROUBLESHOOTER'S GUIDE IS GIVEN AND A CHECK LIST OF TEN ITEMS WHICH DRILL OPERATORS SHOULD OBSERVE TO ELIMINATE TROUBLE IS GIVEN. TO TEST DRILL EFFICIENCY A COMPARATIVE OPERATION TEST CAN BE USED OR A MORE COMPLICATED SET UP USED FOR OBTAINING STRIKING RATE AND POWER.

24-65-11003 WILL SLURRY BLASTING AGENTS REPLACE AN/FO?
COOK, V. O. & IRECO CHEMICALS SALT LAKE CITY
ROCK PRODUCTS, 70-72, NOV. 1965. SLURRY BLASTING AGENTS ARE BEING DELIVERED DIRECTLY TO THE CUSTOMERS QUARRY OR MINE USING BULK HANDLING METHODS. ON SITE MIXING AND PUMPING INTO THE BOREHOLE IS AVAILABLE.

24-65-12001 BIT-TOOTH PENETRATION UNDER SIMULATED BOREHOLE CONDITIONS (DRILLABILITY)
MAURER, W. C. & ESSO PROD RES CO HOUSTON TEX
JOURNAL OF PETROLEUM TECHNOLOGY - PETROLEUM TRANSACTIONS, 1433-1442, DEC. 1965. A STUDY OF BIT-TOOTH PENETRATION, OR CRATER FORMATION, UNDER SIMULATED BOREHOLE CONDITIONS HAS BEEN MADE. PRESSURE CONDITIONS EXISTING WHEN DRILLING WITH AIR, WATER AND MUD HAVE BEEN SIMULATED FOR DEPTHS OF 0 TO 20,000 FT. THESE WATER TESTS SHOWED THAT A THRESHOLD BIT-TOOTH FORCE MUST BE EXCEEDED BEFORE A CRATER IS FORMED. THIS THRESHOLD FORCE INCREASED WITH BOTH TOOTH DULLNESS AND DIFFERENTIAL PRESSURE BETWEEN THE BOREHOLE AND FORMATION FLUIDS. WITH CONSTANT FORCE OF 6500 LB APPLIED TO THE BIT TEETH, AN INCREASE IN DIFFERENTIAL PRESSURE FROM 0 TO 5,000 PSI REDUCED THE CRATER VOLUMES BY 90 PERCENT. A COMPARABLE INCREASE IN HYDROSTATIC FLUID PRESSURES PRODUCED ONLY A 50 PERCENT DECREASE IN VOLUME WHILE CHANGES IN OVERBURDEN PRESSURE HAD NO DETECTABLE EFFECT ON CRATER VOLUME. CRATER TESTS IN UNCONSOLIDATED SAND SUBJECTED TO DIFFERENTIAL PRESSURE SHOWED THAT HIGH FRICTION WAS PRESENT IN THE SAND AT HIGH PRESSURE.

24-65-12002 AIR DRILLING DEEP HOLES (DRILLING-RATE BIT-LIFE GEOLOGICAL-ANALYSIS COOLING-MEDIUM PERCUSSION)
STAGNITO, H.
COMPRESSED AIR MAGAZINE, (70) 8-11, DEC 1965. APPLICATION OF AIR IN DRILLING HAS SEVERAL ADVANTAGES OVER OTHER PRACTICES. FASTER CUTTING REMOVAL INCREASES SPEED OF BIT PENETRATION. GEOLOGICAL ANALYSIS IS FACILITATED AS CUTTINGS ARE REMOVED ALMOST IMMEDIATELY. BITS HAVE LONGER LIFE. REDUCED HOLE PRESSURES, DUE TO ELIMINATION OF MUD COLUMN WEIGHT, PERMITS FASTER DRILLING. AIR OR GAS DOES NOT CONTAMINATE FORMATIONS. PERCUSSION TOOLS ARE USED WITH AIR, GAS OR MIST AND DRILL TO EXTREME DEPTHS WITH FAVORABLE RESULTS. DRILLING A HOLE TO 7200 FT IN ARK. SUPERVISED BY INGERSOLL-RAND DRILLING SERVICES IS DESCRIBED.

24-65-12003 HIGH PRESSURE VOLE DRILLING IN LEICESTERSHIRE GRANITE (DRILLING-RATE CARBIDE-INSERT DOWN-THE-HOLE-DRILL)
PATEY, D. R.
MIN AND MINERAL ENGR., (1) N 16, 610-615, DEC 1965. IN GRANITE QUARRIES THE 4-IN. DOWN THE HOLE DRILLING MACHINE WITH 100 LB PER SQ. IN. AIR SUPPLY HAS BEEN WIDELY ADOPTED. RECENTLY A VERSION OF THE HOLMAN 4 IN. VOLE DRILL HAMMER HAS BEEN OPERATED ON 150 LB PER SQ. IN. AIR. THIS MODIFICATION OFFERS ECONOMIES BY AT LEAST DOUBLING THE DRILLING RATE. THE 150 LB PER SQ. IN. MACHINE IS MECHANICALLY RELIABLE AND WHEN BIT PERFORMANCE PROBLEMS ARE OVERCOME, IT WILL PROVE A VALUABLE QUARRYING AND OPENCAST MINING TOOL. THE QUARRIED GRANITE HAS 45,000 TO 52,700 LB PER SQ. IN. CRUSHING STRENGTH AND IS CONSIDERED VERY ABRASIVE. 4-IN. CRUCIFORM TUNGSTEN CARBIDE INSERT BITS ARE USED WITH WIDELY VARIED PERFORMANCE. ON PRODUCTION THE HIGH PRESSURE VOLE-DRILL HAS AVERAGED 18 FT PER HR OVERALL WITH A BEST PERFORMANCE OF 32 FT PER HR.

24-65-12004 BIG HOLE DRILLING, A STUDY IN DEPTH (HOLE-DIAMETER HOLE-DEPTH DRILL-STRING ROLLER-BIT)
DELLINGER, T. B. & FENIX AND SCISSON INC TULSA OKLA
MINING ENGINEERING, 71-75, DEC 1965. THIS ARTICLE IS PART OF A PAPER PREPARED FOR THE SECOND SYMP. ON SALT, CLEVELAND, MAY 1, 1965. TABLE I GIVES INFORMATION ON 175 HOLES FROM 36 IN. DIAM TO 301 IN. AND 205 FT TO 3000 FT DEEP. ANOTHER TABLE GIVES INFORMATION ON AEC TEST HOLES FROM 29 IN. DIAM TO 160 IN. AND FROM 306 TO 4800 FT DEEP. PUBLISHED ARTICLES HAVE DISCUSSED DRILLING PROCEDURES AND PROBLEMS. COSTS ARE EXTREMELY VARIED DUE TO VARIED CONTRACT AND DRILLING CONDITIONS. ILLUSTRATED ARE A 72-IN. ROLLER BIT COSTING $12,000 AND A 160-IN. DIAM BIT COSTING $22,000. BOTH SINGLE AND DUAL DRILL STRINGS ARE SHOWN.

24-66-00001 SMOOTH BLASTING AND PRE-SPLITTING
FENNELL, M. H. + PLEWMAN, R. P. + BROWN, A. N.
SOUTH AFRICA PAPERS & DISCUSSIONS, 811-63, 1966-1967. TECHNIQUES OF EXCAVATION BY CONTROLLED BLASTING, PRODUCING SMOOTH, UNDISTURBED SURFACES OF ROCK WALLS ARE DISCUSSED AND THEIR THEORETICAL BASIS EXPLAINED. EXPERIENCE REQUIRED IN SOUTH AFRICAN GOLD MINES SINCE 1965 IN USE OF SMOOTH BLASTING AND PRESPLITTING METHODS IS REPORTED AND COST DATA IS GIVEN. 14 REFS.

24-66-01001 HOW BOTTOM-HOLE PRESSURE AFFECTS PENETRATION RATE (OIL-WELL CRATERS DRILLING-RATE)
MAURER, W. C. & ESSO PROD RES CO HOUSTON TEX
THE OIL AND GAS JOURNAL, (64) 61-65, JAN 10, 1966. A PRESSURE CHAMBER WAS USED TO STUDY HOW A BIT TOOTH PENETRATES ROCK UNDER BOTTOM-HOLE-PRESSURE CONDITIONS. THE THREE BOTTOM-HOLE PRESSURES WERE VARIED INDEPENDENTLY TO SIMULATE DRILLING WITH AIR, WATER, AND MUD. A BIT TOOTH FORMS A CRATER WHEN THE TOOTH IMPACTS THE ROCK. THE CRATER VOLUME IN WATER DRILLING DECREASED A SMALLER AMOUNT WHICH IS ONE OF THE REASONS WATER DRILLS FASTER THAN MUD. THE CRATER VOLUME IN AIR DRILLING DID NOT CHANGE WHICH IS ONE REASON AIR DRILLS FASTER THAN WATER OR MUD. DRILLING RATE DECREASES RAPIDLY AS BOREHOLE PRESSURE INCREASES. SAND UNDER DIFFERENTIAL PRESSURE ACTS LIKE SOLID ROCK. MICROBIT DRILLING RATE IN LOOSE SAND DECREASES AS DIFFERENTIAL FLUID PRESSURE INCREASES.

24-66-06001 SHAFT BORING WITH OIL WELL DRILLING EQUIPMENT AT LYNN LAKE
CAIN, P. A. + FOLINSBEE, J. C. & SHERRITT GORDON MINES
THE CANADIAN MINING AND METALLURGICAL BULLETIN, 725-732, JUNE 1966. A 4-FT-DIA. SHAFT HAS BEEN DRILLED TO A DEPTH OF 2,790 FT. IN STRONG, HARD, BASIC PRECAMBRIAN ROCKS AT LYNN LAKE, MANITOBA. THE DRILLING WAS DONE UNDER CONTRACT BY TWO DRILLING COMPANIES. PETER BAWDEN DRILLING (1964) LTD. DRILLED THE INITIAL 12-1/4 IN PILOT HOLE TO A DEPTH OF 3,000 FT. SHAFT DRILLERS LTD. OF CANADA THEN REAMED THE HOLE TO 4 FT IN DIA. TO A DEPTH OF 2790 FT. AT THIS POINT, THE REAMING WAS STOPPED BECAUSE OF THE DIFFICULTY IN PASSING A CHANGE IN DIRECTION IN THE LINE OF THE PILOT HOLE. THE HOLE WAS COMPLETED BY DRIVING A RAISE 200 FT FROM THE 3,000 LEVEL TO THE BOTTOM OF THE 4-FT. HOLE USING A ALIMAK RAISE CLIMBER. THE ELAPSED TIME FROM THE START OF THE PILOT HOLE TO THE COMPLETION OF THE REAMING OPERATION WAS TEN MONTHS, WITH AN AVERAGE ADVANCE OF 279 FT PER MONTH. THERE WAS A TWO MONTH DELAY BETWEEN THE COMPLETION OF THE PILOT HOLE AND THE START OF THE REAMING OPERATION. THE 12-1/4 IN. HOLE WAS DRILLED IN AN ELAPSED TIME OF 45 DAYS FROM THE TIME OF SETTING UP THE RIG. AVERAGE ADVANCE PER DAY WAS 66.8 FT. THE REAMING OPERATION TOOK 194 DAYS. A ONE-MONTH DELAY REQUIRED TO REPAIR DAMAGED EQUIPMENT LEFT 163 DAYS FOR THE DRILLING AND SETTING-UP OPERATION FOR AN ADVANCE PER DAY OF 17.1 FT.

24-66-06002 SOME ASPECTS OF ROCK CUTTING BY HIGH SPEED WATER JETS (JET-PENETRATION NOZZLE PRESSURE VELOCITY ROCK-STRENGTH)
LEACH, S. J. + WALKER, G. L. & SAFETY IN MINES RES EST
ROYAL SOC OF LONDON, PHILOSOPHICAL TRANSACTION, SERIES A, (260) 295-308, JUNE 16, 1966. HIGH SPEED WATER JETS MAY PROVIDE A COAL CUTTING METHOD FREE FROM METHANE IGNITION HAZARD. WATER JETS PRODUCED BY 600 ATMOSPHERES AND 5000 ATMOSPHERES PRESSURE WERE EXAMINED BY SHORT EXPOSURE OPTICAL PHOTOGRAPHY TO DETERMINE JET VELOCITY DECAY WITH DISTANCE FROM A NOZZLE AND TO COMPARE NOZZLE DESIGN. MAXIMUM PRESSURE WAS HALF THE PUMP PRESSURE AT A DISTANCE OF 350 NOZZLE DIAMETERS. A THEORY OF PRESSURE DISTRIBUTION ON A TARGET PLATE WAS FOUND TO BE IN AGREEMENT WITH EXPERIMENTS. FIVE ROCKS WITH COMPRESSIVE STRENGTHS OF 4,850 PSI TO 21,462 PSI WERE TESTED WITH A JET FROM A 1 MM DIAM NOZZLE AT A VELOCITY OF 1000 M/S (2,237 MI PER HR). MOST COMMONLY OBSERVED DAMAGE WAS A 5 MM DIAM HOLE 2 CM DEEP. THE TESTS ON THE THREE HARDER ROCKS SUGGEST THERE IS A CRITICAL PRESSURE BELOW WHICH SIGNIFICANT PENETRATION DOES NOT TAKE PLACE WHICH IS AS HIGH AS 2000 ATM FOR THE 21,462 PSI COMPRESSIVE STRENGTH ROCK, A PENNANT SANDSTONE. IT WAS PROPOSED TO DO FURTHER WORK WITH AN INTENSIFIER GIVING 2 LITERS OF WATER AT 5000 ATMOSPHERES IN ORDER TO STUDY TRAVERSING EFFECTS.

24-66-06003 DISCUSSION OF SOME ASPECTS OF ROCK CUTTING BY HIGH SPEED WATER JETS (JET-CUTTING PRESSURE ROCK-STRENGTH
FARMER, I. W. + LEACH, S. J. & UNIV SHEFFIELD ENGLAND
ROYAL SOCIETY OF LONDON, PHILOSOPHICAL TRANSACTION SERIES A, (260) 309-310, JUNE 16, 1966. (FARMER) JET ATTACK ON HARD ROCK MUST FRACTURE THE ROCK PARTLY BY COMPRESSION AND SHEAR, PARTLY BY THE INDUCTION OF REFLECTED TENSILE STRESSES IN THE IMPACT ZONE, AND PARTLY BY HYDRAULIC WEDGING ACTION. WATER JET IMPACT TESTS ON A SERIES OF ROCKS AT PRESSURES UP TO 1700 ATM HAVE SHOWN THAT MOST ROCKS ARE RELATIVELY EASILY PENETRATED BY WATER JETS TO FORM A CYLINDRICAL OR CYLINDRI-CONICAL CRATER. (LEACH) A STEADY WATER JET BREAKS UP GIVING A RAPID SUCCESSION OF WATER HAMMER IMPULSES ON THE TARGET IN NORMALLY STEADY JETS. FOR THESE REASONS, JETS WHICH ARE MADE DELIBERATELY INTERMITTENT MAY NOT PROVE TO BE USEFUL AT HIGH PRESSURES. TRAVERSING A ROCK SURFACE BY THE WATER JET MAY INCREASE ROCK CUTTING EFFICIENCY.

24-66-07001 HIGH SPEED LIQUID IMPACT (ROCK-BREAKING WATER-JET EROSION)
BRUNTON, J. H. & CAVENDISH LAB CAMBRIDGE MASS
PHILOSOPHICAL TRANSACTIONS ROYAL SOCIETY OF LONDON, SERIES A, (260) 79-85, JULY 28, 1966. A STUDY WAS MADE OF THE DEFORMATION AT HIGH STRAIN RATES OF SOLIDS UNDER THE IMPACT OF LIQUIDS. A METHOD FOR PRODUCING A SHORT LIQUID JET AT SPEEDS UP TO 1,200 M/S IS DESCRIBED. FLOW OF THE LIQUID AND DEFORMATION OF THE SOLID WERE OBSERVED BY HIGH SPEED PHOTOGRAPHIC TECHNIQUES. THE MODE OF DEFORMATION IN BRITTLE AND IN PLASTIC DEFORMING MATERIALS WAS INVESTIGATED AND WAS FOUND TO BE DEPENDENT ON THE MECHANICAL PROPERTIES OF THE SOLID AND ON THE VELOCITY OF IMPACT.

24-66-07002 STRESS WAVES, DEFORMATION, AND FRACTURE CAUSED BY LIQUID IMPACT (ROCK-BREAKING WATER-JET EROSION)
FIELD, J. E. & CAVENDISH LAB CAMBRIDGE MASS
PHILOSOPHICAL TRANSACTION, ROYAL SOCIETY OF LONDON, SERIES A, (260) 86-93, JULY 28, 1966. WHEN A LIQUID MASS STRIKES A SOLID SURFACE COMPRESSIBLE BEHAVIOR RESULTS IN A PRESSURE SPIKE. THE DURATION OF THE PEAK DEPENDS ON DIMENSIONS AND IMPACT VELOCITY OF THE LIQUID MASS AND ON THE COMPRESSIONAL WAVE VELOCITY FOR THE LIQUID. THE FRACTURE AND DEFORMATION OF GLASSES AND POLYMERS, SINGLE CRYSTALS AND CERAMIC MATERIALS BY LIQUID IMPACT AT VELOCITIES UP TO 1,000 M/S IS DESCRIBED.

24-66-07003 THE FORMATION OF MICROJETS (EROSION WATER-JET)
BOWDEN, F. P. & CAVENDISH LAB CAMBRIDGE MASS
PHILOSOPHICAL TRANSACTIONS, ROYAL SOCIETY OF LONDON, SERIES A, (260) 94-95, JULY 28, 1966. IF A SMALL CAVITY OR BUBBLE OF LIQUID IS SUBJECTED TO IMPACT OR SHOCK, TINY MONROE JETS MAY BE FORMED ON ITS CONCAVE SURFACE. THE VELOCITY OF THESE MICROJETS MAY BE HIGH. (3 PLATES ARE USED TO ILLUSTRATE THESE JETS.)

24-66-07004 THE RESISTANCE OF MATERIALS TO IMPACT EROSION DAMAGE
BAKER, D. W. C. + JOLLIFFE, K. H. + PEARSON, D.
PHILOSOPHICAL TRANSACTIONS, ROYAL SOCIETY OF LONDON, SERIES A, (260) 193-194, JULY 28, 1966. THE BEHAVIOR OF ESTABLISHED AND POTENTIAL TURBINE BLADE AND EROSION SHIELD MATERIALS SUBJECT TO EROSION TO WATER DROPLETS OF CONTROLLED SIZE WERE INVESTIGATED OVER A RANGE OF IMPACT VELOCITIES UP TO 1040 FT/S.

24-66-07005 THE COLLAPSE OF CAVITATION BUBBLES AND THE PRESSURES PRODUCED AGAINST SOLID BOUNDARIES (EROSION WATER-JETS)
BENJAMIN, T. B. + ELLIS, A. T. & UNIV CAMBRIDGE
PHILOSOPHICAL TRANSACTION, ROYAL SOCIETY OF LONDON, SERIES A, (260) 221-240, JULY 28, 1966. A BROAD REVIEW OF CAVITATIONS AS A BRANCH OF HYDRODYNAMICS INCLUDING THE IMPLOSION MECHANISM ANALYZED BY LORD RAYLEIGH AND THE NEWER IDEA THAT EFFECTS OF EQUALLY GREAT VIOLENCE MAY ARISE THROUGH IMPACT OF LIQUID JETS FORMED BY COLLAPSING CAVITIES. THE SIGNIFICANCE OF AVAILABLE THEORETICAL AND EXPERIMENTAL INFORMATION ABOUT CAVITY COLLAPSE IS DISCUSSED. AN EXPOSITION ON IDEAS ABOUT THE FACTORS CONTRIBUTING TO SHAPE CHANGES AND EVENTUAL JET FORMATION BY COLLAPSING CAVITIES IS PRESENTED. NEW EXPERIMENTAL OBSERVATIONS ON THE UNSYMMETRICAL COLLAPSE OF VAPOR FILLED CAVITIES ARE PRESENTED.

24-66-07006 CONTRIBUTION TO THE DISCUSSION OF: AN INVESTIGATION AIMED AT IMPROVING THE EFFICIENCY OF DRILLING ROCK BY PERCUSSION DRILLING BY V. F. LONG
FAIRHURST, C. + HUSTRULID, W. A. & UNIV MINN MINNEAPOLIS MINN
JOURNAL OF SOUTH AFRICAN INSTITUTE OF MINING AND METALLURGY, 687-691, JULY 1966. THE AUTHOR OF THE ORIGINAL PAPER PRESENTED SOME RESULTS OF HIS ATTEMPTS TO GENERATE IN A DRILL ROD A STRAIN PULSE OF SUCH A FORM THAT THE ENTIRE ENERGY OF THE PULSE IS USED IN ROCK BREAKAGE. THE CONTRIBUTORS DISAGREE, CLAIMING IT IS ONLY THEORETICAL KNOWLEDGE. THEIR ARGUMENTS INCLUDE: 1) FAILURE TO SATISFY THE LINEAR FORCE-DISPLACEMENT CONDITION, AND 2) FAILURE TO GENERATE THE 'IDEAL' PREDETERMINED WAVEFORM. TESTS INDICATED NO VARIATION OF THE AVERAGE FORCE-PENETRATION RELATIONSHIP AND AVERAGE ENERGY REQUIRED PER UNIT ROCK CRATER VOLUME OVER A WIDE RANGE OF IMPACT VELOCITIES. ALSO, THE IDEAL WAVEFORM SHOULD DROP INSTANTANEOUSLY TO ZERO STRAIN FROM THE PEAK VALUE. SINCE REBOUND IS ESSENTIAL, IT IS LEGITIMATE TO REGARD THIS PORTION OF THE ENERGY AS CONTRIBUTING TO DRILL EFFICIENCY. THE STANDARD PERCUSSION MACHINE THUS HAS A PEAK OF 90 TO 95 PERCENT. THE PREDETERMINED WAVE MAY THEORETICALLY ACHIEVE 100 PERCENT ENERGY TRANSMISSION EFFICIENCY FOR ONE BLOW BUT THE LACK OF ENERGY FOR REBOUND WILL RESULT IN A BIT REMAINING IN THE CRATER. DUE TO THE LOW TORQUE CAPACITY OF CONVENTIONAL MACHINES, THE BIT WILL BE UNABLE TO ROTATE AND THE MACHINE WILL STALL. THEREFORE EFFICIENCY IS ZERO.

24-66-07007 CHECK YOUR PSI FOR BETTER ROCK DRILL FOOTAGES (JACKHAMMER AIR-PRESSURE COMPRESSOR LIMESTONE)
PEVRIFOY, R. L. & OKLA STATE UNIV
ROAD AND STREETS, 72-73, JULY 1966. JACKHAMMER DRILLING TESTS WERE CONDUCTED IN CONCRETE AND LIMESTONE. THE RATE OF DRILLING INCREASED FROM 10 TO 12.5 IN PER MINUTE WHEN THE AIR PRESSURE WAS INCREASED FROM 60 PSI TO 80 PSI IN CONCRETE. THE RATE INCREASED FROM 14 TO 17 IN PER MINUTE IN LIMESTONE IN THE SAME PRESSURE RANGE. THE RATES 10 PERCENT WHICH FALL ABOVE AND BELOW THE CURVES MAY HAVE RESULTED FROM VARIATIONS IN THE TEMPERATURE WHICH VARIED FROM 63 DEGREES F TO 14 DEGREES F.

24-66-08001 MEASUREMENT OF SOME MECHANICAL PROPERTIES OF ROCKS AND THEIR RELATIONSHIP TO ROCK DRILLABILITY (SPECIFIC-DISINTEGRATION HARDNESS)
GSTALDER, S. + RAYNAL, J. & S.N.P.A. PAU FRANCE
JOURNAL OF PETROLEUM TECHNOLOGY, (18), 991-996, AUG. 1966. CONSIDERATION WAS GIVEN TO A SIMPLE TEST WHICH COULD BE PERFORMED ON ROCKS TO GIVE A MEASURE OF ROCK DRILLABILITY. VARIOUS METHODS OF BREAKING ROCKS WERE CONSIDERED AND THE HARDNESS TEST DEVELOPED BY SCHREINER WAS SELECTED FOR THIS STUDY. THE TEST INVOLVES APPLICATION OF AN INCREASING LOAD ON THE ROCK FACE THROUGH A FLAT-FACED CYLINDRICAL PUNCH UNTIL RUPTURE OCCURS. TEST RESULTS SHOW THAT HARDNESS IS A GOOD MEASURE OF THE BREAKING STRENGTH OF ROCKS. USEFUL RELATIONSHIPS ARE SHOWN TO EXIST BETWEEN HARDNESS AND OTHER PHYSICAL QUANTITIES SUCH AS SPECIFIC DISINTEGRATION, YOUNG'S MODULUS, AND SONIC VELOCITY. SPECIFIC DISINTEGRATION (VOLUME OF ROCK BROKEN PER UNIT OF WORK INPUT) PROVIDES A POSSIBLE MEANS OF COMPARING THE EFFECTIVENESS OF OTHER METHODS OF ROCK BREAKAGE. THE RELATIONSHIP BETWEEN HARDNESS AND SONIC VELOCITY MAY BE VERY SIGNIFICANT FOR IT MAY BE POSSIBLE TO DEDUCE ROCK DRILLABILITY FROM SONIC LOG DATA, PROVIDED THAT A MINERALOGICAL FACTOR IS TAKEN INTO ACCOUNT. TO TEST FURTHER THE RESULTS OF THE WORK, LABORATORY DRILLING TESTS WERE PERFORMED WHICH CLOSELY SIMULATED DOWN-HOLE PRESSURE CONDITIONS. CORRELATION OF DRILLING RESULTS WITH ROCK HARDNESS MEASUREMENTS WERE QUITE GOOD. IT WAS CONCLUDED THAT ROCK HARDNESS, AS MEASURED IN THE LABORATORY OR AS DEDUCED FROM SONIC LOGS, COULD BE USED IN RELATIONS FOR PREDICTING ROCK DRILLING PERFORMANCE.

24-66-09001 STUDIES ON ROCK DRILLING UTILIZING ULTRASONIC VIBRATIONS
TANAKA, M. + TENEDA, K. & WASEDA UNIV
MINING AND METALLURGICAL INST. OF JAPAN, (82) N 941, 1-8, SEPT 1966. ONE OF THE IMPORTANT PROBLEMS IN TUNNELING TECHNIQUE IS DRILLING, ESPECIALLY, DRILLING OF HARD ROCKS. IT IS SAID THAT BRITTLE MATERIALS ARE EASILY FRACTURED BY IMPACT. THEREFORE, SUPERSONIC VIBRATION HAS BEEN USED FOR CUTTING OF HARD, BRITTLE MATERIALS. APPLICATION OF VIBRATION CUTTING ON THE ROCKS ARE STATED IN THIS PAPER USING THE ORDINARY ROTARY DRILLING APPARATUS ON WHICH SUPERSONIC VIBRATION IS ADDED. ALTHOUGH COMPLETE DATA ON VIBRATION DRILLING WERE NOT OBTAINED IN THIS SERIES OF EXPERIMENTS, SOME INTERMEDIATE CONCLUSIONS ARE AS FOLLOWS- (1) PENETRATION RATE IS INCREASED WITH LOW THRUST, ON THE CONTRARY, CUTTING TORQUE IS DECREASED BY ADDING VIBRATION ON THE ROTARY DRILLING. (2) ON THE SUPERSONIC DRILLING BITS. A) SHAPE OF BITS- ROTARY TYPE OF BITS IS EFFECTIVE COMPARED WITH ROTARY-PERCUSSIVE TYPE OF BITS WHEN VIBRATION (ABOUT 15 MU) IS ADDED ON THE ROTARY DRILLING. B) ABRASION OF CUTTING EDGE- ABRASION OF CUTTING EDGE IS SMALL WHEN VIBRATION IS ADDED ON THE ROTARY DRILLING, AND ABRASION RATE IS DECREASED IN ACCORDANCE WITH THE INCREASING AMPLITUDE OF VIBRATION. ALSO, BETTER PENETRATION DATA ARE OBTAINED WHEN HIGH THRUST IS ADDED ON SLOW ROTATION. (3) EFFECTS OF AMPLITUDE. IT IS FOUND THAT SOME APPROPRIATE COMBINATIONS ARE NECESSARY BETWEEN THRUST AND AMPLITUDE TO GET GOOD RESULTS ON VIBRATION DRILLING. THEREFORE, TO INCREASE THE PENETRATION RATE, OPTIMUM THRUST AND AMPLITUDE SHOULD BE GIVEN IN ACCORDANCE WITH HARDNESS OF SAMPLE ROCKS.

24-66-09002 SHOT-HOLE DRILLING IN FRIABLE ROCK (MAGNESITE PERCUSSIVE-ROTARY ROTARY-PERCUSSIVE CARBIDE DRILL-POLE)
RIEDLER, H. & RADENTHEIN
ZEITSCHRIFT FUR ERZBERGBAU U. METALLHUETTENWESEN, (19) N 1, 9-12, SEPT. 12, 1966. IN DRILLING A 60 M THICK MAGNESITE QUARRY WITH A 70 DEG INCLINATION, A NEW TECHNIQUE WAS REQUIRED AS IT WENT UNDERGROUND. WORKING LENGTH OF DRILL POLES WAS LIMITED TO 1400 MM AS FRIABLE ROCK DEMANDED IMMEDIATE ROOF LINING. COMBINATIONS OF TEN DIFFERENT HAMMER DRILL TYPES AND FIVE DRILL POLE TYPES WERE TESTED. ONLY THREE TYPES OF HAMMER DRILLS AND TWO TYPES OF DRILL POLE FULFILLED THE SPECIFICATIONS. PERCUSSIVE-ROTARY DRILLS PRODUCING A HIGH TORQUE AT PERCUSSION ENERGY EXPENSE WERE THE BEST DRILLS. 32/22 MM HOLLOW SPIRAL DRILL POLES WITH TURNED AND FINISHED 1:12 CONE FOR CARBIDE TIPPED SLIP-ON DRILLS WITH A 36 MM CROSS-TYPE CUTTING EDGE WERE MOST ECONOMICAL. A SPECIAL POST-TREATMENT OF THE CONE WAS NECESSARY TO REDUCE BREAKAGE. THIS ROCK BRITTLENESS AND WEAKNESS DID NOT REQUIRE PARTICULARLY HIGH PERCUSSIVE FORCE BUT A LARGE NUMBER OF PERCUSSIONS AND A HIGH TORQUE TO COVER THE FISSURES AND FRIABLE ZONES RELIABLY. (IN GERMAN)

24-66-10001 BOTTOM-HOLE PERCUSSION TOOLS-WHERE AND HOW TO USE THEM (DRILLING)
BERUBE, S. C. + YOUNG, R. N. & MISSION MFG CO HOUSTON TEX
ROCK PRODUCTS. (69) 69-81, OCT. 1966. BOTTOM-HOLE PERCUSSION DRILLING TRIES TO ALLEVIATE SLOW PENETRATION, HIGH BIT COST, AND SOARING MAINTENANCE COST. TEN REQUIREMENTS FOR THE SUCCESSFUL APPLICATION OF THE BOTTOM HOLE PERCUSSION DRILLING METHOD ARE GIVEN. HIGH PRESSURE TOOL (200 PSI) ALMOST DOUBLES THAT OBTAINED WITH 100 PSI TOOLS. FOR HOLES OVER 100 FT. DEEP THE PROPER SIZE DRILL PIPE IS EXTREMELY IMPORTANT. ADDITIONAL PULL DOWN OVER THE NORMAL RANGE OF 2,000 TO 4,000 LB. DOES NOT INCREASE PENETRATION RATE BUT ONLY RESULTS IN ACCELERATED BIT WEAR AND INCREASES THE CHANCES OF SHEARING OF CARBIDES AGAINST THE ROCK FACE. ROTATION SPEEDS ARE GENERALLY SLOWER THAN WHEN ROTARY DRILLING, BUT MUST BE VARIED ACCORDING TO CONDITIONS. ROCK DRILL OIL LUBRICATION IS RECOMMENDED. WATER INJECTION INTO THE AIR STREAM CAN PREVENT CUTTINGS FROM INHIBITING THE CIRCULATION. THERE MUST BE PROPER BREAKOUT EQUIPMENT TO SERVICE THE TOOL AND A MEANS OF SHARPENING BITS IS NEEDED.

24-66-11001 A NEW SLANT ON DRILLING (DRILL-BITS HARD-ROCK)
BERGSTROM, J. H.
ROCK PRODUCTS, (69) 74-75, NOV 1966. THE GENERAL CRUSHED STONE CO EASTON PA HAS BEEN USING RAM-BLAST (TRADE NAME) THROW-AWAY "BUTTON" BITS TO REDUCE DIRECT DRILLING COST BY 40% AND ALSO REDUCE DRILLING MANPOWER. THE PENETRATION RATE HAS INCREASED FROM 9 FT PER HR TO 16 FT PER HR. BIT LIFE INCREASED FROM 450 FT TO 750 FT IN HARD TRAP ROCK. THE AMOUNT OF BIT SHAPENING WAS ALSO DECREASED. THE BIT COST WAS REDUCED FROM $1.00 PER FT TO $.61 PER FT. THE BITS ARE MANUFACTURED BY THE HUGHES TOOL CO. DRILLING AT 20 DEG FROM THE VERTICAL ALSO HELPED INCREASE THE OVERALL EFFICIENCY OF QUARRY OPERATIONS. LESS SPECTACULAR RESULTS WERE OBTAINED AT TWO OTHER QUARRIES. BUT UNDER PROPER CONDITIONS THESE TECHNIQUES CAN PAY VERY GOOD DIVIDENDS.

24-67-00001 THE STATE OF APPLICATION OF CARBIDE METAL IN THE GERMAN MINING INDUSTRY (TOOLS DRILLING)
MULLER, O.
GLUCKAUF, (103) NO. 13, 636-645, 1967. IN MOST APPLICATIONS OF CEMENTED CARBIDE MINING TOOLS THE TYPES OF CEMENTED CARBIDES USED HAVE TO SATISFY HIGH REQUIREMENTS REGARDING THEIR TOUGHNESS. THE AMOUNT OF WEAR ON THE MOLDED CEMENTED CARBIDE OBJECTS WHICH ARE BRAZED INTO THE TOOL SUPPORT IN THE CASE OF PERCUSSIVE DRILLS AND BRAZED ON ROTARY DRILLS, CUTTERS AND PLOUGH TIPS, IS PRIMARILY CHARACTERIZED BY THE SLIDING AND FRICTION PROCESSES AT THE ORE TO BE WORKED. THE WEAR STRENGTH OF THE CEMENTED CARBIDE FOR WHICH THE VICKERS HARDNESS, AMONG OTHERS, CAN REPRESENT A QUALITY VALUE SHOULD BE SUCH THAT AN ECONOMICAL LIFE OF THE TOOLS CAN BE GUARANTEED. THIS DEMAND INFLUENCES THE CHOICE OF THE TYPE, THE GEOMETRIC DIMENSIONS OF THE MOLDED CEMENTED CARBIDE OBJECTS AND THE TOOL ANGLE. THE COMPRESSIVE STRENGTH OF THE CEMENTED CARBIDE, WHICH IS TWICE AS HIGH AS STEEL, IS OF ADVANTAGE IN TOOLS WHICH ARE SUBJECTED TO HIGH COMPRESSIVE STRESSES. THIS HOLDS TRUE PARTICULARLY FOR PERCUSSIVE CUTTER HEADS AND THE KNIVES IN COAL PLOUGHS AND ARCHWALL COAL CUTTERS. PLASTIC DEFORMATIONS AND THERMAL STRESS CRACKS IN THE CEMENTED CARBIDE CAN OCCUR IN COMBINATION WITH HIGH HEAT DUE TO FRICTION. IN THE PERCUSSIVE CUTTER HEAD SECTION, TOOLS USED IN INCREASING NUMBERS FOR SHOTHOLES ARE DISCUSSED TOGETHER WITH CONVENTIONAL DESIGNS, AND CUTTER HEADS UP TO 200 MM DIAMETER ARE DISCUSSED WHICH ARE UTILIZED IN HAMMER DRILLS PARTICULARLY FOR ROCK AND ORE MINING IN OPEN PIT MINES BUT ALSO FOR GAS DRILLING. IN THE CASE OF THE MONOBLOC DRILLS, IT IS MENTIONED WITH RESPECT TO AN INCREASE IN THE LIFE OF THE HOLLOW DRILL ROD THAT THE TOOLS SHOULD BE STRESSED AS LITTLE AS POSSIBLE BY ALTERNATING BENDING STRESSES, WHICH IS OBTAINED BY STEPPED DRILL LENGTHS AND BY GUIDES. DRILL CUTTER HEADS HARDFACED WITH DRILL TIPS WORK QUITE ECONOMICALLY IN SOFT AND MEDIUM HARD ROCK EVEN WHEN IT IS BRITTLE. IN FISSURE AND HARD ROCK THE CEMENTED CARBIDE DRILL TIPS INTO WHICH DIAMOND CHIPS HAVE BEEN SINTERED ARE FREQUENTLY SUPERIOR TO THE PURE DIAMOND CUTTER HEADS. ROTARY CUTTER HEADS OF THE TWO-FLUTE FORM WITH ROUND, FLAT OR SQUARE TANGS ARE USED FOR DRILLING SHOTHOLES IN COAL AND AND IN POTASH AS WELL AS FOR IMPREGNATING HOLES IN COAL. (IN GERMAN)

24-67-00002 DIAMOND DRILLING ON ZAMBIAN COPPERBELT WITH NOTES ON DEEP SLIM HOLE DRILLING IN SOUTH AFRICA (ROCK-DRILLING)
DAVIES, S. G. G. + PERKINS, C. + POPPLEWELL, E.
SCIENCE AND TECHNOLOGY OF INDUSTRIAL DIAMONDS, PROCEEDINGS OF INTERNATIONAL INDUSTRIAL DIAMOND CONFERENCE, OXFORD, (2) 143-50, 1966, 1967. EXPLORATORY DRILLING, BOTH ON SURFACE AND UNDERGROUND, EXCEEDS HALF MILLION FEET ANNUALLY, WHILE SOME 3 MILLION FT OF UNDERGROUND BLASTHOLE DRILLING IS CARRIED OUT WITH NON-CORING DIAMOND CROWN OVER SAME PERIOD; DIACARB LTD BUILT AND EQUIPPED FACTORY IN NDOLA, CONTAINING EQUIPMENT TO PRODUCE ENTIRE RANGE OF DIAMOND CROWN FROM X-RAY SIZE TO 5 1/2 IN.; TO COMPLETE CYCLE IN DIAMOND DRILLING INDUSTRY, PLANT IS EQUIPPED WITH BURN-OUT SECTION FOR SALVAGING DIAMONDS FROM CROWNS RETURNED FROM FIELD.

24-67-01001 CIRCUMFERENTIAL-TOOTHED ROCK BITS (PENETRATION-PERFORMANCE)
BOURNE, H. A. + REICHMUTH, D. R. + HADEN, E. L. & CONTINENTAL OIL CO PONCA CITY
JOURNAL OF PETROLEUM TECHNOLOGY, (19) 113-119, JAN 1967. PENETRATION PERFORMANCE INCREASES PROPORTIONALLY WITH INCREASED INTERIOR ATTACK ANGLE OVER 45 DEGREES. CIRCUMFERENTIAL TOOTHED AND DISC-TYPE ROLLER CUTTERS EXHIBIT A NEARLY CONSTANT SPECIFIC PENETRATION RATE.

24-67-01002 ROCK FRACTURE BY WATER JET IMPACT (ROCK-DISINTEGRATION-METHODS COAL-MINING)
FARMER, I. W. & UNIV SHEFFIELD ENGLAND
COLLIERY ENGINEERING, 23-26, JAN 1967. THE ARTICLE DISCUSSES MECHANISM OF JET IMPACT. A SINGLE STAGE INTENSIFIER WAS USED TO PROJECT A SERIES OF WATER JETS WITH VELOCITIES UP TO 1000 M/SEC TO STRIKE SPECIMENS OF CONCRETE, SANDSTONE, MARBLE, ANHYDRITE, GRANITE, AND GRANODIORITE. FOR A CONSTANT JET VELOCITY THE SCALE OF FRACTURE WILL BE INVERSELY PROPORTIONAL TO THE STRENGTH PARAMETER OF THE ROCK. JETS USED FOR COAL MINING HAVE VELOCITIES OF 200 M/SEC (EQUIV. TO 3000 PSI).

24-67-01003 DIAMOND DRILLING TECHNOLOGY AND MINERAL EXPLORATION (COST CORE-DRILLING)
MCBEAN, J. W. + CHARLEWOOD, G. H. & HEATH AND SHERWOOD DRILLING ONT
THE CANADIAN MINING AND METALLURGICAL BULLETIN FOR MONTREAL, 63-67, JAN 1967. ONE HUNDRED YEARS AFTER BEING DEVELOPED, THE DIAMOND DRILL IS STILL AN ESSENTIAL TOOL IN MINERAL EXPLORATION. THE BASIC PRINCIPLE IS UNCHANGED BUT THE TECHNIQUE HAS BEEN REVOLUTIONIZED, PARTICULARLY IN THE PAST FIFTEEN YEARS. MECHANICAL SETTING, CASTING IN METAL AND PRESSING IN A POWDER METAL MATRIX TO FORM A BIT ARE EXAMPLES OF IMPROVED TECHNOLOGY. THE COST OF CORE DRILLING HAS NOT KEPT PACE WITH THE RISING COST OF LIVING. THE PRICE OF MACHINERY, SUPPLIES AND LABOR IN DRILLING HAS DOUBLED SINCE 1946. SOME OF THE TECHNIQUES SUCH AS HOLE STABILIZATION, LIGHTWEIGHT EQUIPMENT, COMPRESSED AIR, ETC. ARE DESCRIBED. THESE TECHNIQUES HAVE MADE IT POSSIBLE TO HOLD THE PRICE LINE.

24-67-02001 STORM SEWER TUNNELING IN SANDSTONE (EROSION LININGS HYDRAULIC-MINING MOLES COST)
MCRAE, K. K. & MINNESOTA HIGHWAY DEPT
PUBLIC WORKS, 110-111, FEB 1967. SEPARATION OF SEWERS IN MINN. - ST. PAUL REQUIRED MAIN LINE SEWERS OF SIZE THAT ENCOURAGED TUNNELLING. TWIN CITIES AREA HAS A ROCK FORMATION EASY TO TUNNEL - ST. PETER SANDSTONE. SOME TUNNELS ARE MINED HYDRAULICALLY, OTHERS BY MOLES. SIZE VARIES 8 TO 14 FEET DIA. TEMPORARY SUPPORTS WERE STEEL RING BEAMS. FINAL LINER IS UNREINFORCED CONCRETE. COST/FT WAS ABOUT $250. RATE OF ADVANCE AVERAGED 30 TO 50 FT FOR AN 8 HR SHIFT, 12 MILES OF TRUNK SEWER COST $22 MILLION.

24-67-04001 TECHNIQUES AND DEFLECTION TOOLS IN HIGH-ANGLE DRILLING: PAST, PRESENT AND FUTURE (DIRECTIONAL-DRILLING WATER-CONTROL)
PICKETT, G. W. & GULF OIL CORP
JOURNAL OF PETROLEUM TECH, (19) 469-76, APRIL 1967. DIRECTIONAL DRILLING WAS STARTED IN THE EARLY 1930'S. IT COMES UNDER THREE GENERAL HEADINGS, SIDETRACKING, STRAIGHTENING UP OF A WELL BORE, AND PLANNED DIRECTIONAL DRILLING. THE LATTER IS THE MOST IMPORTANT WITH ITS LARGEST APPLICATION BEING OFFSHORE DRILLING. ONE OF THE EARLIEST DEFLECTING TOOLS WAS THE INVERTED WEDGE OR WHIPSTOCK. THIS METHOD OF DIRECTIONAL DRILLING SAW NO IMPROVEMENT FOR 15 YEARS. THEN IN THE MID 1950'S THE JET-BIT DEFLECTION METHOD WAS DEVISED. THIS WORKED BY JETTING A DRILLING FLUID AT HIGH PRESSURE THROUGH A BIT NOZZLE ORIENTED TO A SPECIFIC DIRECTION. A SECOND MAJOR IMPROVEMENT IN THE MID 50'S WAS THE FULL-GAUGE WHIPSTOCK. IN 1960 THE TURBO-DRILL AND DYNA-DRILLS WERE PERFECTED. IN THE DYNA-DRILL INSTEAD OF MOTOR DRIVING THE PUMP, THE PUMP DRIVES THE MOTOR (IN THIS CASE THE BIT). ANOTHER IMPORTANT IMPROVEMENT IS THE BOTTOM-HOLE ORIENTATION. THE LATEST DEVELOPMENTS INCLUDE THE REBEL TOOL NONMAGNETIC TOOL JOINTS FOR NONMAGNETIC DRILL COLLARS, CIRCULATING WHIPSTOCKS, AND COMPUTER COMPLETION REPORTS. IMPROVEMENTS CAN BE EXPECTED ON THE TURBO DRILL AND DYNA-DRILL TYPES OF DEFLECTION TOOLS WITH INNOVATIONS IN TYPES OF BITS AND DEFLECTION TOOLS.

24-67-04002 MICROBIT STUDIES OF THE EFFECT OF FLUID PROPERTIES AND HYDRAULICS ON DRILLING RATE
ECKEL, J. R. & ESSO PROD RES CO HOUSTON TEX
JOURNAL OF PETROLEUM TECHNOLOG, (19) 541-546, APR 1967. DRILLING WITH WATER IS AS MUCH AS SIX TIMES FASTER THAN WITH MUD. THE REASONS FOR THE FASTER RATE ARE NOT KNOWN. RECENT STUDIES SHOW WHAT FLUID PROPERTIES GOVERN MICROBIT DRILLING RATE AND ALSO PROVIDE A QUANTITATIVE CORRELATION OF THESE FLUID PROPERTIES AND HYDRAULICS WITH MICROBIT DRILLING RATE. ALL THE MICROBIT TESTS REPORTED IN THIS PAPER WERE MADE WITH A LOW PERMEABILITY (ABOUT 10 MD) LIMESTONE. THEY WERE CONDUCTED AT A CONSTANT BIT WEIGHT AND ROTARY SPEED WITH VARYING FLUID PROPERTIES, FLOW RATE Q AND NOZZLE DIAMETER D. THE TEST SHOWED THAT DRILLING RATE IN A GIVEN SYSTEM WITH A CONSTANT CIRCULATING RATE AND NOZZLE VELOCITY IS A FUNCTION OF THE KINEMATIC VISCOSITY OF THE DRILLING FLUID MEASURED AT NEAR BIT NOZZLE SHEAR RATES; THE COMBINED EFFECT OF FLUID PROPERTIES AND HYDRAULICS ON MICROBIT DRILLING RATE IS DEFINED BY A REYNOLDS NUMBER FUNCTION (FORMULA GIVEN IN ARTICLE); FOR THE SAME KINEMATIC VISCOSITY, DRILLING RATE IS INDEPENDENT OF SOLIDS CONTENT, OR FLUID LOSS.

24-67-06001 FACTORS AFFECTING CUTTINGS REMOVAL DURING ROTARY DRILLING (RESEARCH DRILLING-MUD)
HOPKIN, A. E. & SHELL DEV CO HOUSTON
JOURNAL OF PETROLEUM TECHNOLOGY, (19) 307, JUNE 1967. A CORRELATION WAS OBSERVED BETWEEN FUNNEL VISCOSITY AND PARTICLE SLIP VELOCITY. A RELATIONSHIP WAS OBSERVED BETWEEN THE BINGHAM YIELD VALUE OF THE MUD AND THE PARTICLE SLIP VELOCITY. FIELD TESTS SHOW THAT DURING FAST UPPER-HOLE DRILLING, THE RATE OF CUTTING REMOVAL MUST BE SUFFICIENT TO MAINTAIN THE CONCENTRATION IN THE ANNULUS LESS THAN 5 PERCENT BY VOLUME.

24-67-06002 WHAT TO CONSIDER IN SELECTING ROCK BITS (PRECUSSIVE-DRILLING)
SINGH, M. M. & IIT RES INST CHICAGO ILL
ENGINEERING AND MINING JOURNAL, (168) 165-172, JUNE 1967. BITS USED IN PERCUSSIVE DRILLING ARE EITHER INTEGRAL OR DETACHABLE. DETACHABLE INSERT TYPE BITS ARE PREFERRED BECAUSE THEY GIVE ABOUT 30 TIMES THE FOOTAGE, HOLE GAGE IS MORE CONSTANT THUS SMALLER BITS CAN BE USED, HARDER AND MORE ABRASIVE ROCKS CAN BE DRILLED, AND THE DETACHABLE BITS CAN BE SHARPENED WHEREAS THE OTHER TYPE IS DISCARDED. EXPERIMENTAL FINDINGS SHOW THAT BLUNT WEDGES (ANGLES FROM 70 DEGREES TO 120 DEGREES) ON THE BIT GIVE BETTER RESULTS. MULTI-WING BITS ARE PREFERRED TO CHISEL BITS BECAUSE OF LESS DANGER OF JAMMING, DECREASED WEAR, ETC. IN WEAK ROCKS, HEAT TREATED STEEL OR ALLOY STEEL IS SATISFACTORY. FOR STRONGER ROCK THE BITS CONSIST OF INSERTS OF MINUTE GRAINS OF HIGHLY ABRASIVE TUNGSTON CARBIDE CEMENTED BY A MATRIX OF TOUGH METAL USUALLY COBALT. TO REDUCE GAGE WEAR, INCREASE FOOTAGE PER BIT. MAKE CLEANER HOLES AND LOWER COST PER FOOT HOLE THE BIT BEING USED SHOULD BE EQUIPPED FOR THE FLUSHING OF THE HOLE TO REMOVE THE CUTTINGS. THE TWO FLUSHING FLUIDS THAT ARE USED MOST ARE WATER AND AIR. AIR IS ADVANTAGEOUS BECAUSE IT IS FASTER AND THERE IS LESS BIT WEAR.

24-67-06003 APPLICATION OF HARD ALLOYS IN GERMAN MINING INDUSTRY (PERCUSSION-DRILLS)
MUELLER, O.
GLUECKAUF, (103) 636-645, JUNE 22, 1967. CHARACTERISTICS OF PERCUSSION DRILLS USED IN COAL MINES, ORE MINES, AND POTASH MINES. COAL CUTTERS AND EQUIPMENT USED IN STRIPPING OPERATIONS, DRIFTING AND IN TUNNELING. (IN GERMAN)

24-67-07001 RESEARCH IN IMPROVED METHODS OF ROCK BREAKAGE (SIZE-REDUCTION DISINTEGRATION)
GELLER, L. B. & DEPT MINES OTTOWA CAN & OTTAWA CANADA
MINING AND METALLURGICAL INST., JAPAN, (76) 105-124, JULY 1967. THE VOLUME OF BROKEN ROCK DEPENDS PRIMARILY UPON THE AMOUNT OF SPECIFIC ENERGY WHICH IT CAN BE FORCED TO ACCEPT. IT IS RECOMMENDED THAT TWO INDEPENDENTLY INDUCED, YET COMPLEMENTARY, STRESS FIELDS BE SUPERIMPOSED. THESE ARE TO BE GENERATED BY TWO MECHANICAL METHODS OR BY A MECHANICAL AND A THERMAL ONE. THE ADDITIONAL FLEXIBILITY IS AN ASSET. IT SEEMS UNLIKELY THAT, ON AN ECONOMICALLY VIABLE BASIS, PURELY THERMAL ROCK BREAKAGE METHODS CAN BE GREATLY EXPANDED BEYOND THEIR SPECIALIZED FIELDS OF ACCEPTANCE. IF BLASTING IS TO BE AVOIDED, THE IMPROVED ROCK BREAKAGE TOOLS SHOULD BE USED FOR TUNNELLING OR FOR RAPID ROCK CHIPPING OVER LARGE AREAS AND TO SHALLOW DEPTHS. THE CONSIDERABLE ADVANTAGES OF BLASTING COULD ALSO BE BETTER UTILIZED IF, ON IMPLEMENTING SUGGESTED CHANGES, BLAST-HOLE DRILLING COSTS WERE FOUND TO BE REDUCED.

24-67-07002 CUTTING ACTION OF A SINGLE DIAMOND UNDER SIMULATED BOREHOLE CONDITIONS (DRILLING)
GARNER, N. E. & ESSO PROD RES CO HOUSTON TEX
JOURNAL OF PETROLEUM TECHNOLOGY, (19) 937-942, JULY, 1967. LABORATORY TESTS MADE ON CUTTING OF LIMESTONE AND SHALE BY A SINGLE DIAMOND UNDER SIMULATED DOWN-HOLE CONDITIONS. HIGH DIFFERENTIAL PRESSURE REDUCED THE VOLUME OF ROCK OUT AT A GIVEN BIT WEIGHT BY STRENGTHENING THE ROCK AND CHANGING THE MODE OF FAILURE. A FINELY POWERED ROCK LEFT IN THE BOTTOM OF THE GROOVES REDUCED THE VOLUME CUT AS MUCH AS 50 PERCENT. ORIENTATION OF THE DIAMOND ABOUT THE AXIS OF A DRILL POINT AFFECTED THE EFFICIENCY.

24-67-07003 INVESTIGATION INTO THE POSSIBILITY OF PROLONGING THE LIFE OF DRILL STEEL BY ADJUSTING THE PH OF MACHINE WATER
ROLLINS, V. + ARNOLD, B. + LARDNER, E. & LANCHESTER COLL TECH COVENTRY
MINING & METALLURGICAL INST., JAPAN, (76) 102-104, JULY 10, 1967. SMALL FATIGUE TEST PIECES OF DRILL STEEL WERE TESTED ON GILL ROTATING BENDING FATIGUE MACHINES TO INVESTIGATE THE EFFECT OF VARYING THE PH OF A SALINE SOLUTION ON THE CORROSION FATIGUE LIFE OF A TYPICAL ROCK DRILL STEEL. IT WAS FOUND THAT CORROSION FATIGUE OF THE STEEL WAS COMPLETELY SUPPRESSED AT A PH OF 12.0 IT IS PROPOSED THAT ROCK DRILLS MIGHT THEREFORE BE PROTECTED BY INCREASING THE PH OF THE MACHINE WATER TO 12.0 BY ADDING LIME.

24-67-09001 STUDIES ON ELECTRICAL DISINTEGRATION DRILLING (ROCK BREAKING)
ITO, I. + SASSA, K. + INADA, Y. & KYOTO UNIV JAPAN
MINING AND METALLURGICAL INST., JAPEN, (83) 1071-6, SEPT 1967. IN THIS STUDY, THE PHYSICAL AND MECHANICAL PROPERTIES OF THE SPECIMEN WERE EXAMINED AT FIRST IN CONNECTION WITH THE ELECTRICAL DISINTEGRATING DRILLING AND THEN SOME EXPERIMENTS WERE CARRIED OUT TO DETERMINE HOW EFFECTIVELY THE ELECTRICAL DISINTEGRATING DRILLING CAN BE USED IN COMPARISON WITH CONVENTIONAL ROTARY DRILLING. THE SPECIMEN USED THROUGHOUT THIS STUDY WAS THE CEMENT MORTAR. THE MAIN RESULTS OBTAINED CAN BE SUMMARIZED AS FOLLOWS: (1) BOTH THE STRENGTH AND THE YOUNG'S MODULUS OF THE CEMENT MORTAR DECREASED GREATLY BY COOLING IT RAPIDLY AFTER IT HAD BEEN HEATED OVER 300 DEGREES C. (2) WHEN THE VOLTAGE APPLIED ON THE BIT WAS LARGER THAN 750 V, THE EFFECT OF ELECTRICAL DISINTEGRATION APPEARED REMARKABLY AND THE RATE OF PENETRATION IN THESE CASES REACHED 1.7 - 2.0 TIME LARGER THAN THAT OBTAINED BY A CONVENTIONAL ROTARY DRILLING UNDER THE IDENTICAL CONDITION. (3) FOR METHOD OF DRILLING, THE BIT HAVING A SELF-SHARPENING ACTION WAS CONSIDEREDTO BE MORE EFFECTIVE THAN THE CUTTING TYPE ONE. (4) TO GET THE EFFECTIVE DRILLING WITH THE TRI-CONE BIT, THE ELECTRICAL ENERGY BEYOUND 3 KWS HAD TO BE SPENT PER UNIT LENGTH OF OF PENETRATION.

24-67-09002 EFFECTS OF HARDNESS REDUCERS ON FAILURE CHARACTERISTICS OF ROCK (CHEMICAL-SOFTENING)
ROBINSON, L. H., JR. & ESSO PROD RES CO HOUSTON TEX
SOCIETY OF PETROLEUM ENGINEERS JOURNAL, 295-299, SEPT 1967. TEST USING A SERIES OF SODIUM SALTS OF DICARBOXYLIC ACIDS SHOW THAT ODD NUMBER CARBON-ATOM CHAINS DECREASE THE YIELD STRENGTH AS MUCH AS 3,000 PSI AND EVEN-NUMBER INCREASE THE YIELD STRENGTH AS MUCH AS 900 PSI. SODIUM CITRATE DECREASED THE YIELD STRENGTH OF INDIANA LIMESTONE FROM 16,000 TO 12,000 PSI. USING WATER AS A REFERENCE THE HARDNESS REDUCERS DECREASED THE DRILLING RATE. EVEN THOUGH THE ROCK MIGHT BE WEAKER, AN INCREASE IN PLASTICITY DECREASES THE DRILLING RATE. A PROCESS IN WHICH MICROCRACKS ARE GENERATED DURING ELASTIC DEFORMATION WAS NOT SUPPORTED BECAUSE NO HARDNESS REDUCER EFFECT WAS OBSERVED IN THE BRITTLE FAILURE TESTS.

24-67-09003 AN EXPERIMENTAL STUDY OF INDEXED DULL BIT-TOOTH PENETRATION INTO DRY ROCK UNDER CONFINING PRESSURE (DRILLING RESEARCH)
GNIRK, P. F. & RICE UNIV HOUSTON
JOURNAL OF PETROLEUM TECHNOLOGY, (19) 1225-33, SEPT. 1967. PENETRATION OF A SINGLE DULL TOOTH UNDER STATICALLY APPLIED LOADS INTO ROCK SUBJECTED TO CONFINING PRESSURES FROM ATMOSPHERIC TO 5000 PSI AND ATMOSPHERIC PORE PRESSURE WAS STUDIED. TWO LIMESTONES AND ONE SANDSTONE WERE TESTED WITH A 45 DEGREES WEDGE TOOTH OVER THE SAME PRESSURE RANGE WITH A VARIETY OF INDEXING DISTANCES AND TWO DEGREES OF TOOTH DULLNESS. THE OPTIMUM DISTANCE BETWEEN SUCCESSIVE BIT TOOTH PENETRATIONS REQUIRED FOR MAXIMUM ROCK DAMAGE AND CHIP FORMATION DECREASES SUBSTANTIALLY WITH CONFINING PRESSURE ABOVE THE BRITTLE-TO-DUCTIBLE TRANSITION PRESSURE BUT STAYS ESSENTIALLY CONSTANT BELOW TRANSITION. EXPERIMENTS COMPARE FAVORABLY WITH PREVIOUS THEORETICAL RESULTS.

24-67-12001 TEN YEARS OF PLOWSHARE (CRATERING BREAKING PERMEABILITY RADIATION NUCLEAR-EXPLOSION)
JACKSON, M. W. & HOLMES NARVER INC
CIVIL ENGINEERING, 34-38, DEC 1967. NUCLEAR EXPLOSIONS HAVE BEEN SUCCESSFULLY USED FOR CRATERING, ROW CHARGE, BREAKING AND CRUSHING PREPARATORY TO EXTRACTING AND SHOCK-INDUCED PERMEABILITY CHANGES IN ROCK FORMATIONS. GREAT EMPHASIS IS PLACED ON RADIATION AND THE APPROACH IS TO REDUCE RADIATION BY REDUCING THE AMOUNT OF FISSION IN RELATION TO TOTAL YIELD AND BY SPECIAL EMPLACEMENT TECHNIQUES.

24-67-12002 NEW METHODS CHALLENGE ROTARIES (WATER-JET EROSION-DRILLING)
ROGERS, L. C.
THE OIL AND GAS JOURNAL, 83-87, DEC 1967. EROSION DRILLING REDUCES WEIGHT OF BITS, REDUCES ROTATING SPEEDS FROM 250-300 RPM TO 40-60 RPM. HYDRAULIC JET VELOCITY MUST EXCEED CRITICAL MINIMUM CUTTING SPEED OF THE ROCK. AT MINIMUM CUTTING SPEED A 3-20 PERCENT CONCENTRATION BY VOLUME OF ABRASIVE MATERIAL GIVES OPTIMUM PENETRATION RATES. GULF OIL, IN FIELD TESTS, DRILLED 60 FEET/HOUR USING EROSION DRILLING AS COMPARED TO CONVENTIONAL RATES OF 20 FT/HR.

24-68-02001 MISSILE MINING BY IMPACT (JETS PROJECTILES)
DOLBEAR, S. H.
ENGR AND MINING J., (169) N 2, 112-13, FEB. 1968. METHODS AND EQUIPMENT ARE SUGGESTED FOR BREAKING OF MINERAL OREBODIES IN PLACE BY JET STREAM OF WATER, AIR OR OTHER MEDIA CONTAINING SOLID PARTICLES HAVING SUFFICIENT HARDNESS AND STRENGTH TO SURVIVE THE IMPACT. IN CASE OF JETS OF LIQUIDS, METHODS OF HANDLING SOLUBLE AND INSOLUBLE MINERALS ARE DISCUSSED.

24-68-03001 ELECTROHYDRAULICS (DRILLING-METHODS)
BROWN, W. R. + ALLEN, M. + SCHROM, E. C. & GE R&D CTR SCHENECTADY
SCIENCE JOURNAL, 61-66, MAR 1968. HARD OR BRITTLE MATERIAL MAY EFFECTIVELY BE SHATTERED BY ELECTROHYDRAULIC ACTION. SUCH AN ELECTRICAL ENERGY SYSTEM COULD REPLACE EXPLOSIVES AND THEREBY AVOID PRODUCTION OF NOXIOUS FUMES IN MINES. SYSTEM IS NOT PRESENTLY ECONOMICALLY FEASIBLE FOR GENERAL USE BUT COULD BE IN SPECIAL SITUATIONS.

24-68-03002 ASSESSING DEFORMABILITY OF ROCK AT BOTTOM OF VERTICAL BOREHOLE (DRILLING)
MATAEV, G. A. + MALACHIKHANOV, R. B. & MALACHIKHANOV, N. B.
SOVIET MIN SCI, (2) 108-11, MAR-APR 1968. SEDIMENTARY ROCKS, ASSOCIATED WITH MINERAL EXTRACTION, COME INTO STATE OF GEOSTATIC EQUILIBRIUM FOLLOWING THEIR DEPOSITION OWING TO STRESS RELAXATION, STATE OF STRESS OF ROCK REGARDED AS HYDROSTATIC; IN HYDROSTATIC PHENOMENA LIQUIDS AND SOLIDS BEHAVE AS IF THEY WERE IDEALLY ELASTIC. CUTTING OF EXCAVATION IN ROCK WILL CAUSE STRESSES. PAPER PRESENTS MATHEMATICAL ANALYSIS OF THOSE STRESSES IN ORDER TO DETERMINE CRITICAL VALUE OF PRESSURE BENEATH BIT AT WHICH STRUCTURE OF ROCK CHANGES FROM ELASTIC TO PLASTIC, REQUIRING MORE ENERGY TO BE CUT. 10 REFS. ENGLISH TRANSLATION OF RUSSIAN ARTICLE IN FIZIKO-TEKHNICHESKIE PROBLEMY RAZRABOTKI POLEZNYKH ISKOPAEMYKH, N 2, 18-22, MAR-APR 1968.

24-68-04001 ROCK-CUTTING AND ITS POTENTIALITIES AS A NEW METHOD OF MINING (GOLD-MINES KERF-CUTTING)
COOK, N. G. W. + JOUGIN, N. C. + WIEBOLS, G. A. & CHAMBER OF MINES SO AFRICA
JOURNAL OF THE SOUTH AFRICAN INSTITUTE OF MINING AND METALLURGY, (68) NO 10, 435-454, MAY 1965. NEW GOLD MINES IN SO AFRICA HAVE REEF THICKNESS OF ONLY A FEW INCHES. CURRENT PRACTICE REQUIRES A STOPING WIDTH OF 40 INCHES, WHICH IS MANY TIMES THE REEF WIDTH, DILUTING THE ORE. KNOWN ROCK BREAKING PROCESSES ARE ANALYZED IN TERMS OF SPECIFIC ENERGY AND FRAGMENT SIZE. MECHANICAL ROCK CUTTING APPEARS TO BE A FEASIBLE OPERATION ON WHICH TO BASE A NEW SYSTEM. LAB TESTS ON QUARTZITE ARE REPORTED AND THE DESIGN OF A PROTOTYPE MACHINE IS GIVEN. A SYSTEM OF MINING USING THE METHOD IS OUTLINED IN WHICH THE REEF IS CUT FIRST, THE WASTE IS BROKEN OUT AND PACKED BEHIND THE WORKING AREA.

24-68-05001 PART 1 - NOVEL ROCK DRILL SERIES, SURVEY OF EXOTIC DRILLING METHODS POINTS TO ROCK DRILL OF THE FUTURE (FUSION VAPORIZATION THERMAL-SPALLING CHEMICAL-REACTIONS MECHANICALLY-INDUCED-STRESSES)
MAURER, W. C.
ENGR AND MINING J., 73-77, MAY 1968. SOVIET EXPLOSIVE DRILLS ARE CAPABLE OF DRILLING 40 FEET PER HOUR. EROSION DRILLS HAVE DRILLED 0.2 IN DIA. HOLES IN GRANITE AT 240 FEET PER MINUTE. NOVEL DRILLS REMOVE ROCK BY FOUR BASIC MECHANISMS - FUSION AND VAPORIZATION, THERMAL SPALLING, CHEMICAL REACTIONS, AND MECHANICALLY INDUCED STRESSES.

24-68-05002 EXPERIMENTAL STUDY RELATING THERMAL CONDUCTIVITY TO THERMAL PIERCING OF ROCKS (FLAME-JET ROCK-BREAKING)
MIRKOVICH, V. V.
INT J ROCK MECHANICS AND MIN SCIENCES, (5) N 3, 205-18, MAY 1968. THERMAL CONDUCTIVITY OF 19 SELECTED CANADIAN ROCKS WAS MEASURED TO DETERMINE EFFECT OF THERMAL CONDUCTIVITY ON THERMAL PIERCING OF ROCKS. ROCKS WITH HIGHER THERMAL CONDUCTIVITY GENERALLY TEND TO PIERCE BETTER, BUT DEFINITE RELATION COULD NOT BE ESTABLISHED. HOWEVER, VERY GOOD CORRELATION WAS OBTAINED BETWEEN THERMAL PIERCING RATE AND PRODUCT OF THERMAL DIFFUSIVITY AND THERMAL EXPANSION. 23 REFS.

24-68-05003 ON CUTTING FORCE OF ROCK AND CEMENT MORTAR (TOOLS CHIP-FORMATION CRACK-INITIATION)
SUZUKI, K. + NISIMATSU, Y.
MINING AND METALLURGICAL INST., JAPAN, (84) N 961, 548-52, MAY 1968. EXPERIMENTS WERE PERFORMED WITH SANDSTONE AND CEMENT MORTAR SPECIMENS USING ORTHOGONAL CUTTING TOOLS. MECHANISMS OF CUTTING, PROCESS OF CHIP FORMATION AND CUTTING FORCE WERE STUDIED; RESULTS ARE DESCRIBED AND CORRELATED BY EMPIRICAL EQUATIONS, WHICH TAKE INTO ACCOUNT CRUSHING RESISTANCE TO PENETRATION OF TOOL WEDGE, FORCE FOR CRACK INITIATION, ANGLE OF FRICTION, STRESS DISTRIBUTION. IT IS SUGGESTED THAT CRUSHING ZONE AT TOP OF WEDGE HAS 2 IMPORTANT EFFECTS ON CUTTING FORCE OF BRITTLE MATERIALS. IN JAPANESE WITH ENGLISH ABSTRACT.

24-68-06001 PART 2 - NOVEL ROCK DRILL SERIES, THERMAL SPALLING EXPERIMENTAL DRILLS USE HEAT, ELECTRICITY, MICROWAVES, CHEMICALS (ROCK-DISINTEGRATION)
MAURER, W. C. & ESSO PROD RES CO HOUSTON TEX
ENGR AND MINING J., 101-106, JUNE 1968. THERMAL SPALLING IS PRODUCED BY THERMAL STRESSES CAUSED BY DIFFERENTIAL THERMAL EXPANSION OF THE CONSTITUENT CRYSTALS AND GRAINS WHEN ROCK IS HEATED TO 700 DEGREES F OR ABOVE. IN MANY ROCKS THIS HEATING WILL REDUCE ROCK STRENGTH BY AS MUCH AS 50 TO 75 PERCENT. MECHANICAL MEANS ARE REQUIRED REMOVE THE ROCK. JET PIERCING DRILLS USE A CHEAP SOURCE OF ENERGY AND CAN TRANSMIT LARGE AMOUNTS OF POWER TO ROCK. JET DRILLS BURNING 40 GAL OF FUEL OIL PER HOUR PRODUCE A POWER OF APPROXIMATELY 1,000 HP. THEY BURN OXYGEN AND FUEL OIL TO PRODUCE A FLAME TEMPERATURE OF 4,300 DEGREES F AND A VELOCITY OF 6000 FEET PER SECOND. OTHER DRILLS BEING DEVELOPED BUT NOT AS EFFICIENT AS JET PIERCING ARE: FORCED FLAME DRILLS, ELECTRIC DISINTEGRATION DRILL, HIGH FREQUENCY ELECTRIC DRILLS, MICROWAVE DRILLS, INDUCTION DRILLS, CHEMICAL DRILLS.

24-68-07001 PART 3 - NOVEL ROCK DRILL SERIES, NOVEL MECHANICAL TYPES INVOLVE TURBINES, PELLETS, IMPLOSION, ULTRASONICS, SPARKS (RESEARCH)
MAURER, W. C. & ESSO PROD RES CO HOUSTON TEX
ENGR AND MINING J., JULY, 1968. SEVERAL MECHANICAL NOVEL DRILLS WITH THEIR ENERGY SOURCES NOT MECHANICAL. THE SPARK DRILLS ARE VERY PROMISING BECAUSE OF THEIR HIGH-POWER OUTPUT AND HIGH POTENTIAL DRILLING RATE. DRILLING RATES OF 9.9 FEET PER HOUR IN SHALE HAVE BEEN FOUND. EROSION DRILLS ARE CAPABLE OF DRILLING RATES OF 32 FEET PER MINUTE IN MARBLE. THEY CAN PRODUCE POWER OUTPUTS OF 3,000 TO 6,000 HP.

24-68-08001 PART 4 NOVEL ROCK DRILL SERIES - RESEARCH SPECIALIST EVALUATES POTENTIAL OF 25 NOVEL ROCK DRILL TYPES (TUNNEL-DRILLING)
MAURER, W. C. & ESSO PROD RES CO HOUSTON TEX
ENGR AND MINING J., 76-77, AUG 1968. SOME DRILLS ARE LIMITED BY THEIR POWER OUTPUTS OR THE AMOUNT OF POWER THAT THE ROCK WILL ACCEPT FROM THE DRILL. THE POWER OUTPUT OF COMMERCIAL LASERS HAS INCREASED OVER FIFTY-FOLD DURING THE LAST THREE YEARS. SIGNIFICANT IMPROVEMENTS WILL CONTINUE TO BE MADE ON LASERS AND OTHER NOVEL DRILLS. THESE NOVEL TECHNIQUES WILL ALSO BE USED IN CONJUNCTION WITH CONVENTIONAL TUNNEL BORERS TO DEGRADE AND WEAKEN THE ROCK AND THEN THE CONVENTIONAL CUTTERS CAN REMOVE THE ROCK. THE CONVENTIONAL TUNNEL BORERS ARE NOT EFFECTIVE BECAUSE THEY DULL RAPIDLY AND HIGH THRUSTS ARE REQUIRED ON THESE CUTTERS.

24-68-08002 ROCK BREAKAGE BY CRUSHING, BLASTING, AND DRILLING
CHEATHAM, J. B., JR.
ENG GEOLOGY, (2) N 5, 293-314, AUG. 1968. REVIEW OF LITERATURE DEALING WITH ROCK FRAGMENTATION AND WITH MEANS FOR PREDICTING ENERGY REQUIREMENTS FOR THESE PROCESSES. EXPERIMENTAL PROCEDURES AND METHODS OF ANALYSIS USED IN COMMINUTION STUDIES ARE DESCRIBED. PARTICULAR EMPHASIS IS GIVEN TO DISCUSSIONS OF ROLE THAT MECHANICAL PROPERTIES OF ROCKS PLAY IN ROCK BREAKAGE PROCESSES. ESTIMATES OF ENERGY REQUIRED TO REDUCE ROCK PARTICLE SIZE INDICATE THAT ONLY SMALL PORTION OF TOTAL ENERGY IS UTILIZED AS SURFACE ENERGY AND MUCH OF ENERGY IS DISSIPATED AS THERMAL ENERGY. 39 REFS.

24-68-09001 ANALYSIS OF CUTTING ACTION OF SINGLE DIAMOND
APPEL, F. C. + ROWLEY, D. S.
SOC PETROLEUM ENGRS J, (8) 269-80, SEPT. 1968. ASSUMING THAT ROCK BEHAVIER, DURING CUTTING WITHA SINGLE DIAMOND, MAY BE APPROXIMATED BY THAT OF RIGID, COULOMB, PLASTIC MATERIAL, THEORY OF SINGLE DIAMOND CUTTING ACTION HAS BEEN DEVELOPED. USING THIS THEORY, STRESSES ON DIAMOND CUTTING SURFACE AND COMPONENTS OF CUTTING FORCE HAVE BEEN DETERMINED. THEORETICAL RESULTS AGREE REASONABLY WELL WITH AVAILABLE EXPERIMENTAL DATA. THEORY OF CUTTING OF SINGLE DIAMONDS MAY BE USED AS BASIS FOR SUBSEQUENT STUDY OF PERFORMANCE OF SURFACE SET DIAMOND DRILL BITS AND OTHER SURFACE SET DIAMOND CUTTING TOOLS. 16 REFS.

24-68-10001 ROCK CUTTING MATERIALS - HAS A DESIGN BARRIER BEEN REACHED? (TUNGSTEN-CARBIDE-INSERT ROCK-DRILL)
LEWIS, W.
MINING ENGINEERING, 58-60, OCT. 1968. THE INTRODUCTION OF THE TUNGSTEN CARBIDE INSERT ROCK-DRILL BIT CREATED THE PROBLEM OF TRANSFERRAL OF FAILURE AND BREAKAGE TO THE ATTACHMENT DEVICES. IN THE PAST TEN YEARS, THE GREATEST DEVELOPMENTS HAVE BEEN IN MORE-SPECIALIZED CARBIDE MATERIALS FOR SPECIALIZED USES, THUS CAUSING A TRADE-OFF OF DESIRABLE PROPERTIES. THIS CREATES A BUILT-IN CEILING ON THE AMOUNT OF EFFECTIVE ENERGY THAT CAN BE APPLIED WITH EXISTING CUTTING MATERIALS. IMPROVEMENT IN CUTTER ELEMENT TECHNOLOGY IS AT A STANDSTILL. TO DEVELOP A MORE EFFECTIVE RESEARCH ROUTE, THE CRITICAL POINT IS AT THE CUTTING TOOL - ROCK INTEREACE. THE ROCK MUST BE MADE MORE AMENABLE TO CUTTING AT ENERGY LEVELS BELOW THE BUILT-IN LIMITATION FACTOR. THIS CAN BE ACCOMPLISHED BY CHANGING THE PROPERTIES OF THE ROCK ON WHICH THE CUTTING TOOL IS ACTING. ONE ANSWER WOULD BE TO DEVELOP WAYS OF GETTING ENERGY INTO THE ROCK OTHER THAN BY THE CUTTING TOOL ALONE. THE MOST PROMISING MEANS ARE HEATING BY MEANS OF ELECTRON BEAM, LASER, PLASMA JET, ETC. CHEMICAL SOFTENING OR EMBRITTLEMENT IN CONJUNCTION WITH THE CUTTING TOOL MAY ALSO BE POSSIBLE.

24-68-11001 MECHANISM OF PERCUSSIVE WEAR OF TUNGSTEN CARBIDE COMPOSITES
MONTGOMERY, R. S.
WEAR, (12) N 5, 309-29, NOV. 1968. IN ORDER TO INVESTIGATE MECHANISM OF WEAR ON FACES OF TUNGSTEN CARBIDE INSERTS, BITS WORN IN ACTUAL FIELD OPERATION WERE STUDIED AND LABORATORY EXPERIMENTS SIMULATING ROCK DRILLING CARRIED OUT. CHIEF WEAR MECHANISM IS FATIGUE MICROSPALLING OF CARBIDE SURFACE RELATED TO BLOWS. CONTRIBUTION OF SLIDING WAS FOUND TO BE MINOR. FROM WEAR DATA OBTAINED WITH DRILL SIMULATOR, IT WAS FOUND THAT NUMBER OF SITES OF POSSIBLE SPALL FORMATION IS SMALL.

24-68-12001 DETERMINATION OF STRESS WAVE FORMS PRODUCED BY PERCUSSIVE DRILL PISTONS OF VARIOUS GEOMETRICAL DESIGN (COMPUTER-PROGRAM)
DUTTA, P. K.
INT J ROCK MECHANICS AND MIN SCIENCES, (5) N 6, 501-518, NOV 1968. CONTROL OF IMPACT ENERGY DELIVERED TO BIT OF PERCUSSIVE ROCK DRILL IS DETERMINED BY PISTON IMPACT VELOCITY AND PISTON GEOMETRY. BASIC EQUATIONS DESCRIBING GENERATION, TRANSMISSION, AND REFLECTION OF STRESS WAVE ARE DEFINED AND COMPUTER PROGRAM IS DESCRIBED BY MEANS OF WHICH PISTONS MAY BE DESIGNED TO PRODUCE WAVEFORMS OF DESIRED CHARACTERISTICS. 7 REFS.

24-68-12002 FRACTURE DYNAMICS OF ROCK (CRACK-PROPAGATION)
BIENLAWSKI, Z. T.
INT J FRACTURE MECHANICS, (4) N 4, 415-30, DEC. 4, 1968. CONCEPT OF FRACTURE DYNAMICS OF ROCK IS INTRODUCED, THREE ASPECTS OF FRACTURE BEING DISCUSSED, NAMELY, STABILITY OF FRACTURE PROPAGATION, TERMINAL FRACTURE VELOCITY AND DYNAMIC STRESSES CREATED BY PROPAGATING CRACK. WORK RELATED TO THIS NEW FIELD OF RESEARCH IS REVIEWED AND THEORETICAL AND EXPERIMENTAL STUDIES ON ROCK ARE REPORTED. PRACTICAL SIGNIFICANCE OF FRACTURE DYNAMICS CONCEPT IN ROCK MECHANICS IS OUTLINED. 28 REFS.

24-69-00001 THE PENETRATION OF ROCK BY HIGH-SPEED WATER JETS (DRILLING-METHODS WATER-JETS)
BROOK, N. + SUMMERS, D. A. & UNIV LEEDS
INT ROCK MECHANICS AND MIN SCIENCE, (6) 249-258, 1969. THE EFFECT OF PRESSURE, STAND-OFF DISTANCE AND TIME ON THE PENETRATION OF SANDSTONES BY A 0.84 MM JET OF WATER WAS INVESTIGATED. PRESSURES RANGED UP TO 9000 LB/SQ.IN., STAND-OFF DISTANCES TO 2 IN. (5.08 CM), AND TIJE FROM 0.5 TO 30 SEC. THE USE OF A FRICTION REDUCING AGENT INCREASED AVERAGE PENETRATION. JET INTERRUPTION, ROTATION OF ROCK TARGET, AND SHORT PERIOD EXPOSURE WERE THE METHODS USED TO GREATLY INCREASE THE PENETRATION RATE. FREE ACCESS OF THE JET TO THE TARGET IS EMPHASIZED BY AN EXPERIMENT WITH AN ANGLED JET AND ROTATING AS A TYPE OF DRILL.

24-69-03001 HYDRO-BLAST SHOOTS AHEAD (EXPLOSION-SLURRY-PUMPING)
FLY, A. B.
MINING ENGINEERING, (21) N 3, 56-58, MAR. 1969. SUBSURFACE HYDRAULIC MINING THROUGH 16-IN. DIA BOREHOLES HAS BEEN MADE POSSIBLE THROUGH DEVELOPMENT OF NEW EXPLOSION-TYPE SLURRY PUMPING SYSTEM AND RELATED SLURRY HANDLING EQUIPMENT AND ITS POTENTIALITIES IN MINING APPLICATIONS ARE DISCUSSED.

24-69-03002 HYDRO-BLAST MINING SHOOTS AHEAD (PRESSURE EROSION-JETS ABRASIVES VOLUME ECONOMY EXPLOSION-PUMPING)
FLY, A. B. & HYDRO-JET SERVICES INC
MINING ENGINEERING, 56-58, MAR 1969. SATISFACTORY HYDROBLAST MINING HAS BEEN DEMONSTRATED WITH CLEAN WATER SIDEWALL JETS AVERAGING 400 GPM AT 800 PSI PLUS 100 GPM THRU WATER COURSES IN THE DRILL BIT. WITH THIS ARRANGEMENT ONE CUBIC YARD PER MINUTE OF SANDSTONE, WEATHERED LIMESTONE OR LAMINATED SHALE CAN BE MINED. A JET PUMP SYSTEM COMBINED WITH AIR LIFT AND BOREHOLE PRESSURIZATION WOULD BE FEASIBLE FOR OPERATIONS TO DEPTHS OF 1500 FEET. UNTIL THE RECENT DEVELOPMENT OF THE EXPLOSION PUMP, MAINTENANCE PROBLEMS MADE FLUIDS WITH SUSPENDED ABRASIVE PARTICLES UNECONOMICAL. WITH A FLUID-ABRASIVE SYSTEM MINING WITH A 60 FOOT DIAMETER PATTERN 220 TONS OF MATERIAL COULD BE PRODUCED PER FOOT OF THICKNESS AND HYDRO-BLAST MINING COULD BE VERY COMPETITIVE WITH CONVENTIONAL METHODS AS WELL AS BEING SAFER AND HEALTHIER AND ALLOW DEVELOPMENT OF SOME SUBECONOMIC MINERAL DEPOSITS.

24-69-06001 ELECTRON BEAMS APPLY AN OLD PRINCIPLE TO MODERN ROCK-BREAKING (RESEARCH)
SCHUMACHER, B. W. & WESTINGHOUSE ELEC CORP
ENGR AND MINING J., 116-119, JUNE 1969. AUTHOR CLAIMS THAT HIS ELECTRON BEAM WILL CUT ROCK FASTER AND MORE EFFICIENTLY THAN FLAME JET PIERCING, WATER CANNON AND OTHER NEW TYPE ROCK BREAKING METHODS. NO SOURCE GIVEN FOR DATA. A 10 KW ELECTRON GUN WAS BUILT AND TESTED ON FOUR TYPES OF ROCK SANDSTONE, GRANODIORITE, ROSE QUARTZ AND LIMESTONE. MELT CUT IN ALL FOUR WAS 3500 JOULES/CU CM. NOZZLE MUST BE WITHIN 1 TO 3 CM OF THE ROCK SURFACE.

24-69-06002 THE PENETRATION OF ROCK BY HIGH-SPEED WATER JETS
BROOK, N. + SUMMERS, D. A. & UNIV LEEDS & UNIV MO ROLLA MO
INT J. ROCK MECHANICS AND MIN SCIENCE, (6) 249-258, 1969. THE EFFECTS OF PRESSURE, STANDOFF AND TIME OF ATTACK BY AN 0.84 MM WATER JET ON SANDSTONE WERE INVESTIGATED. USE OF 100 PPM POLYETHYLENE OXIDE IMPROVED THE PENETRATION 10 TO 30 PERCENT. THE ADVANTAGE OF ALLOWING THE SPENT WATER TO ESCAPE WAS DEMONSTRATED BY INTERRUPTING THE JET AND BY

ROTATING THE TARGET. ROTATION PROVED TO BE OF MUCH MORE VALUE THAN INTERRUPTING THE JET. AN INCLINED ROTATING JET CUT A 5 CM DIAMETER HOLE 10 CM DEEP IN 15 SECONDS.

24-70-01001 INFLUENCE OF ROCK CHARACTERISTICS ON THE STABILITY OF ROCK CAVITIES PART 1 (ROCK-MECHANICS SUPPORTS TUNNEL-LININGS)
LOMBARDI, G.
TUNNELS AND TUNNELING, (2) NO 1, 19-22, JAN. 1970. ROCK MECHANICS IS A NEW SCIENCE BUT TUNNELING IN ROCK IS AN OLD ART. A REPORT ON THE PRESENT STATE OF ROCK MECHANICS AS A SCIENCE IS ATTEMPTED IN THIS TWO PART ARTICLE. SEE 24-70-03001 FOR PART 2.

24-70-03001 INFLUENCE OF ROCK CHARACTERISTICS ON THE STABILITY OF ROCK CAVITIES PART 2 (ROCK-MECHANICS SUPPORTS TUNNEL-LININGS)
LOMBARDI, G.
TUNNELS AND TUNNELING, (2) NO 2, 104-109, MAR. 1970. CONTINUATION OF ARTICLE STARTED IN 24-70-01001. EXAMPLES ARE GIVEN TO PROVE THAT IT IS POSSIBLE TO DETERMINE THE FORCES AROUND A TUNNEL.

24-70-05001 EXPERIENCE FROM BLASTING 12 FT DIA MERSEY PILOT TUNNEL - GROUND VIBRATIONS FROM TUNNEL BLASTING
DAVIES, J. V. & MOTT HAY AND ANDERSON
TUNNELS AND TUNNELING, (2) NO 3, 141-144, MAY 1970. THE BASIC PROPERTIES OF A GROUND WAVE ARE FREQUENCY AND AMPLITUDE. THE FREQUENCY DEPENDS ON THE TYPE OF GROUND WHILE AMPLITUDE DEPENDS ON EXPLOSIVE CHARGE, GROUND TYPE, AND DISTANCE FROM BLAST. THE MORRIS FORMULA FOR PREDICTING AMPLITUDE OF VIBRATION IS SHOWN TO BE INADEQUATE AT SHORT DISTANCES. A MODIFICATION IS DEVELOPED. A COMPARISON IS MADE OF VIBRATIONS IN THE BEDROCK AND IN THE CLAY OVERBURDEN AND THE EFFECT OF USING SHORT DELAY DETONATORS IS OBSERVED. THE EFFECT ON BUILDINGS IS DESCRIBED AND A CRITERION FOR DAMAGE IS GIVEN. IT IS SHOWN THAT HUMAN TOLERANCE IS LOW SO A LOWER CRITERION MUST BE USED IF THERE ARE RESIDENCES NEARBY.

FIELD 25 NEWS ITEMS

25-63-11001 JET PIERCING, CHAMBERING, PERCUSSION DRILLING COMBINED FOR FIRST TIME IN SINKING BLASTHOLES (AIR-FUEL OXYGEN-FUEL COST ABRASIVE-FORMATIONS)
PIT & QUARRY, 129-131, NOV 1963. FOR ABRASIVE OR EXTREMELY HARD FORMATIONS THREE NEW JET MACHINES HAVE BEEN DEVELOPED. ONE IS A NEW JET PIERCING RIG EQUIPPED WITH A RECENTLY INVENTED BURNER NOZZLE UTILIZING AIR FUEL MIXTURES. IT IS SELFCONTAINED WITH RESPECT TO ALL SERVICES EXCEPT COOLING WATER SUPPLY. THE RIG IS ALSO USED IN CONJUNCTION WITH A GARDNER-DENVER PERCUSSION DRILL FOR PRIMARY DRILLING IN CHAMBERING A DRILLED HOLE. A SECOND RIG WEIGHING 50,000 LBS HAS A 20 FT LONG 5 IN. DIAMETER BLOWPIPE WITH AN AIR FUEL JET PIERCER BURNER NOZZLE WHICH REACHES 3,200 DEG. F. THIS IS LESS THAN THAT OF OXYGEN FUEL BURNERS BUT IT HAS A HIGHER JET ACTION RESULTING IN 4 TIMES THE RATE OF ROCK REMOVAL. THE THIRD MACHINE IS AN OXYGEN FUEL TYPE USED PRIMARILY FOR CHAMBERING. ITS FLAME REACHES 4,000 TO 4,500 DEG. F. FIELD PERFORMANCE DEMONSTRATES DEFINITE COST SAVINGS IN APPLICATIONS FOR WHICH THESE MACHINES WERE DESIGNED.

25-63-12001 JET PIERCING WITH COMPRESSED AIR (JET DRILLING)
THE CANADIAN MINING AND METALLURGIAL BULLETIN, (84) N 12, 35, DEC 1963. UNION CARBIDES' JPAM-100 IS CAPABLE OF PUTTING DOWN HOLES UP TO 24 INCHES IN DIAMETER AND 55 FEET DEEP. MAXIMUM EFFICIENCY IS THUS ACHIEVED BY FIRST DRILLING A SMALL DIAMETER HOLE BY CONVENTIONAL DRILLING METHODS. (1) INCREASES BLASTING EFFICIENCY (2) DRILLS FEWER HOLES. OVER 100 TONS PER FOOT OF HOLES HAVE BEEN BROKEN. (3) LESS EXPENSIVE COMBUSTIBLES (4) LOWER COST PER TON OF WELL-FRAGMENTED ROCK (5) ELIMINATION OF "TOE" CONDITIONS AND REDUCTION OF SUB-GRADE DRILLING. RATE OF ROCK REMOVAL WHEN CHAMBERING IS 25 TO 30 CUBIC FEET PER HOUR. A 9-INCH HOLE IS 40 TO 50 FEET PER HOUR. COSTS FOR CHAMBERING MAY BE EXPECTED TO VARY FROM 1 1/2 CENTS TO 6 CENTS PER TON BROKEN DEPENDING ON QUANTITY AND TYPE OF ROCK. SMALLER MACHINE THE JPCM-80 EMPLOYES PURE OXYGEN FOR CHAMBERING OF SMALLER PRE-DRILLED HOLES OF 3 1/2 INCHES UP TO 9 INCHES AND TO DEPTHS OF 60 FEET. IT IS MOUNTED ON A TRUCK TYPE CHASSIS WHICH CAN CLIMB GRADES UP TO 30 PERCENT.

25-64-02001 AIR HAMMER CUTS COST IN ARKOMA BASIN (ADVANCE HARD-ROCK)
THE OIL & GAS JOURNAL, (62) 120-123, FEB 10, 1964. ROTARY PERCUSSION DRILLING HAS BEEN PARTICULARLY ADVANTAGEOUS IN HARD-ROCK FORMATIONS. IMPROVED DESIGNS HAVE SOLVED SUCH PROBLEMS AS FREEZING AND PLUGGING. THE HAMMERS INCREASE PENETRATION RATES TWO TO FIVE FOLD OVER AIR-AND-GAS ARE 5 TO 10 TIMES FASTER THAN MUD-ROTARY AND HAVE COMPARABLE BIT LIFE WHILE REDUCING THE COST PER FT. OF HOLE BY A THIRD.

25-64-05001 HOW THOSE 72 INCH HOLES ARE BEING DRILLED (RIG BIT DRILL-PIPE CIRCULATION)
BURKE, R. G.
THE OIL & GAS JOURNAL, (62) NO 18, 70-73, MAY 4, 1964. WHEN DRILLING 72 IN. DIAMETER HOLES A MILLION LB. RIG IS REQUIRED TO WITHSTAND 200,000 FT. LB. OF TORQUE. FOUR TYPES OF 72 IN. BITS ARE USED EACH HAVING CANTILEVER OR SADDLE TYPE REMOVABLE CUTTERS. A 4,000 FT STRING OF 13 3/8 O.D. DRILL PIPE WITH 16 IN. TOOL JOINTS WILL WEIGH 700,000 LBS. BIT ROTATES AT 5 TO 10 RPM. DRILLING IS DONE WITH REVERSE AIR FLOW WHICH REACHES 8,000 FT PER MIN. AND BRINGS UP ROCK AS LARGE AS A MAN'S FIST BUT LOST CIRCULATION CUTS DOWN THIS FORCE AND MOST CUTTINGS COME OUT AS FINELY GROUND DUST. ONCE WATER ENTERS THE HOLE THERE'S TROUBLE AS CUTTINGS BALL UP, MUD PLUGS THE SWIVEL AND CAKES INSIDE THE DRILL PIPE. WATER CAN SOMETIMES BE STOPPED BY DUSTING OR A DETERGENT ADDED TO MAKE A CONVEYABLE FOAM. DUE TO WATER EROSION A HOLE MAY CAVE IN. IN ONE INSTANCE A 96 IN. HOLE WAS DRILLED FOR 650 FT AND CASED TO SEAL OFF THE LOST-CIRCULATION ZONE. THE REST OF THE 4,500 FT HOLE WILL BE DRILLED 72 IN. DIAMETER. SMITH TOOL CO. COMPTON, CALIF. MAKES A THREE-POINT HOLE OPENER 78 IN. IN DIAMETER AND AT LEAST THREE OTHER MANUFACTURERS MAKE BITS THIS LARGE OR LARGER.

25-64-09001 DEEPEST 72 IN. DIAMETER ROTARY DRILLED SHAFT SANK FOR AEC BY LOFFLAND BROS (DRILLING-RATE BIT DRILL-COLLAR REVERSE-CIRCULATION NUCLEAR-TESTING)
MINING ENGINEERING, 68-69, SEPT 1964. LOFFLAND SPUDDED THE 72 IN. SHAFT ON JAN 7 AND BY JULY 1 THE 15,000 LB BIT HAD REACHED 2602 FT OF THE PROJECTED 3200 FT DEPTH. BITS HAVE DRILLED AS MUCH AS 60 HOURS BUT IT HAS BEEN A PRACTICE TO PULL THE BIT EVERY 36 HOURS TO INSPECT IT AND INSURE AGAINST DAMAGE TO THE BIT BODY. AT 1400 TO 1900 FT A TRIP TO CHANGE BITS TAKES 5 TO 7 HOURS INCLUDING TIME FOR BOTTOMHOLE SURVEYS AND TWO HOURS OR MORE TO CHANGE BITS OR CUTTER ASSEMBLIES. A 60 IN. DIAMETER 300,000 LB DRILL COLLAR IS MOUNTED ON A 16 IN. HEAVY WALL TUBE DIRECTLY ABOVE THE BIT. 24,000 CFM OF REVERSE CIRCULATION AIR IS USED TO EXHAUST THE CUTTINGS THRU THE 13 3/8 IN. DIA DRILL PIPE. THE SHAFT IS BEING DRILLED TO ENABLE NEVADA OPERATIONS OFFICE OF AEC TO CONDUCT HIGHER YIELD AND DEEPER UNDERGROUND NUCLEAR TESTS.

25-64-09002 BLAST HOLE PRODUCTION WITH THE AIR-FUEL JET BURNER (JET-DRILLING COST)
THE CANADIAN MINING AND METALLURGICAL BULLETIN, 927-931, SEPT 1964. THE JPAM-100 (UNION CARBIDE'S JET PIERCING DRILL) COST PER CU.FT. OF ROCK REMOVED WAS $1.52 FOR CHAMBERING AND $1.96 FOR PIERCING. THE AVERAGE ROCK REMOVAL RATE WAS 23.7 CU. FEET/HR. AND 19.0 CU. FT/HR. FOR CHAMBERING AND PIERCING RESPECTIVELY. JPAM-100 AT BEAUHARNOIS INDICATE A COST OF 1.5 TO 2.0 CENTS PER TON ON AN ANNUAL PRODUCTION OF 1,000,000 TONS. UNION CARBIDE CANADA LIMITED KNOWS THAT THE JPAM-200 MACHINE WILL PROVIDE A RELIABLE, FLEXIBLE BASE FOR THE OPERATION OF THE AIR FUEL JET BURNER. THE COST DUE TO CHAMBERING WILL RANGE BETWEEN 1.5 AND 2.25 CENTS PER TON OF ORE, DEPENDING UPON LOCAL CONDITIONS. THIS MACHINE HAS A 30 PERCENT INCREASE IN BURNER POWER WHICH SHOULD IMPROVE PERFORMANCE BY 50 TO 60 PERCENT.

25-64-09003 TRUCK PUMPS SLURRY INTO HOLES (BLASTING-SLURRY)
EXCAVATING ENGINEER, 32-33, AUG 1964. HERCULES POWDER CO. HAS DEVELOPED A NEW TECHNIQUE FOR DELIVERY OF FLOGEL, A SLURRY-TYPE BLASTING AGENT. A 20,000 LB. TANK TRUCK DELIVERS FLOGEL IN LIQUID FORM AND PUMPS DIRECTLY TO THE BLASTHOLES AT 250 LB/MIN. THE SLURRY IS HEAVIER THAN WATER SO DISPLACES IT IN VERTICAL HOLES. A 30,000LB. TRAILER PROVIDES ADDITIONAL LOGISTIC SUPPORT FOR LARGE JOBS.

25-64-10001 HERE'S A WRAP-UP OF BIG HOLE DRILLING AT NEVADA TEST SITE (ROTARY-RIG BIT CIRCULATION COST SPECIFICATIONS)
HOBBS, M. F.
WORLD OIL, 113-119, OCT 1964. FOUR WELL DRILLING CONTRACTORS ARE USING LARGE BEEFED-UP ROTARY RIGS, REVERSE AIR CIRCULATION AND HUGE EXOTIC BITS, DRILL COLLARS AND STABILIZERS TO DRILL 72 IN. DIAMETER NUCLEAR EMPLACEMENT HOLES TO ABOUT 4,000 FEET ON PAHUTE MESA AT USAEC NEVADA TEST SITE. HOLES REQUIRE ABOUT EIGHT MONTHS TO DRILL AND COST ABOUT $2 MILLION TO DRILL AND CASE WITH 48 IN. CASING. TWENTY-FIVE BASIC REQUIREMENTS OF EQUIPMENT, RATINGS AND MATERIALS FURNISHED BY THE DRILLING CONTRACTOR ARE GIVEN. TWENTY-FIVE ITEMS, FACILITIES AND SERVICES FURNISHED BY THE GOVERNMENT ARE LISTED. ENGINEERING SPECIFICATIONS FOR HOLE EMPLACEMENT ARE GIVEN AND BIG HOLE DRILLING EQUIPMENT AND TECHNIQUES ARE DESCRIBED.

25-65-03001 ELECTRIC DRILL MELTS WAY THROUGH ROCK (ROCK-DRILL)
ENGINEERING NEWS-RECORD, (174), 158-159, MAR 1965. NEW ELECTRIC DRILL USES HEAT TO PENETRATE ROCK. THE DRILL GIVES PROMISE OF DRILLING HOLES TO PRESENTLY UNOBTAINABLE DEPTHS IN ANY TYPE OF ROCK. THE DRILL CONSISTS OF A STEEL TUBE WITH A HEATING ELEMENT ATTACHED TO THE TIP. THE HEAT MELTS THE ROCK, DOWN-PRESSURE OF THE DRILL FORCES THE ROCK THROUGH A TUBE WHICH LEADS TO A COOLING DEVICE WHICH CHILLS THE ROCK FROM 2,192 DEGREES F TO LESS THAN 212 DEGREES F. GASES USED IN COOLING THEN CARRY ROCK PARTICLES TO THE SURFACE. ADVANTAGES - EASE OF USE, NO MOVING PARTS, UNAFFECTED BY DEPTH, AND WORKS IN ANY TYPE OF ROCK.

25-65-03002 DEPTH RECORDS IN 107 COUNTRIES (DRILLING)
PETROLEUM MANAGEMENT, 116-117, APR 1965. A LIST OF THE DEEPEST OIL WELLS IN EACH OF 107 COUNTRIES BY COUNTRY AND INCLUDES THE NAME, LOCATION AND DEPTH OF THE WELL.

25-65-03003 DEEP WELLS SET NEW MARK (DIAMOND BIT COST HAND SUCCESS-RATIO)
SCOTT, J. J.
PETROLEUM MANAGEMENT, (37) 105-108, MAR 1965. THE DIAMOND BIT IS RESPONSIBLE FOR THE STEADY EDGING BACK IN BIT REQUIREMENTS IN ALL SECTIONS OF THE COUNTRY. THIS AND GRADUAL DECLINE IN MUD COSTS, COMING AT A TIME WHEN DEEP DRILLING IS INCREASING STEADILY, IS A TRIBUTE TO NEWER AND BETTER ENGINEERING AND DRILLING TECHNIQUES AND CHEAPER PER FOOT DRILLING COSTS. TABLES ARE GIVEN ON DEEP WELL (MORE THAN 15,000 FT) DRILLING DATA AND THEIR SUCCESS RATIO. AN ALL TIME RECORD DEEP HOLE OF 25,340 FT. WAS DRILLED IN TEXAS.

25-66-06001 NINE BITS CHEW UP, SPIT OUT ROCK (DRILLING ROCK BITS)
N.J. DRILLING CO
ENGINEERING NEWS-RECORD, (176) 39, JUNE 30, 1966. A NINE BIT PERCUSSION DRILL WAS USED TO SINK AN ELEVATOR SHAFT IN SOLID ROCK AT A RATE OF 8 FT/HR. THE EXHAUST AIR BLOWS ROCK FRAGMENTS UP TO THE SURFACE THROUGH THE SPACE AROUND THE DRILL PIPE.

25-66-08001 SUBTRACT COSTLY HOURS WITH SHARP DRILL BITS
WILLS, D. B. & NORTON CO WORCESTER MASS
ROCK PRODUCTS, (69) 106-107, AUG 1966. THE FIVE BASIC BIT TYPES THAT REQUIRE RESHARPENING ARE CLASSIFIED AS: ROCK BIT DRILLS, ROCK BIT CHISELS, ROOF BITS, DRILL BITS, AND CUTTER BITS. AN ILLUSTRATION OF EACH BIT IS GIVEN. INSTRUCTION FOR THE TECHNIQUE OF RESHARPENING OF EACH BIT IS ALSO GIVEN.

25-66-09001 WITH ITS RADICAL DRILL FEED SYSTEM, ATLAS COPCO PROMISES SPEED AND ECONOMY (ROCK-DRILL)
ENGINEERING AND MINING JOURNAL, 27, SEPT 1966. AUTO FEED IS A NEW TYPE OF MECHANIZED ROCK DRILL FEED ARRANGEMENT FROM ATLAS COPCO. BASIC AUTO FEED PACKAGE. A 17.5-FT. STEEL FEED BEAM MOUNTING A STANDARD LIGHTWEIGHT AC ROCK DRILL ON A SLIDING CRADLE, IS DRIVEN BY A DOUBLE- ACTING AIR FEED CYLINDER. IT RECENTLY WAS USED TO DRIVE A 42-FT DIA., 1,720-FT LONG DIVERSION TUNNEL IN IDAHO, AND SEVERAL POWER TUNNELS ON THE MANICOUAGAN (QUEBEC) PROJECT. A NEW MAGNETIC READER, ONE OF FINLAND'S OUTOKUMPU OY MINING-METALLURGICAL INSTRUMENTS MEASURES TO 0.1 % IN ABOUT A MINUTE. SOME OF THE POSSIBLE APPLICATIONS ARE DETERMINING THE MAGNETIC CONTENT OF IRON ORE, CONCENTRATE AND WASTE. A NEW LINE OF TWO-STAGE HEAVY DUTY CRUSHERS FOR SIZING COKE AND SINTER FOR BLAST FURNACES HAS JUST BEEN INTRODUCED BY T. J. GUNDLACH MACHINE CO.

25-66-11001 LOGGING TOOLS RIDE ROCKETS DOWN-HOLE (DRILLING SOLID-FUEL-THRUSTER ROCKETS)
THE OIL AND GAS JOURNAL, (64) 65-66, NOV 7, 1966. LANE-WELLS CO. HAS DEVELOPED A METHOD OF SOLVING THE PROBLEM OF TOOLS STICKING IN THE MUD ALONG THE SIDES OF THE HOLE AND THUS NOT REACHING THE BOTTOM. THEY ARE USING SOLID-FUEL THRUSTERS. THESE ROCKETS ARE ATTACHED ABOVE LOGGING TOOL AND CAN BE FIRED SELECTIVELY. THE TOOL IS LOWERED DOWN THE HOLE UNTIL THE ANGLE BECOMES SO GREAT THAT FRICTION OF THE TOOL AND THE WIRE LINE OVERCOMES THE PULL OF GRAVITY AND THE TOOL STOPS. THE OPERATOR THEN FIRES A ROCKET, FORCING THE TOOL TO CONTINUE ITS FALL. THE PROCESS IS CONTINUED UNTIL THE TOOL REACHES ITS DESTINATION. TOOLS USED TO DATE HAVE BEEN EQUIPPED WITH 6 TO 15 ROCKETS, IN CLUSTERS OF THREE. AT THE EXPERIMENTAL SITE, EAST WILMINGTON, CAL., ROCKET MOTORS HAVE SUCCEEDED IN CARRYING TOOLS TO 2,700 FT, 2,800 FT SHORT OF THE GOAL. THE ROCKETS PRODUCED THE JOURNEY FROM 1,600 FT TO 2,700 FT. OPERATORS ARE ALSO DEVELOPING CENTRALIZERS FOR LOGGING TOOLS. A CENTRALIZER WOULD PREVENT THE TOOLS STICKING TO THE MUD-CAKED SIDES AND REDUCE DRAG ON THE TOOL.

25-66-11002 LASER BREAKTHROUGH WAY TO SHATTER ROCK (TUNNELS)
THE WASHINGTON POST, NOV 25, 1966. SCIENTISTS AT MIT HAVE FOUND A WAY TO USE A LASER BEAM TO SHATTER ROCK RATHER THAN FUSE AND MELT IT. THE TECHNIQUE MAY HOLD PROMISE FOR BUILDING TUNNELS IN THE TRANSPORTATION AND OTHER FIELDS. PRIOR EFFORTS TO USE THE LASER BEAM ON ROCKS WERE DISAPPOINTING BECAUSE THE INTENSE HEAT MELTED THEM.

25-66-11003 LASER BEAM USED TO SOFTEN MARBLE (TUNNELING-MACHINES HARD-ROCK-FORMATIONS)
THE NEW YORK TIMES, NOV 25, 1966. TWO SOPHOMORES AT MIT HAVE DISCOVERED THAT IF YOU TURN AN INFRARED LASER LIGHT BEAM ON GRANITE OR MARBLE, SECONDS LATER THEY ARE AS SOFT AND CRUMBLY AS SANDSTONE. DEPT. OF COMMERCE OFFICIALS SAY THE TECHNIQUE MAY HALF SOLVE A PROBLEM BLOCKING EFFECTIVE USE OF TUNNELING MACHINES. SUCH MACHINES WORK WELL IN SOFT ROCK BUT ARE STOPPED BY HARD ROCK FORMATIONS SUCH AS GRANITE AND MARBLE.

25-66-12001 LASER MAY BE HARD-ROCK TUNNELER (TUNNELING-MACHINES GRANITE MARBLE)
ENGINEERING NEWS-RECORD, (177) 19, DEC 1, 1966. TWO STUDENTS AT MIT IN A SPECIAL LAB COURSE EXPERIMENTED WITH A 1 KW CONTINUOUS CARBON DIOXIDE GAS LASER AND 1-1/2 DIAMETER UNFOCUSSED INFRARED BEAM 10.6 MICRON WAVELENGTH. GRANITE AND MARBLE SAMPLES DEVELOPED MICROSCOPIC CRACKS AFTER ONLY A FEW SECONDS, VISIBLE FRACTURES IN 30 SECONDS WITH TREMENDOUS REDUCTIONS IN THE ROCK STRENGTH. TUNNELING MACHINES ALREADY EXIST THAT WILL MINE HARDROCK AND WOULD BE PRACTICABLE IF ONLY CUTTER TEETH AND BITS DIDN'T WEAR OUT SO FAST. MIT ENGINEERS SEE THE FIRST PROBABLE FIELD APPLICATIONS OF THE LASER AS A WEAKENER RATHER THAN A DESTROYER OF ROCK.

25-66-12002 LASER BEAMS AND SOPHOMORES (ROCK-FRACTURE-RESEARCH TUNNELING-TECHNIQUES)
ENGINEERING NEWS-RECORD, (177) 80, DEC 1, 1966. EDITORIAL ON LASER BEAM EXPERIMENTATIONS AT MIT OFFERING THE EXCITING PROSPECT OF A BREAKTHROUGH IN ROCK EXCAVATION PARTICULARLY IN MECHANICAL MINING OF TUNNELS. STRESSED IS THE FACT THAT TWO SOPHOMORES MADE THE DISCOVERY THAT THE LASER BEAM CAN CREATE CONTROLLED PATTERNS OF WEAKNESS IN ROCK AND EVEN FRACTURE IT. THE KEY PART THE STUDENTS HAVE PLAYED SPEAKS WELL FOR ENGINEERING EDUCATION AT MIT SHOWING THAT RESEARCH AND TEACHING IDEALLY CAN BE BROUGHT TOGETHER TO THE BENEFIT OF THE STUDENTS.

25-66-12003 ROCK DRILL ATTACHMENT FOR HYDRAULIC EXCAVATORS (DRILLING)
THE ENGINEER, 986, DEC 30, 1966. CONVENTIONAL HYDRAULIC EXCAVATORS CAN BE CONVERTED ON SITE INTO MOBILE DRILL

RIGS. STANDARD CHAIN FEED ROCK DRILL UNITS CAN BE QUICKLY FITTED ON EXCAVATOR UPPER ARMS. THE SYSTEM IS ADAPTABLE TO MOST MAKES OF EXCAVATORS AND CALLS FOR NO MODIFICATION OF THE MACHINE. EXCAVATORS THAT ARE WORN CAN BE USED AS EFFECTIVE MOBILE DRILL RIGS. A COMBINATION OF TWO ATLAS CAPCO BBE56 ROCK DRILLS WITH CHAIN FEED AND 3-IN SANVIK COROMANT BITS, AN OPERATOR CAN ACHIEVE DRILLING RATES OF 216 FEET/HR.

25-67-01001 BIG-HOLE DRILLING METHODS ARE USED FOR MINE SHAFT (GROUTING)
KEMNITZ, G. E. & FENIX AND SCISSON INC TULSA OKLA
THE OIL & GAS JOURNAL, (65) 114-116, JAN 9, 1967. A VENTILATION SHAFT 60-IN. IN DIAMETER AND 1500 FT DEEP WAS RECENTLY COMPLETED BY FENIX & SCISSION, INC. FOR THE BUNKER HILL CO. AT THE HIGDON MINE NEAR FREDRICKTOWN, MO. THE HOLE WAS COMPLETED AND CASED IN FOUR MONTHS WITH NO EXTREME DIFFICULTIES ENCOUNTERED. THE HOLE WAS LINED WITH A GROUT ENCASED 46-IN. ID STEEL LINER. THE FIRST PHASE WAS TO DRILL A 96-IN.-DIA. HOLE THROUGH THE OVERBURDEN TO A DEPTH OF 116 FT AND LINE IT WITH 113 FT OF 67-IN. ID STEEL LINER. NEXT THE 60 IN. HOLE WAS DUG FOR THE REMAINING 1,384 FT. THE MAJOR PROBLEM ENCOUNTERED IN DRILLING OCCURRED AT THE 980 FT. LEVEL WHEN THE MUD CIRCULATION WAS TEMPORARILY LOST. THE HYDROSTATIC PRESSURE FROM THE MUD COLUMN EXCEEDED THE FORMATION PRESSURE CAUSING THE MUD TO FLOW INTO THE FORMATION RATHER THAN RETURNING TO THE SURFACE. THIS WAS OVERCOME BY CHANGING THE PHYSICAL CHARACTERISTICS OF THE MUD. AFTER COMPLETION OF THE DRILLING, 930,000 LB OF 46 IN ID LINER CONSISTING OF 36 JOINTS IN 40 FT. LONG SECTIONS WERE LOWERED AND WELDED TOGETHER IN THE HOLE. THE FINAL PHASE WAS GROUTING WITH A SPECIAL CEMENT DESIGNED TO EXPAND APPROXIMATELY 0.5% TO GET THE BEST POSSIBLE SEAL. THIS WAS DONE FOR LOWER SECTION FROM 1442 UP TO 1131 FT. THE REMAINDER WAS GROUTED WITH A LIGHT WEIGHT, HIGH-YIELD SLURRY.

25-67-05001 RAPID PENETRATION IS MAIN FEATURE OF NEW ATLAS COPCO DRILL (ROCK-DRILL HARD-ROCK FRONTHEAD BACKHEAD AIRLEG JIBS JUMBOS)
ENGR AND MINING J., 27, MAY 1967. ATLAS COPCO'S BBC-34 ROCK DRILL--THE "LEOPARD" DELIVERED 2200 BLOWS PER MINUTE IN A CONTROLLED HARDROCK TEST. AN IMPORTANT DESIGN FEATURE IS THE INTERCHANGEABILITY OF THE NEW DRILL'S FRONTHEAD AND BACKHEAD PARTS WITH THE LIGHTER WEIGHT MODELS. THE NEW DRILL WEIGHS 69 LBS., HAS AN AIR CONSUMPTION OF 179 CFM OF AIR AT 85 PSI AND IS DESIGNED FOR EITHER PUSHER AIRLEG USE OR HYDRAULIC JIBS MOUNTED ON UNDERGROUND JUMBOS.

25-67-06001 SHELL STUDY CITES COST FACTORS IN DEEP DRILLING
PETROLEUM ENGINEER, 92, JUNE 1967. DEEP EXPLORATORY HOLES (TO 15,000 FT AND DEEPER) IN 1966 ACCOUNTED FOR $6,000,000 OF $8,500,000 SPENT ON WILDCATTING. OF $16,000,000 SPENT ON DEVELOPMENT HOLES, $5,500,000 WAS ON THOSE 15,000 FEET AND DEEPER. DRILLING ENCOUNTERS DIFFICULTIES AT GREAT DEPTHS. THE PHOSPHORIA FORMATION IN THE PHEASANT AND HUB FIELD AREAS OF JOHNSON COUNTY, WYO. WAS A COSTLY PROBLEM FOR SHELL IN 1966. THE UNSTABLE PHOSPHORIA WAS SOLVED BY DRILLING THROUGH WITH 16-LB MUD AND CASTING IT OFF. DIAMOND BITS WERE USED TO ATTAIN PROPER PENETRATION RATES IN HARD AND ABRASIVE FORMATIONS IN VARIOUS LOCATIONS. OTHER DEEP DRILLING PROBLEMS CENTER AROUND DRILL STRING DESIGN AND INSPECTION, CEMENTING, AND SEVERE TORQUE. COSTS INVOLVED ARE RIG SIZE AND TIME, MUD, BITS, AND TRIP COSTS. ON A 15,000-FT HOLE, ABOUT A WEEK IS SPENT CUTTING THE FIRST 5,000 FEET, WHILE THE LAST 5,000 FT WILL TAKE 60 DAYS OR MORE. BIT AND TRIP COSTS ARE KEY COST FACTORS. THE USE OF MORE EXPENSIVE DIAMOND BITS HAS BEEN JUSTIFIED BECAUSE OF THE LONGER LIFE AND CONSEQUENT FEWER CHANGES. SHELL POINTS OUT A 5,000 FT. HOLE COSTS $8/FT OR $40,000, WHILE ONE OF 15,000 COSTS $32/FT OR $480,000 - 300 PERCENT HIGHER THAN THE ANTICIPATED COST BASED ON EXPENSE OF 5,000 FT.

25-67-07001 DEEP-DRILLING COST BITES DEEPER INTO BUDGETS
ABERNATHY, J. H. & BIG CHIEF DRILLING CO OKLA CITY
THE OIL AND GAS JOURNAL, (65) 57-62, JULY 24, 1967. THE COST OF DEEP DRILLING IS STEADILY INCREASING EACH YEAR. FROM 1958 TO 1966, THE AVERAGE DEEP WELL COST INCREASED FROM $756,000 TO $1,286,000 (BASED ON FOUR MAJOR COMPANIES AND ONE LEADING INDEPENDENT). IF TOTAL DEVELOPMENT AND EQUIPPING EXPENDITURES ARE NOT TO EXCEED 2.3 BILLION YR. SHALLOWER DRILLING WILL HAVE TO BE CURTAILED BECAUSE IN 1966 1.1% OF TOTAL WELLS DRILLED ACCOUNTED FOR OVER 20% OF ALL COST. IT WAS POINTED OUT THAT NO MAJOR BREAKTHROUGHS HAVE BEEN MADE IN RECENT YEARS. ONLY IMPROVEMENT AND BETTER APPLICATIONS OF KNOWN TECHNOLOGY HAVE BEEN MADE. THIS SEEMS TO INDICATE THAT THE COST OF DEEP DRILLING WILL CONTINUE TO INCREASE. TABLES OF DRILLING COST ARE GIVEN ALONG WITH TABLES CONTAINING THE NUMBER AND LOCATION OF DEEP WELLS DUG OVER THE TEN YEAR PERIOD FROM 1956 TO 1966. 15 REFS.

25-67-11001 RAISE BORERS A SUCCESS IN HARD-ROCK MINING (MOLES BORING MACHINES)
ENGR AND MINING J., 112, NOV 1967. RAISE BORING MACHINES PRODUCE SMOOTH, CIRCULAR RAISES IN LESS TIME WITH LESS COST AND GREATER SAFETY THAN CONVENTIONALLY DRIVEN OPENINGS. THE RAISE BORERS ELIMINATE SLOPE RAISE REPAIRS. RAISE BORERS CAN BORE AT ANGLES UP TO 30 DEGREES WITH THE VERTICAL WITH VERY LITTLE VARIATION IN DIRECTION. A DRILL RAISE IS 50 PERCENT AS EXPENSIVE AS A CONVENTIONAL RAISE.

25-68-01001 BIG HOLES POINT TO DEEP WELLS (CASINGS CUTTERS DRILLING-RIGS SHAFTS)
BURKE, R. G.
THE OIL & GAS JOURNAL, (66) 65-70, JAN 22, 1968. HOLES AS LARGE AS 90 INCHES DIAMETER AND 6,000 FEET DEEP ARE BEING DRILLED BY THE AEC ON AMCHITKA ISLAND. A NUMBER OF ANTICIPATED IMPROVEMENTS ARE GIVEN. AEC'S NEXT STEP WILL BE TO GO TO A 140 INCH DIAMETER HOLE. THERE IS POTENTIAL IN DRILLING MINING SHAFTS RATHER THAN USING THE CONVENTIONAL MINING METHOD. RIGS AND DRILLING ARE DESCRIBED FOR THE LARGE AND REGULAR HOLES. KERF-TYPE CUTTERS WITH TUNGSTEN CARBIDE INSERTS ARE BEING TRIED, ALSO COMBINING MILL-TYPE AND KERF TYPE CUTTERS MAY ALLOW TWICE THE PENETRATION BEFORE CUTTER REPLACEMENT. FLUID DISCHARGE AT THE BOTTOM MAY CLEAN THE BIT FACE MORE EFFICIENTLY AND SO IMPROVE PENETRATION RATES AND CUTTER LIFE.

25-68-01002 DRILLING ADVANCES AIMED AT LOWER WELL COSTS (DEEP-WELL STICKING TILT-RIG POLYMER-MUD)
FUNDERBURK, J. C. & WORLD OIL
WORLD OIL, 58-61, JAN. 1968. A SURVEY OF THE LATEST TECHNIQUES FOR ECONOMICAL DRILLING WAS MADE. SHALE DENSITY MEASURING HAS GIVEN FASTER DRILLING. TOOL EVALUATION STUDIES SAVED $345,000.00 AND 57 1/2 DAYS IN 25 WELLS. SQUARE DRILL COLLARS ARE USED TO LIMIT LATERAL DRIFT. SPIRAL GROOVED LINERS HAVE BEEN USED TO REDUCE STICKING. DRILLING HYDROSTATICALLY USING BRINE HAS PROVIDED HIGHER PENETRATION RATES, LOWER MUD MAINTENANCE COSTS AND LOWER CIRCULATING PRESSURES IN A GAS WELL. A POLYMER DRILLING FLUID MET THE NEED FOR VISCOSITY BUILDING WITH 1/10 TO 1/20 OF THE MATERIAL FORMERLY USED. BIT LIFE WAS INCREASED AND WATER CONSUMPTION FOR MUD DILUTION WAS REDUCED 40 PER CENT WHEN THE NEW MUD WAS USED. A TILT RIG PLATFORM WAS USED TO DRILL SHALLOW OFF SHORE WELLS EFFICIENTLY AND ECONOMICALLY.

25-68-02001 FULL-FACE SHOTS CARVE OUT UNDERGROUND CAVERN
CONSTRUCTION METHODS, 68-69, FEB 1968. IN THREE UNDERGROUND GAS STORAGE CAVERNS NEAR LEMONT, ILL. A CONTROLLED BLASTING TECHNIQUE AND A HIGH-CAPACITY TWIN BUCKET MUCKING SYSTEM SPEED THE OPERATION. INSTEAD OF FOLLOWING STANDARD PROCEDURE AND WORKING AT THE FACE OF AN UNDERGROUND EXCAVATION, A LOADER SHUTTLES ON RAILS FROM MUCK PILE TO SHAFT, FEEDING A BUCKET SYSTEM THAT SPEEDS SHOT ROCK TOPSIDE.

25-68-04001 AN ELECTRON 'GUN' CAN CUT CONCRETE (ROCK-DISINTEGRATION-METHODS)
STEVENS, W. K.
THE NEW YORK TIMES, MAY 13, 1968. THIS ELECTRON GUN MAY BE EMPLOYED IN CARVING MOUNTAIN TUNNELS. TECHNOLOGY IS AVAILABLE TODAY TO BE USED FOR PRACTICAL DEVELOPMENT OF A ELECTRON-BEAM ROCK CUTTER. DR. SCHUMACHER OF WASHINGTON RESEARCH LABORATORIES IN PITTSBURGH SAYS PROBABLY COULD CUT ROCK FASTER THAN EXISTING MECHANICAL CUTTERS. EXPERIMENTAL INSTRUMENT PRODUCES 9000 WATT ELECTRON BEAM AT 150,000 VOLTS.

25-68-04002 USBM EXAMINES EXOTIC WAYS OF BREAKING ROCK (ROCK-FRAGMENTATION STUDIES RESEARCH)
U.S. BUR MINES TWIN CITIES
ENGR AND MINING J., 85-92, APRIL 1968. RESEARCH DEPARTMENT STUDYING ROCK DISINTEGRATION BY MEANS OF ALL MECHANISMS

WHICH IMPART ENERGY TO ROCK. THEORETICAL STUDIES INCLUDE ROCK BEHAVIOR UNDER STRESS AND MAXIMUM YIELD STRENGTH AS AN INDICATOR OF ROCK DRILLABILITY. EXPERIMENTAL STUDIES COVER WATER JETS, CHEMICAL ACTION, HEAT TRANSFER, AND BLASTING EFFECTS OF VARIOUS EXPLOSIVES. A GENERAL OUTLINE OF STUDIES IN PROGRESS, NO TECHNICAL DATA.

25-68-11001 BIG HOLES FOR NUCLEAR TESTS (DRILLING-MACHINE RIG)
CIVIL ENGR, ASCE 33, NOV 1968. DRILLING RIGS WITH 2,000,000 LB NOMINAL CAPACITY AND HOISTS OF 3,000 HP CAPACITY HAVE BEEN DEVELOPED FOR UNDERGROUND NUCLEAR WEAPONS TESTS. THIS DRILLING MACHINE HAS THE POTENTIAL FOR OIL EXPLORATION AT DEPTHS FAR BELOW THE PRESENT 25,000 FT LIMIT.

25-69-01001 12-DRILL JUMBO SPEEDS TUNNELING CYCLE (DRILL-AND-BLAST SUPPORTS)
CONSTRUCTION METHODS AND EQUIPMENT, (51) NO 1, 56-62, JAN 1, 1969. HOW MINERS PUNCHED BIG HORSESHOE TUNNEL THROUGH MILE AND HALF OF SOLID MOUNTAIN IN COLORADO ROCKIES 60 MI WEST OF DENVER. FOUR DRILLS WORKED ON TOP AND BOTTOM DECKS AND ADDITIONAL FOUR WERE SIDE MOUNTED ON JUMBO RIDING RAILS INTO 8146 FT. LONG TUNNEL. TOP RIB SECTIONS, WEIGHING 211 LB/FT WERE SET WITH HYDRAULIC EQUIPMENT.

25-69-01002 EROSION DRILL SHOWS ASTONISHING SPEED (HYDRAULIC-JET WATER-JET)
KENNEDY, J. L.
THE OIL & GAS JOURNAL, (67) 92-93, JAN 27, 1969. MAURER AND HEILHECKER OF ESSO PRODUCTION RESEARCH CO. REPORTED ON A NEW JET EROSION DRILL AT THE FOURTH CONFERENCE ON DRILLING AND ROCK MECHANICS AT UNIVERSITY OF TEXAS. SPECIFIC ENERGY DROPS TO 31,000 FT-LB/CU IN AT 5,000 PSI FOR BEREA SANDSTONE. A 2-INCH DIAMETER 830 HP EROSION DRILL CUT CARTHAGE MARBLE AT 180 FT/HR, INDIANA LIMESTONE AT 280 FT/HR, BEREA SANDSTONE AT 300 FT/HR.

25-69-07001 WATER POWER'S NEW USES (WATER-CANNON EXOTECH WATER-JET)
THE WASHINGTON POST, H1, JULY 27, 1969. EXOTECH, INC. OF ROCKVILLE, MD., HAS DEVELOPED TWO DEVICES. ONE, A WATER CANNON, CAN BLAST THROUGH LARGE BLOCKS OF ROCK. THE OTHER, CALLED A "CUMULATIVE" JET BLASTING SYSTEM CAN PIERCE A 1/2-IN-THICK ARMOR PLATE WITH A BULLET OF WATER OR OTHER LIQUID. THE WATER CANNON SHOOTS TEN-PULSE-PER-SEC. BLASTS OF WATER REACHED IMPACT PRESSURES OF 40,000 TO 80,000 PSI. THE COMPANY IS TALKING WITH CONSTRUCTION COMPANIES ABOUT BUILDING A 200 HP MACHINE PRODUCING TWO OR THREE PULSES PER SEC. AND IMPACT RATES OF MORE THAN 200,000 PSI. THE CUMULATIVE JET, FIRES A 1/16 IN. DIA. MISSILE OF WATER OR GLYCERINE GEL FROM THE SPECIALLY EQUIPPED NOZZLE OF A .38 CALIBER BARREL. THE MISSILE MOVES SO FAST, - 25,000 FT PER SEC. THAT IT STRIKES A TARGET AT A PRESSURE OF 50 MILLION PSI. EXOTECH IS NOW CONCENTRATING ITS RESEARCH EFFORT ON COMBINING THE GREATER PUNCH OF THE CUMULATIVE JET WITH THE LARGE SCALE POTENTIAL OF THE CANNON.

FIELD 26 COMPANY BROCHURES

26-67-05001 BLAST AND SPRAY ON B.C. TUNNEL DRIVE (ROCK-DISINTEGRATION RAIL-TUNNEL GROUND-SUPPORT)
RIMES, L.
SF 342 SIKA CHEM. CORP., LYNDHURST, N.J., REPRINT FROM HEAVY CONSTRUCTION NEWS, MAY 1, 1967. CONTRACTORS ON A 24-FT-HIGH, 17-FT-WIDE, 10760-FT-LONG RAILWAY TUNNEL IN VANCOUVER, CANADA, ARE USING SEMIGELATIN 70% CILGEL TYPE DYNAMITE TO REDUCE BLAST VIBRATIONS AND BOOST YD ADVANCES. A SWISS-MADE ALVA CONCRETE MIXER IS BEING USED TO SPRAY CONCRETE AS A PRIMARY LINING. DRILLING IS DONE WITH TWO-LEVEL JUMBO MOUNTING SIX GARDNER-DENVER D93 DRILLS. THE TUNNEL IS BEING DRIVEN BY NORTHERN CONSTRUCTION AND J.W. STEWART LTD., AND PERINI PACIFIC LTD.

FIELD 28 PATENTS

28-63-12001 METHOD OF DRILLING WITH HIGH VELOCITY JET CUTTER ROCK BIT (PATENT)
BORO, R. A. & PHILLIPS PETROLEUM CO
U.S. PATENT NO. 3112800, DEC 3, 1963. A METHOD FOR DRILLING A WELL COMPRISING IMPINGING A STREAM OF FLUID (GAS OR LIQUID) AT A PRESSURE GREATER THAN CONVENTIONAL WELL FLUID CIRCULATING PRESSURE AND AT HIGH VELOCITY DOWNWARD AND DIRECTLY AGAINST AN EARTH FORMATION AT THE BOTTOM OF THE WELL AND ADJACENT TO THE WALL, CUTTING AN ANNULAR GROOVE AROUND THE PERIPHERY. PRESSURES OF 2500 PSI TO 20,000 PSI ARE USED WITH DRILLING MUD WITH SAND OR OTHER PELLETS.

28-67-09001 JET NOZZLE FOR OBTAINING HIGH PULSE DYNAMIC PRESSURE HEADS (PATENT PULSE-JET EXTREME-PRESSURE)
VOITSEKHOVSKY, B. V.
U.S. PATENT NO. 3343794, SEPT 26, 1967. A JET NOZZLE FOR OBTAINING HIGH PULSE DYNAMIC PRESSURE HEADS IN INSTALLATIONS WHICH USE THE IMPACT OF A FREELY ACCELERATING PISTON ACTING ON A LIQUID AND FORCING THE LIQUID THROUGH A NOZZLE HAVING AN INTERNAL CAVITY WHICH IS FREE OF LIQUID AT THE INSTANT OF IMPACT. BETTER UTILIZATION OF ENERGY AND PULSES WITH DYNAMIC PRESSURE HEADS UP TO 1 MILLION KG/SQ CM ARE CLAIMED.

28-67-12001 RETRIEVABLE BIT (ABRASIVE-DRILLING WATER-JET HYDRAULIC-JET)
GAYLORD, E. W.
U.S. PATENT 3,360,095, DEC 26, 1967. A METHOD FOR DRILLING OF WELLS THROUGH EXTREMELY HARD FORMATIONS IN WHICH AN ABRASIVE-LADEN SLURRY IS PUMPED DOWN THE WELL AND DISCHARGED AT EXTREMELY HIGH VELOCITY THROUGH NOZZLES. THE BIT IS ROTATED DURING DRILLING. NUMBER AND LOCATION OF NOZZLES DETERMINE WHETHER THE JETS CUT THE ENTIRE BORE HOLE OR CUT A SERIES OF CIRCULAR GROOVES LEAVING NARROW RIDGES WHICH ARE EASILY BROKEN. VELOCITY OF ABRASIVE LADEN FLUID MUST BE AT LEAST 500 FT/SEC WITH NOZZLES FROM 1/2 INCH TO 1 1/4 INCHES. 4000 TO 5000 PSI ACROSS THE NOZZLE IS PREFERRED. THIS INVENTION PROVIDES A METHOD FOR RAPID REPLACEMENT OF NOZZLES WITHOUT REMOVING THE DRILL PIPE.

28-68-04001 METHOD OF TREATING ABRASIVE-LADEN DRILLING LIQUID (WATER-JET HYDRAULIC-JET)
GOODWIN, R. J. + MORI, E. A. + PEKAREK, J. L. & SCHAUB, P. W. & GULF RES AND DEV CO PITTSBURGH
U.S. PATENT 3375886, APRIL 2, 1968. A METHOD OF TREATING ABRASIVE-LADEN LIQUID DISCHARGED FROM THE WELL IN A HYDRAULIC JET DRILLING PROCESS BY SEPARATING CUTTINGS LARGER THAN THE ORIGINAL ABRASIVE PARTICLES, THEN SEPARATING THE ABRASIVE PARTICLES, THEN SEPARATING THE FINES. THE DRILLING FLUID IS RECONSTITUTED FROM THE LIQUID AND ABRASIVES. A SYSTEM USING TWO IMMISCIBLE FLUIDS IS ALSO DESCRIBED.

28-68-04002 METHOD OF DRILLING IN HARD FORMATIONS (HYDRAULIC-JET ABRASIVE WATER-JET)
GOODWIN, R. J. + MORI, E. A. + PEKAREK, J. L. & SCHAUB, P. W. + ZINKHAM, R. E.
& GULF RES AND DEV CO PITTSBURGH
U.S. PATENT 3375887 APRIL 2, 1968. A HYDRAULIC JET METHOD OF DRILLING IN WHICH A PLURALITY OF JET STREAMS OF ABRASIVE-LADEN LIQUID ARE DISCHARGED DOWNWARD AT EXTREMELY HIGH VELOCITIES FROM NOZZLES IN A DRILL BIT ROTATING AT THE BOTTOM OF THE BOREHOLE AROUND A VERTICAL AXIS. THE NOZZLES ARE POSITIONED TO PROVIDE A HIGH RATE OF DRILLING, A LOW RATE OF EROSION OF THE BIT BY REBOUNDING ABRASIVE PARTICLES WITH SUBSTANTIALLY UNIFORM PENETRATION OF THE FORMATION OVER THE AREA OF IMPINGEMENT.

28-68-05001 DRILLING METHOD AND COMPOSITION THEREFOR (WATER-JET HYDRAULIC-JET ABRASIVE)
PEKAREK, J. L. + SCHAUB, P. W. & GULF RES AND DEV CO PITTSBURGH
U.S. PATENT 3384189, MAY 21, 1968. A HYDRAULIC JET METHOD OF DRILLING A WELL IN WHICH HIGH VELOCITY STREAMS OF AN ABRASIVE-LADEN LIQUID ARE DISCHARGED AGAINST THE BOTTOM OF THE BOREHOLE OF THE WELL TO PENETRATE THE FORMATION. A FERROUS ABRASIVE OF ROCKWELL C HARDNESS OF AT LEAST 55. DATA SHOW THAT ONLY STEEL SHOT OF 60-65 ROCKWELL C HARDNESS GIVE AS GREAT PENETRATION, AS LITTLE BREAK UP, OR AS LITTLE NOZZLE WEAR AS THE STEEL GRIT PREFERRED.

28-68-05002 HYDRAULIC JET BIT (WATER-JET ABRASIVE)
GOODWIN, R. J. + PEKAREK, J. L. & GULF RES AND DEV CO PITTSBURGH
U.S. PATENT 3384192, MAY 21, 1968. A DRILL BIT FOR HYDRAULIC JET DRILLING COMPRISING AN ELONGATED DRILL BIT BODY HAVING A CENTRAL OPENING THEREIN CLOSED AT ITS LOWER END BY A BOTTOM MEMBER, THE LOWER SURFACE OF WHICH IS COVERED WITH AN ABRASIVE-RESISTANT BACK SPLASH PLATE AT LEAST ONE INCH THICK. ABRASION RESISTANT NOZZLES EXTEND DOWNWARD THROUGH THE BOTTOM MEMBER AND THE BACK SPLASH PLATES WITH OUTLETS SUBSTANTIALLY FLUSH. STANDOFF BARS UNITARY WITH THE BACK SPLASH PLATE MAINTAIN THE REQUIRED SPACING BETWEEN THE OUTLETS OF THE NOZZLES AND THE BOTTOM OF THE BOREHOLE.

28-68-05003 HYDRAULIC JET BIT (WATER-JET ABRASIVE)
GOODWIN, R. J. + MORI, E. A. + PEKAREK, J. L. & SCHAUB, P. W. + ZINKHAM, R. E.
& GULF RES AND DEV CO PITTSBURGH
U.S. PATENT 3385386, MAY 28, 1968. A DRILL BIT FOR DRILLING A WELL THROUGH HARD FORMATIONS BY HIGH VELOCITY JET STREAMS OF ABRASIVE-LADEN FLUID. THE BIT HAS A CLOSED LOWER END THROUGH WHICH A PLURALITY OF NOZZLES EXTEND. STANDOFF BARS OF 1/2 INCH TO 1 1/4 INCHES ARE PROVIDED. CUTS

28-68-06001 RETRIEVABLE PISTON ADVANCE JET BITS (WATER-JET ABRASIVE HYDRAULIC JET DRILLING)
MORI, E. A. + SCHAUB, P. W. & GULF RES AND DEV CO PITTSBURGH
U.S. PATENT NO. 3389759, JUNE 25, 1968. A RETRIEVABLE BIT FOR DRILLING WELLS BY MEANS OF HIGH VELOCITY STREAMS OF ABRASIVE-LADEN LIQUID IN WHICH A NOZZLE HOLDER WHICH CAN BE PUMPED DOWN DRILL PIPE ENGAGES AN INWARDLY EXTENDING SHOULDER AT THE LOWER END OF THE DRILL PIPE. CUTS A HOLE OF LARGER DIAMETER THAN THE DRILL PIPE.

FIELD 3 GROUND CONTROL AND LININGS

FIELD 31 BOOKS

31-64-00001 ROCK TUNNELING WITH STEEL SUPPORTS (GEOLOGY MECHANICAL-DEFECTS CHEMICAL-DEFECTS SUPPORT-LOADS DESIGN STRESS METHODS-OF-SUPPORT)
PROCTOR, R. V. + WHITE, T. L.
COMMERCIAL SHEARING AND STAMPING CO YOUNGSTOWN OHIO, YOUNGSTOWN PRINTING CO., 1 - 282, 1946 (REPRINTED 1964). TUNNEL SUPPORT SYSTEMS PROBLEMS WITH SUGGESTIONS FOR SOLVING. FOUR SECTIONS: (1) ENGINEERING GEOLOGICAL INFORMATION REQUIRED FOR ESTIMATING THE ROCK PRESSURE ON TUNNEL SUPPORTS. DESCRIPTION OF ROCK BEHAVIOR CHARACTERISTICS, AND THE TYPE AND ACCURACY OF A GEOLOGICAL SURVEY REQUIRED PRIOR TO THE CONSTRUCTION OF A TUNNEL. THE PRINCIPAL TYPES OF ROCK, THEIR SPECIFIC PROPERTIES, THEIR MOST COMMON MECHANICAL AND CHEMICAL DEFECTS WHICH HAVE A DIRECT BEARING ON TUNNELING ARE USED AS THE BASIS FOR AN INQUIRY INTO THE SOURCES AND THE INTENSITY OF THE LOAD WHICH ACTS UPON THE ARTIFICIAL SUPPORT OF THE WALLS OF TUNNEL IN BROKEN, CRUSHED, AND DECOMPOSED ROCK. THE PROCEDURES FOR ESTIMATING THE ROCK ARE GIVEN WITH A FEW REFS. (2) DISCUSSION OF THE RELATIONSHIPS BETWEEN ROCK BEHAVIOR, TYPE OF STEEL SUPPORT, AND THE METHOD OF EXCAVATION. VARIOUS CHAPTERS DISCUSS THE FACTORS AFFECTING LAYOUT OF TUNNEL SUPPORT, CONSTITUENTS OF TUNNEL SUPPORTS, AND TUNNELING IN SOFR GROUND. (3) THE ANALYTICAL METHODS OF DESIGN OF THE SUPPORTING STRUCTURE UNDER ASSUMED LOADING CONDITIONS. VARIOUS CHAPTERS GIVE BASIC CONCEPTS AND DATA, FORCES AND STRESSES IN BLOCKED RIBS, WITH A DETAIL PROCEDURE FOR AND EXAMPLES OF COMPUTATION OF STRESSES CONCLUDING THIS SECTION. (4) A CATALOG CONTAINING A DESCRIPTION OF THE STEEL SUPPORTS MANUFACTURED BY COMMERCIAL SHEARING AND STAMPING CO AND A LIST OF ROCK TUNNELS IN WHICH "COMMERCIAL" STEEL SUPPORTS WERE USED.

FIELD 32 SYMPOSIA

32-56-04001 A REPORT ON THE STRATA CONTROL RESEARCH PROGRAM OF THE SCHOOL OF MINES DURHAM ENGLAND (BLASTING ROCK-MECHANICS)
BARISTER, D. & SCH OF MINES DURHAM ENG
QUARTERLY OF THE COLO SCHOOL OF MINES FIRST SYMP ON ROCK MECHANICS, (51) N. 3, 39-61, JULY 1956. THE PROGRAM CONCERNS THE DETERMINATION OF LOADS ON UNDERGROUND SUPPORTS. DEVELOPMENT AND CONSTRUCTION OF THE EQUIPMENT USED IN THE STUDY ARE DESCRIBED. TWO EXPERIMENTS ARE USED TO ILLUSTRATE THE SCOPE OF INVESTIGATIONS USING SUPPORT-LOAD MEASURING EQUIPMENT. EXPERIMENTS WERE CARRIED OUT AT A NORTHUMBERLAND COLLIERY, ON A 98 YD LONG-WALL FACE, IN THE PLESSEY SEAM, TO COMPARE THE RESULTS OBTAINED BY DIFFERENT SHOT FIRING TECHNIQUES. SEAM OVERLAY WAS 600 FT OF ROCK. THE FIRST EXPERIMENT EXAMINED SINGLE SHOT, SIMULTANEOUS SIXSHOT WITH VARYING DELAYS AND SEQUENCES, AND FULL FACE SHORT DELAY FIRING. MEASUREMENTS WERE MADE OF COAL SIZING, AFTER DETONATION FUMES, AIRBORNE DUST, METHANE EMISSION, STRATA VIBRATIONS AND EXPLOSIVES CONSUMPTION. RESULTS INDICATE THAT AN IMPROVEMENT IN THE PRODUCT SIZE MIGHT OCCUR WITH SHORT DELAY DETONATORS WITH FULL FACE FIRING. THE SECOND EXPERIMENT, A STRATA-CONTROL INVESTIGATION ON A "GOFAR" CLOCK INSTALLATION EXPERIENCING DIFFICULT CONDITIONS, CONSISTED OF "GOFAR" CLOCKS SET AT 4 FT CENTERS ON A ROCK FACE TO PROVIDE A STRONG BACK LINE OF SUPPORT HOPEFULLY CAPABLE OF RESISTING THE TENDENCY OF THE ROOF BEDS TO CONVERGE AND THE RESULTANT HIGH LOADS TO TRANSFER TO THESE SUPPORTS. RESULTS SHOW THAT SOME DEGREE OF CLOSURE BETWEEN ROOF AND THE FLOOR IN THE WORKING AREA OF A COAL FACE IS INEVITABLE. THE EFFECTIVENESS OF ANY SUPPORT IS GAGED BY ITS YIELD-RESISTANCE CHARACTERISTICS RATHER THAN BY ITS LOAD CAPACITY. THE RIGIDITY OF ANY SUPPORT IS GOVERNED LARGELY BY THE STRENGTH AND NATURE OF THE ROOF. 5 REFS.

32-56-04002 MINE OPENING STABILIZATION BY STRESS REDISTRIBUTION (ROCK-MECHANICS)
REED, J. J. & UNIV CAL BERKELEY CAL
QUARTERLY OF THE COLO SCHOOL OF MINES FIRST SYMP ON ROCK MECHANICS, (51) N. 3, 65-97, APRIL 1956. THIS WAS AN EXPERIMENTAL INVESTIGATION OF THE NATURAL STRESS DISTRIBUTION IN THE WALLS OF A MINE OPENING UNDER HYDROSTATIC LOAD, AND OF A METHOD TO CAUSE A MORE FAVORABLE REDISTRIBUTION OF THE STRESS IN ORDER TO INCREASE OPENING STABILITY. REDISTRIBUTION WAS ACCOMPLISHED BY MEANS OF FLAT PRESSURE TUBES WHICH INCREASED THE STRESS AT DEPTH IN THE WALLS, AND CONSEQUENTLY DECREASED THE SKIN STRESS. PLASTER MODELS WITH IMBEDDED AND APPLIED SR-4 RESISTANCE WIRE STRAIN GAGES WERE USED TO DETERMINE STRESS DISTRIBUTION EXPERIMENTALLY. THE MODELS WERE JACKETED AND LOADED HYDRO-STATICALLY IN A CLOSED VESSEL. FLATTENED BRASS TUBES WERE IMBEDDED IN THE WALLS ORIENTED ON RADII, AND AT A DEPTH OF ABOUT ONE OPENING-RADIUS. THESE TUBES WERE PRESSURIZED SEPARATELY FROM THE EXTERIOR LOADING PRESSURE, AND EXERTED A DIRECTIONAL WEDGING ACTION WHICH CAUSED IMPORTANT CHANGES IN THE STRESS DISTRIBUTION IN THE WALLS OF THE OPENING. BY INCREASING THE COMPRESSIVE STRESS AT DEPTH, THE CRITICALLY HIGH SKIN STRESS IS APPRECIABLY REDUCED, WHICH SHOULD INCREASE THE GENERAL STABILITY OF THE OPENING. THE RESULTS OF 13 MODEL TESTS DEMONSTRATED THE VALIDITY OF THIS PROCEDURE CONCLUSIVELY AS REGARDS STRESS REDISTRIBUTION. APPENDICES GAVE THE PREPARATION AND TESTING OF STRAIN GAGES AND THE STRESS CORRECTING CALCULATIONS FOR TRIAXIAL LOADING. 79 REFS.

32-56-04003 CONCRETE FOR GROUND SUPPORT IN THE KELLEY MINE (BLOCK-CAVING)
HANNIFAN, M. & ANACONDA CO BUTTE MONT
QUARTERLY OF THE COLO SCHOOL OF MINES FIRST SYMP ON ROCK MECHANICS, (51) N. 3, APRIL 1956. USE OF CONCRETE SUPPORT HAS PROVED VERY SUCCESSFUL IN MINIMIZING THE SERIOUS PROBLEMS RESULTING FROM THE FAILURE OF TIMBERED EXTRACTION OPENINGS IN THE MINING BLOCKS OF THE ANACONDA CO'S KELLEY MINE IN BUTTE MONT. THE REDUCTION IN THE COST OF BLOCK REPAIRS ALONE (76 PERCENT) MORE THAN BALANCES THE ADDITIONAL DEVELOPMENT COST OF CONCRETE SUPPORT FOR THE GRIZZLY LEVEL, PLUS THE ADDITION OF A CONCRETED SLUSHER LEVEL, PLUS THE ADDITIONAL OPENINGS REQUIRED TO REDUCE THE DRAWPOINT AREA 25 PERCENT. CREDIT FOR THE INCREASED EFFICIENCY AND REDUCED COST OF ORE DRAWING AND TRAMMING IS SHARED BY THE EFFECTIVENESS OF CONCRETE SUPPORT AND THE CHANGES IN BLOCK DESIGN TO A GRIZZLY-CONTROL SLUSHER SYSTEM.

32-57-04001 THEORY AND PRACTICE OF ROCK BOLTING (ROCK-MECHANICS ROOF-SUPPORT)
SCHMUCK, H. K. & COLO FUEL AND IRON CORP DENVER
QUARTERLY OF THE COLO SCHOOL OF MINES SECOND SYMP ON ROCK MECHANICS, (52) NO 3, 233-265, APR 1957. BECAUSE SCIENTIFIC DATA ON ROCK BOLTING HAVE BEEN SCARCE, THIS PAPER IS BASED PRIMARILY ON THE AUTHOR'S PERSONAL EXPERIENCE AND ON LITERATURE BASED ON PRACTICAL APPLICATIONS. DISCUSSION INVOLVES THE THEORY OF BOLTING, TYPES OF BOLT, BOLTING PROCEDURES AND CHARACTERISTICS, AND FINALLY THE DEVELOPMENT AND RESEARCH WORK THAT NEEDS TO BE DONE. SUCCESSFUL ROCK BOLTING IS BEING DONE IN ALL ROCKS, SEDIMENTARY, METAMORPHOSED, AND IGNEOUS AND IN ALL TYPES OF MINE OPENINGS FOR THE PURPOSE OF REINFORCING ROCK BEAMS, SUSPENDING OF MATERIALS AND PROVIDING SHEAR STRENGTH TO THE BOUNDARIES OF OPENINGS. THE ONLY LIMITING FACTOR, BESIDES ECONOMICS, IS THE ABILITY OF THE BOLT TO DEVELOP AND MAINTAIN ADEQUATE ANCHORAGE. 12 REFS.

32-57-04002 CEMENTATION IN STRENGTHENING ROCK (ROCK-MECHANICS CHEMICAL-GROUTING)
GROSVENOR, N. E.
QUARTERLY OF THE COLO SCHOOL OF MINES SECOND SYMP ON ROCK MECHANICS, (52) NO 3, 265-276, APR 1957. A REVIEW OF THE EXPERIMENTAL WORK THAT HAS BEEN DONE AT THE COLORADO SCHOOL OF MINES TO FIND A MATERIAL WITH A HIGH TENSILE BONDING STRENGTH. IT ALSO REVIEWS OTHER WORK IN THE FIELD OF CEMENTATION AROUND UNDERGROUND OPENINGS, AND WILL ALSO DISCUSS SOME OF THE EXPERIMENTAL WORK BEING CARRIED ON BY THE CLIMAX MOLYBDENUM COMPANY AT CLIMAX, COLORADO, AND ON THE CARLTON TUNNEL NEAR LEADVILLE, COLORADO. AN INVESTIGATION OF ADDITIVE MATERIALS USED IN CONCRETE TO GIVE ADDED STRENGTH IN TENSION AND COMPRESSION WAS CONTINUED USING REGULAR NX CORES OF UNAWEEP GRANITE AND DAKOTA SANDSTONE. THE TENSILE STRENGTH OF THE CORES WAS OBTAINED AND THEN CEMENTED BACK TOGETHER USING SEVERAL DIFFERENT TYPES OF CEMENTING MATERIALS. THE CEMENTED CORES WERE TESTED AFTER 1, 3, 7, AND 28 DAYS TO OBTAIN THE STRENGTH CURING CURVES. THE EXPERIMENTAL DATA SHOW THAT FOR THE GRANITE ROCK USED PORTLAND CEMENT TYPE I WITH BERYLEX ADDITIVE ATTAINED AN AVERAGE BONDING VALUE OF 300 PSI IN 28 DAYS. IT ALSO SHOWED THAT THE POROUS TYPE SANDSTONE ROCK BONDED WELL WITH SODIUM SILICATE AND FAIRLY WELL WITH PORTLAND CEMENT TYPE I WITH BERYLEX.

32-57-11001 GARRISON DAM - TUNNEL TEST SECTION INVESTIGATION (LINING)
BURKE, H. H. & BECHTEL CORP SAN FRANCISCO
J. SOIL MECHANICS AND FOUNDATIONS DIV. PAPER 1438, 1-50, NOV. 1957. DESIGN OF TEMPORARY SUPPORT AND PERMANENT LINING FOR TUNNELS AT GARRISON DAM WAS APPROACHED BY EARLY CONSTRUCTION OF A 240-FT. LENGTH IN ONE OF THE EIGHT MAIN TUNNELS AND EQUIPPING THIS AS A TEST SECTION. TOTAL OBSERVATION TOOK 6 YEARS. A CLEARER INSIGHT WAS GAINED INTO THE ACTION OF CIRCULAR LINING. PROBLEMS OF EXTERNAL PRESSURES, PRESSURE DEVELOPMENT, PRESSURE RELIEF, AND LOAD TRANSFER TO ADJACENT TUNNELS WAS INVESTIGATED. A GREAT REDUCTION IN STEEL RIB SUPPORT WAS REACHED DUE TO LOW STRESSES. A MAJOR SAVING OF CONSTRUCTION OCCURRED BY HAVING A MAJOR SECTION OF THE TUNNEL AVAILABLE FOR INSPECTION BY BIDDERS, PLUS A GREATER KNOWLEDGE OF CONSTRUCTION WAS AVAILABLE. THE USE OF JUMBOS MOUNTED ON WELLS ABOVE THE INVERT AND MODIFICATION OF THE MUCKER PROVED ECONOMICALLY SUCCESSFUL AND SPEEDY. THE FORT UNION MATERIAL TURNED OUT FAVORABLY, DUE TO ITS LACK OF SWELLING OR SQUEEZING PROPERTIES. ONLY A MINIMUM OF GROUTING WAS NEEDED, DUE TO THE CONCRETE LINING'S FILLING CAPACITY. THE MECHANICAL INSTRUMENTATION PERFORMED BETTER THAN THE ELECTRICAL. THE WHITTEMORE STRAIN GAGES, THE EXTENSOMETER TAPES, AND THE CARLSON STRAIN METERS OPERATED SATISFACTORILY. THE SR-4 GAGE INSTALLATION WAS UNSATISFACTORY. THE TEMPERATURE CHANGES WERE GREATER THAN ANTICIPATED, WITH MORE ATTENTION AND INVESTIGATION NEEDED.

32-58-00001 FURTHER PROGRESS IN THE SCIENTIFIC APPROACH TO STRATA CONTROL (LOAD-CELLS STRESSMETERS)
POTTS, E. L. J. & KING'S COLLEGE DURHAM ENG
TRANSACTIONS INSTITUTE OF MINING ENGINEERS, (117) 203-219, 1957-58. SINCE 1956 WHEN THE ORIGINAL PAPER "A SCIENTIFIC APPROACH TO STRATA CONTROL" WAS PRESENTED TECHNIQUES THEN DESCRIBED HAVE BEEN ADVANCED AND DEVELOPMENT OF INSTRUMENTS HAS CONTINUED. NEW TECHNIQUES AND INSTRUMENTS ASSIST IN UNDERGROUND MEASUREMENTS AND EXPERIMENTAL RESEARCH BUT ONLY EXPERIENCE GAINED OVER MANY YEARS CAN ENABLE ONE TO FORECAST AND IMPROVE BAD STRATA CONDITIONS. DEVELOPMENTS MADE IN PROP LOAD CELLS, ROOF BOLT LOAD CELLS, STRESSMETERS TO INVESTIGATE LOAD DISTRIBUTION IN ADVANCE OF COAL FACE, AND HARD ROCK STRESSMETERS ARE DESCRIBED. EXAMPLES OF SUPPORT LOADS AT MOTHER GATE AND TAIL GATE OF THE FACE AND ROOF BOLT LOADS ARE GIVEN. APPLICATION OF SONIC METHOD UNDERGROUND HAS BEEN FURTHER DEVELOPED AS WELL AS ULTRASONIC ROCK SAMPLE TESTING. INSTRUMENTATION APPLICATIONS SHOULD INCREASE AND RESEARCH COORDINATION SHOULD RESULT IN BETTER UNDERSTANDING OF STRATA PRESSURE MOVEMENT AND CONTROL.

32-59-07001 BENTONITE GROUTING IN SHAFTS AND TUNNELS - EXPERIENCES IN HUNGARY (GROUTING GROUND-CONTROL SUPPORT-MATERIALS
SAROSI, L. + FITZEK, A. & CIVIL ENGRS BUDAPEST
PROC OF THE SYMP ON SHAFT SINKING AND TUNNELING, 201-214, JULY, 1959 (THE INSTITUTION OF MINING ENGINEERS, 1960). EMPHASIS IS PLACED ON THE EXCLUSION OF GROUND WATER BY GROUTING. THE SUCCESS OF BENTONITE GROUTING IS COMPARED WITH THAT OF CEMENT AND BITUMEN GROUTING. THE TECHNIQUE OF BENTONITE GROUTING CONSISTS OF PRELIMINARY SURVEYS, EDGE WATER ANALYSIS, AND TRIAL GROUTINGS. ACTUAL GROUTING IS THROUGH INJECTION PIPES AT PRESSURES RELATIVE TO WALL STABILITY, ROCK STRUCTURE, GEOLOGICAL CONDITIONS, HYDROSTATIC PRESSURE AND COMPOSITION OF OF GROUTING MATERIAL. EXAMPLES OF SHAFT AND TUNNEL GROUTING ARE GIVEN, INCLUDING A BRIEF SUMMARY OF BENTONITE GROUTING IN HUNGARY.

32-59-07002 THEORETICAL INVESTIGATIONS INTO THE ROCK FREEZING PROCESS (GROUND-SUPPORT-METHODS)
MANKOVSKY, G. I. & MINING INST ACAD OF SCI USSR
PROC OF THE SYMP ON SHAFT SINKING AND TUNNELING, 439-456, JULY, 1959 (THE INSTITUTION OF MINING ENGINEERS, 1960). INVESTIGATIONS BY THE MINING INSTITUTE OF THE ACADEMY OF SCIENCES OF THE U.S.S.R. ON ROCK-FREEZING METHODS HAVE MADE IT POSSIBLE TO PROPOSE MORE ACCURATE METHODS OF CALCULATING AND SPEEDING UP THE FREEZING PROCESS UNDER VARIOUS CONDITIONS. THREE MAIN PROBLEMS ARE THE METHODS: OF CALCULATING TEMP. FIELDS IN ROCK FREEZING; OF ACCELERATING ROCK FREEZING AT GREAT DEPTHS; AND ROCK FREEZING UNDER FILTRATION FLOW CONDITIONS. DESCRIPTIONS ARE GIVEN OF THE HYDRAULIC MODELS USED DURING THE INVESTIGATIONS, AND EQUATIONS ARE SHOWN FOR THE VARIOUS TESTS AND OPERATIONS.

32-59-07003 CONSTRUCTION BY FREEZING OF A NEW 50-METRE LENGTH OF TUBBING WHILE MAINTAINING NORMAL WINDING OF 3000 TONS PER DAY (SHAFT-SINKING GROUND-SUPPORT-METHODS)
VENDER, J. & INST NATL IND CHARBONNIERE
PROC OF THE SYMP ON SHAFT SINKING AND TUNNELING, 457-467, JULY, 1959 (THE INSTITUTION OF MINING ENGINEERS, 1960). IN ANDRE DUMONT COLLIERY IN CAMPINE, BELGIUM, A CAST-IRON TUBBING (SHAFT LINING) 6 M IN DIA. AND 543 M IN HT. WAS DAMAGED BY GROUND MOVEMENTS CAUSED BY EXPLOITATION. LARGE INFLUXES OF WATER WERE PRODUCED BETWEEN DEPTHS OF 25-55 M. UP TO 65 M WAS RE-FROZEN AND A REINFORCED CONCRETE CYLINDER, 1.20 M THICK, WAS ADDED BY SUCCESSIVE RINGS TO THE TUBBING'S EXTERIOR. THIS WORK WAS DONE ENTIRELY OUTSIDE THE SHAFT WITHOUT INTERRUPTING NORMAL EXTRACTION.

32-61-02001 THEORY AND PRACTICE OF ROCK BOLTING (SUPPORT BOLT-SPACING TORQUE ANCHORAGE)
LANG, T. A. & BECHTEL CORP
TRANSACTIONS AMERICAN INSTITUTE OF MINING ENGINEERS, (220) 333-348, FEB 1961. FOR PERMANENT STRUCTURES UNDERGROUND, WHERE ROCK IS NOT COMPETENT, SUPPORT USUALLY IS CONCRETE OR REINFORCED CONCRETE. TEMPORARY SUPPORT IS OFTEN NEEDED AND THIS CAN BE TIMBER, STEEL AND DURING THE PAST 50 YEARS ROCK BOLTS. ILLUSTRATIONS AND DETAILED STUDIES OF FIELD ROCK BOLTING AND THE BEHAVIOR OF ROCK ARE DISCUSSED. MATHEMATICAL FORMULAE FOR ROCK BOLT APPLICATIONS, ANALYSIS OF VARIOUS ROCK BOLTING OPERATIONS AND DESCRIPTIONS OF BOLTS ARE GIVEN.

32-64-10001 DEVELOPMENT OF A ROCK BOLT SYSTEM FOR PERMANENT SUPPORT AT NORAD (PATTERN SLOT-WEDGE-BOLTS GROUT GRANITE PULL-TEST STATIC-STRESS)
UNDERWOOD, L. B. + DISTEFANO, C. J. & U.S. ARMY CORPS OF ENGR
UNIV MO AT ROLLA PROC OF THE SIXTH SYMP ON ROCK MECHANICS, 43-86, OCT 1964. THE NORAD PROJECT UNDERGROUND COMBAT

OPERATIONS CENTER COLO SPRINGS COLO IS DESCRIBED BRIEFLY AND THE GEOLOGICAL FEATURES ARE DISCUSSED IN DETAIL. THE DEVELOPMENT OF REQUIREMENTS FOR AND TECHNIQUES OF BLASTING TO PRODUCE SOUND UNDAMAGED ROCK SURROUNDING THE EXCAVATION ARE DESCRIBED. ONLY METHODS THAT INSURE DEVELOMENT OF A SHEAR PLANE BETWEEN PERIPHERY HOLES TO MINIMIZE STRAIN AND DEVELOPMENT OF CRACKS IN THE ROCK BEYOND THE BLASTING PERIPHERY WERE ACCEPTABLE. THE BLASTING WORK IS DESCRIBED WHEREBY NEARLY 450,000 YARDS OF GRANITE WERE EXCAVATED IN AN 18 MONTH PERIOD ON SCHEDULE WITHOUT A SINGLE FATALITY. EXTENSIVE STUDIES WERE MADE OF SUPPORT SYSTEMS, ROCK BOLTING WAS SELECTED AND BOLTING PATTERNS AND PROCEDURES WORKED OUT USING UNGROUTED SLOT-WEDGE BOLTS. THE CARE USED AND DIFFICULTIES ENCOUNTERED ARE RELATED. PULL TESTS WERE PERFORMED TO DETERMINE ANCHORAGE STRENGTHS. IT WAS FOUND THAT IN BAD ROCK UNGROUTED SLOTTED BOLTS NEEDED TO BE SUPPLEMENTED BY GROUTED ROCK BOLTS. QUALITY CONTROL PULL TESTS ON SLOTTED BOLTS ARE DESCRIBED WHERE ONE IN EVERY 200 INSTALLED BOLTS WERE TESTED DURING A 6 MONTH PERIOD. AS A RESULT OF THESE TEST THAT INCLUDED A COMPARATIVE HOLE SIZE TESTS, MORE RAPID CONTROLS FOR INSTALLING SLOT AND WEDGE TYPE BOLTS WERE ESTABLISHED. A SERIES OF GROUTED BOLT TESTS DETERMINED THAT ANCHORAGE STRENGTH OF SLOT AND WEDGE TYPE BOLTS COULD BE SATISFACTORILY UPGRADED AND RESULTED IN THE DECISION TO GROUT ALL THE SLOT AND WEDGE BOLTS WITHIN THE CHAMBER AREAS. TROUBLES DEVELOPED AT CORNERS OF CHAMBER AND CORRIDOR INTERSECTIONS. USE OF HIGH STRENGTH BOLTS, AND MEASURES TAKEN TO REINFORCE THESE CORNERS ARE DESCRIBED IN DETAIL. THE PAPER DESCRIBES THE DETERMINATION OF STATIC STRESSES IN THE INSTALLATION AND OFFERS CONCLUSIONS DERIVED FROM EXPERIENCE GAINED DURING PROGRESS OF THIS ROCK EXCAVATION PROJECT.

32-64-10002 CHEMICAL GROUTING AT NORAD (FRACTURED-GRANITE FAULTED-ROCK EPOXY-RESIN ROCK-BOLT-HOLES JOINT SHEAR-PLANE BOND)
ERICKSON, H. B. & U.S. ARMY CORPS OF ENGR
UNIV MO ROLLA PROC OF THE SIXTH SYMP ON ROCK MECHANICS, 87-108, OCT 1964. THIS PAPER PRESENTS RESULTS OF LABORATORY TESTS AND DESCRIPTION OF FIELD INJECTION OF CHEMICAL GROUT IN FRACTURED GRANITE AT THE NORAD UNDERGROUND COMBAT OPERATIONS CENTER NEAR COLO SPRINGS, COLO, BY THE OMAHA DISTRICT OF THE U.S. ARMY CORPS OF ENGRS. CHEMICAL GROUT WAS INJECTED TO STABILIZE AND STRENGTHEN AREAS OF FAULTED ROCK WHERE MOVEMENT WAS OCCURRING IN CORNERS OF CHAMBER INTERSECTIONS AND TO STRENGTHEN THE ROCK TO RESIST POSSIBLE FUTURE DYNAMIC LOADING. A SPECIALLY FORMULATED STRESS-RELIEVED EPOXY RESIN WAS USED. RELATIVELY SIMPLE EQUIPMENT WAS DEVISED FOR INJECTION INTO GROUT HOLES AND ROCK BOLT HOLES. MOVEMENT GAGES INSTALLED IN ONE AREA INDICATED THAT ROCK MOVEMENT STOPPED AFTER INJECTION OF THE EPOXY RESIN. OTHER OBSERVATIONS ALSO INDICATED THAT THE AREAS WERE BENEFICIATED BY GROUTING. THE GROUTING WAS PERFORMED IN TWO PHASES. THE FIRST PHASE WORK CONSISTED OF INJECTING GROUT IN ONE CORNER OF A CHAMBER INTERSECTION. IN THE SECOND PHASE ADDITIONAL GROUT WAS INJECTED INTO THE FIRST CORNER AND INTO AN ADJOINING CORNER OF THE SAME CHAMBER INTERSECTION AND THE WALL ADJACENT TO THIS CORNER. PHYSICAL DATA FOR THE EPOXY RESIN IS GIVEN AND PHOTOGRAPHS OF EQUIPMENT USED ARE SHOWN.

32-64-10003 FAILURE OF ROCK IN THE TRIAXIAL SHEAR TEST
SCHWARTZ, A. E.
UNIV MO ROLLA PROC OF THE SIXTH SYMP ON ROCK MECHANICS, 98-108, OCT 1964. AN INVESTIGATION WAS MADE TO STUDY ROCK FAILURE PHENOMENA AS IT OCCURS IN HIGH PRESSURE TRIAXIAL SHEAR TESTS. MORE THAN 160 TESTS WERE CONDUCTED, EMPLOYING LATERAL PRESSURES OF ZERO TO 10,000 PSI AND INDEPENDENTLY CONTROLLED PORE PRESSURES OF ZERO TO 5,000 PSI. CORE SAMPLES OF INDIANA LIMESTONE, GEORGIA MARBLE, STONE MOUNTAIN GRANITE, AND POTTSVILLE SANDSTONE WERE TESTED. THE FAILURE SURFACES WERE EXAMINED USING PHOTOMICROGRAPHS. IT WAS CONLUDED FROM THIS STUDY THAT CONFINING PRESSURES INFLUENCE FAILURE MODE, THE ANGLE OF SLIP IS CLOSELY PREDICTED BY THE MOHR CRITERION, AND AN ADDITIONAL PARAMETER, "FRACTURE INTERFERENCE", MAY BE INCLUDED IN THE SHEAR STRENGTH EQUATION.

32-64-10004 EVALUATION OF A BLASTING TECHNIQUE FOR DESTRESSING GROUND SUBJECT TO ROCKBURSTING (CUT-AND-FILL-STAGE CLOSURE-STATIONS PHOTOELASTIC-STRAIN-GAGES DRIFTS STRESS-ZONES DRILLING BOREHOLES STRAIN-ANALYSIS CLOSURE-MEASUREMENTS)
MORUZI, G. A. + PASIKA, A. R. & FALCONBRIDGE MINE
UNIV MO AT ROLLA PROC OF THE SIXTH SYMP ON ROCK MECHANICS, 185-204, OCT 1964. BLASTING AS A DESTRESSING TECHNIQUE WAS APPLIED TO THE HANGING WALL OF A CUT AND FILL STOPE. A TROUBLESOME STOPE AREA AT FALCONBRIDGE MINE WAS CHOSEN AS A TEST SITE TO EVALUATE THE DESTRESSING TECHNIQUE FOR SUBSEQUENT APPLICATION TO BURSTING AREAS WHICH MIGHT DEVELOP AS ORE EXTRACTION PROGRESSES TO GREATER DEPTHS. WHERE STOPE CROWN OR LEVEL PILLARS ARE ENCLOSED ON ONE OR BOTH WALLS BY HIGHLY SILICIFIED AND EXTREMELY BRITTLE ROCKS, THE EXTRACTION OF THESE PILLARS RESULTS IN CONDITIONS PRODUCING ROCKBURSTS. IN ORDER TO ESTIMATE THE EFFECTIVENESS OF BLASTING, FRACTURE AND PHOTOELASTIC STRAIN ANALYSES WERE CONDUCTED ON CORE SAMPLES TAKEN FROM BLAST HOLES AND SIMILAR INSPECTION HOLES DRILLED AFTER THE BLASTING. USING CLOSURE STATIONS AND PHOTOELASTIC STRAIN GAUGES, OBSERVATIONS WERE ALSO MADE ON THE EFFECTS OF THE ROCKBURSTS THEMSELVES. PHOTOGRAPHS, SKETCHES, DIAGRAMS, AND CURVES PRESENT DATA OBTAINED IN THE TESTS. AFTER THOROUGH ANALYSIS OF ALL DATA, IT IS DOUBTFUL THAT THE BLASTS HAD ANY MARKED DESTRESSING EFFECT ON THE ROCK, BUT CONCEIVABLY, COULD HAVE PREVENTED STRESS BUILD UP RESULTING IN BURSTS OF GREATER VIOLENCE THAN EXPERIENCED. ALSO, IT IS POSSIBLE THAT INSUFFICIENT HOLES AND BLAST SHOCK WERE APPLIED TO DESTRESS THE TEST ZONE. THE TESTS GIVE SOME INDICATIONS OF THE NATURE OR VIOLENCE OF ROCK FAILURE THAT CAN BE EXPECTED IN SITU AND THE MEASUREMENTS MAY BE MOST USEFUL IN YIELDING DATA ON DYNAMIC BEHAVIOR OF GROUND.

32-64-10005 COMBATTING WEIGHT PROBLEMS AT CLIMAX (PANEL-CAVING CUTOFF ORE-BODY EXTENSOMETER-MEASUREMENTS HAULAGE-DRIFT FAULT TIMBER-SETS YIELDABLE-STEEL-ARCH-SETS)
JULIN, D. F. & CLIMAX MOLYBDENUM CO CLIMAX COLO
UNIV MO AT ROLLA PROC OF THE SIXTH SYMP ON ROCK MECHANICS, 205-217, OCT 1964. SINCE 1924 APPROXIMATELY 170 MILLION TONS OF ORE HAS BEEN REMOVED FROM THE CLIMAX MINE. PRIOR TO 1959, DAMAGING WEIGHT WAS NOT A SERIOUS PROBLEM. STARTING IN 1959 AND CONTINUING TO THE PRESENT WEIGHT HAS BECOME A MAJOR PROBLEM, CRUSHING SLUSHER DRIFTS, BLOCKING HAULAGE DRIFTS AND HAMPERING PRODUCTION. THIS PAPER DESCRIBES CONDITIONS THAT CONTRIBUTE TO THE WEIGHT PROBLEM, METHODS OF MONITORING, CONTROL, AND REPAIR, AND PLANS FUTURE MINING TO AVOID REPETITION OF DAMAGING WEIGHT. THE PHILLIPSON LEVEL MINE LAYOUT IS USED TO ILLUSTRATE THE PROBLEM AND THE MINING METHOD OF PANEL CAVING IS DESCRIBED ALONG WITH GEOLOGICAL CONDITIONS AFFECTING THE WORKINGS. MEASURE POINTS WERE ESTABLISHED IN THE SLUSHER DRIFTS AND DEFLECTION OF THE ROOF WAS MEASURED BY USE OF EXTENSOMETERS TO MONITOR THE EFFECTS OF THE WEIGHT PROBLEM. READINGS WERE TAKEN AT A FREQUENCY RELATED TO RATE OF DEFLECTION AND MEASUREMENTS WERE PLOTTED ON A CONTOUR MAP SHOWING AREAS OF THE GREATEST DEFLECTION. BY COMPARING MONTHLY MAPS, THE CHANGE IN DEFLECTION COULD BE FOLLOWED. THE CENTER OF THE WEIGHT SEEMED TO FALL ABOUT 70 FT AHEAD OF THE CAVE LINE INTO THE UNCAVED ORE. THE WEIGHT WAS CONTROLLABLE IN SOME AREAS BY DRAWING ORE FROM CRITICAL AREAS. IN OTHERS TIMBER SETS WERE USED TO MAINTAIN HAULAGE DRIFTS AS WELL AS BEING CONCRETE LINED, BUT OFTEN WERE OVERCOME BY EXCESSIVE WEIGHT. TO MAINTAIN THESE IN ADDITION TO CONCRETE LININGS POINTS, YIELDABLE STEEL ARCH SETS WERE INSTALLLED WHICH PROVED TO BE THE BEST SOLUTION. THE PAPER ALSO OUTLINES PLANS FOR FUTURE MINING AT A DEPTH 300 FT BELOW THE PRESENT ONE, THAT AVOIDS TRANSFERENCE OF WEIGHT TO PRODUCTION AREAS.

32-64-10006 THEORY AND MODEL OF UNDERGROUND OPENING AND SUPPORT SYSTEM (TRIAXIAL-PROPERTIES MOHR-ANALYSIS STRESS-FIELD CONTINUUM-MECHANICS TRANSITION-TEST)
SERATA, S. & MICH STATE UNIV
UNIV MO AT ROLLA PROC OF THE SIXTH SYMP ON ROCK MECHANICS, 260-292, OCT 1964. THERE IS NO SATISFACTORY METHOD OF DETERMINING THE TRIAXIAL PROPERTIES OF ROCKS IN THEIR FULL SCOPE, INCLUDING ELASTICITY, VISCOELASTICITY, VISCOPLASTICITY, BRITTLENESS, AND STRAIN-HARDENING. FOR THIS PAPER THE TRIAXIAL PROPERTIES OF ROCKS AND THE UNDERGROUND STRESS FIELD WERE STUDIED IN ORDER TO ESTABLISH A THEORETICAL BASIS FOR MATHEMATICAL ANALYSIS OF THE UNDERGROUND STRUCTURES. THE CONCEPT OF CONTINUUM MECHANICS WAS APPLIED SUCCESSFULLY. ROCK SALT OF UNIFORM QUALITY WAS USED AS A MODEL MATERIAL TO VERIFY THE THEORIES OF CONTINUUM MECHANICS. USING ROCK SALT AS A MODEL ROCK, THE ELASTIC AND TIME-DEPENDENT PROPERTIES WERE EXAMINED AND PROVEN TO AGREE WITH THE MATHEMATICAL THEORY. A TRANSITIONAL TEST METHOD WAS DEVELOPED FOR THIS STUDY TO DETERMINE THE SIX BASIC MATERIAL COEFFICIENTS OF A CONTINUUM OF THE ROCK. ALTHOUGH ROCK SALT WAS USED EXCLUSIVELY FOR THE DEVELOPMENT OF THE MECHANICAL MODEL, THE MODEL SHOULD BE APPLICABLE TO

ROCKS IN GENERAL. THE ONLY DIFFERENCE AMONG VARIOUS ROCKS WOULD BE THEIR MAGNITUDES AND RELATIVE PROPORTIONS OF THE SIX BASIC COEFFICIENTS. BASED ON THE MECHANICAL MODEL OF THE ROCK, THE PRINCIPLES OF UNDERGROUND STRESS FIELD WERE FORMULATED AND A MODEL TECHNIQUE FOR STUDYING IN UNDERGROUND OPENING AND SUPPORT SYSTEM WAS DEVELOPED. THE AUTHOR OFFERS VARIOUS CONCLUSIONS DERIVED FROM THE THEORY DEVELOPED AND MODEL TESTS. PHOTOGRAPHS OF THE VARIOUS MODELS AND TEST EQUIPMENT ARE SHOWN, THE THEORY IS DISCUSSED BY USE OF DIAGRAMS AND SKETCHES. FORMULATION IS GIVEN AND DATA IS PRESENTED USING CURVES DEVELOPED IN THE TESTS.

32-64-10007 MECHANISM OF LOAD LOSS IN ROOF BOLTS (BLEED-OFF GROUND-CONTROL ANCHORAGE LOAD-TIME-CHARACTERISTICS DYNAMIC-TEST STATIC-TEST EXPANSION-SHELL SERRATIONS ROCK-STRESS CREEP)
STAFANKO, R. + DELLA CRUZ, R. V. & PENN STATE UNIV
UNIV MO AT ROLLA PROC OF THE SIXTH SYMP ON ROCK MECHANICS, 293-309, OCT 1964. LABORATORY TESTS OF ROCK BOLTING WERE CONDUCTED AT PA STATE UNIV. THE MECHANICS AND OBJECTIVES OF ROCK BOLTING FOR GROUND CONTROL ARE DISCUSSED AND THE TYPES OF TESTING TO DETERMINE EFFECTIVENESS OF THE BOLTING ARE DEFINED. A DYNAMIC TEST (PULL TEST) IS DEFINED AS AN ANCHORAGE CAPACITY TEST, WHEREAS THE STATIC TEST IS AN ANCHORAGE EFFICIENCY TEST TO DETERMINE THE LOAD-TIME CHARACTERISTIC CURVE OF AN INSTALLED BOLT UNDER LONG TERM CONDITIONS. TWO EARLIER STATIC UNDERGROUND STUDIES REVEALED THE TIME-DEPENDENT BEHAVIOR OF ANCHORAGE WHICH LED TO THE CAREFULLY CONTROLLED RESEARCH REPORTED IN THIS PAPER. IN ORDER TO APPLY THE NUMEROUS FINDINGS OF INDENTATION RESEARCH, SOME MODIFICATIONS AND ASSUMPTIONS ARE CALLED FOR BY THE SPECIAL FEATURES OF THE PENETRATIONS OF ANCHOR SHELL SERRATIONS. UTILIZING THESE, EXPRESSIONS RELATING THE RELEVANT VARIABLES WITH THE INDUCED STRESSES AND CORRESPONDING DISPLACEMENTS AT THE ANCHORAGE SITE WERE OBTAINED FOR THREE DIFFERENT ANCHOR SHELLS. THE ANCHORS TESTED INCLUDED A SMOOTH SHELL, A SHELL WITH FLAT SURFACE OF SERRATIONS FACING THE LINE OF PULL AND A SHELL WITH THE SLOPING SURFACE ANGLED TO THE LINE OF PULL. THE LATTER TYPE PROVED SUPERIOR TO THE OTHERS IN THE TEST AND POINT THE WAY TOWARDS FURTHER RESEARCH. CURVES ARE PRESENTED TO SHOW VARIATION IN BOLT LOAD WITH TIME, AXIAL AND TRANSVERSE DISPLACEMENTS WITH VARYING LOADS, AND VARIATIONS IN LOADING WITH TIME AT SELECTED INITIAL LOADS, FOR THE THREE SHELLS. A DISCUSSION IS PRESENTED OF AN ASSUMED MULTIFRACTURING PROCESS ACCOMPANYING BOLT LOADING AND CONCLUSIONS DRAWN AS A RESULT OF THE TESTS PERFORMED.

32-64-10008 A SONIC UNIT FOR THE DETERMINATION OF IN-SITU DYNAMIC PROPERTIES AND FOR OUTLINING OF FRACTURE ZONES (ABSORPTION ATTENUATION SONIC-VELOCITY TRANSIT-TIME DISCONTINUITIES ROCK BOREHOLES MINES STOPE-PILLARS)
LAROCQUE, G. E. & CANADA DEPT MINES OTTAWA CANADA
UNIV MO AT ROLLA PROC OF THE SIXTH SYMP ON ROCK MECHANICS, 358-380, OCT 1969. AUXILIARY METHODS FOR ASSESSING THE MECHANICAL STATE OF A ROCK MASS AND THE UNIFORMITY OF ITS ELASTIC PROPERTIES INDEPENDENTLY OF STRESS MEASUREMENTS WERE THE OBJECTIVE OF THE RESEARCH REPORTED IN THIS PAPER. SONIC PROBING IS PROPOSED AS AN INEXPENSIVE MEANS OF MAKING SUCH ASSESSMENTS. WHEN SONIC PROBING IS CONTEMPLATED FOR FIELD USE, ONLY TWO TYPES OF MEASUREMENTS ARE AVAILABLE: ENERGY ABSORPTION AND TRANSIT TIME. IN THE ENERGY ABSORPTION TYPE A STUDY IS MADE OF THE ATTENUATION OF SONIC WAVES IN THE ROCK MASS AS A FUNCTION OF TIME AND POSITION; INCREASES IN ATTENUATION ARE ASSOCIATED WITH DETERIORATION IN THE COMPETENCY OF THE ROCK MASS. THE DEVELOPMENT OF CRACKS AND DISCONTINUITIES ALSO AFFECTS THE VELOCITY OF PROPAGATION OF SONIC WAVES, I.E., TRANSIT TIME. A SONIC SYSTEM IS DESCRIBED WHICH WAS DEVELOPED FOR PROBING THE ROCK AROUND MINE OPENINGS. TRANSIT TIME MEASUREMENTS OF A FEW HUNDRED MICROSECONDS TO MANY MILLISECONDS CAN BE MADE WITH AN ACCURACY OF 5 PERCENT WITH THIS SYSTEM. THE SONIC TEST EQUIPMENT IS RELATIVELY PORTABLE AND OPERATES ON ITS OWN POWER SUPPLY, ALLOWING ITS USE IN REMOTE MINING LOCATIONS. A HAMMER BLOW IS USED AS THE SIGNAL SOURCE. TRANSIT TIME MEASUREMENTS ARE MADE BETWEEN BORE HOLES IN WHICH HYDRAULICALLY WEDGED TRANSMITTING AND RECEIVING UNITS HAVE BEEN INSERTED. SURFACE UNITS WERE ALSO DEVELOPED AND TESTED. THE ASSUMPTIONS ON WHICH SONIC TRANSIT VELOCITY IS RELATED TO FRACTURE ZONES ARE STATED AND CURVES ILLUSTRATE THE RESULTANT TEST DATA. POSSIBLE APPLICATIONS OF SUCH MEASUREMENTS ARE OUTLINED AND FIELD MEASUREMENTS ARE PRESENTED TO SUBSTANTIATE STATEMENTS THAT ARE MADE.

32-65-05001 UNLINED TUNNELS OF THE SOUTHERN CALIFORNIA EDISON COMPANY (LININGS)
WOWTON, F. S.
AM. SOC. CIVIL ENGRG., PROC. (91 PO 1 NO. 43130) 130, 131, MAY 1965. DISCUSSION OF PAPER BY SPENCER, ET AL. PROC. PAPER 4087, OCT. 1964. IMPLICATIONS ARE THAT PRESSURE LINING MAY NOT BE REQUIRED WHERE THE HEIGHT OF OVERHEAD COVER IS GREATER THAN 75 PERCENT OF THE STATIC HEAD. THE ADVANTAGES OF AN UNLINED TUNNEL AS COMPARED TO A CONCRETE LINED TUNNEL ARE REALISTIC.

32-65-05002 CONTRACTOR'S VIEW ON UNLINED TUNNELS - DISCUSSION (JOINTS ROCK-BOLTS STEEL-RIB OVERBURDEN ROCK-QUALITY)
LAWTON, F. L. + MORRIS, J. W. & ALUMINIUM LTD
PROC A.S.C.E. JOURNAL OF THE POWER DIVISION POI, 128-129, MAY 1965. THE AUTHOR CORRECTLY EMPHASIZED CONTROLLING PARAMETERS, AND MADE VALUABLE OBSERVATIONS ON UNLINED TUNNELS. HOWEVER, PROPER ATTENTION WAS NOT GIVEN TO THE TREATMENT THAT MUST BE ACCORDED JOINTS CONTAINING SOFT OR SOLUBLE MATERIAL WHICH CAN BE REMOVED BY FLOWING WATER UNDER FLUCTUATING PRESSURE. TUNNEL SIZE AND SHAPE, QUALITY OF ROCK AND DEPTH OF OVER-BURDEN COVER ARE INTERRELATED IN DETERMINING A TUNNEL LINING. COMPETENCY OF ROCK MAY BE DEVELOPED BY PROPER ROCK BOLTING. THE BASIS FOR THE STATEMENT OF RANGE OF DEPTHS WHERE LINING IS MOST LIKELY TO BE UNNECESSARY IS DESIRABLE. EXCESSIVE INCREASE IN TUNNEL COST OVER THAT EXPECTED IS MOST COMMONLY CAUSED BY REQUIRING STEEL RIB SUPPORTED TUNNEL SECTIONS WHERE AN UNSUPPORTED OR ROCK BOLTED SECTION WAS ANTICIPATED.

32-66-00001 MEASUREMENTS ON THE PILOT BORE FOR THE STRAIGHT CREEK TUNNEL (DESIGN SUPPORT STRAIN SAFETY CONTROL)
GROSVENOR, N. E. + ABEL, J. F., JR.
NATIONAL RESEARCH COUNCIL, HIGHWAY RESEARCH BOARD, RESEARCH RECORD, NO. 135, 27-34, 1966. THE 11 FT HIGH BY 11 FT WIDE PILOT BORE FOR THE STRAIGHT CREEK INTERSTATE HIGHWAY TUNNEL WAS INSTRUMENTED AT 44 PRIMARY AND 2 SPECIAL STATION TO OBTAIN INFORMATION FOR THE FINAL TUNNEL SUPPORT. TERRAMETRICS INC. MEASURED ROCK LOADS AND GROUND MOVEMENTS IN RELATION TO THE TUNNEL EXCAVATION, RELATIONSHIP BETWEEN LOAD IMPOSED ON STEEL SETS AND DESIGNED LOAD, ZONE OF INFLUENCE AROUND TUNNEL WHERE GROUND IS STRAINED AS RESULT OF TUNNEL EXCAVATION, STRAIN VARIATION OUTWARD FROM TUNNEL WALLS RESULTING FROM TUNNEL EXCAVATION, AND RATE OF DECREASE OF OVERALL GROUND STRAIN RATES WITH TIME AND TUNNEL FACE ADVANCE. ABILITY TO TO ACCURATELY MEASURE LOADS AND ROCK STRAINS MAKES IT POSSIBLE TO RATIONALLY DESIGN SUPPORTS TO WITHSTAND APPLIED LOADS AND ACCOMODATE ASSOCIATED STRAINS. DETERMINATION OF ROCK STRUCTURE SAFETY NEED NOT BE LEFT TO A NEBULOUS EXPERIENCE FACTOR. WHEN SUPPORT LOADS STABILIZE AND ROCK STRAINS CEASE OR BECOME NEGLIGIBLE WE THEN HAVE AN EFFECTIVELY SAFE STRUCTURE. ABILITY TO MEASURE IS MAJOR STEP TOWARD ABILITY TO CONTROL.

32-69-10001 PRINCIPLES OF SOIL-STRUCTURE INTERACTION APPLIED TO TUNNEL LININGS (STIFFNESS MODELS DISPLACEMENT ELASTICITY ARCHING)
GABRIEL, L. H. & SACRAMENTO STATE COLLEGE
SACRAMENTO STATE COLLEGE, CAL. SECOND SYMP ON RAPID EXCAVATION, 1-1 TO 1-11, OCT 16, 1969. IN SOIL-STRUCTURE ANALYSIS THE STRUCTURE IS CONSIDERED ELASTIC AND THE SOIL RESPONDS OTHER THAN ELASTIC. ABILITY TO DEFORM UNDER EXCESSIVE LOAD IS SOMETIMES BENEFICIAL AND IS ONE ADVANTAGE OF STEEL TUNNEL SUPPORTS. IF STRUCTURE'S RELATIVE STIFFNESS IS LESS THAN THAT OF THE MEDIA THEN SOIL OR ROCK SIDE ABETMENTS WILL HELP TO FORM AN ARCH, IF GREATER THEN THE STRUCTURE FORMS A PILLAR AND WILL CARRY GREATER LOADS TOWARDS THE STRUCTURE - AN EFFECT THAT MIGHT BE UNDESIRABLE. LOADING EXPERIMENTS ON PLASTER CYLINDERS 9 IN O.D. 1/4 IN WALL AND 21 IN LONG SURROUNDED BY 0, 1/2, 1 AND 2 INCHES OF POLYFOAM RUBBER SHOWED MEASURABLE BENEFIT TO RESISTING APPLIED LOAD IF A COLLAR OR SLEEVE MATERIAL EXISTED. THERE APPEARS TO BE EXCITING POTENTIAL IN SUCH CONSTRUCTION. EFFECTS OF DESIGN INPUT SHOULD BE DETERMINED AFTER CONSTRUCTION. FOR THIS THE MEASUREMENT OF INTERIOR DISPLACEMENT IS A SUFFICIENT MEASURE FOR ARTICULATION OF DISPLACEMENT LOADS.

32-69-10002 RATIONAL DESIGN OF TUNNEL SUPPORTS (MODELS COMPUTERS COST ROCK-STRESS LABORATORY-TESTS EXCAVATION-METHODS)
DAEMEN, J. J. K. + FAIRHURST, C. & STARFIELD, A. M. & UNIV MINN MINNEAPOLIS MINN

SACRAMENTO STATE COLLEGE, CAL SECOND SYMP ON RAPID EXCAVATION, 2-1 TO 2-23, OCT 16, 1969. TUNNEL SUPPORTS CAN NOT BE RATIONALLY DESIGNED WITHOUT CONSIDERATION OF SUPPORT-ROCK INTERACTION. LOADS IMPOSED ON A SUPPORT ARE STRONGLY INFLUENCED BY SUPPORT DEFORMABILITY, AMOUNT OF ROCK DEFORMATION ALLOWED BEFORE SUPPORT INSTALLATION, GEOSTATIC STRESS FIELD AND ROCK MASS MECHANICAL PROPERTIES. HIGH SPEED COMPUTERS HAVE FACILITATED NUMERICAL METHODS ANALYSES SO THAT REALISTIC TUNNEL SUPPORT DESIGN IS NO LONGER RESTRICTED BY MATHEMATICAL COMPLEXITY. LACK OF INFORMATION ON ROCK MASS PROPERTIES, AS INFLUENCED BY TUNNEL EXCAVATION METHODS IS THE MAJOR OBSTACLE TO RATIONAL DESIGN PROCEDURES. ROCK BEHAVIOR CAN BE OBTAINED FROM LABORATORY STUDIES AND NUMERICAL EXPERIMENTS BUT A FULLER UNDERSTANDING REQUIRES, IN CONJUNCTION WITH THESE STUDIES, INTERPRETATION OF FIELD DATA. HAVING TO SPECIFY A SUBSTANTIAL PART OF SUPPORT DESIGN IN ADVANCE OF EXCAVATION IMPOSES LIMITS ON DESIGN PRECISION. MANY DESIGN METHODS USE QUITE UNREALISTIC MODELS OF ROCK FAILURE. SUBSTANTIAL SAVINGS IN TUNNEL COSTS SHOULD BE POSSIBLE, PARTICULARLY AS DETAILS OF ROCK MASS DEFORMATION BEHAVIOR ARE CLARIFIED.

32-70-00001 TUNNEL SUPPORTS AND LININGS - A REVIEW (ROCK-BOLTS SHOTCRETE STEEL-SETS)
MATHEWS, A. A. & AA MATHEWS INC ARCADIA CAL
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 23. THE DESIGN OF SUPPORTS SHOULD BE AN INTEGRAL PART OF TUNNEL DESIGN. NEW METHODS OF TUNNEL CONSTRUCTION ALLOW MORE OF A CHOICE IN SUPPORT DESIGN. HANDLING OF SUPPORTS MUST BE A PRIMARY DESIGN FEATURE OF THE BORING MACHINES.

32-70-00002 RECENT TUNNELING EXPERIENCE IN EUROPE (SHOTCRETE AUSTRIAN-METHOD ITALY)
ANGERER, K. & UNIV H AND T AKTIENGESELLSCHAFT
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 24. SPRAYING OF CONCRETE (NOT GROUT) ON ROCK SOON AFTER BLASTING WAS FOUND TO PREVENT ROCK BURSTS. BASED ON THIS FACT, "THE AUSTRIAN TUNNELING METHOD", NOW USUALLY CALLED "SHOTCRETE" WAS DEVELOPED IN 1950 AND IS BEING USED IN MANY EUROPEAN COUNTRIES. THE METHOD HAS BEEN IMPROVED AND IS NOW USED ON PRACTICALLY ALL UNDERGROUND OPENING BUILT IN AUSTRIA. HARDENING ACCELERATORS GIVE QUICKEN STRENGTH AND ALLOW USE IN WET TUNNELS. AGGREGATE UP TO 25 MM DIAMETER CAN BE USED. AN HISTORICAL REVIEW OF THE USE IN SPECIFIC TUNNELS IS GIVEN FOLLOWED BY AN EXPLANATION OF THE PRINCIPLES OF THE METHOD WITH A DISCUSSION OF THE IMPORTANT EFFECTS OF THE METHOD.

32-70-00003 THE FUNCTION OF SHOTCRETE IN SUPPORT AND LINING OF THE VANCONVER RAILWAY TUNNEL (COST CANADA INSTRUMENTATION)
MASON, E. E. & DOLMAGE MASON AND STEWART LTD
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RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 25. THIS IS THE FIRST AMERICAN JOB TO USE COARSE-AGGREGATE (+ 1/2 INCH) SHOTCRETE TECHNIQUE FOR PRIMARY SUPPORT AND LINING. THE ESTIMATE FOR CONVENTIONAL STEEL SUPPORT AND CONCRETE LINING FOR THE 29 X 20 FT 10,760 FT LONG TUNNEL WAS $400/LIN FT. SHOTCRETE SUPPORT OF 6 INCHES ON ARCH 4 INCHES ON WALLS WAS STABLE AND COST ONLY $100/LIN FT. SHOTCRETE WAS APPLIED TO THE ARCH FROM A FLYING DECK WHICH WAS EXTENDED OVER THE MUCK PILE FROM THE JUMBO. DESIGN PRINCIPLES, INSTRUMENTATION USED AND METHOD OF APPLICATION ARE GIVEN.

32-70-00004 FREEZING TECHNIQUES FOR SHAFT SUPPORT
BRAITHWAITE, T. R. & CEMENTATION CO. OF CAN. LTD
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 27. FREEZING METHOD FOR SINKING SHAFTS THROUGH UNSTABLE WATERBEARING FORMATIONS CAN OBTAIN AVERAGE RATES OF 140 FT/MO. METHOD IS DISCRIBED. A COLOR FILM SHOWING FREEZING TECHNIQUES IS AVAILABLE FROM AUTHORS COMPANY.

FIELD 33 GOVERNMENT REPORTS

33-68-10001 DESIGN OF TUNNEL LINERS AND SUPPORT SYSTEMS (EXCAVATION TRANSPORTATION UNDERGROUND ROCK SOILS STRESS

STRAIN ELASTIC PLASTIC GEOLOGICAL-CLASSIFICATION)
DEERE, D. U. & UNIV ILLINOIS &
UNIVERSITY OF ILLINOIS, INTERIM REPORT, (125 PAGES) UNDER CONTRACT NO. 3-0152 FOR OFFICE OF HIGH SPEED GROUND TRANSPORATION, U. S. DEPARTMENT OF TRANSPORTATION, OCT 1968. ON THE BASIS OF AN ESTIMATED EXPENDITURE OF $70 MILLION ON EXCAVATION OF UNDERGROUND FACILITIES AND ALSO THAT TUNNEL LINING WILL ACCOUNT FOR 30 TO 40 PERCENT OF TUNNEL COSTS, THE REPORT PROPOSES THAT EVEN MINOR IMPROVEMENTS IN DESIGN AND CONSTRUCTION CAN RESULT IN LARGE SAVINGS. TUNNEL LININGS ARE AT PRESENT DESIGNED PRIMARILY BY SIMPLIFIED EMPIRICAL METHODS. THIS REPORT PROPOSES NEW TUNNEL LINING DESIGN METHODS BASED ON A UNION OF THEORETICAL CONSIDERATION AND EMPIRICAL KNOWLEDGE GAINED FROM FIELD OBSERVATIONS WITH WHICH IMPROVED AND MORE ECONOMICAL TUNNEL LINING CAN BE DEVELOPED. THE REPORT CONSIDERS THE FUNDAMENTAL CONCEPTS OF TUNNEL BEHAVIOR AND THE EFFECTS OF THE CONSTRUCTION PROCESS ON THE TIME-DEPENDED EQUILIBRIUM CONDITIONS OF THE TUNNEL MEDIUM. EXISTING THEORIES AND PRACTICES OF TUNNEL LINING ARE REVIEWED. A GENERAL CLASSIFICATION SYSTEM FOR GEOLOGIC MATERIALS IS PRESENTED. A GENERAL RELATION IS DRAWN BETWEEN GEOLOGIC MATERIALS, PROBLEMS AND BEHAVIOR OF TUNNELS IN THOSE MATERIALS, AND THE GENERAL DESIGN APPROACH (SOIL-MECHANICS, ROCK-MECHANIC, AND CONTINUUM MECHANICS) TO BE USED. THE BEHAVIOR OF INDIVIDUAL LINED AND UNLINED TUNNELS IS CONSIDERED. FIELD OBSERVATIONS OF DEFORMATIONS AND STRESSES IN SPECIFIC TUNNELS ARE EXAMINED AND EVALUATED. RECOMMENDATIONS ARE GIVEN FOR IMPROVED TUNNEL LINING DESIGN PROCEDURES AND CONSTRUCTION TECHNIQUES WHICH ALSO INCLUDE INNOVATIONS IN TECHNIQUES AND MATERIALS.

33-69-02001 DESIGN OF TUNNEL LINERS AND SUPPORT SYSTEMS (STRESS STRAIN BLASTING BORING)
DERRE, D. U. + MONSCES, J. E. + PECK, R. B. & SCHMIDT, B. & UNIV ILLINOIS
FINAL REPORT FOR OFFICE OF HIGH SPEED GROUND TRANSPORTATION, FEB 1969. THIS INCLUDES WORK FROM THE EXPLORATORY STAGE TO THE TUNNELS COMPLETION. TUNNEL LINER AND SUPPORT SYSTEM DESIGN DEPENDS TO A LARGE EXTENT ON THE GEOLOGY THROUGH WHICH THE TUNNEL PASSES AND THE METHOD OF TUNNELING. LINING COSTS MAY RANGE FROM 10 TO 20 PERCENT OF THE TOTAL COST FOR MACHINED TUNNELS IN COMPETENT ROCK TO MORE THAN 50 PERCENT FOR BLASTED TUNNELS IN POOR ROCK. ALL TUNNELS ARE IN STRATA WHICH WAS STATICALLY OR DYNAMICALLY IN BALANCE BEFORE DRILLING. TO MAINTAIN THIS EQUILIBRIUM THE CALCULATED SUPPORT SHOULD BE INSTALLED AS QUICKLY AS POSSIBLE. HOWEVER, THE SUPPORT MECHANISM SHOULD BE SUCH THAT THE MATERIAL AROUND THE TUNNEL WILL DEVELOP ITS GREATEST STRENGTH. STRUCTURE AT TUNNEL LEVEL CAN BE DETERMINED BY FIELD MAPPING, AIR PHOTOS, PREVIOUS AREA EXPERIENCE AND EXPLORATORY BORING. RECOMMENDED BORING SPACINGS FOR VARIOUS TUNNEL DEPTHS ARE GIVEN. WITH THIS INFORMATION TUNNEL STABILITY CAN BE ANALYZED AND PRELIMINARY DESIGN INITIATED. APPENDIX III GIVES A THOROUGH ANALYSIS OF STRESS DISTRIBUTION AND DEFORMATION AROUND CIRCULAR UNDERGROUND OPENINGS. TUNNEL STRUCTURE CAN BE COMPUTERIZED AND FOR VARIOUS CONDITIONS THE STRESSES AND STRAINS OBTAINED. ILL UNIV HAS DEVELOPED A ROCK QUALITY DETERMINATION (RQD) WHICH IS LISTED WITH TUNNEL SIZE TO GIVE SUPPORT REQUIREMENTS. RQD HAS ALSO BEEN CORRELATED WITH "ROCK LOADS AND CLASSIFICATIONS", "UNIFIED CLASSIFICATION OF GEOLOGIC MATERIALS", "CORRELATION OF JOINT-SPACING CLASSIFICATION", "RELATIONSHIP BETWEEN TERZAGHI'S BEHAVIORISTIC CLASSIFICATION AND THE PRIMARY CLASSIFICATION INCLUDING THE EFFECT OF THE HYDRAULIC CONDITIONS" AND "SUPPORT RECOMMENDATIONS FOR TUNNELS IN ROCK" TO AID IN TUNNEL SUPPORT EVALUATION. TUNNELING BY BORING IS STILL DEVELOPMENTAL. BORING IS FASTER AND DOES NOT DISTURB THE FORMATION AS MUCH AS ORDINARY BLASTING BUT HAD THE DISADVANTAGES OF LARGE INITIAL EQUIPMENT COST, ELAPSED TIME FOR BORING EQUIPMENT DELIVERY AND THE EQUIPMENT INTERFERENCE WITH CONSTRUCTING TUNNEL SUPPORTS SUCH AS SHOTCRETE OR ROCK BOLTS. BLASTING TECHNIQUES HAVE BEEN IMPROVED BY SMOOTHWALL PERIMETER BLASTING AND MICROSECOND DELAY BLAST DETONATION BUT AS YET THESE HAVE NOT BEEN PROPERLY EVALUATED. ROCK BEHAVES NEITHER AS AN ELASTIC NOR AS AN ELASTIC-PLASTIC MATERIAL BUT LARGELY AS AN ERRATIC AND UNPREDICTABLE DISCONTINUUM. PROBLEMS ARE GENERALLY INTANGIBLE AND DESIGN DEPENDS ON THE ACCURACY OF ESTIMATES AND THE COST OF REPAIRING OCCASIONAL LOCAL FAILURES. BY COMBINING THEORETICAL AND EMPIRICAL KNOWLEDGE MORE ECONOMICAL TUNNEL LININGS CAN BE DEVELOPED. STRUCTURAL REASONS MAY REQUIRE VARIOUS SUPPORT SYSTEMS BUT THAT USED MAY BE TO ACHIEVE UNIFORM CONSTRUCTION PROCEDURE OR WORKER PSYCHOLOGICAL WELL-BEING. WHEN SUPPORT FAILURES DO OCCUR THEY GENERALLY APPEAR AS GRADUAL YIELDING OR BUCKLING WHICH PROVIDES TIME FOR CORRECTIVE MEASURES. UNFORTUNATELY CORRECTIVE MEASURES ARE USUALLY TAKEN WITHOUT ANY EFFORT BEING MADE TO PRESENT THE CASE HISTORY. 166 REFS.

33-69-09001 STRUCTURAL DESIGN DATA FOR UNREINFORCED CONCRETE TUNNEL LININGS
DIXON, J. D. & U.S. BUR MINES DENVER
U.S. BUR. MINES - REPORT INVESTIGATIONS 7297, 43, SEPT. 1969. STRUCTURAL DESIGN DATA FOR UNREINFORCED CONCRETE TUNNEL LINERS. THREE BASIC SHAPES ARE USED - CIRCULAR, RECTANGULAR AND HORSESHOE WITH DIMENSIONS DEVELOPED AS STANDARD BY MINING INDUSTRY. THE DIRECT STIFFNESS MATRIX METHOD WAS USED TO MAKE THE ANALYSIS. A COMPUTER WAS USED TO DEVELOP THE STRESS AND DEFLECTION COEFFICIENTS.

FIELD 34 ARTICLES

34-37-07001 MODERN TUNNEL-LINING METHODS (RAILROAD-TUNNELS CONCRETE-LINING PNEUMATIC-PLACED-CONCRETE)
MAYO, R. S.
COMPRESSED AIR MAGAZINE, (42) 5376-5378, JULY 1937. DEVELOPMENT OF CONCRETE LINING METHODS HAS CHANGED THE PATTERN OF TUNNEL LININGS. MOST EARLY TUNNELS WERE UNLINED BECAUSE BRICK AND STONE MASONRY WAS SO EXPENSIVE. NOW TUNNELS ARE LINED WITH CONCRETE AS A GENERAL PRACTICE. THE PNEUMATIC CONCRETE GUN HAS REPLACED HAND PLACING. USE OF TELESCOPING FORMS AND LOCAL MIXERS HAS INCREASED THE SPEED OF PLACEMENT TO ABOUT 200 FT/DAY. WITH MODERN MACHINERY A CONCRETE GANG CAN LINE BETWEEN 4,000 AND 5,000 FT OF TUNNEL IN A MONTH.

34-44-11001 STRESSES IN THE LINING OF SHIELD-DRIVEN TUNNELS (PRESSURE-DISTRIBUTION STEEL)
BULL, A. & BOARD OF TRANS N.Y.
AM SOC OF CIVIL ENGRS, (70) 1363-1394, NOV. 1944. IN DESIGNING LINING OF SHIELD-DRIVEN TUNNELS, THE ERRONEOUS ASSUMPTION IS CURRENTLY MADE THAT VERTICAL SOIL REACTIONS ARE UNIFORMLY DISTRIBUTED OVER THE HORIZONTAL DIAM OF THE LINING. "ACTIVE" PRESSURES, THOSE OF THE SURROUNDING GROUND, AND RESULTING "PASSIVE" PRESSURES EXIST; THESE VARY FROM POINT TO POINT. WHEN THEIR DISTRIBUTION IS DETERMINED BY RATIONAL METHODS IT IS FOUND THAT THE STRESSES ARE LOWER THAN PREVIOUSLY FOUND, PERMITTING THE CROSS SECTION TO BE REDUCED. SUCH REDUCTION, BECAUSE OF THE CONSEQUENT INCREASE IN FLEXIBILITY, FURTHER REDUCES THE STRESSES AND, THUS, AN ECONOMIC CROSS SECTION MAY BE DETERMINED. STEEL IS MORE ECONOMICAL THAN CAST IRON BECAUSE OF ITS HIGHER TENSILE STRENGTH, LIGHTER WEIGHT SEGMENTS, ABILITY TO SPAN WIDER ANGLES, SO THAT THE NUMBER OF JOINTS PER RING MAY BE REDUCED AND ERECTION FACILITATED. STEEL SEGMENTS ARE SIMPLER TO MANUFACTURE AND MAY BE JOINED BY RESISTANCE WELDING, THUS FACILITATING ERECTION AND WATERPROOFING. ONE OBJECTION TO REDUCTION OF WEIGHT OF LINING MIGHT BE THAT A LARGE CROSS SECTION IS NECESSARY FOR RESISTING PRESSURES OF SHOVING JACKS. A SOLUTION WOULD BE SCAFFOLDING OF WHICH A SUITABLE METHOD MUST BE, AND CAN BE, DEVELOPED.

34-61-03001 USE OF PRESSURE GROUTING TO STABILIZE GROUND IN THE SAN MANUEL MINES (GROUND-SUPPORT)
GOSS, J. W. + COOLBAUGH, M. J. & SAN MANUEL COPPER CO ARIZ
MINING ENGINEERING, (13) 255-261, MAR 1961. THE SAN MANUEL COPPER CORP. IS ONE OF THE FIRST MINES IN AMERICA TO USE PRESSURE GROUT EXTENSIVELY AS A GROUND STABILIZER. NEW TIMBER IS BEING REPLACED BY CONCRETE WHICH DIMINISHES THE NEED FOR REPAIR GROUTING. WITH NEW DEVELOPMENTS AND APPLICATIONS, THE EMPHASIS WILL BE SHIFTED TO GROUTING IN PREPARATION FOR EXCAVATION.

34-62-06001 EARTH PRESSURE ON MULTIPLE TUNNELS (EARTH-MECHANICS GROUND-STRESS)
COATES, D. F. + MCRORIE, E. L. & STEEP ROCK IRON MINES LTD
CANADIAN NATIONAL RESEARCH COUNCIL--ASSOCIATED COMMITTEE ON SOIL AND SNOW MECHANICS SOC., (5) 115-137, JUNE 1962. YIELDING ARCH SETS WERE INSTALLED IN THREE PARALLEL TUNNELS WHICH WERE DRIVEN 650 FT. BELOW THE GROUND SURFACE. LOAD CELLS WERE INSTALLED UNDER THE LEGS OF THE SETS AND IN THE GROUND ADJACENT TO THE SETS. DEFORMATION READINGS OF SETS WERE OBSERVED. RESULTS OF LABORATORY AND FIELD TESTS ARE REPORTED. EMPIRICAL DATA INDICATING THE MAGNITUDE OF THE LOADS ARE PRESENTED. DATA IS ANALYZED TO DETERMINE ACTUAL EARTH PRESSURES. VERTICAL PRESSURE WAS ABOUT THE SAME AS THE WEIGHT OF FROM 4.0 FT. TO 7.8 FT. OF BROKEN MATERIAL.

34-63-08001 GROUTED ROCK BOLTS FOR PERMANENT SUPPORT OF MAJOR UNDERGROUND WORKS (DEFORMED-BARS HOLLOW-CORE-BARS EPOXY COST BOND)
PENDER, E. B. + HOSKING, A. D. + MATTNER, R. H. & SNOWY MTN HYDRO-ELECTRIC AUTH
THE INSTITUTION OF ENGINEERS, AUSTRALIA, (35) 129-150, JULY-AUG 1963. ROCK BOLTS HAVE BEEN USED IN MINING FOR CONSIDERABLE TIME BUT HAVE BEEN APPLIED TO CIVIL ENGINEERING UNDERGROUND WORK ONLY SINCE 1950. THE AUTHORITY'S FIRST MAJOR USE OF ROCK BOLTS WAS IN 1956. USUALLY 1 INCH DIAMETER 8 FEET LONG BOLTS ARE PLACED IN 1-5/8 INCH DIAMETER HOLES. DEFORMED HOLLOW CORE BARS ARE USED FOR ALL GROUTED BARS. PROPERTIES OF VARIOUS BARS ARE GIVEN AND THE RESULTS OF PULL OUT TESTS ON PLAIN, EPOXY RESIN COATED, SAND EPOXY COATED, DEFORMED HOLLOW CORE AND CONTINUOUSLY THREADED BARS ARE GIVEN. SAND EPOXY COATED BARS HAD HIGHEST BOND STRENGTH BUT NOT SUFFICIENTLY BETTER THAN DEFORMED BARS TO WARRANT THE GREATER EPOXY PROCESS COST. HOLLOW CORE BARS PERMIT DEAERATION WHILE INJECTION GROUTING. ROCK BOLT SEALING METHODS, GROUT FORMULATIONS AND GROUTING PROCEDURES ARE DISCUSSED. THE THEORY OF ROCK BOLT SUPPORT, ROCK BEHAVIOR AND ADVANTAGES OF ROCK BOLTS ARE GIVEN. NORMAL ROCK BOLTING ALLOWED TWICE THE ADVANCE RATE OBTAINED WHEN USING LIGHT STEEL SETS.

34-64-01001 USE OF RESINS IN MINE ROOF SUPPORT (CEMENT CURING CORROSION PULL-TESTS)
MCLEAN, D. C. & AMERICAN CYANAMID CO
MINING ENGINEERING, 36-40, JAN. 1967. THE USE OF RESIN IN CONJUNCTION WITH ROOF BOLTS MAKES THE PERMANENT BOLT ANCHORAGE KNOWN. TO REDUCE THE COST NEW INJECTION TECHNIQUES WERE DEVELOPED. THE PRESENT COST FOR A 7/8-IN RE-BAR IN A 6-FT HOLE IS A MAXIMUM OF $4.50. RESIN CAN BE USED IN WET AND DRY CONDITIONS; IT HAS A MAXIMUM TENSILE STRENGTH OF 8000 PSI, COMPRESSIVE STRENGTH UP TO 20,000 PSI.

34-64-03001 HOW TO FORM SMALL-TUNNEL LININGS ECONOMICALLY (CONCRETE-LINING PNEUMATIC-CONCRETE)
DOWIE, J. G. & DELEUW CATHER AND CO
ENGINEERING AND CONTRACT RECORD, 57-60, MAR 1964. A SPECIALLY DEVELOPED SHOP MANUFACTURED HINGED STEEL FORM IS AN ECONOMICAL MEANS OF FORMING 6 FT. TO 15 FT. DIAMETER TUNNEL LININGS. IT IS DESIGNED FOR LIMITED SPACE, EASY ERECTION AND STRIPPING. BUILT IN 10 FT. SECTIONS, IT COMES IN TWO SECTIONS WHICH BOLT TOGETHER FOR A FULL CIRCLE. IN SUCH SMALL DIAMETER TUNNELS CONCRETE MUST BE PLACED PNEUMATICALLY AND VIBRATED THOROUGHLY. SPECIAL PROBLEMS HAVE BEEN SOLVED SO THAT THE METHOD IS QUITE VERSATILE.

34-64-03002 SOME INVESTIGATIONS INTO THE TENSIONAL BEHAVIOR AND INFLUENCE OF BOLTING REINFORCEMENTS IN MINE ROADWAYS (SUPPORTS GROUND-CONTROL ROOF-BOLTS)
PEARSON, G. M. + SMITH, R. J. & UNIV NEWCASTLE UPON TYNE
MINING ENGINEERING, 688-703, MAR 11, 1964. A SUMMARY OF FOUR YEARS OF STUDY OF BOLTING REINFORCEMENT IN THE NORTHERN COALFIELDS (ENGLAND) AND IN THE STRATA CONTROL RESEARCH LAB AT KINGS COLLEGE, UNIVERSITY OF NEWCASTLE UPON TYNE. A SUMMARY OF THE GENERAL PRINCIPLES OF BOLT REINFORCEMENT AND THE ROLE OF BOLT ANCHORAGE AND INITIAL TENSION.

34-64-04001 PREFABRICATED SECTIONS USED IN CONSTRUCTION OF WEBSTER STREET TUNNEL (SUBAQUEOUS-TUNNELS)
SALTER, R. J.
CIVIL ENGINEERING AND PUBLIC WORKS REVIEW, 453-4, APR 1964. WEBSTER STREET TUNNEL BETWEEN OAKLAND AND ALAMEDA, CALIF. TOOK 3 1/2 YRS AND $17 MILLION TO BUILD. THE PORTALS WILL CONTAIN ALL VENTILATING AND ELECTRICAL EQUIPMENT. A CAST IN PLACE SECTION OF 783 FT. WAS BUILT UNDER THE SHORE AND 12 PERCENT SEGMENTS OF 200 FT. EACH WERE SUNK WITH A DREDGED TRENCH. THE SEGMENTS HAVE AN OD OF 37 FT. AND A WALL THICKNESS OF 2 1/2 FT. THE ROADWAY IS 24 FT. WIDE WITH A VERTICAL CLEARANCE OF 15 FT. AND HAS A 3 FT. WIDE FOOTPATH FOR PEDESTRIANS. THE VOID BENEATH THE ROAD SUPPLIES FRESH AIR AND THE SPACE ABOVE THE ROOF EXHAUSTS THE AIR. METHODS OF CONSTRUCTION AND PLACING AND THE VARIOUS DIFFICULTIES ENCOUNTERED ARE DESCRIBED.

34-64-06001 MODERN METHODS OF LINING TUNNELS (SUPPORTS)
HASWELL, C. K. & CONSULTING ENGRS
CIVIL ENGINEERING TUNNELS FEATURE, 893-899, JUNE 1965. IN CERTAIN ROCKS NO LINING IS REQUIRED. AS CONCRETE IS KNOWN TO INCREASE IN VOLUME UNDER WATER THIS USE OF WATER STOPS HAS GENERALLY BEEN ABANDONED. THIS STOPS THE PROBLEM OF PROPER COMPACTION OF CONCRETE AT WATER STOPS. WHEN THE ROCK IS GOOD, ALL THAT IS NEEDED IS A FACING TO A TUNNEL. CONCRETE CAN BE SPRAYED ON BY USE OF AN ALIVAGUN. SPEEDS OF UP TO 18 CU. YD. OF CONCRETE PER HOUR MAY BE ACHIEVED USING SOME 500 CU. FT. OF COMPRESSED AIR PER MINUTE. THE CIRCULAR SHIELD OF CAST IRON IS USED FOR SOFT GROUND. CONCRETE IS USED TODAY IN LINING. THE LENGTH OF SEGMENT IS USUALLY 2 FEET AS COMPARED WITH 1 FOOT 8 IN. FOR CAST IRON. FLEXIBLE LININGS ARE BEING USED MADE UP WITH PLAIN-PRECAST CONCRETE SEGMENTS. A SECONDARY TUNNEL LINING HAS THE FUNCTION OF REDUCING HYDRAULIC LOSSES OR DEALING WITH GROUND- WATER PERCOLATION. IF THE LINING IS NOT IMPERMEABLE AND WATER SEEPAGE HAS TO BE DEALT WITH EFFECTIVELY EITHER A WATER PROOF MEMBRANE SHOULD BE INSTALLED AT THE EXTRADOS OF THE TUNNEL OR A SECONDARY LINING WITH AN AIR GAP SHOULD BE USED.

34-64-10001 RECENT DEVELOPMENTS IN ROOF BOLTING AND ROOF BOLT INSTALLATION PROCEDURE (ROOF-STUDS SUPPORTS)
THIEL, P. S. & F L BATEMAN LTD JOHANNESBURG
CANADIAN MINING AND METALLURGICAL BULLETIN, (57) 1050-1062, OCT 1964. ROOF BOLTS AND STUDS ANCHOR ROCK TO PREVENT COLLAPSE. CORRECT INSTALLATION PROCEDURE IS IMPORTANT. TWENTY-FIVE PERCENT OF ALL PROPERLY INSTALLED BOLTS HAVE LATER BEEN FOUND TO BE LOOSE OR INEFFECTIVE. FACTORS CAUSING LOSS OF TENSION (1) FRICTION (2) OVERSIZE HOLES (3) RIFLING OF HOLE SIDES (4) SHOCK WAVES. ROOF STUDS ARE MORE USEFUL THAN ROOF BOLTS BECAUSE (1) THREADED ON BOTH ENDS (2) TORSIONAL EFFECTS ARE REDUCED.

34-64-11001 THE NEW AUSTRIAN TUNNELING METHOD, PART I (LININGS SPRAYED-CONCRETE ROCK-BOLTS SHOT-CRETE)
RABCEWICZ, L. V.
WATER POWER, 453-457, NOV 1964. AFTER DESCRIBING THE INFLUENCE OF ROCK PRESSURE EFFECTS ON TUNNEL LININGS, THE AUTHOR UNDERLINES THE INADEQUACY OF CONVENTIONAL TUNNEL DRIVING AND LINING METHODS IN POOR GROUND AND EXPLAINS THE EFFECTIVENESS AND RELIABILITY OF A NEW METHOD CONSISTING OF A THIN SPRAYED CONCRETE LINING CLOSED AT THE EARLIEST MOMENT BY AN INVERT TO A COMPLETE RING (AUXILIARY ARCH). SEE 34-64-12003 AND 34-65-010001 FOR REST OF ARTICLE.

34-64-12001 FLOW SLIDES PROVE HAZARDOUS IN COLOMBIA TUNNELS (SUPPORTS LININGS WATER-TUNNELS)
LI, C. Y.
CIVIL ENGINEERING, 51-53, DEC 1964. FLOW SLIDES WERE EXPERIENCED REPEATEDLY IN DRIVING THE EARTH SECTIONS OF TENCHE TUNNEL AND THE DIVERSION TUNNEL FOR MIRAFLORA DAM. CAUSES OF THE FLOWS AND REMEDIAL ACTION TO CONTROL FLOWS ARE DETAILED.

34-64-12002 USE OF RESINS IN MINE ROOF SUPPORT (GROUTING RE-BARS ROCK-CONSOLIDATION)
MCLEAN, D. C. + MCKAY, S. A. & PENN UNIV
AM. INST. MIN. METAL. & PETROLEUM ENGR. TRANS., (229) 384-385, DEC. 1964. GROUTED ROOF BOLTS PRESERVE THE ORIGINAL ROCK WHICH IS THE BEST AND CHEAPEST MATERIAL FOR GROUND SUPPORT. RESIN PROVIDES MANY ROCK CONSOLIDATION TECHNIQUES PREVIOUSLY UNAVAILABLE. STEEL RE-BARS (7/8 DIAM X 6 FT) WERE FULLY GROUTED ON 24- TO 30-IN. CENTERS AND FILLED WITH 60 CU. IN. OF RESIN. FORTY-EIGHT HOURS LATER POST TENSION BOLTS SUPPORTED MAXIMUM OF 400 FT-LBS TORQUE (CREIGHTON NO. 3 OPERATIONS). THE APPLICATIONS DESCRIBED ARE THOSE IN WHICH CYANAMID'> ROC LOC MINING KITS WERE USED EXCLUSIVELY.

34-64-12003 THE NEW AUSTRIAN TUNNELING METHOD PART II (LININGS SPRAYED-CONCRETE ROCK BOLTS SHOTCRETE)
RABCEWICZ, L. V.
WATER POWER, 511-515, DEC 1964. SEVERAL ACTUAL TUNNELS USING THE SHOTCRETE METHOD ARE DESCRIBED. SEE ALSO 34-64-11001 AND 34-65-01001.

34-65-01001 THE NEW AUSTRIAN TUNNELING METHOD PART III (LININGS SPRAYED-CONCRETE ROCK-BOLTS SHOT-CRETE)
RABCEWICZ, L. V.
WATER POWER, 19-24, JAN 1965. DEFORMATION MEASUREMENTS MUST BE MADE TO DETERMINE THE THICKNESS OF LINING NEEDED. SHOT CRETE MUST FOLLOW THE DRIVING PROCESS VERY CLOSELY TO OBTAIN MAXIMUM BENEFIT. THE WORSE THE ROCK THE GREATER THE SAVINGS POTENTIAL. AN EXAMPLE IS GIVEN OF A TUNNEL CONSTRUCTION WHICH WAS RESCUED BY USE OF OF SHOTCRETE. SEE ALSO 34-64-1101 AND 34-64-12003.

34-65-03001 JOINT DESIGN OF REINFORCED CONCRETE TUBING IN TUNNEL CONSTRUCTION (CURING LEAKING LOAD-CARRYING EPOXY-RESIN HEAT-CURING TUNNEL-LINERS)
KRABBE, W. & HAMBURG
DIE BAUTECHNIK, 79-86, MAR 1965. UNDERWATER TUNNEL LININGS MUST BE WATERTIGHT AND SUPPORT THE ADVANCING SHIELD. THE HIGH DELIVERY COST OF THE CONVENTIONAL CAST IRON LINERS HAS MADE PRECAST REINFORCED CONCRETE ECONOMICALLY ATTRACTIVE. HOWEVER ONLY FOR LOW-PRESSURE JOINTS WHERE SOFT WOOD, LEAD, BITUMINOUS ASBESTOS CEMENT PLATES, BITUMINOUS FELT AND RAPID SETTING PLASTIC RESIN MORTAR HAVE PROVED SATISFACTORY HAVE JOINTS BEEN MADE SATISFACTORILY. A LARGE NUMBER OF POSSIBLE JOINT MATERIALS HAVE BEEN INVESTIGATED WITH THE FOLLOWING CONCLUSIONS: EPOXY MORTAR GIVES SURFACE FORCE TRANSMISSION AND TEMPORARY SEALING AND ITS CURING TIME CAN BE ACCELERATED BY HEATING. JOINTS LEAKING WITH EPOXY MORTAR SEAL CAN BE CAULKED TIGHT WITH AN EXPANDING CEMENT AND ASBESTOS FIBER IN AN INNER GROOVE, AND BOTH SEALED WITH A GROMMET AGAINST A STEEL PLATE CEMENTED TO THE CONCRETE. A NEW METHOD OF SEALING WITH PREFINISHED RESIN SEALER PLATES WHICH ARE ELECTRICALLY HEATED IN THE JOINTS PROMISES TO BE EVEN BETTER. (IN GERMAN)

34-65-11001 POTOMAC INTERCEPTOR SERVER TUNNELS AND RIVER CROSSING CONSTRUCTION (CONCRETE PIPE)
MCGANN, J. H.
AMERICAN CONCRETE INSTITUTE JOURNAL, (162) 1363-1373, 1797-1799, NOV 1965. CONSTRUCTION FEATURES OF THE 3000 FT. RIVER CROSSING OF A SEWER LINE BUILT OF 78 INCH PRECAST CONCRETE PIPE AND THE 14,000 AND 9000 FT. TUNNELS AT EITHER END ARE DESCRIBED. PUMPING OF THE CAST-IN-PLACE TUNNEL LININGS IS ALSO DESCRIBED.

34-66-01001 NOTE ON ELASTIC STRESS IN TUNNEL LININGS
JORDAN, D. W.
J. STRAIN ANALYSIS, (1) N 3, 110-14, JAN. 1966. DESIGNING TUNNEL LINING WHICH UNDER SPECIFIC CONDITIONS HAS LEAST TENDENCY TO GO INTO TENSION. IT IS SHOWN THAT IDEALIZED CIRCULAR LINING INCREASE IN RIGIDITY IS NOT ASSOCIATED WITH INCREASE IN TENSILE STRENGTH, FLEXIBILITY CAN BE ACHIEVED BY SLIDING FIT OF LINING TO ROCK RATHER THAN BY CLOSE KEYING LAMINATING, OR LOWERING YOUNG'S MODULUS. LOAD ON LINING IS DEDUCED FROM MEASUREMENTS OF CIRCUMFERENTIAL STRAIN UNDER ASSUMPTION THAT LINING BEHAVES LIKE BENDING BEAM.

34-66-05001 LINING OF THE MCCLOUD-PIT TUNNELS (SUPPORTS CONCRETE)
BRODERSON, G. E. + FLINT, W. K. & PACIFIC GAS AND ELECTRIC CO
AMERICAN CONCRETE INSTITUTE JOURNAL, 543-551, MAY 1966. THE MCCLOUD PIT TUNNELS ARE 14 FEET IN DIA. THE INVERT SECTION OF THE LINING WAS PLACED FIRST THEN THE ARCH. A 2500 PSI COMPRESSIVE STRENGTH TEST WITH 80 PERCENT REQUIRED TO PASS. FINISH STEENS AGGREGATES PRODUCED 15 PERCENT GREATER STRENGTHS. THE MIXER'S EFFICIENCY WAS LESSENED IN PROPORTION TO BLADE AND LINING WEAR. THE CONCRETE WAS DELIVERED BY RAIL IN ROTATABLE CYLINDRICAL CARS. THE CONCRETE WAS TRANSPORTED TO A CONVEYOR BELT BY ROTATING THE TRANSPORTERS. CONCRETE FOR THE INVERT WAS LAID WITH A 2 TO 3 IN SLUMP. THE ARCH CONCRETE WAS TRANSPORTED THE SAME WAY BUT THE CONCRETE WAS PLACED WITH A CONCRETE GUN (90 PSI AIR PRESSURE). THE CONCRETE WAS PLACED WITH A 5-IN SLUMP. FORMS FOR THE ARCH WERE ASSEMBLED IN 24 FEET SECTIONS MOUNTED ON RAIL TRUCKS. THE USE OF FIELD EQUIPMENT AND FIELD MATERIALS FOR ON-THE JOB TRIAL MIXING WAS FOUND TO BE PRACTICAL.

34-66-08001 WHAT YOU SHOULD KNOW ABOUT TUNNELING TECHNIQUES (LINING UTILIDOR)
WHITE, T. L. + TORADOSH, S. + VAUPEL, K. H.
PUBLIC WORKS, 105-106, AUG. 1966. THE THREE GENERAL TYPES OF TUNNEL ARE - CONSTRUCTION-SOFT EARTH, ROCK, AND A COMBINATION OF ROCK AND SOIL CALLED MIXED FACE CONNECTED WITH LININGS.

34-66-09001 THE CASE FOR STEEL-ARCH SUPPORTS (LININGS)
CHLUMERBY, N. + ELLIS, L. N. & SHEARING AND STAMPING CO
COAL AGE, 71-74, SEPT. 1966. STEEL ARCH TYPE SUPPORTS PROVIDE PERMANENT PROTECTION WITH MINIMUM MAINTENANCE, KEEPING OVER ALL COST TO A MINIMUM. RIGID ARCHES ARE DESIGNED TO SUPPORT A GIVEN LOAD WITHOUT YIELDING. BASIC TYPES OF ARCHES 1) THE CONTINUOUS RIB, 2) THE RIB AND POST, 3) INVERT-STRUT-TYPE. COLD WORKING GIVES ARCHES ULTIMATE STRENGTH OF 60,000 TO 72,000 PSI. LINER PLATES CAN BE MADE WATERPROOF BY GROUTING. THE ABILITY OF THE LINER PLATE ARCH DEPENDS ON CROSS-SECTIONAL AREA AND THE JOINT THE PLATE MAKES WITH ADJACENT PLATES TO TRANSMIT THRUST. THE YIELDABLE ARCH IS DISTRIBUTED SO THAT MAXIMUM STRENGTH DEVELOPS FROM THE SECTION AROUND BOTH NEUTRAL AXES. YIELDABLE ARCHES ADVANTAGES ARE 1) GREATER LOAD CARRYING CAPACITY, 2) THE JOINTS YIELD BEFORE THE STEEL 3) ARCHES CAN BE USED AGAIN 4) ALMOST MAINTENANCE-FREE INSTALLATION.

34-66-10001 THE CONSTRUCTION OF SEWERS IN TUNNEL AND HEADING THE PRACTICAL PROBLEMS (GROUND CONDITIONS ECONOMIC LININGS)
HUMPHRIES C. F. & COUNTY BOROUGH IPSWICH ENG
INSTITUTION OF MUNICIPAL ENG., (93) 333-7, OCT. 1966. TUNNELS ARE BEING EXPLORED FOR SEWAGE DISPOSAL TO AVOID TRAFFIC CONGESTION AND INCONVENIENCE TO THE GENERAL PUBLIC. TUNNELS CAN BE DRIVEN IN BAD GROUND BY USING SHIELDS, PUMPED WELLS, COMPRESSED AIR AND CHEMICAL INJECTION PROCESSES. ADEQUATE GROUND CONDITIONS SHOULD BE KNOWN BEFORE TUNNELS BEGIN. STANDARD PENETRATION TESTS GIVE AN INDICATION OF THE RELATIVE FIRMNESS. THE HIGHER THE PENETRATION TEST THE GREATER SHOULD BE THE RATE OF PROGRESS. STANDPIPES SHOULD BE INSERTED IN BOREHOLES WHERE WATER IS ENCOUNTERED. WHERE LARGE GROUND WATER IS FOUND PERMEABILITY TEST SHOULD BE PERFORMED. DEPENDING UPON THE TYPE OF GROUND CONSIDERED AND THE CONDITION, THE DRIVING METHODS AND CHOICE OF CONSTRUCTION CAN BE MADE. THERE ARE LIMITING FACTORS IN TUNNEL WORK, SUCH AS THE IDEAL WORKING SHAFT IS 75 FEET X 75 FEET AND THE MINIMUM IS 30 FEET X 50 FEET. A 54-INCH DIAMETER TUNNEL IS THE MINIMUM PRACTICAL TUNNEL SIZE. THE CHEAPEST HEADING IS 39-INCH DIAMETER PIPES THEY ARE THE BEST SIZE TO DRIVE USING TWO MINERS. THE TWO TYPES OF SEWER TUNNEL LINING IN SOFT GROUND ARE BOLTED PRECAST CONCRETE TYPE AND THE SMOOTH BORE INTERLOCKING PRECAST CONCRETE. IN HEADING CONSTRUCTION USE THE BOX HEADING AND ARCH RIB TYPE. TUNNEL SHIELDS INCREASE PROGRESS BY 9 FT/SHIFT.

34-66-10002 BEHAVIOR OF ELASTIC TUBES IN COHESION-FREE CONTINUUM (LINERS SAND)
SONNTAG, G.
EXPERIMENTAL MECHANICS (6) N 10, 508-10, OCT. 1966. MODEL IS MADE OF PLAIN CROSS SECTION OF TUBE (TUNNEL LINING) IN COHESION-FREE CONTINUUM (ROLLING MATERIAL, SAND); STRESS OF TUBE IS MEASURED BY PHOTOELASTICITY; THESE EXPERIMENTS START OF LARGE PROGRAM OF INVESTIGATION TO CALCULATE STRESS DEFORMATION AND BUCKLING OF ELASTIC TUBES UNDER DIFFERENT LOADING CONDITIONS IN ROLLING MATERIAL.

34-67-01001 STRUCTURAL BEHAVIOR OF PRECAST CONCRETE TUNNEL LINERS (SUPPORTS LINING BARTD)
GAMBLE, W. L. & UNIV ILLINOIS
AMERICAN INSTITUTE JOURNAL, (64) 1-11, JAN. 1967. TEST WERE CONDUCTED ON PRECAST CONCRETE SEGNENTED TUNNEL LINERS IN THE SAN FRANCISCO SUBWAY TUNNEL. TWO LINER RINGS WERE TESTED WITH LOADS APPLIED TO THE OUTER SURFACE IN 12 POINTS. THE BEHAVIOR WAS GOOD. CRITERIA REQUIRED THAT THE RINGS DEFLECT AT LEAST 1 INCH WITHOUT VISIBLE DAMAGE. TUNNELS WERE CONSTRUCTED BY USE OF A CIRCULAR TUNNELING SHIELD. THE LOADING WAS A UNIFORM ALL-AROUND EARTH PRESSURE OF 5500 LB PER SQ. FT. EACH TUNNEL WAS 16 FEET 4 IN INSIDE DIA. WITH AN O. D. OF 17 FEET 6 IN. THE CONCRETE WAS MADE WITH CRUSHED GRANITE AGGREGATE AND TYPE II CEMENT. THE SLUMP WAS LESS THAN 1 IN. THE CONCRETE WAS STEAM CURED ON A 2-DAY CYCLE. IT IS POSSIBLE TO CAST SEGMENTS TO WITHIN THE SPECIFIED TOLERANCES, AND GRINDING OF THE SEGMENT FACES IS NOT NECESSARY IF SUFFICIENT CARE IS TAKEN IN THE MANUFACTURING PROCESS.

34-67-01002 STABILITY OF CLAY AT VERTICAL OPENINGS (COMPRESSED-AIR OVERBURDEN SEWER-MAINS PIPE-PUSHING)
BROMS, B. B. + BENNERMARK, H. & SWEDISH GEOTECH INST STOCKHOLM
J. SOIL MECHANICS AND FOUNDATIONS DIV. PROC. ASCE, (93) 71-94, JAN. 1967. IN NOVEMBER 1964 AT EDSADALEN, SWEDEN, A SLIDE OCCURRED IN SOFT CLAY WHEN A 6.5 FT DIAM. HOLE WAS CUT AT THE BASE OF VERTICAL SHEET PILE WALL THAT SUPPORTED A 35-FT DEEP EXCAVATION. INVESTIGATION BEGAN. THE METHOD PROPOSED CAN ALSO BE USED TO EVALUATE THE EFFECTIVENESS OF COMPRESSED AIR TO PREVENT COHESIVE SOIL FROM FLOWING THROUGH OPENINGS. TWO SERIES OF EXPERIMENTS WERE CARRIED OUT ON BOTH UNDISTURBED AND REMOLDED CLAY SAMPLES. SEVERAL WATER AND SEWER MAINS HAVE BEEN CONSTRUCTED SUCCESSFULLY IN GOTHENBURG, SWEDEN. ONE WAS CONSTRUCTED BY PUSHING CIRCULAR CONCRETE SEGMENTS THROUGH A SOFT CLAY FOR 215 FT.

34-67-05001 SMALL TUNNELS MAKE GOOD SEWERS (SUPPORTS COST LINERS UTILITY-TUNNELS)
GARNETT, J. B. & GORE AND STORRIE LTD
WATER AND POLLUTION CONTROL, 46, 48, 49, AND 56, MAY 1967. TRUNK SEWERS IN TUNNELS AVOID DISRUPTION OF TRAFFIC, INTERRUPTION OF BUSINESS, COSTLY ROAD REPAIR. IMPRACTICAL TO USE AN OPEN CUT TRENCH BELOW 25 FEET. IN A LIGHTLY POPULATED AREA IT IS NOT ECONOMIC TO TUNNEL UNLESS DEEP INSTALLATIONS ARE NEEDED. NOISE AND UNSIGHTLINESS AFFECT SHAFT LOCATION. EXCAVATION TECHNIQUE FOR SMALL-DIAMETER TUNNEL SHAFTS IS USE OF A CONCRETE CAISSON. HYDRAULIC REQUIREMENTS HAVE SHOWN A 5 FT DIAMETER TO BE A MINIMUM. CONSTRUCTION REQUIREMENTS CAUSE THE BUILDING OF TUNNELS WITH A TURNING RADIUS OF LESS THAN 50 FT. TO BE UNECONOMIC. THREE MEN AT THE FACE, A DECK MAN AND A JOIST MAN PLUS A TRUCK DRIVER ARE REQUIRED FOR TUNNELS TO 7-FT. DIAMETER. AIR PRESSURE GOVERNS THE TIME LENGTH OF A SHIFT. AT PRESSURES EXCEEDING 15 PSI, THE TIME A CREW MAY REMAIN IN THE TUNNEL IS REDUCED SO AN ENTIRE EXTRA SHIFT IS NEEDED. SUPPORT IN SMALL-DIAMETER TUNNELS 6-FT. DIA IS A POST AND A CAP A FRAME OF 8 OR 10 IN SQUARE TIMBERS SET AT 6 FEET CENTRES. STEEL PLATES IN THE ROOF OFFER FURTHER PRECAUTION. IN WET GROUND COMPRESSED AIR IS THE MOST SUCCESSFUL. TO HELP REDUCE THE NOISE IN TUNNELS ONE USE CENTIFRUGAL COMPRESSORS WITH MUFFLED EXHAUSTS. THE GROUT IS INJECTED THROUGH A HOLE IN THE CONCRETE 5 TO 10 FEET INTERVALS.

34-67-07001 THE VACUUM-CONCRETE PROCESS AND ITS APPLICATION FOR THE CONSTRUCTION OF SEWERS (CONCRETE-LININGS)
BEYRER, R. H.
DE INGENIEUR, (79) N 30, 51-61, JULY 28, 1967. THE VACUUM-CONCRETE METHOD PERMITS EARLY REMOVAL OF FORMS, IMPROVES TIGHTNESS, REDUCED SHRINKAGE AND CREEP, AND REMOVES THE NEED TO TREAT THE CONCRETE SURFACE. THE METHOD IMPROVES THE COMPRESSIVE, TENSILE, FLEXURAL, AND WEAR STRENGTH. PROCESS IS PATENTED.

34-68-01001 SHAFT DESIGN AND HOISTING EQUIPMENT FOR A DEEP-LEVEL SOUTH AFRICAN GOLD MINE (COST VENTILATION LININGS)
MARTIN, W. & ANGLO AM CORP SO AFRICA
THE CANADIAN MINING AND METALLURGICAL BULLETIN, 26-37, JAN. 1968. A SINGLE SHAFT 33 FEET, 6 INCHES IN DIAMETER WITH A PRESTRESSED CONCRETE BRATTICE WALL DIVISION TO FORM UPCAST AND DOWNCAST AIRWAYS AND SINGLE-LIFT HOISTING FROM 7,500 FEET. THE VENTILATION REQUIREMENT IS 1.1 MILLION CUBIC FEET OF FREE AIR PER MINUTE. THE TEMPERATURE AT 7,000 FEET IS 123 DEGREES F. THEREFORE THE COST OF REFRIGERATION IS $7,000,000. THE ESTIMATED COST PER FOOT SUNK AND LINED WILL BE ABOUT $850. THE COST OF THE BRATTICE WALL AND INSTALLATION WILL BE $190 PER FOOT. THE PRESTRESSED CONCRETE SLABS HAVE TONGUE AND GROOVE TYPE JOINT WHICH IS FILLED WITH AN EPOXY MASTIC SEALING MATERIAL. THE WALL MUST BE ABLE TO WITHSTAND A WATER GAUGE OF 33 INCHES. IT HAS TO BE SIMPLE TO INSTALL AT A RATE OF ABOUT 200 FEET PER DAY.

34-68-02001 EFFECT OF JOINT RIGIDITY ON STRESSES IN LININGS FOR SHIELD TUNNELLING
KUBO, K. + YUKI, T.
JAPAN SOC. CIV. ENGRS. TRANS., (150) 27-34, FEB. 1968. INVESTIGATION OF BEHAVIOR OF RINGS USED FOR CONNECTION OF OF CAST IRON OR CONCRETE SEGMENTS OF TUNNEL LINING; SEGMENTS ARE CONNECTED BY BOLTING AND SUBJECTED TO BIAXIALLY SYMMETRICAL DISTRIBUTED LOADS. IN JAPANESE WITH ENGLISH SUMMARY.

34-68-02002 THEORY OF DESIGN FOR MULTI-HINGED SEGMENTAL RING (LINING SHIELD-DRIVEN-TUNNEL JAPAN)
YAMAMOTO, M. + ENDO, K. + FUKUI, S.
JAPAN SOC. CIV. ENGRS. TRANS., (150) 9-26, FEB. 1968. THEORY FOR DESIGNING SEGMENTAL LINING OF CIRCULAR SHIELD-DRIVEN TUNNEL IS PRESENTED. MULTI-HINGED SEGMENTAL RING WITH MORE THAN 3 HINGES IS SHOWN TO BE AN UNSTABLE STRUCTURE. IT IS SHOWN THAT WHEN RING IS UNDERGROUND, IT DEFORMS MAINLY BY LINK MOTION BETWEEN SEGMENTS, WHICH TRANSFORMS UNSTABLE STRUCTURE. UNDER EXTERNAL LOAD ACTING AS ACTIVE EARTH PRESSURE AND ITS REACTION ACTING AS PASSIVE EARTH PRESSURE REACTIONS ACTING ON SEGMENTS SURROUNDED BY SOIL MAY BE REPLACED BY STRESS OF SPRING SET AT EACH HINGE OF RING. IN JAPANESE WITH ENGLISH SUMMARY.

34-68-03001 EVALUATION OF ROCK LOADS FOR DESIGN OF STEEL SUPPORTS FOR TUNNELS
GUPTA, O. P.
INDIAN J POWER & RIVER VALLEY DEVELOPMENT, (18) N 3, 106-11, MAR 3, 1968. METHODS FOR EVALUATION OF LOADS FOR DESIGN OF SUPPORTS WITH REFERENCE TO RAMGANGA TUNNELS UNDER CONSTRUCTION IN HIMALAYAN REGION OF UTTAR PRADESH IN INDIA; K. TERZAGHI EMPIRICAL APPROACH FENNER'S THEORY, RELATIVE YIELD THEORY, ELASTIC APPROACH AND THEORY OF PROTODIAKOV USED IN SOVIET UNION FOR ROCK LOAD EVALUATION AND SUPPORT DESIGN FOR TUNNELS ARE OUTLINED; TUNNELS DESCRIBED PASS THROUGH ALTERNATE BANDS OF SANDROCKS AND CLAYSHALES LATTER COVERING ABOUT 25 PERCENT OF THEIR ENTIRE LENGTH.

34-68-04001 METHODS OF STRAIN MEASUREMENTS IN TUNNEL LINING (WARSAW-UNDERGROUND SUBWAY POLAND)
DYLAG, Z.
ARCHIWUM INZYNIERII, (14) N 4, 741-87, APRIL 1968. PAPER DEALS WITH METHODS AS APPLIED TO EXPERIMENTS ON SEGMENT OF WARSAW UNDERGROUND; CONDITIONS OF TESTS ARE DISCUSSED AND NECESSARY REQUIREMENTS ARE LISTED. FOLLOWING METHODS ARE PRESENTED; REPEATED STRAIN MEASUREMENTS BY MEANS OF MECHANICAL STRAIN GAGES, AND LOCAL UNLOADING BY MEANS OF TREPANNING AND STRAIN MEASURING WITH RESISTANCE STRAIN GAGES. 25 REFS. IN POLISH WITH ENGLISH ABSTRACT.

34-68-05001 THE FUNCTION OF SHOTCRETE IN SUPPORT AND LINING OF THE VANCOUVER R. R. TUNNEL (AGGREGATE OVER-CORING)
MASON, E. E. & DOLMAGE MASON AND STEWART LTD
TUNNEL AND SHAFT CONFERENCE, UNIV. MINN, MAY 17, 1968 (PREPRINT). THE CANADIAN NATIONAL RAILWAY SYSTEM IS COMPLETING CONSTRUCTION OF THE FIRST MAJOR NORTH AMERICAN TUNNEL TO USE COARSE AGGREGATE SHOTCRETE TECHNIQUE. WITH THE EXCEPTION OF 1400 FT IN SOIL, IT PASSES THROUGH A YOUNG SERIES OF FLAT-LYING SEDIMENTARY BEDS. FOR A CONVENTIONAL STEEL SUPPORT SYSTEM, THE COST WAS ESTIMATED AT $400 PER LINEAR FOOT. FOR SHOTCRETE SUPPORT, THE COST WAS PROJECTED AT $100 PER LINEAR FT. SHOTCRETE COMBINES THE DESIRABLE QUALITIES OF PNEUMATICALLY APPLIED MORTAR AND CONCRETE. IT ADHERES TO WET AND RUNNING WATER SURFACES AND SUPPLIES BOTH A SEAL AND SUPPORT. IT IS CHARACTERIZED BY HIGH EARLY STRENGTHS AND CAN SUSTAIN SIGNIFICANT DEFORMATION OVER MONTHS OR YEARS WITHOUT FAILURE BY CRACKING. IT CAN BE USED AS A STRUCTURAL OR NONSTRUCTURAL SUPPORT. THIS SHOTCRETE WAS CHOSEN FOR THE VANCOUVER TUNNEL FOR ITS SEAL AND SUPPORT FEATURES, MAJOR SAVINGS, AND INSTRUMENTION VALUES FOR FINAL LINING. INSTRUMENTATION CONSISTED OF SPOT CHECKS AND OVERCORING. IT WAS EVIDENT THAT THE LINING DOES NOT SUPPORT LOADS BY TRANSFERRING THEM TO TUNNEL FLOOR. THUS A FINAL LINING WAS NOT NEEDED.

34-68-06001 TUNNEL LINERS FOR BART SUBWAYS (COST)
WOLCOTT, W. W. + BIRK MYER & BECHTEL CORP SAN FRANCISCO
CIVIL ENGINEERING, (38) N. 6, 55-59, JUNE 1968. BART SYSTEM REQUIRES LININGS FOR 64,000 FT OF 18 IN DIAMETER SHIELD DRIVEN TUNNELS. WELDED STEEL PROVED TO BE CHEAPER THAN DUCTILE IRON, CAST IRON AND PRECAST CONCRETE. SEGMENTED LINERS WERE DEVELOPED CAPABLE OF WITHSTANDING THE SHIELD JACKING LOADS, GROUND WATER CONDITIONS AND THE GROUND LOAD. DEVELOPMENT OF THE DESIGN IS GIVEN. BIDS RECEIVED GAVE AVERAGE PRICE (PER 30 IN RING) OF: (1) $924 FOR FABRICATED STEEL, (2) $1130 FOR CAST IRON, AND $943 FOR PRECAST CONCRETE.

34-68-07001 ROCK MECHANICS INSTRUMENTATION IN TUNNELS
SELLERS, J. B.
WATER POWER, (20) N 7, 272-6, JULY 1968. MEASUREMENT TECHNIQUES TO PROVIDE DATA FOR DESIGN OF TUNNEL AND ITS SUPPORTS, AND TO PROVIDE DATA FOR CONTROL OF SAFETY AND ECONOMY OF TUNNEL SUPPORTS DURING EXCAVATION; MEASUREMENT OF INHERENT ROCK STRESSES, MODULUS OF DEFORMATION, AND ROCK STRENGTH AND STRENGTH OF PLANES OF WEAKNESS; FEATURES OF VARIOUS CONTROL AND MONITORING DEVICES. 17 REFS.

34-68-10001 FORMWORK FOR INSITU CONCRETE TUNNEL LININGS
GAYNER, J. F. C.
CIVIL ENGINEERING (LOND), (63) N 747, 1103-9, OCT. 1968. ARTICLE IS CONCERNED WITH FORMWORK FOR CONSTRUCTION OF LININGS AFTER TUNNELING OPERATION IS COMPLETED, WALL AND CROWN FORM AND TRAVELER AS USED ON NEWPORT BY-PASS TUNNEL IN GREAT BRITAIN, EXAMPLES OF FORMWORK DESIGN USED FOR LINING HORSESHOE AND FULLY CIRCULAR TUNNELS, AND ARRANGEMENT OF CONCRETING PLANT IN TUNNEL.

34-68-10002 ANALYSIS OF TUNNEL LINER-PACKING SYSTEMS (DYNAMIC-LOADING)
DAWKINS, W. P.
ASCE - ANNUAL & NATIONAL MEETING ON STRUCTURAL ENGINEERING PITTSBURGH, PA. PREPRINT 770, 1-24, SEPT. 30, 1968. METHOD IS PRESENTED FOR ANALYZING MINE TUNNEL LINER-PACKING SYSTEMS SUBJECTED TO TRANSIENT DYNAMIC LOADING; LUMPED PARAMETER MODEL OF CONTINUOUS SYSTEM HAS BEEN FORMULATED IN WHICH INELASTIC BEHAVIOR OF CONSTITUENTS IS PERMITTED. EQUATIONS OF MOTION FOR MODEL ARE DERIVED AND SOLVED BY BETA-METHOD OF INTEGRATION. DISPLACEMENTS AND DEFORMATIONS OF MODEL ARE DETERMINED BY SUMMATION OF PIECE-WISE "SMALL" DISPLACEMENTS. SOLUTION OBTAINED WAS TESTED FOR STABILITY AND CONVERGENCE THROUGH VARIATIONS IN SYSTEM PARAMETERS.

34-68-10003 SUBTERRANEAN SHAFT LINERS AND ROOMS (DESIGN SAFETY)
DEHART, R. C. + KIESLING, E. W. + MICHIE, J. D.
ASCE - ANNUAL AND NATIONAL MEETING ON STRUCTURAL ENGINEERING, PITTSBURGH, PA., 719, 1-19, SEPT. 30 - OCT. 4, 1968 (PREPRINT). OUTLINE OF SYSTEMS STUDIES UNDERWAY AT SOUTHWEST RESEARCH INSTITUTE, PURPOSE OF WHICH IS TO PROVIDE DESIGN PROCEDURES FOR SHAFT LINERS AND TUNNEL LINERS AND SUBTERRANEAN ROOMS THAT WILL RESULT IN MINIMUM COSTS, COMMENSURATE WITH ADEQUATE SAFETY FACTORS.

34-68-10004 SLURRY WALL CONSTRUCTION FOR BART SUBWAY STATIONS (SUPPORTS SOLDIER-PILE-TREMIC-CONCRETE)
THON, J. G. + HARLAN, R. C. & BECHTEL CORP SAN FRANCISCO
ASCE ANNUAL AND NATIONAL MEETING ON STRUCTURAL ENGR. PITTSBURGH PA. - PREPRINT 746, 1-34, OCT. 4, 1968. NEW DESIGN AND CONSTRUCTION METHODS FOR CIVIC CENTER SUBWAY STATION IN SAN FRANCISCO ARE EXPLAINED. USE OF TEMPORARY GROUND SUPPORT SYSTEM FOR PERMANENT STRUCTURAL WALL MAKES FOR BETTER SCHEDULING. THE METHOD SELECTED - SOLDIER-PILE-TREMIE-CONCRETE - PROVIDES GOOD CONTROL OF GROUND WATER.

34-68-11001 FIRST USE OF THE DOUBLE STEEL AND CONCRETE SANDWICH LINING FOR KEEPING HIGH PRESSURE WATER OUT OF A POTASH SHAFT (SHAFT-SINKING ENVIRONMENTAL-CONTROL)
STORCK, U. & ALWINSAL POTASH OF CAN LTD
CANADIAN BULLETIN INSTITUTE OF MINING AND METALLURGY, 1305-1307, NOV. 1968. SHAFT SINKING FOR EXPLOITATION OF THE DEEP POTASH BEDS IN SASKATCHEWAN INVOLVED GREAT DIFFICULTIES FROM THE VERY FIRST BECAUSE OF THE NEED TO EXCLUDE FROM THE SHAFT THE HIGH-PRESSURE WATER ENCOUNTERED IN THE OVERBURDEN. CONTROL OF THE TROUBLESOME BLAIRMORE QUICKSANDS WAS ACHIEVED RELATIVELY QUICKLY BY USE OF THE FREEZING METHOD AND BY LINING WITH CAST IRON TUBBING. THE UNSOLVED PROBLEM REMAINED, HOWEVER, OF SEALING THE WATER-BEARING DEVONIAN WHERE THE FORMATIONS HAD EXTREMELY LOW PERMEABILITY AND WERE THUS HARD TO GROUT. LONG EXPERIENCE IN GERMAN POTASH MINES HAD SHOWN THAT THE PERMANENCY OF THE WHOLE MINE WOULD BE SERIOUSLY ENDANGERED IF LARGE AMOUNTS OF UNSATURATED SALT WATER WERE ALLOWED TO FLOW IN FROM THE SHAFT WALL AND MERELY REMOVED BY PUMPING. THE PREVENTION OF WATER MOVEMENT AND THE RESULTING DISSOLUTION OF SALT IN THE OVERBURDEN WERE KNOWN TO BE MOST IMPORTANT. IN THE ALWINSAL SHAFT, WATER FLOW FROM THE DEVONIAN HAS BEEN PREVENTED BY THE USE OF A STEEL AND CONCRETE SANDWICH LINING SIMILAR IN PRINCIPLE TO A KIND OF LINING INTRODUCED A FEW YEARS EARLIER, AND FOR ANOTHER REASON, IN GERMAN COAL SHAFTS. AS ITS INSTALLATION IS NEITHER MORE EXPENSIVE NOR MORE TIME CONSUMING THAN THAT OF CAST IRON TUBBING LINING, THIS SAME LINING WAS ALSO CHOSEN AS PROTECTION AGAINST THE BLAIRMORE QUICKSANDS. THE GREAT ADVANTAGE OF THE STEEL LINING, IN ADDITION TO ITS RELATIVELY HIGH STRENGTH, IS THE FACT THAT IT IS POSSIBLE TO MAKE THE JOINTS OF THE INDIVIDUAL SEGMENTS ABSOLUTELY AND PERMANENTLY WATER-TIGHT BY MEANS OF TESTED WELDS. THE VIRTUAL DRYNESS OF THE ALWINSAL SHAFT WILL ALSO RESULT IN LOWER COSTS BECAUSE SIGNIFICANT CORROSION OF ALL ITS STEEL INSTALLATIONS, INCLUDING SKIPS, CAGE AND ROPES, WILL BE PREVENTED.

34-68-12001 TROUBLE AT SP'S POTRERO HILL TUNNEL
WILLIAMSON T. N.
RY TRACK & STRUCTURES, (64) N 12, 20-22, DEC. 1968, (65) N 1, 25-7, JAN. 1969. DIFFICULTIES THAT DEVELOPED IN 1830-FT DOUBLE-TRACK BORE WHILE EXCAVATION WAS UNDER WAY FOR FREEWAY OVERHEAD, AND MOVEMENTS THAT WERE DISCOVERED TAKING PLACE IN DOUBLE-TRACK TUNNEL ON SOUTHERN PACIFIC AT SAN FRANCISCO AND MEASURES TAKEN TO STABILIZE TUNNEL ARE DISCUSSED.

34-69-06001 EARTHQUAKE DESIGN CRITERIA FOR SUBWAYS (BART)
KUESEL, T. R. & PARSONS-BRINCKERHOFF-QUADE-DOUGL
PROCEEDINGS OF ASCE 95 JOURNEL OF STRUCTURAL DIV N ST6 PAPER 6616, 1213-31, JUNE 1969. DESIGN CRITERIA FOR UNDERGROUND STRUCTURES FOR EARTHQUAKE RESISTANCE IS DUCTILITY TO ABSORB DISTORTIONS WITHOUT LOSING CAPACITY FOR STATIC LOADS. CURVATURE DISTORTION MAY BE CALCULATED FROM DESIGN EARTHQUAKE SPECTRUM GIVING AMPLITUDES AND WAVE LENGTHS. SHEARING DISTORTION RESULTING FROM LAG OF SOIL BEHIND BEDROCK DISPLACEMENT MAY BE CALCULATED FROM SEISMIC VELOCITY OF GROUND AND DEPTH OF OVERBURDEN. EARTHQUAKE DESIGN CRITERIA FOR SAN FRANCISCO BART SUBWAYS ARE LISTED.

34-69-11001 LARGE AGGREGATE SHOTCRETE CHALLENGES STEEL RIBS AS A TUNNEL SUPPORT (LINERS)
SUTCLIFFE, H. + MCCLURE, C. R. & BECHTEL CORP SAN FRANCISCO
CIVIL ENGINEERING, (39) N 11, 51-55, NOV 1969. LARGE AGGRETE SHOTCRETE IS AN ECONOMICAL, RAPID AND EFFECTIVE MEANS OF TUNNEL SURFACE CLOSE BEHIND THE EXCAVATION, IT PREVENTS AIR SLAKING OF ROCK. YIELDING ELASTICALLY AT A DECREASING RATE AS IT GAINS STRENGTH, IT PERMITS FORMATION OF A SELF-SUPPORTING GROUND ARCH ABOVE THE TUNNEL. THE ARTICLE DRAWS ATTENTION TO THE STRUCTURAL POTENTIAL INHERENT IN SHOTCRETE.

34-70-01001 SHOTCRETE SUPPORT IN ROCK TUNNELS IN SCANDINAVIA (LINERS)
CECIL, O. S. & U.S. CORPS OF ENGRS MO RIV DIV
CIVIL ENGINEERING, (40) N 1, 74-79, JAN 1970. SHOTCRETE IS TERMED THE MOST PROMISING ADVANCE IN TUNNEL SUPPORT IN HALF A CENTURY. ITS APPLICATION AND LIMITATIONS IN RESISTING REAL ROCK PRESSURE, LOOSENING PRESSURE, AND SWELLING PRESSURE ARE DESCRIBED. THE AUTHOR OBSERVED NORWEGIAN AND SWEDISH SHOTCRETE PRACTICE WHILE HE WAS IN SCANDINAVIA STUDING ROCK TUNNELS.

34-70-03001 AUSTRALIAN TRENDS IN TUNNEL FORMWORK (SUPPORTS)
SHARLEY, A. N. & RAPID METAL DEVELOPMENTS (AUSTR)
TUNNELS AND TUNNELING, (2) NO 2, 93-98, MAR. 1970. FORM DESIGN IN AUSTRALIA HAS FOLLOWED AMERICAN PRACTICE IN GENERAL THROUGH THE INFLUENCE OF U.S. CONTRACTORS HANDLING MAJOR AUSTRALIAN PROJECTS. NEW TYPES OF FORMS DEVELOPED AND USED IN AUSTRALIA ARE DESCRIBED.

FIELD 35 NEWS ITEMS

35-64-00001 TUNNEL LINERS ARE WHEELED INTO POSITION (SUPPORTS)
CONSTRUCTION METHODS AND EQUIPMENT, 96-97, JAN. 1964. A TRANSPORTER OF A 23-FT DIAMETER STEEL LINER CONSISTED OF FRONT AND REAR DOLLIES THAT HELD A STEEL STRONGBACK. THE STRONG STRONG-BACK EXTENDED TOWARD OVER A CAT D8 TRACTOR THAT TOWED THE RIG AND WAS SECURED BY A SET OF VERTICAL FALLS TO THE FRONT OF THE DOLLY SERVING AS A FULCRUM. TO PICK UP A 23"DIA LINER SECTION, HE TRACTOR OPERATOR BACKED UP AND THREADED THE REAR PORTION OF THE STRONGBACK THROUGH THE SECTION. IT TOOK AN AVERAGE OF A DAY TO TRANSPORT AND INSTALL EACH LINER SECTION. S. L. WIXSON AND CLEON HENDRICKS DESIGNED THE TRANSPORTER WHICH WAS FABRICATED BY CHARLES BRAUN FOR CENTAOR-WIXSON. THE POWER TUNNEL IS PART OF UTAH CONSTR. CO. GENERAL CONTRACT FOR ROUND BUTTE DAM.

35-64-04001 FAST TUNNELLING BY MECHANIZED SHUTTERING (SUPPORTS CONCRETE-FORMS CONTINUOUS-POUR)
ENGINEERING, (172) 518-519, APRIL 10, 1964. A TOTAL OF 12 MILES OF LARGE D-SHAPED TUNNELS WAS INVOLVED WITH FLOOR TO CROWN HEIGHTS RANGING FROM 14 FEET TO 16 FEET 6 IN. BY COMBINING THE GUYREX STANDARD SECTIONS FOR THE SHUTTER AUGMENTED BY STANDARD TRIANGULATED TRUSS AND CENTERING UNITS. BY USING THE RAIL-MOUNTED TRAVELLING GANTRY PRINCIPLE FOR ADVANCING THE SHUTTER AND HYDRAULIC COLLAPSE AND FIXING THE COMPANY SUCCEEDED IN PRODUCING A DRAMATIC IMPROVEMENT. THE USE OF A CONTROL PANEL ENSURED THAT ALL THE 100 PACKS MOVED IN UNISON AND REDUCED THE LABOR FORCE TO ONLY 2 TO 3 MEN/ SHIFT. BOTH UNITS WERE 100 FEET LONG AND COULD BE STRUCK, MOVED FORWARD AND RESET IN TWO HOURS. ONE POUR PER DAY AVERAGING 320 CU. YD. GAVE THE LINING TEAM A RATE OF ADVANCE OF 600 FT. PER WEEK. THE FAWLEY SHUTTER IS AN ADVANCE IN THE USE OF HYDRAULICS. THE TRAVELING RAIL-MOUNTED GANTRY IS MADE UP MAINLY OF BAILEY BRIDGE PANELS. ARTICULATION OF THE FORM IS AT TOP DEAD CENTER CAUSING RETRACTION AROUND THE GANTRY. THE TUNNELS ARE RECTANGULAR SHAPED 10 FEET BY 9 FEET AND EACH TRAVELING FORM IS 60 FT. LONG IN 10 FEET MODULES. EACH MODULE CONTAINS SIX HYDRAULIC RAMS, TWO 3 1/8 IN BORE FOR VERTICAL MOVEMENT AND FOUR OF 4 IN BORE FOR HORIZONTAL EXTENSION.

35-64-04002 VICTORIA SUBWAY SPARKS NEW TUNNEL MAKING METHODS (CONCRETE-LINER UNBOLTED-CAST-IRON-LINER CPM)
ENGINEERING NEWS-RECORD, (172) 26-28, APRIL 30, 1964. A NEW SUBWAY TUNNEL IS BEING BUILT UNDER LONDON, ENGLAND INVOLVING SOME NEW LINING METHODS. TWO METHODS STUDIED WERE A THIN-SHELLED CONCRETE LINER AND A NEW TYPE OF UNBOLTED CAST IRON LINER. THE PROJECT INVOLVED THE USE OF A LARGE SCALE CRITICAL PATH SCHEDULING (CPM) WHICH ONLY WAS ESTIMATED TO GAIN TWO MONTHS IN CONSTRUCTION TIME. THE CONCRETE LINING PROVED TO BE THE CHEAPER. IT WAS NOT NECESSARY TO USE GROUTING IN THE CONSTRUCTION.

35-64-06001 RESIN COMPOUND LOCKS BOLTS IN ROCK (SUPPORT)
ENGINEERING NEWS-RECORD, (172) 40, JUNE 4, 1964. AMERICAN CYANAMID CO. HAS DEVELOPED ROC-LOC WHICH ANCHORS BOLTS IN A HOLE WITH A SPECIAL RESIN COMPOUND. IT ELIMINATES EXPANSION-TYPE BOLTS. IT HAS A VERY HIGH TENSILE AND COMPRESSIVE STRENGTH. THE RESINS CURES IN 8 TO 24 HOURS. THE HIGHER THE TEMPERATURE THE SHORTER THE CURING TIME. THE ROC-LOC SYSTEM USES A TWO PART PLASTIC BAG WHICH CONTAINS THE RESIN AND THE CATALYST.

35-64-09001 CLIMAX FIGHTS HEAVY GROUND AND WINS (ROCK MECHANICS EXPLORATION)
WALKER, M. S. + LUDWIG, J. J. & CLIMAX MOLYBDENUM CO CLIMAX COLO
METAL MINING AND PROCESSING, 27-29, OCT 1964. HISTORY OF STRUGGLE WITH EXTENSIVE CAVING OF CLIMAX MINES. NEW METHODS OF ANALYSIS AND DESIGN OF SUPPORTS PROVIDED NEW METHODS OF CONTROLLING BAD GROUND.

35-64-11001 POLYESTER RESINS HAVE ROCK BOLTING APPLICATIONS (SUPPORTS COST)
MINING CONGRESS JOURNAL, (50) NO 90, NOV 1964. CYANAMID HAS DEVELOPED A RESIN FORMULATION WHICH GELS QUICKLY, CURES FAST, EVEN AT LOW TEMPERATURES AND HAS LOW TOXICITY. WHEN FULLY CURED, TENSILE STRENGTHS UP TO 8100 PSI HAVE BEEN REACHED. IN A SIX FOOT HOLE USING A 3/8-INCH ROOF BOLT OR REBAR RESIN COST WILL BE IN THE RANGE OF $2.50 TO $4.50. A TWO MAN CREW CAN INSTALL 9 SIX-FEET BOLTS IN ABOUT 20 MINUTES WITH A LITTLE EXPERIENCE. APPLICATIONS IN BROKEN ROOF OR PILLARS, OR AT INTERSECTIONS IN COAL MINES; IN RAISES, SHAFTS, CHUTES AND ORE PASSES; AND IN ANCHORING CRUSHERS, SLUSHERS, ETC. TO FOUNDATIONS.

35-64-12001 RESIN AND RE-PAR GIVE NEW LOOK TO ROCK BOLTS (TUNNEL-SUPPORTS)
METAL MINING AND PROCESSING, DEC. 1964. AMERICAN CYANAMID'S ROC-LOC MINING KITS MAY PROVIDE MINES WITH A SAFER, MORE PERMANENT MEANS OF ROCKBOLTING. COST FOR RESIN FOR 6 FEET HOLE WITH 7/8 INCH BOLT IS $2.50 TO $4.50.

35-64-12002 DARTFORD TUNNEL ONLY POSSIBLE THROUGH ADVANCES MADE IN SOIL STABILIZATION (GROUTING)
SOUTH AFRICAN MINING AND ENGINEERING JOURNAL, (74) N. 3751, 1716-1719, DEC. 25, 1964. THE MAIN TUNNEL UNDER THE THAMES BETWEEN DARTFORD, KENT, AND WEST THURROCK, ESSEX, IS 28 FT. 2 IN. DIAMETER, 4,685 FT. LONG, AND COST 11 MILLION POUNDS. IT IS LINED WITH 34,000 TONS MACHINED CAST IRON. THE MINIMUM COVER BETWEEN THE TUNNEL AND THE RIVER CHANNEL IS 19 FT. DIFFICULT STRATA CONDITIONS WERE MET BY INJECTING CEMENT GROUT INTO 40 FT. LENGTHS AHEAD OF THE WORKING FACE IN THE PILOT TUNNEL. 10,000 TONS OF PORTLAND CEMENT WERE INJECTED THROUGH HOLES BORED FROM THE PILOT TUNNEL TO CEMENT THE CHALK LAYER AROUND THE UPPER HALF OF THE FUTURE MAIN TUNNEL. CEMENT WAS NOT FOUND TO BE AN EFFECTIVE GROUTING MATERIAL IN GRAVEL. 305,000 CU-FT OF GROUT WERE INJECTED INTO 30,000 CU-YDS OF GRAVEL. A BELT CONVEYOR CARRIED THE CHALK AND GRAVEL SPOIL TO A CRUSHING MILL, AFTER WHICH IT WAS MIXED WITH WATER AND DELIVERED TO THE SURFACE. 105,000 TONS OF SPOIL WERE SO HANDLED. THERE IS A SUSPENDED ACOUSTICAL CEILING, AND A SINGLE LINE OF FLUORESCENT LAMPS OVER THE CENTER. VENTILATION FANS PROVIDE 130 CU-FT PER MIN PER FT. RUN OF THE TUNNEL OF FRESH AIR.

35-65-01001 SWISS CRACK BOTTLENECK WITH NEW LUCERNE ROAD (LININGS FIBERGLASS)
ENGINEERING NEWS-RECORD, (174) 84-85, JAN. 28, 1965. THERE ARE FOUR TUNNELS THROUGH LOPPER MOUNTAIN. A RAILROAD TUNNEL IS A HALF-MILE LONG AND IS LINED WITH CONVENTIONAL CONCRETE OVER ABOUT ONE-THIRD OF ITS LENGTH AND REINFORCED WITH SPRAYED-ON CONCRETE THROUGHOUT THE REMAINDER. TWO HIGHWAY TUNNELS CROSS OVER THE RAILROAD BORE ONLY 18 INCHES ABOVE; THEY ARE 2,470 FEET AND 922 FEET LONG, LINED WITH CONCRETE WITH A DRAINAGE SYSTEM BETWEEN THE LINING AND THE ROCK. THERE IS ALSO AN INNER STEEL SHEET 2 INCHES FROM THE CONCRETE PROVIDING ADDED PROTECTION FROM WATER SEEPAGE. THE OTHER TUNNEL IS A 256 FOOT BRANCH TUNNEL, IS LINED WITH A COATING OF FIBER GLASS.

35-65-03001 DESIGN AND CONSTRUCTION OF THE CLYDE TUNNEL (LININGS SHIELD SAFETY)
THE SURVEYOR AND MUNICIPAL ENGINEER, (125) NO. 3798, 51-3, MAR 20, 1965. BECAUSE OF THE GROUND CONDITIONS TUNNELLING SHIELDS AND COMPRESSED AIR HAD TO BE USED IN THE CONSTRUCTION. THE ECONOMIC MATERIAL FOR THE LINING WAS CAST IRON FOR ADEQUATE STRENGTH AND DURABILITY. IN CERTAIN SECTIONS OF THE TUNNEL THE ROAD HAD TO BE HEATED BY A LOW-VOLTAGE SYSTEM IN WHICH THE HEATING ELEMENT IS A GRID OF EXPANDED STEEL MESH.

35-65-05001 SAND-FILLED WATER TUNNEL (GROUND-CONTROL IRRIGATION)
ENGINEERING NEWS-RECORD, (174) 20-21, MAY 6, 1965. LEBANON FINISHED A 9.9-MILE 10-FT DIA. TUNNEL AT A COST OF $100-MILLION PLUS. THE TUNNEL WENT UNDER THE 5,500-FT. HIGH MT. NIHA AND IT WILL TRANSFER SOME 70.6 BILLION CU. FT. OF LITANI RIVER WATER. THE WATER WILL IRRIGATE ALMOST THREE TIMES THE PRESENTLY CULTIVATED ACREAGE. THE TUNNEL COMPLETELY FILLED UP WITH ERODED SANDSTONE AS THE TUNNEL CAVED IN.

35-65-12001 ARE TODAY'S TUNNEL DESIGNS ARCHAIC (SUPPORTS)
ENGINEERING NEWS-RECORD, (175) 112-113, DEC. 16, 1965. ALTHOUGH MECHANICAL MOLES HAVE DRASTICALLY CHANGED TUNNEL CONSTRUCTION TECHNIQUES TUNNELS ARE 70 YEARS BEHIND THE DESIGN TIMES. EVERYTHING IS OVERDESIGNED BY FACTORS UP TO 400 PERCENT. MORE NEEDS TO BE KNOWN ABOUT THE SOIL MECHANICS. THE DESIGN OF TUNNELS HAS CONSTRUCTION SUPPORTS HANDLING THE FULL LOAD AND THEN THE INNER LINING IS ALSO DESIGNED TO SUPPORT THE FULL LOAD. LOOSE CONSTRUCTION DECREASES PRESSURE ON THE STRUCTURE.

35-66-02001 HYDRAULICALLY OPERATED ROOF BOLTER USING DUAL BOOMS CUTS CYCLE TIME (COAL-MINE ROTARY-PERCUSSION NOISE)
COAL AGE, 144, FEB 1966. A HYDRAULICALLY OPERATED ROOF BOLTING MACHINE WAS USED IN A COAL MINE. THE MACHINE HAS A DUAL BOOM AND TWO DRILLING HEADS. MINUTES HAVE BEEN CUT FROM THE PRODUCTION CYCLE TIME AND THE MACHINE HAS THE CAPABILITY OF INCREASING THE BOLTING CAPACITY 75 PERCENT. LESS NOISE IS PRODUCED AT THE MINE FACE BECAUSE A ROTARY-PERCUSSION HEAD IS USED.

35-66-07001 DEVELOPMENTS IN CONCRETE TUNNELS (LININGS PRECAST-CONCRETE JACKING)
CONCRETE AND CONSTRUCTIONAL ENGINEERING, 234-244, JULY 1966. NEW TYPES OF PRECAST CONCRETE SEGMENTS WHICH RESULT IN INCREASES IN TUNNEL RATES. AN INCREASING USE OF THE THRUSTING PROCESS IS BEING USED IN INSTALLING PRECAST PIPE-TUNNELS. PRECAST CONCRETE HAS BEEN USED FOR 4 FEET TO 10 FEET 6 IN. IN DIA. TUNNELS WITHOUT A SHIELD. THE TUNNELS FOR THE VICTORIA LINE IN LONDON ARE BEING LINED WITH KNUCKLE-JOINTED CAST IRON SEGMENTS. A RECORD RATE OF 467 FEET/WEEK WAS ACHIEVED. AN ALL PURPOSE CONCRETE LINING OF 6 FEET DIA. IS MANUFACTURED BY MESSRS KINNEAR MOODIE (CONCRETE) LTD. IT IS A KNUCKLE-JOINTED LINING ERECTED ON TO A STEEL FORMER RING IN THE TUNNEL. THE TUNNELLING MACHINES HAVE CYLINDRICAL BODIES SIMILAR TO THOSE OF NORMAL TUNNEL SHIELDS. FOURTEEN HYDRAULIC RAMS, EACH CAPABLE OF EXERTING A FORCE OF 110 TONS. CLOSED CIRCUIT TELEVISION WAS USED FOR INSPECTION OF THE WORKING FACE. PIPE 10 FEET 3 IN DIAMETER AND 55 FEET LONG INSTALLED BY THRUSTING TOOK 240 HOURS TO INSTALL. EACH SECTION OF PRECAST CONCRETE PIPE IS FIVE FEET IN LENGTH AND WEIGHS 7 TONS. THE TYNE TUNNEL USED AN INJECTION OF A CHEMICAL GROUT WHICH HAS LOW VISCOSITY AND A CONTROLLED GELLING TIME. IN THE NEW BLACKWELL TUNNEL, THE TUNNEL HAD TO BE DRIVEN WITH 35 PSI OF COMPRESSED AIR.

35-66-08001 ROCK BOLTS ALONE SUPPORT HUGE CAVERN ROOF (POWER-PLANT-EXCAVATIONS GROUTABLE-BOLTS)
ENGINEERING NEWS-RECORD, (177) 22, AUG 1966. ROCK BOLTS ON A 5 X 5 FEET GRID PATTERN WERE USED TO SUPPORT THE ARCHED ROOF OF A POWERHOUSE MAIN CHAMBER WITH AN AREA OF ALMOST 2 ACRES. THE POWERHOUSE IS PART OF BRITISH COLUMBIA'S PORTAGE MOUNTAIN DAM. EXCAVATIONS ARE UNDERNEATH THE DAM IN A THICKLY BEDDED MEDIUM-GRAINED SANDSTONE, FINE-GRAINED SILTSTONE AND SHALE THAT HAS FINELY SHEARED ZONES AND COAL SEAMS. THE ARTICLE DESCRIBES THE CONSTRUCTION CONDITIONS AND METHODS USED IN THE EXCAVATION.

35-66-09001 SOFT-GROUND TUNNEL GIVES JERSEY SEWER CONTRACTOR HARD TIME (LININGS GROUTING CHEMICAL-GROUT)
ENGINEERING NEWS-RECORD, (177) 26-28, SEPT. 29, 1966. SOFT GROUND WOULD NOT ALLOW DRIVING WELL POINTS. TENA CHEM, INC. USED A LOW-VISIOSITY, ACRYLAMED-BASED CHEMICAL GROUT.

35-67-02001 ROOF BOLTING AT HIGH PACE (LININGS)
COAL-AGE, (72) 148, FEB 1967. A DOUBLE-ARM ROOF BOLTING MACHINE WILL OPERATE IN SEAMS OF 5 1/2 FEET. TWO DRILL ARMS ARE APPROXIMATELY 9 FEET LONG. THE MACHINE IS ENTIRELY HYDRAULIC, DELIVERS A 10,000 LB. VERTICAL THRUST WITH 2,000 PSI HYDRAULIC PRESSURE. THE DRILLING MECHANISMS ARE OPERATED WITH THRUST UP TO 5 TONS WITH A ROTATION SPEED OF 590 RPM.

35-67-03001 NEW LINER PLATE SERVES DUAL ROLE (TUNNEL GASKETED-LINER-PLATES)
ENGINEERING NEWS-RECORD, (178) 32, MAR 9, 1967. NEOPRENE GASKETED CAST IRON LINER PLATES WERE DEVISED, TRIED OUT AND COMPARED TO CONVENTIONAL LINER PLATES IN AN INTERCEPTOR SEWER TUNNEL ON MANHATTAN'S LOWER EAST SIDE. GASKETED LINER PLATE SECTIONS WERE BOTH AIR-TIGHT AND WATER TIGHT PERMITTING CONCRETE LINING OF FULL FACE WITHOUT COMPRESSED AIR. SAVINGS ARE REALIZED WHEN THIS MORE EXPENSIVE METHOD IS WEIGHED AGAINST NEW YORK CITY'S HIGH LABOR COST WHEN WORKING UNDER AIR.

35-67-04001 NEW WAY TO SPRAY ON TUNNEL LINING (SHOT-CRETE ALIVA-METHOD)
RY AGE, (162) N 14, 12-13, APR. 10, 1967. METHOD USED IN 11,190 FT LONG RAILROAD TUNNEL UNDER CONSTRUCTION AT VANCOUVER, BC, IS SIMILAR TO SHOTCRETING BUT WITH SOME MAJOR DIFFERENCES; ONE IS THAT COARSE AGGREGATE CAN BE USED; ANOTHER DIFFERENCE IS THAT DRY MIX IS DELIVERED BY COMPRESSED AIR TO NOZZLE AT WHICH POINT WATER IS ADDED AND ADJUSTED BY VALVE; KNOWN AS ALIVA METHOD, NEW SYSTEM OF CONCRETE SPRAYING IS OF SWISS ORIGIN.

35-67-09001 SURFACE SHAFT PLUMBS DEPTHS TO BURIED TUNNEL (CASING GROUTING DRILLING)
CONSTRUCTION METHODS, 66-68, SEPT. 1967. LAYNE-MINNESOTA CO., MINNEAPOLIS, DRILLED A VERTICAL SHAFT 115 FT. INTO THE 12-IN. CROWN OF AN EXISTING TUNNEL 12 FT. IN DIA. THE HOLE WAS DRILLED TO WITHIN 3-IN. OF THE TARGET. DRILLING WAS COMPLICATED BY A NATURAL HEAD OF WATER THAT ROSE IN THE OPEN HOLE TO THE TOP OF THE LIMESTONE ROCK WHICH WAS ENCOUNTERED AT AN ELEVATION OF 765 FT. THE PROBLEM WAS SOLVED BY SETTING 20-IN. CASING A LITTLE MORE THAN 73 FT. FROM THE SURFACE OF THE HOLE TO THE TOP OF THE LIMESTONE. THEN 46-FT-LONG 16 IN. CASING WAS LOWERED INTO THE HOLE WHICH EXTENDED 4 FT. ABOVE THE LIMESTONE ROCK. TO INSURE GOOD SEALING BETWEEN THE HOLE AND THE 16-IN. CASING A 2-IN-DIA PIPE WAS INSERTED INTO A SPECIAL CONCRETE SHOE WHICH DIRECTED GROUT FLOW. THE GROUT WAS THEN INJECTED UNDER PRESSURE. THIS ALSO PREVENTED WATER CARRIED SAND FROM POURING INTO THE TUNNEL WHEN THE FINAL PENETRATION WAS MADE.

35-67-09002 REUSABLE FORMS LOCK AND ROLL TO CAST TUNNEL (LINING)
CONSTRUCTION METHODS & EQUIPMENT, (49) N 9, 79-89, SEPT. 1967. ROLLING WALL AND DECK FORMS THAT SHIFT INTO CASTING POSITION ON SPECIAL RETRACTABLE DOLLY WHEELS REDUCE SETUP TIMES AND CONCRETING COSTS OF BUILDING VEHICULAR TUNNEL IN MINNEAPOLIS. ADDING TO EFFICIENCY OF OPERATION ARE STRUCTURAL STEEL FOOTING FORMS (ALSO REUSEABLE) WHOSE SIDES AND TOPS EITHER LOCK TOGETHER TIGHTLY OR SEPARATE QUICKLY, DEPENDING ON DIRECTION SMALL WEDGES ARE TAPPED WITH HAMMER. USE OF BOLTED 30-FT FORM AS WALL SECTION, AND 90-FT LONG TRUSS BEARING FRAMEWORK TO SUPPORT TUNNEL DECK POURS ARE DESCRIBED.

35-67-10001 ROOF SUPPORT; TECHNIQUES AND TOOLS (STANDARDS ROOF-BOLTS)
COAL AGE, (72) 108-113, OCT. 1967. AS A RESULT OF A STUDY MADE OF ROOF-CONTROLS MADE IN 1961, NEW METHODS HAVE BEEN DISCOVERED AT NORTH AMERICAN COAL CORPORATION. IT HAS ESTABLISHED A SET OF MINIMUM STANDARDS FOR TIMBERING AND BOLTING, BUT, WITH VARYING CONDITIONS, EACH MINE MUST HANDLE ITS OWN PROBLEM. ROOF BOLT RECOVERING IS PRACTICED AT POWHATTEN NO. 1 AND IS ECONOMICALLY FEASIBLE. UP TO 225 BOLTS CAN BE RECOVERED PER SHIFT. ALSO AT POWHATTEN NOS. 1 AND 3, LIGHT-WEIGHT H BEAMS ARE USED TO PROVIDE TEMPORARY ROOF SUPPORT. THE RIPPER-TYPE CONTINUOUS MINERS WORK CONTINUALLY WITHOUT THE USUAL ROOF-BOLTING DELAYS. THE BEAMS ARE RECOVERED AND REUSED. MINERS ALSO ADVANCE THE FACES IN TWO LIFTS. THE MINER ADVANCES EACH LIFT NO FARTHER THAN THE PRESENT BOLT LINE. THE OPERATOR THEN STARTS THE OTHER LIFT. NO. 3 IS TESTING A NEW GALIS 350B PROTOTYPE ROOF BOLTER TO SIMPLIFY THE SPOTTING OF ROOF BOLTS. THE ROOF BOLTER OPERATOR RUNS THE MACHINE DOWN THE LIFT CENTERLINE, EMPLOYS THE SWING AND TRAM MECHANISMS, RATHER THAN MOVING THE MACHINE. AT NO. 5, A SUCCESSFUL PILLARING PROGRAM IS DISCOURAGED BY THE STRONG LIMESTONE FORMATION THAT NORMALLY OCCURS AT ABOUT 6 TO 10 FT ABOVE PITTSBURGH NO. 8 SEAM. EXCESSIVE SQUEEZING OCCURS, THE SOLUTION HERE IS TO LEAVE THE PILLARS. TO FURNISH EXTRA SUPPORT, ROOM PANELS ARE DEVELOPED ON A STAGGERED THREE-ROOM SYSTEM. 68-FT WIDE PILLARS ARE ESTABLISHED BETWEEN EACH SET OF THREE ROOMS. HOW TO HANDLE THE THICKNESS OF DRAWSLATE THAT OCCURS ABOVE THE COAL IS ANOTHER PROBLEM, THE SLATE IS SUPPORTED AND LEFT IN PLACE WHERE SAFETY PERMITS. OTHERWISE FULL SEAM MINING IS PRACTICED. AT CONEMAUGH, CHANGES IN PANEL ENTRIES HAVE OCCURRED. MAIN ENTRIES ARE NOW BEING DRIVEN WITH SEVEN HEADINGS ON 50- AND 85-FT CENTERS; LARGER PILLARS ARE ESTABLISHED ON THE RETREAT SIDE. ROOM DEVELOPMENT AND PILLAR EXTRACTION ON THE LEFT SIDE PRACTICED ON ADVANCE, THE RIGHT ON THE RETREAT.

35-68-11001 HERE'S METCALFE ROOF BOLT
COAL MIN. & PROC., (5) N 11, 37-8, NOV. 1968. DESCRIPTION OF RECENTLY PATENTED ROOF BOLT DESIGNED TO OBTAIN MAXIMUM ANCHORAGE WITH MINIMUM OF INSTALLATION TIME, GIVES PROMISE OF REDUCING ROOF BOLT FAILURES, DUE TO IMPROVED ANCHORAGE. INVENTION USES OPPOSING CAM SURFACES TO ADVANCE EXPANDER INTO SEGMENTED EXPANSIBLE PIECE OR SHELL SO IT WILL GRIP BOREHOLE WALL AND PROVIDE ANCHORAGE. ADVANTAGES OF NEW DESIGN ARE STRESSED.

35-69-02001 FAULT SUSPENDS TUNNEL DRIVING (CONTINGENCIES GEOLOGY EXPLORATION COST HIGHWAY)
ENGINEERING NEWS-RECORD, (182) 30, FEB 20, 1969. THE PAIR OF HIGHWAY TUNNELS 4,229 FT LONG ON I 77 IN SOUTHWEST

VIRGINIA COSTING $26 MILLION WERE STOPPED BY A FAULT, A SHALLOW SEAM OF DIRT AND ROCK HALFWAY THRU THE MOUNTAIN. GEOLOGICAL INFORMATION THERE INDICATED FULL TUNNEL LENGTH WOULD BE IN SOUND ROCK OR ROCK NOT REQUIRING OTHER THAN NOMINAL SUPPORT. THE BIG QUESTION IS WHO WILL PAY FOR CHANGING CONSTRUCTION PROCEDURE WHICH BOTH HIGHWAY DEPARTMENT AND CONTRACTORS AGREE IS NECESSARY TO CONTINUE DRILLING. HIGHWAY ENGINEERS SAY TUBES COULD BE MADE SAFE BY PUTTING IN STEEL PLATES ON THE SIDE OF THE 27 FT. THICK PILLAR BETWEEN THE TUBES, PROVIDING CONCRETE BULKHEADS OR CHANGING DRILLING PROCEDURE.

35-69-03001 ROAD GOES UP, TUNNEL GOES UNDER (SUPPORT)
ENGINEERING NEWS-RECORD, (182) 32-33, MAR 6, 1969. WHERE THE SAN FRANCISCO BAY AREA RAPID TRANSIT DISTRICTS THRU TUNNELS CURVE UNDER THE HIMITZ FREEWAY IN OAKLAND THE FOOTINGS OF EIGHT COLUMNS WERE TEMPORARILY REMOVED. WHEN COMPLETED 5 OF THESE WILL BEAR ON THE TUNNEL AND THE OTHER THREE ON DEEPER FOOTINGS. A MASSIVE GRILLAGE WAS USED TO TEMPORARILY SUPPORT THE SIX LANE FREEWAY. THE 16 FT WIDE 15 FT HIGH TUNNEL SECTIONS HAVING 2 FT THICK FLOOR AND 1 1/2 FT THICK WALLS AND CEILINGS WILL HAVE 1 1/2 FT ADDED TO THE TOP SLAB AND 6 IN. TO THE WALLS WHERE THE COLUMNS REST ON THE ROOF.

35-70-04001 PRECAST SUBWAY LINERS GO IN FROM TOP TO BOTTOM (MEXICO-CITY SUBWAY SHIELD)
ENGR. NEWS-RECORD, (184) 26-27, APR. 16, 1970. SOLUM SA PART OF THE INGENIEROS CIVILES ASOCIADOS GRUPO HAS THE $4 MILLION CONTRACT FOR THE 3700 FT SECTION OF SUBWAY TUNNEL UNDER THE CITIES EAST-WEST FREEWAY AND A BUSY COMMERCIAL AREA. A 30 FT DIA SHIELD KEEPS GROUTING TO A MINIMUM BY HYDRAULICALLY EXPANDING THE TUNNEL LINER SEGMENTS AGAINST THE SOFT SOIL BORE AS IT MOVES FORWARD TO PLACE THE NEXT LINER RING. MEN USE PNEUMATIC HAND SPADES TO REMOVE THE MUCK FROM THE FACE. A FRONT END LOADER TAKES THE MUCK OUT OF THE SHIELD FACE THROUGH A LINGED DOOR.

35-70-05002 APPLYING WATERPROOF SHEETINGS AS TUNNEL LININGS BY MACHINES
TUNNELS AND TUNNELING, (2) NO 3, 177-178, MAY 1970. SIKA EXPERIENCE IN INSTALLING WATERPROOFING IN EUROPEAN TUNNELS.

FIELD 36 COMPANY BROCHURES

36-65-10001 ROCK BOLTING THEORY (BOLT-SPACING CEMENT-GROUTING RESIN-GROUTING ROCK-STRESSES SUPPORT)
KAROL, R. H. & AMERICAN CYANAMID CO
AMERICAN CYANAMID, ENGINEERING CHEMICALS, 5-2226-1000-1, OCT 1965. UNTIL 40 YEARS AGO (1925) ROOFS WERE SUPPORTED BY VARIOUS PROP MEANS. THESE REQUIRED ADDITIONAL MOVEMENT OF THE SUPPORTED ROCK MASS BEFORE ASSUMING LOAD. WITH THE ADVENT OF ROCK BOLTS, ROCK MASS MOVEMENT WAS RESTRAINED AND BY TENSIONING, PREVIOUS CRACKS WERE PARTIALLY OR COMPLETELY CLOSED. ORIGINALLY ANCHOR BOLTS WERE TIED TO THE ROCK MASS ONLY AT THE TWO END POINTS. IF ONE END FAILED THE ENTIRE BOLT FAILED. PORTLAND CEMENT WAS FIRST USED FOR FULL BOLT BONDING BUT HAD LOW IMPACT RESISTANCE AND DETERIORATED FROM SULFATE WATERS. RECENT DEVELOPMENT OF HIGH STRENGTH, HIGH-IMPACT-RESISTANT BONDING RESINS HAS SOLVED SOME BAD ROOF AND SHOCK CONDITIONS. VERTICAL AND HORIZONTAL FORCES FROM GROUND LOADS ARE DISCUSSED AND BENEFITS OF ROCK BOLTS EXPLAINED. TO FORM A CONTINUOUS INFLUENCE ZONE BOLT SPACINGS SHOULD NOT EXCEED HALF THE BOLT LENGTH.

36-66-02001 ROC-LOC APPLICATIONS, CASE HISTORIES (RESIN-GROUTING ROCK-BOLTS TRANSFER-TUBE)
AMERICAN CYANAMID CO
AMERICAN CYANAMID, ENGINEERING CHEMICALS, 6-2005-1500-2/66, 1-25, FEB 1966. THE NEW RESIN-GROUTED-BOLT CONCEPT OF GROUND SUPPORT OFFERS COST SAVINGS, GREATER PERMANENCY AND A MINIMUM OF DOWN TIME IN VITAL PRODUCTION AREAS IN MINES. TWENTY-THREE MINERAL MINE CASE HISTORIES OF ECONOMICAL ROC-LOC GROUTING ARE GIVEN.

36-67-01001 REPEATED LOAD TESTS ON REINFORCING BARS GROUTED ROC-LOC MINING KITS (ACTIVATOR CURING
RESIN-GROUTED-ROCK-BOLTS PULL-TESTS)
KAROL, R. H. & AMERICAN CYANAMID CO
AMERICAN CYANAMID, ENGINEERING CHEMICALS, 6-2087-1000-1/67, 1-11, JAN. 1967. PULL TESTS SHOW THAT FULL RESIN CURE IS OBTAINED AT 75 DEGREES F OR ABOVE, BELOW THIS ACTIVATOR ADDITION WILL EFFECT FULL CURE. EVEN IF THE DEGREE OF CURE IS LOW THE IMBEDMENT WILL DEVELOP A PULL OUT RESISTANCE APPROACHING THE ROD TENSILE STRENGTH. LOADING TO FAILURE DOES NOT DESTROY THE LOAD CARRYING CAPACITY OF RESIN GROUTED BOLTS AS WHEN UNLOADED THEY CAN BE RELOADED TO EVEN MORE THAN THE ORIGINAL FAILURE LOAD. THIS RELOADING FACTOR IS IMPORTANT IN SEVERE SHOCK AREAS.

36-67-08001 ROC-LOC 540 MINING KIT - INSTRUCTIONS FOR HANDLING AND USE (CHEMICAL-PROPERTIES CURE GELATIN
PHYSICAL-PROPERTIES RESIN TRANSFER-TUBE)
AMERICAN CYANAMID CO
AMERICAN CYANAMID, ENGINEERING CHEMICALS, 4-2119-500-2000-8/67, 1-9, AUG. 1967. ROC-LOC 540 MINING KITS CONTAIN 540 CUBIC INCHES OF MIXED VOLUME OF PASTE, HARDENER AND ACTIVATOR AND COMES WITH A TRANSFER TUBE AND PISTON. BESIDES MIXING INSTRUCTIONS, REQUIRED MIXED VOLUME CHARTS FOR VARIOUS REBAR, HOLE SIZE COMBINATIONS AND RESIN POT LIFE ARE GIVEN. FOUR TYPICAL REBAR APPLICATIONS ARE SHOWN. TEST RESULTS ON 7/8 REBAR IN 1 1/4 DIAMETER HOLES IN HARD IGNEOUS ROCK ARE TABULATED FOR VARIOUS CURE TIMES, TEMPERATURES AND REBAR LENGTHS. CHEMICAL AND PHYSICAL PROPERTIES OF ROC-LOC AND PLAIN CONCRETE ARE LISTED. IN PULL TESTS THE ABILITY OF ROC-LOC ANCHORED REBARS TO SLIP AND THEN SUSTAIN A RELOAD AS GREAT AS THE ORIGINAL SLIPPAGE LOAD WAS OBSERVED. THEREFORE, SHOCK LOADS ON RESIN GROUTED REBARS WILL NOT CAUSE CATASTROPHIC FAILURE.

36-68-10001 ROC-LOC "A" ANCHORAGE RESIN (ROCK-BOLTS RESIN-GROUT)
AMERICAN CYANAMID CO
AMERICAN CYANAMID, ENGINEERING CHEMICALS, 8-2094-500-10/68, 1-6, OCT. 1968. ROC-LOC "A" HAS GREATER PERMANENCE THAN OTHER ANCHORAGE METHODS. IT REDUCES BLEED-OFF AND BOLT DISPLACEMENT AND HAS GREATER BEARING CAPACITY AND BLASTING SHOCK RESISTANCE. IT CAN ECONOMICALLY PROTECT CRITICAL AREAS. THE ROC-LOC "A" FOIL CARTRIDGE HAS A CLIP SEPARATING THE TWO REACTIVE COMPONENTS. WHEN USING, REMOVE THE CLIP, KNEAD THE PACKAGE AND INSERT IN THE BOLT HOLE WITH A STRONG STEADY PRESSURE AS FROM A DRILLING MACHINE, A STOPER MAY NOT HAVE ENOUGH FORCE, TORQUE IMMEDIATELY. RESIN REACHES FULL STRENGTH IN A MATTER OF HOURS. THE RESIN MIXTURE MOVES UNDER PRESSURE TO FLOW AROUND THE EXPANSION SHIELD WITHOUT RUNNING DOWN THE SHANK. IN POOR ROCK, ROC-LOC PROVIDES ANCHORAGE WHERE CONVENTIONAL SHELLS WILL NOT HOLD.

FIELD 37 LETTERS

37-69-03001 REPORT ON CHEMICAL SOIL GROUTING JOB (GEOSEAL CONSOLIDATION)
KIERULF, H. & ROBERT MCALPINE LTD
LETTER TO BORDEN CHEM. CO. MAR. 27, 1969, W/REPRINT FROM HEAVY EQUIPMENT NEWS, MAR. 31, 1969. HUMBER RIVER SEWAGE TREATMENT PLANT - A WATER INFLOW WAS FOUND WHEN INSTALLATION OF A PIPE BEGAN. GEOSEAL FROM BORDEN CHEMICAL CO. WAS CHOSEN FOR CONSOLIDATION OF AN ADJACENT LAND FILL. DIFFICULTY WAS EXPERIENCED IN DRILLING THROUGH A 2' THICK CONCRETE WALL, BUT GEOSEAL PROVED SUCCESSFUL. SPADINA SEWER TUNNEL - DIFFICULTY WITH LOOSE SAND. GEOSEAL WAS INJECTED WITH COMPRESSED AIR, SUCCESSFULLY FOR THE WHOLE OPERATION. TORONTO TRANSIT COMMISSION'S, 21-MI. LONG SUBWAY SYSTEM. WATER SEEPAGE THROUGH POROUS, CRACKED, OR HONEYCOMBED CONCRETE WAS THE PROBLEM. SOLUTION-INJECTION GROUTING TECHNIQUES. PASSENGERS OF TRAINS WERE NOT TO BE INCONVENIENCED. AN ITALIAN GROUT PUMP PERONI PNEUMATIC CEMENT INJECTION PUMP WAS USED. BREAKING THROUGH THE WALL WAS NOT DESIRABLE BECAUSE SATURATED QUICKSAND BEHIND COULD FLOW OUT OF THE DRILL HOLE AND INTO THE VOIDS OF CONCRETE. THESE VOIDS WERE FILLED WITH GEOSEAL RESIN. IN ORDER TO CHECK TO PREDICT GROUTING EFFECTIVENESS, A FLUORESCEIN GREEN DYE MAY BE INJECTED VIA PERONI PUMP.

37-69-06001 GEOSEAL (CHEMICAL-GROUTING)
DAHLENBURG, J. L. & BORDEN INC
BORDEN, INC/CHEM. DIV. BROCHURE, JUNE 30, 1969. CHEMICAL GROUTING IS A PROCESS OF INJECTING A CHEMICAL SOLUTION INTO VOIDS SUCH AS THOSE FOUND IN POROUS CONCRETE, FRACTURED ROCK, OR PERMEABLE SOILS. THE CHEMICAL DISPLACES THE WATER OR AIR, SETS, AND CONSOLIDATES THE NETWORK. BORDEN CHEMICAL COMPANY IS MARKETING A NEW MATERIAL, GEOSEAL. WHICH IS SOLUBLE IN WATER AND USES STANDARD PUMPING EQUIPMENT. AN ANALYSIS OF SITE CONDITIONS IS IMPORTANT AND A COST CAN THEN BE ACCURATELY PROJECTED, THE ENGINEER HAS COMPLETE CONTROL OF VISCOSITY AND SETTING TIME. GEOSEAL IS IMPERVIOUS TO WATER, ELASTIC WHEN FINAL GEL IS REACHED, INSOLUBLE IN WATER, NONCORROSIVE TO METALS NORMALLY ON AN ENGINEERING SITE. OTHER USES BESIDES THOSE IN MINING OR TUNNELING ARE: ROADBED AND SURFACING, BINDER FOR HERBICIDES, SOIL CHELATING AGENTS, SOIL EROSION. GEOSEAL WAS USED SUCCESSFULLY IN THE COW GREEN RESERVOIR DAM AND IN NORTHUMBERLAND AT THE BEWICK DRIFT. IN COMPARISON WITH OTHER MATERIALS, GEOSEAL RESINS ARE LOW COST. IT WAS USED FOR: THE IMPERMEABILISATION OF UNDERGROUND WORKS AT HOLBURN, LONDON, PICCADILLY, WESTMINSTER SUBWAY; STABILISING SOIL UNDER AN EXISTING FOUNDATION AT TECHNICAL COLLEGE EXTENSION, WESTON-SUPER-MARE; AND REPAIRING BROKEN DRAINAGE SYSTEMS.

FIELD 4 MATERIALS HANDLING

FIELD 42 SYMPOSIA

42-55-00001 HYDRAULIC CONVEYING OF SOLIDS IN HORIZONTAL PIPES (VELOCITY CONCENTRATION SIZE-PARTICLES DENSITY FLOW)
NEWITT, D. M. + RICHARDSON, J. F. + ABBOTT, M. & TURTLE, R. B. & IMPERIAL COL LONDON ENG
TRANS INSTN CHEM ENGRS, (33) 93-113, 1955. FLOW CHARACTERISTICS ENCOUNTERED IN HYDRAULIC CONVEYING IN HORIZONTAL PIPES DEPEND ON MEAN VELOCITY OF FLOW, CONCENTRATION, MEAN SIZE AND DENSITY OF SOLIDS AND PIPE DIAMETER. EQUATIONS ARE DERIVED TO RELATE PRESSURE LOSSES ALONG PIPE TO THESE VARIABLES FOR VARIOUS TYPES OF FLOW. DATA OBTAINED FOR A RANGE OF VELOCITY, PARTICLE SIZE AND DENSITY, IN A 1 INCH PIPE ARE SUCCESSFULLY CORRELATED BY THESE EQUATIONS, WHICH CAN BE USED TO PREDICT TYPE OF FLOW AND HEAD LOSSES FOR ANY GIVEN CONDITIONS. INSUFFICIENT DATA ARE AVAILABLE FROM THE LITERATURE FOR PIPE DIAMETER EFFECT TO BE ESTABLISHED WITH CERTAINTY. THESE CONCLUSIONS, WHICH RELATE TO CLOSELY-GRADED MATERIAL, MAY BE APPLIED TO TRANSPORT OF MIXTURES OF WIDELY DIFFERING SIZES, THOUGH WITH LOSS OF ACCURACY. RESULTS OBTAINED WITH MIXTURES OF FINER COMPONENT INCREASES TRANSPORT OF COARSER, AND GENERALLY AN OPTIMUM MIXTURE COMPOSITION FOR MOST ECONOMICAL MATERIAL CONVEYING IS INDICATED. HYDRAULIC CONVEYING WOULD BE A MUCH MORE IMPORTANT INDUSTRIAL PROCESS IF HYDRAULIC MECHANISMS INVOLVED WERE BETTER UNDERSTOOD AND THESE WERE MORE COMMONLY KNOWN.

42-61-10001 HYDRAULIC CONVEYING OF SOLIDS IN VERTICAL PIPES (VELOCITY SETTLING CONCENTRATION DENSITY)
NEWITT, D. M. + RICHARDSON, J. F. + GLIDDON, B. J. & IMPERIAL COL LONDON ENG
TRANS INSTN CHEM ENGRS, (39) 93-100, 1961. VERTICAL TRANSPORT WILL OCCUR PROVIDED LIQUID VELOCITY EXCEEDS PARTICLE SETTLING VELOCITY. THE TENDENCY OF PARTICLES NEAR THE WALL OF A VERTICAL CONVEYING PIPE TO ROTATE AND MOVE TOWARDS THE PIPE AXIS IS ONLY APPRECIABLE FOR LARGE PARTICLES TRAVELLING AT HIGH VELOCITY CLOSE TO THE PIPE WALL. FOR HORIZONTAL PIPE A SLURRY OF SMALL PARTICLES ACTED AS A MORE EFFECTIVE TRANSPORT MEDIUM THAN WATER ALONE BUT IN VERTICAL TRANSPORT THERE IS NO APPRECIABLE EFFECT. EXPERIMENTS WERE RUN USING VARIOUS CONCENTRATIONS OF 4 SIZES OF SAND, ONE PEBBLE SIZE, ZIRCON, MANGANESE DIOXIDE AND PERSPEX WITH A VACSEAL HAVING A 9 INCH DIAMETER IMPELLER CAPABLE OF PRODUCING 90 FOOT WATER HEAD. ONE INCH AND TWO INCH INSIDE DIAMETER PIPES WERE USED. THE TEST RESULTS WERE FOUND TO BE SATISFACTORILY CORRELATED WITH AN EMPIRICAL EQUATION.

42-66-00001 THE PRESSURE DROP IN THE HYDRAULIC LIFTING OF DENSE SLURRIES OF LARGE SOLIDS WITH WIDE SIZE DISTRIBUTION (VELOCITY FREE-SETTLING EFFICIENCY)
OEDJOE, D. + BUCHANAN, R. H. & UNIV NEW SOUTH WALES
TRANS INSTN CHEM ENGRS., (44) T364-T370, 1966. PRESSURE DROP EQUATIONS WERE FOUND TO APPLY FAIRLY CLOSELY TO DENSE SLURRIES OF LARGE SOLIDS WITH WIDE SIZE DISTRIBUTIONS WHEN FREE-SETTLING VELOCITY OF WEIGHT-AVERAGE PARTICLE SIZE IS EMPLOYED. IN THE EXPERIMENTAL APPARATUS 50 FOOT LENGTHS OF 2, 3 AND 4 INCH STANDARD GALVANIZED STEEL PIPE WERE USED. THREE DIFFERENT GRADINGS OF COAL, THREE DIFFERENT GRAVEL GRADINGS AND ONE SAND WERE USED. NO ALLOWANCE WAS MADE IN THE PRESSURE DROP EQUATION FOR FRICTIONAL LOSSES CAUSED BY SOLIDS COLLIDING WITH EACH OTHER AND THE WALL. EFFICIENCY OF A HYDRAULIC LIFTING SYSTEM GOES THROUGH A MAXIMUM WHEN THE RATIO OF THE AVERAGE VELOCITY OF SOLIDS-LIQUID MIXTURE TO THE FREE SETTLING VELOCITY OF SOLIDS IS BETWEEN 2 AND 4 DEPENDING ON SOLID'S PROPERTIES AND DELIVERED CONCENTRATION.

42-67-02001 THE TRANSPORT OF SOLIDS IN HELICALLY-RIBBED PIPES (VELOCITY PITCH POWER)
WOLFE, S. E. & UNIV TORONTO
THE CANADIAN MINING AND METALLURGICAL BULLETIN, 221-223, FEB 1967. HELICAL RIBS IN SMOOTH BORE ROUND PIPE RESULT IN GRANULAR SOLID PARTICLE TRANSPORT IN WATER AT A MUCH LOWER VELOCITY THAN REQUIRED IN A SMOOTH PIPE. HELICAL MOTION IMPARTED TO FLOWING MIXTURE EFFECTIVELY RETURNS SETTLED SOLID PARTICLES TO MAIN STREAM. FLOW MAY BE STOPPED AND RESTARTED WITHOUT DIFFICULTY. DUE TO LOWER TRANSPORT VELOCITY LARGE POWER SAVINGS ARE REALIZED AND WEAR ON PIPE WALLS IS MUCH REDUCED. THESE EXPERIMENTS WITH HELIX ANGLES OF 20, 30 AND 45 DEGREES SHOWED THAT PREVIOUS UNSATISFACTORY EXPERIENCE WITH RIBS WAS DUE TO SMALL HELIX ANGLE (ABOUT 10 DEGREES). SUCH SMALL ANGLES HAVE A NEGLIGIBLE EFFECT EXCEPT AT HIGH VELOCITIES. A 45 DEGREE HELIX APPEARS OPTIMUM IN CAUSING SLURRY ROTATION AT MINIMUM ENERGY. DEEP RIBS ARE NOT NECESSARY. TO PREVENT DEAD AREAS BETWEEN RIBS THEY SHOULD BE NOT MORE THAN 4 TO 6 INCHES APART.

42-67-04001 DEVELOPMENTS IN CONVEYOR-BELTING FOR MINES (FIRE SAFETY STATIC-ELECTRICITY)
KITCHIN, J. B. & FENNER INTERNATIONAL LTD
THE CANADIAN MINING AND METALLURGICAL BULLETIN, 421-427, APR 1967. A DISASTROUS FIRE ON A MAJOR TRUNK CONVEYOR AT CRESWELL COLLIERY IN BRITAIN LED TO A MANDATORY REQUIREMENT FOR UNDERGROUND BELTING TO BE NON-INFLAMMABLE. P.V.C. WAS A NON-INFLAMMABLE MATERIAL. INITIALLY THIS MATERIAL COMPARED VERY UNFAVORABLY WITH CONVENTIONAL RUBBER COTTON DUCK BELTS AS FLEXIBILITY WAS DIFFICULT TO ACHIEVE, BELTS WERE HARD AND DIFFICULT TO TROUGH. ADHESION BETWEEN PLIES WAS OFTEN LOW AND BELTS OFTEN SLIPPED ON THE DRIVE PULLEY. DURING RECENT YEARS IT HAS BEEN FOUND IN PRACTICE THAT PVC COMPOUNDS WILL OFTEN OUT PERFORM RUBBER. THE ELECTROSTATIC SPARK HAZARD FROM BELTS WAS SOLVED BY COMPOUNDING ELECTRICAL CONDUCTIVE ADDITIVES INTO THE PVC. SOME DIFFICULTIES IN CONVEYING IN MINES HAVE BEEN SHOWN TO BE CAPABLE OF SOLUTION.

42-67-05001 HETEROGENEOUS FLOW OF SOLIDS IN PIPELINES (PREDICTION, HEAD-LOSS PILOT-PLANT DURAND)
ZANDI, I. + GOVATOS, G. & PENN UNIV
PROC OF THE ASCE JOURNAL OF THE HYDRAULICS DIVISION, (93) HY3 PAPER 5244, 145-159, MAY 1967. SOLID CONVEYANCE THROUGH PIPES IS NOW AN INDUSTRIAL REALITY. A LIST OF INDUSTRIAL SOLID PIPELINES AROUND THE WORLD IS GIVEN WITH THEIR SIZE AND CAPACITY. DESPITE THE POTENTIAL OF SOLID PIPELINE SYSTEMS, INABILITY TO ACCURATELY PREDICT HEAD LOSSES HAS BEEN ONE FACTOR IMPEDING DEVELOPMENT AND WIDESPREAD USE OF HYDRAULIC TRANSPORTATION. AVAILABLE EQUATIONS FOR HEAD LOSS GIVE SUCH UNRELIABLE RESULTS THAT EXPENSIVE PILOT PLANT STUDIES ARE NECESSARY PRIOR TO DESIGN WORK. WHEN A SOLID-LIQUID MIXTURE IS CONVEYED THROUGH A PIPE, FOUR FLOW CONDITIONS MAY MEAN FLOW VELOCITY, LIQUID DENSITY, LIQUID VISCOSITY, SLURRY SOLIDS CONCENTRATION AND PIPE DIAMETER. IN HOMOGENEOUS FLOW PARTICLES ARE KEPT IN SUSPENSION. IN HETEROGENEOUS FLOW A PARTIAL SEPARATION OF SOLIDS FROM FLUID OCCURS. IN INTERMEDIATE FLOW CONDITION, HOMOGENEOUS AND HETEROGENEOUS FLOW EXIST SIMULTANEOUSLY. IN SALTATION, SOLID PARTICLES JOIN THE BED LOAD. A DATA BANK FROM 2,549 POINTS WAS COLLECTED. LEADING EQUATIONS OF SLURRY FLOW WERE COMPARED. TWO EQUATIONS OF THE DURAND TYPE WERE PROPOSED TO ACCURATELY PREDICT HETEROGENEOUS REGIMES.

42-68-03001 THE EFFECTS OF SOLIDS ON CENTRIFUGAL PUMP CHARACTERISTICS (SLURRY-PUMPING MATERIALS-HANDLING)
HUNT, W. A. + FADDICK, R. R. & MONTANA STATE UNIV BOZEMAN MONT
ADVANCES IN SOLID-LIQUID FLOW IN PIPES AND ITS APPLICATION. IN PRESS. PAPER PRESENTED AT INTERNATIONAL SYMPOSIUM ON

SOLID-LIQUID FLOW IN PIPES, PHILADELPHIA, PA., MAR 4-6, 1968. PERFORMANCE TESTS OF THREE CENTRIFUGAL PUMPS CONDUCTED ON AQUEOUS MIXTURES CONTAINING UP TO 20 PERCENT CONCENTRATIONS OF CHIP-SHAPED PLASTIC PARTICLES ARE SUMMARIZED. CHARACTERISTIC CURVES PLOTTED WITH REDUCED VARIABLES SHOW THAT THE HEAD DEVELOPED BY ONE OF THE PUMPS WAS 1.5 PERCENT GREATER FOR A MIXTURE CONTAINING 20 PERCENT SOLIDS THAN FOR CLEAR WATER AT THE SAME DISCHARGE RATES. NUMERICAL EXAMPLES ARE GIVEN TO ILLUSTRATE INCREASE IN HEAD IS POSSIBLE BY USING AN EQUATION FOR THE THEORETICAL HEAD MODIFIED TO CONSIDER THE RATE OF CHANGE OF THE ANGULAR MOMENTUM OF THE SOLIDS SEPARATELY FROM THAT OF THE TRANSPORTING LIQUID. THE TESTS INDICATE A 2 TO 8 PERCENT DECREASE IN THE EFFICIENCIES OF THE PUMPS WHICH CAUSES AN INCREASE IN THE BRAKE HORSEPOWER. PREVIOUS WORK BY FAIRBANK AND HERBICH ON PUMPING LIQUID-SOLID MIXTURES IS REVIEWED.

42-68-03002 HEAD LOSS IN SPIRAL SOLID-LIQUID FLOW IN PIPES (SLURRY-PUMPING SOLIDS-TRANSPORT MATERIALS-HANDLING)
CHIU, C. L. + SEMAN, J. J. & UNIV PITTSBURGH
ADVANCES IN SOLID-LIQUID FLOW IN PIPES AND ITS APPLICATION. IN PRESS. PAPER PRESENTED AT INTERNATIONAL SYMPOSIUM ON SOLID-LIQUID FLOW IN PIPES. PHILADELPHIA, PA., MAR 4-6, 1968. A SPIRAL FLOW IS THE RESULTANT OF PRIMARY AND SECONDARY FLOWS: IN A REGULAR CIRCULAR PIPE, SPIRAL FLOW DOES NOT EXIST. THERE ARE TWO METHODS OF GENERATING SPIRAL CURRENTS IN A CLOSED CONDUIT: (1) INSTALLING HELICAL RIBS INSIDE REGULAR CIRCULAR PIPES AND (2) USING NONCIRCULAR PIPES. CHARACTERISTICS OF SPIRAL SOLID-LIQUID FLOWS GENERATED BY THESE TWO METHODS ARE STUDIED AND COMPARED WITH THOSE OF REGULAR CIRCULAR PIPES. THE CRITICAL DEPOSIT VELOCITY AND THE HEAD LOSS AT VARIOUS FLOW VELOCITIES IN EACH PIPE ARE COMPARED AND ANALYZED. THE RESULTS SHOW THAT THERE IS A GOOD POSSIBILITY THAT SQUARE PIPES MAY BE USED TO REPLACE THE TRADITIONAL CIRCULAR PIPES FOR THE TRANSPORT OF SOLIDS.

42-68-03003 HYDRAULIC CONVEYANCE OF SOLIDS IN PIPE (MATERIALS-HANDLING)
HAYDEN, J. W. + STELSON, T. E. & UNIV MINN MINNEAPOLIS MINN
ADVANCES IN SOLID-LIQUID FLOW IN PIPES AND ITS APPLICATION. IN PRESS. PAPER PRESENTED AT INTERNATIONAL SYMPOSIUM ON SOLID-LIQUID FLOW IN PIPES. PHILADELPHIA, PA., MAR 4-6, 1968. A STUDY WAS MADE OF THE FLOW OF SOLID-WATER MIXTURES THROUGH HORIZONTAL PIPES. SIX SERIES OF TESTS ARE REPORTED USING SEPARATE MIXTURES OF THREE DIFFERENT SOLIDS IN ONE- AND TWO-INCH DIAMETER PIPES. MEASUREMENTS OF HYDRAULIC GRADIENT, SOLIDS CONCENTRATION, AND DISCHARGE WERE MADE. PARTICLE BEHAVIOR WAS OBSERVED FOR FLOW WITH A STATIONARY BED, SALTATION FLOW, AND HETEROGENEOUS FLOW IN ORDER TO STUDY THE MECHANICS OF PARTICLE MOVEMENT. THE DATA HAVE BEEN CORRELATED WITH THE RESULTS OF PREVIOUS INVESTIGATORS.

42-68-03004 PARTICLE AND FLUID VELOCITIES OF TURBULENT FLOWS OF SUSPENSIONS OF NEUTRALLY BUOYANT PARTICLES (HYDRAULIC-TRANSPORT SLURRY-PUMPING SOLIDS-PIPELINE)
ROBERTS, C. P. R. + KENNEDY, J. F. & UNIV PRETORIA REP SO AFR
ADVANCES IN SOLID-LIQUID FLOW IN PIPES AND ITS APPLICATION. IN PRESS. PAPER PRESENTED AT INTERNATIONAL SYMPOSIUM ON SOLID-LIQUID FLOW IN PIPES. PHILADELPHIA, PA., MAR 4-6, 1968. A STUDY OF THE VELOCITY OF PARTICLES AND OF THE FLUID IN SOLID-LIQUID SYSTEMS INDICATES THAT THE PARTICLES AND THE FLUID MOVE AT DIFFERENT RATES. AT HIGH LIQUID VELOCITY THE PARTICLES MOVE FASTER THAN THE FLUID.

42-68-03005 SANITARY SEWAGE TRANSPORT VELOCITY (SLURRY-PUMPING MATERIALS-HANDLING HYDRAULIC-TRANSPORT)
MCPHERSON, M. B. + TUCKER, L. S. + HOBBS, M. F. & HARVARD UNIV CAMBRIDGE MASS
ADVANCES IN SOLID-LIQUID FLOW IN PIPES AND ITS APPLICATION. IN PRESS. PAPER PRESENTED AT INTERNATIONAL SYMPOSIUM ON SOLID-LIQUID FLOW IN PIPES. PHILADELPHIA, PA., MAR 4-6, 1968. A SUMMARY OF RESEARCH ON THE MINIMUM VELOCITY REQUIRED FOR TRANSPORT OF SANITARY SEWAGE. GENERAL CRITERIA APPLICABLE TO THE DESIGN OF PRESSURE CONDUITS ARE GIVEN AND TENTATIVE FINDINGS FOR OPEN CHANNEL FLOW ARE SET FORTH. TESTS WERE CONDUCTED USING SEWAGE IN A SPECIAL LABORATORY-FIELD INSTALLATION.

42-68-03006 TRANSIENT FLOW OF SOLID-LIQUID MIXTURES IN PIPES (HYDRAULIC-TRANSPORT SLURRY-PUMPING MATERIALS-HANDLING)
WOOD, D. J. + KAO, T. Y. & UNIV KENTUCKY LEXINGTON KY
ADVANCES IN SOLID-LIQUID FLOW IN PIPES AND ITS APPLICATION. IN PRESS. PAPER PRESENTED AT INTERNATIONAL SYMPOSIUM ON SOLID-LIQUID FLOW IN PIPES. PHILADELPHIA, PA., MAR 4-6, 1968. THE BASIC RELATIONSHIPS NEEDED FOR A ONE-DIMENSIONAL PLANE WAVE ANALYSIS OF TRANSIENT SOLID-LIQUID FLOW ARE PRESENTED. THESE RELATIONSHIPS INCLUDE EXPRESSIONS FOR PRESSURE WAVE VELOCITIES AND WAVE MAGNITUDES AND BASIC CONTINUITY AND MOMENTUM EXPRESSIONS WHICH MUST BE APPLIED AFTER A PRESSURE WAVE PASSES. ALSO VISCOUS EFFECTS ARE CONSIDERED INCLUDING THE MOMENTUM EXCHANGE BETWEEN THE PHASES DUE TO VISCOUS DRAG AND THE CONTRIBUTION OF WALL SHEAR. PREVIOUSLY REPORTED WORK DEALT PRIMARILY WITH PRESSURE WAVE VELOCITIES IN SOLID-LIQUID FLOW AND PRESSURE AND FLOW CONDITIONS ADJACENT TO A BOUNDARY. IN THIS PAPER, THE ANALYSIS IS EXTENDED TO ANY POINT IN THE FLOW SYSTEM. THE EFFECTS OF VISCOUS WALL SHEAR ARE CONSIDERED. A BASIC RELATIONSHIP FOR FLOW CONTINUITY IN AN UNBOUNDED CONTROL VOLUME IS DERIVED TO STUDY CONDITIONS AFTER A PRESSURE WAVE PASSES. THE BASIC RELATIONSHIPS ARE THEN COMBINED TO FORM A PLANE WAVE ANALYSIS OF PRESSURE AND FLOW CONDITIONS AT ANY POINT IN THE FLOW SYSTEM. EXPERIMENTAL RESULTS ARE PRESENTED WHICH AGREE CLOSELY WITH THE THEORETICAL PREDICTIONS. HIGH SPEED MOVIES WERE EMPLOYED TO RECORD VELOCITY HISTORIES IN THE TRANSIENT FLOW.

42-68-03007 HYDRAULIC DISPOSAL OF SOLID WASTE (HYDRAULIC-TRANSPORT SLURRY-PUMPING MATERIALS-HANDLING MINE-WASTES)
CONDOLIOS, E. & SOGREAH CO GRENOBLE FRANCE
ADVANCES IN SOLID-LIQUID FLOW IN PIPES AND ITS APPLICATION. IN PRESS. PAPER PRESENTED AT INTERNATIONAL SYMPOSIUM ON SOLID-LIQUID FLOW IN PIPES. PHILADELPHIA, PA., MAR 4-6, 1968. A REVIEW OF THE PHYSICAL LAWS GOVERNING HYDRAULIC TRANSPORT AND TWO EXAMPLES OF WASTE DISPOSAL SCHEMES, ONE IN JAPAN, ONE ON THE MEDITERRANEAN SEA. METHODS OF SPREADING THE WASTE ARE PRESENTED INCLUDING SPREADING IN HILLY AREAS, BEHIND A DAM, IN A LOWLAND AREA, IN A LAGOON, IN A PLAINS REGION AND ON SEA BEDS.

42-68-03008 PRE-CRUSHING SOLID WASTES FOR PIPELINE TRANSPORTATION (MATERIALS-HANDLING HYDRAULIC-TRANSPORT)
CRAIG, S. N. & WASCON SYSTEMS INC HATBORO PA
ADVANCES IN SOLID-LIQUID FLOW IN PIPES AND ITS APPLICATIONS. IN PRESS. PAPER PRESENTED AT INTERNATIONAL SYMPOSIUM ON SOLID-LIQUID FLOW IN PIPES, PHILADELPHIA, PA., MAR 4-6, 1968. FEASIBILITY STUDY OF TWO-STAGE SYSTEM FOR MECHANICAL PREPARATION OF SOLID URBAN WASTES FOR TRANSPORTATION TO DISTANT POINTS IN HYDRAULIC PIPING. SYSTEM EVOLVED DURING STUDY EMPLOYS COMBINATION OF EXISTING WET-PULPING AND POSITIVE GRINDING EQUIPMENT, CONNECTED IN SERIES. TWO-STAGE PROCESS CONVERTS APPROXIMATELY 95% OF TYPICAL URBAN WASTES INTO FORM SUITABLE FOR TRANSPORTATION BY HYDRAULIC PIPELINE.

42-68-03009 SOME PHASE-SEPARATION PHENOMENA IN ISO-DENSITY, FLOWS (SLURRY-PUMPING HYDRAULIC-TRANSPORT)
BUGLIARELLO, G. + YANIZESKI, G. & CARNEGIE-MELLON INSTITUTE
ADVANCES IN SOLID-LIQUID FLOW IN PIPES AND ITS APPLICATION. IN PRESS. PAPER PRESENTED AT INTERNATIONAL SYMPOSIUM ON SOLID-LIQUID FLOW IN PIPES, PHILADELPHIA, PA., MAR 4-6, 1968. AN OVERVIEW OF THE PHASE SEPARATION EFFECTS WHICH CAN BE ACHIEVED IN ISO-DENSITY, TWO-PHASE FLOWS BY HYDRODYNAMIC MEANS.

42-68-03010 NEW SOLIDS PUMPING TECHNIQUES AND ANALYSIS (SLURRY-PUMPING HYDRAULIC-TRANSPORT)
FRAZIER, D. M. & ERICKSON ENGR CO TAMPA FLA
ADVANCES IN SOLID-LIQUID FLOW IN PIPES AND ITS APPLICATIONS. IN PRESS. PAPER PRESENTED AT INTERNATIONAL SYMPOSIUM ON SOLID-LIQUID FLOW IN PIPES, PHILADELPHIA, PA., MAR 4-6, 1968. IN THE STUDY OF PIPELINE TRANSPORTATION OF SOLIDS THE EMPHASIS HAS BEEN ON PIPELINE PHENOMENON, PUMPS HAVE BEEN NEGLECTED. CURRENT ANALYTICAL TECHNIQUE IS NOT BASICALLY ORIENTED TOWARD THE FUNDAMENTAL ENERGY-POWER CONCEPTS. AS A CONSEQUENCE PUMP AND PIPELINE ENERGY LOSSES HAVE NOT BEEN DISTINGUISHED OR ISOLATED, AND THE POSSIBILITIES FOR SIMPLE AND CONCISE EVALUATION OF EITHER OR BOTH HAVE BEEN LOST. PIPELINE LOSSES ARE LESS THAN USUALLY CALCULATED AND PUMP LOSSES ARE GREATER. CENTRIFUGAL, POSITIVE DISPLACEMENT AND JET PUMPS HAVE UNIQUE AND DIFFERING LOSS CHARACTERISTICS WHEN PUMPING SOLIDS. WHEN THESE ARE ANALYZED WITHIN THE FRAME-WORK OF HYDRAULIC ENERGY, PIPELINE SYSTEM DESIGN PARAMETERS BECOME CLEAR. JET PUMPS ARE BASICALLY THE MOST EFFICIENT PUMPS PUMPING HEAVY CONCENTRATIONS OF SOLIDS, AND MORE RESEARCH AND DEVELOPMENT IS NEEDED TO DEVELOP HIGHER JET PUMP SYSTEMS.

42-68-03011 HYDRAULIC TRANSPORT OF BULKY MATERIALS (ECONOMY CORROSION EROSION SOLID-LIQUID FLOW)
ZANDI, I. & PENN UNIV
ADVANCES IN SOLID-LIQUID FLOW IN PIPES AND ITS APPLICATION (IN PRESS) PAPER PRESENTED AT INTERNATIONAL SYMP ON SOLID-LIQUID FLOW IN PIPES, PHILADELPHIA, PA., MAR 4-6, 1968. A UNIVERSALLY ACCEPTED TECHNIQUE FOR PREDICTING HEAD LOSS OF CONVEYED SOLID-LIQUID MIXTURES DOES NOT EXIST. SEVERAL EMPIRICAL FLOW EQUATIONS ARE GIVEN. IN THE TABLES ARE LISTED: EXAMPLES OF FLUIDS, COMPARISON OF PREDICTED FRICTION FACTORS WITH EXPERIMENTAL, GOVERNING EQUATIONS FOR HETEROGENEOUS FLOW, ACCURACY OF PREDICTION OF HEAD LOSS WITH SEVERAL GIVEN EQUATIONS, CRITERION FOR CALCULATING CRITICAL VELOCITY, DIFFERENT METHODS OF AVERAGING PARTICLE SIZE CHARACTERISTICS, EFFECT OF INHIBITOR ON CORROSION AND ESTIMATED COST OF SEVERAL SOLID PIPELINES. FOR LONG LINES PIPES ARE ECONOMICAL FOR CONVEYING SLURRIES AS THEY ARE SIMPLE, ALL-WEATHER, HAVE LOW LABOR COST AND CAN BE COMPLETELY AUTOMATED. 166 REFS.

42-68-03012 TRANSPORT OF SOLIDS AT LOW CONCENTRATIONS IN HORIZONTAL PIPES (FLOW-PIPE SOLID-LIQUIDS VISCOSITY DENSITY VELOCITY)
WICKS, M. & SHELL PIPE LINE CORP
ADVANCES IN SOLID-LIQUID FLOW IN PIPES AND ITS APPLICATIONS. IN PRESS, PAPER PRESENTED AT INTERNATIONAL SYMPOSIUM ON SOLID-LIQUID FLOW IN PIPES, PHILADELPHIA, PA., MAR 4-6, 1968. TESTS WERE MADE WITH WATER AND OIL CONVEYING ONE PERCENT BY VOLUME SHARP SAND SIZED, THRU TO MESH RETAINED ON 100 MESH, THRU 1.049 I.D. PLASTIC TUBING AND 5.50 I.D. PLEXIGLAS PIPE AT VARIOUS VELOCITIES TO INTER-RELATE FLOW RATE, PIPE DIAMETER, FLUID PROPERTIES AND SAND PROPERTIES AND BED DEPOSIT DEPTH. TWO GROUPS HAVE PREVOUSLY WORKED ON MINIMUM FLOW NEEDED TO MOVE SOLID PARTICLES ONE IN OPEN CHANNELS THE OTHER IN PIPE. CALCULATING THE CRITICAL DEPOSIT VELOCITY IN PIPE BY FIVE EMPIRICAL FORMULAS SUGGESTS THAT THESE FORMULAS ARE VALID ONLY FOR THE DATA USED IN THEIR ESTABLISHMENT. A CORRELATION OF EXPERIMENTAL DATA FOR SAND TRANSPORT IS GIVEN.

42-68-03013 PROGRAM OF THE INTERNATIONAL SYMP ON SOLID-LIQUID FLOW IN PIPES AND ITS APPLICATION TO SOLID WASTE COLLECTION AND REMOVAL (FLOW-SOLID-LIQUIDS PUMPING-SOLID-LIQUIDS WASTE)
AMERICAN SOCIETY OF CIVIL ENGRS & PENN UNIV
PENN UNIV TOWNE HALL, MAR 4-6, 1968. THE SYMPOSIUM WAS A THREE DAY SESSION ON PUMPING, TREATMENT AND FLOW OF SOLID-LIQUID SYSTEMS. THERE WERE FORTY-THREE SPEAKERS FROM CANADA, CZECHOSLOVAKIA, FRANCE, GERMANY, ITALY, RUSSIA, TURKEY AND THE UNITED STATES. SOME PAPERS ARE ABSTRACTED SEPARATELY. SEE 42-68-03001.

42-68-09001 ECONOMIC TRANSPORT OF DIGESTED SLUDGE SLURRIES (HYDRAULIC-TRANSPORT SLURRY-PUMPING)
RAYNES, B. C. & RAND DEV CORP CLEVELAND
41ST ANNUAL CONFERENCE OF THE WATER POLLUTION CONTROL FEDERATION CONRAD HILTON HOTEL CHICAGO SEPT 22-27, 1968 (DRAFT OF UNPUBLISHED PAPER). PIPELINE TRANSPORT OF DIGESTED SEWAGE SLUDGE SLURRIES IS PREDICTED TO BE OF SUBSTANTIAL ECONOMIC BENEFIT TO SEWAGE TREATMENT PLANT OPERATIONS AS COMPARED WITH CONVENTIONAL PRACTICE OF FILTRATION AND SOLIDS INCINERATION. ECONOMIC DISPOSAL ON LAND AT CONSIDERABLE DISTANCES FROM THE ORIGINATING SEWAGE TREATMENT PLANT CAN BE COMBINED WITH RECLAMATION AND LAND RESTORATION AS AN ADDED BENEFIT AND AT LITTLE COST. AT SOLIDS CONCENTRATIONS ABOUT 5 PERCENT AND BELOW, DIGESTED SLUDGE SLURRIES ARE NEWTONIAN IN FLOW BEHAVIOR; ABOVE 5 PERCENT, THEY ARE BINGHAM IN NATURE. DILUTION TO THE NEWTONIAN REGION, WHERE NECESSARY, SHOULD BE THE MOST ECONOMICAL PROCEDURE DESPITE THE INCREASED VOLUME OF MATERIAL TO BE TRANSPORTED. THE QUANTITY OF DIGESTED SLUDGE AVAILABLE IN MANY TOWNS AND CITIES DICTATES THE CONSIDERATION OF THE USE OF RELATIVELY SMALL PIPELINE DIA.

42-69-02001 THE CURRENT STATE OF THE ART OF THE HYDRAULIC TRANSPORTATION OF SOLIDS IN PIPELINES (DESIGN)
CORNISH, E. C. & COLO SCHOOL OF MINES GOLDEN COLO
AMERICAN INSTITUTE OF MINING ENGINEERS, 1-43, FEB 17-20, 1969. TRANSPORTATION OF SOLIDS IN PIPELINES HAS SHOWN SOME SPECTACULAR SUCCESSES LIKE THE AMERICAN GILSONITE CO 72 MI 6 INCH PIPELINE IN UTAH AND COLORADO AND THE CONSOLIDATED COAL CO 108 MI 11 INCH PIPELINE IN OHIO. AFTER CONDUCTING A SERIES OF TESTS ON 6 AND 8 INCH PIPELINES WITH SOLIDS RANGING FROM IRON ORE CONCENTRATES TO CEMENT RAW MATERIALS, THE AUTHOR COMMENTS ON THE WORKABILITY OF THE THEORETICAL EQUATIONS THAT ARE AVAILABLE FOR DESIGNING SLURRY SYSTEMS. MOST THEORIES ARE BASED ON SOPHISTICATED ANALYSES OF LIMITED DATA ON SMALL SCALE (SINCE LARGE SCALE EQUIPMENT IS TOO EXPENSIVE AND TIME CONSUMING FOR MOST EXPERIMENTERS). THE VARIOUS FORMULAE ARE COMPARED AND EVALUATED. DATA FROM THE AUTHOR'S TESTS ARE ANALYZED AND COMPARED WITH THE THEORETICAL VALUES. AN EXTENSIVE LARGE SCALE TEST PROGRAM FOR THE DEVELOPMENT OF MORE RELIABLE DESIGN CRITERIA FOR SOLIDS PIPELINES IS PROPOSED.

42-69-10001 PNEUMATIC MATERIAL HANDLING BELOW-GROUND (MODERNIZATION ECONOMY FLEXIBITY)
BALL, D. G. & RADMARK ENG SALES LTD
SACRAMENTO STATE COLLEGE, CAL SECOND SYMP ON RAPID EXCAVATION, 5-1 TO 5-16, OCT 16, 1969. PNEUMATIC SYSTEM FLEXIBILITY WITH ABILITY TO CONVEY HORIZONTALLY, VERTICALLY AND AROUND BENDS MAKES IT A DESIRABLE TOOL FOR UNDERGROUND OPERATIONS WHERE MATERIAL HANDLING SYSTEMS NEED TO BE COMPACT AND MOVEABLE. AREAS WHERE IT CAN GREATLY INCREASE EFFICIENCY AND PRODUCTIVITY ARE: BACKFILLING, SPOIL REMOVAL, PNEUMATIC EXCAVATING, AND HOISTING. A CANADIAN MINING COMPANY AND A PNUEMATIC CONVEYING ORGANIZATION SPENT THREE YEARS DEVELOPING AN ECONOMICALLY OPERATING PNEUMATIC SYSTEM HANDLING 17,500 TONS OF 3 IN AND SMALLER MATERIAL IN 200 HOURS. COSTS AND SYSTEM DESIGN DETAILS ARE GIVEN OF THIS BACKFILLING OPERATION. A PNEUMATIC SYSTEM SHOULD BE IDEAL FOR TUNNEL BORING MACHINE SPOIL REMOVAL. PIPE SHOULD BE TWO LAYER WITH A VERY HARD INSIDE. A STUDY TO MOVE 200 TPH THRU 5,200 FT GAVE OPERATING COSTS OF $2.10 PER YARD FOR A PNEUMATIC SYSTEM AGAINST $4.60 PER YARD FOR A CONVENTIONAL SYSTEM. ITS SINGLE DISADVANTAGE IS IT'S NEW, BUT THE INDUSTRY NEEDS TO ADVANCE. FOR PNEUMATIC HOISTING THE ECONOMICS AND FLEXIBILITY OF SUCH A SYSTEM WILL BECOME MORE AND MORE EVIDENT AND THE SMALL MINE OR CONSTRUCTION PROJECT WILL HAVE NO ALTERNATIVE IF THEY ARE TO KEEP PACE WITH A CHANGING ECONOMY.

FIELD 43 GOVERNMENT REPORTS

43-59-00001 MINING & TRANSPORTING COAL UNDERGROUND BY HYDRAULIC METHODS: A LITERATURE SURVEY (RUSSIA NEW ZEALAND POLAND WEST GERMANY CZECHOSLOVAKIA GREAT BRITAIN)
BOYD, W. T. & U.S. BUR MINES
U.S. DEPART OF THE INTERIOR, BUR OF MINES INFORMATION CIRCULAR 7887, JULY 1959. IN 1935 DR. V. S. MUCHNIK OF LENINGRAD MINING INSTITUTE DESIGNED RUSSIA'S FIRST COMPLETE HYDRAULIC MINING SYSTEM. AN EXPERIMENTAL MINE WAS BUILT IN THE DONETS BASIN IN 1939 WHICH PRODUCED 6,000 METRIC TONS MONTHLY. AFTER WORLD WAR II HYDRAULIC MINING WAS INSTALLED IN TWO MORE RUSSIAN AREAS. RUSSIANS ARE DOING BASIC RESEARCH ON DETERMINING COAL HARDNESS, WATER PRESSURES AND CAPACITIES NEEDED TO BREAK AND TRANSPORT COAL, NOZZLE AND MONITOR DESIGNS, ROOF SUPPORTS AND COAL PUMPS. IN ANOTHER RUSSIAN MINE HAVING COAL WITH A HARDNESS OF 1.3 (PROTODYAKANOV SCALE) AND NO CRACKS OR FISSURES, PRESHOOTING WAS NECESSARY BEFORE THE COAL COULD BE MINED WITH 470 TO 588 PSI WATER PRESSURE, 69 UNDERGOUND HYDRAULIC MINING UNITS ARE SCHEDULED TO START IN THE RUSSIAN 1956-60 FIVE YEAR PLAN. IN NEW ZEALAND WATER HAS UNTIL RECENTLY BEEN USED ONLY FOR CONVEYING COAL. A NEW DEVELOPMENT PLANS BOTH HYDRAULIC MINING AND TRANSPORTATION. POLAND IS HYDRAULICALLY MINING COAL WITH 3,270 PSI WATER, WEST GERMANY WITH 2,940 PSI, CZECHOSLOVAKIA 588 PSI, GREAT BRITAIN 1,2000 PSI. THE FEDERAL BUREAU OF MINES PLANS TO CONDUCT A FIELD INVESTIGATION OF HYDRAULIC MINING. 33 PAGES.

FIELD 44 ARTICLES

44-60-03001 PIPELINE TRANSPORTATION OF CONCENTRATES (HYDRAULIC)
FRASER, D. A. & INT NICKEL CO OF CANADA
MINING CONGRESS JOURNAL, (46) 44-48, MAR. 1960. CAREFUL PILOT PLANT WORK WAS PERFORMED TO DETERMINE PIPE SIZE,

PUMPING STATION LOCATIONS AND POWER REQUIREMENTS PRIOR TO INSTALLING A HYDRAULIC TRANSPORT TO DELIVER 1800 TONS/DAY OF NICKEL CONCENTRATE OVER A 7 1/2 MILE DISTANCE. THE COMPLETED SYSTEM IS DESCRIBED.

44-62-09001 HYDRAULIC HOISTING OF COAL AND ORES (SLURRY-PUMPING-COSTS FRICTIONAL-HEAD-LOSS CONCENTRATION POWER)
CHAPUS, E. E. + CONDOLIOS, E. + COURATIN, P. & SOGREAH CO GRENOBLE FRANCE
MINING CONGRESS JOURNAL, 46-49, SEPT 1962. EXTENSIVE RESEARCH AND TEST PROGRAMS HAVE BEEN CARRIED OUT BY THE SOGREAH CO. THE HYDRAULIC HOISTING AND TRANSPORT PROJECTS HAVE PROVEN NOT ONLY FEASIBLE BUT OFFER A NUMBER OF ATTRACTIVE FEATURES SUCH AS SMALL SHAFT REQUIREMENTS, LOW INVESTMENT COSTS, LOWER OPERATING COSTS AND EASE OF COMBINING HOISTING WITH HORIZONTAL TRANSPORT. FRICTION HEADS FOR TRANSPORT SOLIDS, CONCENTRATION FACTOR, AND CALCULATIONS OF POWER REQUIREMENTS ARE ILLUSTRATED. A LOCK CHAMBER SYSTEM FOR TRANSFERRING SOLID MATERIAL FROM ATMOSPHERIC TO HIGH PRESSURES IS DESCRIBED AND SOLIDS UP TO 3 IN ARE HOISTED 590 FT. EXTENDING THEIR FINDINGS THEY EXPECT TO HOIST 200 TONS PER HOUR OF MINUS 4 IN COAL 1600 FT AT A COST OF 5 CENTS PER TON AND 300 TPH OF MINUS 1 1/4 IN COPPER ORE 2600 FT AT A COST OF 6.1 CENTS PER TON.

44-63-03001 PUMPING ORES UP VERTICAL SHAFTS (DESIGN TESTING FEED)
CONDOLIOS, E. + COURATIN, P. + CHAPUS, E. E. & SOGREAH CO GRENOBLE FRANCE
THE CANADIAN MINING AND METALLURGICAL BULLETIN, (56) 187-198, MAR 1963. HYDRAULIC HOISTING OFFERS ATTRACTIVE FEATURES OVER CONVENTIONAL HOISTING METHODS. THESE ARE SMALL SHAFT SPACE REQUIREMENTS, GREAT FLEXIBILITY OF LAYOUT, INCLUDING PICK-UP OR DELIVERY OF MATERIAL AT POINTS DISTANT FROM MINE SHAFT AND LOW INVESTMENT AND OPERATING COSTS. LIMITED PRACTICAL EXPERIENCE WITH THIS TYPE OF HOISTING DICTATES THAT CAREFUL DESIGN AND FREQUENTLY EXTENSIVE TESTING BE DONE BY COMPETENT ENGINEERS BEFORE LARGE SCALE INSTALLATIONS ARE BUILT. BASIC LAWS AND DESIGN CRITERIA FOR HYDRAULIC HOISTING INSTALLATIONS ARE GIVEN AND A COAL HOISTING INSTALLATION OPERATING SINCE 1960, HAVING A 600 FOOT VERTICAL LIFT AND AN ANNUAL CAPACITY OF 500,000 TONS OF LESS THAN 3 1/4 INCH COAL IS DESCRIBED. THE LOCK FEED SYSTEM USED FOR COAL CAN ALSO BE USED FOR ORES.

44-63-06001 TRANSPORTING SOLID MATERIALS IN PIPELINES (HYDRAULIC-TRANSPORT SLURRY-PUMPING)
CONDOLIOS, E. + CHAPUS, E. E. & SOGREAH CO GRENOBLE FRANCE
CHEMICAL ENGR., 93-98, JUNE 24, 1963. TESTS WERE CONDUCTED BY THE SOGREAH CO. OF GRENOBLE, FRANCE, TO DETERMINE THE BASIC HYDRAULIC CONDITIONS GOVERNING THE ECONOMIC OPERATION OF INDUSTRIAL PLANTS WITH EMPHASIS ON TRANSPORT VELOCITIES AND HEAD LOSSES IN THE HYDRAULIC TRANSPORT OF SOLID MATERIAL. THE WORK COVERED THE HYDRAULIC TRANSPORT OF A WIDE RANGE OF MATERIALS, FROM FINE PARTICLE TO COARSE. EXPERIMENTAL DATA, CALCULATIONS, AND GRAPHS ARE PRESENTED.

44-63-07001 DESIGNING SOLIDS-HANDLING PIPELINES (CRITICAL-VELOCITY CONCENTRATION SIZE DENSITY DURAND-CONDOLIOS)
CONDOLIOS, E. + CHAPUS, E. E. & SOGREAH CO GRENOBLE FRANCE
CHEMICAL ENGR., 131-138, JULY 8, 1963. ECONOMIC TRANSPORT CONDITIONS ARE ASSOCIATED WITH MATERIAL CONCENTRATION. IF CONCENTRATION IS TOO LOW TOO MUCH WATER IS CARRIED. IF TOO HIGH, YIELD VALUE BECOMES VERY LARGE, CONSIDERABLY INCREASING HEAD LOSSES. BESIDES THE SOLIDS CONCENTRATION AND CLEAR WATER HEAD LOSS TRANSPORT IS AFFECTED BY ANOTHER FACTOR WHICH IS A FUNCTION OF THE FROUDE NUMBER OF THE FLOW AND ALSO SIZE AND SPECIFIC GRAVITY OF THE SOLID MATERIAL. THIS RELATION CALLED THE DURAND-COLDOLIOS LAW HAS BEEN CHECKED FOR MIXTURES OF MATERIALS WITH WIDE GRAIN-SIZE DISTRIBUTION. THE CRITICAL DEPOSIT VELOCITY DETERMINES THE POINT OF ECONOMIC OPERATION AND WAS DETERMINED IN TWO DIFFERENT WAYS: BY DIRECT OBSERVATION OF THE INSTANT THE FAST PARTICLES DEPOSITED IN THE PIPE AND BY CAREFUL OBSERVATION OF THE DEPOSIT IN THE PIPE UNDER DEPOSIT-REGIME CONDITIONS. IN VERTICAL TRANSPORT, AFTER TAKING INTO ACCOUNT THE STATIC EFFECT DUE TO DIFFERENCES IN WEIGHT BETWEEN THE MIXTURE AND WATER, THE HEAD LOSSES ARE THE SAME AS THOSE FOR CLEAR WATER. SOGREAH CO. HAS PATENTED ADDING FINE MATERIAL TO COARSE TO REDUCE HEAD LOSS IN HORIZONTAL TRANSPORT. CAREFUL INSTALLATION STUDIES ARE REQUIRED TO DESIGN A STABLE OPERATION WITHOUT RISK OF OBSTRUCTION. SECOND OF A SERIES SO. OF THREE. SEE 44-63-06001 AND 44-63-07022.

44-63-07002 OPERATING SOLID PIPELINES (SLURRY-PUMPING DESIGN HYDRAULIC-TRANSPORT)
CONDOLIOS, E. + CHAPUS, E. E. & SOGREAH CO GRENOBLE FRANCE
CHEMICAL ENGR., 145-150, JULY 22, 1963. TWO CAUSES COULD INITIATE TRANSPORT INTERRUPTIONS, BLOCKAGE OF PIPE AND INSTABILITY OF THE FLOW REGIME. THE PIPE DIAM SHOULD BE EQUAL TO, OR GREATER THAN, 3 TIMES DIAM OF THE LARGEST PARTICLES, OR, IF A PUMP IS USED, THE MAXIMUM PARTICLE DIAM WOULD BE ONE-HALF THE SMALLEST CANAL DIMENSION. GRAVITY INSTALLATIONS HAVE THE LOWEST OPERATING COSTS; WATER-HAMMER AND CORROSION ARE AT A MINIMUM. IN PUMPING STATIONS HAVING CLEAR-WATER PUMPS, THE POSSIBILITY OF INTRODUCING THE MATERIALS DOWNSTREAM EXISTS. THE PUMPS CAN BE OF SINGLE- OR MULTIPLE-STAGE CENTRIFUGAL, PISTON OR MEMBRANE TYPES. THE ABRASION EFFECTS IN THE PIPES MAY BE DUE TO FRICTION OR SHOCK. ABNORMAL WEAR IS SOMETIMES FOUND, ESPECIALLY AT PIPE CONNECTING FLANGES. THIS INDICATES DISCONTINUITY IN THE FLOW PATTERN. THE REQUIREMENTS OF THE PUMP ARE: GOOD EFFICIENCY, ROBUSTNESS, EASE OF DISMANTLING, WEAR RESISTANCE. A DIAPHRAGM PUMP IS SUITED TO CONVEYING FINE PULPS AT LOW RATES, ITS WEAKNESS LIES IN THE VALVES. RECIPROCATING PUMPS EXCEL WITH HIGH-PRESSURE REQUIREMENTS, ABRASION IS A PROBLEM. CENTRIFUGAL PUMPS ARE MOST COMMON. PART 3 OF A SERIES.

44-63-08001 ECONOMY OF RAIL, CONVEYOR, AND HYDRAULIC TRANSPORTATION UNDERGROUND (COST-COMPARISON)
SMITH, E. L. + YOUNG, T. R. + KOCH, L. W. & COLO SCHOOL OF MINES GOLDEN COLO
MINING CONGRESS JOURNAL, 36-40, AUG 1963. COST COMPARISON FOR A HYPOTHETICAL MINE SHOWS THAT RAIL TRANSPORTATION PER TON OF COAL IS 36.8 CENTS WHILE CONVEYOR BELT TRANSPORTATION COST IS 37.7 CENTS AND HYDRAULIC MOVEMENT IS 38.4 CENTS. ALTHOUGH THERE ARE MANY UNCONTROLLABLE VARIABLES RAIL TRANSPORTATION SEEMS TO BE THE MOST ECONOMICAL.

44-64-01001 1,300 FEET CONVEYOR (CONTINUOUS-MINING MATERIAL-HANDLING)
SMITH, G. R.
CONSTRUCTION METHODS, 84-87, JAN 1964. CONTINUOUS MINING MACHINE USES A 1320 FEET CONVEYOR SYSTEM TO TRANSPORT MUCK. THE CONVEYOR PERMITS A SHIFT CREW TO DRILL 80 FT PER DAY AS COMPARED TO 45 FT PER DAY FOR A MUCK-CAR SYSTEM. CONCRETE LINING IS POURED ON A SECOND SHIFT.

44-64-02001 BEST MINES SHAFT-SINKING MACHINE DRAWS BEAD ON CONTINUOUS MUCKING (MATERIAL-HANDLING)
BOGERT, J. R.
METAL MINING AND PROCESSING, 41-43, FEB 1964. LEW HUELSDONK'S MUCKER-SKIP IS A PATENTED SHAFT SINKING TOOL THAT COMBINES MUCKING, LOADING, AND DRILLING INTO A SINGLE UNIT. AT A 42 DEGREE INCLINE WITH A SECTION OF 14 X 7 FEET THE MUCKER-SKIP AVERAGES 0.5 FEET PER MANSHIFT.

44-64-02002 SOLIDS IN PIPES (HYDRAULIC-TRANSPORT SLURRY SLUG-FLOW CAPSULES)
KOCH, L. W.
INTERNATIONAL SCIENCE AND TECHNOLOGY, 68-78, FEB. 1964. SOLIDS RANGING FROM 50 MICRONS TO SEVERAL INCHES IN DIA. CAN BE TRANSPORTED HYDRAULICALLY IF THE LIQUID MOVES FAST ENOUGH TO PREVENT SETTLING. FOR SLURRIES THAT SETTLE EASILY THERE IS A CRITICAL VELOCITY ABOVE WHICH A SUSPENSION IS OBTAINED. IN THESE HETEROGENOUS SYSTEMS PIPE FRICTION IS A MINIMUM. IN HOMOGENEOUS SLURRIES ENOUGH FINES ARE PRESENT TO IMPEDE THE SETTLING OF THE LARGER PARTICLES. IF PARTICLES BECOME TOO LARGE OR VELOCITY TOO LOW HOMOGENOUS SLURRIES BECOME HETEROGENEOUS OR SOLIDS DEPOSIT ON THE BOTTOM. POWER REQUIREMENTS ARE HIGH IN ALL THESE REGIMES. A NEW CONCEPT, SLUG OR CAPSULE PIPELINING, INTRODUCES SOLIDS AS LARGE COHERENT SEGMENTS OF THE MOVING STREAM. THEY MOVE FASTER THAN THE AVERAGE FLUID VELOCITY BUT CAN BE TRANSPORTED AT LOWER VELOCITY AND LOWER POWER COST THAN SOLIDS IN SUSPENSION.

44-64-09001 ROCK HANDLING IN HYDRAULIC MINES (SLURRY-PUMPING)
TOLKATSER, D. YA. + BORISENKO, L. D.
UGOL, N 9, 67-74, SEPT 1964. INVESTIGATION OF ECONOMIC EFFICIENCY OF SYSTEMS OF DISTRIBUTION AND TRANSPORTATION OF

ROCK UNDER CONDITIONS OF HYDRAULIC TRANSPORTATION AND LIFT OF WASTE ROCK. STOWAGE OF WASTE ROCK IN HYDRAULIC MINES. (IN RUSSIAN)

44-64-09002 HYDRAULIC TRANSPORT IN HYDROMINES AND MEANS OF IMPROVING (PIPELINES)
SMOLDYREV, A. E.
UGOL, (39) N 9, 93-6, SEPT 1964. THE EFFICIENT DEVELOPMENT OF HYDRAULIC COAL MINING DEPENDS ON PROVIDING EFFECTIVE TRANSPORT FOR PRODUCTIONS OF UP TO 25,000 TON/DAY AND DISTANCES OF HUNDREDS OF KILOMETERS. HYDRAULIC TRANSPORT EQUIPMENT HAS BEEN DEVELOPED TO CREATE HEADS OF 350 TO 500 M WITH CAPACITY OF 2000 CU M/HR. THE IMPROVEMENTS CAN BE MADE BY INCREASING THE WEAR RESISTANCE OF EQUIPMENT AND BY MATCHING THE NEW EQUIPMENT WITH NEW SYSTEMS TO GIVE MOST EFFICIENT OPERATION.

44-64-09003 NEW MATERIALS HANDLING METHODS FOR EFFICIENT SHAFT SINKING (SOUTH-AFRICA COST SINKING-RATE FREEZING SAFETY)
SCHWARTZ, D. M. + ENGLAND, J. & EIMCO CORP
SOCIETY OF AUTOMOTIVE ENGINEERS, PAPER 904A, 1-9, SEPT 14-17, 1964. SINCE THE END OF WORLD WAR II, A GREAT TRANSITION HAS TAKEN IN SHAFT SINKING. PRIOR TO THAT TIME VIRTUALLY ALL MUCKING WAS DONE BY HAND LABORERS. TO INCREASE SINKING RATE AND DECREASE COST, MECHANICAL LOADERS, CLAMSHELL SHOVELS, AND GRAB EQUIPMENT ARE USED EXTENSIVELY. SOUTH AFRICANS HAVE SUNK MORE AND DEEPER SHAFTS THAN ANYONE ELSE AND WORKING WITH THEIR TWO STAGE SINKING OUTFITS THEY HAVE THE SHAFT SINKING RECORD. SOME NEWER TECHNIQUES UTILIZE CRAWLER-MOUNTED, DIESEL POWERED FRONT END LOADERS AND TRACTOR DOZERS OR AIR POWERED, CRAWLER-MOUNTED OVERHEAD DISCHARGE LOADERS. COST COMPARISONS GIVEN FOR VARIOUS SHAFT SINKING METHODS.

44-65-01001 APPLICATION OF ISOTOPES IN INVESTIGATIONS OF THE FLOW OF AQUEOUS MIXTURES (SLURRY-PUMPING MATERIALS-HANDLING)
JURKIEWICZ, L. + KORBEL, K. + PRZEWLOCKI, K.
ARCHIWUM GORNICTWA, (10) N 1, 91-106, JAN 1965. PROBLEMS CONNECTED WITH THE MEASUREMENTS OF FLOW PARAMETERS IN WATER MIXTURES (SLURRIES) ARE DISCUSSED. ALL TESTS WERE PERFORMED IN A MINE. THE AUTHORS NOTICED A BOTTOM DEPOSIT AT A VELOCITY OF 3 M/SEC. IN ORDER TO CHARACTERIZE THE FLOW THEY SUGGEST A NEW NOTION OF THE "RATIONAL VELOCITY" I.E., SUCH A VELOCITY AT WHICH HEAD LOSSES PER UNIT VOLUME OF THE TRANSPORTED SOLIDS ATTAIN THEIR MINIMUM. (IN RUSSIAN).

44-65-02001 COMPARATIVE COST OF HANDLING MATERIALS WITH DRIVERLESS TRACTOR-TRAILER TRAINS (MATERIALS-HANDLING RAIL SYSTEMS AUTOMATION ELECTRONIC-GUIDANCE)
REAGAN, C. H. & UNION BAG-CAMP PAPER CO SAV GA
TECH. ASSN OF THE PULP AND PAPER INDUSTRY, (28) N 2, 44A-46A, FEB 1965. A DRIVERLESS TRACTOR-TRAILER SYSTEM IS COMPARED ECONOMICALLY WITH OTHER MATERIALS HANDLING METHODS. IN AN EXAMPLE OF 400 TONS PER DAY TO A WAREHOUSE 1000 FEET AWAY THE TRACTOR-TRAILER WAS THE MOST ATTRACTIVE METHOD. SYSTEM USES EITHER A MAGNETIC OR OPTICAL GUIDANCE SYSTEM.

44-65-03001 SLUSHER TRAIN ADAPTS TO GROUND (MATERIALS-HANDLING)
RUSSELL, J. K. & GEORGE M. PHILPOTT CO
WESTERN CONSTRUCTION, 88, 90, 92, MAR 1965. A TRAIN LOADER AND SLUSHER COMBINATION PROVIDES, WITH A LONG ONE-PIECE CAR, THE FLEXIBILITY NEEDED IN THE TEHACHAPI EXPLORATORY TUNNEL. AN 8-TON PLYMOUTH DIESEL LOCOMOTIVE IS USED TO DRAW THE SLUSHER. HOWEVER, THE SLUSHER WAS NOT ADEQUATE, AND A MODEL 12-B EIMCO LOADER WAS ADDED. THE TRAIN VIRTUALLY FILLS THE 6' X 8' TUNNEL AND FREQUENTLY STRIKES SIDE TIMBERS.

44-65-03002 HYDRAULIC RIG SETS STEEL FOR HIGH-UP TUNNEL ROOF (AIR-MOTOR HYDRAULIC-WRIST)
DEMARCO, P. G. & MCLEAN GROVE SHEPHERD CO
CONSTRUCTION METHODS, (47) N 3, 103-105, MAR. 1965. TO ERECT 33 AND 36 IN. WIDE FLANGE ROOF BEAMS IN THE 6TH AVE SUBWAY TUNNEL IN NEW YORK CITY, A HYDRAULIC WRIST WAS DESIGNED. NEW YORK STATE PROHIBITS OPERATION OF INTERNAL COMBUSTION ENGINES UNDERGROUND SO THE AUSTIN-WESTERN 410 P HYDRAULIC CRANE WAS ORDERED WITHOUT ITS 100 HP GASOLINE FUELED PRIME MOVER. THE BIGGEST AVAILABLE 23 HP AIR MOTOR WAS USED TO POWER THE VICKERS PUMPS WHICH SUPPLIED A 1,200 PSI SYSTEM AND A 3,000 PSI SYSTEM. HAND AND LOAD ARE RAISED TO THE WRIST RECTANGULAR SOCKET WITH A SERIES OF SHEAVES AND PINNED THERE. THE HYDRAULIC WRIST NOW PLACES THE STEEL FOR COLUMN CONNECTIONS TO BE MADE. ERECTION CYCLE IS 5 MIN. AS COMPARED TO THE USUAL METHOD TAKING A COUPLE OF HOURS.

44-65-04001 AIR CUSHION HANDLING DEVICES FOR HORIZONTAL MOVEMENT OF MATERIAL (MATERIALS-HANDLING AIR-IN-PALLET SYSTEM)
WALTERS, J. & CLARK EQUIPMENT CO
IRON AND STEEL ENGINEER, 153-155, APRIL 1965. AIR FILM ELIMINATES FRICTION BETWEEN MACHINE AND SURFACE. SMALL WHEELS CAN BE USED FOR GUIDANCE PURPOSES AND TO PULL ON 3-4 PERCENT SLOPES. LARGER SLOPES REQUIRE ADDITIONAL POWER. FOR A 12,000 LB. UNIT, 50-100 CFM OF AIR ARE REQUIRED.

44-65-05001 NEW CONTINUOUS HAULAGE SYSTEM PACES PRODUCTION GAINS AT B & Z
FLOWERS, A. E. & COAL AGE
COAL AGE, (70) 68-74, MAY 1965. BELL AND ZOLLERS ZEIGLER NO 4 MINE AT JOHNSTON CITY, ILL. AFTER SOME 10 MONTHS EXPERIMENTING WITH CONTINUOUS MINING WITH A MOBILE-BRIDGE BELT-CONVEYOR SYSTEM HAS PERFECTED ITS CONTINUOUS HAULAGE SYSTEM AND PRODUCES OUTPUT PEAKS OF 300 TONS/HR.

44-65-06001 HYDRAULIC TRANSPORTATION OF ROCKS USING CHARGING DEVICES
KORZHAEV, S. A. + KODOLOV, O. M. + SELIVANOV, YU. I.
UGOL, N 6, 27-30, JUNE 1965. DEVICES TO INTRODUCE SOLIDS DIRECTLY INTO HYDRAULIC STREAM WERE DEVELOPED. A DEVICE IN WHICH ROCK FRAGMENTS ARE PICKED UP BY ASCENDING FLOW OF WATER AND EQUIPPED WITH CONTROLLING, THROTTLING VALVE PERFORMED WELL. (IN RUSSIAN)

44-65-07001 REMOTELY-CONTROLLED COAL MINE (MATERIALS-HANDLING AUTOMATION)
ADCOCK, W. J. & NATIONAL COAL BOARD ENGLAND
THE ENGINEER, 79-80, JULY 16, 1965. ABOUT 93 PERCENT OF THE UNITED KINGDOM'S DEEPMINED COAL IS TAKEN FROM LONGWALL FACES WITH HIGHLY MECHANIZED EQUIPMENT. FUTURE FACES WILL BE ALMOST ENTIRELY AUTOMATED WITH CONTROL CONSOLES AT STRATEGIC POINTS AND A MAIN CONSOLE ON THE SURFACE. TRANSPORT OF MINED COAL FROM FACE TO SURFACE WILL BE BY MEANS OF CONVEYORS.

44-65-10001 LONG DISTANCE CONVEYING OF SOLIDS BY PIPELINE (CAPSULES CANADA)
NESBITT, E. T.
CANADIAN PIT AND QUARRY, 24, OCT. 1965. THE RESEARCH COUNCIL OF THE PROVINCE OF ALBERTA DISPLAYED A WORKING MODEL OF THEIR CAPSULE PIPELINING SYSTEM AT THE PACIFIC NATIONAL EXHIBITION IN VANCONVER B.C. MANY KINDS OF MATERIAL CAN BE TRANSPORTED PRACTICALLY UNLIMITED DISTANCES BY USING BOOSTER PUMPING STATIONS. IT IS CLAIMED THAT THE METHOD TRANSPORTS SOLIDS FASTER AND MORE ECONOMICALLY THAN RAIL OR TRUCK.

44-65-11001 THE MATERIAL-HANDLING COMPLEX FOR CONSTRUCTION OF OROVILLE DAM (BELT-CONVEYORS RAILROAD)
HANSEN, J. A. & MCDOWELL-WELLMAN ENGR, CLEVELAND
IEEE TRANS ON INDUSTRY AND GENERAL APPLICATIONS, IGA-1, (6) 417-422, NOV/DEC 1965. A COMPLEX OF MATERIAL-HANDLING MACHINERY IS EMPLOYED IN A UNIQUE MANNER TO MOVE 77.5 MILLION CUBIC YARDS OF ROCK AND DIRT 12 MILES UP THE FEATHER RIVER. THE HEART OF THE SYSTEM IS A GIANT WHEEL EXCAVATOR, WHICH FILLS A 110-TON RAILROAD CAR EVERY MINUTE. FROM THE

WHEEL, THE MATERIAL IS TAKEN VIA BELT CONVEYORS AND A RAILROAD TO A STOCKPILE LOCATED NEAR THE DAM SITE. HERE IT IS PLACED ON A STORAGE PILE, SEGREGATED INTO PERVIOUS, IMPERVIOUS, AND SAND PILES, WHERE IT IS RECLAIMED IN THE PROPER MIXTURES TO SATISFY THE PLACEMENT PLAN. THE FEATURES OF THE MACHINERY AND THE SYSTEM AS A WHOLE ARE DESCRIBED, AND SOME OF THE PROBLEMS ENCOUNTERED AND THEIR SOLUTIONS ARE INCLUDED.

44-66-04001 DESIGN OF SLURRY DISTRIBUTION MANIFOLDS (MODEL ENERGY-EQUATION)
TURTON, R. K. & LONGHBOROUGH COLLEGE
THE ENGINEER, (21) 641-643, APR 29, 1966. MANIFOLD DESIGN TO DISTRIBUTE EQUAL QUANTITIES OF COAL SLURRY TO A BATTERY OF SIX CYCLONE TYPE SEPARATORS WAS STUDIED AND EXPERIMENTAL WORK PERFORMED ON A MODEL MANIFOLD USING BOTH WATER AND SLURRY. IT WAS SHOWN THAT A TECHNIQUE BASED UPON MODIFICATION OF THE GENERAL ENERGY EQUATION USING PUBLISHED DATA FOR HEAD LOSSES IN PIPE SYSTEMS, RESULTS IN A MANIFOLD DESIGN WHICH SATISFIES THE SPECIFIED REQUIREMENTS FOR SLURRY DISTRIBUTION. THE TESTS HOWEVER WERE ON A MODEL AND A FULL-SCALE LAYOUT SUPPLYING CYCLONES WOULD BE NEEDED TO COMPLETELY SUBSTANTIATE THE DESCRIBED APPROACH.

44-66-09001 ENGINEERED CONVEYORS CAN DO THE IMPOSSIBLE (MATERIALS-HANDLING)
FRANK, J.
MILL AND FACTORY, (79) 60-63, SEPT. 1966. THE OBJECTIVE OF AN ENGINEERED CONVEYOR SYSTEM IS TO INTEGRATE VARIOUS MATERIAL HANDLING EQUIPMENT TO CONTROL THE MATERIAL FLOW SO THAT NEITHER GAPS NOR BUILDUPS OCCUR IN PRODUCTION OR SECONDARY LINES. CURRENTLY THE TREND IS TOWARD PARTIAL OR COMPLETE AUTOMATION. THE END RESULTS OF A WELL-ENGINEERED MATERIAL HANDLING SYSTEM CAN BE MEASURED IN LOWER HANDLING COSTS, AND IN DOLLAR SAVINGS FROM WELL-INTEGRATED PRODUCTION, ASSEMBLY, AND WAREHOUSING OPERATIONS. THE SYSTEM CAN BE AS UNCONVENTIONAL AS MONEY CAN MAKE IT. THANKS TO MODULAR LAYOUT, CAPACITY CAN BE EXPANDED TO MEET NEEDS FOR YEARS IN THE FUTURE WITH ALMOST NO MORE IMMEDIATE INVESTMENT THAN IS NECESSARY FOR CURRENT PRODUCTION. SPECIAL CONTROLS AVAILABLE INCLUDE: AUTOMATIC DISPATCH, AUTOMATIC PICKUP AND DELIVERY, LIVE ROLLER TURNTABLE, REVOLVING TURNTABLE, UPENDERS AND DOWN-ENDERS, ROLLOVERS, PRESSLOADERS, DRUM CONTROLLERS, MOTOR-OPERATED DEFLECTORS, TRAFFIC CONTROLLERS, PUSHBUTTON SELECTORS, AND RIGHT-ANGLE PUSHERS.

44-66-10001 SHAFT HOISTING EQUIPMENT FOR A TUNNEL CONSTRUCTION PROJECT (BUNKER CHUTE AUTOMATIC-DUMPING)
GRONEBAUM, R. &
FOERDERN U HEBEN, (16) N 10, 782-784, OCT. 1966. IN CONSTRUCTING A 15.5 MI LONG IRRIGATION TUNNEL IN A MIDDLE EASTERN COUNTRY HOISTING EQUIPMENT WAS INSTALLED TO FURNISH TWO NEW SITES FOR ADVANCING. A COMBINED SKIP-FRAME WINDING OFFERED A SOLUTION REQUIRING A MINIMUM EXPENDITURE FOR MECHANICAL EQUIPMENT AND STEEL STRUCTURES. THE PRINCIPLES ARE: COMBINATION OF SKIP AND FRAME; SIMPLE CHUTE LOADING INSTALLATION WITH CONSISTENT MINE CAR AND SKIP CAPACITY; SKIP UNLOADING INTO BUNKER ADJACENT TO SHAFT; ALL MECHANICAL INSTALLATIONS AND STEEL STRUCTURES ARE A MINIMUM. VERTICAL DISTANCE BETWEEN TUNNEL FLOOR AND SURFACE IS 65 METERS. HANDLES 52 TONS PER HR.

44-67-03001 PREVIEW OF THE PRACTICAL ONES - TODAY'S ANSWER TO TOMORROW'S MINING EQUIPMENT PROBLEMS (TRANSPORTATION MATERIALS-HANDLING)
TUOMI, W. E. & U.S. STEEL CORP PITTSBURGH PA
MINING ENGINEERING, 68-71, MAR. 1967. THE MINING INDUSTRY MUST DEVELOP MORE EFFICIENT METHODS OF EXTRACTION, HANDLING, AND UPGRADING. SOME NEW IDEAS BEING CONSIDERED: THE ROLL-OVER BUCKET LOADER IS USED FOR HIGHLY EFFICIENT PRODUCTION LOADING. ITS PROPOSED 7-10 CU-YD BUCKET IS CAPABLE OF PICKING UP 20-30 TONS OF HIGH BULK DENSITY MATERIAL. THE BUCKET TRAVELS IN A FREE-UPWARD, ELLIPTICAL PATH BY MEANS OF THE LINKAGE OF THE LIFTING ARMS AND THE HYDRAULIC CYLINDER ARRANGEMENT. A BATTERY-POWERED SHUTTLE CAR FILLS THE NEED FOR AN UNDERGROUND MATERIAL HAULAGE VEHICLE HAVING NO LIMITATIONS ON MANEUVERABILITY. INCREASED ENERGY CAPACITY AND REDUCTIONS IN BATTERY WEIGHTS ARE ITS RESULTS. IT AIMS TO ATTAIN GREATER FLEXIBILITY, PERMIT FEWER TRANSFER POINTS, HAVE LOWER INITIAL COSTS AND OPERATING EXPENSE, AND TO PROVIDE GREATER FACILITY FOR SUPPLY HANDLING. HIGH RATIO OF PAYLOAD TO WEIGHT EXISTS. IN THE TWIN-MAST BLAST HOLE DRILL RIG, EFFICIENCY IS THE OBJECTIVE. BY REDUCING MOVING TIME, SETUP TIME AND CREW REQUIREMENTS, A MINOR INCREASE IN CAPITAL INVESTMENT CAN BE OFFSET BY MAJOR INCREASE IN PRODUCTIVITY. IT CONSISTS OF TWO MASTS MOUNTED ON EXTENSIBLE DRILLING PLATFORMS. IT ALSO FEATURES AUTOMATIC ROD AND BIT CHANGING. IT INCORPORATES SENSING DEVICES, A HUMAN ENGINEERED CONTROL SYSTEM, ENVIRONMENTAL CAB CONTROL, PRESSURIZED ENGINE COMPARTMENT AND AUTOMATIC LEVELING DEVICES. THE HIGH-SPEED, HIGH-CAPACITY MATERIALS HAULAGE SYSTEM IS DESIGNED FOR MOVEMENT OF ORE AND WASTE ROCK OVER DISTANCES EXCEEDING THE ECONOMIC LIMITS OF TRUCK HAULAGE. IT COMBINES BOTH RAIL AND TRUCK ASSETS, BUT ELIMINATES LOAD TRANSFER (INTERMEDIATE) AND THUS MANPOWER REQUIREMENTS ARE REDUCED. THE SYSTEM IS OPERATED BY A PRIME MOVER. THE USEFULNESS OF THE SYSTEM IS DEPENDENT UPON THE STRUCTURAL DESIGN OF THE HAULAGE TRAILER WHICH WILL BE SUBJECTED TO EXTREME LOADING CONDITIONS.

44-67-05001 NEW TRENDS IN SOLIDS PIPELINES (MATERIALS-HANDLING SLURRIES SOLIDS-PUMPING PIPELINES)
CONDOLIOS, E. + CHAPUS, E. E. + CONSTANS, J. A. & SOGREAH CO GRENOBLE FRANCE
CHEMICAL ENGR., 131-138, MAY 8, 1965. ADVANTAGES OF SOLIDS PIPELINES ARE EXCELLENT CAPACITY/ SPACE RATIO, EASE OF DIRECTION CHANGES, AND LAYOUT FLEXIBILITY. HOWEVER, DIFFICULTIES ARISE WHEN MATERIAL OTHER THAN THAT FOR WHICH THE SYSTEM WAS DESIGNED ARE TRANSPORTED. TWO MAIN TYPES OF SOLIDS MIXTURES TRANSPORTED ARE HOMOGENEOUS AND HETEROGENEOUS. HOMOGENEOUS SOLIDS AT A GIVEN CONCENTRATION CAN BE TRANSPORTED AT A VELOCITY WHICH INSURES AGAINST SOLIDS DEPOSITION. HETEROGENEOUS SOLIDS PRESENT ABRASION PROBLEMS. FOR HOMOGENEOUS MATERIAL 100 TONS/HR USES .08-.13 KW/TON-MI. WHILE FOR HETEROGENEOUS MATERIAL THE USAGES MAY BE 4-7 KW/TON-MI.

44-67-06001 THE CASE FOR TOWER-MOUNTED FRICTION HOISTS (DRUM-HOISTS MOTORS MOTOR-VENTILATION ROPING)
TILEY, G. L. & CANADIAN WESTINGHOUSE CO
ENGINEERING AND MINING JOURNAL, 1967, GUIDEBOOK-UNDERGROUND MINING, 177-182, JUNE 1967. PRODUCTION AND SERVICE HOISTS ARE USUALLY THE LARGEST AND MOST EXPENSIVE MACHINES ON A MINE BUT THEY RAPELY ACCOUNT FOR 2 PERCENT OF THE INITIAL CAPITAL INVESTMENT. THEREFORE, MARGINAL DESIGN IS NOT GOOD ECONOMY DUE TO BOTH DOWNTIME AND FUTURE EXPANSION. FRICTION HOISTS HAVE FOUR MAIN ADVANTAGES OVER DRUM HOISTS. THESE ARE: THEIR SIMPLICITY MEANS GREATER RELIABILITY, THEY ARE OUT OF THE WAY ABOVE THE SHAFT, THEIR MODIFICATION TO MEET INCREASED PRODUCTION CAN BE MORE READILY HANDLED AND THEIR ROPES CAN BE MORE EASILY ARRANGED TO PREVENT TORSIONAL REACTION AT THE CONVEYANCE. ALSO FRICTION HOISTS HAVE MANY MORE MONITORING AND SAFETY DEVICES THAN DRUM HOISTS. ALSO DISCUSSED ARE: AC AND DC DRIVES, GEARED OR DIRECT COUPLED MOTORS, NATURAL OR FORCED VENTILATION, WHEELS, SHAFT AND BEARINGS, ROPING THE HOIST, LUBRICANT AND MAINTENANCE.

44-67-06002 CONVEYORS FOR MINING - A BASIC GUIDE FOR SPECIFICATIONS AND HARDWARE (BELT-CONVEYORS)
WESTINGHOUSE AIR BRAKE
ENGINEERING AND MINING JOURNAL, 1967, GUIDEBOOK-CONVEYORS FOR MINING, 183-185, JUNE 1967. A BASIC GUIDE FOR SPECIFICATIONS AND HARDWARE FOR CONVEYORS FOR MINING GIVES THREE PAGES OF TABLES AND DIAGRAMS FOR JUST A SAMPLING OF A WELL-PLANNED INTRODUCTION TO BELT CONCEPTS AND APPLICATIONS.

44-67-06003 WEIGHING ARRANGEMENTS-A SYSTEMS REVIEW
BIERMAN, R. J. & RAMSEY ENGR CO
ENGINEERING AND MINING JOURNAL, 1967, GUIDEBOOK-CONVEYORS FOR MINING, 186, JUNE 1967. WEIGHING ARRANGEMENTS FOR BELT CONVEYORS ARE AUTOMATIC RECORDING AND TEMPERATURE COMPENSATED OF THE MECHANICAL, ELECTRICAL, ELECTRONIC, HYDRAULIC, PNEUMATIC OR NUCLEAR TYPE. TEN MANUFACTURERS OF BELT CONVEYOR WEIGHING DEVICES ARE GIVEN

44-67-06004 PORTABLE MODULE SYSTEMS FOR OPEN PITS (ALTERATIONS INVENTORY STANDARDIZATION)
YU, A. T. & W SOUTH AM OVERSEAS CORP
ENGINEERING AND MINING JOURNAL, 1967, GUIDEBOOK-CONVEYOR FOR MINING, 187-191, JUNE 1967. MODULE SYSTEM IS UNITIZING COMPONENTS PRIOR TO ASSEMBLY. WHEREVER SPACE BECOMES A PROBLEM MOBILE MODULE UNITS HAVE TURNED OUT TO BE AN IDEAL SOLUTION. THE FLEXIBILITY AND SIMPLICITY OF UNITS EASES PLANT ALTERATIONS. BENEFICATION PLANTS BELT CONVEYORS,

FEEDERS, SCREENS AND OTHER COMPONENTS HAVE BEEN STANDARDIZED REDUCING SPARE PARTS INVENTORY AND FACILITATING INTERCHANGEABILITY.

44-67-06005 TRUCKS VS BELTS - THE HAULAGE WAR (CONVEYORS OPERATING-COSTS OVERHEAD-COSTS PRECRUSHERS TRUCKS OPEN-PIT)
WEISS, H. & WESERHUTT OTTO WOLFF
ENGINEERING AND MINING JOURNAL, 1967, GUIDEBOOK-CONVEYORS FOR MINING, 192-197, JUNE 1967. STANDARD OPEN PIT OPERATION WAS LOAD, HAUL, CRUSH. A NEW METHOD, MOBILE PRECRUSH, CHANGES THIS TO CRUSH, LOAD, HAUL. CONVEYING BY BELT WAS IMPRACTICAL IN THE OLD METHOD BUT IS NOT ONLY PRACTICAL BUT ECONOMICAL IN THE NEW. DETAILED COST FIGURES ARE GIVEN FOR TRUCKS AND CONVEYORS. SOME COSTS ESPECIALLY REPAIRS, OVERHEAD AND RISK CAN VARY GREATLY. WITH THE GREAT COST DIFFERENTIAL IN FAVOR OF BELT HAULAGE, USING PRECRUSHING AND REPLACING TRUCK HAULAGE BY BELT WILL BRING SUBSTANTIAL ADVANTAGES IN ALL EXTRACTION OPERATIONS. RISING LABOR COSTS MAKE CONVEYORS OVER TRUCKS ALL THE MORE FAVORABLE.

44-67-06006 COMPUTERIZED DESIGN OF BELT SYSTEMS (CONVEYOR-BELTS FLEXURE SPEED WIDTH TENSION)
SWANK, J. L. + VERNER, W. J. & OHIO STATE UNIV
ENGINEERING AND MINING JOURNAL, 1967, GUIDEBOOK-CONVEYORS FOR MINING, 198-200, JUNE 1967. IN NORMAL CONVEYOR BELT CALCULATIONS A BELT WIDTH IS ASSUMED AND THE SPEED CALCULATED TO DELIVER THE REQUIRED QUANTITY OF MATERIAL. TENSION AND FLEXURE CRITERIA WILL DETERMINE IF A STANDARD PLY AND WEIGHT WILL MEET THESE REQUIREMENTS. IF A STANDARD BELT IS NOT AVAILABLE A NEW BELT WIDTH IS ASSUMED AND THE CALCULATIONS REPEATED. BY COMPUTERIZING THESE FIGURES ALL THE POSSIBLE BELT WIDTHS TO MEET THE REQUIREMENTS CAN BE OBTAINED AND THESE ARE COMPARED AS TO INITIAL COST AND OPERATING COST TO MAKE A FINAL DECISION. COMPUTER CALCULATIONS ARE FASTER AND MORE ACCURATE. FIXTURE REFINEMENTS CAN BE INTRODUCED INTO A COMPUTER PROGRAM.

44-67-12001 TRANSPORTATION FROM A LONGWALL FACE (MATERIALS-HANDLING CONVEYORS)
WATSON, B. & BETHLEHEM MINES CORP
MINING CONGRESS JOURNAL, 53, 28-32, DEC 1967. TO COMPETE WITH CONTINUOUS MINERS AND BORERS, A LONGWALL SECTION MUST AVERAGE 1,000 TONS PER SHIFT THROUGHOUT ITS LIFETIME. THE CONVEYOR SYSTEM PRESENTS NUMEROUS PROBLEMS SUCH AS STALLING, EXCESSIVE WEAR, AND CLOGGING. PROJECTED TONNAGE ON FUTURE LONGWALLS IS 1 1/2 MILLION TONS WITH A PAN LIFE OF 3/4 MILLION TONS. GOAL IS 600 TONS PER HOUR WITH AVAILABLE EQUIPMENT.

44-68-03001 CHINO PUTS ELECTRIC WHEEL TRUCK ON TROLLEY LINE (MATERIALS-HANDLING)
SCHMIDT, D. W. + SHUSTER, J. W.
MINING ENGINEERING, 53-54, MAR 1968. CHINO HAS MODIFIED OPERATION OF 100-TON CAPACITY ELECTRIC WHEEL DRIVE TRUCKS ON 7 PERCENT ADVERSE GRADE ROADWAYS BY SUSPENDING TROLLEY LINES ABOVE THE ROAD FOR 1300 FEET. A SWITCH ON THE DASHBOARD, WHEN SWITCHED TO DIESEL-TROLLEY MODE CAUSED AUTOMATIC SWITCHOVER WHEN CONTACT IS MADE OR LOST WITH THE TROLLEY WIRES WITHOUT INTERRUPTION OF POWER TO THE DRIVE MOTORS. A FLEET OF 100-TON TRUCKS HAULING 14 MILLION TONS PER YEAR OVER A 12,000-FT. ROAD WITH 7 PERCENT GRADES PRODUCED REASONABLE SAVINGS IN DIRECT HAULAGE COSTS OF APPROXIMATELY 12 PERCENT WHICH OFFSET THE CAPITAL REQUIRED FOR TRUCK MODIFICATION AND ELECTRIFICATION.

44-68-04001 ROPE SIDE FRAMED CONVEYORS (MATERIALS-HANDLING BRITISH-MINES)
CLARK, D.
COLLIERY GUARDIAN, (216) N 5579, 350-8, APRIL 1968. SURVEY OF RECENT DEVELOPMENTS ACCOMPLISHED IN BRITISH MINES, IN DESIGN AND OPERATION OF ROPE SIDE FRAMED CONVEYORS COMPRISES CHANGES OF BASIC DESIGN NATURE AS WELL AS THOSE MEETING REQUIREMENTS OF SPECIAL APPLICATIONS. DEVICES DESIGNED TO IMPROVE BELT CONTROL AND CHANGES IN DESIGN OF RETURN ROLLER ARE DISCUSSED. APPLICATION OF SYSTEM FOR CONVEYING MEN OR MATERIALS, AND EXAMPLES OF SUSPENSION BRIDGE CONVEYORS ARE DESCRIBED.

44-68-08001 CONTINUOUS MINING AT PAWNEE (SHUTTLE-CARS)
WHITLOW, C. R. & PEABODY COAL CO PAWNEE ILL
MINING CONGRESS JOURNAL, 58-60, AUG 1968. AT THE PEABODY COAL CO. MINE NO 10 IN PAWNEE, ILL. COAL IS DUMPED BY 10SC SHUTTLE CARS ON THE TAIL OF 36-IN BELTS OR IN LOADING HEADS. THESE LOADING HEADS MAKE MOVING AND SETTING UP EASIER, AND HELP TO LAYER LOAD THE COAL WITH LESS SPILLAGE. THE MINE HAS LIMITED TRACK HAULAGE WITH SPECIALLY DESIGNED CARS. MOST OF THE BULK SUPPLIES ARE HANDLED IN PACKAGED UNITS; THESE READILY LEND THEMSELVES TO MATERIAL HANDLING EQUIPMENT. MOST OF THE COAL IS PRODUCED BY CONVENTIONAL TRACKLESS MINING EQUIPMENT. THE MINERS RUN THREE SHIFTS A DAY, FIVE DAYS A WEEK. MAINTENANCE, GREASING AND SERVICING ARE DONE BETWEEN SHIFTS. THE ONLY IDLE TIME IS WHEN THE BELT IS BEING SHORTENED OR EXTENDED. ONE OF THE UNDESIRABLE FEATURES OF CONTINUOUS MINERS IS THE FINE COAL PRODUCED. THE JOY 8 CM WORKS WELL IN BOTH GOOD AND BAD TOP CONDITIONS. WHILE AVERAGE TONNAGE IS CONSEQUENTLY LOWER, AVERAGE DOWNTIME IS LESS. THE NEW JEFFREY 120 HAS SEVERAL GOOD FEATURES: (1) SUMPS AND CUTS FASTER THAN THE OTHER MINERS; (2) NO OSCILLATION; (3) AUGER ENDS EXTEND OUT WITH HYDRAULIC JACKS; (4) HYDRAULIC SYSTEM IS LOW PRESSURE; (5) HAS THREE TRAMMING SPEEDS; (6) LOW TRAM SPEED IS HYDRAULIC OTHERS MECHANICAL; (7) HIGH TRAM SPEED IS 120 FPM. THE 8 CM CUTS 6.75 PERCENT LESS FINE COAL THAN THE 120 AND 8.38 PCT. LESS THAN 4SE.

44-68-08002 SEDIMENT TRANSPORT IN CONVEYANCE SYSTEMS PART 1 A PHYSICAL MODEL FOR SEDIMENT TRANSPORT IN CONVEYANCE SYSTEMS (HYDRAULIC-TRANSPORT SLURRY-PUMPING)
GRAF, W. H. + ACAROGLU, E. R. & LEHIGH UNIV BETHLEHEM PA
PUBLICATION OF THE INTERNATIONAL ASSOCIATION OF SCIENTIFIC HYDROLOGY XIII ANNEE, NO 2, 20-39, AUG. 1968. THE EXISTENCE OF A FUNCTIONAL RELATIONSHIP BETWEEN THE "SHEAR INTENSITY PARAMETER" AND THE "TRANSPORT PARAMETER" HAS BEEN ESTABLISHED WITH THE HELP OF A PHYSICAL MODEL. THE PROPOSED FUNCTION GIVES INFORMATION ON THE TRANSPORT OF THE TOTAL SEDIMENT LOAD IN A CONVEYANCE SYSTEM WHICH MAY BE AN OPEN CHANNEL OR CLOSED CONDUIT.

44-68-08003 HYDROMECHANICAL COAL MINING AND HYDRAULIC COAL TRANSPORT (GERMANY)
MAURER, H. + LEMKE, K.
BRENNSTOFF-WARME-KRAFT, (20) N 8, 395-401, AUG. 8, 1968. HYDROMECHANICAL COAL MINING AND HYDRAULIC COAL TRANSPORT, A MEANS OF CUTTING COSTS FROM COALFACE TO POWER PLANT. APPLICATION OF HYDROMECHANICAL COAL-MINING RESULTS IN REDUCTION IN COSTS AND INCREASED SAFETY. NEW METHODS AND NEW MACHINES ARE DESCRIBED. UNDER CERTAIN CONDITIONS HYDRAULIC TRANSPORT OF ENTIRE SOLID MATERIAL EVEN FROM GREAT DEPTHS CAN BE ECONOMIC. TRANSFER OF HYDROMECHANICALLY MINED COAL INTO COMBUSTIBLE COAL-WATER, SUSPENSION UNDERGROUND WOULD NOT BE ADVISABLE FROM AN ECONOMIC VIEWPOINT; PUMPING GRADES BELOW 2 MM FROM DEPTH OF 750 M CAN BE TECHNICALLY AND ECONOMICALLY SATISFACTORY. 6 REF. (IN GERMAN)

44-68-08004 TIRE RESEARCH LOWERS EQUIPMENT OPERATING COSTS (MATERIALS-HANDLING MUCKING-EQUIPMENT)
CATERPILLAR TRACTOR CO
MINING CONGRESS JOURNAL, 54-56, AUG 1968. THE IMPROVED COMPOUND AND INCREASED TREAD OF THE RECENTLY INTRODUCED EXTRA TREAD AND EXTRA DEEP TREAD TIRES ARE BRINGING ABOUT COST REDUCTIONS OF AT LEAST 39 PERCENT OVER A WORK PERIOD OF THREE YEARS IN SEVERE, HARD WEARING UNDERFOOT CONDITIONS LIKE THOSE EXPERIENCED IN MINING OPERATIONS. SINCE TEMPERATURE IS NO PROBLEM IN THESE TIRES, INCREASING THE TREAD DEPTH AND THICKNESS OF UNDERTREAD WOULD BE PRACTICAL. TODAY DUALS ARE USED FOR LONG HAUL, HIGH SPEED JOBS. WITH THE PRESENT IMPROVEMENTS TO THE WHEEL LOADER TIRE, TIRE COMPANIES HAVE PROVIDED A TIRE WITH A BETTER COMPOUND AND TWICE THE RUBBER. THE NEXT STEP SHOULD BE IMPROVEMENT OF CARCASS CONSTRUCTION, AS INTERNAL CONSTRUCTION AFFECTS THE WAY THE RUBBER REACTS ON THE GROUND. TWO DIFFERENT CONCEPTS ARE BEING CONSIDERED--THE BELTED BIAS TIRE AND THE RADIAL CORD TIRE.

44-68-09001 SEDIMENT TRANSPORT IN CONVEYANCE SYSTEMS PART II THE MODES OF SEDIMENT TRANSPORT AND THEIR RELATED BED FORMS IN CONVEYANCE SYSTEMS (HYDRAULIC-TRANSPORT SLURRY-PUMPING)

ACAROGLU, E. R. + GRAF, W. H. & MIDDLE EAST TECH U ANKARA TURK
PUBLICATION OF THE INTERNATIONAL ASSOCIATION OF SCIENTIFIC HYDROLOGY, XIII ANNEE NO. 3, 123-135, SEPT. 1968. THIS PAPER ATTEMPTS TO DETERMINE THE FUNCTIONAL RELATIONSHIP BETWEEN THE SHEAR INTENSITY PARAMETER AND THE PARTICLE REYNOLDS NUMBER FOR SEDIMENT TRANSPORT. THE POSSIBILITY OF USING THE ESTABLISHED FUNCTION AS A CRITERION FOR THE VARIOUS MODES OF SEDIMENT TRANSPORT AND FOR THE RELATED BED FORMS IS ALSO SOUGHT. THE METHOD OF MODEL INVESTIGATION WAS USED.

44-68-10001 AUTOMATED TRANSPORTATION SYSTEMS (SECCAM DASHAVEYOR CONVEYOR-TRAIN CABLE-RIDING-BELT)
SCHENCK, G. H. K. & PENN STATE UNIV
MINING CONGRESS JOURNAL, (54) N. 10, 50-55, OCT. 1968. DASHAVEYOR CORPORATION HAS TESTED A PROTOTYPE AND IS NOW INSTALLING 5 1/2 MILES OF A NEW TYPE AUTOMATED TRANSPORT SYSTEM AT THE WHITE PINE COPPER CO MINE. THE SYSTEM IS A MODULAR CONVEYOR-TRAIN. INDIVIDUAL CARS ARE POWERED BY A SELF CONTAINED ELECTRIC DRIVE AND CAN TRAVEL AT SPEEDS UP TO 45 MPH. UNION CARBIDE IS INSTALLING A 6 MI LONG SECCAM CABLE-RIDING BELT CONVEYOR IN ITS PUTNAM MINE IN W. VA. CAPACITY IS 16000 TPH. IT CAN TAKE HORIZONTAL AND VERTICAL CURVES.

44-68-11001 TRANSPORTATION BEHIND CONTINUOUS MINERS (CONVEYORS SHUTTLE-CAR)
HINKS, W. H., JR. & RUSHTON MINING CO
MINING CONGRESS JOURNAL, (54) NO 11, 86-89, NOV. 1968. CONTINUOUS MINING REQUIRES A TREMENDOUS AND CONTINUOUS CARRYING CAPACITY TO ENSURE MAXIMUM BENEFITS. A CONTINUOUS TRANSPORTATION SYSTEM USING CHAIN CONVEYORS HAS BEEN INSTALLED IN THE RUSHTON MINE LOCATED NEAR PHILIPSBURG, PA.

44-68-12001 NEW TESTS UPDATE CRITERIA FOR SLURRY PUMP SELECTION (HYDRAULIC-TRANSPORT PUMP-DESIGN)
CONE, E. E. & ARTHUR G MCKEE CO
EIMS, 82-88, DEC 1968. DESIGN EQUATIONS FOR SELECTION OF PUMPS FOR HYDRAULIC TRANSPORTATION OF SOLIDS IN PIPELINES ARE DEVELOPED. EXAMPLE PROBLEMS GIVEN.

44-69-06001 TUNNEL EXCAVATION SYSTEM KEEPS VENTILATION COSTS DOWN (NORWAY MUCK-HANDLING)
CAPLAN, B.
WORLD CONSTRUCTION, (22) NO 6, 36C, JUNE 1969. THE MUCK HANDLING SYSTEM FOR NORWAY'S LONGEST TUNNEL IS DESIGNED TO SOLVE VENTILATION PROBLEM. THE TUNNEL IS 21 MILES LONG, HAS A CROSS SECTIONAL AREA OF 320 SQ FT AND IS 2600 FT ABOVE SEA LEVEL. DIESEL LOCOMOTIVES HAUL TRAIN OF CARS THROUGH TUNNEL HALTING AT A DISTANCE OF 100 TO 400 YARDS FROM THE FACE WHERE THE TRACK BRANCHES. A PAIR OF PARALLEL TRACKS RUNS UP TO THE FACE ITSELF.

44-70-06001 HYDRAULIC HOISTING OF COAL (PIPELINE SLURRIES)
SINGHAL, R. K.
COAL MINING AND PROCESSING, 44-47, JUNE 1970. THE HITACHI HYDRO-HOIST IS BEING USED TO HOIST COAL SLURRIES 830 FT AND 1690 FT AT TWO JAPANESE COLLIERIES, WHERE WATER PRODUCED IN THE MINE IS UP TO 10 TIMES THE VOLUME OF COAL PRODUCED. DESCRIPTION OF THE EQUIPMENT AND THE METHOD OF OPERATION ARE PRESENTED.

FIELD 45 NEWS ITEMS

45-64-06001 LE CHANTIER DU TUNNEL SOUS LE MONT BLANC (SAFETY DISEASES NOISE VENTILATION)
DE ROCHEFORT, M. H. + JACCON, A.
INSTITUT TECHNIQUE DU BATIMENT ET DES TRAVAUX PUBLICS, (17) N 198, 701-719, JUNE 1964. A TUNNEL UNDER MONT BLANC WAS 11,600 METERS IN LENGTH. GOOD SAFETY MEASURES HAVE BEEN TAKEN AND THE GOOD WORK PERFORMANCE SHOWS THE EXCELLENT RESULTS. THE DISEASES OF SILICOSIS AND ANKYLOSTOMIASIS HAVE NOT SHOWN UP IN THE CONSTRUCTION OF THIS TUNNEL. PROTECTION AGAINST NOISE WAS SATISFACTORY. (IN FRENCH).

45-64-11001 ECONOMICAL LONG DISTANCE PIPELINING OF MINERALS IS NOW A REALITY (HYDRAULIC-TRANSPORT MATERIALS-HANDLING SLURRY-PUMPING)
CONSTANTINE, R. & PARSONS-JORDEN CORP N.Y.
METAL MINING AND PROCESSING, 27-29, 36, NOV 1964. A CANADIAN COMPANY PLANS TO PUMP POTASH 1300 MILES TO CHICAGO. A 6 INCH ID SLURRY PIPELINE OF ANDES COPPER MINING CO. IN CHILI CARRIES 800 TONS/DAY OF COPPER CONCENTRATE 14 MILES. AMERICAN GILSONITE HAS OPERATED A 72 MILE PIPELINE SINCE 1957. PITTSBURGH CONSOLIDATED COMPANY'S 108 MILE PIPELINE IN OHIO SINCE 1958. MANY POTENTIAL USES SUGGESTED.

45-65-01001 MONORAIL TRANSPORT SYSTEMS (MATERIALS-HANDLING SOUTH-AFRICAN EUROPEAN)
MINING AND MINERALS ENGINEERING, (1) NO 5, 185-92, JAN 1965. A SUMMARY NEWS ARTICLE ON TYPES OF MONORAIL SYSTEMS USED IN EUROPEAN AND SOUTH AFRICAN MINES BOTH SURFACE AND UNDERGROUND FOR MOVING MEN AND MATERIALS. INCLUDES ROPE OPERATED, TRACK DRIVEN, LOCOMOTIVE HAULED. OVERHEAD AND GROUND MOUNTED TYPES ARE IN USE.

45-65-01002 MONORAIL SYSTEM DISPLAYS ADVANTAGES IN SOUTH AFRICA (MATERIALS-HANDLING MONORAIL)
CANADIAN MINING JOURNAL, (86) N 1, JAN 1965. MONORAIL SYSTEM IS CAPABLE OF NEGOTIATING HORIZONTAL AND VERTICAL CURVES OF 25-FOOT RADIUS. DIESEL LOCOMOTIVE FURNISHES 6,800 LBS. DRAWBAR PULL AS COMPARED TO 2,600 LBS FOR A CONVENTIONAL 5-TON 2-RAIL LOCOMOTIVE. UNDER TEST LOAD OF 30 TONS THE LOCOMOTIVE PULLED UP 15-DEGREE INCLINES WITHOUT SLIPPING. STOPPING DISTANCE WAS 7 FEET FROM 10 MPH. THE ORE CARS (TUBS) ARE RATED AT 3 1/2 TONS AND CAN NEGOTIATE TURNS OF JUST OVER 2-FEET RADIUS. USED IN THE ANGLO-VAAL GROUP'S LORAINE GOLD MINE.

45-65-01003 FOR LONDON TRANSPORT - THE DEEP TUBE (MOLES SHIELD TUNNELING-MACHINE LINING MATERIALS-HANDLING)
ENGINEERING, (199) 42-46, JAN 8, 1965. A SHIELD IS THE BASIC METHOD USED FOR DRIVING THE RUNNING TUNNELS, FROM 13 FT. 1 IN. TO 14 FT. IN DIAMETER OUTSIDE THE LINING. THE LATEST VERSIONS ARE THE "DRUM DIGGER" AND THE MCALPINE TUNNELING MACHINE. THE JOHN MOWLEM SYSTEM OF REMOVING SPOIL IS HIGHLY MECHANIZED. AS THE DRUM DIGGER SHIELD ADVANCES, A 2 FT. 6 IN. RAIL TRACK IS LAID ON WHICH RUN TWO BOGIE CARS WITH A CHAIN CONVEYOR ON THE FLOOR. THE ONE NEAREST THE SHIELD ACTS AS THE RECEIVER OF SPOIL AND IS BIG ENOUGH TO HOLD 2 LINEAL FT. OF TUNNEL. THE SECOND CAR IS POWERED HYDRAULICALLY AND RUNS A SHUTTLE SERVICE BETWEEN THE RECEIVER CAR AS IT BECOMES FULL AND THE FOOT OF THE WORKING SHAFT WHERE THE SPOIL IS TRANSFERRED TO A BUCKET ELEVATOR TO OVERHEAD STORAGE BINS FOR DISPOSAL. USING DRUM DIGGER SHIELDS, AS MUCH AS 3 FT. OF TUNNEL HAS BEEN COMPLETED PER HOUR. THE STATION TUNNELS ARE LINED WITH CONVENTIONAL DESIGN CAST IRON SEGMENTS BOLTED TOGETHER WITH THE INTERVENING SPACE BETWEEN LINING AND CLAY FILLED WITH CEMENT GROUT. IN THE RUNNING TUNNELS CAST IRON OR PRECAST CONCRETE SEGMENTS ARE ERECTED BEHIND THE SHIELD AND THEN EXPANDED WITH JACKS AND WEDGES AS SOON AS THE 2 FT. LENGTH OF A SEGMENT HAS BEEN DUG SO THAT THEY FIT HARD AGAINST THE SURFACE. BLUE CLAY REMAINS SELF-SUPPORTING FOR A SHORT PERIOD AFTER EXPOSURE TO AIR, WHILE IT RETAINS MOISTURE. THE SHIELDS WERE ASSEMBLED AND DISMANTLED IN SPECIAL SHIELD CHAMBERS--TEMPORARY ENLARGEMENTS IN LINE WITH THE FINAL TUNNEL. A FT.-THICK 350 FT. LONG LAYER OF WATER-BEARING GRAVEL WAS TREATED WITH A SINGLE SHOT CHEMICAL INJECTION GROUTING PROCESS KNOWN AS TDM, BY THE CEMENTATION COMPANY.

45-65-03001 NEW CONVEYOR SHUTTLE TRAIN FROM SWEDEN (MUCKING)
COLLIERY ENGINEERING, (42) N 493, 113-14, MAR 1965. A NEW TYPE OF RAIL MOUNTED SHUTTLE CAR, DESIGNED AND BUILT BY HAGGLUNDS OF SWEDEN. SIX SIZES 7.2 TO 15 YARDS. EACH CAR EQUIPPED WITH AN AIR DRIVEN CONVEYOR BELT BOTTOM FOR REDISTRIBUTING LOAD. CAN BE COMBINED INTO TRAINS.

45-65-05001 BOTTOM-DUMP RIG HAULS 240 TONS (MATERIALS-HANDLING)
ENGINEERING NEWS-RECORD, (174) 31, MAY 13, 1965. CATERPILLAR TRACTOR CO. HAS DEVELOPED A TANDEM-POWERED COAL HAULER WITH A CAPACITY OF 240 TONS (STRUCK CAPACITY OF 275 CU. YD.) POWERED BY TWO V-12 DIESELS, EACH DELIVERING

900-1000 FLYWHEEL HORSEPOWER. BOTTOM-DUMP CAN BE RAISED TO 50 INCHES ABOVE GROUND. WEIGHT IS 95 TONS EMPTY, TURNING RADIUS 85 FEET.

45-65-05002 COAL-SLURRY PIPELINE FAVORED FOR BIG WESTERN POWER PROJECT (MATERIALS-HANDLING)
THE OIL AND GAS JOURNAL, 160-161, MAY 16, 1965. A 16 INCH OR LARGER PIPELINE IS BEING CONSIDERED TO SHIP PULVERIZED COAL FROM NORTHERN ARIZONA TO A POWER PLANT NEAR MOHAVE, NEVADA. ONLY TWO CHOICES ARE RAILROAD AND PIPELINE. LINE WOULD BE 278 MILES LONG.

45-66-06001 SOLIDS HANDLING PUMP (MATERIALS-HANDLING)
MECHANICAL ENGINEERING, 60, JUNE 1966. A NEW PUMP (SYKES UV/CWG 5/4 UNIVAC) HAS BEEN DESIGNED TO HANDLE ALL TYPES OF SOLIDS AND SLURRIES. ESPECIALLY DESIGNED FOR MATERIAL 25 PERCENT BY WEIGHT OF SOLIDS AND PARTICLES 1 INCH IN DIAMETER. CAPABLE OF DELIVERING 900 IMPERIAL G.P.M. AGAINST A TOTAL HEAD OF 100 FT AT A PUMP SPEED OF 1,000 RPM, AND 1,000 IMPERIAL G.P.M. AGAINST A TOTAL HEAD OF 300 FEET AT A PUMP SPEED OF 1,800 RPM.

45-66-07001 SOLIDS PIPELINING SEEN 'AROUND CORNER' (SLURRY DRILLING-MUD RECIPROCATING-PUMP)
MID-AMERICA OIL & GAS REPORTER, 17-19, JULY 1966. A. B. FLY OF AMARILLO IS TESTING AN IMPROVED DESIGN FOR A UNIQUE SLURRY PUMP. SLURRIES HAVE BEEN PUMPED THAT CARRIED AS MUCH AS 60 PERCENT SOLIDS BY WEIGHT IN THE PARTICLE RANGE FROM COLLOIDAL TO 8 MESH. IN USE THE PUMP COORDINATES THE WORK OF SIX CYLINDERS, EACH OF WHICH IS A RECIPROCATING INTERVAL COMBUSTION ENGINE AND A RECIPROCATING PUMP. THIS PUMP IS APPLICABLE AS A DRILLING MUD PUMP OR IN CONJUNCTION WITH A TUNNEL BORING MACHINE FOR MUCK REMOVAL. THE TRADE-NAME FOR THE PUMP IS 'HYDROTORQ'.

45-66-07002 UNDERREAMER EXPOSED NEW PUMP NEED
MID-AMERICA OIL & GAS REPORTER, (9) NO 4, 20, JULY 1966. RECIRCULATING MUDDY WATER AT HIGH PRESSURE CAUSED CONVENTIONAL OILFIELD MUD PUMPS TO BREAK DOWN. A. B. FLY INVENTED THE HYDRO-TORQ PUMP FOR THIS SERVICE AND WORKING THROUGH AT 13 3/8 INCH CASING AT A DEPTH OF 332 TO 342 FEET CUT A HOLE 30 FEET IN DIAMETER FOR THE ADOBE OIL CO. HE ALSO CUT A 60 FOOT DIAMETER CAVITY AT 200 FEET WORKING THROUGH 16 INCH CASING UNDER AN IRRIGATION WELL.

45-66-08001 PNEUMATIC COAL TRANSPORT: DIFFICULT BUT PROMISING (FEEDING METERING)
KANE, L. J. + SPENCER, J. D.
POWER ENGINEERING, 58-59, AUG 1966. AT THE FIRST U.S. SYMPOSIUM ON THE PNEUMATIC TRANSPORTATION OF SOLIDS TWENTY-TWO TECHNICAL PAPERS IDENTIFIED RECENT DEVELOPMENTS IN FEEDING, TRANSPORTING, RECOMPRESSING AND UTILIZING GAS SOLIDS SUSPENSION. SERIOUS PROBLEMS REMAIN TO BE SOLVED IN PNEUMATIC TRANSPORT BUT POSITIVE RESULTS HAVE BEEN ACHIEVED IN AREAS SUCH AS SOLIDS FEEDING AND IN UTILIZATION.

45-66-11001 PIPE BEATS RAIL FOR COAL HAUL (MATERIALS-HANDLING)
ENGINEERING NEWS-RECORD, (177) 17, NOV 24, 1966. A 270-MILE COAL SLURRY PIPELINE WAS FOUND TO BE 50 PERCENT CHEAPER THAN A RAIL ROUTE PROPOSED BY THE ATCHISON, TOPEKA, AND SANTA FE RAILROAD COMPANY. THE NEW LINE WILL BE 20 INCHES IN DIAMETER.

45-66-12001 INDUSTRIAL ROLLER COASTER MOVES BULK MATERIALS (MATERIALS-HANDLING CONVEYORS SELF-PROPELLED CONVEYORS)
THE IRON AGE, 91, DEC 15, 1966. THE DASHAVEYOR CONSISTS OF A NUMBER OF SELF-PROPELLED MODULES WHICH MAY BE LINKED TOGETHER OR LEFT SEPARATE. SUBSTITUTES HIGH-SPEED OPERATION FOR LARGER AND SLOWER METHODS OF MATERIALS HANDLING. MAXIMUM SPEED IS APPROXIMATELY 40 MPH. THE MACHINE CAN TRAVEL IN HORIZONTAL, VERTICAL, INCLINED, UPRIGHT, OR INVERTED POSITION. CONTROLLED AT A CENTRAL CONTROL POINT.

45-67-01001 SLURRY PIPELINE WILL FEED WEST'S 1,510-MW MOHAVE PLANT. (POLLUTION CENTRIFUGE PULVERIZER)
ELECTRICAL WORLD, 67-68, JAN 23, 1967. WEST CONSISTS OF 22 MEMBER UTILITIES IN SEVEN WESTERN STATES. WHEN ITS 1,510-MW MOHAVE PLANT IS COMPLETE IN 1971 IT WILL BE FIRED WITH COAL TRANSPORTED VIA A 275 MILE SLURRY PIPELINE. 117 MILLION TONS OF COAL ARE TO BE DELIVERED OVER A 35 YEAR PERIOD AT THE RATE OF 330 TONS OF PULVERIZED COAL SLURRY PER HOUR. THE SLURRY WILL BE A HALF AND HALF COAL-WATER MIXTURE BY WEIGHT. CENTRIFUGES WILL DE-WATER THE SLURRY TO 25 PERCENT WATER BY WEIGHT. THIS WILL BE FED INTO THE GENERATOR PULVERIZERS FOR FINAL DRYING AND GRINDING. SPECIAL STEPS WILL BE TAKEN TO PREVENT POLLUTION. THE WASTE WATER IN THE PLANT WILL BE DISPOSED OF IN AN EVAPORATION POND.

45-67-02001 WHEELED LOADERS AND ROCK WAGONS SCAMPER THROUGH TUNNEL (MATERIALS-HANDLING)
CONSTRUCTION METHODS, 62-74, SEPT 1967. BECAUSE NO STANDARD SCRAPER OF SUFFICIENT CAPACITY COULD BE USED IN THE ANGELES TUNNEL, THE TRACTOR FROM A CAT 621 SCRAPER WAS MATED WITH A 16-YD. OTHEY ROCK WAGON. FIFTEEN OF THESE UNITS ARE USED TO TRANSPORT MUCK OUT OF THE 36-FT. DIAMETER TUNNEL. DUE TO SIZE RESTRICTIONS IN THE ADITS, A BUCKET WITH A MOVEABLE END PLATE WAS DESIGNED FOR A CAT 988. THE OPERATOR SWEEPS THE LOAD INTO THE WAGON INSTEAD OF DUMPING.

45-67-04001 SLIDING WORK FLOOR SPEEDS WET TUNNEL (ENVIRONMENTAL-CONTROL MATERIALS-HANDLING MUCKING)
CONSTRUCTION METHODS, 107-112, APRIL 1967. STORY OF PROBLEMS WITH WATER IN THE SIX MI 32 FT DIA TAILRACE TUNNEL FOR NEW ZEALAND'S LAKE MANAPOURI HYDRO PROJECT. FIRST 10 MONTHS HEAVY WATER INFLUX SLOWED ADVANCE TO A TOTAL OF 2000 FT. IN A RELATIVELY DRY SECTION MADE 2000 FT IN TWO MONTHS (38+ FT/ DAY). A JACOBS ' MAGIC CARPET ' WAS USED (DETAILS OF CONSTRUCTION INCLUDED). DRILLING AND BLASTING GEAR IS DESCRIBED. WHEN WATER WAS ENCOUNTERED MUCH SPECIAL DRILLING AND GROUTING WAS REQUIRED.

45-67-10001 FRANKFURT BUILDS HUGE TERMINAL (PASSENGER-TUNNEL MOVING-SIDEWALK)
ENGINEERING NEWS-RECORD, 24, OCT 25, 1967. FRANKFURT AIRPORT EXPANSION INCLUDES ADDITION OF 1000 FOOT PASSENGER TUNNEL EQUIPPED WITH A MOVING SIDEWALK.

45-67-10002 BIDS ARE REQUESTED FOR INVITATION NO. C-6810-H (TUNNEL EXCAVATION)
ENGINEERING NEWS-RECORD, (179) 68, OCT 26, 1967. REQUEST FOR BIDS FOR CONSTRUCTION OF CENTER LEG INNER LOOP, D. STREET S.W. TO DISTRICT N.W. AND MALL TUNNEL DR. 2 PENNA. AVE. NW TO CONSTITUTION AVE., NW, WASH., D. C.

45-67-10003 LOUVRE GOES UNDERGROUND (SUBWAY-SYSTEM PASSENGERS RUBBER-TIRE-SYSTEM TRAINS)
THE WASHINGTON POST, A21, OCT 29, 1967. AS PART OF THE OVERHAUL OF THE METRO SYSTEM AND ITS 344 STATIONS THE LOUVRE STATION WILL BECOME PART OF THE MUSEUM. OTHER PHASES OF THE OVERHAUL INCLUDE REPLACEMENT OF STATIONS AT A RATE OF 30 TO 50 A YEAR, CONVERSION OF 3 MAJOR LINES TO RUBBER TIRE SYSTEMS WITH 2 MORE SCHEDULED FOR CONVERSION, AND ADDITION OF A NEW 35 MPH EXPRESS LINE DEEP INTO CITY'S EASTERN AND WESTERN SUBURBS. LOSS OF ABOUT $100 MILLION LAST YEAR CAUSED RAISE IN FARES BY 40 PERCENT WITH ANOTHER 20 PERCENT RAISE NEEDED FOR THE SYSTEM TO PAY ITS WAY.

45-68-07001 WHITE PINE PREPARING TO USE NEW TRANSPORT CONCEPT (DASHAVEYOR AUTOMATION COSTS)
MINING ENGINEERING (SME), 154-155, JULY 1968. THE DASHAVEYOR INSTALLATION AT WHITE PINE COPPER CO WILL TRANSPORT 10 INCH COPPER ORE 5 1/2 MILES FROM MINE TO CONCENTRATION USING TWO GROUPS OF 48 MODULES EACH, WILL CARRY 72 TONS PER TRIP AND MAKE THE 11 MILE ROUND TRIP IN 17 MIN. MODULES WILL BE LOADED AUTOMATICALLY AT THE MINE AND WILL BE DUMPED AUTOMATICALLY BY AN INVERTING LOOP. CAPITAL COST ABOUT $2.5 MILLION PLUS $300,000 FOR SITE PREPARATIONS. AT 8 MIL/KW, POWER COSTS WILL BE $0.004/TON-MILE. LABOR AND MAINTENANCE COSTS ANOTHER $0.004/TON-MILE.

45-68-09001 FEDERAL PROGRAM IS URGED FOR DIGGING UP NEW EXCAVATION TECHNIQUES AND MACHINERY
BUSINESS WEEK, SEPT 14, 1968. THE NATIONAL ACADEMY OF SCIENCES HAS RECOMMENDED IMMEDIATE START OF A 10-YEAR, $200 MILLION FEDERALLY FUNDED PROGRAM FOR R AND D IN UNDERGROUND EXCAVATION MACHINERY AND TECHNIQUES.

45-69-03001 DEEP TUNNEL STORAGE MAY SOLVE CITY STORM WATER PROBLEMS (DISPOSAL COST SEWERS)
JOURNAL OF ENVIRONMENTAL SCIENCE AND TECHNOLOGY, (3) NO. 3, 209-211, MAR 1969. CHICAGO PLANS TO CONTROL WATER POLLUTION BY CAPTURING STORM AND SEWAGE RUNOFF IN CAVERNS CARVED FROM BEDROCK 800 FT UNDER GROUND. WITH CAPACITY UP TO 18,000 ACRE FT OF WATER, CAVERNS WILL REQUIRE REMOVAL OF 60 MILLION CU YDS OF MATERIAL. COST OF THE 10-YR PROJECT IS EXPECTED TO BE $1.02 BILLION.

45-69-10001 CEMENT CO BUILDING PIPELINE TO CARRY LIMESTONE SLURRY
STOCKTON (CALIF) RECORD, OCT. 29, 1969. CALAVERAS CEMENT CO IS CONSTRUCTING A 17.6 MILE 7 INCH PIPELINE TO CARRY CRUSHED LIMESTONE FROM A QUARRY TO THE SAN ANDREAS PLANT.

45-70-01001 HYDRO-ELECTRIC PRACTICE (TUNNELS ADVANCE COST MUCKING LINING)
FULTON, A. & INSTITUTE OF CIVIL ENGRS
CIVIL ENGINEERING & PUBLIC WORKS REVIEW, 70-71, JAN 1970. CONCURRENTLY WITH ACTIVITY IN HIGH PRESSURE PIPELINE DEVELOPMENT FOR HYDROELECTRIC INSTALLATIONS THERE HAS BEEN A GROWING TENDENCY TO ELIMINATE THEM BY USING MORE PRESSURE TUNNELS AND SHAFTS. FACTORS HASTENING THIS PROCESS WERE: ASTHETICS, FEW PEOPLE REALLY LIKE TO SEE ROWS OF PIPES COMING DOWN A HILLSIDE; SUBSTANTIAL RATE OF DRIVING TUNNELS IN ROCK ESPECIALLY WHERE MECHANICAL AIDS IN MUCKING COULD BE USED; INCREASED SIZE OF NEW HYDROELECTRIC PROJECTS; SAVINGS BY USING UNDERGROUND POWER STATIONS; AND REPLACEMENT OF STEEL LININGS WITH CONCRETE.

45-70-04001 PIPELINE MOVES COAL OVER ARIZONA'S TOUGH TERRAIN (SLURRY-PUMPING)
ENGR. NEWS-RECORD, (184) 26, APR. 23, 1970. THE BLACK MESA PIPELINE RUNNING FROM KAYENTA TO THE 1580 MEGAWATT PLANT ON THE NEVADA BANK OF THE COLORADO RIVER NEAR BULLHEAD CITY, ARZ WILL BE 273 MILES LONG AND WILL CARRY COAL SLURRY AT 4500 GPM WILL TRAVEL AT 4 MPH AND WILL MOVE THE EQUIVALENT OF 200 RAILROAD CARS OF COAL EACH DAY. A RAILROD TO DO THE SAME JOB WOULD BE 100 MILES LONGER DUE TO ROUGH TERRAIN. THE COAL WILL BE STRIP MINED, PULVERIZED MIXED INTO A 50-50 SLURRY WITH WATER, AND PUMPED BY 13 1700 HP RECIPROCATING PISTON PUMPS AT FOUR PUMPHOUSES AT THE MINE. THE INDIAN OWNERS OF THE MINE WILL GET $30 MILLION IN ROYALTIES OVER A 35 YEAR PERIOD.

45-70-07001 DAM CONTRACTORS VACUUM TUNNEL, SLOW TRUCKS WITH ENGINE BRAKES (MOLE PNEUMATIC-MUCKING BONNEVILLE)
ENGR. NEWS-RECORD, (185) 22, JULY 9, 1970. BOYLES BROS DRILLING CO IS USING A GIANT VACUUM CLEANER ON ITS $5.6 MILLION CONTRACT TO DIG THE 4.1 MILE 13 FT DIA WATER HOLLOW TUNNEL, PART OF BU REC'S BONNEVILLE UNIT OF THE CENTRAL UTAH PROJECT. THE RAIL MOUNTED PNEUMATIC MUCKING SYSTEM HAS A 200 HP ELECTRIC MOTOR DRIVING TWO LARGE FANS AT 3600 RPM TO PRODUCE THE VACUUM WHICH IS APPLIED BY A BOOM MOUNTED 8 IN DIA HOSE. DEBRIS GOES INTO A VACUUM BOX 4 FT WIDE, 4 FT HIGH, 25 FT LONG.

FIELD 5 ENVIRONMENTAL CONTROL AND SAFETY

FIELD 51 BOOKS

51-61-00001 MINE VENTILATION AND AIR CONDITIONING (QUALITY-CONTROL TEMP-HUMIDITY-CONTROL)
HARTMAN, H. L. & PENN STATE UNIV
MINE VENTILATION AND AIR CONDITIONING RONALD PRESS, 398, 1961. DISCUSSION OF MINE VENTILATION WITH EMPHASIS ON THE TOTAL MINE ATMOSPHERIC ENVIRONMENT AND ITS CONTROL. FROM THE BASIC PHYSICS OF GASES, THE THEORY IS DEVELOPED TO COVER AIR MEASURMENTS, THE FLOW OF AIR THROUGH DUCTS, THROUGH OPENINGS, AND THROUGH CIRCUITS, THE DESIGN OF NETWORKS, AND THE DESIGN OF TEMPERATURE-HUMIDITY CONTROL SYSTEMS. SOLUTIONS OF EXAMPLE PROBLEMS ARE GIVEN. ATTENTION IS DIRECTED TO THE PART ECONOMICS PLAYS IN DESIGN AND OPERATION. EQUATIONS ARE DERIVED TO ALLOW THE TOTAL COST OF A DESIGN TO BE DETERMINED, ACTUAL WORKING PLANTS ARE STUDIED FROM DESIGN THROUGH OPERATION. THE VARIOUS INSTRUMENTS AND EQUIPMENT AVAILABLE ARE DESCRIBED ALONG WITH THE CIRCUMSTANCES THAT DICTATE THEIR CHOICE. TABLES DEMONSTRATING THE RELATIVE MERITS OF THE VARIOUS TYPES OF EQUIPMENT ARE PROVIDED. THE FEDERAL AND STATE LAWS THAT AFFECT DESIGN ARE LISTED AND THEIR EFFECTS ON DESIGN ARE DISCUSSED. THE BASIC PRINCIPLES OF OPERATING AND MAINTENANCE ARE INCLUDED.

51-62-00001 DUST CONTROL IN CONNECTION WITH CONTINUOUS-MINING OPERATIONS (SAFETY ENVIRONMENTAL-CONTROL)
ANDERSON, F. G. & U.S. BUR MINES
COAL MIN. INST. OF AMERICA, 60-74, 1962. THE BUREAU OF MINES IS CONDUCTING AN INVESTIGATION OF CONTINUOUS MINING IN BITUMINOUS COAL MINES TO OBTAIN DATA PERTINENT TO DUST EXPOSURE OBJECTIVES. DUST CONTROL IS JUDGED TO BE ADEQUATE WHEN DUST CONCENTRATIONS NO HIGHER THAN 35 MILLION PARTICLES PER CU-FT RESULT. WHEN 4,000 CFM OF AIR ARE USED, NO LESS THAN ABOUT 5 GPM OF WATER SHOULD BE USED. RESULTS SHOWED THE UNDESIRABILITY OF USING A BLOWING SYSTEM FOR FACE VENTILATION. THE FOLLOWING CONDITIONS WERE NECESSARY FOR DUST CONTROL: 1) AIR UNPOLLUTED WITH DUST SHOULD BE DIRECTED OVER ALL OF CREW; 2) JOY CONTINUOUS MINER OPERATIONS NEED A MINIMUM OF 2,500 CFM OF AIR FOR FACE VENTILATION AND ABOUT 10 GPM OF WATER FOR ALLAYING DUST; 3) LEE NORSE MINER OPERATIONS NEED 3,500 CFM OF AIR FOR FACE VENTILATION AND ABOUT 10 GPM OF WATER, AND 4) MEN INSTALLING ROOF SUPPORTS SHOULD WEAR RESPIRATORS.

FIELD 52 SYMPOSIA

52-62-05001 STATIC-ELECTRICITY HAZARDS IN THE PNEUMATIC LOADING OF BLASTING AGENTS (CONDUCTION CAPACITANCE GROUNDING)
PRUGH, R. W. + RUCKER, K. G. & E. I. DUPONT DENEMOURS
MINN UNIV FIFTH SYMP ON ROCK MECHANICS, 419-438, MAY 1962. THE OBJECTIVE WAS THE ELIMINATION OF STATIC ELECTRICITY FROM OPERATORS OR EQUIPMENT AS A CAUSE OF PREMATURE BLASTING CAP IGNITION DURING PNEUMATIC LOADING OPERATIONS. IN ELIMINATING STATIC ELECTRICITY TOO LOW A GROUND SHOULD NOT BE USED AS IT MAY BRING STRAY OR GALVANIC CURRENTS TO THE EQUIPMENT. RESISTANCE TO GROUND AT THE BOREHOLE AND AT VARIOUS PARTS OF THE LOADING SYSTEM SHOW THAT 10 MEGOHM MAXIMUM RESISTANCE WOULD BE ACCEPTABLE. CONDUCTIVE HOSE, GROUNDED DRILL CONTAINER AND NO NON-CONDUCTIVE BORE LINERS SHOULD BE USED WHEN PNEUMATIC LOADING.

52-70-00001 EXCAVATION AND ENVIRONMENT - A REVIEW (STANDARDS SAFETY)
HARTMAN, H. L. & SACRAMENTO STATE COLLEGE
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 28. CONCLUSIONS OF THIS OVERVIEW ARE: (1) THERE IS A LACK OF QUANTITATIVE EFFECTIVENESS MEASUREMENTS; (2) MOST SEVERE HAZARDS ARE DUST, HEAT, NOISE, ROOF FALLS AND ELECTROMAGNETIC ACCIDENTS; (3) TREND TO CONTINUOUS SYSTEMS INCREASES SEVERITY AND EXTENT OF ALL HAZARDS; (4) NEED TO DEVELOP TOLERANCE AND COMFORT STANDARDS FOR HEAT AND ILLUMINATION; (5) ADEQUACY OF TECHNOLOGY OF SAFETY IS LESS FOR NEWER TECHNIQUES; AND (6) PRESENT SAFETY TECHNIQUES WILL NOT BE ADEQUATE FOR THE EXOTIC EXCAVATION TECHNIQUES OF THE FUTURE.

52-70-00002 ENVIRONMENTAL PROBLEMS IN UNDERGROUND MINES (SAFETY VENTILATION GAS-REMOVAL)
HOLTZ, J. C. & U.S. BUR MINES PITTSBURGH PA
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 29. ADEQUATE VENTILATION CAN SOLVE MANY HEALTH AND SAFETY PROBLEMS IN MINES. REMOVAL OF EXPLOSIVE GASES, SUPPRESSION OF DUST, REMOVAL OF BLASTING GASES AND ENGINE EXHAUSTS, AND MAINTAINING COMFORTABLE TEMPERATURES CAN ALL BE OBTAINED BY PROPER VENTILATION TECHNIQUES.

02-70-00003 TUNNELING IN A SUBFREEZING ENVIRONMENT (SAFETY ICE PERMAFROST)
MCANERNEY, J. M. & U.S. ARMY TER. SCI. CENTER
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 30. SMALL TUNNELS WERE SUCCESSFULLY DRIVEN IN GLACIAL ICE AND VARIOUS FROZEN SOILS USING CONVENTIONAL METHODS. MECHANIZED MINING WAS ALSO DEMONSTRATED TO BE PRACTICAL IN ICE AND FINE GRAINED FROZEN SOILS BUT NOT FOR GRAVEL CONTAINING BOULDERS. EQUIPMENT MUST BE WINTERIZED AND SPECIAL CARE MUST BE GIVEN PERSONNEL. NATURAL WINTER VENTILATION IN AREAS OF MARGINAL PERMAFROST ARRESTS DEFORMATION OF OPENINGS.

FIELD 53 GOVERNMENT REPORTS

53-42-00001 SOME HAULAGE SAFETY DEVICES FOR USE ON GRADES, SLOPES AND INCLINED SHAFTS (INSPECTION MAINTENANCE)
GROVE, G. W. + ASH, S. H. + RISTEDT, F. J. & SAFETY DIV BUR OF MINES
MINERS' CIRCULAR 43 U.S. DEPT OF INTERIOR, BUR OF MINES, 1942. DOUBLE OR MULTIPLE COUPLING OF CARS IS ALMOST UNIVERSAL. PREVENTIVE MAINTENANCE AND INSPECTION OF HOISTING FACILITIES AND TRACK IS MORE IMPORTANT THAN SAFETY DEVICES AS SUCH DEVICES MAY DERAIL OR OVERTURN CARS CREATING AN EXTRA HAZARD. A NUMBER OF SAFETY DEVICES ARE DESCRIBED AND EVALUATED. AT PRESENT PERSONNEL PROTECTION IN RUN-AWAY CARS, TRIPS OR SKIPS IS BY NO MEANS SATISFACTORY. 44 PAGES.

53-49-00001 ACCIDENT STATISTICS AS AN AID TO PREVENTION OF ACCIDENTS IN BITUMINOUS COAL MINES (
ACCIDENT-PREVENTION-COURSE SAFETY-EDUCATION)
MINERS' CIRCULAR 47, U.S. DEPT OF INTERIOR, BUR OF MINES, 1949. CAREFUL ANALYSIS OF ACCIDENT RECORDS AND STATISTICS POINT THE WAY TO ACCIDENT REDUCTION TO A MINIMUM. THE INSTITUTION OF A COMPREHENSIVE ACCIDENT-PREVENTION COURSE WILL BE A BENEFIT TO ALL. SECTION 1 OF ACCIDENT PREVENTION COURSE. 42 PAGES.

53-51-00001 QUESTIONS AND ANSWERS ON ROOF SUPPORT IN BITUMINOUS-COAL MINES (ROOF RIB PROPS CROSS-BARS ROCK-BOLTS)
FORBES, J. J. + THOMAS, E. + BARRY, A. J. & U.S. BUR MINES
HANDBOOK BY THE U.S. DEPT OF INTERIOR, BUR OF MINES, 1-90, 1951. MANY ASPECTS OF MINING ARE SIMILAR TO TUNNELING. DESCRIPTIONS, SKETCHES AND PICTURES OF VARIOUS ROOF SUPPORTS IN MINES ARE GIVEN. ESSENTIAL STEPS ARE LISTED IN FORMULATING A PROGRAM TO PREVENT ACCIDENTS FROM FALLS. THE MOST HAZARDOUS AREA IS THAT AT AND IN BACK OF THE FACE AND IT SHOULD BE GIVEN SPECIAL ATTENTION. ROCK BOLTS ARE ESPECIALLY ADVANTAGEOUS IN MINING ROOF SUPPORT AS THEY MINIMIZE EQUIPMENT OBSTRUCTION. 182 QUESTIONS ABOUT MINING, ROOFS AND SUPPORTS ARE ANSWERED.

53-53-10001 FEDERAL MINE SAFETY CODE PART I (EXPLOSIVES ROOF FACE VENTILATION TRANSPORTATION)
MCKAY, D. & U.S. BUR MINES
U.S. DEPT OF THE INTERIOR BUR OF MINES SAFETY CODE, PART I, 1-48, OCT 14, 1953. THE FEDERAL MINE SAFETY CODE FOR U.S. ANTHRACITE MINES GIVES MINIMUM STANDARDS FOR REASONABLE HEALTH AND SAFETY FOR ALL EMPLOYEES AT UNDERGROUND ANTHRACITE MINES. ARTICLES ON CONTROL OF ROOF, FACE AND RIBS; EXPLOSIVES AND BLASTING; VENTILATION AND MINE GASES; TRANSPORTATION; ELECTRICITY; AND GENERAL SAFETY ARE APPLICABLE TO TUNNELING PROCEDURES. ALL TUNNELING PERSONNEL SHOULD BE FAMILIAR WITH THIS MINE SAFETY CODE.

53-54-00001 EXPLOSIONS AND FIRES IN BITUMINOUS COAL MINES (ACCIDENT-PREVENTION-COURSE SAFETY-EDUCATUON)
U.S. DEPT. OF INTERIOR, U.S. BUREAU OF MINES, MINERS' CIRCULAR 50, 1954. THE TREND TO DECREASED LOSS OF LIFE IN UNDERGROUND DISASTERS REQUIRES CONTINUED EFFORT. THE FOLLOWING STEPS ARE OF PARTICULAR IMPORTANCE - ONLY PERMISSABLE EQUIPMENT MAINTAINED AS SUCH SHOULD BE USED, ONLY PERMISSIBLE EXPLOSIVES FIRED IN A PERMISSIBLE MANNER SHOULD BE USED, ROCK DUST HAS PROVED ITS VALUE IN PREVENTING AND CONFINING EXPLOSIONS AND IN EXTINGUISHING FIRES, BETTER INSTALLATION, INSPECTION, AND REPAIR OF ELECTRICAL SYSTEMS IS NEEDED, PREVENTION OF EXPLOSIONS AND FIRES IS MUCH LESS EXPENSIVE THAN RECOVERY AFTER THEIR OCCURRENCE. SECTION 4 OF ACCIDENT PREVENTION COURSE.

53-54-00002 MISCELLANEOUS ACCIDENTS IN BITUMINOUS COAL MINES (ACCIDENT-PREVENTION-COURSE SAFETY-EDUCATION)
U.S. DEPT. OF INTERIOR, BUR OF MINES, MINERS5 CIRCULAR 60, 1954. STATE MINING LAWS, COMPANY SAFETY RULES AND REGULATIONS, AND RECOMMENDATIONS OF THE BUREAU OF MINES HAVE THE PRIMARY PURPOSE OF REDUCING ACCIDENTS TO A MINIMUM. IN MANY CASES THE GUIDE LINES ESTABLISHED BY THIS BODY OF LITERATURE ARE THE RESULT OF COMPROMISES OF OPINION. SAFE OPERATIONS NEED CONTINUING ATTENTION PARTICULARLY AS NEW KNOWLEDGE IS DEVELOPED. SECTION 7 OF ACCIDENT PREVENTION COURSE.

53-55-00001 ACCIDENTS FROM HOISTING AND HAULAGE IN BITUMINOUS COAL MINES (ACCIDENT-PREVENTION-COURSE
SAFETY-EDUCATION)
MINERS' CIRCULAR 49, U.S. DEPT OF INTERIOR, BUR OF MINES, 1955. ONE-FOURTH OF SERIOUS INJURIES OCCUR FROM HAULAGE ACCIDENTS. ENFORCEMENT OF COMPANY SAFETY RULES AND STATE MINING LAWS COUPLED WITH SAFETY EDUCATION WILL SUBSTANTIALLY REDUCE THE NUMBER AND SEVERITY OF THIS TYPE ACCIDENT. ALL ACCIDENTS SHOULD BE INVESTIGATED TO PREVENT RECURRENCE OF SIMILAR ACCIDENTS. SECTION 3 OF ACCIDENT PREVENTION COURSE.

53-55-00002 EXPLOSIVES ACCIDENTS IN BITUMINOUS COAL MINES (ACCIDENT-PREVENTION-COURSE SAFETY-EDUCATION)
MINERS' CIRCULAR 58, U.S. DEPT. OF INTERIOR, BUR OF MINES, 1955. THE METHOD OF OBTAINING MAXIMUM SAFETY IN THE TRANSPORTATION, HANDLING, AND USE OF EXPLOSIVES IS OUTLINED. THE SOURCE OF CONTINUED ACCIDENTS AND NEEDED COURSE FOR FURTHER REDUCTION IS SHOWN. SECTION 5 OF ACCIDENT PREVENTION COURSE.

53-55-00003 ELECTRICAL ACCIDENTS IN BITUMINOUS COAL MINES (ACCIDENT-PREVENTION-COURSE SAFETY-EDUCATION)
MINERS' CIRCULAR 59, U.S. DEPT. OF INTERIOR, BUR OF MINES, 1955. MANY OF THE HAZARDS ASSOCIATED WITH THE USE OF ELECTRICAL EQUIPMENT ARE OUTLINED. RECOMMENDATIONS TO MINIMIZE THE HAZARDS ARE GIVEN. PERMISSABLE EQUIPMENT PROPERLY MAINTAINED HAS HELPED IN ACCIDENT REDUCTION. SECTION 6 OF ACCIDENT PREVENTION COURSE.

53-58-00001 ACCIDENTS FROM FALLS OF ROOF AND COAL IN BITUMINOUS COAL MINES (ACCIDENT-PREVENTION-COURSE
SAFETY-EDUCATION)
U.S. DEPT. OF INTERIOR, BUR OF MINES, MINERS CIRCULAR, 48, 1958. THE PREVENTION OF ACCIDENTS FROM FALLS OF ROOF IS ONE OF THE MAJOR PROBLEMS IN UNDERGROUND OPERATIONS. IT HAS BEEN DEMONSTRATED THAT MOST FALLS OF ROOF CAN BE PREVENTED BY A COMBINATION OF PROPER MENTAL ATTITUDE AND APPLICATION OF SOUND PREVENTIVE MEASURES. SECTION 2 OF ACCIDENT PREVENTION COURSE.

53-61-04001 RECENT DEVELOPMENTS IN FIRE-RESISTANT HYDRAULIC FLUIDS FOR UNDERGROUND USE
POLACK, S. P. + SMITH, A. F. + BARTHE, H. P. & U.S. BUR MINES
U.S. BUR MINES IC8043, APR. 1961. REVIEWS INVESTIGATIONS ON FIRE HAZARD IN COAL MINING FROM FLAMMABLE PETROLEUM HYDRAULIC OILS AND SUMMARIZES RESEARCH ON FIRE RESISTANT HYDRAULIC FLUIDS. ALL PETROLEUM HYDRAULIC OILS UPON IGNITION WILL PROPAGATE FLAME AND WILL BURN AS LONG AS OIL IS AVAILABLE. THREE TEST PROCEDURES FOR CERTIFYING FIRE-RESISTANT HYDRAULIC FLUIDS WERE ADOPTED FOR SCHEDULE 30 APPROVAL. THEY ARE AUTOGENOUS-IGNITION TEMPERATURE, TEMPERATURE-PRESSURE SPRAY-IGNITION AND EFFECT OF EVAPORATION ON FLAMMABILITY. IN 1960 NINE COMPANIES HAD FIRE-RESISTANT HYDRAULIC FLUIDS APPROVED AND THREE MORE WERE ADDED AT THE START OF 1961. THE FIRE-RESISTANT HYDRAULIC FLUIDS ARE AS CHEAP AND PERFORM AS WELL AS THE PETROLEUM HYDRAULIC OILS.

53-67-02001 A THEORETICAL TREATMENT OF DISPERSION INTO A TURBULENT STREAM IN A PIPE (NOXIOUS-GASES DUST-CONTROL
SAFETY ENVIRONMENTAL-CONTROL)
SEAGER, J. S. + FITZPATRICK, R. D. & SMRE GREAT BRITAIN

SAFETY IN MINES RES ESTAB GREAT BRITAIN, REPORT 245, FEB 1967. THE DISPERSION OF MATERIAL FROM A CONTINUOUSLY EMITTING POINT SOURCE ON THE AXIS OF A PIPE IS CONSIDERED. THE FLOW THROUGH THE PIPE IS SUPPOSED TURBULENT, THE EDDY DIFFUSIVITY K AND THE STREAM VELOCITY U ARE ASSUMED CONSTANT AND BUOYANCY IS NEGLECTED. IT IS SUGGESTED THAT THE EQUATIONS DERIVED WITH THESE ASSUMPTIONS SHOULD ALSO BE APPLICABLE TO STEADY-STATE FLOWS WHERE K AND U VARY SLOWLY WITH U/K CONSTANT. THREE TYPES OF SOLUTION OF THE EQUATIONS ARE FOUND USEFUL. NEAR THE SOURCE THE RELATIVELY SIMPLE SOLUTION FOR A POINT SOURCE IN A FREE STREAM APPLIES. FURTHER DOWNSTREAM A MORE ELABORATE SERIES SOLUTION IS NECESSARY. THIS SOLUTION DEPENDS ONLY ON THE NON-DIMENSIONAL PARAMETER UA/2K, WHERE A IS THE PIPE RADIUS. WELL DOWNSTREAM ANOTHER SIMPLE SOLUTION, WITH A POLYNOMIAL FORM, BECOMES ADEQUATE. METHODS ARE DEVELOPED FOR FITTING THE SOLUTIONS TO EXPERIMENTAL DATA AND REASONABLE AGREEMENT IS OBTAINED FOR ONE SET OF SUCH DATA.

53-67-02002 MODEL STUDIES OF HEAT TRANSFER IN MINE FIRES (SAFETY VENTILATION)
ROBERTS, A. F. + CLOUGH, G. & SAFETY IN MINES RES ENGLAND
MINISTRY OF POWER - SAFETY IN MINES RESEARCH ESTABLISHMENT, RPT 247, 21, 1967. PROPAGATION OF FIRE ALONG TIMBER-LINED VENTILATING-ROADWAYS HAS BEEN INVESTIGATED EXPERIMENTALLY IN 30 M LONG, HAVING 0.3 SQ M CROSS SECTION, REFRACTORY LINED, STEEL DUCT. WALLS AND ROOF OF SIMULATED PASSAGEWAY WERE LINED WITH WOOD WHICH HAS BEEN IGNITED AT UPWIND END. SPEED OF BURNING, WALL AND GAS TEMPERATURE DISTRIBUTIONS AND HEAT-TRANSFER RATES WERE MEASURED. ANALYSIS CONFIRMS EXPERIMENTAL OBSERVATION THAT TEMPERATURE DISTRIBUTIONS RELATIVE TO FIRE APPROACH QUASI-STEADY STATE.

53-68-00001 TUNNELING - RECOMMENDED SAFETY RULES
BUREAU OF MINES, U.S. DEPT. OF THE INTERIOR, BUL. 644, 1968. THIS PUBLICATION, A REVISION OF BULLETIN 439, IS DESIGNED TO BE HELPFUL IN PROMOTING HEALTH AND SAFETY IN TUNNELING AND RELATED OPERATIONS. THE FORMAT HAS BEEN SELECTED AND ARRANGED TO PROVIDE A CONDENSED GUIDE FOR SAFETY PERSONNEL, INSPECTION AND INVESTIGATIVE AGENCIES, DESIGN AND PROJECT ENGINEERS, AND OTHERS RESPONSIBLE FOR THE HEALTH AND SAFETY OF WORKMEN. ALL THE PRECAUTIONARY MEASURES RECOMMENDED ARE BASED ON ACTUAL CONDITIONS OBSERVED, FROM INVESTIGATIONS OF FATAL OR SERIOUS ACCIDENTS, AND FROM RESEARCH CONDUCTED TO FIND WAYS AND MEANS OF ALLEVIATING HAZARDS AND UNHEALTHFUL CONDITIONS. MANY OF THE RECOMMENDED RULES ARE INCLUDED IN STATE LAWS AND IN THE GENERAL SAFETY REQUIREMENTS OF THE CONSTRUCTION INDUSTRY. INCLUDED IN THE APPENDIXES ARE SPECIAL PRECAUTIONS FOR GASSY (METHANE ATMOSPHERES) TUNNELS AND TUNNELS WHERE PETROLEUM PRODUCTS ARE ENCOUNTERED.

53-68-03001 RECOMMENDED SAFETY STANDARDS FOR SHAFT SINKING
U.S. BUREAU OF MINES, U.S. DEPT OF INTERIOR, INFORMATION CIRCULAR 8385, MAR 1968. THE RECOMMENDED STANDARDS PRESENTED WERE COMPILED FROM ALL AREAS WHERE SHAFT SINKING IS PRACTICED. EXISTING APPLICABLE STATE RULES WERE INCLUDED. REPRESENTATIVES OF INDUSTRY WERE GIVEN AN OPPORTUNITY TO PARTICIPATE IN PREPARING THE SUGGESTED STANDARDS. AREAS COVERED INCLUDE - FIRE PREVENTION AND PROTECTION, ELECTRICITY, EXPLOSIVES, TIMBERING, MATERIALS HANDLING, VENTILATION, DRILLING, AND LIGHTING.

53-68-06001 SUPPORTING STUDIES TO ESTABLISH SAFETY DESIGN CRITERIA FOR STORAGE AND PROCESSING OF EXPLOSIVE MATERIALS (BLAST-OUTPUT PROTECTIVE-CONSTRUCTION)
RINDER, R. M. + WACHTELL, S.
ARMED SER EXPLOSIVES SAFETY BD QUARTERLY REPT. 23, APR 1 TO JUNE 30, 1968. THE SAFETY DESIGN MANUAL WAS COMPLETED AND DISTRIBUTED FOR COMMENTS. ONE SECTION CONTAINS A QUALITATIVE DESCRIPTION OF DONOR, ACCEPTOR AND PROTECTIVE BARRIER OF AN EXPLOSIVE SYSTEM. A SECOND PART PRESENTS QUANTITATIVE PROCEDURES FOR COMPUTING THE DONOR OUTPUT BOTH BLAST AND FRAGMENTS. THE THIRD PART DISCUSSES METHODS OF DETAILING AND CONSTRUCTION AND OTHER FEATURES OF PROTECTIVE CONSTRUCTION.

FIELD 54 ARTICLES

54-41-05001 HOW TO INCULCATE SAFETY TO MINE WORKERS AT THEIR WORKING PLACES (ACCIDENT-PREVENTION-COURSE SAFETY-EDUCATION-METHODS)
WALKER, W. D. & BUTLER CONS COAL CO WILDWOOD PA
COAL AGE, 65, MAY 1941. ONE OF THE BEST METHODS OF SAFETY EDUCATION FOR NEW EMPLOYEES IS USED BY THE PHELPS DODGE CORP WHICH HAS PUT ASIDE A STANDARD SECTION OF THE MINE TO BE OPERATED BY A CAREFULLY SELECTED TEACHER WHOSE PRIMARY INTEREST IS THE USE OF AND INSTRUCTION IN SAFE METHODS. SAFETY PROCEDURE AT THE WILDWOOD PA COAL MINE INCLUDES INSTRUCTIONS FROM THE SECTION FOREMAN'S OFFICE, OLDER WORKMAN SUPERVISION FOR PROBATIONAL PERIOD, FREQUENT VISITS BY FOREMAN, AND A SECTION OFFICE WITH FIRSTAID MATERIALS, SECTION MAPS, POSTERS, AND GENERAL INFORMATION POSTED ON THE WALLS. APPRENTICESHIPS ARE FOLLOWED BY SPECIFIC INSTRUCTIONS AS TO THE HAZARDS OF THE MECHANIZED WORK THEY HAVE TO UNDERTAKE. SAFETY PROVISIONS INVOLVE: AN INCREASE IN THE NUMBER OF WORKING PLACES SO THAT THE MEN IN THE VARIOUS JOBS IN THE CYCLE ARE NOT CROWDED; AN ASSISTANT MINE FOREMAN IS ASSIGNED TO SUPERVISE THE WORK OF EACH PRODUCTION GROUP OF 16-18 MEN; SHIFTS ARE ARRANGED SO THAT THE SAME ASSISTANT FOREMAN AND WORKMEN ARE CONTINUOUSLY TEAMED TOGETHER.

54-63-04001 A LOOK AT AN-FO'S INVISIBLE FUMES (SAFETY ENVIRONMENTAL)
TODD, J. A., JR. & DU PONT WILMINGTON DEL
MINING ENGINEERING, 43-46, APR. 1963. USE OF AN-FO IN UNDERGROUND OPERATIONS HAS GREATLY REDUCED THE COST OF PRIMARY EXPLOSIVES. IT IS ALSO LESS SENSITIVE THAN CONVENTIONAL DYNAMITES AND SAFER. OXYGEN BALANCED AN-FO PRODUCES NO GREATER AMOUNTS OF TOXIC FUMES THAN OTHER DYNAMITES. THE MAJOR HAZARD IN FUMES FROM EXPLOSIVES IS NO2. AN-FO WILL USUALLY GIVE GREATER QUANTITIES OF NO2 THAN OTHER EXPLOSIVES. THEREFORE AN-FO MUST RETAIN THE 6 PERCENT OIL. OIL CONTENT MUST BE UNIFORM THROUGHOUT THE BAG. TWO MEANS OF ASSURING RETENTION OF FUEL HAVE BEEN EVALUATED. A PORTION OF NO. 2 FUEL OIL WITH A SOLID FUEL SUCH AS PULVERIZED COAL OR COKE, USE HIGH VISCOSITY OIL THAT IS NOT SUBJECT TO EVAPORATION OR MIGRATION. DUPONT HAS DEVELOPED TWO TESTERS. ONE FOR NITROGEN DIOXIDE AND ANOTHER FOR CARBON MONOXIDE.

54-63-11001 NOISE SUPPRESSION ON ROCK DRILLS (SAFETY ENVIRONMENTAL-CONTROL)
GORDON, J. E. & JOY MFG CO
THE CANADIAN MINING AND METALLURGICAL BULLETIN, 835-838, NOV 1963. PNEUMATIC ROCK DRILLS ARE A MAJOR CAUSE OF ON-THE-JOB LOSS OF HEARING. MOST DAMAGING NOISE COMES FROM THE WORKING PARTS OF THE DRILL RATHER THAN ITS EXHAUST. PROPER DESIGN CAN SUCCESSFULLY MUFFLE NOISE AND AT THE SAME TIME PERFORM AS WELL OR BETTER THAN AN UNMUFFLED DRILL. A NOISE STANDARD IS NEEDED WHICH BALANCES DESIRABLE LIMITS AND ECONOMIC CONSIDERATIONS.

54-64-01001 REPORT OF THE NATIONAL MINING CONVENTION ON "SCIENTIFIC AND ENGINEERING EFFORTS TO IMPROVE SAFETY IN THE MINING INDUSTRY" (SUPPORTS ROCK-MECHANICS POLAND)
WANAT, J.
ARCHIWUM GORNICTWA, (9) N 1, 129-176, JAN 1964. IN ORDER TO ACHIEVE GREATER SAFETY CONDITIONS AGAINST CAVE-IN ACCIDENTS, THE FOLLOWING WERE RECOMMENDED: 1) AVOID LEAVING SUPPORTING COLUMNS LOCATED ABOVE OR BELOW DEPOSIT BEDS EXPOSED TO CAVE-IN PERILS, 2) A MECHANICAL METHOD OF ORIENTED ROOF CONSTRUCTION SHOULD BE APPLIED, 3) ANTICIPATION OF ROCK PRESSURE, 4) SPECIAL CREWS FOR TIMBERING. RECOMMENDATIONS FOR COMBATING COAL DUST EXPLOSIONS: 1) INCREASE APPLICATION OF BARRIERS MADE OF ROCK DUST, 2) INCREASE SCOPE OF COAL-DUST EXPLOSION PREVENTION BY INVESTIGATION, 3) ESTABLISH EFFICIENT INSPECTION PROGRAM. EXPERIENCE IN GAS-IMPERILED MINES INDICATES THAT THE ARMSTRONG EQUIPMENT IS MOST SUITABLE FOR EXCAVATION. (IN POLISH) MORE THAN 2000 PERSONS PARTICIPATED IN THE CONFERENCE AND ITS SESSIONS IN MAY 1963.

54-64-01002 REPORT ON REGIONAL MINING CONFERENCE ON CONTRIBUTION OF SCIENCE AND ENGINEERING TO SAFETY IN MINING (FIRE-PREVENTION VENTILATION ROOF-CONTROL)
WANAT, J.
ARCHIWUM GORNICTWA, (9) NO 1, 129-176, 1964. THE CONFERENCE PRESENTED 146 PAPERS ON SAFETY IN MINES. THE SUBJECTS OF THE 12 SECTIONS OF THE CONFERENCE WERE: HUMAN FACTORS IN SAFETY, TRAINING, DESIGN OF NEW MINES, ROOF CONTROL, UNDERGROUND FIRES, VENTILATION AND AIR CONDITIONING, FIREDAMP HAZARD, DUST EXPLOSIONS, WATER DRAINAGE, SAFETY IN MECHANIZATION, HEALTH HAZARDS AND REHABILITATION, ACCIDENT PREVENTION DURING BLASTING. A LIST OF THE PAPERS WITH AUTHOR, TITLE AND SESSION NUMBER WHERE PRESENTED IS INCLUDED. (IN POLISH)

54-64-02001 SANITARY-HYGIENIC CONDITIONS DURING ELECTRO-ROTARY DRILLING IN HARD ROCKS (ATMOSPHERE-CONTROL NOISE-CONTROL DUST-CONTROL)
BOZHKO, K. F. + KOLBIN, A. M. + POPOV, YU. P.
GORNYI ZHURNAL, N 2, 73-76, FEB 1964. EVIDENCE IS PRESENTED TO SHOW THAT USE OF ELECTRIC ROTARY DRILLS IN SILICIFIED LIMESTONE AND JASPEROIDS RESULTS IN REDUCTION OF DUST, VIBRATIONS AND NOISE. (IN RUSSIAN)

54-64-03001 DRIVING THE CHANRION TUNNEL (LOADING MATERIALS-HANDLING SAVINGS COST)
BRETZ, K. W. & MARTIGNY./BOURG SWITZERLAND
WATER POWER, 114-121, MAR 1964. TUNNELING RATE OF 3500 M IN ONE WORKING YEAR WAS ACHIEVED. THE PROGRESS IS DUE TO THE ADOPTION OF A CONTINUOUS LOADING PROCESS BY MEANS OF THE SALZGITTER LOADER AND BUNKER TRAIN AT CHANRION AND THE USE OF AN INTERMITTENT LOADING PROCESS BY MEANS OF A ROCKER SHOVEL LOADING INTO 2 CUBIC METERS MINE CARS IN THE FEEDER TUNNEL. THE SALZGITTER BUNKER TRAIN RESULTED IN AN INCREASE OF 37 PERCENT IN THE NUMBER OF ROUNDS PER SHIFT AND OF 38 PERCENT IN THE RATE OF ADVANCE. A REDUCTION OF 40 PERCENT IN THE TOTAL WORKING TIME REQUIRED. IN DRILLING JUMBO'S AND BOOM MOUNTED DRILLING MACHINES SHOULD BE USED. THE EXTRA TIME THAT IS NOT BEING USED OR IDLE TIME SHOULD BE USED FOR PERFECTION OF DRILLING AND BLASTING. IN THIS TUNNEL LOADING CAPACITY CAN BE INCREASED BY 20 PERCENT FOR MEDIUM-FRAGMENTED ROCK IF A LARGE BUCKET IS USED ON THE SHOVEL LOADER. IF LARGER MOTORS ARE USED ON THE MOTORS, THE ROCK SHOULD BE WELL FRAGMENTED BY USING MULTI-SECOND DETONATORS. EXTENSION RAILS COULD SAVE TIME IF THEY WERE USED.

54-64-04001 A SAFETY EVALUATION OF UNDERGROUND DIESEL EQUIPMENT (VENTILATION)
LOVE, R. F. + FURSE, J. H. & FMC CORP
MINING CONGRESS JOURNAL, (50) NO 4, 58-60, APRIL 1964. DIESEL ENGINES ARE USED BY FMC CORP. IN THE GREEN RIVER MINE. COLORIMETRIC GAS DETERMINATIONS SHOWED THAT WHEN THE BUREAU OF MINES VENTILATION REQUIREMENTS ARE MET, TOXIC EXHAUST GASES WILL NOT EXCEED TRACE AMOUNTS. AT 50 PERCENT OF REQUIRED VENTILATION TOXIC GASES ARE AT 10-60 PERCENT OF MAXIMUM ALLOWABLE AMOUNTS. ODOR AND EYE IRRITATION BECOME UNBEARABLE BEFORE TOXIC GAS CONCENTRATIONS REACH MAXIMUM ALLOWABLE CONCENTRATIONS.

54-64-11001 AN EXPLANATION OF UNIQUE PREMATURE DETONATION OF EXPLOSIVES IN SHOTHOLES (EXPLOSIVES SAFETY)
PARKER, R. L. & MINISTRY OF POWER
MINING ELECTRICAL & MECHANICS ENGINEER, (45) 120-126, NOV. 1964. AS SAFETY PRECAUTIONS TO PREVENT PREMATURE FIRING, DETONATOR LEADS SHOULD BE SHORT-CIRCUITED UNTIL THE MOMENT OF FIRING. ALSO, ALL FIRING CIRCUITS SHOULD BE SHORT-CIRCUITED UNTIL CONNECTED TO THE EXPLODER PRIOR TO FIRING.

54-64-12002 CERRO TUNNELS THROUGH 100,000 GPM (DOUBLE-TUNNELS PERU)
ARGALL, G. O., JR.
METAL MINING AND PROCESSING, 27-29, DEC. 1964. CERRO DE PASCO IS DRIVING TWO TUNNELS, EACH WITH A PROJECTED LENGTH OF 11,360 METERS, TO DRAIN AND VENTILATE THE CASAPALCA MINE IN THE PERUVIAN ANDES. THE TUNNELS WILL END AT AN ELEVATION OF 3,232 METERS. HEAT AND DIFFICULTY OF VENTILATION MORE THAN THE PROBLEM OF PUMPING WATER FORCED TERMINATIONS OF DEVELOPMENT AND MINING BELOW THE 2700 LEVEL. THE HIGH MINE GRADE ORE HERE, TOTALING 850,000 TONS, IS THE TARGET FOR THE GRATON TUNNEL. ONE TUNNEL WILL BE USED FOR DRAINAGE OF HOT WATER. IT IS TWO METERS LOWER THAN THE SECOND, THE HAULAGE AND VENTILATION TUNNEL. EACH TUNNEL HAS A SEMI-CIRCULAR ARCHED BACK WITH STRAIGHT SIDES. THE TUNNELS MEASURE 10 X 10 FT AND ARE DRIVEN AT A GRADE OF 0.3 PERCENT. LARGE WATER INFLOWS WERE ENCOUNTERED, BUT WERE SUCCESSFULLY HANDLED. CROSS CUTS WERE DRIVEN ALONG WITH DIAMOND DRILL HOLES. THE TWO TUNNELS ARE INTERCONNECTED ABOUT EVERY 600 METERS BY A CROSS-CUT TURNED OFF THE HAULAGE TUNNEL AT 26.5 DEG. SIX LOADED 4-CU-YD. CARS CAN BE HAULED UP THE FIVE PERCENT GRADE WITH ONE MOTOR. NORMAL CREWS IN EACH HEADING NUMBER 18 TO 22 PER SHIFT. TARGET DATE FOR COMPLETION IS EARLY 1967. AS A SAFETY PRECAUTION, IT IS ROUTINE TO DIAMOND DRILL A 2 5/8-IN. PILOT HOLE WELL AHEAD OF THE FACE. TO DATE, THE TUNNEL HAS BEEN DRIVEN THROUGH QUARTZITE, LIMESTONE, AND TUFF. NORMAL CONDITIONS PREVAILED. TRAINING OF CREWS, ETC. WAS OF PRIMARY CONCERN DURING FIRST DRIVING PROCEDURES. NO EFFORT WAS MADE TO KEEP THE DRAINAGE TUNNEL FACE AHEAD OF THE HAULAGE TUNNEL FACE. VENTILATION HAS BEEN DEEMED "BEST EVER SEEN". CONNECTION OF THE END OF THE TUNNEL WILL BE INTERESTING. ONE POSSIBILITY: THE DRIVING OF A LONG INCLINED RAISE FROM THE TUNNEL AND THE DRIVING OF A VERTICAL RAISE. COSTS TO DATE HAVE BEEN CLOSE TO ESTIMATES.

54-65-03001 CLYDE TUNNEL: DESIGN,CONSTRUCTION AND TUNNEL SERVICES (LIGHTING VENTILATION)
MORGAN, H. D. + HASWELL, C. K. + PIRIE, E. S. & SIR WM. HALCROW AND PARTNERS
INST. OF CIVIL ENGINEERS, 291-322, MARCH 1965. THE CLYDE TUNNEL CONSISTS OF TWO LANE TUNNEL BENEATH THE RIVER CLYDE. A FORMULA WAS DEVISED TO REDUCE TO A MINIMUM THE UNCERTAINTIES IN CONSTRUCTIONAL COSTS. A HEAVY CAST-IRON LINING WAS USED TO MEET THE DIFFICULT DRIVING CONDITIONS. THE PORTALS AND APPROACHES WERE MADE OF HEAVY REINFORCED CONCRETE. THE PROBLEM OF RESISTING FLOTATION WAS SOLVED BY THE USE OF LARGE DIAMETER TENSION PILES. TUNNEL HAS PROVISION FOR TRANSVERSE VENTILATION UP TO 50 PERCENT OF MAXIMUM CAPACITY. CARBON MONOXIDE ALARMS AND A MONITORING SYSTEM ARE SET UP, LIGHTING IS BY HOT CATHODE FLUORESCENT TUBES THROUGHOUT AND THE LIGHTING LEVEL IS INCREASED AT THE ENTRANCES.

54-65-03002 PROGRAM FOR SYSTEMATIC UNDERGROUND SAFETY (ACCIDENT-RATE SAFETY-RESPONSIBILITY EFFICIENCY COST MORALE)
COLLIER, W. R. & MAGMA COPPER CO
MINING CONGRESS JOURNAL, 36-38, MAR 1965. SAN MANUAL MINE OPERATES 3 SHIFTS A DAY, 7 DAYS A WEEK WITH A TOTAL WORK FORCE OF 1200 TO PRODUCE 1,000,000 TONS OF LOW GRADE COPPER ORE EACH MONTH FROM ITS UNDERGROUND MINE. A SYSTEMATIC SAFETY PROGRAM HAS RESULTED IN ONE OF THE FINEST SAFETY RECORDS IN THE UNDERGROUND MINING INDUSTRY. EMPLOYEE SAFETY RESTS ENTIRELY WITH SUPERVISORY STAFF. BY INTENSIFYING ITS PROGRAM ACCIDENTS PER 1,000,000 MAN-HRS WORKED WERE REDUCED FROM 35.71 IN 1960 TO 13.61 IN 1962. BESIDES ITS PROGRAM TO MAKE EMPLOYEES MORE SAFETY CONSCIOUS IT CONTINUALLY STRIVES TO SPOT HAZARDS, LEARN THE CAUSE, FIND THE CURE, AND MAKE THE CURE STICK. EFFICIENCY AND MORALE HAVE BEEN INCREASED WITH A CORRESPONDING PRODUCTION COST REDUCTION.

54-65-05001 ULTRASONIC SENSING IN MINES (SAFETY)
SAINS, H. + REEVE, G. R. & WESTOOL LTD
INSTRUMENT PRACTICE, 436-439, MAY 1965. THE USE OF ULTRASONIC SENSING HAS BEEN RESTRICTED PENDING THE GRANTING OF CERTIFICATION. TO OBTAIN THIS, THE EQUIPMENT MUST BE CAPABLE OF BEING FED FROM A 15 V A.C. SUPPLY WHICH HAS AN INTERNAL IMPEDANCE WHICH IS HIGH ENOUGH TO LIMIT THE SHORT CIRCUIT CURRENT TO A VALUE WHICH WILL NOT IGNITE THE PARTICULAR GROUP OF GASES FOR WHICH IT IS CERTIFIED "SAFE." THE STORAGE OF MATERIAL IS ONE OF THE PROBLEMS FACED IN MINING. THE STEEL OR REINFORCED CONCRETE HOPPERS ARE USED, BUT COAL LEVEL IS DIFFICULT TO DETERMINE. THE FITTING OF SENSING DEVICES TO EXISTING HOPPERS IS ALSO A PROBLEM. BUT THE USE OF ULTRASONIC SENSING DEVICES HAS OVERCOME THESE DIFFICULTIES. A LADDER IS CONSTRUCTED, HOUSING THE DEVICES. IT IS THEN LOWERED INTO THE HOPPER. TO KEEP FACES WORKING AT ALL TIMES, CONVEYOR BUNKERS ARE INSTALLED USING TWO SENSING DEVICES. OVER-LOADED OR JAMMED CONVEYORS CAN BE AIDED BY SENSING DEVICES ON EITHER SIDE OF THE CHUTE. ULTRASONIC DEVICES HAVE ALSO PROVED EFFECTIVE IN SENSING THE HEIGHT OF COAL AND CONTROLLING BOOMS. THESE DEVICES ARE ALSO USED IN MINE CAGE AND MINE CAR POSITIONING AND TRAFFIC CONTROL. THE SYSTEM IS EFFECTIVE IN ADVERSE WEATHER CONDITIONS AND IN A DUST-LADEN ATMOSPHERE.

54-65-06001 DUST CONTROL DURING BLASTING (ROCK-BREAKAGE SAFETY ENVIRONMENTAL-CONTROL AIR HANDLING VENTILATION STEMMING)
WILD, W. H. & OBERHAUSEN GER
GLUECKAUF, (101) N 12, 706-712, JUNE 1965. TWO TYPES OF DUST ARE PRODUCED BY MINE BLASTING, PRIMARY AND SECONDARY. SUFFICIENT VENTILATION IS A NECESSITY. DUST CONTROL MEASURES ARE DRY FILTERING (EXPENSIVE), FOG CURTAIN (REQUIRES CAREFUL MAINTENANCE), AND STEMMING (DUST PREVENTORS IN SHOT HOLES). MOST-USED STEMMING MATERIAL TO WATER AMPULE AND TRABANT PASTE. THESE TWO ARE EQUAL IN DUST-TRAPPING EFFECT. WATER CONTENT OF THE STEMMING CARTRIDGES HAS A DECISIVE INFLUENCE ON DUST TRAPPING. MINIMUM VOLUME OF WATER FOR WATER AMPULE STEMMING IS 250 CUBIC METERS AND 265 CUBIC METERS FOR TRABANT PASTE STEMMING.

54-65-12001 STATE OF RESEARCH IN THE FIELD OF MINE VENTILATION (ENVIRONMENTAL-CONTROL SAFETY)
LINSEL, E.
GLUECKAUF, (101) NO 26, 1517-21, DEC 22, 1965. AIR TEMPERATURES IN MINES OF THE RUHR HAVE INCREASED MORE THAN THE 1 DEG C PER 30 METERS DEPTH CAUSED BY THE 10 METER/YR. INCREASE IN DEPTH MADE IN THE LAST 3 YEARS. THE GREATEST RISE IS DUE TO INCREASED RATE OF PRODUCTION. STUDIES WERE MADE TO DETERMINE RATES OF HEAT TRANSFER FROM COAL IN VARIOUS FORMS TO THE ATMOSPHERE. STEPS ARE BEING TAKEN TO PREDICT ATMOSPHERE TEMPERATURES FROM MOUNTAIN TEMPERATURES AND AIR FLOW RATES. METHODS OF MEASURING METHANE CONTENT OF COAL ARE BEING DEVELOPED. STUDY OF METHANE STRATIFICATION BY MODELS SHOWS THAT AIR VELOCITIES HAVE TO BE UNACCEPTABLY HIGH TO PREVENT OR BREAK DOWN ALL METHANE LAYERS. SPECIAL AIR MOVEMENT EQUIPMENT WAS DEVELOPED TO ASSIST IN PREVENTING METHANE STRATIFICATION.

54-66-03001 ROLE OF URETHANE FOAM IN MINES (SAFETY COST)
MITCHELL, D. W. + MURPHY, E. M. & U.S. BUR MINES PITTSBURGH PA
COAL AGE, 72-74, MAR 1966. URETHANE FOAM WHEN PROPERLY USED REDUCES OPERATING COSTS, IMPROVES VENTILATION, AND REDUCES MAINTENANCE COST OF COATED SURFACES. GUNITE COATINGS MUST BE RENEWED EVERY 2-4 YEARS WHILE FOAM APPLICATIONS LAST OVER TWICE AS LONG. TWO MEN CAN FOAM 3000-5000 SQUARE FEET PER SHIFT WHILE FOUR MEN APPLY GUNITE TO 600-1500 SQUARE FEET PER SHIFT.

54-66-03002 REVERSAL OF AIR FLOW BY A FIRE (VENTILATION)
MAAS, W. + SADEE, C. & DUTCH STATE MINES
GEOLOGIE EN MIJNBOUW, (45) N 3, 54-69, MAR 1966. PROFESSOR BUDRYK (POLAND) WARNS THAT IF, IN A MINE WITH ASCENSIONAL VENTILATION, TWO DISTRICTS ARE VENTILATED IN PARALLEL A FIRE IN ONE OF THESE DISTRICTS MAY CAUSE SO GREAT A NATURAL VENTILATION AS TO CAUSE A REVERSAL OF THE AIR CURRENT IN THE DISTRICT NOT AFFECTED BY THE FIRE. IT WAS CONCLUDED THAT THE CHANCE OF A REVERSAL OF THE AIR CURRENT AS A RESULT OF A FIRE IN A MINE WITH UPCAST VENTILATION IS SMALLER THAN BUDRYK CALCULATED. DECREASING THE QUANTITY OF AIR FLOWING THROUGH A DISTRICT AS SOON AS A FIRE IS REPORTED, AS IS ADVISED BY BUDRYK MAY CAUSE A SMALL ORIGINAL FIRE TO DEVELOP MORE QUICKLY INTO A BIG TIMBER FIRE. THROTTLING OF A TIMBER FIRE DECREASES THE CHANCE OF THE AIRFLOW IN OTHER DISTRICTS, DECREASES ALL OTHER EFFECTS OF THE FIRE AND INCREASES THE EFFECTIVENESS OF FIREPROOF ZONES. WHEN AIR TEMP. IN A ZONE BEHIND THE FIRE HAS SURPASSED THE SELF-IGNITION TEMP. OF WOOD, ANY INCR. OF OXYGEN WILL START A TIMBER FIRE THERE. ESTIMATIONS OF THE TEMPERATURE BEHIND THE FIRE CAN BE MADE WITH THE METHOD GIVEN.

54-68-10001 RESEARCH ON PNEUMOCONIOSIS CONTROL AT THE SAFETY IN MINES RESEARCH ESTABLISHMENT (ENVIRONMENTAL-CONTROL)
CRITCHLOW, A. + MAGUIRE, B. A. & SAFETY IN MINES RES EST
INSTITUTION OF MINING AND METALLURGY TRANSACTIONS, SECTION A, (77) A 158-A 166, OCT 1968. THE SAFETY IN MINES RESEARCH ESTABLISHMENT'S WORK IN PNEUMOCONIOSIS CONTROL IN MINES IS CONCERNED MAINLY WITH (1) THE PHYSICS OF RESPIRABLE DUST AND THE DESIGN OF DUST SAMPLING INSTRUMENTS (2) THE ANALYSIS OF HUMAN LUNG MATERIAL, AND (3) THE ANALYSIS OF THE RESULTS OF EXPERIMENTS IN WHICH LABORATORY ANIMALS ARE EXPOSED TO HIGH AIRBORNE-DUST CONCENTRATIONS.

54-68-10002 PHOTOELECTRIC READINGS, THEIR SIGNIFICANCE FOR DUST CONTROL ON COLLIERIES (DUST-SUPPRESSION DUST-ANALYSIS)
KITSON, G. H. J. + HAVEN, Y. J. F. & CHAMBER OF MINES SOUTH AFRICA
JOURNAL OF SOUTH AFRICAN INSTITUTE OF MINING AND METALLURGY, (130) 137-138, OCT. 1968. ROUTINE DUST MEASUREMENTS ARE ESSENTIAL IN DUST SUPPRESSION. THEY CAN BE MADE QUICKLY AND ACCURATELY WITH WELL-KNOWN INSTRUMENTS, SUCH AS THE MODIFIED THERMAL PRECIPITATOR AND THE TYNDALLOSCOPE. THESE SAMPLINGS HELP MANAGERS IN IMPROVING CONDITIONS IN COLLIERIES. THE SAMPLES ARE DRIED AND THEN ASSESSED PHOTOELECTRICALLY. THE SAMPLING TECHNIQUE FULFILLS THE REQUIREMENTS OF CONTROL SAMPLING, VIZ, (1) REPEATABILITY, (2) RELATIVELY SHORT PERIOD OF SAMPLING, (3) ABILITY TO TAKE SEVERAL SAMPLES, (4) RAPID AND CONVENIENT USE, AND (5) RAPID AND CONVENIENT ANALYSIS OF RESULTS. P.E.R. VALUES AND CONFIDENCE INTERVALS SIGNIFY WHEN THERE IS AN IMPROVEMENT. DETERIORATION, OR NO CHANGE. THE IMPROVEMENT IN DUST CONDITIONS FROM 1956 TO 1957 IS ENCOURAGING AND ILLUSTRATES THE SUCCESS OF THE SYSTEM.

54-69-08001 TUNNEL VENTILATION (SAFETY)
BAKER, P. J.
CONSULTING ENGINEER (LONDON), (33) NO 6, 54-6, JUNE 1969. A REPORT ON THE MODEL TESTS MADE BY BRITISH HYDROMECHANICS RESEARCH ASSN FOR A 7000 FT HIGHWAY-RAIL TUNNEL IN CANADA. BEST METHOD OF DISTRIBUTING AND EXHAUSTING AIR WERE DETERMINED. A DESIGN WAS PRODUCED WHICH GAVE PROPER DISTRIBUTION AND EXTRACTION DUCTS FOR UNIFORM VENTILATION. LOW LOSS BENDS FOR DUCTS WERE DEVELOPED.

FIELD 55 NEWS ITEMS

55-64-04001 WET DRILLING ELIMINATES DUST (HEALTH BITS DRILL-STEEL DETERGENT)
CONSTRUCTION METHODS & EQUIPMENT, 143, APR 1964. INJECTING WATER OR A WEAK DETERGENT INTO THE DRILL HOLE VIA THE BLOWING HOSE WAS DEVELOPED IN CANADA AND NOW USED IN CALIFORNIA HIGHWAY PROJECTS TO ELIMINATE THE SERIOUS DUST HEALTH HAZARD. IT ALSO PROLONGS DRILL STEEL AND BIT LIFE. A DETAILED DESCRIPTION OF THE SYSTEM IS GIVEN. LIQUID MUST BE CAREFULLY REGULATED AS TOO MUCH MUDDIES THE HOLE WHILE TOO LITTLE GIVES NO DUST CONTROL. ABOUT ONE GALLON OF DETERGENT AND WATER OR TWO GALLONS OF WATER ARE REQUIRED PER HOUR FOR PROPER DUST CONTROL.

55-64-09001 UNDERWATER ROAD BORE IS UNLINED (COSTS)
ENGINEERING NEWS-RECORD, (173) N 12, 144-146, 150, SEPT 17, 1964. THE SWEDISH BORE, OR MUSES TUNNEL IS 1 3/4 MILES, 200 FT. UNDERWATER, HAS LIGHTS AND VENTILATION, BUT NO ARCH RIBS OR STRUCTUPAL LINING EXCEPT AT THE PORTALS. ITS COST OF CONSTRUCTION $2.5 MILLION OR $262/FT. THE HOLE HAS A RECTANGULAR CROSS SECTION OF 398 SQ. FT; THE ROADWAY IS 19 FT. 8 IN. WIDE, ROOF CLEARANCE IS 14 FT. 9 IN. THE ROCK COMPOSITION IS MAINLY COMPACT GNEISS OR GRANITE GNEISS. IN CUTTING DRIFTS FROM THE SHAFTS, THE BURNING CUT METHOD WITH FIVE CENTRAL HOLES WAS USED. THE AVERAGE DAILY ADVANCE THROUGH THE HOLE WAS 14 3/4 FT. (2 12 HR. SHIFTS). AT BOTH PORTALS, THE ROOF OF THE TUNNEL IS REINFORCED WITH RIBS; A CANTILEVER SLAB OF REINFORCED, CAST-IN PLACE CONCRETE EXTENDS OVER THE ROADWAY FOR 5 FT. LEAKS WITHIN THE BORE WERE SEALED BY THE INJECTION OF GROUT. THE ROOF WAS SPRAYED PNEUMATICALLY WITH ONE OR TWO COATS OF MORTAR TO REINFORCE THE ROCK, PREVENT AIR-CAUSED DETERIORATION, TO IMPROVE LIGHTING. THE TUNNEL HAS LENGTHWISE VENTILATION.

55-65-07001 OPENING OF MONT BLANC TUNNEL (VENTILATION LIGHTING)
THE ENGINEER, 109-110, JULY 16, 1965. THE LENGTH IS 11,600 M. ROCK CONDITIONS WERE GOOD CONSISTING FOR THE MOST PART OF PROTOGINE. ON THE ITALIAN SIDE THE BRITTLENESS AND UNCERTAINTY OF THE NATURE OF THE ROCK DEMANDED A FLEXIBLE

APPROACH. THE MUCKING OUT WAS DONE BY RUBBER-TIRED DIESEL DUMPER TRUCK. ON THE FRENCH SIDE A HIGHER DEGREE OF MECHANIZATION BASED ON A FULL-SECTION ADVANCE FOR THE WHOLE LENGTH OF THE TUNNEL. DRILLING WAS DONE BY A RAIL MOUNTED JUMBO WITH 15 44 MN DIAMETER PNEUMATIC DRILLS. THE VENTILATION IS ARTIFICIAL WHICH IS PART AIR PASSING ACROSS THE TUNNEL AND FRESH AIR BEING DISTRIBUTED AT REGULAR INTERVALS AT RIGHT ANGLES TO THE TUNNEL AXIS WHILE THE EXHAUST AIR IS EXHAUSTED LONGITUDINALLY ALONG THE WHOLE LENGTH OF THE TUNNEL. THE STANDARD OF LIGHTING IS SET AT 30 LUX. THE ANNUAL TRAFFIC IS EXPECTED TO BE ABOUT 450,000 VEHICLES.

55-65-08001 A FEW EASY TO FOLLOW RULES FOR EFFECTIVE ROOF SAFETY (ROOF-BOLTS SUPPORTS)
ENGINEERING AND MINING JOURNAL, (166) 113, AUG. 1965. MAKE SURE THE BOLT HOLE IS DRILLED TO AS CLOSE A TOLERANCE AS POSSIBLE. PERIODIC HOLE SIZE CHECKS WITH AN ACCURATE HOLE GAUGE. MAKE SURE THE BOLT HEAD AND ROOF PLATE ARE FIRMLY AGAINST THE ROOF. IF USING HYDRAULIC MACHINES CHECK TORQUE SETTING. THE BOLT PULL TEST - SUBJECTING THE BOLT AND EXPANSION UNIT TO ABNORMALLY HIGH LOADING IS THE BEST WAY TO DETERMINE THE COMPLETE INSTALLATION.

55-65-08002 TUNNEL EASES 21-YEAR TRAFFIC JAM (COST LININGS)
ENGINEERING NEWS-RECORD, (175) 110, AUG 12, 1965. TO EASE TRAFFIC PROBLEMS IN MARSEILLES, FRANCE A 1950 FEET SUNKEN TWIN TUBE TUNNEL WILL BE BUILT ACROSS A FINGER OF THE SEA FOR $12 MILLION WHICH WILL TAKE CARE OF 60,000 CARS DAILY. THE TUNNEL WILL BE MADE OF REINFORCED CONCRETE SEGMENTS PRE-FABRICATED.

55-66-02001 MYSTERIOUS GAS KILLS 17 IN SWISS HYDRO TUNNEL (POWER-PROJECT)
ENGINEERING NEWS-RECORD, (176) 19, FEB 24, 1966. INVESTIGATORS ARE STILL TRYING TO DETERMINE THE ORIGIN AND IDENTITY OF GAS IN A SWISS HYDROELECTRIC TUNNEL THAT KILLED 17 PEOPLE. THE TUNNEL IS PART OF THE MAGGIA POWER PROJECT IN SOUTH CENTRAL SWITZERLAND NEAR THE ITALIAN BORDER. THE PROJECT HAS A MAZE OF TUNNELS, DAMS AND POWERHOUSE. WORKMEN WERE KILLED WHEN ENTERING THE TUNNEL AT THREE DIFFERENT POINTS.

55-67-02001 BETTER BOLTING METHODS IMPROVE SAFETY AND OUTPUT (ROCK-BOLTING)
COAL AGE, 134-135, FEB 1967. FLEXIBLE AIR HOSE ADDED TO THE PNEUMATIC ROOF-BOLTING OPERATION HAS INCREASED PRODUCTION AND IMPROVED SAFETY. POOL. BOLTING CONTINUES RIGHT UP TO THE WORKING FACE AS THE CONTINUOUS MINER ADVANCES. THE FLEXIBLE HOSE IS CONNECTED TO A CENTRAL COMPRESSOR.

55-67-11001 15 ASPHYXIATED IN HYDRO TUNNEL (PERU GAS-TEST DUST-POCKET)
ENGINEERING NEWS-RECORD, (179) 20, NOV 16, 1967. A ROUTINE DYNAMITE BLAST IN A TUNNEL IN PERU CAUSED THE DEATH OF FIFTEEN MEN BY ASPHYXIATION. NONE OF THE MEN CARRIED MASKS AND THE VENTILATION PIPE ENDED 100 YD. BACK FROM THE TUNNEL FACE. A POPULAR THEORY IS THAT THE DYNAMITE BLAST OPENED A POCKET OF EXTREMELY FINE DUST.

55-67-12001 TUNNEL UNDER ENGLISH CHANNEL TO DISLOCATE FOUR FRENCH VILLAGES
THE WASHINGTON POST, A6, DEC 14, 1967. THE FRENCH ENTRY TO THE TUNNEL-TO-BE UNDER THE ENGLISH CHANNEL HAS MADE IT IMPERATIVE FOR 1000 PERSONS TO FIND NEW HOMES IN FRANCE. CONSTRUCTION DETAILS FOR THE TUNNEL ARE STILL INCOMPLETE, BUT PREPARATIONS FOR THE RELOCATION OF THE PEOPLE ARE ALREADY BEING MADE. FRENCH OFFICIALS HAVE SET 1970 AS THE DATE FOR THE START OF BORING.

55-68-01001 TUNNEL CAVE-IN TRAPS 17 FOR 17 HOURS, INJURES NONE
ENGINEERING NEWS-RECORD, JAN 4, 1968. THE CARLEY V. PORTER TUNNEL, ONE OF FOUR TUNNELS IN THE TEHACHAPI MOUNTAINS CAVED IN. A MECHANICAL MOLE WAS BEING USED WHEN AN 80 FT-LONG CAVE-IN OCCURRED 1450 FEET FROM THE SOUTH PORTAL. THE SOUTH HEADING IS 7,785 FEET FROM THE PORTAL.

55-68-02001 SAFETY ASPECTS OF RAISE BORING (ROBBINS-BORER)
MINING MAGAZINE, (118) N 2, 98-103, FEB. 2, 1968. DESCRIPTION OF ROBBINS RAISE BORER, DEVELOPED AT HOMER-WAUSECA IRON ORE MINE AT IRON RIVER, MICH; CRAWLER MOUNTED BORER DRILLS DOWNWARD 9 7/8 IN. DIAM HOLE WHICH UPON REACHING DESIRED POINT ON LOWER LEVEL, IS REAMED UPWARD TO 40 IN. DIAM. BORING EQUIPMENT AND TECHNIQUE OF ITS OPERATION DISCUSSED WITH PARTICULAR EMPHASIS ON SAFETY OF OPERATING CREW. APPLICATIONS OF RAISE BORER ARE OUTLINED AND PERFORMANCE DATA OVER 5 YR. PERIOD IS TABULATED.

55-68-06001 NADER BRANDS COAL MINE INSPECTIONS A 'FARCE' (SAFETY PNEUMOCONEOSIS)
THE WASHINGTON POST, C8, JUNE 29, 1968. NEEDED IMPROVEMENT IN MINE VENTILATION AND DUST SUPPRESSION TECHNIQUES ARE NEEDED. PNEUMOCONIOSIS AFFLICTS ONE IN 10 EMPLOYED MINERS.

55-68-09001 STRICTER COAL MINE SAFETY ACT SOUGHT (CAVE-INS EXPLOSIONS UNSAFE-EQUIPMENT MINE-FACE HEALTH-STANDARDS)
COHN, V. & WASHINGTON POST WASH D.C.
THE WASHINGTON POST, A7, SEPT 12, 1968. NEWS ITEM ON PRESIDENT JOHNSON SENDING TO CONGRESS A PROPOSED FEDERAL COAL MINE HEALTH AND SAFETY ACT TO CORRECT WEAKNESSES OF PRESENT LAW. FEATURES OF THE ACT AND DESCRIPTION OF INADEQUACIES ARE OUTLINED.

55-68-10001 PRESIDENT PROPOSES NEW LAW ON COAL MINE HEALTH, SAFETY
MINING CONGRESS JOURNAL, (54) NO 10, 70, OCT 1968. PRESIDENT JOHNSON PROPOSED TO CONGRESS A NEW COAL MINING HEALTH AND SAFETY ACT WHICH WOULD EXTEND FEDERAL ENFORCEMENT TO THE WORKING FACE, ABOLISH THE GRANDFATHER CLAUSE RE ELECTRICAL EQUIPMENT, GIVE SECY OF INT. AUTHORITY TO DEVELOP SAFETY STANDARDS, REQUIRE INT. TO ENFORCE THE STANDARDS.

55-68-10002 NEW HEALTH, SAFETY STANDARDS UNDER WALSH-HEALY ACT SOUGHT (NOISE TOXIC-GASES)
MINING CONGRESS JOURNAL, (54) NO 10, 70, OCT 1968. SECY. OF LABOR WIRTZ PROPOSES (1) A LIMIT OF 85 DECIBELS ON THE LEVEL OF OCCUPATIONAL NOISE, (2) STANDARDS ON THE BASIS OF CONSENSUS SIMILAR TO USA STANDARDS INSTITUTE (3) RADIATION STANDARD DEVELOPED BY AEC, AND (4) THRESHOLD LIMITS FOR EXPOSURE TO TOXIC MATERIALS. PUBLIC HEARINGS WILL BE HELD IN NOVEMBER 1968.

55-69-01001 COUGHING COAL MINERS RALLY FOR SAFETY BILLS (BLACK-LUNG SAFETY)
BURCHARD, H. & WASHINGTON POST WASH D.C.
THE WASHINGTON POST, A6, JAN 6, 1969. A RALLY IN LOGAN W.VA MAY HELP BRING PASSAGE OF A BILL TO REQUIRE NEW MINING SAFETY STANDARDS. COAL MINING IS THE MOST DEADLY OF ALL MAJOR OCCUPATIONS IN THE U.S. AT LEAST ONE COAL MINER IN FIVE SUFFERS FROM PNEUMOCONIOSIS WHICH IS CAUSED BY PROLONGED BREATHING OF VERY FINE COAL DUST. UNDER THE NEW LEGISLATION, THE DISEASE WOULD FALL UNDER THE STATE WORKMEN'S COMPENSATION LAW.

55-69-02001 HEARING ON MINE PERILS OPENS (BLACK-LUNG COMPENSATION LEGISLATION)
BURCHARD, H.
THE WASHINGTON POST, A8, FEB 12, 1969. BLACK-LUNG (PNEUMOCONIOSIS) CAUSED BY PROLONGED BREATHING OF VERY FINE COAL DUST HAS BEEN INTERNATIONALLY RECOGNIZED WITH DUST CONTROL MEASURES SINCE 1943 BY EVERY MAJOR COAL-PRODUCING NATION EXCEPT THE U.S. IN TESTIMONY AT CHARLESTON W. VA ON LEGISLATION AND COMPENSATION IT WAS BROUGHT OUT THAT BLACK-LUNG DOES NOT NECESSARILY SHOW UP ON X-RAYS AND DOCTOR AFTER DOCTOR DISAGREED WITH EACH OTHER. THE FATE OF THE BILLS IS UNCERTAIN BUT PROOF IS BEING SHIFTED FROM THE MINER TO THE COMPANY.

55-69-02002 WITH ONLY 90 FT TO GO TUNNELERS HIT RUNNING SAND (SAFETY WATER-TUNNEL)
WESTERN CONSTRUCTION, (44) N 2, 62-6, FEB. 1969. TECHNIQUES AND SAFETY MEASURES USED IN CONSTRUCTION OF LAKE CHAPLAIN WATER TUNNEL FOR CITY OF EVERETT, WASH; OUTLET CONSISTS OF 590 FT OF 96-IN. STEEL PIPE LAID ON 2 TO 1 SLOPE DOWN FROM TUNNEL PORTAL.

55-69-04001 DOCTOR PRAISES CZECH MINE SAFETY (COAL-MINES DUST BLACK LUNG)
BURCHARD, H. & WASHINGTON POST WASH D.C.
THE WASHINGTON POST, A11, APRIL 16, 1969. DR. I. E. BUFF CLAIMS THAT SAFETY AND HEALTH CONDITICNS IN CZECHOSLOVAKIA COAL MINES ARE DECADES AHEAD OF U.S. MINES. FILTER MASK, SAFETY CAMPAIGNS, WETTING COAL SEAM AHEAD OF MINING MACHINE, CHEMICAL MASKS, EXTREME VENTILATION PRECAUTIONS AND ROUTINE HEALTH EXAMINATIONS ARE CITED.

55-69-07001 HOUSE LABOR UNIT DRAFTS MINE SAFETY BILL (ATMOSPHERIC-CONTROL COALDUST)
SPENCER, R. W.
THE WASHINGTON POST, A14, JULY 10, 1969. BILL PROVIDES FOR LIMITING ACCEPTABLE CONCENTRATIONS CF COAL DUST IN COAL MINES. CONTAINS OTHER SAFETY PROVISIONS TO REDUCE THE LIKELIHOOD OF EXPLOSIONS, MAJOR ACCIDENTS, AND CAVEINS.

55-69-07002 TAX ON MINES URGED TO CURB BLACK LUNG (SAFETY DISEASE COMPENSATION)
THE WASHINGTON POST, A4, JULY 11, 1969. DR. I. E. BUFF OF CHARLESTON W.VA CHAIRMAN OF THE PHYSICIANS COMMITTEE FOR MINERS HEALTH AND SAFETY TOLD A HOUSE LABOR COMMITTEE THAT MINE OPERATORS SHOULD BE TAXED TO PROVIDE $125 A MONTH COMPENSATION FOR SICK OR INJURED WORKERS.

55-69-08001 SENATE UNIT UNANIMOUSLY BACKS TOUGH COAL MINE SAFETY BILL
THE WASHINGTON POST, A2, AUG. 1, 1969. A TOUGH NEW COAL MINE SAFETY BILL, WITH THE NATIONS FIRST DUST-CONTROL STANDARDS TO COMBAT THE LETHAL BLACK LUNG DISEASE, WAS APPROVED BY THE SENATE LABOR AND PUBLIC WELFARE COMMITTEE YESTERDAY. THE BILL PERMITS THE SECRETARY OF INTERIOR TO SHUT ANY MINE WHERE THERE IS IMMINENT DANGER OR AN UNCORRECTED VIOLATION OR WHERE CONDITIONS ARE INHERENTLY IF NOT IMMEDIATELY DANGEROUS. OTHER PROVISIONS PROVIDE FOR THE END BETWEEN "GASSY" AND NONGASSY MINES AND FOR LIMITS ON THE CONCENTRATIONS OF BREATHEABLE COAL DUST.

55-69-09001 2D AVE SUBWAY FOR GARBAGE URGED (GARBAGE SANITATION)
THE WASHINGTON POST, SEPT 23, 1969. A PROPOSED HIGH-SPEED CONVEYOR BELT WILL COLLECT GARBAGE AND WHISK IT ALONG PARALLEL TO SUBWAY TRAINS. THIS WILL ELIMINATE GARBAGE TRUCKS FROM TRAFFIC JAMS AND FREE SANITARY MEN FOR STREET CLEANING. OPEN CUTS ARE USED FOR SUBWAY CONSTRUCTION IN NEW YORK.

55-69-10001 BLACK LUNG PAYMENTS GAIN ON HILL (ASSESSMENT COMPENSATION HEALTH SAFETY)
THE WASHINGTON POST, A3, OCT 1, 1969. A SENATE AMENDMENT TO THE COAL MINE SAFETY BILL CALLS FOR 70 MILLION IN FEDERAL OUTLAYS. THIS SIDESTEPPED AN ASSESSMENT OF ONE TO FOUR CENTS A TON ON EACH TON OF COAL MINED TO PAY FOR COAL MINE HEALTH AND SAFETY RESEARCH. STATES WOULD PAY PART OF THE COMPENSATION PROGRAM ADDED TO THE BILL.

FIELD 6 COST ESTIMATES AND TUNNELING RECORDS

FIELD 64 ARTICLES

64-52-05001 TUNNEL DRIVING IN FRANCE (BLASTING DRILLING JUMBO STAR-DRILL SEEPAGE)
VIVIAN, C. H.
COMPRESSED AIR MAGAZINE, (57) N 5, 124-128, MAY 1952. THE SO-CALLED SWEDISH METHOD OF DRILLING AND BLASTING WAS LATER CHANGED TO THE LATEST TYPE OF AMERICAN EQUIPMENT IN A TUNNELING PROJECT IN FRANCE. THE SWEDES' CONTENTION THAT WITH THEIR SYSTEM OF SMALL HOLES THEY GOT ECONOMY AND SUPERIOR ROCK FRAGMENTATION WAS NOT PROVED WHEN HARD ROCK WAS ENCOUNTERED. THE NEW EQUIPMENT MADE A WEEKLY PROGRESS OF 95 1/2 FT. THE CONVENTIONAL AMERICAN DRILL BITS (STAR DRILL) ARE GIVING 473 FT PER BIT AS COMPARED TO THE SWEDISH BIT LIFE OF ONLY 272 FT PER BIT. THE SWEDISH BIT HAS A CHISEL POINT CUTTING EDGE. AN AVERAGE OF 21 LBS, 14 OZ. OF EXPLOSIVES IS USED PER CU-YD OF MATERIAL. A LOADING CREW ON EACH SHIFT CONSISTS OF A SUPERINTENDENT AND 21 MEN.

64-64-02001 TUNNEL VENTILATION SYSTEM DESIGN (HIGHWAY-TUNNELS)
EGILSRUD, P. & SVEDRUP AND PARCEL
AIR ENGINEERING, 19-23, FEB 1964. SYSTEM DESIGN OF THE COMPACT VENTILATION SYSTEM FOR TWO 6000 FT. TUNNELS AT BOTTOM OF CHESAPEAKE BAY WITH AIR CHANGE EVERY 1.7 MINUTES. 24 FANS LOCATED IN FOUR VENTILATING BUILDINGS. EACH FAN CAN DELIVER 300,000 CFM. SYSTEM DESIGNED FOR 225 CFM PER LINEAL FOOT OF TUNNEL.

64-64-09001 SOME ASPECTS OF HIGH SPEED HARD ROCK TUNNELLING IN THE SNOWY MOUNTAINS (TUNNELLING-RATES COST MATERIALS HANDLING)
ANDREWS, K. E. + MCINTYRE, A. R. + MATTNER, R. H. & SNOWY MTS HYDRO-ELECTRIC AUTH
CIVIL ENGINEERING TRANSACTIONS, 51-70, 1964. RAPID PROGRESS IN TUNNELLING RATES IS DUE TO EXTENSIVE GEOLOGICAL INVESTIGATION. ALSO, A USE OF INCENTIVE SCHEME TO AUGMENT PAYMENTS TO MEMBERS OF THE TUNNELLING CREWS. DRILLING PATTERNS SHOULD BE 2 1/2 TO 3 FEET ON THE HOLES. AN INCREASED RELIABILITY OF EQUIPMENT, SIZE OF EQUIPMENT AND IMPROVED DRILL STEELS AND BITS GAVE INCREASED PROGRESS. HALF SECOND DELAY DETONATORS GIVE TIME FOR SUCCESSIVE SERIES TO "PULL" EACH SECTION OF THE FACE AND CAUSE LESS SHATTERING TO THE SURROUNDING ROCK. THE SLIDING-FLOORS INCREASE THE SPEED OF HANDLING MUCK. USE OF THE LARGEST POSSIBLE EQUIPMENT FOR THE TUNNEL WILL LOWER COST. HAVE THE HIGHEST POSSIBLE STANDARD OF MAINTENANCE. HAVE GOOD WORKING CONDITIONS FOR WORKERS. MATCH EQUIPMENT TO THE WORK. ADAPT ROCK BOLTING TECHNIQUES TO TUNNELLING PRACTICES. THE COST OF DRIVING THE 11 FEET 10 INCH HORSESHOE TUNNEL AVERAGED 85 POUNDS PER LINEAR FOOT. THE EXPECTED COST ON THE 22 FT. 4 IN WILL BE 148 POUNDS PER LINEAR FOOT.

64-67-06001 ECONOMIC FACTORS OF MECHANICAL ROCK TUNNELING (JARVA MOLE COSTS)
NORMAN, N. E. + STIER, R.
MINING ENGINEERING, SOCIETY OF MINING ENGINEERS, 75-78, JUNE 1967. TUNNELING MACHINES ARE COMPARED IN PRICE AND SPEED WITH CONVENTIONAL METHODS. MOLES COST ABOUT $1000 PER HORSEPOWER TO BUILD. CUTTERS USED VARY WITH ROCK TYPE AND ARE THE MAJOR MAINTENANCE COST FOR MOLES. INITIAL CAPITAL INVESTMENT FOR MOLE TUNNELING ABOUT 3 1/4 TIMES GREATER THAN FOR CONVENTIONAL. MANPOWER REQUIRED IS ABOUT 55 PERCENT THAT OF CONVENTIONAL. SPEED VARIES BUT FREQUENTLY IS FROM 20 PERCENT TO 100 PERCENT FASTER.

64-68-11001 MAJOR CHANGES IN CAPITAL GOODS USED IN UNDERGROUND PRODUCTION OF BITUMINOUS COAL (COST-ESTIMATES)
SCHENCK, G. H. K. & PENN STATE UNIV
MINING ENGINEERING, 75-78, NOV. 1968. MINES USING A COMBINED CONVEYOR AND RAIL SYSTEM MAY PRODUCE MORE COAL THAN MINES USING ONLY ONE SYSTEM. MAIN-LINE RAIL AND MAIN BELT TRANSPORTATION HAVE SIMILAR COSTS. BASED ON A 4-1/4 MI. PRIMARY HAUL, CAPITAL COST - $70/FT. AN ESTIMATED 142 MILLION TONS REPRESENTING 43 PERCENT OF UNDERGROUND PRODUCTION WAS MINED BY CONTINUOUS MINING METHODS IN 1965. CAP. INVESTMENT REQUIRED FOR EQUIPPING A SECTION WITH A CONTINUOUS MINER IS HIGH AND MIGHT EASILY EXCEED BY 30 PERCENT TO 50 PERCENT OF THE ESTIMATED $250,000 COST OF A NEW CONVENTIONAL SYSTEM. THE QUALITY OF MANAGEMENT IS NOT VERY DIFFERENT THAN IT IS WITH CONVENTIONAL MINING. MATERIALS MUST BE AVAILABLE IN A FORM TO BE USED QUICKLY AND EFFECTIVELY. COSTS OF A PLANER SECTION ARE LOWER IN FACE COST, BECAUSE OF REPAIR AND MAINTENANCE, TIMBERING, WHILE PRODUCTION IS DOUBLED AND SEAM RECOVERY IS HIGHER (15 PERCENT). CONTINUOUS MINING TENDS TO INCREASE THE REFUSE (21 PERCENT OF ROM COAL CLEANED IS NOW REJECTED). ROOF CONTROL MAY BE EITHER A CAPITAL OR AN OPERATING EXPENSE. VENTILATION AND WATER CONTROL ARE MATTERS OF CAPITAL GOODS AND MANAGEMENT INPUT. THE OVERALL EFFECT OF INCR. AMT. AND QUALITY OF MAT. INPUT HAS BEEN TO DECREASE THE AMOUNT OF LABOR INPUT REQUIRED.

FIELD 65 NEWS ITEMS

65-59-12001 TUNNEL ESTIMATING IMPROVED: TIED TO GEOLOGY (ROCK-CONDITIONS TUNNELING-METHODS COSTS EXCAVATION MUCKING LINING)
ENGINEERING NEWS-RECORD, (1963) 64, DEC 17, 1959. A GUIDE FOR ESTIMATING TUNNEL COSTS AS A KEY TO ITS USE. THE GUIDE IS BASED ON A STUDY OF 99 TUNNELS MADE BY THE CALIF DEPT OF WATER RESOURCES. ROCK CONDITIONS ARE CLASSIFIED AND DEFINED, AND THE TUNNELING METHODS CONSIDERED ARE LISTED FOLLOWED BY INSTRUCTIONS OF HOW TO USE THE GUIDE. TABULATED DATA INCLUDES UNIT COSTS FOR VARIOUS ROCK CONDITIONS VERSUS TUNNEL DIA, WAGE RATES AND PERSONNEL REQUIREMENTS, EQUIPMENT AND MATERIAL COSTS, EXCAVATION COSTS, RATES OF ADVANCE, SUPPORT COSTS, LAGGING AND CONCRETE LINING COSTS.

65-65-03001 ROCK PLAGUES TUNNELER ON SEWER SYSTEM (COST)
ENGINEERING NEWS-RECORD, (174) MAR 18, 1965. A $2.4 MILLION CONTRACT WAS AWARDED TO JAMES P. MCHUGH CONSTRUCTING CO. FOR A 1 1/2 MILE ROCK TUNNEL SEWER FOR ROCHESTER, N.Y. THE SEWER IS HORSE-SHOE SHAPED, CONCRETE-LINED WITH A MAXIMUM DEPTH OF 67 FEET. UNIT PRICES - APPROXIMATELY ONE MILE OF 10.5 FT X 7 FT AT $280 PER FOOT, AND APPROXIMATELY 1/2 MILE OF 7 FT X 7 FT AT $195 PER FOOT.

65-65-03002 ANDES TUNNEL TO TAP AMAZON (COSTS IRRIGATION)
ENGINEERING NEWS-RECORD, (174) 154, MAR 18, 1965. AN ANDES TUNNEL 12 1/2 MILES IS OPEN FOR BIDS. IT WILL BE PART OF A $100 MILLION IRRIGATION PROJECT.

65-65-04001 OKLAHOMA POWER TUNNEL (COST UNIT-PRICES)
ENGINEERING NEWS-RECORD, (174) 76, APR 1965. THE $5.5 MILLION PROJECT WILL INCLUDE A 25 FT TUNNEL 1800 FT LONG. IT WILL PROVIDE NEEDED WATER SUPPLY, FLOOD CONTROL AND HYDROELECTRIC POWER AT BROKEN BOW DAM.

65-65-05001 SWISS TUNNEL IS HOLED THROUGH (COST)
ENGINEERING NEWS-RECORD, (17) 53, MAY 13, 1965. THE 4.1-MILE-LONG SAN BERNARDINE BORE IN SWITZERLAND IS 35 FEET WIDE AND 31 FEET HIGH. COST - $35 MILLION. HOLING THROUGH WAS DELAYED BY ENCOUNTER WITH MUCH FRIABLE ROCK, WHICH SLOWED PROGRESS, DAMAGED EQUIPMENT, CAUSED TROUBLE AND ACCIDENTS.

65-65-07001 BIG WATER TUNNEL JOB A BARGAIN (COST)
ENGINEERING NEWS-RECORD, (175) 16, JULY 1965. DRAVO CORP. OF PITTSBURGH WAS THE LOW BIDDER ON THE 4.8 MILE WATER TUNNEL THROUGH CALIFORNIA'S TEHACHAPI MOUNTAINS. THE BID WAS $33,788,800 TO BUILD THE CARLEY V. PORTER TUNNEL. THE TUNNELS WILL LINK A PUMP LIFT. TUNNEL ONE WILL BE 1.5 MILES LONG, THE SECOND WILL RUN 0.6 MILES AND NO. 3 WILL BE 1.1 MILES. THE TUNNELS WILL GO THROUGH THE TEHACHAPIS AT AN ELEVATION OF 3100 FEET ABOVE SEA LEVEL. PENNI CORP. OF FRAMINGHAM, MASS. AND MORRISON-KNUDSEN CO., INC. BID LOW FOR A 1.2 MILE LONG 45 FT DIA. DIVERSION TUNNEL FOR FICA DAM ON THE COLUMBIA RIVER (BRITISH COLUMBIA'S). THE BID WAS FOR $21,155,388.

65-65-10001 CPM REQUIRED FOR WATER TUNNEL (COST)
ENGINEERING NEWS-RECORD, (175) 59, OCT 1965. THE GLENDORA TUNNEL SIX MILES LONG CONCRETE LINED TO A 15.5 FEET DIA. HORSESHOE SECTION WILL COST $22 MILLION.

65-65-12001 TUNNELS AND DAMS IN COLORADO (COST)
ENGINEERING NEWS-RECORD, (175) 67, DEC 9, 1965. TUNNELS AND DAMS OF THE FRYINGPAN - ARKANSAS WATER DIVERSION PROJECT WILL COST $17.6 MILLION. THE CONTRACTOR (WINSTON BROTHERS, FOLEY BROTHERS, HURLEY CONSTRUCTION CO. AND FRASIER DAVIS) WILL EXCAVATE AND CONCRETE LINE THREE HORSESHOE-SHAPED TUNNELS, TOTALING 11 MILES. THE CONTRACT INCLUDES EARTH WORK AND CONSTRUCTION OF THREE DIVERSION DAMS, CONCRETE CONDUITS, AND 12 MILES OF ACCESS ROADS.

65-66-06001 DRILL HOLE FOR NUCLEAR TESTS (COST)
ENGINEERING NEWS-RECORD, (176) 132, JUNE 16, 1966. FIVE HOLES WILL BE DRILLED FOR NUCLEAR TEST IN MERCURY, NEVADA AT A COST OF $255,864. THREE 26-INCH DIAMETER HOLES CASED TO 20 INCH I D AND TWO 15-INCH DIAMETER HOLES CASED TO 10.75 INCH I D ALL 1,300 FEET DEEP. THE MAJOR COST ITEM ON THE JOB IS DRILLING 3,840 FEET OF 26-INCH MINIMUM DIAMETER HOLES.

65-66-06002 KENTUCKY DIVERSION TUNNELS (COST)
ENGINEERING NEWS-RECORD, (176) 136 AND 138, JUNE 16, 1966. THE DIVERSION TUNNELS FOR THE LAUREL RESERVOIR PROJECT WILL BE DRIVEN THROUGH BLOCKS OF SANDSTONE AND SHALES. WHEN SOFT LAYERS OF SHALE ARE PUNCTURED THE OVERLYING BLOCKS OF SANDSTONE SETTLE AND MOVE OUTWARD. FENIX AND SCISSON, INC. OF TULSA, OKLA. BID $2.7 MILLION ON A 900 FOOT POWER TUNNEL WITH A 19 FOOT I D AND A 605 FOOT CONCRETE-LINED DIVERSION TUNNEL. THE POWER TUNNEL WILL BE STEEL LINED FOR 567 FEET AND CONCRETE LINED FOR 333 FEET.

65-66-06003 WASHINGTON EXPRESSWAY TUNNEL (COST)
ENGINEERING NEWS-RECORD, (176) 57, JUNE 23, 1966. THE PROJECT CONSISTS OF A 599-FOOT PORTION OF THREE-LANE TUNNEL AND 390 FEET OF RETAINING WALL ON THE NORTH APPROACH TO THE NINTH STREET EXPRESSWAY TUNNEL. REGAL CONSTRUCTION CO. OF WASHINGTON, D. C. WAS LOW BIDDER AT $2.3 MILLION.

65-66-08001 THE HIGH COST OF SUBWAYS
ENGINEERING NEWS-RECORD, (177) 22, AUG 4, 1966. CONSTRUCTION WEEK ANNOUNCEMENT THAT BARTD HAD OPENED BIDS FOR 3700 FEET OF SUBWAY THAT GAVE THE CITY OF BERKELEY SOME NOTION OF HOW MUCH EXTRA THEY WOULD HAVE TO PAY FOR LESS ELEVATED STRUCTURE AND MORE SUBWAY.

65-66-08002 SHARP PENCILS (COST)
ENGINEERING NEWS-RECORD, (177) 20, AUG 25, 1966. A LOW BID OF $95,039,650 WAS SUBMITTED FOR A 7-MILE-LONG, 30-FT-DIA ANGELES TUNNEL UNIT OF THE STATE WATER PROJECT IN SOUTHERN CALIFORNIA. THE TUNNEL WILL BE LINED MOSTLY WITH CONCRETE, BUT SOME PARTS WILL BE STEEL LINED. CONTRACTOR IS A JOINT VENTURE OF J. F. SHEA CO., KAISER ENGRS, LOCKHEED SHIP BUILDING AND CONSTRUCTION CO., AND IDEALY CO.

65-66-09001 NORTHERN CALIFORNIA WATER TUNNEL (COST MOLES)
ENGINEERING NEWS-RECORD, (177) 63, SEPT 8, 1966. A LOW BID OF $8.6 MILLION WAS A JOINT VENTURE OF GATES & FOX INC. GORDON H.; BALL ENTERPRISES; GRANITE CONSTRUCTION ON THE CRYSTAL SPRING BYPASS WATER TUNNEL IN CALIFORNIA. THE 3 1/4 MILE CICULAR TUNNEL, 9 FT. 6 IN. DIAMETER WILL HAVE A FREE FLOW CAPACITY OF 215 MGD. THE WALLS WILL HAVE A MIN. 12 IN. CONCRETE LINER EXCEPT AT STEEL RIB SUPPORTS AND 500 FT. OF TUNNEL AT THE SOUTH ENTRANCE WHICH WILL BE LINED WITH STEEL PIPE. SINCE A GOOD PORTION OF THE SOIL IS A COMBINATION OF SANDSTONE, SHALES AND VARIOUS METAMORPHIC ROCKS, IT WILL BE SUITABLE FOR TUNNELING MACHINES.

65-66-10001 DALLAS PLANS TO BURY ITS TRUCKS (TRANSPORTATION SYSTEM)
ENGINEERING NEWS-RECORD, (177) 13, OCT 20, 1966. DALLAS ADOPTED A LONG-RANGE TRANSPORTATION PLAN TO SERVE THE CENTRAL BUSINESS DISTRICT TO THE YEAR 2000. A 1 1/4 MILE LONG TRUCK TUNNEL UNDER MAIN ST. AT $15 MILLION.

65-67-03001 TUNNEL JOB HITS ANOTHER SNAG (SUBWAY SHIELD-DRIVEN-COMPRESSED-AIR-METHOD SUNKEN-TUBE-TRENCH-METHOD)
ENGINEERING NEWS-RECORD, (178) 305, MAR 17, 1967. LABOR GROUPS ARE NOW OPPOSING NEW YORK CITIES TRANSIT AUTHORITY PLANS TO CHANGE CONSTRUCTION OF A 2 TRACK SUBWAY TUNNEL UNDER EAST RIVER TO A POINT BETWEEN MANHATTAN AND QUEENS FROM A SHIELD DRIVEN - COMPRESSED AIR METHOD TO A SUNKEN TUBE TRENCH TYPE METHOD. AS RECOMMENDED BY PRIVATE CONSULTING ENGINEERS THE CHANGE SHOULD DROP COSTS FROM INITIAL BID OF $101 MILLION TO $33.5 MILLION. THEIR REPORT CHARACTERIZED TUNNELS UNDER COMPRESSED AIR AS HIGH RISK PROJECTS. THE UNION PREDICTED THE CHANGE WOULD CAUSE DELAYS UP TO 2 YEARS

AND CITED CORPS OF ENGINEERS RULES FOR CHANNEL DEPTHS WOULD INCREASE COSTS AND BLASTING USING THE TRENCH METHOD WOULD REQUIRE CLOSING THE DEEPER CHANNEL TO SHIPPING. UNIONS WILL STUDY WORKING RULES AND CONDITIONS FOR POSSIBLE CHANGES TO RESULT IN LOWER COSTS IN COMPRESSED AIR WORK.

65-67-04001 TUNNEL GETS BIGGER AND RICHER (SUNKEN-TUBE SHIELD-DRIVER COST-ESTIMATES)
ENGINEERING NEWS-RECORD, (178) 93, APR 20, 1967. PROJECT MONEY ALLOCATIONS HAVE BEEN INCREASED BY BOTH THE STATE AND CITY FOR THE TUNNEL AND CONNECTING LINES LINKING MANHATTAN ISLAND AND THE BOROUGH OF QUEENS. PART OF ESCALATION RESULTS FROM INCREASING TUNNEL CAPACITY FROM TWO TRACKS IN ONE TUBE TO FOUR TRACKS IN TWO TUBES. JOB WAS RE-ESTIMATED AND CHANGED TO SUNKEN-TUBE METHOD OF CONSTRUCTION RATHER THAN DRIVING WITH A SHIELD AND COMPRESSED AIR WITH ESTIMATED SAVINGS OF $16.8 MILLION AND 15 MONTHS.

65-67-05001 CONTRACTS AND LOW BIDS (RAIL-LINE COST)
ENGINEERING NEWS-RECORD, (178) 150, MAY 25, 1967. VIRGINIA - ANNOUNCEMENT OF AWARD OF CONTRACT FOR 4,000 FOOT TUNNEL IN $7 MILLION 8.4 MILE RAIL LINE TO THE BUCHANAN COUNTY COAL FIELDS.

65-67-05002 BIDS DUE SOON ON VIRGINIA HIGHWAY JOBS (TUNNEL INTERSTATE-HIGHWAY ESTIMATED COST)
THE WASHINGTON POST, MAY 28, 1967. BIDS WILL BE INVITED LATER IN 1967 FOR 117 HIGHWAY PROJECTS WHICH INCLUDE A TUNNEL THROUGH BIG WALKER MOUNTAIN IN SOUTHWEST VIRGINIA FOR HIGHWAY 77.

65-67-10001 WATER TUNNEL IN CALIFORNIA (COST)
ENGINEERING NEWS-RECORD, (179) 73, OCT 12, 1967. A WATER TUNNEL THROUGH THE SAN BERNARDINO MOUNTAINS IS ESTIMATED TO COST ABOUT $1,000 PER FOOT. THE LOW CONTRACT BID EXCEEDED THE ENGINEERS ESTIMATE BY 12.9 PERCENT. THE PROJECT WILL REQUIRE ABOUT 11 MILLION CUBIC YARDS OF EXCAVATION.

65-67-11001 OFFSHORE AIRPORT FEASIBLE FOR CHICAGO (POLDER SIX-LANE-TUNNEL)
ENGINEERING NEWS-RECORD, (179) 60, NOV 1967. AN ENGINEERING FIRM IN CHICAGO HAS SUBMITTED A REPORT CALLING FOR AN AIRPORT TO BE BUILT ON A POLDER IN LAKE MICHIGAN AND LINKED TO AN EXPRESSWAY BY MEANS OF A TUNNEL. THE REPORT CALLS FOR A 400 FT. LONG SIX-LANE TUNNEL INTO THE AIRPORT SITE. THE TUNNEL WILL GO BENEATH AN OPEN CHANNEL, 200 FEET LENGTH AND 20 FEET DEEP, ALLOWING ALL BUT DEEP DRAFT SHIPS TO PASS THROUGH. IT WAS RECOMMENDED TO CONSTRUCT THE TUNNEL IN A COFFERDAM INSTEAD OF USING THE SUNKEN-TUBE METHOD FOR ECONOMIC REASONS.

65-68-06001 BIDS JOIN TWO CHICAGO SEWER JOBS (COST)
ENGINEERING NEWS-RECORD, (180) 47, JUNE 27, 1968. SEWER SECTIONS IN CHICAGO WILL BE A 5 1/2-FT. TUNNEL DRILLED WITH A MECHANICAL MOLE. THE TWO BIDS WILL COVER 5 MILES AND WILL COST $2,380,245 AND $3,549,247.

65-68-05002 GRANDUC'S TUNNELING RECORD - 518 FT IN 6 DAYS (LININGS)
MAMEN, C.
CANADIAN MINING JOURNAL, (89) N 6, 46-8, JUNE 1968. AUSTRALIA'S JINDABYNE TUNNEL APR 1968 RECORD ADVANCE IN SIX DAYS HAS BEEN BETTERED BY ONE FOOT BY CREWS DRIVING GRANDUC (ALASKA) 15X15 FT WITH 8 FT RADIUS ARCHED BACK TUNNEL; CLASSIC DRILL, BLAST AND LOAD METHOD EMPLOYING 89 MEN IN 24 HR IS USED. DETAILS OF EQUIPMENT USED, DRILLING PATTERN AND SUPPORT OF ROOF ARE INCLUDED. BEST DAILY ADVANCE WAS 99 FT MADE ON JAN. 19, 1968.

65-68-07001 HOLES GROW DEEPER IN BIG WALKER (COST HIGHWAY-TUNNEL)
BEAGLE, P.
THE ROANOKE TIMES, C2, JULY 28, 1968. A $26 MILLION MOUNTAIN ROAD BUILDING PROJECT THROUGH BIG WALKER MOUNTAIN IS IN PROCESS AND OF THIS AMOUNT $20.8 MILLION IS FOR THE TUNNELS. THE TUNNELS WILL BE EIGHT-TENTHS OF A MILE LONG. TWIN DRILLING RIGS WITH NINE DRILLS ON THE FRONT END WHICH MOVE ON RAILS INTO THE TUNNELS' BORES AND BORE HOLES FOR DYNAMITE. 45-TON TRUCKS HAVE A DEVICE WHICH TAKES OUT THE CARBON MONOXIDE. THE AIR INSIDE THE TUNNELS CAN BE CHANGED IN TWO MINUTES BY 24 FANS.

65-68-11001 TUNNEL SOLVES PEPCO LINE PROBLEM
THE WASHINGTON POST, BUSINESS AND FINANCE, C8, NOV 1968. A UTILITY COMPANY USES A TUNNEL TO PLACE ITS OWN POWER LINES WHEN IT COULD NOT DIG UP A HIGHWAY.

FIELD 7 MECHANICAL TUNNELING DEVICES

FIELD 72 SYMPOSIA

72-59-07001 A NEW MINING MACHINE FOR HIGH-SPEED SHAFT SINKING AND ROADWAY TUNNELING (DRILLING-DEVICES MOLE TUNNELING-MACHINE)
VORCPINOV, J. + KITTRICK, R. & ACAD OF MINING OSTRAVA CZECH
PROCEEDINGS OF THE SYMPOSIUM ON SHAFT SINKING AND TUNNELING, 482-491, JULY, 1959 (THE INSTITUTION OF MINING ENGINEERS, 1960). A NEW DRILLING MACHINE IS NOW BEING DEVELOPED IN SOVIET AND CZECHOSLOVAKIAN LABORATORIES AND TESTING MINES. THE MACHINE CAN MAINTAIN A NORMAL MONTHLY SINKING RATE OF FROM 300-600 M WITH SHAFT-LINING GOING ON AT THE SAME TIME. THE EFFECTIVENESS OF THE NEW MACHINE UNDER SUCH PROBLEMS AS INFLOW OF WATER, THE PRESENCE OF GAS, AND LACK OF STABILITY IN THE WALLS OF THE SHAFT IS DISCUSSED. THE DEVICE CAN BE USED TO DRILL TUNNELS.

72-65-05001 MACHINE TUNNELING ON MISSOURI POWER DAMS (BLASTING SMOOTH-BORE ROCK LINING COST MOLE)
UNDERWOOD, L. B. & U.S. CORPS OF ENGRS
PROC OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS, JOURNAL OF THE CONSTRUCTION DIVISION, CO 1, NO. 4314, 1-27, MAY 1965. DURING THE PAST 25 YEARS, 15 MILES OF TUNNELS RANGING TO MORE THAN 30 FT. IN DIA. HAVE BEEN DRIVEN AT FOUR MAJOR DAMS ON THE MISSOURI RIVER THRU SOFT ROCK. IN 1934 TUNNELING BEGAN AT FORT PICK DAM BY DRIVING A PILOT BORE AND ENLARGING TO 32 FT OR 30 FT 8 IN DIAMETER. MECHANIZATION BY CUTTING 9 FT. DEEP KERFS AROUND THE PERIPHERY WAS ABANDONED DUE TO DIFFICULTIES IN HOLDING THE SAW IN POSITION. AT GARRISON DAM MINING WAS IMPROVED BY FULL FACE OPERATION FROM A JUMBO HAVING BREAST AND CROWN JACKS. AT FORT RANDALL DAM A KERF CUTTER WAS SATISFACTORILY USED BY MOUNTING IT ON THE JUMBO. A TUNNELING MACHINE WAS FIRST USED AT OAHE DAM WHERE THE CONTRACTOR PREFERRED IT TO SMOOTH WALL BLASTING. A DESCRIPTION OF TUNNELING AT ALL THESE PROJECTS IS GIVEN. TABLE ONE SHOWS THE PHYSICAL PROPERTIES OF TUNNEL ROCKS. TABLE TWO GIVES A COMPARISON OF TUNNEL SUPPORT AND LINER DESIGN. TABLE THREE GIVES THE DATA ON THE OAHE TUNNELING MACHINES: MITTRY MOLE, OAHE MOLE, M-K MINER AND PRAIRIE MINER. IN TABLE FOUR A COST COMPARISON PER CU. YD. OF EXCAVATION IS GIVEN FOR THE MISSOURI RIVER TUNNELS. TUNNELING WILL ALWAYS PRESENT A CHALLENGE BUT THESE UNCERTAINTIES MAKE IT AMONG THE MOST INTERESTING AND REWARDING OF ENGINEERING ACTIVITIES.

72-56-01001 MACHINE TUNNELING ON MISSOURI RIVER DAMS (BLASTING MOLE MITTRY)
SANDERS, W. L. & W. L. SANDERS CO
AM. SOC. CIVIL ENG. PROCEEDINGS, (92) CO 1, NO. 4597, 79-81, JAN 1966. IN THIS DISCUSSION OF PROC. PAPER 4314. IT IS STATED THAT BLASTING WAS NOT PROHIBITED. THE FIRST TUNNEL SPECIFICATION STATED IN PART: "IN BLASTING, ALL PRECAUTIONS SHALL BE TAKEN TO PREVENT DAMAGE TO RING BEAMS AND ALL PNEUMATICALLY PLACED MORTAR. NO BLASTING SHALL BE PERFORMED IN TUNNELS UNTIL ENTIRE TUNNEL PERIPHEY TO DEPTH PROPOSED FOR BLASTING HAS BEEN SEVERED BY MEANS OF SAW CUTTING, CLOSELY SPACED LINE DRILLING OR SIMILAR METHODS APPROVED BY THE CONTRACTING OFFICER." THE USE OF CONTINUOUS MECHANICAL MINERS OR OTHER EQUIPMENT FOR TUNNEL CONSTRUCTION WILL BE CONSIDERED FOR APPROVAL AND PERMITTED IF SATISFACTORY TUNNEL CONSTRUCTION CAN BE OBTAINED IN CONFORMANCE WITH PLANS AND SPECIFICATIONS. AFTER THE MITTRY MOLE

HAD PROVEN THE FEASIBILITY OF MACHINE TUNNELING, BLASTING WAS PROHIBITED. THE RISK OF THE TUNNELING MACHINE WAS TAKEN OF THE CONTRACTORS OWN VOLITION AND NOT AS A RESULT OF ANY LIMITATION ESTABLISHED BY THE SPECIFICATION.

72-68-00001 HARD ROCK TUNNELING MACHINES (MOLES SAFETY COST COMPARISON)
MUIRHEAD, I. R. + GLOSSOP, L. G. & INSTITUTION OF MIN AND MET
INSTITUTION MIN & MET TRANS, (77) SEC A, A1-A21, 1968. BRIEF OUTLINE OF HISTORICAL DEVELOPMENT OF MECHANICAL TUNNELING FOLLOWED BY SURVEY OF TO-DATE DEVELOPED TUNNELING MACHINES; PRINCIPLE OF OPERATION AND DESIGN CHARACTERISTICS ARE DESCRIBED AND TABULATED; CONVENTIONAL TUNNELING (BY DRILLING, BLASTING AND MUCKING TECHNIQUE) IS COMPARED WITH MECHANICAL TUNNELING, INSOFAR AS SAFETY, OVERBREAK AND SUPPORTS OF ROOF, COST OF LABOR, MUCK DISPOSAL, CAPITAL OUTLAY, ROCK HARDNESS, DUST FACTOR AND POWER CONSUMED ARE CONCERNED. TUNNEL ADVANCE RATE DATA BASED ON CONSTRUCTION OF 19 TUNNELS DRIVEN IN VARIOUS COUNTRIES OF WORLD IS TABULATED. ECONOMICS OF MECHANICAL TUNNELING ARE DISCUSSED AND APPLICATION OF METHOD TO MINING IS ANALYZED; CHARACTERISTICS, APPLICATION, PERFORMANCE, AND COST DATA OF ALL KNOWN HARD ROCK TUNNELING MACHINES ARE TABULATED IN APPENDIX.

72-68-02001 THE INEVITABLE MARRIAGE OF UNDERGROUND MINING AND BIG HOLE DRILLING (DRILLING SHAFT MOLES)
NORMAN, N. E. & REED DRILLING TOOLS HOUSTON TEX
NATIONAL A.I.M.E. MEETING, UNDERGROUND MINING SESSION, 1-36, FEB. 26, 1968. THE ADVANTAGES OF ROTARY SHAFT DRILLING ARE: 1) CAPABILITY OF DRILLING ECONOMICALLY, 2) RATE OF PENETRATION, 3) SAFETY IN ROTARY SHAFT SINKING, 4) QUICKER LINING AND CEMENTING OF CASING LINERS, ABILITY TO DRILL SMALL DIAM SHAFTS. LIMITATIONS ARE: 1) COST, 2) TECHNICAL PROBLEMS. AREAS WHERE GREATEST IMPROVEMENTS ARE REQUIRED: 1) HOLE DEVIATION, 2) CUTTING REMOVAL, 3) SHAFT LINING, 4) CEMENTING, 5) LOSS OF CIRCULATION, 6) EQUIPMENT HANDLING, AND 7) TRANSPORTATION. AREAS WHICH PROVE MOST CRITICAL: 1) RIG DESIGN, 2) FLUID OR AIR CIRCULATING SYSTEMS, 3) BIT DESIGN, 4) DRILL STRING DESIGN. ADVANTAGES OF MECHANICAL TUNNELING: 1) INCREASED SAFETY, 2) REDUCED OVERBREAK, 3) REDUCED LABOR REQUIREMENTS, 4) CONTINUOUS MUCK REMOVAL, 5) GREATER RATES OF ADVANCE, 6) LESS SUPPORT REQUIREMENTS. MAIN AREAS FOR IMPROVEMENT INCLUDE: 1) ABILITY TO BORE AROUND SHORTER RADIUS CURVES, 2) ABILITY TO BORE UP OR DOWNGRADE AT 20 TO 30 DEG. HORIZ., 3) ABILITY TO BORE HARDER ROCK ECONOMICALLY, 4) BETTER DUST CONTROL SYSTEMS, 5) MORE ACCURATE LINE AND GRADE CONTROLS. RAISE BORING'S MAIN ADVANTAGES ARE COST, SAFETY, SPEED. LIMITATIONS ARE: INVESTMENT, OPERATION, SITE PREPARATION, HOLE DEVIATION, AIR CONSUMPTION, TRAINING CREWS, CUTTER LIFE, PLANNING, MOBILITY.

72-68-04001 DISCUSSION OF HARD ROCK TUNNELING MACHINES (RESEARCH ECONOMY PICKS ROTARY-BITS DRIVES DUST)
PIRRIE, N. D. + GOSSOP, L. G. + SHEPHERD, R. & BURGESS, R. P. + MEGAW, T. M.
& SIR ROBERT MCALPINE AND SONS
INSTITUTE OF MINING + METALLURGY TRANSACTIONS, (77) NO. 740, A118-A121, APR 1968. PIRRIE SUGGESTED THAT RESEARCH COULD BE APPLIED TO EXCAVATING ROCK BY DRAG PICK. ALREADY THEY HAVE MOVED UP FROM SUCCESSFULLY CUTTING 12,000 TO 15,000 PSI FORMATIONS TO 20,000 TO 30,000 COMPRESSIVE STRENGTH. PICKS WERE CHEAPER THAN ROTARY BITS. WAS THE GREAT PLAY FOR HIGH SPEED NECESSARY? SPEED IS ONLY ONE CONSIDERATION IN ECONOMICAL CONSTRUCTION. GLOSSOP SAID THAT THE AIM OF HIS PAPER WAS TO ACQUAINT MINING ENGINEERS WITH THE GREAT STRIDES MADE BY CIVIL ENGINEERS IN TUNNELING WHICH MIGHT BE APPIED TO MINING. THE ADVANTAGES AND DISADVANTAGES OF TUNNELING MACHINES ARE GIVEN. SHEPHERD WAS PARTICULARLY INTERESTED IN THE HABEGGER MACHINE WHICH CUTS IN TENSION RATHER THAN COMPRESSION. BURGESS DISCUSSED THE PROBLEMS OF HYDRAULIC VERSUS ELECTRIC DRIVE AND CUTTER ORIENTATION TO REDUCT THE REQUIRED THRUST. MEGAW GAVE THE REASONS FOR SELECTING A TUNNELING MACHINE IN EXCAVATING THE 33 FT 11 IN DIAMETER 7000 FT LONG MERSEY ROAD TUNNEL. THIS MACHINE COULD EXCAVATE FOR A 4 FT RING IN AN HOUR BUT LINING BUILDING AND GROUTING COMPLETION BEHIND IT WAS THE GOVERNING FACTOR IN ADVANCE. LOMAS OF THE NATIONAL COAL BOARD SAID THAT DUST SUPPRESSION WAS THE MAJOR PROBLEM IN MINING COAL WITH TUNNELING MACHINES.

72-68-05001 ROBBINS TUNNEL BORING MACHINES. A STATUS REPORT WITH AN EYE TO THE FUTURE (JUMBO SHIELD GRIPPER HISTORY)
ROBBINS, R. J.
CONFERENCE, TUNNEL AND SHAFT UNIV OF MINN., MAY 15-17, 1968 (PREPRINT). A BRIEF HISTORICAL DESCRIPTION OF THE TUNNEL BORING INDUSTRY. TWO REASONS WHY MOLES ARE NOT USED FOR MOST TUNNEL CONSTRUCTION ARE - LACK OF VERSATILITY AND INABILITY TO DEFINE THE REQUIREMENTS FOR A SPECIFIC JOB. THE THREE TYPES OF ROBBINS BORERS ARE JUMBO, SHIELD AND GRIPPER. ALL THE SMALLER DIAMETER (LESS THAN 10 FEET) TUNNELS USE THE GRIPPER. MAJOR DEVELOPMENT IS NEEDED IN THE HARD ROCK CUTTERS. 8 PAGES.

72-68-05002 EQUIPMENT RELIABILITY (ROCK-FRACTURE CUTTERS·CUTTING-METHODS MUCKING GROUND-CONTROL ENGINEERING MANUFACTURING MAINTENANCE)
HAMILTON, W. H. & LAWRENCE MFG CO
TUNNEL AND SHAFT CONFERENCE, UNIV OF MINN, MAY 15-17, 1968 (PREPRINT). BORING RATES CAN BE INCREASED THROUGH FASTER ROCK FRACTURE, IMPROVED SUPPORT SYSTEMS, MORE HORSEPOWER, BETTER CUTTERS, IMPROVED CUTTING METHODS, BETTER MATERIAL HANDLING SYSTEMS AND BETTER GROUND CONTROL SYSTEMS. EQUALLY IMPORTANT IN INCREASING BORING RATES IS BETTER UTILIZATION OF TUNNELING MACHINE AND EQUIPMENT THROUGH GREATER EQUIPMENT RELIABILITY. IMPETUS IS BEING GIVEN TO MECHANICAL BORING AS A RESULT OF ITS LARGE POTENTIAL ECONOMIC ADVANTAGE OVER CONVENTIONAL DRILL + BLAST METHODS. DETAILS FOR THE FOUR AREAS: BETTER ENGINEERING, BETTER MANUFACTURING CONTROL, BETTER PREVENTIVE MAINTENANCE PROGRAMS, AND BETTER UNDERSTANDING BY MACHINE DESIGNERS OF THE PROBLEM FACING THE TUNNEL CONTRACTOR AND MINE OPERATOR, THROUGH WHICH RELIABILITY CAN BE INCREASED ARE GIVEN.

72-69-10001 SAN FRANCISCO APPROACH TUNNELS TO THE TRANS-BAY TUBE (TREMIE-WALL SHIELDS CONSTRUCTION-RATE COST PROBLEM-AREAS EXPLORATORY-DRILLING ALIGNMENT)
WHITEMAN, J. C., JR. & PARSONS BRINKERHOFF
SACRAMENTO STATE COLLEGE, CAL SECOND SYMP ON RAPID EXCAVATION, 10-1 TO 10-37, OCT 16, 1969. SPEAR STREET VENTILATION SHAFT IS TWO 38 FOOT OUTSIDE DIAMETER LOBES WITH TWO FOOT THICK WALLS 100 FEET DEEP. FRANKI FOUNDATION CO OF BOSTON BUILT THE TREMIE CONCRETE WALLS WITH SPECIAL EQUIPMENT. TWO 18' - 6 1/2" O.D. CALDWELL TUNNEL SHIELDS WERE USED TO CONSTRUCT THE 1300 FOOT LONG BAY TUNNELS. INSIDE DIAMETER, OF THE 2-1/4 INCH THICK SKIN PLATE WAS JUST 2 INCHES LARGER THAN THE DIAMETER OF THE 2-1/2 FOOT LONG TUNNEL RINGS ERECTED WITH A RUCKER ERECTOR. ALIGNMENT WAS VERY IMPORTANT AND THERE WAS A HORIZONTAL AND VERTICAL CURVE IN THE ALIGNMENT. EVERY WEEK A CHECK SURVEY WAS RUN ON VERTICAL AND HORIZONTAL ALIGNMENT. TWELVE 75 TON JACKS SUPPORTED THE TUNNEL FACE AND TWENTY-FOUR 125 TON SHOVE JACKS WERE DISTRIBUTED AROUND THE TAIL OF THE SHIELD. THE BERKELEY HILLS TUNNELS EACH 16,240 FEET LONG AND 21 FOOT DIAMETER (OUTSIDE) HORSESHOE TUNNELS WERE CONSTRUCTED BY STANDARD DRILLING AND SHOOTING FROM FOUR HEADINGS IN 20 MONTHS. TABULATIONS OF PROGRESS RATE AND SUPPORT DATA ARE GIVEN AND PROBLEM AREAS DESCRIBED. DIVIDENDS EARNED IN TAKING CARE OF THE GROUND AS PROBLEMS AROSE ARE WELL ILLUSTRATED. THE CONSTRUCTION WITH CONCRETE LINING COST 30.5 MILLION DOLLARS. EXPLORATORY CORE DRILLING AND DRIFTING INDICATED TUNNEL CONDITIONS.

72-69-10002 RIVER MOUNTAIN TUNNEL CONSTRUCTION (COST GUIDANCE MOLE SUPPORT CUTTERS MUCKING PRODUCTION)
SPERRY, P. E. & FLUOR UTAH ENG CONSTRS INC
SACRAMENTO STATE COLLEGE CAL SECOND SYMP ON RAPID EXCAVATION, 11-1 TO 11-12, OCT 16, 1969. RIVER MOUNTAIN TUNNEL WAS BORED WITH A JARVA MK 11-1200 TO 12 FEET DIAMETER AND WAS 19,970 FEET LONG. MANY THOUGHT THE ROCK THRU WHICH THIS TUNNEL RAN WAS TOO HARD TO MOLE. THE LOW BID FOR THIS TUNNEL WITH A MINIMUM 7-1/2 INCH THICK CONCRETE LINING WAS 3.9 MILLION DOLLARS WHICH WAS 1.3 MILLION BELOW THE SECOND BIDDER. LESS THAN 5 PERCENT OF THE TUNNEL WAS SUPPORTED AND THIS ENTIRELY WITH ROCK BOLTS. FOR CONVENTIONAL DRILL AND SHOOT EXCAVATION 50 TO 70 PERCENT STEEL RIB SUPPORT WAS ESTIMATED. DETAILS OF GEOLOGY, MOLE, CUTTERS, MUCK HANDLING, UTILITIES, CREWS, PRODUCTION AND LASER GUIDANCE ARE GIVEN. SUCCESS OF THIS PROJECT SHOULD OPEN NEW AREAS FOR MECHANICAL TUNNELING.

72-69-10003 RIVER MOUNTAIN TUNNEL PRECONSTRUCTION DATA AND FUTURE NEEDS (GEOLOGY MOLE MUCKING LASER DRILLABILITY BORING-RATE)
SAMSON, G. A. & U.S. BUR RECL DENVER COLO
SACRAMENTO STATE COLLEGE, CAL SECOND SYMP ON RAPID EXCAVATION, 11-13 TO 11-20, OCT 16, 1969. EXTENSIVE GEOLOGICAL EXPLORATIONS ALONG THE RIVER MOUNTAIN TUNNEL ALINEMENT GAVE CONTRACTORS DETAILED INFORMATION UPON WHICH TO BASE A SOUND BID. SEVENTEEN TUNNELS HAVE BEEN COMPLETED WITH BORING MACHINES. EACH HAS CONTRIBUTED TO MACHINE AND OPERATION IMPROVEMENTS. THIS TUNNEL DEMONSTRATED THAT HARDER ROCK CAN BE MOLED AND THAT 1,000 FOOT PER WEEK DRILLING RATE IN ANY KIND OF ROCK IS A GOAL WITHIN REACH. LASER GUIDANCE WILL GIVE ACCURATE TUNNEL ALIGNMENT. MATERIALS HANDLING AND SUPPORT METHODS BOTH NEED IMPROVEMENT. A DRILLABILITY INDEX FOR ALL TYPES OF ROCK WILL MATERIALLY AID CONTRACTORS BIDDING TUNNEL WORK. A COMBINATION OF THE BEST FEATURES OF THE 20 MAKES OF MOLES SHOULD RESULT IN THE ALMOST EXCLUSIVE USE OF SUCH EQUIPMENT FOR TUNNELING.

72-69-10004 RIVER MOUNTAIN TUNNEL, JARVA MK11-1200 MOLE (BORING POWER LUBRICATION CUTTERS HYDRAULIC-SYSTEM DUST-COLLECTION)
GAGLIONE, A. T. + FINK, T. & JARVA INC SOLON OHIO
SACRAMENTO STATE COLLEGE, CAL SECOND SYMP ON RAPID EXCAVATION, 11-21 TO 11-26, OCT 16, 1969. PREVIOUS TO USING THIS 12 FOOT DIAMETER BORING MACHINE, ONE OF TEN FOOT DIAMETER WAS USED TO EXCAVATE AN INCLINED SHAFT IN NEW YORK. AT PRESENT A NEW MACHINE IS BEING BUILT FOR AN 11 FOOT 2 INCH DIAMETER MILWAUKEE TUNNEL. FOR HARD MATERIALS A CRUSHING ACTION IS USED RATHER THAN SHAVING OR MILLING. THIS REQUIRES HYDRAULIC CLAMPING IN THE BORE FOR THE MACHINE'S TWO FOOT STROKE. THE 9 RPM CUTTER IS POWERED BY FOUR 100 HP MOTORS. THE 2000 PSI HYDRAULIC SYSTEM IS POWERED BY A TANDEM GEAR PUMP DRIVEN BY A 40 HP ELECTRIC MOTOR. A FEW FEET BACK FROM THE FACE IS A DUST SHIELD WHICH CAN OPERATE EITHER WET OR DRY. PROBLEMS OF GEAR FAILURE, CLAMPING POWER, HYDRAULIC PROBLEMS, LUBE SYSTEM AND SHOCK ABSORBERS ARE DISCUSSED. THESE PROBLEMS CLEARLY INDICATE THE NEED FOR MORE FIELD TEST AND OPERATING DATA TO PRODUCE A TRULY RELIABLE MOLE.

72-69-10005 RIVER MOUNTAIN TUNNEL - CUTTER PERFORMANCE (MOLE TUNGSTEN-CARBIDE MAINTENANCE COST)
NORMAN, N. E. & REED DRILLING TOOLS HOUSTON TEX
SACRAMENTO STATE COLLEGE, CAL SECOND SYMP ON RAPID EXCAVATION, 11-27 TO 11-28, OCT 16, 1969. MACHINE AND CUTTER MANUFACTURERS MADE MODIFICATIONS THROUGHOUT THE PROJECT WHICH CONTRIBUTED TO INCREASED CUTTER LIFE AND REDUCED DOWNTIME. BY SCHEDULED MAINTENANCE CUTTERS COULD BE REMOVED AND REBUILT BEFORE FAILURE. AVERAGE CUTTER COST ON THIS 12 FOOT DIAMETER BORE WAS LESS THAN 15 DOLLARS PER FOOT. THE MACHINE WAS EQUIPPED WITH 30 SADDLE MOUNTED CUTTERS AND ONE CANTILEVER. EACH CONCENTRIC ROW OF CUTTERS ROLLED OVER A 6 INCH WIDE RING. TWO CUTTERS PER RING WERE MOUNTED OUT TO 6 FEET DIAMETER AND FOUR CUTTERS PER RING FROM THERE TO THE GAGE. QH-1 CENTER CUTTERS WERE USED IN ALL FORMATIONS. QK STEEL DISC CUTTERS WERE MOST ECONOMICAL FOR THE INTERIOR AND MILLED TOOTH, STEEL DISC OR KERF CUTTERS WITH TUNGSTEN CARBIDE INSERTS DEPENDING ON THE FORMATION WERE USED FOR GAGE CUTTERS.

72-69-10006 A SYSTEM STUDY OF NEW SOFT GROUND TUNNELING CONCEPTS (MOLE SHIELD)
WILLIS, B. H. + STONE, R. B. & ARTHUR D LITTLE INC
SACRAMENTO STATE COLLEGE, CAL SECOND SYMP ON RAPID EXCAVATION, 13-1 TO 13-19, OCT 16, 1969. SOFT GROUND TUNNELING WILL ALWAYS BE REQUIRED FOR CERTAIN PROJECTS BUT IF ITS COST COULD BE REDUCED IT WOULD HAVE MUCH WIDER APPLICATION FOR TRANSPORTATION, UTILITIES AND OTHER SERVICES. SOFT GROUND TUNNELING'S HIGH COST IS DUE TO THE SINGULARITY OF EACH PROJECT MAKING MASS PRODUCTION UNATTRACTIVE. TO REDUCE COSTS AND ADVANCE THE STATE OF THE ART A SYSTEMS APPROACH WITH THE FOLLOWING BASIC STEPS IS PROPOSED (1) COMPLETE SYSTEM DELINEATION (2) STUDY OF RELATIONSHIPS AMONG INTERACTING SYSTEM PARTS (3) ENUMERATION OF ALTERNATIVE CANDIDATE SYSTEMS TO ACHIEVE THE GOALS (4) ANALYTICAL EVALUATION OF ALTERNATIVES AND (5) PRESENTATION OF RESULTS TO PERMIT SELECTION OF BEST SYSTEM RELATIVE TO SPECIFIED SELECTION CRITERIA. IN APPLYING THIS APPROACH THREE PHASES OF THE STUDY WERE (1) RESEARCH (2) SYSTEM SYNTHESIS AND (3) TECHNICAL AND COST ANALYSIS. FROM A SUMMARIZED ANALYSIS FIVE SPECIFIC CONCEPTS WERE SELECTED AS SHOWING THE MOST PROMISE AND THEIR ESTIMATED COSTS, ADVANCE RATES AND RESEARCH AND DEVELOPMENT COSTS ARE GIVEN. RESEARCH AND DEVELOPMENT BESIDES IMPROVING COSTS AND PERFORMANCE SHOULD STIMULATE A MORE INNOVATIVE ATTITUDE IN THE SEARCH FOR NEW TECHNOLOGY.

72-70-00001 EXPERIENCE WITH THE HABEGGER MOLE (GERMANY SWITZERLAND JAPAN CUTTER-PERFORMANCE)
BRODBECK, H. W. & HABEGGER LTD THUN SWITZERLAND
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 12. WOHLMEYER, AN AUSTRIAN, DEVELOPED A METHOD OF CUTTING ROCK IN A MANNER SIMILAR TO MILLING OF METALS. THE FIRST EXPERIMENTAL MACHINE WORKED IN COAL AND SHALE IN A GERMAN COAL MINE. HABEGGAR TOOK OVER WOHLMEYERS PATENTS AND FURTHER DEVELOPED THE PRINCIPLE. THE CUTTING PRINCIPLE IS DESCRIBED. THE COMPONENTS OF A HABEGGAR MOLE ARE LISTED AND THE PURPOSE OF EACH IS GIVEN. PERFORMANCE CHARACTERISTICS FROM TWO MACHINES ARE PRESENTED - A HARD ROCK MOLE IN SWITZERLAND AND A SOFT ROCK ONE IN JAPAN.

72-70-00002 DRIVING THE OSO TUNNEL WITH A MECHANICAL MOLE (ROBBINS RECORD)
STEVENS, V. L. & BROYLE BROS DRILL CO SALT LAKE
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 14. THE 26660 FT LONG, 122 IN DIAMETER OSO TUNNEL WAS DRIVEN BY A JOINT VENTURE OF BOYLES BROS DRILLING CO., GIBBONS AND REED CO. AND CIRNCO FOR THE U.S. BUREAU OF RECLAMATION USING A ROBBINS MOLE OF THE R221 SERIES. THE MOLE HAS 22 DISK TYPE CUTTERS AND ONE CENTER PILOT TRICONE BIT. IT CAN ADJUST FROM 119 IN TO 127 INCHES WITHOUT MAJOR CHANGES. HEAD IS POWERED BY FOUR 75 HP ELECTRIC MOTORS. GRIPPER CYCLE IS 3 FT. BUCKETS SCOOP UP MUCK BEHIND EACH CUTTER ON THE PERIMETER AND DUMP IT ON A CONVEYOR WHICH CARRIES IT TO A 350 FT. LONG GANTRY TYPE CONVEYOR WHICH IS PULLED BY THE MOLE. THE GANTRY HAS ROOM FOR TWO FLAT CARS, ELEVEN 5 CU YD MUCK CARS AND A LOCOMOTIVE, AND IS FOLLOWED BY A CALIFORNIA SWITCH. CONTRACT WAS LIT IN FEB 1966. MOLE STARTED WORK ON AUG. 18, 1966. TUNNEL WAS HOLED THROUGH AUG. 30, 1967. A 6 MONTHS DELAY WAS CAUSED BY AN UNEXPECTED GLACIAL TROUGH. THE OSO MOLE CONTAINED MANY IMPROVEMENTS OVER THE AZCTEA MOLE. BEST 8 HR. SHIFT - 156 FT. BEST 24 HR. DAY 419 FT. BEST 6-DAY WEEK 1905 FT. BEST 26 DAY MONTH 6849 FT. LABOR FORCE 22 MEN PER SHIFT.

72-70-00003 MECHANICAL RAISE AND TUNNEL-BORING EXPERIENCE AT THE MATHER MINE (MOLE JARVA)
BEINLICH, E. G., JR. & CLEVELAND CLIFFS IRON CO
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 16. THE MATHER IRON MINE STARTED AN EXPERIMENTAL RAISE-BORING PROGRAM IN 1961. A HUGHES MACHINE WAS DESIGNED TO DRILL A PILOT HOLE UPWARD WITH A 12 1/4 IN. BIT AND REAM DOWNWARD TO FULL 48 IN. DIAMETER. A SECOND, LARGER MACHINE WAS PUT INTO OPERATION IN 1965. A THIRD MACHINE WAS USED IN THE SUMMER OF 1965, A MODEL 41-R WHICH DRILLS THE PILOT HOLE DOWN TO A LOWER LEVEL AND REAMS BACK UP. USE OF THE RAISE BORERS HAS MINIMIZED DEVELOPMENT TIME AND COSTS. FURTHER - 6000 FT. OF RAISE HAS BEEN DEVELOPED IN PAST 6 YRS. WITHOUT LOSS OF TIME DUE TO INJURIES. MECHANICAL BORING OF DRIFTS WAS CONSIDERED IN 1960 BUT THE BITS WERE NOT CAPABLE OF CUTTING THE GRAYWACKE. IN 1966 A JARVA MARK 14-1 SELF-PROPELLED MODEL WAS SELECTED TO MAKE THE ATTEMPT. THE MACHINE CONTAINS 25 REED ROLLING CUTTERS, IS POWERED BY FOUR 125-HP ELECTRIC MOTORS. IT PROVIDES 275,000 FT-LBS. OF TORQUE AT 8 3/4 RPM. FOUR HYDRAULIC CYLINDERS PROVIDE A TOTAL 693,000 LBS. OF THRUST USING A 40 HP ELECTRIC MOTOR. DIFFICULTIES ENCOUNTERED AND SOLUTIONS ARE RECOUNTED. DESPITE THE TROUBLES IT SEEMS THAT TUNNEL BORING WILL BE USED TO AN INCREASING EXTENT.

72-70-00004 THE "CALWELD" MOLES (HARD-ROCK SOFT-ROCK)
HORN, C. L. & CALWELD SANTA FE SPRINGS CAL
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 17. DETAILED DISCRIPTION OF THE CALWELD MOLES BUILT FROM 1963 THROUGH 1967 ARE GIVEN.

72-70-00005 THE "JARVA" MOLE (CUTTERS STEERING HARD-ROCK)
DELISIO, C. J. & JARVA INC SOLON OHIO
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 18. CHARACTERISTICS OF THE JARVA MACHINES DESIGNED AND BUILT ORIGINALLY BY THE S AND M CONSTRUCTORS. JARVA CORPORATION WAS FORMED TO BUILD AND MARKET THE MACHINES.

72-70-00006 THE LAWRENCE MOLE (ALKIRK RELIABILITY MATERIAL-CONTROL MAINTENANCE)
HAMILTON, W. H. & LAWRENCE MFG CO SEATTLE
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 19. SEE 72-68-05002 FOR ABSTRACT.

72-70-00007 THE HUGHES TOOL MOLE DEVELOPMENT (BETTI-1 NAVAJO-PROJECT)
GLASS, J. M. + SHOLTESS, C. D. & HUGHES TOOL CO HOUSTON TEX
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 20. STEPS IN THE DEVELOPMENT OF A MARKETABLE MACHINE: (1) A PROBLEM IS DEFINED, (2) AN IDEA IS BORN TO ELIMINATE THE PROBLEM, (3) BASIC FUNCTIONS ARE TESTED TO DETERMINE FEASIBILITY, (4) A PRODUCT INCORPORATING PROVEN FUNCTIONS IS MARKETED ON LIMITED BASIS, (5) UNFORESEEN DIFFICULTIES MATERIALIZE, (6) CORRECTIVE MEASURES ARE APPLIED (7) MARKETABILITY, TECHNOLOGICAL STATURE, ECONOMICS AND MANUFACTURING ADAPTABILITY ARE EVALUATED AND (8) A MARKETABLE MACHINE IS INTRODUCED. ILLUSTRATIONS OF THESE STEPS IN DEVELOPING HUGHES MOLES ARE GIVEN.

72-70-00008 THE ROBBINS MOLES - STATUS AND FUTURE (OAHE SHIELDS GRIPPERS)
ROBBINS, R. J. & JAMES S ROBBINS ASSOC SEATTLE
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 21. SEE 72-68-05001 FOR ABSTRACT.

72-70-00009 PANEL DISCUSSION ON MOLE TUNNELING - SOME BRIEF COMMENTS ON MOLES
ADAIR, T. & PERINI CORP SPRING LAKE NJ
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 22. PERINI CORP HAS BEEN INVOLVED FOR 15 YEARS IN EFFORTS TO DEVELOP THE MECHANIZED MINER. PROBLEMS STILL TO BE SOLVED ARE MENTIONED.

72-70-00010 PANEL DISCUSSION ON MOLE TUNNELING - PROBLEMS ASSOCIATED WITH RAISE BORING IN HARD ROCK
BROWN, R. M. & INTERNATIONAL NICKEL CO
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 22. INTERNATIONAL NICKEL CO OPERATES 10 MINES AND IS DEVELOPING 4 MORE IN THE SUDBURY DISTRICT OF ONTARIO. SUCH A LARGE DEVELOPMENT EFFORT IS REQUIRED THAT INCO HAS INSTALLED FOUR ROBBINS 61R AND ONE 41R RAISE BORERS. OPERATING CHARACTERISTICS ARE GIVEN. MOST OF THE DIFFICULTIES HAVE BEEN OVERCOME AND MUCH MORE MECHANICAL RAISE BORING IS EXPECTED.

72-70-00011 PANEL DISCUSSION ON MOLE TUNNELING - TUNNEL BORING AT THE NAVAJO INDIAN IRRIGATION PROJECT, FARMINGTON N.M.
GEARY, D. & FENIX AND SCISSON INC TULSA OKLA
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 22. A HUGHES CO MOLE, THE BETTI I, WAS USED TO DRILL THE 10,000 FT. LONG 18 FT. FINISHED DIAMETER (19 FT - 10 IN. OD) TUNNEL NO 1 FOR THE US BUR RECL NAVAJO PROJECT. FORMATION WAS FLAT LYING, THICK BEDDED MODERATELY WELL CEMENTED SANDSTONE. CHARACTERISTIC OF THE MACHINE AND PERFORMANCE RECORD ARE CITED.

72-70-00012 PANEL DISCUSSION ON MOLE TUNNELING - DRIFT BORING AT WHITE PINE COPPER
GARFIELD, L. A. & WHITE PINE COPPER CO
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 22. WHITE PINE COPPER CO PRODUCES OVER 20,000 TONS/DAY OF LOW GRADE ORE. EXTENSIVE DEVELOPMENT REQUIREMENTS CAUSED THE COMPANY TO INVESTIGATE BORING MACHINES. A 7 FT. HUGHES MACHINE WAS TRIED. AFTER BECOMING FAMILIAR WITH THE PROBLEMS INVOLVED, A NEW TEST PROGRAM WAS STARTED USING A ROBBINS MACHINE. A DESCRIPTION OF THE DEVELOPMENT PASSAGEWAYS AND THE MUCKING EQUIPMENT IS GIVEN.

72-70-00013 PANEL DISCUSSION ON MOLE TUNNELING - MOLE BORING OF SHAFTS
COX, K. C. & KENNETH C COX CONSULTANT
RAPID EXCAVATION - PROBLEMS AND PROGRESS. PROCEEDINGS OF THE TUNNEL AND SHAFT CONFERENCE MINNEAPOLIS, MAY 15-17, 1968. SOC. MINING ENGRS 1970. CHAPTER 22. A DESCRIPTION OF EARTH BORING MACHINES PATENTED BY THE AUTHOR AND THEIR USE IN BORING SHAFTS. AUTHOR LISTS 6 FACTORS HE CONSIDERS IMPORTANT FOR FUTURE DEVELOPMENT IN MOLE TUNNELING.

FIELD 73 GOVERNMENT REPORTS

73-59-10001 THE DEVELOPMENT OF LARGE DIAMETER ROTARY DRILLING MACHINES AND EQUIPMENT FOR THE MINING AND CONSTRUCTION INDUSTRIES (ROLLING-CUTTERS HARD-ROCK CORE-DRILLING SHAFT-SINKING MOLES)
ALLEN, J. H. & H. B. WILLIAMS MFG CO DALLAS TEX
BULLETIN OF THE MINERAL INDUSTRIES EXPERIMENT STATION, PENN STATE UNIVERSITY, 71-81, OCT. 1959. THE PAPER SUMMARIZES THE HISTORY OF DEVELOPMENT OF ROTARY DRILLING EQUIPMENT AND ROLLING COTTERS AND DESCRIBES VARIOUS TYPES AND APPLICATIONS OF ROTARY DRILLING EQUIPMENT INCLUDING: THE ZENI 76 INCH HARD-ROCK CORE DRILLING MACHINE, THE ZENI-MCKINNEY-WILLIAMS 76 INCH HARDROCK SHAFT SINKING MACHINE, THE HUGH B. WILLIAMS 40 INCH HARD ROCK TUNNELING MACHINE AND ITS SCALED UP VERSION OF A PROPOSED 12 FOOT DIAMETER TUNNEL MACHINE BOTH DESIGNED TO DRILL 7,000 PSI COMPRESSIVE STRENGTH ROCK AT A RATE OF 8 - 12 FEET PER HOUR. ALSO DESCRIBED IS THE WILLIAMS LL DH FOUNDATION DRILLING MACHINE FOR DIGGING 8 FOOT DIAMETER HOLES TO 120 FEET DEPTH UNDER IDEAL DRILLING CONDITIONS, AND A PROPOSED VERSION USING REVERSE CIRCULATION FOR DRILLING 8 FOOT HOLES TO 3,000 FOOT DEPTHS IN MEDIUM - SOFT FORMATIONS.

73-66-03001 POTENTIAL FOR TUNNEL BORING MACHINES NEVADA TEST SITE (LOST-TIME ROCK-STRENGTH CUTTERS ROCK-BOLTS)
ANTONIDES, L. E. & U.S. AEC LAS VEGAS NEV
AEC CONTRACT, (26-1)-38, MAR 1966. TUNNELING WITH FULL-FACE BORING MACHINES HAS BOTH TIME AND COST-ADVANTAGES OVER CONVENTIONAL DRILL AND BLAST METHOD IN ROCKS UP TO MEDIUM HARDNESS AND STRENGTH, PROVIDED PLANNED FOOTAGE EXCEEDS A CERTAIN MINIMUM. HOWEVER, SUCH ADVANTAGES ARE ALSO CONTINGENT UPON ACCEPTANCE OF A CIRCULAR TUNNEL, HAVING LIMITED VARIATION IN DIAMETER AND GRADUAL CURVES. FACTORS AND FORMULAS ARE PRESENTED TO ESTIMATE TIME AND COST SAVINGS ON ANY PLANNED PROJECT. BEST SAVINGS RESULT WHEN MACHINES ARE FITTED WITH DISC CUTTERS AND TUNNEL LINING CONSISTS OF ROCK BOLTS AND WIRE MESH. A SELECTED BIBLIOGRAPHY OF ROCK TUNNEL BORING, A LIST OF U.S. ROCK TUNNEL BORER MANUFACTURERS, ILLUSTRATIONS OF U.S. COMMERCIAL BORERS, POSSIBLE BORE CROSS SECTIONS AND DETAILED COST ESTIMATE CALCULATIONS ARE GIVEN IN THE APPENDIX.

73-68-09001 HORIZONTAL BORING TECHNOLOGY - A STATE OF THE ART STUDY (DRILLS SOIL-MECHANICS COSTS UNDERGROUND STRUCTURES MOLE)
PAONE, J. + BRUCE, W. E. + MORRELL, R. J.
U.S. BUREAU OF MINES, INFORMATION CIRCULAR IC-8392, SEPT 1968. THE REPORT DESCRIBES THE DIFFERENT MACHINES AND METHODS USED IN AUGERING, IMPACTING, PUSHING, DRILLING, AND MACHINE TUNNELING HORIZONTAL HOLES THROUGH SOIL AND ROCK. A REVIEW OF THE BOREHOLE SURVEY AND GUIDANCE TOOLS AND TECHNIQUES APPLICABLE TO THESE METHODS IS ALSO GIVEN. NONBORING METHODS USED FOR EMPLACEMENT OF POWER DISTRIBUTION AND TRANSMISSION LINES ARE BRIEFLY DISCUSSED.

FIELD 74 ARTICLES

74-55-08001 THE MARTIN BORER (ADVANCE COAL BLASTING DRIVE WEIGHT)
ASCHACHER, M. & DUPRET, L. & WEST CANADIAN COLLIERIES
COAL AGE, 58-59, AUG 1955. SEVERAL BORING MACHINES HAVE BEEN DEVELOPED FOR DRILLING LARGE-DIAMETER HOLES IN PITCHING COAL SEAMS BUT ALL WERE TOO CUMBERSOME TO BE MOVED EASILY THRU NARROW PASSAGES AND CRAMPED QUARTERS. AN ANALYSIS OF THE PROBLEM LED TO DEVELOPING A MACHINE WHOSE CUTTING HEAD WOULD BE PULLED INSTEAD OF PUSHED. A 10HP MACHINE WAS BUILT WHICH ENLARGES A 2 IN. PILOT HOLE, BORED BY CONVENTIONAL METHODS, TO 20 IN. AND THEN ENLARGES THIS TO 36 IN. THE DRIVE WEIGHS 1,700 LBS. EACH 5 FT LENGTH OF ROD WEIGHTS 140 LBS AND THE 20 IN. AND 36 IN. CUTTING HEADS WEIGH 200 AND 360 LBS. IN LESS THAN TWO SHIFTS, TWO OPERATORS SET UP THE MACHINE, DRILL THE 2 IN. PILOT HOLE, THEN THE 20 IN. GUIDE HOLE AND FINALLY THE 36 IN. HOLE ON ANY PITCH FROM 45 UP TO 90 DIG. BECAUSE STRATA ARE NOT DISTURBED BY BLASTING, THE HOLES HAVE STOOD WITHOUT ANY TIMBERING. CONTINUOUS MINERS HAVE RESULTED IN SUBSTANTIAL PROFITS. IT IS EXPECTED THAT A MACHINE WILL BE DEVELOPED WITH A 5 OR 6 FT CUTTING HEAD USING THE 36 IN. HOLE AS A GUIDE, THUS DOING AWAY WITH BLASTING ENTIRELY.

74-56-03001 TUNNEL RIG CHEWS THROUGH SHALE (ADVANCE CUTTER LINING MUCK PILOT)
FELLER, J. L. & OAHE CONSTRUCTORS
CONSTRUCTION METHODS & EQUIPMENT, 78-94, MAR 1956. A 26 FT DIAM. 129 TON TUNNELING MACHINE IS BORING 6 DIVERSION TUNNELS AVERAGING 1,600 FT. EACH AT OAHE DAM IN SOFT SHALE. MINING IS DONE WITH TWO CONCENTRIC ROTARY CUTTERHEADS. THE OUTER CUTTERHEAD ALSO INCORPORATES SIX BUCKETS FOR PLACING THE MUCK ON A BELT CONVEYOR. RING BEAMS FOR GROUND SUPPORT ARE ASSEMBLED AND PLACED BY A SPECIAL JIG MOUNTED ON THE MACHINE DIRECTLY BEHIND THE CUTTERHEAD. INVERT AND ARCH FORMS ARE USED TO POUR THE CONCRETE LINING. THE JAMES S. ROBBINS MACHINE AVERAGES 3.5 FT ADVANCE PER HR. WITH AS MUCH AS 56 FT. IN 7 HRS. AND 129 FT IN 24 HRS. KERFS ARE CUT WITH FIXED TEETH AND THE MATERIAL BETWEEN SHATTERED WITH DISKS. IN DRIVING THE SIX TUNNELS ONLY SIX DISKS WERE REPLACED AND THESE BECAUSE OF BEARING SEAL FAILURE RATHER THAN DISK EDGE WEAR. A CIRCULAR STEEL SEGMENT SERVES AS A SLIDING ROOF SUPPORT AS THE MACHINE MOVES FORWARD. A SMALL PILOT BIT AND CONE PROJECTING 16 IN. AHEAD OF THE CUTTERHEAD HELPS HOLD LINE AND GRADE.

74-59-06001 WORLD'S LARGEST MOLE TUNNELS AT OAHE DAM (MOLE CUTTERS MUCKING GEOLOGY TUNNELING-RATE TOOL-COST)
KAROLEVITZ, R.
EXCAVATING ENGR., (53) N 6, 31-32, JUNE 1959. FOR DIVERSION AND POWER TUNNELS AT OAHE DAM ON MISSOURI RIVER NEAR PIERRE, S.D., U. S. ARMY CORPS OF ENGINEERS SPECIFIED NO BLASTING PERMITTED BECAUSE OF TREACHEROUS PIERRE SHALE STRATA UNDERLYING DAM SITE. HARD LIMESTONE AND SHALE ARE THE FORMATIONS THROUGH WHICH A MOLE DESIGNED BY ROBBINS AND ASSOCIATES, SEATTLE, WASH. CUTS TO EXACT SIZE. SIX DIVERSION TUNNELS 25 FT, 9 IN. IN DIAM, 1,800 FT LONG WERE BORED WITH THE FIRST MACHINE. A NEW 29-1/2 FT, 200 TON 55 FT LONG MACHINE WAS BUILT FOR THE POWER TUNNEL PHASE. CUTTER HEAD HAS EIGHT CUTTING ARMS ON ITS FACE AND EIGHT ADDITIONAL CUTTERS ON AN OUTER RIM WHICH ALSO CARRIES THE BUCKETS FOR CUTTING REMOVAL. DRAG TYPE TUNGSTEN CARBIDE BITS CUT GROOVES OR KERFS AND DISK SHAPED HARD FACED STEEL CUTTERS BREAKUP THE ROCK BETWEEN THE KERFS. TWO 400 HP ELECTRIC MOTORS POWER THE DEVICE WHICH HAS AUTOMATIC POWER SHUTOFF IF IT BECOMES TOO WET. STEEL RIBS ARE PLACED EVERY FOUR FT WHICH WILL ALSO ACT AS CONCRETE TUNNEL LINING REINFORCEMENT. ROLLER CUTTERS SELDOM REQUIRED REPLACEMENT BUT CARBIDE FIXED TOOLS NEEDED REGULAR REPLACEMENT AMOUNTING TO LESS THAN 5 DOLLARS PER FOOT OF TUNNEL. THE LARGE MACHINE IS EXPECTED TO ADVANCE AT A MAXIMUM RATE OF 12 FT PER HR ATTAINED BY THE SMALLER MACHINE.

74-62-05001 SHIELD METHOD FOR LARGE RAILWAY TUNNEL AT BERNE (SWITZERLAND)
DESPONDS, R.
WORLD CONSTRUCTION, (15) NO 5, 56-63, MAY 1962. A SHIELD IS BEING USED TO DRIVE A RAILROAD TUNNEL THROUGH MORAINIC AND NON COHERENT GROUND IN SWITZERLAND. METHOD OF BORING AND DETAILS OF THE SHIELD ARE GIVEN.

74-63-00001 RESULTS AND POSSIBLE APPLICATIONS OF THE MARIETTA CONTINUOUS MINING IN DRIFTING WORK (MECHANICAL TUNNELLING DEVICES COST MOLES)
VERDET, J.
INTERNATIONAL CONFERENCE ON RAPID ADVANCE OF WORKINGS IN COAL MINES, SECTION B, PAPER B, 86-103, 1963. THE MARIETTA CONTINOUS MINER COMPARED TO DRIFTING BY EXPLOSIVES WITH A SCRAPER ON A BELT CONVEYOR SHOWS 20.7 M/DAY FOR THE MARIETTA AND 9.60 M/DAY FOR SCRAPER. THE EXPENDITURES FOR SCRAPER WERE 415 FRANCS/M 313 FRANCS/M DRIVEN FOR THE MARIETTA. A LARGER ADVANCE IS NEEDED IN THE MARIETTA PER DAY THAN IN THE CONVENTIONAL METHOD. WITH THE PROPER ORGANIZATION OF WORK TO BE DONE AND A COMPLETE ANALYSIS OF THE GROUND BEFORE WORK BEGINS THE MARIETTA HAS GREATER POSSIBILITY OF INCREASING PRODUCTION RATES.

74-63-03001 MACHINE TUNNELING IN TASMANIA (TAILRACE-TUNNEL MOLE HYDRAULIC DUST MUDSTONE)
THOMAS, H. H. & HYDRO-ELECT COMM TASMANIA AUST
CIVIL ENGINEERING, MAR 1963. THE TAILRACE TUNNEL FOR THE TASMANIA, GREAT LAKE POWER PROJECT THAT IS 16 FEET DIAMETER HAS BEEN SUCCESSFULLY DRIVEN THROUGH 14,600 FEET OF HARD MUDSTONE. THE 120 TON MACHINE COSTING ABOUT $470,000 IS NOW BEING MODIFIED FOR USE IN A TUNNEL THROUGH SANDSTONE AFTER 70% OF ITS ORIGINAL COST WAS WRITTEN OFF AGAINST THE TAILRACE TUNNEL. THE ARTICLE BRIEFLY OUTLINES THE HIGH POINTS OF THE OPERATION.

74-63-07001 LONG WALL MINING OF POTASH WITH BORER TYPE CONTINUOUS MINERS (CRUSHER ECONOMICS SHUTTLE-CARS CONVEYOR)
HORNE, J. C. + PIERSON, F. L. & U.S. BORAX CHEMICAL CORP
MINING CONGRESS JOURNAL, JULY 1963. THE ARTICLE DESCRIBES THE ECONOMICS, EQUIPMENT, FUNCTIONAL APPLICATIONS AND DEVELOPMENTS IN THE USE OF LONGWALL MINING USING BORER TYPE CONTINUOUS MINERS IN POTASH BEDS 1000 FEET BELOW THE DESERT IN THE CARLSBAD BASIN. INCREASES IN PRODUCTION OF 145% HAVE BEEN ACHIEVED IN TONS PER MAN-SHIFT OVER CONVENTIONAL MINING SYSTEM USING TRACK HAULAGE, DRILLS, UNDERCUTTERS, DYNAMITE, LOADERS AND SHUTTLE CARS IN THE ROOM AND PILLAR METHOD. STUDIES BY THE U.S. BORAX AND CHEMICAL CORP. RESULTED IN THE PIONEERING OF BORER MINER AND DEVELOPMENT OF THE MODIFIED LONGWALL MINING SYSTEM OF POTASH TO REDUCE MINING COSTS IN LOWER HEIGHT, LOWER GRADE ORE. CONVENTIONAL MINING WAS APPLICABLE IN THE RICH ORE AREAS WHERE BEDS WERE UP TO 15 FEET THICK. CONTINUOUS MINER OPERATIONS ARE LIMITED TO AREAS OF 8 FEET AND LESS IN HEIGHT.

74-64-02001 MODERN TRENDS IN SOFT GROUND TUNNELING (SHIELDS)
HASWELL, C. K. & SIR WM. HALCROW AND PARTNERS
CIVIL ENGINEERING AND PUBLIC WORKS REVIEW, 181-188, FEB. 1964. THE RATE OF ADVANCE AND SAFETY OF SHIELD TUNNELING OPERATIONS HAVE INCREASED GREATLY IN RECENT YEARS BECAUSE OF MECHANIZATION OF THE OPERATIONS AND USE OF COMPRESSED AIR TO KEEP WATER OUT OF THE SHIELD.

74-64-03001 HARD ROCK MOLE TEAMS UP WITH RAISE BORER TO HELP DEVELOP HOMER-WANSICA IRON MINE (ADVANCE CUTTERS COST)
CANNON, R. E. & DRESSER INDUSTRIES
ENGINEERING & MINING JOURNAL, (165) NO 3, 86-89, MAR 1964. THE 7 FT. DRIFT AND 40 IN. DIA RAISE BORERS MANUFACTURED BY JAMES S. ROBBINS CUT CIRCULAR KERF GROOVES AND THEN FORCE THE ROCK TO BREAK BETWEEN THE GROOVES. THE IRON OXIDES ARE RELATIVELY SOFT, 3000 PSI BUT JASPERITE WITH A 35,000 PSI COMPRESSIVE STRENGTH ASSOCIATED WITH IT MUST ALSO BE CUT. THESE MACHINES ARE SO SUCCESSFUL THAT PRODUCTION MINING AS WELL AS DEVELOPMENT MINING IS BEING PLANNED WITH THEM. THE DRIFT MACHINE HAS A 10 RPM ROTATING HEAD. A THRUST OF OVER 500,000 LB., AND A TORQUE OF OVER 100,000 FT. LB. ITS MAXIMUM RATE OF ADVANCE HAS NOT BEEN OBTAINED DUE TO LACK OF OPERATOR PROFICIENCY AND MUCK REMOVAL PROBLEMS BUT 25 FT OF 7 FT DIA DRIFT PER 8 HR SHIFT SHOULD BE ATTAINED WITH NO DIFFICULTY. THE RAISE BORER REAMS A PILOT HOLE TO 40 INCHES WITH A TOOL HAVING CUTTERS ON SEVERAL PLANES INSTEAD OF ONE. A PRODUCTION BORING RATE CAPABLE OF COMPLETING 200 FT. OF 40 IN. DIA. RAISE IN 48 HRS. OPERATING RESULTS SHOW THAT THESE TYPES OF MACHINES CAN BE DESIGNED TO BORE ANY FORMATION ECONOMICALLY. A TABLE IS GIVEN OF TYPICAL COST AND PERFORMANCE IN BORING 200 FT RAISE 40 IN. DIA.

74-64-06001 HYDRAULIC FOREPOLING SHIELD DRIVES CAVED-IN TUNNEL DRIFT (SHIELD RUNNING-GROUND SEWER)
MONAGHAN, J. O. & CONSTRUCTION METHODS
CONSTRUCTION METHODS, 96-101, JUNE 1964. ON A JOB THAT WAS TAKEN OUT OF AN EARLIER CONTRACT WHEN UNEXPECTED GROUND CONDITIONS CAUSED TWO CAVE INS, HURLEY CONSTRUCTION CO. IS MAKING GOOD TIME IN UNSURE SOIL WITH A NEW TYPE SHIELD WHICH IS FRONTED BY SEVEN HYDRAULIC FOREPOLING PLATES EACH WITH 60 TONS OF JACK POWER. THE SHIELD HAS MINED 129 FT. OF RUNNING GROUND SAFELY, AND IS MOVING THROUGH SANDSTONE AT 35 FT. PER DAY. THE 15 1/2 FT. DIA, 18 FT. LONG SHIELD IS EQUIPPED WITH A 10,000 PSI HYDRAULIC SYSTEM WHICH PUSHES THE 3 FT. WIDE POLING PLATES FOUR FT. AHEAD OF THE SHIELD. IN RUNNING GROUND, THE FOREPOLES REMAIN EXTENDED FOR COVER. IN SANDSTONE THEY HELP BY TRIMMING ABOVE THE SPRINGLINE.

74-64-07001 AN ENGLISH CHANNEL CROSSING (BRIDGE-TUNNEL RAILROAD-TUNNEL BORED-TUNNEL SUNKEN-TUBE TUNNEL)
BICKEL, J. O.
CIVIL ENGINEERING, 35-39, JULY 1964. A PROPOSAL HAS BEEN MADE TO BUILD A RAIL TUNNEL AT AN EXPECTED COST OF MORE THAN $400 MILLION AND TO REQUIRE FIVE OR SIX YEARS TO COMPLETE. 23 MILES OF ITS LENGTH WILL BE UNDER WATER. THE GEOLOGICAL HISTORY OF THE CHANNEL IS ODD IN THAT THERE APPEARS TO HAVE BEEN A NEVER-ENDING SUCCESSION OF SUBSIDENCE AND ELEVATION OF LARGE AREAS. A STUDY GROUP UNDERTOOK TWO EXPLORATORY PROJECTS - (1) A SERIES OF BORINGS AND (2) A SPARKER SURVEY - A HIGH-POWER, BROADBAND ECHO SOUNDER IN WHICH THE DISCHARGE OF AN ELECTRICAL SPARK IN THE WATER PRODUCES ACOUSTICAL ENERGY. SEVERAL METHODS FOR GETTING ACROSS THE CHANNEL WERE STUDIED. THESE METHODS WERE - (1) A BRIDGE (2) A BRIDGE-TUNNEL COMBINATION (3) TWO TYPES OF TUNNELS (4) A BORED TUNNEL AND (5) A SUNKEN TUBE TUNNEL. THE RESULTS OF THIS STUDY CONFIRM A RAILROAD TUNNEL AS THE LOGICAL SOLUTION SINCE THE VENTILATION PROBLEM WOULD BE SIMPLE AND THE COST WOULD BE LOWER.

74-64-12001 TRENDS IN RAISING MECHANIZATION (BIRD-CAGING SAFETY)
KELLOGG, J. L. & CERRO CORP
MINING CONGRESS JOURNAL, (50) 42-47, DEC. 1964. THE PRINCIPAL MECHANIZED METHODS OF RAISE DRIVING PERFECTED TO DATE ARE RAISE CLIMBING, BIRD CAGING, AND RAISE DRILLING. IN RAISE CLIMBING, THE COMPETENCE OF THE GROUND AND CHARACTERS OF THE WORKMEN HAVE MORE EFFECT THAN MECHANICS DO ON HEIGHT. CAPITAL COST OF EQUIPMENT CANNOT ALWAYS JUSTIFY COST SAVINGS. BIRD CAGING HAS TWO ADVANTAGES: THE PILOT HOLE MAY BE USED AS A BURN HOLE AND FOR THE INTRODUCTION OF LARGE VOLUMES OF VENTILATING. THE ECONOMIC ASPECTS ARE LIKE THOSE OF RAISE CLIMBING. RAISE DRILLING ELIMINATES CONVENTIONAL DRILLING AND PERSONNEL ENTERING RAISES. THE LIP-REAMING METHOD HAS ITS PRINCIPAL ADVANTAGE IN THE REAMING CYCLE. REAMING TO 40 OR 48 IN. DIA HAS INTRODUCED PROBLEMS. THRUST UP TO 100,000 LB AND TORQUE IN THE RANGE OF 20,000 TO 30,000 FT.-LB. MUST BE DEVELOPED. THIS IMPOSES STRAIN ON CUTTER, ETC. VARIOUS SHAPES OF REAMING HEADS HAVE BEEN TRIED SUCCESSFULLY, THE BEST BEING CONE PATTERNS. ADVANTAGES OF RAISE BORING INCLUDE: SAFETY, THE ULTIMATE IN SELF-SUPPORT, MINIMUM RESISTANCE TO AIR FLOW. IN SHAFT EXCAVATION, MORE USE IS BEING MADE OF THE PILOT RAISE AND SLABBING TECHNIQUE. ONE OF THE MOST COMMON RECENT APPLICATIONS OF RAISES IS THEIR USE FOR THE INTRODUCTION OF WASTE FILL DIRECTLY INTO EMPTY STOPES FOR THE CONTROL OF SUBSIDENCE.

74-65-06001 HARDROCK TUNNELING IN PEGMATITE (CUTTER-COOLING PENETRATION THRUST TORQUE HYDRAULIC-POWER MOLE)
WATKINS, W. W. & LAWRENCE MFG CO
MINING CONGRESS JOURNAL, JUNE 1965. A REPORT ON TEST OPERATIONS OF AN ALKIRK HARDROCK TUNNELER PERFORMED IN LATE 1964 AND EARLY 1965 AT THE RICHMOND WATER TUNNEL IN NEW YORK CITY BETWEEN STATEN ISLAND AND BROOKLYN. THE TESTS WERE PERFORMED AT A DEPTH OF 936 FEET AT THE BASE OF THE STATEN ISLAND SHAFT IN A PEGMATITE INTRUSION. SPECIFICATIONS FOR THE TUNNELER ARE GIVEN AND OPERATIONS AND TEST RESULTS ARE DESCRIBED.

74-65-06002 TESTING OF A SEVEN-FT TUNNEL BORER (MOLE IRON-ORE ROBBINS)
MCAULIFFE, J. D. & HANNA MINING CO
MINING CONGRESS JOURNAL, 49-55, JUNE 1965. A 7 FT TUNNEL BORER MADE BY JAMES S ROBBINS ASSOC. WAS TESTED IN THE HOMER-WAUSEGA ORE BODY STARTING IN OCT 1963. THE POWER WAS TOO SMALL, THE CUTTERS INADEQUATE AND CUTTERS WERE HARD TO REPLACE. HOWEVER, BY JUNE 1964 MOST OF THE DEFICIENCIES WERE CORRECTED. A NEW MOLE BASED ON RESULTS OF THESE TESTS COULD BE AMORTIZED IN 250 DAYS BY SAVINGS IN LABOR.

74-65-06003 HISTORY AND PROBLEMS OF ROCK BORING (MOLES)
WILLIAMSON, T. N. & HUGHES TOOL CO HOUSTON TEX
MINING CONGRESS JOURNAL, (51) 39-44, JUNE 1965. SHORT DESCRIPTIONS OF MACHINES DEVELOPED IN 19TH CENTURY AND OF HOWARD HUGHES, SR'S WORK ON ROCK DRILLS ARE GIVEN. HUGH B. WILLIAMS CO DEVELOPED CUTTING HEAD FOR ENGLAND'S NATIONAL COAL BOARD AND BUILT A 40 IN PROTOTYPE MACHINE FOR TESTING. THE COAL INDUSTRY SPARKED THE DEVELOPMENT OF HORIZONTAL BORERS WITH SEVERAL COMPANIES IN THE FIELD. JAMES S. ROBBINS, USING GOODMAN PATENTS, DEVELOPED MACHINES FOR THE DAKOTA MISSOURI RIVER TUNNELS FOR THE U.S. CORP OF ENGR. MANY SOIL BORERS HAVE BEEN BUILT AND USED IN DETROIT, CHICAGO, MILWAUKEE, HOUSTON, LOS ANGELES, SEATTLE, KANSAS CITY. ABOUT 20 ROCK TUNNELERS HAVE BEEN BUILT. ABILITY TO CUT HARDER ROCK IS IMPROVING. LASER GUIDANCE SYSTEMS HAVE RECENTLY BEEN USED.

74-65-06004 TUNNELING IN SANDSTONE (MOLE ROBBINS HUGHES)
OTTER, J. V. & MORRISON-KNUDSEN CO INC
MINING CONGRESS JOURNAL, (51) 44-45, JUNE 1965. MORRISON-KNUDSEN CO TRIED OUT HUGHES TOOL CO AND JAMES S. ROBBINS CO BORING MACHINE DURING 1963-64 FOR DRIVING A 7 FT TUNNEL IN COCONINO SANDSTONES WITH BREAKUP HARDNESS OF 3.5 TO 4.5 AND A MOHR'S HARDNESS OF 7 TO 7.5. COMPRESSIVE STRENGTH OF THE ROCK VARIED FROM 2000 TO 12000 PSI. EVALUATION WAS INCOMPLETE DUE TO PROJECT CHANGES. TUNNEL BORERS CAN BE EXPECTED TO BE DEVELOPED TO ENABLE DRILLING OF ANY ONE TYPE OF ROCK BUT VERSATILITY IS LIMITED.

74-65-07001 HARD ROCK TUNNEL DRIVING ON THE MOON (CUTTER MUCKING GUIDANCE BORING-MACHINES MOLE)
WILLIAMSON, T. N. & HUGHES TOOL CO HOUSTON TEX
MINING ENGINEERING, 147-151, JULY 1965. TUNNEL DRIVERS ARE BEING TRIED WITH INCREASING FREQUENCY DESPITE THEIR HEAVY INVESTMENT, LABOR OPPOSITION AND SOME SPECTACULAR FAILURES. TUNNELING ON THE MOON WILL PROVIDE PERSONNEL SHELTER, OXYGEN FROM MINERALS, WATER FROM HYDROUS ROCK, BUILDING MATERIAL FOR SURFACE STRUCTURES AND RECOVERY OF NEW MATERIALS. THE FEW BORING MACHINES THAT HAVE BEEN BUILT WITH ENOUGH POWER WERE SO MASSIVE THEY WERE DIFFICULT TO CONTROL AND ALMOST IMPOSSIBLE TO MAINTAIN. HOWEVER WITH TECHNICAL ADVANCES A 10-FT DIAM MACHINE WITH 100 HP, USING 100,000 LBS OF THRUST MIGHT WEIGH 50,000 LBS ABOUT ONE-THIRD OF A SIMILAR 1965 MACHINE AND COMBINED WITH A SHAKER CONVEYOR FOR MUCK REMOVAL WOULD BE VERY EFFECTIVE. TOOTH-TYPE ROLLER CUTTERS WITH 500,000 PSI MATERIAL SHOULD BE AVAILABLE TO INCREASE CUTTER LIFE AND DRILLING RATE. THE GUIDANCE PROBLEM HAS ALREADY BEEN ELIMINATED BY THE GAS LASER.

74-65-10001 BIG-BORE MOLE SETS PACE THAT OVERTAXES MUCKING SYSTEM (LASER-TRANSIT FANLINE CONVEYOR CONCRETING)
JUERGENS, R. E. & CONSTRUCTION METHODS
CONSTRUCTION METHODS, 142-149, OCT. 1965. A 21 FOOT DIAMETER MOLE WAS BUILT BY HUGHES TOOL CO. FOR FENIX AND SCISSON, CONTRACTOR FOR THE BU REC NAVAJO TUNNEL N1. THE BIG MACHINE ALMOST IMMEDIATELY BEGAN TO OUTRUN ITS BACKUP EQUIPMENT. THE POTENTIAL RATE OF ADVANCE IS 10 FEET PER HOUR BUT THIS HAS NOT BEEN ACHIEVED PRIMARILY BECAUSE OF GROUND CONDITIONS. A LASER-BEAM GUIDANCE SYSTEM ACTIVATES ELECTRONIC SENSORS TO HELP THE OPERATOR KEEP THE MOLE ON LINE. MUCK IS CLEARED FROM THE TUNNEL FACE BY CUTTER HEAD BUCKETS WHICH SCOOP UP THE ROCK CHIPS AS THE HEAD ROTATES AND DUMPS THEM ONTO AN OVERHEAD CONVEYOR. THE 300 FPM BELT EXTENDS TO THE REAR OF THE MOLE AND DISCHARGES ONTO A SECOND CONVEYOR, WHICH CARRIES THE SPOIL ANOTHER 250 FEET TO THE REAR OF THE MUCKING TRAIN. THE FANLINE IS INSTALLED AT THE TOP OF THE MUCK CONVEYOR BY USING A HIGHLY MECHANIZED OPERATION TO AVOID CLUTTERING THE LIMITED SPACE NEAR THE PORTAL OF THE TUNNEL.

74-65-11001 JUMBO DESIGN TRENDS - PAST AND PRESENT (AUTOMATION)
ANDREWS, I. W.
ROCK PRODUCTS, 63-64, NOV. 1965. FUTURE JUMBO MAY BE PUSH-BUTTON OPERATED, CAPABLE OF DRILLING AROUND TO A PRE-DETERMINED PATTERN WITHOUT RELYING ON HUMAN JUDGEMENT FOR COLLARING HOLE ADJUSTMENT, SPACING, DEPTH AND FEEDING. THE PAPER DISCUSSES THE MANY DEVELOPMENTS LEADING TO THE PRESENT DAY JUMBO.

74-65-12001 SOFT GROUND TUNNELING FOR TORONTO SUBWAY (CANADA SHIELDS)
SURVEYOR, (126) NO 3835, 29-30, DEC. 4, 1965. FOUR SHIELDS ARE BEING USED FOR THE 17 1/2 FT OD RUNNING TUNNELS AND TWO SHIELDS 25 FT 9 IN ARE BEING USED TO DRIVE THE STATION TUNNELS. ALL HYDRAULIC EQUIPMENT WAS INSTALLED COMPLETELY WITHIN THE SHIELD STRUCTURE.

74-66-03001 NEW DEVELOPMENTS IN TUNNELING MACHINES (CUTTERS LINING MOLES MUCK HARD-ROCK)
JUERGENS, R. E.
CONSTRUCTION METHODS & MATERIALS, (48) NO 3, 130-144, MAR 1966. TUNNELING MACHINES HAVE THE ADVANTAGE OVER DRILLING AND SHOOTING OF: NO NOISE OR EARTH SHOCK, NO FUMES OR NOXIOUS GASES, MINIMIZED OVERBREAK AND MINING AND MUCKING ARE CONTINUOUS. AFTER IT WAS SHOWN THAT MECHANICAL TUNNELING ALSO COULD BE MORE ECONOMICAL SUCH MACHINES FOR SOFT AND MEDIUM HARD ROCK WERE BUILT AND IMPROVED. THE MACHINES AND THEIR SATISFACTORY OPERATION ARE DISCRIBED FOR JAMES S. ROBBINS, AMERICAN HOIST & DERRICK CO., HUGHES TOOL CO., S&M CONTRACTORS, HUGH B. WILLIAMS, ELMER C. GARDNER, MACHINES. PROGRESS HAS BEEN MADE IN MUCKING BUT AS YET FORMING A MUCK SLURRY AND CONVEYING IT IN PIPE HAS NOT BEEN SATISFACTORY. A FAILURE IN HARD ROCK TUNNELING IS DISCRIBED FOR THE ALKIRK HARDROCK TUNNELER IN MANHATTAN SCHILT RATED AT ABOUT 7 ON THE MOH'S SCALE. A TABLE IS GIVEN RATING ROCKS AND MINERALS ACCORDING TO MOH'S SCALE. IMPORTANT BREAKTHROUGHS ARE JUST AROUND THE CORNER AS ARE HARD ROCK TUNNELERS THAT CAN DO THE JOB EFFICIENTLY AND ECONOMICALLY. MANY AMERICAN MACHINES HAVE BEEN USED ABROAD. FOREIGN PRODUCED MACHINES SO FAR HAVE ONLY BEEN USED EXPERIMENTALLY. PART 1 OF A TWO PART ARTICLE. SEE 74-66-04001.

74-66-04001 NEW DEVELOPMENTS IN TUNNELING MACHINES (ADVANCE SAFETY CUTTERS BAD-GROUND MUCK LINERS TRANSPORTATION WASTE-DISPOSAL)
JUERGENS, R. E.
CONSTRUCTION METHODS, (48) N 4, 126-145, APR 1966. DIGGING EARTH TUNNELS BY MACHINE IS BECOMING STANDARD OPERATING PROCEDURE ALL OVER THE WORLD AND IS BEING DONE FASTER, CHEAPER AND SAFER. THE CALWELD, CONSTRUCTION EQUIPMENT CO., DIXIE FORM AND STEEL CO., GARDNER, MEMCO, MID-STATES TOOL & DIE, SCOTT AND TERRA-FORM FOOTING CO. MACHINES AND THEIR PERFORMANCE ARE DESCRIBED. FOREPOLING IS PROVIDED ON SOME MACHINES AS WELL AS PRESSURIZATION. METHODS OF CONTROLLING BAD GROUND ARE DISCUSSED. MORE EFFICIENT MUCK HANDLING METHODS ARE BEING DEVELOPED. ERECTION OF LINER PLATES IS BEING ACCELERATED. IN FOREIGN COUNTRIES SEVERAL INTERESTING MULTIPLE WHEEL MACHINES HAVE BEEN DEVELOPED IN THE SOVIET UNION AND JAPAN. THE LONDON TRANSPORT AUTHORITY TESTED A NUMBER OF MACHINES FOR THE VICTORIA SUBWAY LINES AND SETTLED ON ONE WITH TWO CONCENTRIC DRUMS. IN JAPAN A NOVEL TUNNELER HAS BEEN DEVELOPED WITH 4 ROTARY CUTTING BUCKETS. IT SEEMS CLEAR THAT PRESENT AND BRIGHTEST FUTURE FOR SOFT GROUND MOLES IS IN BIG CITIES FOR THEIR TRANSPORTATION AND WASTE-DISPOSAL. PART 2 OF A TWO PART ARTICLE. SEE 74-66-03001.

74-66-05001 SERVICE MOLE TRIMS COST OF TUNNEL RIBS AND CONCRETE (BORING SEEPAGE CUTTERS)
CONSTRUCTION METHODS, MAY 1966. MACHINE BORING AND DRILL-AND-SHOOT METHODS WERE USED IN A SEWER PROJECT. ADVANTAGES OF THE MACHINE METHODS INCLUDE 80% LESS CONCRETING, LESS SUPPORTING, LESS WATER SEEPAGE, 40 PERCENT LESS MANPOWER AND USAGE IN AN AREA WHERE BLASTING IS IMPOSSIBLE OR IMPRACTICAL. MAXIMUM PENETRATION RATE WAS 5 FT PER HOUR WITH A 4-FT-PER-HOUR AVERAGE. MACHINE TUNNELING IS AT LEAST AS FAST AS CONVENTIONAL METHODS. NEW DEVELOPED CUTTERS WITH TUNGSTEN CARBIDE BUTTONS ARRANGED IN A CIRCUMFERENTIAL PATTERN, HAVE INCREASED THE AVERAGE PENETRATION BY ALMOST ONE FT PER HOUR. CUTTER LIFE WAS IMPROVED CONSIDERABLY BY ADDING SCRAPERS TO THE CUTTING WHEEL TO PREVENT THE ACCUMULATION OF FINES AGAINST THE LOWER ARC OF THE FACE. SHOCK ABSORPTION WAS OVERCOME BY USING A FLEXIBLE DRIVE COUPLING BEHIND THE CUTTING WHEEL AND EIGHT HOLDING ARMS TO GRIP THE TUNNEL WALL WITH 48 STUDS.

74-66-05002 LASER GUIDES MONSTER MOLE
WILLIAMSON, T. N. & HUGHES TOOL CO HOUSTON TEX
CONTROL ENGINEERING, (13) 127, MAY 1966. KEEPING THE HUGHES TOOL CO'S 280 TON, 21 FT. DIA HARD ROCK MINER ON LINE AT THE NAVAJO INDIAN IRRIGATION PROJECT IS NO EASY TASK. A PERKIN-ELMER GAS LASER, A SMALL HELIUM-NEON INSTRUMENT IS USED. PHOTOCELLS ARE MOUNTED AT THE MACHINES FRONT AND BACK AND TIED INTO A PANEL BY THE DRIVER WHERE COMPENSATION FOR MACHINE ROLL CAN BE MADE. THE DRIVER CAN AIM THE MACHINE ACCORDINGLY TO KEEP IT ON LINE.

74-67-05001 MACHINERY FOR THE MINING INDUSTRY AT THE BAUMA 1967
HOFHERR, K.
GLUECKAUF, (103) N 11, 525-530, MAY 25, 1967. THE XIV BAUMA, INTERN. CONSTRUCTION MACHINERY FAIR (MAR. 11 TO 19, 1967) IN MUNICH DISPLAYED THE FOLLOWING INNOVATIONS: THE SALZGITTER MASCHINEN AG DEVELOPED THE DRILL RIG LB 24. IT IS POSSIBLE TO DRILL BLAST-HOLES UP TO 115 MM DIA AND 100 M. DEPTH WITH 76 MM RODS. THE ALFRED WIRTH & CO. EXHIBITED THE EXTENSIVE PROGRAM OF THEIR HYDRAULICALLY DRIVEN DRILLING MACHINES. DUE TO LOW WEIGHT OF ALUMINUM RODS, THE BOREHOLE DEPTHS ARE INCREASED, TRANSPORTATION COSTS ARE REDUCED, HANDLING IS SIMPLIFIED (TIME REDUCED BY 50 PERCENT). THE NEW URD 475 ROTARY HAMMER MOUNTED ON THE DRILL RIG HAS A SEPARATE FRONT-MOUNTED DRIVE FOR THE ROTARY MOTION. A LEVER ALLOWS SELECTION OF TWO DIFFERENT DRILLING PROCESSES; THE SPIRAL DRILL IS ELIMINATED. ATLAS COPCO DEUTSCHLAND GMBH EXHIBITED THEIR MINUTEMAN DRILL WHICH CAN DRILL HOLES OF 3 TO 12 IN. DIA WITH AUGERS OR INSERT CORE DRILLS. THE EISENWERK GEBR. FRISCH KG, AUGSBURG, EXHIBITED LOADER WITH HINGED STEERING. THE TILTING ANGLE OF 45 DEGREES AND THEIR TRACTOR DUMPING ANGLE OF 90 DEGREES PERMIT EXTENSIVE BUCKET FILL AND GOOD EMPTYING CHARACTERISTICS. INVESTIGATIONS ON THE GRADING BLADE ARE UNDERWAY. IMPROVEMENTS HAVE BEEN MADE IN HYDRAULIC DREDGES, MAINLY IN THE AREA OF THE UNDERCARRIAGE. (IN GERMAN)

74-67-07001 MACHINE-BORED TUNNEL AND RAISES. THEIR APPLICATION TO UNDERGROUND MINING (VERSATILITY COST SAFETY PRODUCTION ROCK MAINTENANCE)
ROBBINS, R. J. + ANDERSON, D. L. & JAMES S ROBBINS ASSOC SEATTLE
MINING ENGINEERING, 156-160, JULY 1967. A TUNNEL BORER HAS POTENTIAL USE IN ALMOST ANY TYPE MINING HAVING A LARGE ENOUGH ACCESS SHAFT AND WHERE THE OREBODY IS OF SUFFICIENT SIZE TO WARRANT ITS USE. AN EIGHT FT DIAMETER BORING MACHINE WOULD USE ABOUT THE SAME MANPOWER AND POWER AS A MULTI-MACHINE JUMBO PLUS PNEUMATIC LOADER BUT ITS RATE OF ADVANCE WOULD BE THREE TIMES AS FAST. SEVERAL YEARS AGO TUNNEL BORERS COULD BE USED ONLY IN SEDIMENTARY ROCK OF LOW TO MEDIUM STRENGTH. TODAY DESIGN AND MATERIALS IMPROVEMENTS HAVE MADE RAISE BORING UNITS APPLICABLE TO ANY ROCK AND TUNNEL BORERS TO ALL ROCK EXCEPT THOSE WITH EXCEPTIONALLY HIGH STRENGTH PROPERTIES. MINING SHOULD BE DONE BY RAISE OR TUNNEL BORING RATHER THAN THE CONVENTIONAL DRILL AND BLAST AS IT WOULD BE MORE VERSATILE, REDUCE OPERATING COST, SIMPLIFY OPERATION AND LOWER MAINTENANCE. BORING MACHINES ARE NO MIRACLE BUT THEY HAVE DEVELOPED TO HIGH PERFORMANCE MACHINES. WITHIN TEN YEARS 80 PERCENT OF ALL TUNNELS SHOULD BE DRIVEN BY TUNNEL BORERS AND THE MINING INDUSTRY SHOULD AVAIL ITSELF OF THIS EQUIPMENT.

74-67-08001 RECORD TUNNEL EXCAVATION WITH BORING MACHINES (COST ADVANCE GEOLOGY SIZE)
CANNON, D. F. & U.S. BUR RECL DENVER COLO
CIVIL ENGINEERING, 45-48, AUG 1967. IN DIVERTING 110,000 ACRE-FEET OF WATER ANNUALLY FROM THE SAN JUAN RIVER TO THE RIO GRANDE BASIN THREE TUNNELS WILL BE REQUIRED: BLANCO BORED TO 10 FT. AND LINED TO 8 FT. 7 IN. IS 8.6 MILES LONG. OSO THE SAME SIZE AS BLANCO IS 5.3 MILES LONG, AZOTEA WHICH CARRIES THEIR COMBINED FLOW IS BORED TO 12 FT 6 IN AND LINED TO 10 FT. 11 IN. IS 12.7 MILES LONG. SPECIFICATIONS FOR ALL TUNNELS GAVE THE OPTION OF CONVENTIONAL MINING HORSESHOE SHAPE OR CIRCULAR. ALL LOW BIDS WERE FOR MACHINE BORED CIRCULAR SHAPE. AZOTEA LOW BID WAS $13,791000. BLANCO LOW BID WAS $10,600,000 INCLUDING $1,411,000 FOR A DIVERSION DAM. OSO FIGURES ARE NOT GIVEN. J. S. ROBBINS

MOLES WERE USED ON ALL TUNNELS. ROCK FORMATION IS FINE GRAINED SANDSTONE AND SHALE WITH COMPRESSIVE STRENGTHS BETWEEN 1,380 AND 5,890 PSI. AZOTEA THE MACHINE OPERATED 2,480 HOURS IN 12 MONTHS FOR 30,000 FEET ADVANCE, AN AVERAGE OF 12.1 FEET PER HOUR. TOP DAY WAS 241 FT. AT BLANCO TOP ADVANCE WAS 375 IN. ONE DAY AND A 12 MONTH TOTAL OF 7.8 MILES. AT OSO TOP DAILY ADVANCE WAS 403 FT. AND MONTHLY ADVANCE WAS 6,851 FT. THESE MACHINES STILL HAVE THE DISADVANTAGES OF HIGH INITIAL INVESTMENT, LONG DELIVERY PERIOD, CUSTOM MADE AND LIMITED TO SOFTER ROCKS.

74-67-11001 RAPID EXCAVATION (BORING HAULAGE SUPPORTS VENTILATION MOLES)
HOWARD, T. E.
SCIENTIFIC AMERICAN, 74-85, NOV 1967. A NUMBER OF BORING MACHINES HAVE BEEN SUCCESSFUL IN BORING TUNNELS FROM EIGHT TO MORE THAN 20 FT IN DIA. THE MACHINES ARE ALREADY OUTPERFORMING DRILL-BLAST METHODS IN BOTH SPEED AND ECONOMY. PENETRATION RATES OF 20 FT PER HR HAVE BEEN ACHIEVED. THE CONTINUOUS TUNNEL BORER ELIMINATES THE LOST MOTION OF REPLACING VARIOUS MACHINES FOR EACH STEP IN THE PROCESS SUCH AS THE "JUMBO" AND THE MECHANICAL LOADER. PRESENT METHODS OF HAULAGE, SUPPORT, INSTALLATION AND VENTILATION ARE NOT ABLE TO KEEP UP WITH THE MACHINE.

74-68-04001 LASER APPLICATIONS GO UNDERGROUND (ALIGNMENT GUIDANCE)
HALEY, E. A. & PERKIN-ELMER CORP NORWALK CONN
MINING ENGINEERING, 65-67, APR. 1968. A COMPLETE LASER ALIGNMENT SYSTEM HAS BEEN DEVELOPED BY PERKIN-ELMER CORP. THE SYSTEM PROVIDES ACCURACIES WITHIN 10 MICRO IN. PER FT WHEN USED WITH AN ACCESSORY CENTERING DETECTOR. SETTING UP AND OPERATING THE SYSTEM CAN BE DONE BY A SINGLE, UNSKILLED OPERATOR IN MINUTES. THE LASER IS SUPPORTED BY A TOOLING LASER STAND. ONCE POSITIONED, IT MAY BE LEFT UNATTENDED. THE BEAM MAY BE PROJECTED UNINTERRUPTED FOR 24 HOURS A DAY, REDUCING LABOR COSTS. RESETTING IS USUALLY REQUIRED ONLY EVERY 2000-3000 FT. BEAM DIA. AT 3000 FT IS 3 IN. SINCE THE LASER PROJECTS ITS OWN "LINE OF SIGHT" THROUGH THE TUNNEL, THERE IS NO NEED FOR AN INSTRUMENT MAN, AGAIN CUTTING LABOR COSTS. THE LASER HAS ALSO BEEN USED IN SHIELD DRIVING FOR STABILIZING THE PITCH AND YAW OF THE SHIELD.

74-68-04002 FURTHER DEVELOPMENT OF TUNNELING MACHINES FOR ABRASIVE, HARD ROCK (MOLES GERMAN-MACHINES)
DORSTEWITZ, G. + HENDRIKS, H.
GLUECKAUF, (104) N 8, 309-16, APR 11, 1968. TABULATION OF AVAILABLE TUNNEL MACHINES DEPENDING ON HARDNESS AND ABRASIVE ACTION OF ROCK. MACHINES WITH HARD-METAL CUTTING HEADS FAILED IN HARD, ABRASIVE ROCK AND HAD TO BE REPLACED BY MACHINES EQUIPPED WITH HARD-METAL ROLLERS. TEST APPARATUS HAS BEEN DEVELOPED AT MINING INSTITUTE OF CLAUSTHAL (WEST GERMANY) TECHNICAL UNIVERSITY TO DETERMINE DESIGN AND OPERATION OF HARD METAL ROLLERS TO GIVE MAXIMUM SPEED OF ADVANCE ON TUNNEL FACE AT MINIMUM PRESSURE ON ROCK AND WEAR OF ROLLERS. TEST RESULTS ARE TABULATED AND SHOWN IN GRAPHS. (IN GERMAN).

74-68-06001 SOFT-GROUND TUNNELS FOR BART (MOLE LININGS GROUT)
THON, J. G. + AMOS, M. J.
CIVIL ENGINEERING, (38) N 6, 52-5, JUNE 1968. TWO SUPPORT SYSTEMS, UNDERPINNING AND COLUMN PICKUP, ARE USED TO PROTECT EXISTING BUILDINGS AGAINST SETTLEMENT; MECHANICAL MOLE IS BEING EMPLOYED ON ONE OF TUNNELING CONTRACTS CUTTING EDGES ON MACHINE FACE SCRAPE SOIL ONTO CONVEYOR INSIDE MACHINE AND INTO MUCK CARS; MACHINE IS STEERED BY VARYING LOAD ON 29 JACKS AROUND CIRCUMFERENCE; MOLE HAS HYDRAULIC ERECTOR ARM FOR PLACING TUNNEL LINER SEGMENTS; SPACE BETWEEN GROUND AND LINING IS THEN GROUTED AS LINING LEAVES TAIL OF MACHINE.

74-68-10001 WHAT'S AHEAD FOR TUNNELING MACHINES? (COST HARDROCK-TUNNELING FORECASTS)
HILL, G. & INGERSOLL-RAND CO
ASCE JOURNAL, PAPER NO 6178, (94) NO 2, 211-231, OCT 1968. ONE THOUSAND OF THE 3,240 MILES OF WORLDWIDE TUNNEL CONSTRUCTION WHICH IS FORECAST FROM 1966 TO 1976 WILL BE DONE BY TUNNELING MACHINES. DETAILED PREDICTION MADE ON TYPE, USE, AND LOCATION OF FUTURE TUNNELS. AN ECONOMIC EVALUATION OF TUNNELING MACHINES WAS FOLLOWED BY A DETAILED COST ESTIMATE OF VARIOUS MACHINES. THE COMPARISON IS MADE BETWEEN CALIFORNIA STATE DEPT. OF WATER RESOURCES DATA (UPDATED TO 1968) AND EXPECTED MACHINE TUNNEL COSTS. OPTIMUM RATE OF ADVANCE FOR A MOLE WAS PREDICTED TO BE ABOUT 12 FT/HR AT A COST OF $42/CU YD COMPARED TO $71.05/CU YD DRILL AND BLAST SAME DIAMETER.

74-68-10002 FULLY MECHANIZED TUNNELING MACHINES FOR WORK IN ROCK (GERMAN-MACHINES SHIELD)
KAMPFEMDEN, G.
FOERDERN U HEBEN, (18) N 13, 818-20, OCT. 1968. SINCE 1965 FIRST EXPERIMENTAL MACHINES, AND, SUBSEQUENTLY, MACHINES OF ONE MODEL SERIES HAVE BEEN DRIVING GALLERIES AND TUNNELS WITH TOTAL LENGTH OF 5000 M (30,000 M IN NEAR FUTURE); MACHINES EQUIPPED WITH ROLLER BITS HAVE PROVED CAPABLE OF WORKING BOTH IN HARD ROCK OF UP TO 3500 K LBS/SQ CM AND IN ROCK OF 300 K LBS/SQ CM PROVIDED ROCK IS STRONG ENOUGH FOR SETTING UP TIMBERING; ADVANTAGES AFFORDED BY THESE MACHINES INCLUDE - LOW DIA TOLERANCE, AND LOW TOOL CONSUMPTION. BRIEF DESCRIPTION IS ALSO GIVEN OF "UNICORN" SHIELD HEADING MACHINE FOR SOFT ROCK. (IN GERMAN)

74-69-04001 MECHANICAL SHIELD TUNNELING OF TWO-TRACK TUNNEL IN KINTETSU-NAMBA LINE PLANNING AND RECENT CONSTRUCTION PROGRESS (JAPAN)
MOTAI, T.
JOURNAL OF JAPANESE SOCIETY CIVIL ENGRS, (54) NO 4, 10-16, APR. 1969. 1451 METERS OF THE LINE WAS DRIVEN BY 10 METER DIA MECHANICAL CLOSED-FACE TUNNEL SHIELDS WITH ANGLED CUTTING EDGE AND CUTTER HEAD. REINFORCED CONCRETE BLOCK SEGMENT WAS DEVELOPED TO INCREASE SPEED OF EXCAVATION TO 12 M/DAY. (IN JAPANESE)

74-70-03001 DESIGN AND DEVELOPMENT OF A ROCK TUNNELING MACHINE (MOLE ENGLAND SIR-ROBT-MCALPINE GREENSIDE)
PIRRIE, N. D. & SIR ROBERT MCALPINE AND SONS
TUNNELS AND TUNNELING, (2) NO 2, 98-103, MAR. 1970. SIR ROBT MCALPINE AND SONS BUILT TWO SOFT GROUND TUNNELING MACHINES IN 1957, FOUR MORE FOR THE NEW VICTORIA LINE IN LONDONS SUBWAY SYSTEM AND TWO FOR THE TORONTO SUBWAY IN CANADA. STARTING WITH A GREENSIDE HEADING MACHINE USED FOR ARCHED HEADINGS IN COAL THEY PRODUCED A NEW MACHINE TO CUT CIRCULAR TUNNELS IN ROCK WHICH IS MORE FLEXIBLE IN DIAMETER OF CUT AND REQUIRES LESS THRUST THAN PREVIOUS MOLES FOR OPERATING AGAINST ROCK. THE NEW MACHINE IS CALLED A SECOND GENERATION MACHINE.

FIELD 75 NEWS ITEMS

75-53-07001 MINING MACHINE BORES SEWER TUNNEL (COAL-MINING-MACHINE SHALE ROOF-BOLTS CUTTER-HEAD CONVEYOR)
ENGINEERING NEWS-RECORD, (151) 23, JULY 30, 1953. A BRIEF ACCOUNT OF APPLICATION OF A CONTINUOUS MINING MACHINE TO DIG A 12-FT-DIAM SEWER TUNNEL THROUGH MEDIUM-HARD SHALE IN EUCLID, OHIO. MUCK IS REMOVED, CONVEYED TO MINE CARS, AND BY RAIL TO SHAFT HOIST. IT WAS USED AFTER RESIDENTS COMPLAINTS STOPPED ROUTINE DRILLING-BLASTING AND MUCKING EXCAVATION.

75-54-12001 NEW MACHINE SPEEDS LARGE BORE TUNNELING (JUMBO CUTTER-HEAD HYDRAULIC-JACKS CONVEYORS)
ENGINEERING NEWS-RECORD, (153) 24, DEC. 2, 1954. A TUNNELING MACHINE FOR LARGE BORE TUNNELS IS GETTING ITS FIRST TRIAL AT OAHE DAM NEAR PIERRE, S.D., WHERE A $300,000 JUMBO RIG IS CHEWING OUT THE FIRST SIX TUNNELS FOR THE DAM'S OUTLET. THE PROJECT AND MACHINE MODE OF OPERATION AND DETAILS ARE DESCRIBED BRIEFLY IN THIS ARTICLE.

75-55-01001 MECHANICAL MOLE (TUNNELING-MACHINE LARGE-BORE-DRILLING CUTTER-HEAD CONTINUOUS-MINER)
ENGINEERING NEWS-RECORD, (154) 26, JAN. 13, 1955. A CONTINUOUS MINING MACHINE IS SETTING A NEW RECORD FOR LARGE BORE TUNNELING AT THE ARMY ENGINEERS, OAHE DAM NEAR PIERRE, S.D. THE MACHINE DRILLED 311 FT OF A 25-FT-DIAM TUNNEL AT AN AVERAGE RATE OF 2.1 FT ADVANCE PER HOUR. PRINCIPLES OF OPERATION AND USE OF THE MOLE ON THE PROJECT ARE OUTLINED.

75-55-02001 SOFT-ROCK TUNNELING AT 5 FT. PER HR. (ADVANCE CUTTERS MCKINLEY-HEAD)
WESTERN CONSTRUCTION, 15-17, FEB 1955. MITTRY HAD THE IDEA FOR THIS MOLE DESIGNED BY JAMES S. ROBBINS & ASSOCIATES AND FABRICATED BY CONTINENTAL FOUNDRY & MACHINE CO. THE CUTTING EQUIPMENT KNOWN AS A MCKINLEY HEAD USED IN MINING IS THE HEART OF THE MACHINE. THERE ARE TWO CONCENTRIC HEADS ONE OF WHICH ROTATES CLOCKWISE AND THE OTHER COUNTERCLOCKWISE. CUTTING IS DONE WITH KERF CUTTERS 10 IN. LONG AND 1 IN. THICK AND SHARPLY BEVELED ROLLERS BETWEEN THESE KERF CUTTERS WHICH CRUSH THE MATERIAL. DETAILS OF THE MACHINE AND ITS OPERATION ARE GIVEN. IT IS BEING USED TO BORE SIX PARALLEL TUNNELS AVERAGING 1,560 FT LONG WHICH ARE 85 FEET APART AND ARE BORED TO 26 FT 3 IN. AND 24 FT. 9 IN. DIAMETERS. INCLUDING MAINTENANCE TIME, AVERAGE RATE OF PROGRESS HAS BEEN SLIGHTLY OVER 3 FT. PER HR. THE BEST SPEED IS 5 FT. PER HR. WORK IS BEING DONE ON TWO 10 HR. SHIFTS. THESE TUNNELS ARE FOR OAHE DAM HYDROELECTRIC PROJECT FOR THE OMAHA DISTRICT CORPS OF ENGINEERS. THE 100 TON 72 FT LONG MACHINE IS CUTTING PIERRE SHALE.

75-55-02002 CORPS OF ENGINEERS: MITTRY HAS "REVERSED A TREND"
WESTERN CONSTRUCTION, 17, FEB 1955. COMPARISON OF THE BLASTING TECHNIQUE USED AT FORT PICK. GARRISON AND FORT RANDALL TUNNELS WITH THE MITTRY HOLE USED AT OAHE SHOW THAT SOFT-ROCK TUNNELING EQUIPMENT AND TECHNIQUE MAY IN THE FUTURE BE APPLIED TO HARD ROCK IF POWER REQUIREMENTS CAN BE MET TO OPERATE THE MACHINE AND CUTTING TEETH DEVELOPED TO WITHSTAND THE WEAR OF DIGGING HARDER ROCK.

75-55-11001 ROBBINS TUNNEL BORING MACHINE (ADVANCE CUTTERS SAFETY LINING HARD-ROCK MOLE)
CANADIAN MINING JOURNAL, 72-74, NOV 1955. A ROBBINS TUNNEL BORING MACHINE HAS DRIVEN A 25 FT 9 IN. CIRCULAR TUNNEL THROUGH SHALE AT A RATE OF 12 FT AN HR WITHOUT BENEFIT OF EXPLOSIVES. LOW COSTS AND INCREASED SAFETY ARE OTHER BENEFITS AT OAHE DAM DIVERSION TUNNELS IN SOUTH DAKOTA WHERE CONVENTIONAL METHODS WERE DISCARDED FOR THIS REVOLUTIONARY MACHINE. A 2 1/2 FOOT THICK REINFORCED CONCRETE LINING HAS TO BE APPLIED WITHIN 30 DAYS OF ORIGINAL ROCK EXPOSURE. BORING HEAD HAS 3 CENTRAL CUTTING ARMS ROTATING COUNTER CLOCKWISE AND SIX OUTER CUTTING ARMS ROTATING IN THE OPPOSITE DIRECTION. A SHIELD BEHIND THE OUTER CUTTING ELEMENTS CONFINES ROCK AND DUST CLOSE TO THE TUNNEL FACE. CUTTING IS DONE WITH KERF CUTTERS AND DISC SHAPED CUTTERS WHICH CRUSH THE ROCK BETWEEN THE KERFS. EXPERIMENTS ARE UNDERWAY TO SUBSTANTIATE A BELIEF THAT THE MACHINE CAN BE ADAPTED TO BORE HARD ABRASIVE ROCK LIKE GRANITE AND QUARTZ BY ELIMINATING THE FIXED KERF CUTTERS AND USING ONLY THE DISC CUTTERS. STUDIES HAVE INDICATED THAT ADVANCES OF 100 FT PER SHIFT ARE POSSIBLE UNDER GOOD ROCK AND OPERATING CONDITIONS.

75-56-09001 NEW METHOD: HORIZONTAL EARTH BORING (STEEL-PIPE BIT OIL-WELL-DRILLING SLURRY ROTATION JACKING)
GAS AGE, 19, SEPT 20, 1956. ARTICLE DESCRIBES METHOD USED BY CONSOLIDATED EDISON CO TO BORE HORIZONTAL HOLES AND EMPLACE PIPE IN ALL TYPES OF SOIL AND ROCK. BORINGS ARE PUMPED OUT IN A SLURRY AS THE PIPE WITH A BIT SIMILAR TO THOSE USED IN OIL WELL DRILLING IS ROTATED AND JACKED FORWARD.

75-57-04001 THE MOLE COMES THROUGH (MECHANICAL-MINER FLOOD-TUNNEL REVOLVING-CUTTER-HEAD)
ENGINEERING NEWS-RECORD, (158) 28, APR 18, 1957. NEWS ITEM OF THE HOLING THROUGH AND COMPLETION OF SIX 24 FT DIA FLOOD CONTROL TUNNELS BY A CONTINUOUS MECHANICAL MINER AT OAHE DAM, PIERRE S. DAK. OVERALL AVERAGE ADVANCE PER DAY WAS 50 FT COMPARED TO 24 FT BY CONVENTIONAL TUNNELING METHODS ON OTHER MO RIVER DAMS.

75-57-08001 HARD ROCK BORES (ENGLAND MOLE)
COAL AGE, 128-9, AUG. 1957. THE NATIONAL COAL BOARD OF ENGLAND HAS PRODUCED A PROTOTYPE MECHANICAL TUNNELING MACHINE WHICH CAN CUT AN 18 FT DIA TUNNEL THROUGH THE HARDEST SANDSTONE FOUND IN ENGLISH COAL MINES. THE NCB PLANS ON 200 MI OF TUNNEL ANNUALLY FOR THE NEXT 15 YEARS.

75-58-09001 TUNNELING MACHINE TACKLES HARD ROCK (MOLE CANADA)
ENGR NEWS-RECORD, (161) 39, SEPT. 4, 1958. AN 11 FT SEWER TUNNEL UNDER THE HUMBER RIVER IN TORONTO IS BEING DUG IN HARD SHALE AND LIMESTONE BY THE FOUNDATION COMPANY OF TORONTO USING A ROBBINS MOLE CALLED THE FOUNDATION HUMBER.

75-59-02001 BIGGEST TUNNELER GOES TO OAHE (MOLE ROTARY-CUTTING-HEAD TUNNEL-RIBS HOURLY-ADVANCE)
ENGINEERING NEWS-RECORD, (162) 26, FEB. 26, 1959. NEWS ITEM ON FACTORY TRIAL ASSEMBLY IN SEATTLE OF WORLD'S LARGEST MECHANICAL MOLE. WITH A 29 1/2 FT DIA ROTARY CUTTING HEAD, IT IS SCHEDULED TO DRILL SEVEN TUNNELS FROM 1000 TO 1300 FT LONG AT THE OAHE DAM PROJECT ON THE MO RIVER IN S.DAK. PRINCIPAL FEATURES OF THE MACHINE ARE DESCRIBED.

75-59-12001 CONTRACTOR UNVEILS NEW TUNNELER (MOLE TOREDO SLIP-FORM PUMPED-MUCK GARDNER)
ENGR NEWS-RECORD, (163) 43, DEC. 3, 1959. THE GARDNER ENGINEERING CORP HAVE DEVELOPED A NEW TYPE TUNNELING MACHINE WHICH DIGS A TUNNEL, PUMP OUT THE MUCK, PUMPS IN THE CONCRETE LINING CONTINUOUSLY. THE "TEREDO" USES A TOOTHED CHAIN SALVAGED FROM A TRENCHING MACHINE TO EXCAVATE. THE REAR OF THE SHIELD SERVES AS A SLIP FORM FOR THE CONCRETE LINER. GARDNER DESIGNED THE MOLE TO DIG A $490,000 STORM DRAIN - 10 FT IN DIAMETER 3500 FT LONG - FOR HOUSTON.

75-60-03001 TUNNEL BORING THROUGH HARDER ROCK (MOLE CONTINUOUS-BORER ROTARY-CUTTING-HEAD CONVEYORS ADVANCE-RATE)
ENGINEERING AND MINING JOURNAL, MAR 1960. THE ARTICLE DESCRIBES THE ADVANCES MADE IN PRESENT DAY CONTINUOUS BORER TUNNELING MACHINES BUILT BY JAMES S. ROBBINS AND ASSOCIATES OF SEATTLE AND FEATURES THEIR LATEST MODELS NO. 131 AND 351. MACHINE CHARACTERISTICS AND PERFORMANCE DATA ARE GIVEN IN A TABLE AND SEVERAL PHOTOGRAPHS AND SKETCHES ARE USED TO ILLUSTRATE THE DESCRIBED MACHINES. THE TYPES OF GEOLOGICAL FORMATIONS, TROUBLES ENCOUNTERED AND WORKING METHODS FOR SEVERAL TUNNEL DRIVING APPLICATIONS ARE RELATED. DEVELOPMENTS LEADING TO HARDER ROCK BORING MACHINES ARE CITED AND ADVANTAGES AND DISADVANTAGES OF CONTINUOUS BORING ARE LISTED.

75-60-04001 CONTRACTOR BUILDS LOW-COST-TUNNELER (ADVANCE CUTTERS COST LINING MOLE)
ENGINEERING NEWS-RECORD, (164) 42-43, APR 28, 1960. LOREN SCOTT, A TUNNEL ENGINEER, DESIGNED A 2,500 LB. MACHINE FOR A CHICAGO CONTRACTOR WHO BUILT IT IN HIS SHOP FOR $19,000. THE TUNNELER CALLED THE "MINER" SHAVES MATERIAL OFF A VERTICAL CUTTING FACE ONTO A BELT CONVEYOR WHICH LOADS CARS. THE CUTTER HEAD HAS FOUR SPOKES AND IS JACKED AHEAD BY TWO HYDRAULIC RAMS ATTACHED TO THE CENTER TUBE AND SLIDING COLLAR WHICH FORCE THE CUTTING WHEEL AND CENTER TUBE AHEAD. CUTTING WHEELS FROM 7 FT TO 11 FT IN DIAMETER CAN BE USED. WORKING 3 SHIFTS A DAY THE MINER AVERAGED 63 FT OF 11 FT DIA BORE A DAY 50 FT BELOW GRADE. THE $1.2 MILLION CONTRACT CALLS FOR 9,000 FT OF TUNNEL TO SERVE AS A MAIN DRAIN FOR THE SEATTLE ROUTE EXPRESSWAY. THERE ARE FOUR SIZES RANGING FROM 8 FT 7 IN BY 7 FT 9 IN DOWN TO 4 FT 6 IN BY 4 FT. HAND MINING IS DONE DIRECTLY BEHIND THE MACHINE TO CHANGE THE CIRCULAR CROSS SECTIONS TO THE REQUIRED HORESHOE DESIGN. WOOD LAGGING AND STEEL RIBS ARE PLACED UNTIL A REINFORCED CONCRETE LINER IS POURED.

75-60-06001 LASER BEAM GUIDANCE SYSTEM MAKES SUCCESSFUL DEBUT IN MACHINE TUNNELLING PROJECT (GAS-LASER MOLES RECORDS)
MINING ENGINEERING, (18) N 6, 62, JUNE 1966. THE FIRST PRACTICAL AND SUCCESSFUL USE OF A LASER-BEAM GUIDANCE SYSTEM FOR A TUNNEL MACHINE DRILLING TO A REMOTE TARGET HAS BEEN ACHIEVED AT THE BUREAU OF RECLAMATION'S NAVAJO INDIAN IRRIGATION PROJECT. THE MACHINE, HUGHES TOOL "BETTI I", DRILLED A 10,000 FT LONG TUNNEL IN EIGHT MONTHS AND 18 DAYS TO WITHIN 5/8 IN OF ESTABLISHED LINE AND GRADE. THE GUIDING ELECTRONIC SYSTEM FEATURES A GAS LASER WHOSE BEAM IS AIMED AT TWO LIGHT-SENSITIVE TARGETS ON THE BORING MACHINE. THE 64 FT LONG, 280 TON UNIT AVERAGED 1160 FT PER MONTH BORING AS MUCH AS 171 FT A DAY AND 662 FT A WEEK. IT PERFORMED IN A SANDSTONE FORMATION CONTAINING SHALE STRINGERS AT VARIOUS INTERVALS. EXERTING 1.4 MILLION LBS OF THRUST IT WAS HELD IN PLACE BY EIGHT HYDRAULIC JACK PADS, EXPANDED AGAINST THE SIDES OF THE TUNNEL. THE MACHINE CUT AN AVERAGE OF 3,000 TONS OF ROCK DAILY. IN ADDITION TO THE FASTER DRILLING, THE "MACHINE TUNNEL" ALLOWED ENGINEERS TO ESTIMATE ACCURATELY THE AMOUNT OF CONCRETE REQUIRED TO LINE THE TUNNEL WALLS, 3 1/2 TIMES LESS CONCRETE WAS NEEDED. THE TUNNEL IS ONE OF SIX MAKING UP PART OF A 152 MILE LONG WATER DIVERSION SYSTEM. THE PROJECT WILL DIVERT ANNUALLY 580,000 ACRE-FT OF WATER TO IRRIGATE MORE THAN 110,000 ACRES.

75-61-04001 A HYBRID MOLE WRAPS UP OAHE TUNNEL (MINING-MACHINE SHALE HYDRAULIC-RAMS CUTTERHEADS-CONVEYOR RECORD)
ENGINEERING NEWS-RECORD, (166) 56, APR 13, 1961. THE LAST OF SEVEN POWER TUNNELS AT THE CORPS OF ENGINEER'S BIG

OAHE DAM ON THE MISSOURI RIVER HAS BEEN HOLED THROUGH BY THE PRAIRIE MINER, THE FOURTH GENERATION MINING MACHINE USED IN TUNNELING AT THE DAM. THE MOLE MINED THE DOWNSTREAM 2,200 FEET OF 29 FEET 6 INCH TUNNELS THROUGH PIERRE SHALE, THE SAME SHALE THAT CAUSED TROUBLE ON THE POWERHOUSE SUBSTRUCTURES. THE SHALE DETERIORATES ALMOST IMMEDIATELY ON EXPOSURE TO AIR. THE PRAIRIE MINER IS 64 FEET LONG, WEIGHS ABOUT 175 TONS, AND COST $550,000. CONSTRUCTION FEATURES, OPERATING PRINCIPLES, AND TUNNEL SUPPORT AND LINING FEATURES ARE DESCRIBED. THE BEST DAY'S MINING WAS 156 FEET IN 3 EIGHT HOUR SHIFTS WITH AN AVERAGE DAILY ADVANCE OF 93 FEET ON THE FINAL TUNNEL. A 24 MAN CREW OPERATED THE MACHINE DURING EACH SHIFT WITH AN ADDITIONAL 7 MEN SUPPLYING SUPPORT MATERIALS. PREDECESSOR MINING MACHINES ARE BRIEFLY DESCRIBED.

75-61-05001 RAPID TUNNELING IN LONDON CLAY (SHIELD MOLE LININGS VICTORIA-LINE EXPERIMENT)
MINE AND QUARRY ENGR, (27) NO 5, 218-23, MAY 1961. A ROTARY TYPE 'DRUM DIGGER' SHIELD WAS USED TO BORE 14 FT DIA TUNNEL AS AN EXPERIMENTAL JOB TO DETERMINE WHETHER THIS TYPE COULD BE USED FOR THE 11.5 MILE VICTORIA LINE TUBES. FLEXIBLY JOINTED CAST-IRON LINING WITHOUT BOLTS AND WITH SHALLOWER THAN USUAL FLANGES WERE USED.

75-61-06001 THE FUTURE OF CONVENTIONAL MINING EQUIPMENT (CONTINUOUS-MINERS)
MATHESON, J. & ISLAND CREEK COAL CO
MINING CONGRESS JOURNAL, 53-56, JUNE 1961. IN A FULLY DEVELOPED MINE, THE CONTINUOUS MINER PRODUCES 20-25 PERCENT MORE TONNAGE THAN CONVENTIONAL EQUIPMENT. FOR DEVELOPMENT PURPOSES CONVENTIONAL EQUIPMENT IS BETTER. MINING COST IS BASED ON TONS PER PAYROLL MAN.

75-62-06001 HARD ROCK TUNNEL BORING MOVES AHEAD (ADVANCE CUTTERS THRUST TORQUE MUCK SUPPORT LINING)
ENGINEERING AND MINING JOURNAL, (163) NO 6, 172-173, JUNE 1962. JAMES S. ROBBINS HAS DEVELOPED TUNNELING MACHINES FOR EXTREMELY HARD ROCK, FIXED CUTTERS HAVE BEEN REPLACED BY DISK CUTTERS, TORQUE AND FORWARD THRUST HAVE BEEN BOOSTED AND SELF-PROPULSION UNITS HAVE BEEN ADDED. A TABLE WHICH IS A CONTINUATION OF TABLE 1 PAGE 87 OF ENGINEERING & MINING JOURNAL FOR MARCH 1960 GIVES THE MACHINE PERFORMANCE AND CHARACTERISTICS FOR UNITS NO. 8, 9, 10 AND 11. BESIDES RAPID TUNNEL ADVANCE OTHER ADVANTAGES ARE: ROUND, SMOOTH, UNSHATTERED OPENINGS ARE INHERENTTY STRONGER, OVERBREAK IS ELIMINATED, SMALLER LABOR CREWS ARE NEEDED, AND MORE UNIFORMLY BROKEN ROCK PERMITS BELT HAULAGE IF DESIRED.

75-62-07001 SOFT ROCK TUNNELING AT MO RIVER DAMS (EXCAVATION TUNNELING-MACHINES MOLES MINING JUMBO)
UNDERWOOD, L. B. & U.S. CORPS OF ENGRS MO RIV DIV
CIVIL ENGINEERING, 40, JULY 1962. THIS PAPER WAS ONE OF FOUR PRESENTATIONS AT A JOINT SESSION ON TUNNELING WITH MINING MACHINES AT THE ASCE WATER RES ENGR CONF HELD IN OMAHA IN MAY. THE PAPER OUTLINES THE TUNNELING ON FOUR MO RIVER DAMSITE PROJECTS, GEOLOGICAL FORMATIONS ENCOUNTERED, METHODS OF MINING, AND EQUIPMENT USED ON EACH PROJECT. FEATURED IS THE MITTRY MOLE USED IN ROUGH BORING EIGHT MI OF TUNNELS WITH BORES OF 23 FT TO 29.5 FT DIA. DISTINGUISHING FEATURES AND WORK PERFORMED BY EACH VERSION OF TUNNELING MACHINE ARE BRIEFLY DESCRIBED.

75-62-07002 HUMBER RIVER TUNNEL AT TORONTO (CANADA MOLE MECHANICAL-TUNNELER)
WHITE, G. A. & FOUNDATION CO OF CAN TORONTO
CIVIL ENGR, (32) 43, JULY 1962. A ROBBINS MOLE BORED A 10FT 9IN DIA TUNNEL UNDER THE HUMBER RIVER. AT AN AVERAGE RATE OF 5FT/HR.

75-62-07003 SOFT GROUND TUNNELING IN DETROIT (MOLE SHIELD SEWER)
MCINTYRE, K. C. & MICH SEWER CONSTR CO
CIVIL ENGR, (32) 44, JULY 1962. MINING MACHINES HAVE BEEN USED IN DETROIT AREA SINCE MID-TWENTIES. PRESENTLY A SHIELD IS OPERATING AT A RATE OF 60 FT/DAY AND HAS COMPLETED HALF OF A 27,000 FT CONTRACT.

75-62-07004 TUNNELING SILT AND SAND AT OMAHA (SHIELD MOLE SEWER)
ROBERTS, H. H. + SMITH, J. H. & NANCE ENGR OMAHA
CIVIL ENGR, (32) 45, JULY 1962. A 9 FT DIA RELIEF SEWER 7500 FT LONG HAS BEEN DRIVEN UNDER CITY STREETS BY A MINING MACHINE. WORK WAS DONE UNDER 4 TO 14 PSI AIR PRESSURE.

75-62-11001 MINING MACHINE COULD BORE ROCK (PILOT CUTTER THRUST ANCHOR)
ENGINEERING NEWS-RECORD, (169) 58, NOV 29, 1962. LAWRENCE MACHINE & MANUFACTURING CO OF SEATTLE CLAIMS THEIR COAL-MINING MACHINE IS SUITABLE FOR HARD ROCK TUNNELING. THE MACHINE PULLS ITSELF AGAINST THE HEADING WITH TWO PILOT DRILL HEADS THAT ANCHOR THEMSELVES IN PLACE AFTER DRILLING INTO THE FACE. A PAIR OF ROTATING CUTTERHEADS EXCAVATE MATERIAL AS THE PILOT ANCHORS PROVIDE A BEARING. IN ALASKAN TESTS, 15 TONS OF COAL A MINUTE WERE DELIVERED TO A TRAILING CONVEYOR.

75-63-01001 MANGLA'S MOLE'S A MONSTER (MECHANICAL-MINER BUCKET-LOADER CUTTERS)
ENGINEERING NEWS-RECORD, (170) 17, JAN 10, 1963. THE WORLDS LARGEST MECHANICAL MOLE IS ON ITS WAY TO PAKISTAN TO BURROW DIVERSION AND POWER TUNNELS AT THE MANGLA DAM SITE. THE BIG TUNNELER (MAXIMUM BORING DIAMETER 36 FEET 8 INCHES) WEIGHTS 300 TONS AND IS OVER 50 FEET LONG. FEATURES OF THE MOLE ARE DESCRIBED. IT CAN HANDLE VERY SOFT AND VERY HARD HEADINGS AND WILL INSTALL RIBSTEEL MECHANICALLY. IT WILL BORE FIVE 32 FT. DIAMETER TUNNELS 1800 FEET THROUGH SANDSTONE AND LIMESTONE.

75-63-10001 MOLES TO AUDITION FOR SF SUBWAY (ADVANCE PRESSURE MUCK LINING)
ENGINEERING NEWS-RECORD, (171) 18, OCT 31, 1963. BARTD ENGINEERS IN AN EFFORT TO REDUCE COSTS ON UNDERGROUND PORTIONS OF THE 75 MILE RAIL RAPID TRANSIT SYSTEMS WILL TEST A JAMES S. ROBBINS MACHINE AND ONE BY TUNNEL RESEARCH ASSOCIATES WHOSE DETAILS HAVE NOT BEEN RELEASED. THE ROBBINS MACHINE IS SIMILAR TO ONE MADE FOR THE PARIS METRO SYSTEM. THE CUTTER HEAD WILL BE UNDER PRESSURE BUT NO MEN WILL HAVE TO WORK UNDER AIR. MUCK WILL BE REMOVED THROUGH PRESSURIZED LOCKS. HYDRAULIC RAMS PUSHING AGAINST THE LINING WILL MOVE THE MACHINE FORWARD. LINING WILL BE INSTALLED IN SHORT SECTIONS BEHIND THE CUTTER HEAD AS THE MACHINE MOVES ALONG.

75-63-12001 80 INCH TUNNELING MACHINES TO DRIVE THROUGH SANDSTONE (ADVANCE COST MOLE)
MINING ENGINEERING, 16, DEC. 1963. TWO HUGHES TOOL CO TUNNELING MACHINES 32 FT. LONG ARE DRIVING AN 80 INCH TUNNEL EIGHT MILES LONG THRU LOCONINO SANDSTONE AT DEPTHS OF 450 TO 750 FT IN ARIZONA. THE TWO MACHINES WILL DRILL FROM BOTH ENDS SIMULTANEOUSLY. THEIR HEADS REVOLVE AT 15 RPM AND EACH MACHINE WILL ADVANCE AT A RATE OF 7 TO 10 FT. PER HR.

75-64-01001 SONIC PILEDRIVER TAKES TEST AS FAST SOFT-GROUND TUNNELER (SUB-AQUEOUS-TUNNELING PENETRATION HORIZONTAL-CONDUITS)
ENGINEERING NEWS-RECORD, (172) 16, JAN 9, 1964. THE ARTICLE REPORTS THE TESTING OF A BODINE SONIC PILE DRIVER LAST WEEK THAT VIBRATED A HORIZONTAL 12-3/4 INCH O.D. PIPE 58 FEET INTO A NATURAL BANK OF SAND AND GRAVEL IN LESS THAN THREE MINUTES. SET-UP FOR THE TEST WAS MAKESHIFT AND MUCH OF THE TIME WAS SPENT IN EFFORTS OTHER THAN DRIVING WITH THE DRIVING TAKING ONLY A NET 128 SECONDS. IN A SECOND DRIVE OF 58 FEET IT TOOK ONLY 72 SECONDS. FURTHER TESTING IS CONTEMPLATED USING UP TO 36-48 INCH DIAMETER TO GET POINTS ON A CURVE FOR EXTRAPOLATION TO CHECK PRACTICABILITY OF 20 FEET DIAMETER TUNNEL LINING PLACED BY SONIC DRIVING COMBINED WITH HYDRAULIC PULLING. FEATURES OF THE TESTS AND EQUIPMENT ARE DESCRIBED.

75-64-03001 MACHINE WILL BORE HARD ROCK TUNNEL (ALKIRK-HARD-ROCK TUNNELER PILOT-PULL-PRINCIPLE HYDRAULIC-SYSTEM MOLES)
ENGINEERING NEWS-RECORD, (172) 24-25, MAR 12, 1964. A NEW HARDROCK TUNNEL MACHINE CALLED THE ALKIRK HARD ROCK TUNNELER WILL BE USED TO BORE A TUNNEL UNDER NEW YORK HARBOR FOR PERINI CORP AND MORRISON-KNUDSON. DESIGNED AND BUILT BY LAWRENCE MACHINE AND MFG. CO., THE MACHINE WILL BORE THROUGH FELDSPAR AND GARNET WHICH HAS A HARDNESS OF ABOUT 7 ON

A GEOLOGIST'S SCALE. THE MACHINE WILL OPERATE ON THE ALKIRK PILOT-PULL PRINCIPLE WHICH PULLS THE MOLE INSTEAD OF PUSHING. THE MACHINE WILL COST AS MUCH AS BLASTING EXPENSES WOULD HAVE COST. THE HYDRAULIC SYSTEM ELIMINATES CLUTCHES, GEAR TRAINS, AND PERMITS DELICATE THRUST CONTROL.

75-64-07001 TUNNEL BORER AND SHAFT DRILL TEAMED AT AGC'S HYDRAULIC MINING OPERATION (ADVANCE CUTTERS GILSONITE MOLE IRON-ORE SHAFT GUIDANCE)
ENGINEERING AND MINING JOURNAL, (165) N 7, 69-70, JULY 1964. THE AMERICAN GILSONITE CO MINES GILSONITE, AN ASPHALTIC SUBSTANCE WHICH DOES NOT BURN IN THE SOLID STATE BUT HAS A HIGHLY EXPLOSIVE DUST. DEVELOPMENT HAS BEEN CONFINED TO HYDRAULIC JET CUTTING WITH OCCASIONAL WORK WITH PAVING BREAKERS OR PICK AND SHOVEL. TO MEET SAFETY REGULATIONS, ESCAPEWAYS MUST BE PUT DOWN EVERY 1000 TO 1500 FT. CONVENTIONAL SINKING METHODS WERE SLOW SO A 62 IN. DIA. SHAFT DRILL WAS DESIGNED BY AGC AND HUGH B. WILLIAMS CO AND BUILT BY HUGHES TOOL CO. THIS MACHINE BORES TO A DEPTH OF 900 FT. IN TWO OR THREE WEEKS. THREE SUCH HOLES SIMULATE THE STANDARD THREE-COMPARTMENT PRODUCTION SHAFT WHICH REQUIRED SEVERAL MONTHS TO COMPLETE. A DESCRIPTION OF THE DRILL AND ITS OPERATION IS GIVEN. THE SLOW RATE AT WHICH COLLECTION DRIFTS COULD BE DRIVEN LED TO USING A 30 FT LONG SEVEN TON MACHINE BORING A 54 IN. HOLE WITH A CLUSTER OF CUTTER BITS WHICH OPERATES AS A SELF-ADVANCING UNIT WHICH POSSIBLY CAN BE TV DIRECTED. ADVANCE IS AT THE RATE OF 5 FT. PER HR. IN ROCK AND UP TO 20 FT. PER HR. IN GILSONITE. A SIMILAR 80 IN. DIAMETER MACHINE IS BORING AN 8 MILE LONG WATER TUNNEL IN ARIZONA. ANOTHER TUNNELING MACHINE IS BEING USED FOR IRON MINING IN MICHIGAN BY THE HANNA MINING CO.

75-64-07002 BORE DUG IN WET SOIL FOLLOWS TRICKY PATH (ADVANCE MUCKING PRESSURE STABILIZATION LINING MOLE.)
CONSTRUCTION METHODS & EQUIPMENT, 140-146, JULY 1964. 447 FT. OF THE HOUSTON $1.7 MILLION STORM SEWER WAS INSTALLED BY OPEN-CUT. THE REMAINING 6,500 FT. WAS BORED WITH A WHEEL TYPE MACHINE HAVING AN 11 1/2 FT. DIA RIM-DRIVE CUTTING WHEEL AND TEETH MOUNTED ON SIX RADIAL ARMS. 14 SIXTY FT. DEEP WELL PUMPS 75 TO 125 FT. APART PUMPED FOR 3 MONTHS BEFORE THE TUNNEL CREWS HIT THESE SECTIONS TO REDUCE THE WATER TABLE FROM 16 FT BELOW THE SURFACE TO INVERT LEVEL 40 FT. DOWN OR LOWER. ALONG TWO MAJOR TUNNEL SECTIONS, ABOUT HALF ITS LENGTH, MINING EQUIPMENT MFG. CO. AIR LOCKS SEALED THE ENDS AND TUNNELING WAS UNDER 5 TO 10 PSI AIR PRESSURE. IN ONE EXTREMELY TROUBLESOME 15 FT. SECTION A SOLUTION OF ONE PART SODIUM SILICATE AND TWO PARTS SODIUM CHLORIDE WAS INJECTED IN TEN 1 1/2 IN. DIA HOLES TO SUFFICIENTLY SOLIDIFY THE MATERIAL FOR EXCAVATION. A 18 IN. THICK REINFORCED CONCRETE LINING WAS POURED IN 45 FT SECTIONS USING A FULL-CIRCLE COLLAPSIBLE DIXIE FORM & STEEL CO. FORM. ACCESS SHAFTS WERE DRILLED FROM THE SURFACE GIVING THE CONCRETE A 30 FT. BAFFLED DROP TO THE TUNNEL. AVERAGE ADVANCE IN TUNNEL EXCAVATING WITH 50 MEN WORKING 3 SHIFTS IS 20 FT. PER DAY. THE MACHINE KNOWN AS A DETROIT TYPE WAS BUILT BY MID-STATES TOOL & DIE CO. MUCKING IS DONE WITH TWO ELECTRICALLY PROPELLED TRAINS OF 16 TO 20 CARS OF 2 YD. CAPACITY. GUIDANCE HAD TO BE HELD WITHIN A 15 FT. WIDE PATH.

75-64-11001 GERMAN TUNNELING MACHINE RELIEVES TRAFFIC CONGESTION (ADVANCE CUTTER PRESSURE MUCKING GUIDANCE LINING MOLE)
CANADIAN MINING JOURNAL, 76-77, NOV. 1964. A DEMAG TUNNELING MACHINE IS EXCAVATING A 5.75 METER DIA VEHICULAR TUNNEL IN GERMANY, 30 METERS BELOW THE SURFACE. THE MACHINES FRONT PORTION IS DESIGNED AS A PRESSURE CHAMBER FOR A MAX. OF 2.5 ATMOSPHERES. THERE ARE NINE CUTTING MOTORS IN STAR FORMATION. LARGE BOULDERS HAVE TO BE BROKEN UP AT THE FACE OR REMOVED. A CRUSHER BREAKS ROCK TO 80 MILLIMETER SIZE AND THIS MUCK IS EJECTED FROM THE PRESSURE CHAMBER THRU A PNEUMATIC STOWING MACHINE. LINING PANELS ARE INSTALLED WITH AN ERECTING MACHINE IN THE TAIL OF THE MACHINE. IN SOFT GROUND ADVANCE PER 24 HOURS IS 15 METERS SUBJECT TO EFFECTING LINING WORK. IN FIRMER MATERIAL HEADWAY MADE IN 24 HRS. IS ABOUT 8 METERS. USING CONVENTIONAL MANUAL TUNNELING METHODS, THE AVERAGE DAILY ADVANCE WAS 1.5 TO 1.7 METERS. AN APPLIANCE BASED ON THE GYROSCOPIC COMPASS GUIDES THE MACHINE.

75-65-01001 FOR LONDON TRANSPORT - THE DEEP TUBE (GEOLOGY SHIELD CEMENTATION JACKING DRUM-DIGGER PNEUMATIC-SPADES)
ENGINEERING, 42-46, JAN 8, 1965. THE VICTORIA SUBWAY LINE RUNS 69 FT BELOW THE SURFACE OF LONDON IN A TUNNEL 13 FT 1 IN TO 14 FT DIA WITH STATION TUNNELS 21 FT 2 1/2 IN. THE STRUCTURE IS BLUE CLAY WITH OCCASIONAL SEAMS OF WATER-BEARING GRAVEL. A SINGLE SHOT CHEMICAL INJECTION PROCESS KNOWN AS TDM IS USED BY THE CEMENTATION CO TO SEAL THE WATER BEARING GRAVEL. THE RUNNING TUNNEL IS BORED WITH A DRUM DIGGER HAVING A NON-ROTATIVE CYLINDRICAL SHIELD WITH A LEADING CUTTING EDGE WITHIN WHICH ANOTHER DRUM WITH FRONT CUTTERS IS ROTATED AT UP TO 4 RPM UNDER HYDRAULIC POWER. AS THE CUTTERS ROTATE THE SHIELD IS HYDRAULIALY FORCED FORWARD. EXCAVATED MATERIAL IS STORED IN ONE CAR AND SHUTTLED BY ANOTHER TO THE SHAFT. GREATHEAD SHIELDS ARE USED FOR THE STATION TUNNELS. AS THIS SHIELD IS FORCED FORWARD THE CLAY IS MANUALLY GOUGED OUT WITH PNEUMATIC SPADES. LINING IS 60 PERCENT UNBOLTED CONCRETE BLOCK, THE REMAINDER IS CAST IRON SEGMENTS. FORMERLY THE LINING WAS GROUTED IN PLACE. NOW BY JACKING IN PLACE AGAINST THE CLAY, GROUTING IS ELIMINATED.

75-65-02001 MOLE INVADES NEW MEXICO (MUCK CRUSHER SLURRY LINING CUTTERS MAINTENANCE)
WESTERN CONSTRUCTION, 50-54, FEB 1965. A JAMES S. ROBBINS MOLE IS BORING THE 11 FT. 10 IN. TO 13 FT. 3 IN. DIA. WATER DIVERSION TUNNEL 12.7 MILES LONG FOR THE SAN JUAN-CHAMA PROJECT IN NORTHERN NEW MEXICO. ON THIS $13,791,000 PROJECT A GAS ANALYZER PROBES AHEAD. MUCKING IS DONE BY DUMPING IT INTO A CRUSHER AND FROM THERE INTO A PUG-MILL FROM WHICH IT IS PUMPED THRU 6 IN. PIPE TO SLURRY PONDS SOUTH OF THE TUNNEL. MORAN ENGINEERING BUILT THIS MUCK SYSTEM AS WELL AS PUMP CONCRETING SYSTEM TO PLACE THE 8 IN. THICK LINING. WORK IS AT A 3 SHIFT SCHEDULE WITH STOPS AT 300 FT. TO 1,000 FT. TO REPLACE CUTTERS AND TO PROVIDE ROUTINE MAINTENANCE.

75-65-03001 USBR TUNNELS UNDER THE CONTINENTAL DIVIDE (BORING-MACHINE MOLE)
CIVIL ENGINEERING, ASCE, 83, MAR 1965. FIRST OPERATION OF A 76 TON BORING MACHINE OR MOLE WAS SATISFACTORY IN CURRENT TESTS AT THE BUREAU OF RECLAMATION'S 12.7 MILE AZOTEA TUNNEL BENEATH THE CONTINENTAL DIVIDE IN THE COLORADO RIVER BASIN, SOUTHERN COLORADO. IN TEST RUNS THE MACHINE ADVANCED THROUGH WEATHERED MUDSTONE AT THE OUTLET PORTAL OF THE TUNNEL (11 FEET FINISHED DIAMETER) AT A RATE OF 7 TO 8 FEET PER HOUR. THE ARTICLE PRIMARILY DESCRIBES THE WATER DIVERSION PROJECT BUT INCLUDES A PICTURE AND DESCRIPTION OF CONSTRUCTION AND OPERATION OF THE MOLE.

75-65-04001 MOLE OUT, MEN IN (HARDROCK BORING-MACHINE TUNNELERS DRILL-SHOOT-MUCK)
ENGINEERING NEWS-RECORD, (174) 31, APR 15, 1965. THE HARDROCK BORING MACHINE, A 71 TON MOLE, FAILED TO PULL ITS WAY THROUGH NEARLY 5 MILES OF SOLID ROCK SOME 936 FEET UNDER NEW YORK HARBOR AND WAS PULLED OFF THE JOB. AFTER NEARLY A YEAR ON THE JOB, THE MACHINE HAD BORED LESS THAN 300 FEET OF THE 12 FOOT DIAMETER WATER TUNNEL BETWEEN BROOKLYN AND STATEN ISLAND. IT WAS DISMANTLED AFTER NUMEROUS REPAIRS HAD FAILED TO REMOVE THE BUGS FROM ITS OPERATION AND WAS SENT BACK TO ITS MANUFACTURER FOR FURTHER TESTING IN OREGON TO IRON OUT ITS DIFFICULTIES. THE REMAINDER OF THE TUNNELING WILL BE COMPLETED BY THE DRILL SHOOT AND MUCK METHOD.

75-65-05001 U.S. MADE MACHINE SPEEDS TOKYO TUNNEL (ADVANCE COST LINING MUCKING CUTTERS GUIDANCE)
CONSTRUCTION METHODS AND EQUIPMENT, 82-84, MAY 1965. A MEMCO MOLE IS BORING AN 11 FT DIA SEWER TUNNEL THRU STICKY SILT AT AVERAGE RATES OF 67 FT. PER 20 HR. DAY ON THE 2,000 FT LONG PROJECT. IN TESTS THE 150,000 MACHINE CUT THRU SILT AT 40 IN. PER MIN. BUT CURVES AND LINER ERECTION LIMIT THE SHIELDS POTENTIAL. PREVIOUS HAND MINING AVERAGED LESS THAN 4 FT. PER 10 HR DAY. THE STEEL HOOD OF THE 11 FT DIA SHIELD HAS A 6 IN. WIDE SPECIALLY TREATED CUTTING EDGE THAT PROJECTS OVER AND OUTWARD FROM THE CUTTING WHEEL. SHIELD ADVANCE IS WITH TEN 150 TON CAPACITY ROGERS HYDRAULIC JACKS. THE CUTTING WHEEL HAS BUCKETS WHICH DUMP THE MUCK ON A 40 FT LONG CONVEYOR FEEDING 2 1/4 YD CAPACITY CARS PULLED BY BATTERY POWERED LOCOMOTIVES. AN ERECTOR ARM POSITIONS SIX PIECE 30 IN. WIDE LINING SEGMENTS INSIDE THE TAIL SECTION OF THE SHIELD. TRAVEL IS CONTROLLED BY VARYING THE PRESSURE ON THE 10 JACKS AND WITH THREE MECHANICALLY OPERATED STEEL BLOCKS.

75-65-05002 ROCK MOLE MAKES 200 FEET A DAY (TUNNELING-MACHINE CONCRETE-LINED CONVEYOR-SYSTEM MUCK-TRAIN)
ENGINEERING NEWS-RECORD, (174) 30, MAY 13, 1965. A MECHANICAL TUNNELING MACHINE IS BORING A 13 FEET 3 INCH DIAMETER TUNNEL THROUGH THE SHALE OF NEW MEXICO'S SAN JUAN MOUNTAINS AT RATES UP TO 204.5 FEET PER 3 SHIFT DAY. GETTING THE MUCK OUT AND STEEL RING BEAMS IN PLACE AT THE HEADING IS A FORMIDABLE TASK. THE 12.8 MILE LONG AZOTEA

TUNNEL IS EXPECTED TO BE COMPLETED IN THE FALL OF 1967, 2 YEARS AHEAD OF THE CONTRACT DEADLINE. MUCKING IS BY MEANS OF A CONVEYOR BELT ON THE MOLE FEEDING ONTO A 250 FOOT TRAILING CONVEYOR THAT LOADS MUCK TRAINS. TWO TRAINS ARE USED EACH WITH SEVEN 5 CU. YARD CARS, WITH PLANS OF GOING TO 10 OR 12 CAR TRAINS SOON. THE PROJECT WORKING CONDITIONS AND PROGRESS OF THE JOB ARE DESCRIBED.

75-65-05003 ROCK MOLES INFEST SAN JUAN MOUNTAINS (NAVAJO-PROJECT BLANCO-TUNNEL AZEOTEA-TUNNEL)
ENGR NEWS-RECORD, (174) 23, MAY 20, 1965. A BIG MOLE IS ABOUT TO START BORING A 20 FT DIA 2 MILE LONG TUNNEL ON THE U.S. BUREAU OF RECLAMATION'S NAVAJO INDIAN PROJECT ANOTHER MOLE IS DRIVING THE 12.8 MILE LONG 13 1/4 FT DIA AZEOTEA TUNNEL AT 200 FT/DAY. THE BLANCO TUNNEL CONTRACTORS HAVE NOT DECIDED YET BUT PROBABLY WILL USE A MOLE FOR THE 8 1/2 MILE TUNNEL WHICH RUNS THROUGH THE SAME KIND OF SHALE AND SANDSTONE THAT IS IN THE AZEOTEA TUNNEL.

75-65-07001 REMOTE CONTROL MINING (AUTOMATION SAFETY SUPPORTS)
COLLIERY ENGINEER, (42) NO. 497, 268-273, JULY, 1965. THE COAL MINE AT BEVERCOTES, NOTTINGHAMSHIRE IS THE WORLD'S FIRST COMPLETELY AUTOMATED MINE. COMPLETE INFORMATION IS SUPPLIED CONTINUOUSLY TO A CENTRAL POINT OF ALL PARTS OF THE MINE SO THAT THE NECESSARY ACTION CAN BE TAKEN TO MAINTAIN PRODUCTION. MEN ARE NOT USED AT THE COAL FACE. IN THE ROOF SYSTEM THE ROOF ABOVE THE FACE IS SUPPORTED BY MULTIPLE HYDRAULIC CHOCKS MOVED FORWORD AND RE-PRESSURIZED TO MAINTAIN ROOF SUPPORT AS THE FACE IS ADVANCED. HYDRAULIC RAMS MOVE THE FACE CONVEYOR TO A NEW ALIGNMENT AND THE ADVANCE OF BOTH CHOCKS AND CONVEYOR IS PROGRESSIVE. THE OPERATOR CAN SET, CHECK, DETERMINE POSITION OF THE CHOCKS FROM THE CONTROL CABIN. THE COAL IS HANDLED BY GATE CONVEYORS AND IS ALSO MONITORED.

75-65-08001 METRO. SECTION SPONSORS FOREIGN LANGUAGE TECHNICAL SESSIONS (TUNNELING-MACHINE ROTARY-DRILLING-MACHINE CUTTING-HEAD)
CIVIL ENGINEERING, ASCE, 96, AUG 1965. TECHNICAL SESSIONS IN FOREIGN LANGUAGES WERE HELD AT THE UNITED ENGINEERING CENTER. ONE RECENT SESSION IN GERMAN HEARD ABOUT THE DEVELOPMENT OF MECHANICAL ROCK TUNNELERS, SPECIFICALLY THE WSKW ROTARY DRILLING MACHINE. THE CUTTING TOOLS ARE ARRANGED SO THAT FORCE IS APPLIED AT RIGHT ANGLES TO THE DIRECTION OF THE TUNNEL. ONLY 85 KW WAS REQUIRED BY THE CUTTER HEAD MOTOR AND 6 KW TO FORCE THE HEAD INTO CUTTING A 10 FOOT DIAMETER TUNNEL IN SHALE AND COAL. ABOUT HALF THE MATERIAL WAS NOT CUT AT ALL BUT WAS BROKEN BY VIBRATION. AFTER 2400 FT THE CUTTING TOOLS WERE NOT EVEN DULLED.

75-65-10001 ANOTHER MOLE PUSHES JOB TWO YEARS AHEAD OF SCHEDULE (TUNNELING-MACHINE MUCKING WATER-TUNNEL SLURRY PUMPING)
CONSTRUCTION METHODS, 152-157, OCT 1965. AZOTEA CONTRACTORS 13.8 MILLION DOLLAR CONTRACT FOR A 12.7 MILE TUNNEL IS TWO YEARS AHEAD OF SCHEDULE. THE ROBBINS MOLE AVERAGES 14 FEET PER HOUR WHEN WORKING BUT WAITS ABOUT HALF THE TIME FOR MUCKING TO CATCH UP. RECORDS FOR RATE OF ADVANCE ARE 98 FEET IN 8 HOURS, 210 FEET IN 24 HOURS. THE AZOTEA TUNNEL IS A MAJOR LINK IN THE DIVERSION SYSTEM OF BU REC SAN JUAN - CHAMA PROJECT. RING-BEAM SUPPORTS ARE INSTALLED AS FAST AS THE NEW SECTIONS ARE EXPOSED. WHEN MOLE IS DELAYED EXPOSED WALLS ARE COVERED WITH GUNITE TO PREVENT SLAKING OF SHALE SURFACES.

75-65-11001 MOLE BORES TUNNEL NO 1. MINERS, NO 2 (DRILL-BLAST HUGHES BETTI-I)
ENGR NEWS-RECORD, (175) 26-33, NOV. 11, 1965. THE HUGHES MOLE BETTI-I IS DRIVING THE 2 MILE LONG 18 FT DIA TUNNEL NO 1 FOR THE U.S. BUREAU OF RECLAMATIONS NAVAJO INDIAN IRRIGATION PROJECT NEAR FARMINGTON N.M. THE MOLE IS LASER GUIDED. 5 MI LONG TUNNEL NO 2 IS BEING DRIVEN BY CONVENTIONAL DRILL AND BLAST METHODS. DETAILS OF BOTH METHODS ARE GIVEN.

75-65-12001 HUGE MOLE CARVES CLAY ROCK (ADVANCE CAST CUTTERS BLASTING MUCKING PRESSURE)
CONSTRUCTIONS METHODS, 113-115, DEC. 1965. A CALWELD ELECTRO-HYDRAULIC MACHINE AVERAGING 5FT. PER HR. IS TUNNELING A 26 FT. DIA. INTERCEPTOR SEWER 58 MILES LONG. THE $9.4 MILLION CONTRACT INCLUDES A SMALLER CONCRETE LINED TUNNEL RECENTLY STARTED WITH A 23 1/2 FT. DIA. CALWELD MACHINE. THE MACHINE HAS ENTERED A STRETCH OF COMPOSITE MATERIAL CONTAINING A 6FT HIGH DOLOMITE LIMESTONE STRATA WHICH MUST BE DYNAMITED AHEAD OF THE WHEEL. THE WHEEL HAS A NOSE CONE AND EIGHT RADIAL SPOKES ALL HAVING 2 IN. WIDE CUTTING TEETH. OUTER WHEEL RIM CARRIES 16 ONE YD CAPACITY MUCKING FLAPS. MUCK IS TRANSPORTED IN 32 FOUR YD CARS POWERED WITH 13 BATTERY DINKIES. MACHINE OPERATES UNDER 4 TO 6 PSI PRESSURE AND HAS A PERSONNEL LOCK AND A MATERIAL LOCK THAT TAKES 13 CARS. THE 150 TON MACHINE 22 FT. LONG IS THRUST FORWARD IN 3 FT STEPS. THE WHEEL IS TURNED AND THRUST FORWARD BY SIX CHAMBERLAIN HYDRAULIC MOTORS THAT DELIVER 510,000 FT. LB. OF TORQUE.

75-66-04001 LASER LIGHTS THE WAY FOR HUGE TUNNEL DIGGER (ADVANCE THRUST LASER GUIDANCE MOLE)
MACHINE DESIGN, 14, APR 28, 1966. THE HUGHES TOOL CO 280 TON, 64FT LONG CONTINUOUS MINER IS CUTTING A 21 FT. DIA. TUNNEL THRU SANDSTONE AT A RATE OF 10 FT PER HR. THE 1000 HP MACHINE ON THE MAVAJO INDIAN IRRIGATION PROJECT APPLIES A THRUST OF 1.4 MILLION LB. MAX. AT THE FACE. HUGHES TOOL CO. SAID "IT IS NOT UNUSUAL FOR THE MACHINE TO DRIFT OFF COURSE 2 OR 3 IN. IN A 5 FT. ADVANCE. WITH THE PERKIN-ELMER GAS LASER, A CONTINUOUS HELIUM-NEON BEAM OF VISIBLE RED LIGHT AS GUIDANCE, THE MACHINE HAS NOT STRAYED BY MORE THAN 5/8 IN. AFTER AN ADVANCE OF 1.5 MILES. TWO PHOTOCELL TARGETS ARE MOUNTED AT TUNNEL DIGGER'S FRONT AND BACK. THE LIGHT BEAM IMPRINGING ON THESE PHOTOCELLS CAUSES LIGHTS TO GLOW ON A DISPLAY PANEL IN FRONT OF THE MACHINE OPERATOR WHO CAN CORRECT FOR ANY DEVIATIONS AS THEY START TO OCCUR.

75-66-04002 THRUSTING A SUBWAY THROUGH A RAILWAY EMBANKMENT (PIPE-JACKING)
ENGINEERING, (201) 632, APR 1966. A 10 FT. 3 IN. PEDESTRIAN TUNNEL UNDER A RAILWAY IS BEING CONSTRUCTED BY PIPE JACKING. IT IS 100 FEET LONG CONCRETE LINED AND WATERPROOF. THIS METHOD ADVANCE 10 FEET A DAY. ONE PROBLEM IS THAT JAMMING WILL OCCUR IF THE WORK IS STOPPED. FOUR RAMS WERE USED TO EXERT A FORCE OF 600 TONS.

75-66-05001 MOLE FINISHES TWO-MILE ROCK BORE (COST PERFORMANCE-RECORD)
ENGINEERING NEWS-RECORD, (176) 78, MAY 26, 1966. BETTI I THE 280 TON MOLE BUILT BY HUGHES TOOL CO DRILLED 10,000 FT OF 20 FT TUNNEL THROUGH NEW MEXICO SANDSTONE IN 8 MONTHS 18 DAYS FOR AN AVERAGE OF 1160 FT/MO (NEARLY 40 FT/DAY) BEST DAY 171 FT. THE TUNNEL IS PART OF BU REC NAVAJO IRRIGATION PROJECT. A JARVA MOLE CLAIMS A RECORD OF 4 FT AN HOUR IN AN 8 FT DIA ST. LOUIS SEWER TUNNEL.

75-66-10001 TWO WAYS FIGHT FOR TUNNEL FOOTAGE (COST CAPITAL ADVANCE OVERBREAK GUIDANCE SAFETY)
DAY, R.
CONSTRUCTION EQUIPMENT & MATERIALS, 50-56, OCT. 1966. TUNNELING MOLES ARE COMPARED WITH DRILL, SHOOT AND MUCK ON TWO PROJECTS IN SIMILAR ROCK FORMATIONS, ONLY 1/2 MILE APART. THE MOLE BORED A 2 MILE LONG TUNNEL 19 FT 10 IN TO 20 FT 10 IN DIAMETER TUNNEL IN MODERATELY HARD SANDSTONE FOR $5,402,994. THE 3 DECK JUMBO BLASTED 5 MILES OF 18 FT. 7 IN. DIA. HORSESHOE SECTION TUNNEL FOR $8,640,411. COMPARING THE TWO METHODS: CAPITAL COST FOR THE MOLE IS HIGHER, MOLE FOOTAGE ADVANCE IS HIGHER BUT JUMBO IS STEADIER, OVERBREAK TROUBLES THE MOLE BUT IS LESS THAN FOR THE JUMBO, MOLE LASER GUIDANCE IS BETTER THAN JUMBO SURVEYING, MAINTENANCE IS ABOUT EQUAL. MOLE IS SUPERIOR TO JUMBO IN SAFETY, CREW SIZE FOR EITHER METHOD IS ABOUT THE SAME. BOTH SYSTEMS AT THE PRESENT TIME HAVE THEIR STRONG AND WEAK POINTS.

75-66-10002 MOLE BORES 277FPD OF 10 FT. DIA. TUNNEL (ADVANCE GUIDANCE MUCKING CUTTERS COST ROCK)
DAY, R.
CONSTRUCTION EQUIPMENT & MATERIALS, 54-55, OCT. 1966. A MOLE MANUFACTURED BY JAMES S. ROBBINS, 40 FT. LONG AND WEIGHING 120,000 LB. IS BORING THE 10 FT. DIA. BLANCO TUNNEL 7000 FT. LONG IN COLORADO. ADVANCES HAVE BEEN AS HIGH AS 105 FT IN 8 HR, 277 FT. IN 24 HR AND 1189 FT. IN A WEEK. GUIDANCE SYSTEM IS A LASER BEAM DEVICE MANUFACTURED BY I.T.I. OF DENVER MUCKING IS DONE BY TWO TRAINS OF SIX 16 YD. CARS AND A 393 FT LONG CALIFORNIA SWITCH. CUTTER HEAD HAS 24 DISK TYPE 11 IN. ROLLER CUTTERS WHICH CUT CONCENTRIC CIRCLES AT 3 1/2 IN. SPACING. ALSO A BEVELED TRI-CONE BIT IS LOCATED AT CUTTERHEAD CENTER. MOLES HAVE TENDED TO BRING EXCAVATION BID PRICES DOWN. THE SAME BASIC CREW WITH A MOLE

CAN MAKE SIX TIMES THE ADVANCE OF CONVENTIONAL OPERATION. ROCK THREE TIMES HARDER THAN THE PRESENT LEWIS & MANCOS SHALES SHOULD BE ECONOMICALLY BORED.

75-66-12001 FIVE-MILE TUNNEL HOLED THROUGH (HARD-ROCK-TUNNELING-MACHINES MOLES DRILLING-AND-BLASTING)
ENGINEERING NEWS-RECORD, (177) 22, DEC 8, 1966. A BLAST 900 FEET DEEP IN HARD ROCK UNDER SOUTH BROOKLYN MARKED THE HOLING THROUGH OF THE 5 MILE LONG 12 FOOT DIAMETER RICHMOND WATER TUNNEL UNDER NEW YORK HARBOR TO STATEN ISLAND. ALL BUT 200 FEET OF THE TUNNEL WAS DRIVEN BY DRILLING AND BLASTING. THE JOB WAS DELAYED BEYOND SCHEDULE BY THE EXPERIMENTAL USE OF A STILL-PROMISING HARD ROCK TUNNELING MACHINE THAT FINALLY WAS PULLED OFF THE JOB. A DRILL JUMBO, MOUNTING 5 DRIFTERS AND AN 8 INCH BURN-CUT DRILL WAS NOT DESIGNED FOR BLOCKY ROCK BUT COULD HAVE BEEN AND HOPES ARE HIGH FOR ITS FUTURE USE IN THE AREA. THE CONTRACTORS NOTED THAT BLOCKINESS AND INCONSISTENCY OF THE ROCK, A SCHIST LOADED WITH FELDSPAR, PEGMATITE AND GARNET, GAVE THE MOLE THE MOST TROUBLE.

75-66-12002 THIRTY-FOUR HYDRAULIC CYLINDERS TEAM-UP TO BORE GIANT IRRIGATION TUNNEL (ADVANCE COST MOLE SAFETY GUIDANCE MUCKING)
WESTERN MACHINERY & STEEL WORLD, (57) NO 12, 37-38, DEC 1966. A 280 TON 64 FT LONG TUNNEL BORING MACHINE BUILT BY HUGHES TOOL WAS USED TO BORE A 2 MILE LONG 20 FT. DIA. TUNNEL AT UP TO 10 FT. PER HR. TO BRING WATER TO NAVAJO INDIAN IRRIGATION PROJECT IN NEW MEXICO. IT IS THE FIRST OF SOME 13 MILES OF TUNNELS IN THIS $135,000,000 PROJECT TO BE COMPLETED IN 1971. MACHINE CONSISTS OF TWO CONCENTRIC FRAMES; INTERCONNECTING SIDE PLATES, INTERCONNECTING HYDRAULIC CYLINDERS, A DRILLING HEAD, HYDRAULICALLY OPERATED WALL PADS SECURED TO TOP, BOTTOM AND SIDES OF INNER FRAME, HYDRAULICALLY OPERATED WALL PADS SECURED TO TOP, BOTTOM AND SIDES OF OUTER FRAME, HYDRAULIC STEERING CYLINDERS AND HYDRAULIC CYLINDERS WHICH POSITION THE CUTTERS AT 19 FT 10. IN., 20 FT 10 IN. OR 21 FT. 2 IN. FOR DIAMETER. HYDRAULIC SYSTEM OPERATES AT 6000 PSI. MUCKING IS DONE WITH DIESEL ENGINES AND 10 CU. YD. RAIL CARS. BORING MACHINE IS LASER BEAM ALIGNED. FOR SAFETY HYDRAULIC FLUID IS FIRE RESISTANT.

75-66-12003 HARD ROCK TUNNELING MACHINE (ADVANCE FORMATION LINING CUTTERS HEAD)
THE ENGINEER, 930, DEC 16, 1966. WIX & LIESENHOFF ARE USING A DEMAG TUNNEL DRIVING MACHINE ON THE SEWAGE TUNNEL BORED TO 2.1 METERS AND LINED WITH 3 METER LONG CONCRETE SEGMENTS TO 1.75 METERS. IT IS 800 METERS LONG AND IS 12 TO 20 METERS BELOW DORTMUND. CUTTER HEAD CONSISTS OF A SET OF CRUSHING ROLLERS MOUNTED CONCENTRICALLY SUCH THAT A CONE SHAPED FACE IS CUT WITH A PILOT HOLE IN THE CENTER. MACHINE9IS ABOUT 16 METERS LONG, WEIGHS 40 TONS AND CAN BE HYDRAULICALLY ADVANCED 950 MILLIMETERS. TWO HYDRAULIC CYLINDERS PRESS THE CUTTER HEAD AGAINST THE FACE WITH A STEPLESS VARIABLE FORCE OF UP TO 100 TONS. TUNNELING CREW CONSISTS OF FIVE MEN INCLUDING THE CRANE OPERATOR FOR EMPTYING SPOIL AT THE ADIT TRENCH. DRILLING RATE IS 2-3 METERS PER HOUR BUT WITH MUCKING OUT AVERAGE RATE PER SHIFT IS 5.5 METERS WHICH IS FIVE TIMES THAT BY TRADITIONAL METHODS. BORED TUNNEL REQUIRES NO SUPPORT.

75-67-01001 INVENTION IS GARDNER TRADEMARK (TEREDO TUNNELING-MACHINE)
ENGINEERING NEWS-RECORD, (178) 50, JAN 12, 1967. HOUSTON CONTRACTOR ELMER GARDNER, FOUNDER OF GARDNER ENGINEERING CORP. HAS PRODUCED A NEW CONSTRUCTION METHOD OR EQUIPMENT ON EACH NEW JOB ALL DESIGNED AND BUILT IN HIS OWN SHOP. FEATURED IS A TUNNELING MACHINE HE CALLED A TEREDO. ON A $490 THOUSAND SEWER PROJECT, THE MACHINE CHEWED OUT THE SEWER AT A RATE OF 18 TO 20 FEET A DAY LEAVING BEHIND A REINFORCED CONCRETE TUNNEL 10 FEET INSIDE DIAMETER WITH A 9 INCH WALL. THE MACHINE USED A TOOTH CHAIN FROM A TRENCHING MACHINE FOR BITING INTO THE TUNNEL FACE AND THE SPOIL WAS PUMPED OUT.

75-67-01002 BIG MOLE IS DOWN IN THE HOLE (CUTTER-HEAD CONVEYOR MUCK-TRAINS SEMI-HARD-ROCK)
ENGINEERING NEWS-RECORD, (178) 20, JAN 12, 1967. A MECHANICAL MOLE BUILT BY CALWELD DIVISION OF SMITH INDUSTRIES INT., INC. IN LOS ANGELES HAS BEEN LOWERED INTO A SHAFT AND IS BEING READIED TO BORE THE 20 1/2 FOOT DIAMETER, 3 1/2 MILE NEWHALL TUNNEL FOR THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA. THE 25 FOOT DIAMETER CUTTER HEAD ROTATES AT 5 RPM AND DUMPS SOIL IN HOPPER WHICH IS EMPTIED BY A CONVEYOR THAT TRANSFERS IT TO MUCK CARS OPERATING BETWEEN THE MOLE AND THE VERTICAL SHAFT. THE MACHINE WILL MINE ABOUT 100 FEET A DAY UNDER AVERAGE GEOLOGIC CONDITIONS.

75-67-01003 TAIL-PLATES BEND WHEN SHIELD CHANGES COURSE (ADVANCE POWER COST MOLE)
CONSTRUCTION METHODS, 81-82, JAN 1967. FOR A 54 IN. BORE SEWER 550 FT. LONG UNDER THE SEATTLE-EVERETT FREEWAY COSTING $97,550 A $20,000 SHIELD WAS BUILT. THIS BORER HAS 3 SECTIONS: A 2 1/2 FT. LEADING EDGE, A 5 FT LONG WORKING SECTION AND A 2 1/2 FT. LONG ARTICULATED SECTION WITH 1/8 THICK 6 IN. WIDE OVERLAPPING PLATES. AN AIR SPADER OPERATING ON 100 PSI AIR FRAGMENTS THE EARTH FORCED INTO THE SHIELD ON EACH 9 IN. JACKING STROKE. A TWO CYLINDER GMC POWER PLANT GENERATES ELECTRICITY FOR THE CONVEYORS AND HYDRAULIC PUMPS. MUCK IS REMOVED BY CONVEYOR BELT AND A BATTERY POWERED 32 CU. FT. CAR. A FOUR SECTION LINER PLATE 18 IN. WIDE IS INSTALLED IN THE ARTICULATED SECTION. WORKING THREE 7 HR SHIFTS A DAY, FOUR MAN CREWS COMPLETED THE SEWER IN 27 WORKING DAYS. MAXIMUM ADVANCE WAS 39 FT. PER DAY AND AVERAGE WAS 20 FT. PER DAY.

75-67-02001 DIG WE MUST AND FASTER (TUNNELING-MACHINE MOLE)
BUSINESS WEEK, 135, FEB 11, 1967. CITIES HAVE SO MUCH TUNNELING TO DO THAT AUTOMATED MEANS ARE BEING SOUGHT AND USED. THE PRESIDENT ESTIMATED THE NATION'S TUNNELING EXPENDITURE AT $1-BILLION OVER THE NEXT 10 YEARS. WITH THE GROWING SKILLED LABOR SHORTAGE CONTRACTORS ARE TURNING TO SOPHISTICATED TUNNELING MACHINES. THE MECHANICAL MOLE PRODUCES SAVINGS OF TIME AND MONEY UP TO 50% OVER DRILLING AND BLASTING TECHNIQUES. NEW MACHINES AND THEIR MANUFACTURERS ARE DISCUSSED AS WELL AS EXPERIMENTAL USE OF LASERS AND ULTRA SONIC VIBRATORS.

75-67-02002 MOLE CASTS LINING CONTINUOUSLY (TUNNELING-MACHINE ARGENTINA PUMPED-MUCK SLIP FORM MEMCO)
ENGR NEWS-RECORD, (178) 16, FEB 2, 1967. MEMCO HAS BUILT A TUNNELING MACHINE FOR URANINI SPA OF BUENOS AIRES FOR DIGGING A 15.5 FT WATER TUNNEL UNDER THE RIACHUELO RIVER. THE TUNNEL WILL BE 8800 FT LONG.

75-67-04001 TUNNEL CONTRACTOR BURIES $200,000 MOLE (STORM-DRAINAGE TUNNELING-MACHINE)
ENGINEERING NEWS-RECORD, (178) 35, APR 20, 1967. AFTER MINING 5900 FEET OF 16 FOOT DIAMETER STORM DRAINAGE TUNNEL A BIG MECHANICAL MOLE HAD TO BE BURIED. SOME DISTANCE BEHIND THE HEADING A WATER BEARING LIMESTONE LAYER ABOVE THE TUNNEL PROVIDED A HEAVY INFLOW OF WATER SANDSTONE INTO THE TUNNEL. ABOUT 175 FEET OF TUNNEL WAS BULKHEADED OFF AND THAT SECTION CONTAINING THE MOLE WAS BACKFILLED WITH GRAVEL TO SAVE THE REST. THE LINING OF THE UNAFFECTED SECTION OF TUNNEL HAD STEEL RIBS LAGGED SOLID WITH WOOD BUT IS NOW RECEIVING A SECONDARY CONCRETE LINING.

75-67-04002 MOLE DIGS 8 MILES IN 13 MONTHS (BLANCO ROBBINS SWITZERLAND OSO AZOTEA)
ENGR NEWS-RECORD, (178) 23, APR 6, 1967. THE 10 FT DIA 8 MILE LONG BLANCO TUNNEL IN NEW MEXICO WAS COMPLETED BETWEEN FEB 21, 1966 AND MAR 21, 1967. ROBBINS WILL RECONDITION THE MOLE FOR A JOB IN SWITZERLAND. THE OSO MOLE HAS HAD TO BE TAKEN OUT BECAUSE OF BAD GROUND. THE AZOTEA MOLE IS PROGRESSING MORE SLOWLY THAN THE BLANCO TUNNEL DID.

75-67-06001 JAPANESE TEST SOFT-GROUND MOLE (REVERSING RETRACTING PRESSURIZING LINER GROUTING)
ENGINEERING NEWS-RECORD, (178) 15, JUNE 29, 1967. A JAPANESE GOVERNMENT SUBSIDY DESIGNED AND BUILT A 22.9 FT DIAMETER SOFT GROUND TUNNELING MACHINE. ITS AIM IS TO TUNNEL IN SILT, SAND OR CLAY AND IS RIGHT FOR A SINGLE TRACK SUBWAY. CUTTERHEAD ROTATION CAN BE REVERSED AND THE WHEEL CAN BE BACKED AWAY FROM THE FACE WITHOUT BACKING THE WHOLE SHIELD. THE CUTTING END OF THE MACHINE CAN BE PUT UNDER COMPRESSED AIR WHILE ITS OPERATORS AND OTHER WORKERS ARE IN FREE AIR. TWO ERECTOR ARMS IN THE SHIELD'S TAIL PLACE LINER PLATE SEGMENTS, WHILE EIGHT BUILT-IN GROUT INJECTORS SEAL THE TUNNEL LINING AS THE MOLE ADVANCES.

75-67-07001 TUNNELING GRAND SLAM (TUNNELING-RECORD SIZE GEOLOGY)
ENGINEERING NEWS-RECORD, (179) JULY 27, 1967. ON THE 10 FOOT DIAMETER, SOUTH WEST COLORADO, OSO TUNNEL BOYLES BROS DRILLING CO WENT 156 FEET IN 8 HOURS, 419 FEET IN A 24 HOUR PERIOD, 1,905 FEET IN A 6 DAY WEEK AND 6,849 FEET IN A 30 DAY PERIOD WITH A MECHANICAL MOLE THRU SANDSTONE.

75-67-07002 MOLE WIPES EARTH OFF THE FACE OF THE BORE (CUTTERS MUCK ADVANCE ALIGNMENT LINING)
CONSTRUCTION METHODS & EQUIPMENT, 78-82, JUL 1967. LOS ANGELES METROPOLITIAN WATER DISTRICT IS LAYING A LARGE DIAMETER URBAN WATER PIPELINE BY CUT AND COVER EXCEPT WHERE IT IS INSTALLED IN TUNNELS UNDER MAJOR INTERSECTIONS, FLOOD CONTROL CHANNELS AND LINED RIVERS. THERE ARE 6,600 FT. IN THESE 38 TUNNELS MOST OF WHICH ARE SHORT AND MINED WITH VIBRATING HANDSPADES. THE ONLY LONG TUNNEL, 1,277 FT. IS BEING DRIVEN IN SOFT GROUND UNDER SAN GABRIEL FREEWAY WITH A CALDWELD OSCILLATING MOLE HAVING SIX CUTTING ARMS. HYDRAULICALLY CONTROLLED ARMS, SPACED AT 60 DEGREE INTERVALS, HAVE REPLACEABLE FORGED STEEL TEETH AND PIVOT WINDSHIELD WIPER FASHION TO DESCRIBE A 9 FT. 7 IN. DIA. BORE. TRAILING THE CUTTING ARMS AND SHIELD UNIT ARE TEN HYDRAULIC RAMS WHICH PROPEL THE SYSTEM IN 34 IN. STEPS BY PUSHING AGAINST THE 1/4 IN. THICK STEEL LINER. BEHIND THE MOLE IS A TWO STAGE BELT TO WHICH MUCK IS FED AND CARRIED BACK TO LOAD A THREE CAR TRAIN. EVERY TWO FEET THE MOLE POSITION IS CHECKED WITH ELECTRONIC SURVEY EQUIPMENT AND ADJUSTMENTS MADE TO KEEP IT ON LINE. CONCRETE TRUCKS COMBINE WITH PRESSURE EQUIPMENT TO GROUT 300 FT. LONG TUNNEL SECTIONS.

75-67-08001 MOLE PUSHES BARTD UNDERGROUND (TWIN-BORE HYDRAULIC-JACKS RAPID-TRANSIT)
ENGINEERING NEWS-RECORD, (179) 43, AUG 3, 1967. JOINT-VENTURE CONTRACTORS, MORRISON-KNUDSEN, BROWN AND ROOT, AND PERINI CORP. ARE DIGGING ONE TUBE OF A ONE MILE LONG TWIN-BORE RAPID TRANSIT TUNNEL FOR BARTD IN SAN FRANCISCO. MACHINE USED IS A 93-TON MOLE COSTING ABOUT $850,000, WITH A TWIN DUE TO START THE PARALLEL BORE SHORTLY. EACH BORE IS 40 TO 90 FEET BELOW GROUND, AND IS 18 FEET DIAMETER TO CARRY ONE-WAY TRANSIT TRACKS. THE MOLES ARE EXPECTED TO MOVE AT A RATE OF 26 FEET PER DAY.

75-67-08002 MOLE TUNNELING RESEARCH ADVOCATED (ADVANCE COST HARD-ROCK TECHNOLOGY BORING SYSTEMS)
CIVIL ENGINEERING, 48-49, AUG 1967. NINE FEDERAL AGENCIES ESTIMATED THE DEMAND FOR NEW TUNNELS AS FOLLOWS: SUBWAYS BY 1975 ONE HUNDRED MILES, COSTING A BILLION DOLLARS, UTILITIES DURING THE NEXT 30 YEARS $700 BILLION, AS MUCH OF PRESENT POWER TRANSMISSION LINES WILL BE RELOCATED UNDERGROUND WITHIN 30 MILES OF OUR MAJOR CITIES, MINING BUILDS SOME 350 MILES OF TUNNELS YEARLY, URBAN FREEWAYS COST FOR TUNNELING IS BECOMING COMPETITIVE WITH SURFACE OR VIADUCT AND BILLIONS OF DOLLARS WILL BE SPENT. DR. HIBBARD OF THE U.S. BUREAU OF MINES BELIEVED THAT 20 FT. DIAMETER HOLES WOULD BE BORED THROUGH ALMOST ANY OF THE HARD ROCKS AND ADVANCE RATES WOULD RANGE UP TO 4,000 FEET A WEEK. HE ALSO SAID THAT AN AGGRESSIVE, PROPERLY STRUCTURED RESEARCH EFFORT WOULD PRODUCE WITHIN THE NEXT 5 TO 10 YEARS BETTER EXCAVATION TECHNOLOGY AND IMPROVED TUNNEL BORING SYSTEMS THAT COULD REDUCE THE CONSTRUCTION COST BY AS MUCH AS 50 PERCENT SAVING THE PUBLIC BETWEEN $5 AND $8 BILLION. THIS YEAR'S $2.7 MILLION RESEARCH PROGRAM WAS TURNED DOWN BY CONGRESS BUT THEY WILL TRY AGAIN NEXT YEAR, AND WILL HAVE THE BENEFIT OF A REPORT BY A COMMITTEE ON RAPID EXCAVATION STUDYING ADVANCED TUNNELING TECHNOLOGY.

75-67-08003 MEMCO: YOUNG TURKS THAT TACKLE TUNNELS (MOLES SHIELDS HARD-ROCK JAPAN BUENOS AIRES SAN FRANCISCO AUTOMATION)
ENGINEERING NEWS-RECORD, (179) 78-79, AUG 3, 1967. THE HISTORY OF MEMCO-MINING EQUIPMENT MANUFACTURING CO. IS GIVEN. MEMCO'S REAL DEPARTURE FROM CONVENTION WAS ITS INTRODUCTION OF A SHIELD WITH A ROTARY-CUTTER FOR SOFT, PROBLEM GROUND. TWO JAPANESE CONTRACTORS HAVE SUCCESSFULLY USED MOLES ON A TOKYO 12 FT 6 IN SEWER AND A MACHINE HAS BEEN ORDERED FOR THE 35 FT SUBWAY. A PAIR OF MEMCO MOLES ARE DRIVING THE TWIN TUBE MARKET ST SECTION OF SAN FRANCISCO'S NEW SUBWAY. MEMCO PLANS DIGGING TUNNELS BY A COMPLETELY AUTOMATED METHOD HAVING ONLY A HANDFUL OF MEN OUTSIDE AT A CONTROL PANEL. MEMCO HAS A MACHINE IN BUENOS AIRES TO MINE A 15 FT 6 IN WATER TUNNEL WHILE SIMULTANEOUSLY CASTING IN PLACE AN 18 IN NONREINFORCED CONCRETE LINING. MEMCO HAS THE CONTRACT FOR THE 20 1/2 FT DIA 5 MILE LONG SOUTHERN CALIFORNIA METROPOLITAN WATER DISTRICT TUNNEL FOR $35.7 MILLION. THEY SAY THAT AT THE PRESENT TIME THERE IS NO MATERIAL HARD OR TOUGH ENOUGH TO MOLE OUT HARD ROCK ECONOMICALLY.

75-67-08004 MECHANICAL MOLE GOES 8 MILES A YEAR (BLANCO-TUNNEL RECORD)
CONSTRUCTION METHODS, (49) N 8, 63-4, AUG. 1967. OPERATION OF MECHANICAL TUNNELING MACHINE USED FOR BLANCO TUNNEL ON BUREAU OF RECLAMATION SAN JUAN - CHAMA PROJECT IN COLO. AND N. M.; BEST TOTAL PROGRESS -- DRIVING 41,818 FT OF TUNNEL FROM SINGLE HEADING IN 311.33 WORKING DAYS (1.014 YR) OF THREE-SHIFT OPERATION THROUGH SHALE AND SANDSTONE WITH HARDNESS RANGING FROM 2.5 TO 5 ON MOHS SCALE.

75-67-08005 MOLES WOULD BE BETTER (TUNNELING-MACHINE)
ENGINEERING NEWS-RECORD, (179) 36, AUG 31, 1967. CRITICISM OF SOUTH AFRICA'S DEPARTMENT OF WATER AFFAIRS FOR NOT USING MECHANICAL TUNNELING MACHINES TO DRIVE THE 16 FEET 9 INCH BORE FOR THE 52 MILE LONG ORANGE-FISH TUNNEL.

75-67-09001 JAPAN'S PRESSURIZED EXCAVATOR CLAIMS WORLDS FIRST (SAFETY COMPRESSED-AIR SUBWAY-TUNNEL)
AUSTRALASIAN ENGR. 48, SEPT. 1967. FEATURES OF EXCAVATOR WITH DIAMETER OF 7 M EQUIPPED WITH SPECIAL DEVICE TO KEEP INTERNAL AIR PRESSURE EQUIVALENT TO NORMAL ATMOSPHERIC PRESSURE; PRINCIPAL PART OF NEW UNIT IS "PARTIAL PRESSURE SYSTEM" WHICH APPLIES COMPRESSED AIR TO FORWARD CUTTING BLADE ONLY, ENABLING THAT SECTION EXCAVATOR TO WITHSTAND FULL PRESSURE FROM OUTSIDE; AS RESULT OF UNUSUAL BODY DESIGN OF NEW UNIT, EXCAVATOR HOLDS UP SURROUNDING EARTH DURING EXCAVATING OPERATIONS, AND MOVES FORWARD BY PUSHING AGAINST FRONT END; EXCAVATOR IS DESIGNED FOR SINGLE TRACK SUBWAY TUNNEL IN JAPAN AND IS SUITABLE FOR OPERATION UNDER VARIOUS GEOGRAPHICAL OR GEOPHYSICAL CONDITIONS; UNIT IS TENTATIVELY PRICED AT $700,000.

75-67-09002 SUBWAY BORING BEGINS ON COAST (COST COMPRESSED-AIR WEIGHT SIZE LENGTH MOLE)
MILLIMAN, L.
THE WASHINGTON POST, G5, SEPT 21, 1967. THE 75 MILES OF THE $1 BILLION SAN FRANCISCO BAY AREA RAPID TRANSIT DISTRICT SYSTEM WILL INCLUDE 5 MILES OF TWIN AND FOUR-BORE TUBES UNDER SAN FRANCISCO. THE TWIN MILE-LONG BORES 18 FT O.D. COST $17.7 MILLION. TWO MOLES ARE WORKING UNDER MISSION ST. EACH TIME A MOLE MOVES FORWARD 30 IN., ERECTOR ARMS SWING SIX SEGMENT STEEL LINERS INTO PLACE WHICH ARE BOLTED AND GROUTED. THEN BY JACKING AGAINST THE NEWLY INSTALLED LINER THE MACHINE MOVES FORWARD. THE START IS IN A SHAFT AT 15TH AND MISSION STREET. 300 FEET FROM THE SHAFT COMPRESSED AIR WILL BE REQUIRED AND MAN AND MUCK LOCKS WILL BE INSTALLED. THE 93 TON MACHINES COST $850,000 APIECE. THE REST OF THE TUNNELING WILL BE DONE UNDER 8 OTHER CONTRACTS.

75-67-09003 GOPHER BORES THROUGH EARTH BY REMOTE CONTROL.
ROCK PRODUCTS, 19, SEPT. 1967. 2 LOS ANGELES INVENTORS HAVE DEVELOPED AN ELECTRIC DEVICE TO BORE HOLES FOR CABLES THROUGH THE GROUND BY REMOTE CONTROL. IT CHANGES DIRECTION IF IT MEETS AN IMPENETRABLE OBJECT AND SURFACES IF POWER IS TURNED OFF.

75-67-10001 LASER GUIDES GIANT TUNNELER THAT COULD DIG UNDER CHANNEL (LASER-AIMING-SYSTEM BORING-CAPACITY HYDRAULIC-CONTROLS MOLE)
PRODUCT ENGINEERING, 35, OCT 1967. A LASER GUIDED TUNNELING MACHINE HAS BEEN DEVELOPED BY KRUPP, WHICH AVERAGES 5 METERS PER HOUR,FIVE TIMES CONVENTIONAL METHODS. THIS SPEED WAS OBTAINED IN BROWN JURA LIMESTONE. ALL THE CONTROLS EXCEPT THE OIL PUMPS AND THE LIGHTING SYSTEM ARE OPERATED HYDRAULICALLY.

75-67-10002 MOLE BORES AT 16 FT PER HOUR (ADVANCE GUIDANCE MUCK POWER RECORDS)
ENGINEERING NEWS-RECORD, (179) 29, OCT 19, 1967. A 75 TON 78 FT LONG MACHINE WHICH CAN TURN ON A 164 FT RADINS AND COPE WITH SLOPES OF 15 DEG. IS BORING A 9 FT DIA. WATER TUNNEL BETWEEN LAKE CONSTANCE AND STUTTGART IN WEST GERMANY AT THE RATE OF 16 FT. PER HOUR THROUGH LIMESTONE. THE CUTTING HEAD IS FOUR ROTATING STEEL TOOTHED CUTTING WHEELS MOUNTED ON A ROTATING BASE. CRAWLERS STEER IT HORIZONTALLY AND MOVE IT FORWARD AND THE ADJUSTABLE CUTTERHEAD CONTROLS IT VERTICALLY. A CONVEYOR SENDS SPOIL TO REAR. TRAILING CABLES FEED POWER TO THE UNITS 325 KW ELECTRICAL SYSTEM. GUIDANCE IS BY LASER. SUCH A MACHINE HAS BEEN PUBLICIZED AS THE IDEAL EXCAVATOR FOR AN ENGLISH CHANNEL TUNNEL.

75-67-10003 SEVENTY-FIVE TON TUNNEL BORER (ADVANCE GUIDANCE MINING CUTTERS RECORD)
THE GERMAN TRIBUNE, NO. 289, OCT 21, 1967. PART OF THE FRESH WATER LINK BETWEEN STUTTGART AND LAKE CONSTANCE IS A 13 FT. DIA. TUNNEL 16 MILES LONG. THIS IS BEING BORED WITH A 75 TON HYDRAULICALLY OPERATED MACHINE AT THE RATE OF 16 FT/HR IN THE PRESENT LIMESTONE BED. THE MULTIPLE CUTTER HEAD HAS A MAXIMUM DIAMETER OF 20 FT. ITS DIRECTION IS LASER CONTROLLED. IT IS SUITABLE FOR EXCAVATING COAL, MANGANESE SALT, LIMESTONE, CLAY AND BAUXITE WITHOUT DIFFICULTY.

75-67-12001 MOLE SPADES THROUGH SOFT GROUND (LASER-BEAM GUIDANCE HYDRAULIC-PISTONS JACKING-RING)
ENGINEERING NEWS-RECORD, (179) 47, DEC 1967. A SOFT GROUND MECHANICAL MOLE IS BEING USED IN THE CONSTRUCTION OF AN INTERCEPTOR SEWER IN SEATTLE. THE 50-TON MOLE COST $500,000. THE MOLE OPERATES ABOUT 80 PERCENT OF THE TIME WITH NO DOWN TIME FOR SMALL REPAIRS. PROBLEMS HAVE BEEN ENCOUNTERED WITH THE HYDRAULIC SYSTEM DURING SUDDEN CHANGES IN THE MATERIAL AT THE FACE. THE MOLE'S CUTTING EDGE IS DESIGNED TO EXERT PRESSURES UP TO 6,000 PSI. HAND TUNNELING BECAME NECESSARY FOR 15 PERCENT OF THE COMPLETED FOOTAGE DUE TO LARGE BOULDERS.

75-68-01001 HYDRAULIC ARM DIGS TUNNEL, MOVES MUCK TO BELT (COST SHIELD DEMOLITION-HAMMER LASER BREAST-BOARDS)
CONSTRUCTION METHODS, 82-84, JAN 1968. A NEW TYPE EXCAVATING SHIELD 19 FT LONG IS EQUIPPED WITH A HYDRAULIC ARM TERMINATING WITH TWO TOOLS: AN UPWARD FACING INGERSOL-ROAD DEMOLITION HAMMER CARRYING A MOIL POINT AND A DOWNWARD FACING PAW-LIKE HOE. THIS 50 TON, LASER BEAM GUIDED SHIELD WITH A LEVELED CUTTING EDGE SLICES THE BORE FOR THE 12 FT DIA SEWER WITH 750 TONS FORCE. IT IS OPERATING 160 FT BELOW SEATTLE AT 100 FT PER DAY. THE CONTRACTORS ENGINEERS WORKED WITH FISKE ENGINEERING CO TO DESIGN AND BUILD THIS $500,000 MACHINE. TIMBER LOGGING AND 3 PRICE STEEL SETS ARE EXPANDED AGAINST THE BORE WITH A 20 TON HYDRAULIC JACK AFTER WHICH A STEEL STUB BEAM IS INSERTED. FOR POOR GROUND THE MACHINE HAS FOUR HYDRAULICALLY OPERATED BREAST BOARDS WHICH CAN EXERT 4,000 LB PER SQ. FT. PRESSURE. 10,000 FEET OF BORE ARE BEING BUILT FOR 5.719 MILLION, A SHORT DRAG CHAIN CONVEYOR LOADS THE MATERIAL ONTO BELT CONVEYORS WHICH FILL TRAINS OF FOUR TO SIX 2 YD CARS HAULED BY A BATTERY POWERED DINKY TO THE SHAFT.

75-68-01002 THIRD MOLE DIGS BARTO SUBWAY (COST OSCILLATING-ARMS WEIGHT MUCK TEETH)
ENGINEERING NEWS-RECORD, (180) 19, JAN 18, 1968. A $450,000 MOLE DESIGNED AND BUILT BY CALDWELL DIVISION OF SMITH INDUSTRIES INTERNATIONAL WILL DRIVE TWIN 18 FT. DIA TUNNELS FOR A 3,470 FOOT SECTION OF THE BAY AREA RAPID TRANSIT DISTRICTS SUBWAY BEING BUILT FOR $12.7 MILLION. THE 125 TON MACHINE WILL ALTERNATELY EXCAVATE AND INSTALL THE STEEL LINER AS IT ADVANCES. ITS CUTTING FACE HAS FOUR SETS OF THREE OSCILLATING ARMS EQUIPPED WITH FORGED STEEL CUTTING TEETH. EACH SET PIVOTS THRU A 30 DEGREE ARC. HIGH PRESSURE HYDRAULIC JACKS THRUST EACH CUTTING ARM FORWARD WITH A 45 TON FORCE. A 36 IN. CONVEYOR BELT SYSTEM LOADS THE MUCK CARS.

75-68-03001 GIANT MOLE BEGINS TUNNELING JOB IN SAN FRANCISCO (HYDRAULIC-JACKS TUNNELING-MACHINE COST)
ROADS AND STREETS, 119, MAR. 1968. A NEW MECHANICAL MOLE BUILT BY CALDWELL AND VALUED AT $450,000 HAS BEGUN WORK ON A 7,000-FT TUNNEL SECTION FOR THE BAY AREA IN SAN FRANCISCO. TOGETHER WITH ITS CONVEYOR SYSTEM, THE MACHINE IS 160 FT LONG AND WEIGHS MORE THAN 125 TONS. IT WILL BORE HOLES 18 FT IN DIA AT TWO SEPARATE LOCATIONS. IT ALTERNATELY EXCAVATES AND INSTALLS STEEL TUNNEL LINER. HIGH-PRESSURE HYDRAULIC JACKS THRUST THE CUTTING MECHANISM FORWARD WITH A FORCE UP TO 2.750 TONS. AFTER MUCK IS REMOVED AND THE MACHINE MOVES FORWARD, AN ERECTOR ARM INSTALLS STEEL LINER IN 1,100-LB SECTIONS. FOUR OSCILLATING STEEL ARMS - EACH INDEPENDENTLY OPERATING AND CAPABLE OF EXERTING 4,320,000 FT-LB TORQUE - PIVOT ABOUT THE MACHINE; EACH ARM IS EQUIPPED WITH FORGED STEEL CUTTING TEETH. ANOTHER SIMILAR MACHINE HELPED CARVE THE 4,300-FT TUNNELS (EACH 13'4" IN DIAMETER) ACROSS THE BAY. TURNING AT 8 REVOLUTIONS PER MINUTE, 19 ROTATING DISC CUTTERS PENETRATED THE TUNNEL FACE WITH UP TO 264,640 FT-LB. OF TORQUE. 1800 TONS OF THRUST WERE AVAILABLE TO PROPEL THE MACHINE FORWARD. THE TUNNELS ARE PART OF A PROJECT FOR THE EAST BAY METROPOLITAN WATER DISTRICT.

75-68-04001 BIG BITE (HARD-ROCK-DRILLING-TOOL MOLE)
THE CHRISTIAN SCIENCE MONITOR, B7, APR 12, 1968. PACIFIC CAR AND FOUNDRY COMPANY HAS BUILT A 250-TON DRILLING TOOL FOR MINING FOR WHITE PINE COPPER MINE IN MICHIGAN.

75-68-05001 TUNNELING MACHINES (MOLES ENGLAND GERMANY)
MECH. ENGR. (90) N 5, MAY 1968. BSP CALWELD LTD. HAS TWO MOLES ON AN UNDERGROUND RAILWAY PROJECT AT MUNICH, GERMANY, AND HAS SEVERAL SMALLER ONES ON SEWAGE DISPOSAL PROJECTS AT PORTSMOUTH, CHALLAM AND COVENTRY. CHAMBERLAIN INDUSTRIES LTD OF LEYTON, LONDON PRODUCE "STAFFA" M5 A HIGH TORQUE LOW SPEED HYDRAULIC MOTOR FOR USE ON MOLES. A NEW MORE POWERFUL VERSION - B270 INTRODUCES HYDROSTATIC CON RODS, A BALANCE VALVE AND HEAVIER BEARINGS.

75-68-05002 NEW WAY TO DRIVE TUNNELS (MOLES SHIELD CONVEYOR)
WESTERN CONSTRUCTION, (43) N 5, 53-6, MAY 5, 1968. OPERATION OF NEW TYPE OF TUNNELING MACHINE ON CONSTRUCTION OF SAUGUS TUNNEL IN SOUTHERN CALIFORNIA; HYDRAULIC MACHINE FEATURES SHIELD-PROTECTED RIG SPEARHEADED BY WRIST-ACTION RIPPER-BUCKET ON POWERFUL HYDRAULIC BOOM; MUCK THAT MACHINE RAKES ON 6 FT WIDE, 125 FT LONG HYDRAULIC CONVEYOR IS DEPOSITED IN SINGLE MUCK CAR; SHIELD IS EQUIPPED WITH 10 HYDRAULIC POLING PLATES THAT CAN EXTEND CROWN OF SHIELD AHEAD 5 FT TO STOP CAVING FACE OR TO ALLOW MEN TO WORK UNDER FULLY SUPPORTED GROUND IN FRONT OF TUNNELING MACHINE; MINING CYCLE OF MACHINE IS DESCRIBED.

75-68-09001 FEDERAL PROGRAM IS URGED FOR DIGGING UP NEW EXCAVATION TECHNIQUES AND MACHINERY (BORING MUCKING SUBWAY HARD-ROCK)
BUSINESS WEEK, 62, SEPT 14, 1968. THE NATIONAL ACADEMY OF SCIENCES HAS RECOMMENDED THE START OF A $200 MILLION FEDERALLY FUNDED PROGRAM FOR RES AND DEV IN UNDERGROUND MACHINERY AND TECHNIQUES. SOME $35 BILLION WILL BE AVAILABLE FROM 1970 TO 1990 FOR UNDERGROUND EXCAVATION. NAS PROPOSES SEVERAL HIGH-PRIORITY RES AND DEV EFFORTS INCLUDING: IMPROVEMENT OF BORING MACHINES, HARD ROCK BORING, HIGH SPEED, SOFT ROCK BORING, HIGH SPEED MUCKING, AND HANDLING OF SUPPLIES TO KEEP UP WITH THE HIGH SPEED MACHINES. BY 1975, SOME 946 MI OF TUNNELS WILL HAVE TO BE DUG IN THE U.S.

75-68-10001 SHIELDS AND SPECIAL LINER CUT TOKYO SUBWAY COST
ENGINEERING NEWS-RECORD, (181) 40-41, OCT 1968. TWIN BORE TUNNEL RAISED ORIGINAL COST TO $17 MILLION A MILE. $7.8 MILLION OF THIS WAS ON A 1.1 MILE WAS CAUSED BY A SEMIAUTOMATIC DRIVING SHIELD AND RUBBER-LINED PRECAST TUNNEL SEGMENTS. THIS METHOD ELIMINATED THE USUAL 8-IN SECTION WHICH REQUIRED THICK CONCRETE INNER LINING. A THREE-TIERED DRIVING SHIELD WAS USED.

75-68-10002 EXCAVATOR OPENS BORE WITH CLEAN SWEEP FORE AND AFT (MOLE SEWER-TUNNEL)
CONSTRUCTION METHODS AND EQUIPMENT, (50) NO 10, 64-65, OCT. 1968. THE CONTRACTOR FOR A 5500 FT LONG 6 FT SQUARE SEWER TUNNEL DEVELOPED A HYDRAULIC EXCAVATOR EQUIPPED WITH BOOM-MOUNTED BLADE. OPERATOR CONTROLS BLADE TO DIG AND SWEEP MUCK INTO CONVEYOR WHICH DELIVERS MUCK TO SKIP HOIST.

75-68-12001 MOLE SETS FAST PACE IN NEVADA ROCK
WESTERN CONSTRUCTION, (43) N 12, 38-9, DEC 1968. ROTARY MINING MACHINE DRIVING RIVER MOUNTAIN TUNNEL OF SOUTHERN NEVADA WATER PROJECT IS ADVANCING 200 FT/DAY THROUGH BARRIER MOUNTAINS BOUNDING LAKE MEAD: JARVA MOLE, 12 FT IN DIAM IS USED TO DRILL THROUGH ROCK: IT HAS CUTTING HEAD WITH 26 HARDENED STEEL DISK CUTTING WHEELS, AND 1 CENTER AND 4 TRI-CONE CUTTERS OF CARBIDE STEEL: BUSINESS END OF MOLE IS HELD IN PLACE DURING OPERATION BY FOUR HYDRAULIC FEET BEHIND CUTTING COLLAR.

75-68-12002 MOLE MAKES MONKEY OF MOUNTAIN (ADVANCE ROCK MUCKING CUTTERS POWER COST RECORD)
ENGINEERING NEWS-RECORD, (181) 19, DEC. 12, 1968. A JARVA MARK 11/14 WITH 866,000 LB. THRUST HAS STEEL DISC CUTTERS, POWERED WITH FOUR 100SQ MOTORS IS BORING A 12 FT DIA TUNNEL IN IGNEOUS FORMATIONS RANGING IN COMPRESSIVE STRENGTH FROM 1,500 TO 17,000 PSI. AS MUCH AS 250 FT HAS BEEN BORED IN ONE THREE SHIFT DAY. THE 19,700 FOOT LONG

FINISHED TUNNEL WILL COST 3.9 MILLION DOLLARS. CUTTERS ARE MADE BY THE REED DRILLING TOOLS DIV. A 370 FOOT TRAILING COVEYOR SYSTEM LOADS 5 CAR TRAINS OF 16 CU. YD. CARS AND SO FAR KEEPS UP WITH THE MOLE.

75-69-01001 CLAY HOLE GOES 1,025 FT IN WEEK (ADVANCE SOIL LINING RECORD)
ENGINEERING NEWS-RECORD, (182) 26, JAN 16, 1969. KINNEAR MOODIE AND CO. USING LONDON'S METROPOLITAN WATER BOARD'S SHIELD TYPE MOLE IN SOFT GROUND DROVE 1,025 FT OF 8 FT. 4 IN. TUNNEL LINED HAND PLACED PRECAST CONCRETE SEGMENTS IN ONE THREE-SHIFT, FIVE DAY WEEK.

75-69-02001 VERTICAL MOLE SCORES BULLSEYE IN DEEP SHAFT (GUIDANCE ADVANCE LOST LETTERS POWER THRUST)
ENGINEERING NEWS-RECORD, (182) 28-29, FEB 27, 1969. A CONVENTIONAL ROTARY OIL RIG USING SPECIAL DOWN-THE-HOLE SURVEY EQUIPMENT DRILLED A 10 IN. HOLE FOR A 600 FT DEEP SHAFT. THIS PILOT HOLE WAS REAMED TO 22 IN TO ENGAGE THE NOSE CONE OF A MACHINE BORING TO 8 FT. THE CUTTERHEAD POWERED WITH FOUR 40 HP ELECTRIC MOTORS AND THRUSTING WITH 500,000 LB. CUT THE HOLE IN A MONTH. THE LAST CUT FROM 8 FT TO 12 FT SHOULD TAKE LESS TIME THAN THAT FROM 22 IN. TO 8 FT. SPOIL DROPS TO THE BOTTOM OF THE SHAFT AND IS REMOVED HORIZONTALLY THRU A DRIFT. ROLLING CUTTERS ARE USED TO PENETRATE THE ABRASIVE SANDSTONE AND SHALE WITH COMPRESSIVE STRENGTHS RANGING UP TO 35,000 PSI. THE 12 FT DIAMETER 1,6000 FT DEEP HOLE WILL COST $700,000.

75-69-03001 TUNNELING MACHINE HOLES THROUGH FOUR MONTHS EARLY (ADVANCE EXCAVATION LINING MAINTENANCE)
ENGINEERING NEWS-RECORD, (182) 26-28, MAR 6, 1969. A MEMCO MOLE IS BORING A TOTAL OF 5 MILES OF 26 FT ROUGH DIAMETER TUNNEL IN REDDISH, CLAY-LIKE SANDSTONE THAT IS BARELY CONSOLIDATED. THE SHIELD IS FORCED INTO THE MATERIAL AND WHAT IS INSIDE THE SHIELD IS DUG OUT WITH A HYDRAULICALLY OPERATED SHALLOW BUCKET SIMILAR TO CONVENTIONAL BACKHOES. THREE OF THE FOUR TUNNELS IN THE PROJECT HAVE BEEN COMPLETED. THE MAXIMUM 24 HOUR ADVANCE WAS 202 FT WITH AN AVERAGE OF 113 FT. LINING IS PRECAST, 3 SECTION CONCRETE, 12" THICK AND 4 FT WIDE. HOISTS MOUNTED AT THE REAR OF THE MOLE PLACE THE LINING SEGMENTS. THERE ARE BREAKDOWNS. SUCH AN OPERATION MUST HAVE A CERTAIN AMOUNT OF DOWNTIME, IF ONLY FOR ROUTINE MAINTENANCE. MEMCO SUGGESTED THE STEAM CURED PRECAST LINER SEGMENTS INSTEAD OF THE AGE-OLD STEEL RIBS AND STEEL MINE-TIE LOGGING WHICH WOULD HAVE LIMITED ADVANCE TO 20 TO 24 FT. A DAY. CONSTRUCTION IS NOW FOUR MONTHS AHEAD OF SCHEDULE.

75-69-05001 PIPES JACKED BEHIND MINI-MOLE (CHICAGO-SEWER)
ENGR NEWS-RECORD, (182) 45-46, MAY 15, 1969. MICHIGAN SEWER CONSTR CO AND JAY-DEE CONTRACTORS, INC ARE BUILDING A 2 MILE 66 IN OD SANITARY SEWER FOR CHICAGO USING A SPECIAL MINI-MOLE DEVELOPED BY CARL W. DECKER INC OF DETROIT. THE MOLE MINES FOR THREE FEET THEN THE SEWER PIPE IS JACKED FORWARD AS THE MOLE JACKS RETRACT. MOVEMENT IS LUBRICATED BY BENTONITE. MSD ENGINEERS ESTIMATE THE COST TO BE COMPARABLE TO COST OF A 78 IN SEWER USING CONVENTIONAL METHODS IN IDEAL SOIL.

75-69-06001 TUNNELING BREAKTHROUGH? (MOLE CHEMICAL-SOFTENING)
ENGR NEWS-RECORD, (182) 9, JUNE 5, 1969. MIT PROF. MCGARRY IS MAKING A FULL-SCALE TEST OF CHEMICAL SOFTENING OF THE ROCK-FACE IN THE WHITE PINE COPPER CO MINE IN MICHIGAN. AN ALUMINUM CHLORIDE SOLUTION WILL BE SPRAYED ON THE ROCK IN CONJUNCTION WITH THE MOLE OPERATION.

75-69-07001 MOLE BREAKS THROUGH AFTER 293-FT. DAY AND 1114 FT WEEK (HARD-ROCK WATER-TUNNEL COST RECORD)
ENGINEERING NEWS-RECORD, (183) 28-29, JULY 24, 1969. USING A JARVA MARK 11-1200 MACHINE MARKETED BY THE REED DRILLING TOOLS DIVISION OF G. W. MURPHY INDUSTRIES OF HOUSTON, THE UTAH CONSTRUCTION AND MINING CO. DRILLED A 12 FT DIA, 3.9 MILE HARDROCK TUNNEL THROUGH THE NEVADA RIVER MTS. IN NINE MONTHS, A RECORD SETTING ACCOMPLISHMENT. THE RECORD DRILLING RESULTED IN A 293-FT DAY AND A 1114-FT WEEK. CUTTER COSTS VARIED FROM A FEW CENTS PER FT. IN THE SOFT TUFFS TO $43 PER FT. IN THE MASSIVE RHYODACITES. AVERAGE CUTTER COST FOR THE PROJECT WAS LESS THAN $15 PER FT. MUCK TRANSPORT WAS BY TRAINS GENERALLY MADE UP OF SIX 16-CU-YD CARS, 32 FT LONG SKINNY BOXES DESIGNED TO BE HANDLED BY A CAR DUMPER. PRESENT PLANS CALL FOR 270 LIN FT. OF CONCRETE EACH DAY TO FINISH THE TUNNEL. UTAH'S BID FOR THE PROJECT WAS $3,946,619.

75-69-07002 TRANSIT TUNNEL RUNS OBSTACLE COURSE (BART SHIELD)
ENGR. NEWS-RECORD, (183) 22-23, JULY 3, 1969. PERINI-BROWN & ROOT HOLED THROUGH TWIN TRANSIT TUNNELS ON BARTD TRANSBAY TUBE LINK THREE MONTHS AHEAD OF SCHEDULE IN SPITE OF THE CROWDED CONDITIONS, TRICKY PILE REMOVAL JOB AND UNEXPECTEDLY SOFT GROUND. CONSTRUCTION METHODS REPORTED IN DETAIL.

75-69-07003 THOMPSON RIVER MOLE BORE IS LONGEST IN HARD ROCK (AUSTRALIA WATER-DIVERSION)
ENGR NEWS-RECORD, (183) 18, JULY 31, 1969. BORING A 12 MILE TUNNEL FOR DIVERSION OF THE THOMPSON RIVER TO THE YARRA RIVER AT MELBOURNE WILL START IN SEPT. GUY F. ATKINSON INT. AND JOHN HOLLAND ARE THE CONTRACTORS. FIRST STAGE WILL BE THREE HORSESHOE ADITS AND 2.9 MILES OF CONVENTIONAL TUNNEL. 9.1 MILES OF 11 FT 10 IN DIAMETER TUNNEL WILL BE BORED BY A ROBBINS MOLE.

75-69-08001 3.8 MILES OF TUNNEL BORING IN 190 DAYS (GEOLOGY MACHINE-DRILLING PENETRATION DUST CUTTERS LASER-ALIGNMENT MUCKING VENTILATION COST)
U.S. BUR RECL DENVER COLO
ENGINEERING AND MINING JOURNAL, (170) N 8, 98-99, AUG. 1969. UTAH CONSTRUCTION AND MINING CO. DROVE A 12 FT DIA, 20,000 FT LONG TUNNEL THROUGH THE RIVER MOUNTAIN OF NEVADA, THROUGH 7,000 FT OF 1-5,000 PSI TUFF AND RHYOLITE BRECCIA, 4,000 FT OF 3-10,000 PSI RHYOLITE AND 9,000 FT OF 4-23,000 PSI RHYODACITE WITH A JARVA MARK II-1200 TUNNELING MACHINE FOR $3,946,619 IN 190 DAYS. THIS WAS $50/FT LESS THAN FOR CONVENTIONAL EXCAVATION. TROUBLESOME PROBLEMS WERE CUTTER COST, MUCK HAULAGE LINE AND GRADE CONTROL AND DUST SUPPRESSION. ANCHORING AGAINST SIDE WALLS 620,000 LBS OF THRUST WAS DEVELOPED. CUTTERHEAD WAS ELECTRICALLY DRIVEN AT 9.3 RPM WITH 300 HP MOTOR. REED DRILLING TOOLS SUPPLIED THE CUTTERS. 31 CUTTERS MADE AN ASSEMBLY. HARD RHYODACITES REQUIRED TUNGSTEN CARBIDE INSERTS. QK STEEL WAS USED IN RHYOLITES AND TUFFS. 3 SHIFTS WERE USED 5 DAYS A WEEK. 36 FT LONG MUCK CAR CAPACITY WAS 16 CU-YDS. CALIFORNIA SWITCHING WAS USED TO SWITCH CARS AT THE END OF THE 325 FT LONG CONVEYOR TRAILING FROM THE BORING MACHINE. A UNIVERSITY LABORATORY MODEL 650 LASER PROVIDED LINE AND GRADE CONTROL. 18,000 CFM NEGATIVE PRESSURE SUPPRESSED DUST SATISFACTORILY. WATER WAS SUPPLIED FOR COOLING THE HYDRAULIC SYSTEM, DUST SUPPRESSION AND DRILLING.

75-69-09001 RUSSIAN ROCKET DEVELOPMENT REACHES NEW LOW (HORIZONTAL-BORING)
LOWE, J. F.
DESIGN NEWS, 30-31, SEPT. 29, 1969. A ROCKET INVENTED IN RUSSIA, MARKETED BY A WEST GERMAN COMPANY IS BEING USED IN WESTERN EUROPE TO ASSIST IN LAYING PIPES AND CABLES UNDER ROADS. THE PROJECTILE SHAPED BODY FORCES ITS WAY THROUGH SOIL AND SAND BY TRANSFER OF MOMENTUM GENERATED BY AN INTERNALLY VIBRATING MASS. IT IS POWERED BY COMPRESSED AIR AT 6 ATM. HOLE SIZE IS 135 MM BUT EXPANSION DEVICES CAN BE USED TO PROVIDE EITHER 200 OR 250 MM. SPEED OF ADVANCE VARIES FROM 8 METERS/HR IN FROZEN GROUND TO 25 METERS/HR IN AVERAGE COMPACT.

75-69-09002 BORING RESEARCH - FEDERAL PROGRAMS SPARK ADVANCES IN TUNNELING (CHEMICAL-SOFTENING ROBBINS WHITE-PINE COST-ANALYSIS MATERIALS-HANDLING)
ENGR NEWS-RECORD, (183) 23, SEPT 4, 1969. DEPT OF TRANSPORTATION HAS AWARDED A CONTRACT TO HARZA ENGR CO OF CHICAGO TO DEVELOP A COMPUTER PROGRAM FOR ESTIMATING COST OF TUNNELS AND ONE TO HOLMES AND NARVER, INC OF LOS ANGELES FOR A SYSTEMS STUDY OF MATERIALS HANDLING. MIT PROFESSORS MCGARRY AND MOAVENZADEH ARE RUNNING TESTS IN THE WHITE PINE COPPER CO MINE USING A ROBBINS MOLE WITH CHEMICAL SOFTENERS ADDED. THEY REPORT 10 TO 12% INCREASE IN THE RATE OF ADVANCE.

75-69-10001 TUNNEL SHIELD STALLS (STRAIGHT-CREEK COLORADO)
ENGR NEWS-RECORD, (183) 54, OCT. 30, 1969. FAILURE OF BEARINGS STALLED THE SHIELD USED ON THE STRAIGHT CREEK TUNNEL AND WILL BE OUT OF OPERATION 2 TO 3 MONTHS.

75-70-01001 AUGER TEAMS WITH SHIELD TO CUT MIXED TUNNEL FACE (ADVANCE LINING MUCK MOLE)
SMITH, L.
CONSTRUCTION METHODS & EQUIPMENT, (52) NO. 1, 104-106, JAN 1970. BORTUNCO CONSTRUCTED AN AUGERING RIG TO MAKE THE 74 IN. BORE 90 FT UNDER THE HIGHWAY AND 45 FT UNDER THE RAILROAD SEPARATED FROM EACH OTHER BY 30 FT. OF RIGHT-OF-WAY. FIRST A 4 IN. PILOT HOLE WAS BORED AND THIS REAMED TO 7 IN. TO ACCOMMODATE A 5 1/2 IN. DIA DRILL STEM 165 FT LONG. THE SPIRAL SINGLE FLIGHTED AUGER SHAVED THE FACE WHICH WAS TWO THIRDS SOFT LIMESTONE AND UPPER THIRD ROTTEN CLAY WHICH REQUIRED OPERATION INSIDE A SHIELD. RATE OF ADVANCE AVERAGED ONE FT PER HR. A 72 IN. CONCRETE PIPE WAS JACKED INTO THE BORED TUNNEL AS THE SHIELD ADVANCED SO AS TO KEEP THE PIPE ALWAYS WITHIN THE SHIELD. BY HAVING THE DRIVING MECHANISM AT THE FAR END OF THE TUNNEL THE BORE WAS CLEAR FOR THE MUCKING OPERATION.

75-70-01002 TUNNELERS STAKE THEIR CLAIMS (MOLE ADVANCE CLAY SANDSTONE RECORD)
ENGINEERING NEWS-RECORD, (184) N 2, 3, JAN 8 1970. EDMUND NUTTAL, SONS & CO. USING A MOLE IN CLAY BUILT 1,426 FT OF 9 FT 5 IN DIAMETER PRECAST CONCRETE SEGMENT LINED TUNNEL IN A WEEK. BEST SINGLE SHIFT WAS 120 FT IN 12 HOURS. THE MELBOURNE AND METROPOLITON BOARD OF WORKS USING A TUNNELING MACHINE IN MUDSTONE BUILT 752 FT OF 12 FT 8 IN DIAMETER FULL STEEL SUPPORTED TUNNEL IN A WEEK. BEST 8 HOUR SHIFT WAS 67 FT.

75-70-01003 1200,000 THRUSTING CONTRACTS AT SLOUGH AND EPSOM (SEERTHRUST PIPEJACKING ENGLAND)
TUNNELS AND TUNNELING, (2) NO 1, 29, JAN. 1970. WM. F. REES IS INSTALLING AN 8 FT X 4 FT RECTANGULAR BOX CULVERT UNDER THE MOTORWAY AT SLOUGH USING THEIR PATENTED SEERTHRUST TECHNIQUE. THE TUNNEL WILL BE 1150 YDS LONG. THE 3500 FT INTERCEPTOR SEWER AT EPSON WILL BE INSTALLED BY THE SAME METHOD.

75-70-01004 BSP LINKS WITH NUTTALL ON TUNNEL DRIVING MACHINES (SHIELDS MOLES ENGLAND)
TUNNELS AND TUNNELING, (2) NO 1, 12, JAN. 1970. THE BRITISH STEEL PILING CO OF CLAYDON, IPSWICH HAS BEEN APPOINTED SOLE AGENTS FOR THE WORLDWIDE MARKETING OF THE TUNNEL DRIVING MACHINES DESIGNED AND BUILT BY ROBT. E. PRIESTLY LTD A SUBSIDIARY OF EDMUND NUTTALL SONS & CO.

75-70-01006 WORLD TUNNELING RECORD FOR NUTTALLS (SHIELD ENGLAND)
TUNNELS AND TUNNELING, (2) NO 1, 38, JAN. 1970. THE EDMUND NUTTALL SONS & CO OF LONDON SET A NEW TUNNELING RECORD BY A ONE WEEK ADVANCE OF 1425 FT 10 IN OF A 9 FT 5 IN DIA PRECAST CONCRETE LINED TUNNEL THROUGH GAULT CLAY FOR THE ESSEX RIVER AUTHORITY. THE WEEK WAS THE ONE BEGINNING ON MONDAY 1 DEC. 1969.

75-70-01007 LASER STEERS BIG MOLE IN BAD ROCK UNDER LAKE (ALKIRK LAWRENCE WATER-SUPPLY)
ENGR NEWS-RECORD, (184) 26-28, JAN. 8, 1970. AN ALKIRK MOLE, MANUFACTURED BY LAWRENCE CO IS BORING A 6 MILE 18 1/3 FT DIA TUNNEL UNDER LAKE HURON FOR THE DETROIT METROPOLITAN WATER SERVICE BOARD. THE CONTRACTORS - DIPONIO AND GREENFIELD - HAVE A $13.7 MILLION CONTRACT FOR THE TUNNEL. A LASER GUIDES THE MACHINE AUTOMATICALLY. THE FORMATION IS ANTRAM SHALE WITH BOULDER-LIKE HARDHEADS OF SOMETHING LIKE DOLOMITE. THE HARDHEADS GAVE THE MOLE NO TROUBLE BUT THE FAULTS IN THE SHALE DID. A DRILLING AND BOLTING STATION WAS INSTALLED UNDER PROTECTION OF THE MOLES SHIELD SO THAT ROCK BOLTS COULD BE INSTALLED EARLY.

75-70-01008 JET, MOLE TEAM SEEKS TUNNELING BREAKTHROUGH (CALWELD EXOTECH)
ENGR NEWS-RECORD, (184) 48, JAN. 22, 1970. EXOTECH, INC OF ROCKVILLE, MD MAKER OF A WATER CANNON AND CALWELD DIVISION OF SMITH INTERNATIONAL HAVE JOINED FORCES TO PRODUCE A WATER-CANNON MOLE.

75-70-02001 JARVA MARK 21 BORES 6900 FT OF 20 FT DIA TUNNEL AT 5 FT/HR (MOLE RECORD CUTTER-COST)
CONSTRUCTION METHODS & EQUIPMENT, (52) NO 2, 143, FEB 1970. THE 280 TON JARVA MARK 21 AVERAGED 5 FT/HR BORING 6900 FT OF 20 FT DIA TUNNEL FOR BAY AREA RAPID TRANSIT SYSTEM IN SAN FRANCISCO. REED CUTTERS USED TO DRILL MOST OF THE DISTANCE 50% OF CUTTERS LASTED MORE THAN 1000 HRS. MORE THAN 37% CUT THE ENTIRE DISTANCE. CUTTER COST AVERAGED $30/LIN FT.

75-70-03001 MCALPINE WIN ORDER FROM FRANCE FOR TWO ROCK TUNNELERS
TUNNELS AND TUNNELING, (2) NO 2, 66, MAR. 1970. MCALPINE HAS SOLD TWO SECOND-GENERATION ROCK-TUNNELING MACHINES TO ETABLISSEMENTS BILLIARD, THE FRENCH CONTRACTOR FOR THE ST. MAXIMIN PROJECT IN SOUTHERN FRANCE IN THE FACE OF OPPOSITION FROM U.S.A. AND OTHER EUROPEAN MANUFACTURERS. THE MACHINES WILL BE USED TO EXCAVATE A 7 KM LONG WATER SUPPLY TUNNEL IN LIMESTONE ROCK. TWO OTHER MACHINES WERE SOLD TO CHARLES BRAND & SON LTD IN JUNE 1969 AND ANOTHER IS WORKING AT THE HINKLEY NUCLEAR POWER STATION IN ENGLAND.

75-70-04001 MOLE ANCHORS IN PILOT HOLE & PULLS ITSELF AHEAD (ALKIRK CUTTERS GUIDANCE ADVANCE ROCK-BOLT MUCK)
KOLBENSCHLAG, M.
CONSTRUCTION METHODS & EQUIPMENT, 87-95, APR 1970. AN ALKIRK MOLE MADE BY LAWRENCE MFG DIV OF INGERSOLL-RAND CO BORES A 24 IN DIA LEAD HOLE WITH A TRICONE CARBIDE BIT, ELEVEN FT IN FRONT OF CUTTER FACE. THE MOLE HAS 30 ONE FT. DIA. CUTTER WHEELS ON THE CUTTER FACE. A HYDRAULICALLY EXPANDED ANCHOR IN THE LEAD HOLE PULLS THE 18 FT 4 IN. DIA. CUTTER HEAD FORWARD IN 2 FT. STEPS. A LASER SYSTEM KEEPS THE 500 TON SYSTEM ON COURSE BY STEERING WITH RIB JACKS. THE ANTRAM SHALE HAS A NUMBER OF DOLOMITE TYPE DEPOSITS WHICH HAVE NOT GIVEN THE CUTTERS ANY TROUBLE. GROUND THAT HAD NEVER SEEN AIR DRIED, SHORTLY AFTER IT WAS BORED, FROM AIR EXPOSURE AND HUGE PORTIONS WOULD SUDDENLY FALL. TO REMEDY THIS SOME SHIELD NEAREST THE CUTTER WAS REMOVED SO ROCK BOLTS COULD BE INSERTED MINUTES AFTER BORING AND A BACKUP CREW ERECTED ADDITIONAL SUPPORTS AND STEEL PANNING. AN EXCEPTIONAL ADVANCE OF 113 FT. WAS MADE IN JUST UNDER 76 HOURS. SO FAR THE MACHINE HAS BEEN IN A DIFFICULT ROCK AREA BUT IT IS EXPECTED TO HIT AN 8 FT. PER HR STRIDE. LAST MONTH 8,000 FT OF THE 6 MILE TUNNEL TO BRING WATER FROM LAKE HURON TO DETROIT WAS BORED. MUCKING IS DONE WITH CONVEYOR BELT AND 10 CU. YD. CARS WHICH ARE HOISTED TO THE SURFACE.

75-70-04002 REMARKS BY OFFICERS AT ANNUAL MEETING (MOLES DETROIT CHICAGO BOSTON ARIZONA LAWRENCE LASER-GUIDANCE)
WEARLY, W. L. & INGERSOLL-RAND
FIRST QUARTERLY REPORT 1970. APR 23, 1970. LAWRENCE MFG CO HAS TUNNELING MACHINES BORING: (1) A 6 MI 18 FT OF WATER TUNNEL FOR DETROIT; (2) 5 MI O-& 6 66 OEWER TUNNELS IN CHICAGO; (3) A 9000 FT 12 1/2 FT ORE HAULAGE TUNNEL FOR MAGMA COPPER MINE IN ARIZONA AND (4) A 6 1/4 MI WATER TUNNEL IN BOSTON. NEW MACHINES ARE BEING BUILT FOR ITALY AND SOUTH AFRICA. THE MACHINES ARE AUTOMATICALLY GUIDED BY LASER. A REDUCTION OF COST BY 50% IS CLAIMED.

75-70-06001 MOLE READIES FOR TWIN MERSEY BORE AFTER TROUBLE-PRONE FIRST DRIVE (MOLE LINING)
ENGR. NEWS-RECORD, (184) 21-22, JUNE 4, 1970. THE CONTRACTOR FOR THE FIRST MERSEY TUNNEL HAS STARTED DRIVING THE PILOT BORE FOR THE SECOND TUNNEL USING A SPECIALLY BUILT 11 FT MOLE. THE MOLE BORING THE LARGE MAIN TUNNELS IS THE SAME MACHINE THAT BORED THE MANGLA DAM TUNNELS. THE GOING WAS HEAVY AND SLOW ON THE MAIN TUNNEL. THE ROOF HAD TO BE SUPPORTED IN A BADLY FAULTED ZONE FOR ABOUT 600 FT. USING ROOF BOLTS WOULD HAVE DAMAGED THE MOLES CUTTERS SO THE CONTRACTOR RAMMED BAMBOO POLES INTO HOLES DRILLED IN THE ROOF, THEN FORCED GROUT INTO THE FORMATION THROUGH THE BAMBOO POLES. THE MOLE THEN DRILLED THROUGH BAMBOO POLES AND CEMENT WITHOUT DAMAGING ITS TEETH.

75-70-07001 MOLE PESTS MEXICO CITY'S TREACHEROUS SUBSOIL (SOFT-GROUND-TUNNELING-MACHINES)
ENGR. NEWS-RECORD, (185) 20-21, JULY 2, 1970. THREE SOFT GROUND TUNNELING MACHINES OF ENGLISH MANUFACTURE ARE DRIVING 18 MILES OF INTERCEPTOR SEWERS FOR MEXICO CITY'S $132 MILLION SEWER IMPROVEMENT SYSTEM. MEXICAN FIRMS CONSTRUCTORA ESTRELLA, S.A., CAMINOS Y URBANIZACIONES, S.A. AND CONSTRUCCIONES URBANAS HAVE ESTABLISHED CM INFORMAL CONSORTIUM TO EXCHANGE IDEAS AND EXPERIENCE. THE MOLES MAKE A SLURRY OUT OF MUCK (USING GROUND WATER FOUND IN THE SOIL) AND PUMP THE SLURRY TO THE SURFACE. A SMALL RECYCLE STREAM OF MUCK SLURRY IS USED TO PRESSINIZE THE BULKHEADED CUTTING HEAD UP TO 75 PSI.

FIELD 76 COMPANY BROCHURES

76-66-05001 SEWER MOLE TRIMS COST OF TUNNEL RIBS & CONCRETE (CUTTERS HARD LINING SEEPAGE ROCK)
CONSTRUCTION METHODS & EQUIPMENT, MAY 1966 (REPRINT). ON A ST LOUIS SEWER PROJECT THERE WERE FIVE DISTINCT ADVANTAGES IN MECHANICAL BORING OVER DRILL AND SHOOT: REDUCES QUANTITY OF CONCRETE FOR LINING, REQUIRES LESS SUPPORT, REDUCES WATER SEEPAGE, CAN PROCEED IN AREAS WHERE BLASTING IS EITHER IMPOSSIBLE OR EXTREMELY IMPRACTICAL DUE TO SURFACE CONDITIONS, FEWER MEN ARE REQUIRED. THESE WERE CONCLUSIONS FROM DRIVING 23,000 FT OF 6, 6 1/2 & 7 FT DIAMETER TUNNEL IN ROCK. TUNNELING IS BEING DONE IN LIMESTONE WITH CHERT STRATA AND OCCASIONAL ZONES OF HEAVY LAMINATION HAVING COMPRESSIVE STRENGTH RANGES FROM 12,000 TO 15,000 PSI. BEST ADVANCE WAS 5 FT PER HR WITH AN AVERAGE OF 4 FT. PER HR AND A MAXIMUM OF 71 FT PER DAY. REEDS SM-4 MACHINE IS 18 FT LONG, WEIGHS 28 TONS, HAS AN 11,9 RPM ROTATING HEAD AND A 2,000 PSI HYDRAULIC SYSTEM. CHANGING FROM AC SINTERED CARBIDE BUTTON INSERTS TO QKC TUNGSTEN CARBIDE BUTTONS IN CIRCUMFERENTIAL KERF PATTERN INCREASED ADVANCE BY ONE FT. PER HR. WITH A 500 HR. LIFE. SCRAPERS ADDED TO THE CUTTING WHEEL TO CLEAN FINES HAVE INCREASED CUTTER LIFE. A VAPOR CURTAIN WITH SPECIAL WETTING AGENT SATISFACTORILY SUPPRESSES DUST. MATCHING THE CUTTER TO THE FORMATION IS A PRIME CONSIDERATION AND FIVE INTERCHANGEABLE CUTTERS ARE ILLUSTRATED AND DESCRIBED.

76-68-02001 CALWELD BORING SYSTEM - THE ONLY WAY TO TUNNEL (MOLE)
ENGINEERING NEWS-RECORD, (180) 52, MAR 21, 1968. CALWELD, DIVISION OF SMITH INDUSTRIES INTERNATIONAL GIVES A PERFORMANCE SCORE CARD FOR ITS MACHINES AT TWENTY LOCATIONS WHICH RANGED 7 FT TO 26 FT IN DIAMETER AND FROM 4,500 FT TO 4.5 MILES LONG IN MATERIALS FROM CLAY TO SANDSTONE.

76-68-05001 BART'S FIRST COMPRESSED AIR JOB (SUBWAY MOLE)
WESTERN CONSTRUCTION, MAY 1968. TWO 17.5 FEET O.D. STEEL LINED TUNNELS ARE BEING DRILLED BY MOLES BUILT BY MEMCO. EACH USES 14 PLANETARY GEAR UNITS FOR A COMBINED TORQUE OF 1,900,000 FT. LB. MUCK IS CARRIED BY 165 FT. LONG CONVEYOR. DEWATERING LOWERS PRESSURE REQUIREMENT TO KEEP OUT GROUND WATER TO BETWEEN 11 AND 13 1/2 PSIG. A MINE HOIST HANDLES MUCK.

76-68-09001 JARVA TUNNELING MACHINES-REED TUNNELING CUTTERS (BORE SADDLES PENETRATION-RATE ROCK-TESTING DESIGN)
REED DRILLING TOOLS, G. W. MURPHY IND, TB-2.5M-9-68. THIS BROCHURE PROVIDES CATALOG DESCRIPTION AND SPECIFICATION DATA FOR TUNNELING MACHINES MANUFACTURED BY JARVA INC AND SOLD EXCLUSIVELY BY REED DRILLING TOOLS. MACHINES RANGE IN BORE SIZE FROM 8 FT TO 21 FT. CUTTERS, CUTTER AND SADDLE DESIGN AND AVAILABILITY OF LABORATORY ROCK DRILLABILITY TESTING ARE ALSO DESCRIBED. MACHINE OPTIONS ARE DESCRIBED BRIEFLY AND TENTATIVE SPECIFICATIONS FOR LARGER MACHINES, 24, 29, AND 32 FT BORE ARE INCLUDED. ACTUAL MACHINE APPLICATIONS ARE LISTED IN BRIEF SPECIFICATION LISTING FOR ELEVEN TUNNELS.

76-68-09002 REED BIG HOLE PRODUCTS (CUTTERS-DRILLING-BITS REAMING RAISE-BORING ENGINEERING-DATA)
REED DRILLING TOOLS, G. W. MURPHY IND, PRODUCT BROCHURE UNDATED AND NOT NUMBERED. THIS BROCHURE IS A DESCRIPTION OF VARIOUS PRODUCTS OF REED DRILLING TOOLS. FEATURED ARE CUTTER DESIGN, SADDLES, VARIOUS TYPES OF CUTTERS, SHAFT DRILLING BITS, REAMING BITS, RAISE BORE BITS, TUNNELING AND AVAILABILITY OF LABORATORY LISTING SERVICE FOR ROCK DRILLABILITY ANALYSIS. BROCHURE ALSO PROVIDES ENGINEERING DATA INCLUDING SPECIFIC WEIGHTS AND GRAVITIES FOR A WIDE RANGE OF TUNNELING MEDIA PLUS RELATIVE CONVERSION TABLES.

76-68-10001 TUNNELING THROUGH ROCK (TUNNELING-DEVICES MOLES DRILL-BLAST-MUCK)
VAN WALSUM, F. & PER HALL ASSOCIATES MONTREAL
PER HALL ASSOCIATES BROCHURE, OCT 7, 1968. THE BROCHURE PROPOSES A NEW COMBINED METHOD OF TUNNELING, BY COMBINING BLASTING AND TUNNELING BY MOLE, IN ONE OPERATION. IT DISCUSSES SOME OF TUNNELING PROBLEMS SUCH AS WATER INFLOW OVERBREAK, SCALING OF ROCK SURFACES AND VENTILATION. THE METHOD SHOULD BE FASTER THAN CONVENTIONAL METHODS. THE METHOD CAN BE USED ONLY FOR LARGE DIA. HOLES.

76-69-02001 CALWELD RAPID EXCAVATION FOR RAPID TRANSIT (MOLE GRILL TUNNEL CUTTER)
ENGINEERING NEWS-RECORD, (182) 64-65, FEB 6, 1969. IN THE CALWELD TUNNELING AND DRILLING EQUIPMENT ADVERTISEMENT A PHOTOGRAPH IS SHOWN OF THE 26 FOOT DIAMETER OSCILLATING MACHINE FOR THE 17,000 FT. MUNICH SUBWAY. ALSO A PICTURE IS SHOWN OF ONE OF ITS POWERFUL DRILLING UNITS. SUCH UNITS CAPABLE OF DRILLING HOLES FROM 12 IN. TO 240 IN. DIAMETER AND BUCKET TYPE DRILLING RIGS WILL BE FOUND ON ALMOST EVERY RAPID TRANSIT JOB. MOLES HAVE ALSO BEEN USED IN WATER AND SEWAGE PROJECTS THROUGHOUT THE WORLD.

76-70-00001 FRESH WATER FOR DETROIT (MOLE RECORD)
INGERSOLL-RAND COMPANY 1969 ANNUAL REPORT, 12, 1970. A LAWRENCE CO TUNNEL BORING MACHINE IS BEING USED TO DRILL A 6 MI 18 FT 4 IN DIA FRESH WATER TUNNEL UNDER LAKE HURON FOR DETROIT. RECORD ADVANCE WAS 100 FT/SHIFT.

76-70-00002 BIG ORDER DEPARTMENT (MOLE)
INGERSOLL-RAND COMPANY 1969 ANNUAL REPORT, 13, 1970. MAGMA COPPER CO HAS ORDERED A 12 1/2 FT DIA LAWRENCE CO TUNNEL BORING MACHINE TO CUT A 9000 FT LONG HAULAGE TUNNEL THROUGH QUARTZITE

76-70-01001 TUNNELING SHIELDS LARGE AND SMALL
TUNNELS AND TUNNELING, (2) NO 1, 6, JAN. 1970. JOSEPH WESTWOOD & CO LTD OF LONDON ADVERTISEMENT LISTS 13 TUNNELING SHIELDS (17 FT 4.5 IN DIA) SUPPLIED TO THE VICTORIA LINE PROJECT OF THE LONDON TRANSPORT BOARD. ALSO LISTED ARE A 37 FT 9 IN SHIELD FOR HEATHROW AIRPORT TUNNEL, TWO 32 FT 5 IN SHIELDS FOR CLYDE, ONE 34 FT 3 IN SHIELD FOR TYNE, TWO 31 FT SHIELDS FOR POTTERS BAR A 5 FT 6 IN ID SHIELD FOR THE CITY OF MANCHESTER, A 7 FT 7 IN SHIELD FOR THE BOURNEMOUTH SEWER AND TWO 9 FT 7.75 IN ID SHIELDS FOR THE YARDLEY-TYBURN SEWER.

76-70-01002 NEW NOSE SECTION STEPS UP GOPHERS SPEED
ENGR NEWS-RECORD, (184) 123, JAN. 22, 1970. SCHRAMM, INC HAVE INSTALLED A NEW HELICAL GROOVED NOSE SECTION ON THEIR AIR-ACTIVATED, IMPACT-BORING TOOL CALLED PNEUMAGOPHER TO IMPROVE ITS PERFORMANCE IN WET AND SLIPPING SUBSOILS.

76-70-03001 THE SECOND GENERATION GREENSIDE-MCALPINE ROCK TUNNELER
TUNNELS AND TUNNELING, (2) NO 2, 55, MAR. 1970. MCALPINE CONTINUOUS RESEARCH AND DEVELOPMENT PROGRAM COMBINES MCALPINE'S EXPERIENCE IN SOFT GROUND AND HARD ROCK TUNNELING WITH GREENSIDE CO'S KNOWLEDGE OF MACHINE TUNNELING IN THE MINING INDUSTRY. THE SECOND GENERATION MACHINE INCLUDES VARIABLE DIAMETER, CLEAR ACCESS TO FACE, SELF WALKING-FORWARD AND REVERSE, SMOOTH ACCURATE DIMENSIONED BORE, RADIAL CUTTING ACTION AND SIMPLE DESIGN FOR EASY MAINTENANCE IN THE TUNNEL. ADV. BY SIR ROBERT MCALPINE AND SONS.

76-70-03002 LASER SAVES LABOUR IN LINE-UP FOR THE NEW MERSEY TUNNEL (ALIGNMENT ENGLAND)
TUNNELS AND TUNNELING, (2) NO 2, 63, MAR. 1970. NUTTAL ATKINSON & CO, MAIN CONTRACTORS FOR THE SECOND MERSEY TUNNEL ARE USING LASERS TO CREATE REFERENCE LINES. FERRANTI LASER ADV.

76-70-03003 WIRTH TUNNEL BORING MACHINE BORES FULL PROFILE IN SCANDINAVIAN GRANITE (MOLE SWEDEN)
TUNNELS AND TUNNELING, (2) NO 2, 94, MAR. 1970. ALFRED WIRTH AND CO OF GERMANY ADVERTISEMENT GIVES DATA ON 2.4 METER DIA MACHINE WHICH IS BORING A 450 METER SEWER FOR THE MUNICIPAL AUTH OF SOLVA AT STOCKHOLM.

76-70-04001 JARVA MARK 21 BORES 6900 FT OF 20 FT DIA. TUNNEL AT 5 FT PER HOUR (MOLE ADVANCE BART CUTTERS)
REED DRILLING TOOLS HOUSTON TEX
CONSTRUCTION METHODS & EQUIPMENT, 89, APR 1970. THE 280 TON JARVA MARK 21 TUNNELING MACHINE AVERAGED 5 FT PER HOUR

BORING 6900 FT OF 20 FT. DIA. BART TUNNEL. ROCK RANGED FROM 1000 TO 40,000 PSI. AVERAGE CUTTER COST WITH REED QKC CUTTERS WAS ABOUT 30 DOLLARS PER LINEAR FT.

76-70-05001 BSP-NUTTALL TUNNELING MACHINES (WORLD-RECORD)
TUNNELS AND TUNNELING, (2), NO 3, COVER, MAY 1970. MACHINES BASED ON EXPERIENCE OF EDMUND NUTTALL, SONS & CO (LONDON) LTD, DESIGNED AND MANUFACTURED BY R.L. PRIESTLY, LTD ARE AVAILABLE FOR TUNNELING JOBS THROUGHOUT THE WORLD FROM BRITISH STEEL PILING CO, LTD. ONE OF THESE MACHINES HOLDS THE WORLD RECORD FOR SOFT GROUND TUNNELING 1427 FT IN 7 DAYS.

76-70-05002 BORING MACHINE CUTS THROUGH HARD ROCK IN COLORADO MINE (CALWELD MOLE)
ENGR. NEWS-RECORD, (184) 93, MAY 31, 1970. A 13 FT DIA CALWELD MOLE CAN CUT THROUGH HARD ROCK FORMATIONS RANGING UP TO 35,000 PSI. IT IS NOW WORKING IN A MINE NEAR CLIMAX COLO. IT HAS AN OPEN-SPOKED ROTARY CUTTING WHEEL WITH CARBIDE CUTTERS. HYDRAULIC RAMS EXTEND 8 SHOES AGAINST THE TUNNEL WALL WHILE CUTTERHEAD ADVANCES.

76-70-06001 ROCK TUNNEL SUMMARIES (CHICAGO SEWERS MOLES LAWRENCE ROBBINS JARVA)
LETTER FROM S & M CONSTRUCTORS TO M. TIERNEY, JUNE 25, 1970. A LIST OF THE CHARACTERISTICS OF THE JARVA MARK 21 MACHINE WORKING ON THE CALUMET 18E EXT A CONTRACT, THE JAMES S. ROBBINS MACHINE WORKING ON CONTRACT SWIS 13A, AND THE 2 LAWRENCE MACHINES WORKING ON THE LAWRENCE AVENUE SEWER SYSTEMS CONTRACT NO 1.

FIELD 8 MISCELLANEOUS

FIELD 82 SYMPOSIA

82-69-10001 LASER CONTROL FOR CURVILINEAR TUNNEL CONSTRUCTION (SURVEYING-CREW ECONOMY ACCURACY SIMPLICITY)
COLSON, G. P. & ENGR FIELD SERVICES
SACRAMENTO STATE COLLEGE CAL SECOND SYMP ON RAPID EXCAVATION, 6-1 TO 6-11 OCT. 16, 1969. A PATENT "TUNNELASER" SYSTEM IS DESCRIBED. IT IS IMPORTANT TO REALIZE THAT THE LASER SYSTEM IS ONLY AS GOOD AS THE SURVEYING ON WHICH IT IS BASED. THE TUNNELASER SYSTEM WAS DEVELOPED TO MINIMIZE SURVEY CREW TIME AND TO FURNISH PRECISE VISUAL CONTROL FOR TUNNELING MACHINE GUIDANCE. ON A RADIUS OF 500 FEET, THE LENGTH OF RUN IS ABOUT 75 FEET. A TUNNELASER SYSTEM HAS ADVANTAGES OVER A STANDARD SURVEYING CREW IN ECONOMY, ACCURACY AND SIMPLICITY.

FIELD 83 GOVERNMENT REPORTS

83-22-00001 APPLICATION OF THE GEOPHONE TO MINING OPERATIONS (INSTRUMENTS VIBRATIONS)
LEIGHTON, A. & U.S. BUR MINES
U.S. BUR MINES, TECHNICAL PAPER 277, 1922. THE GEOPHONE IS AN ADAPTATION OF THE LISTENING DEVICES DEVELOPED DURING WWI BY THE FRENCH AND ENGLISH TO LISTEN FOR MINING ACTIVITIES OF THE ENEMY. IT IS SIMILAR IN PRINCIPLE TO THE SEISMOGRAPH IN THAT IT HAS A HEAVY SUSPENDED WEIGHT ATTACHED TO AN ELASTIC DIAPHRAGM. BY USING TWO GEOPHONES, THE ORIGIN OF A SOUND CAN BE OBTAINED FAIRLY ACCURATELY BY TRIANGULATION. IT CAN BE USED TO LOCATE BREAKS IN PIPES, TO LOCATE MINERS TRAPPED BELOW THE SURFACE. DETAILS OF THE DESIGN OF THE GEOPHONES ARE GIVEN AND AN EXTENSIVE DISCUSSION OF THE TECHNIQUES OF EMPLOYMENT IS GIVEN. 31 PAGES, 3 TABLES, 14 ILLUSTRATIONS.

FIELD 84 ARTICLES

84-59-08001 HIGHWALL AUGERING WITH A TWIN-AUGER (COAL-MINING THIN-SEAMS DRILLING BENCH-OPERATION PRODUCTION)
KARNAP, J. R. & ELM DEV CO
MINING CONGRESS JOURNAL, 69-70, AUG 1959. ALTHOUGH RELATIVELY NEW, AUGER MINING IS NOW RESPONSIBLE FOR APPROXIMATELY 10 MILLION TONS OF COAL PER YEAR. THIS ARTICLE OUTLINES THE DEVELOPMENT OF THE TWIN AUGER MACHINE AND FEATURES THE APPLICATION OF A 24 IN MODEL WITH A DESCRIPTION OF ITS OPERATION AND TECHNIQUES USED IN MINING A 30 IN SEAM IN A BENCH OPERATION.

84-64-08001 OPERATIONAL EXPERIENCES WITH A SKI-LIFT TYPE MANRIDER
HAMILTON, R. C. + GRAINGER, A. A. & DENBY HALL COLLIERY
COLLIERY GUARDIAN, 189-199, AUG 7, 1966. A SKI-LIFT IS USED TO TRANSPORT WORKERS. THE SKI-LIFT INSTALLATION HAS INCREASED THE TIME AVAILABLE AT THE COAL FACES BY 23 MINS. THE TIME SAVING IS EQUIVALENT TO AN INCREASE IN PRODUCTION OF 88 TON/DAY. THE WAITING TIMES ARE ELIMINATED AND A CONTINUAL FLOW OF WORKMEN IS ACHIEVED.

84-64-12001 TRENDS IN RAISE MECHANIZATION (BIRD-CAGING REAMING)
KELLOGG, J. L. & CERRO CORP
MINING CONGRESS JOURNAL, 42-47, DEC 1964. "BIRD CAGING" IS USED TO DRIVE A RAISE FROM AN UNDERLYING TUNNEL TO THE SURFACE OR ANOTHER TUNNEL. PILOT HOLE IS DRILLED FROM ABOVE AND A WIRE ROPE IS FED THROUGH, ATTACHED TO A WINCH AT THE TOP OF THE HOLE, AND TO A CAGE IN THE TUNNEL. THE CAGE SERVES AS A WORK PLATFORM TO DRILL AND BLAST THE RAISE. ONE DRAWBACK OF BIRD CAGING WAS THE NEED FOR A PILOT HOLE. SWEDISH MINERS INTRODUCED CAGES THAT CLIMB A TOOTHED RAIL ANCHORED TO THE RAISE SIDES WITH ROCK BOLTS. THE CAGE IS POWERED BY AIR-MOTORS AND THE AIR HOSE THAT TRAILS THE CAGE IS FED FROM A HOSE-REEL IN THE TUNNEL. IN THE PAST FEW YEARS, NEW METALS AND MORE ADVANCED ENGINEERING HAVE INCREASED THE USE OF REAMING RAISES. THERE HAVE BEEN TWO APPROACHES TO REAMING, ONE TO SET UP ON TOP OF THE RAISE, DRILL THE PILOT HOLE DOWN AND REAM BACK UP, AND THE OTHER TO SET UP AT THE BOTTOM, DRILL THE PILOT HOLE UP AND REAM BACK DOWN.

84-66-01001 CORE DRILL STANDARD PROVIDES FOR INTERCHANGEABILITY
STARK, J. & JOY MFG CO
THE MAGAZINE OF STANDARDS, 22-24, JAN 1966. THE DIAMOND CORE DRILL MFG ASSOCIATION, DCDMA, HAS DEVELOPED A STANDARD (ASA-B104.1-1964) WHICH CONTAINS NOMENCLATURE AND DIMENSIONS FOR VARIOUS DESIGNS OF DRILL RODS, COUPLINGS, CORE BARRELS, FLUSH COUPLED CASINGS, CASING SHOES AND BITS, AND REAMING SHELLS, FOR CORE DRILLS OF SIZES 1 13/16, 2 1/4, 2 7/8 AND 3 1/2 O.D. CASING. A NEW "X" GROUP OF NESTABLE CASINGS ALLOWS ANY COMBINATION OF CASINGS TO BE USED IN ORDINARY DRILLING. A NEW DRILL ROD WAS SPECIFICALLY DESIGNED FOR BALANCED OPERATION IN THE "X" DESIGN GROUP OF HOLE SIZES.

84-66-06001 MINING AT NEVADA TEST SITE COMES UP WITH NEW ADAPTATIONS OF EQUIPMENT (BIG-HOLE-DRILLING)
WALTMANN, F. D.
MINING ENGINEERING, 67-68, JUNE 1966. THE ARTICLE DISCUSSES NEW ADAPTATIONS OF EQUIPMENT SUCH AS IT HAS BEEN PACKAGED TO DECREASE TIME AND COST OF " SET UP " AND "TAKE DOWN". MOBILITY OF SURFACE EQUIPMENT IS STRESSED. DOWNHOLE INSTALLATION EMPLOYS UNITIZED CONSTRUCTION. VORTEX TUBES ARE USED IN VENTILATION.

84-67-03001 THAT ORNERY ABUSED ROCK DRILL CAN BE A SMOOTH-WORKING TOOL (MAINTENANCE OIL)
POHS, H. A. & GARDNER-DENVER CO CLEV OHIO
ROCK PRODUCTS, MAR 1967. LUBRICATION, PREVENTIVE MAINTENANCE, AND THE REPAIR OR DISCARD OF WORN PARTS ARE VITAL PARTS OF A DRILL MAINTENANCE PROGRAM.

84-67-04001 LASERS USED TO LAY SEWER PIPE (AUTOMATION)
GEORGE, J. C. & JACKSONVILLE ARK
WATER AND WASTES ENGINEERING, (4) NO. 4, 48-50, APR 1967. A SMALL DEVICE WHICH USES A LASER MAKES IT POSSIBLE TO LAY A SEWER PIPE ABSOLUTELY STRAIGHT MORE QUICKLY AND MORE ECONOMICALLY. THIS SAME PRINCIPLE CAN ALSO BE USED IN LAYING ANY KIND OF PIPE. A PATENT ON THE AUTOMATIC GRADE LIGHT WAS ISSUED OCTOBER 18, 1966.

84-67-08001 RAPID SOILS EXCAVATION (CHEMICAL NUCLEAR EXPLOSIVE-EXCAVATING-MACHINE)
JONES, C. W. & U.S. BUR RECL WASH D.C.
NOTICE OF RESEARCH PROJECT, SCIENCE INFORMATION EXCHANGE SMITHSONIAN INSTITUTE, AUG 24, 1967. ACTIVITIES ARE LARGELY DEVOTED TO LITERATURE REVIEW AND CONTACTS WITH OTHER AGENCIES TO KEEP ABREAST OF NEW DEVELOPMENTS IN RAPID EXCAVATION SUCH AS CORPS OF ENGINEERS PROJECT REDSOD, DEVELOPMENT OF AN EXPLOSIVE EXCAVATING MACHINE, AND NUCLEAR AND CHEMICAL EXPLOSIVE EXCAVATING EXPERIMENTS.

84-68-01001 HOISTING EQUIPMENT AND SHAFT DESIGN IN DEEP-LEVEL SOUTH AFRICAN GOLD MINES (HOISTS)
GYNGELL, A. H. & ANGLO AM CORP SO AFRICA
CANADIAN INSTITUTE OF MIN & MET BULLETIN, 15, JAN 1968. HOISTS AND SHAFT LAYOUTS. FRICTION HOISTS AND DOUBLE-DRUM TWIN ROPE BLAIR HOISTS, FRICTION WINDERS ARE DESCRIBED. THE MOST MODERN INSTALLATION OF THIS TYPE EMPLOYS 2-IN. ROPES, HAS A DRUM WITH A DIAMETER OF 19 FEET, 6 INCHES AND HOISTS A 20-TON PAYLOAD FROM 4,900 FEET AT 3,000 FEET PER MINUTE.

84-68-01002 NEW DRILLING RESEARCH TOOL SHOWS WHAT HAPPENS DOWN THE HOLE (TOOL-BIT TORQUE DRILL-STRING OIL-WELL)
DEILY, F. H. + DAREING, W. H. + DAFF, G. H. & ORTLOFF, J. E. + LYNN, R. D.
& ESSO PROD RES CO HOUSTON TEX
THE OIL AND GAS JOURNAL, (66) 55-64, JAN 8, 1968. A DOWN-HOLE TRANSDUCER TOOL FOR MEASURING AND RECORDING DRILL STRING FORCES AND MOTIONS WAS BUILT AND USED. THE TOOL MEASURED AND RECORDED EIGHT FORCES AND MOTIONS SIMULTANEOUSLY WHICH INCLUDE AXIAL LOAD, TORQUE, BENDING MOMENT, AXIAL ACCELERATION, ANGULAR ACCELERATION, PRESSURE INSIDE THE DRILL STRING AND PRESSURE IN THE ANNULUS. MUCH DATA WAS OBTAINED FOR A WIDE VARIETY OF DRILLING CONDITIONS, HOWEVER, DETAILED STUDIES OF ANY SINGLE DRILLING VARIABLE, PARAMETER, OR DEVICE WERE NOT POSSIBLE IN THIS PROGRAM. USING THIS DATA AND HOPEFULLY ADDITIONAL DATA OBTAINED WITH THIS TOOL, DRILLING ENGINEERS CAN BEGIN TO TAKE A RATIONAL DESIGN APPROACH TO BIT LOADS, PIPE FATIGUE AND FAILURE, AND DOWN-HOLE TOOL OPERATIONS. WHILE DRILLING AT A HIGH PENETRATION RATE THE MEAN TORQUE WAS VERY SENSITIVE TO THE MEAN BIT AXIAL FORCE. BOTTOM HOLE IRREGULARITIES SEEM TO BE THE MAJOR CAUSE OF LARGE AMPLITUDE MOTIONS. PUMP PRESSURE VARIATIONS MAY ALSO CAUSE SEVERE VIBRATIONS.

84-68-04001 CONSTRUCTION CONTROL WITH LASERS
BENGSTON, D.
CIVIL ENGINEERING, (38) N 4, 72-4, APR 1968. ON EXCAVATION FOR CARLEY V. PORTER TUNNEL NEAR GORMAN, CAL. LASERS WERE USED TO CONTROL CLOSE TOLERANCES REQUIRED IN INSTALLING LINER PLATE, AND TO CHECK HIGHTS AND STEEL ALIGNMENT; EXPERIENCE INDICATED THAT TUBE LIFE IS INCREASED BY KEEPING LASER IN CONTINUOUS OPERATION; TUBE MUST BE SHELTERED FROM DUST AND MOISTURE TO GUARD AGAINST REDUCED LIGHT OUTPUT; SEVERAL FACTORS MAY CAUSE BEAM TO DEVIATE FROM STRAIGHT PATH AND THESE MUST BE RECOGNIZED IN ANY APPLICATION OF INSTRUMENTS; ON JOB CITED, LASER HAS PRODUCED CONSIDERABLE SAVINGS IN MANPOWER.

FIELD 85 NEWS ITEMS

85-64-03001 HOW PURE DRILLED THE WORLD'S DEEPEST PRODUCING WELL (CASING OIL-WELL-DRILLING)
ODOM, C. B. + HOBBS, M. F. & PURE OIL CO MIDLAND TEX
WORLD OIL, 47-54, MAR. 1964. PURE OIL COMPANY DRILLED THE W. C. TYRELL 1 WELL, LOCATED 11 MI NORTH-NORTHWEST OF FT. STOCKTON, TEX. TO A DEPTH OF 21,603 FT AND COMPLETED BELOW 20,700 FT. THE MAJOR PROBLEMS WERE EXTREME PIPE WEAR, ABNORMAL PRESSURES (UP TO 16,000 PSI) LOST CIRCULATION AND HIGH BOTTOM HOLE TEMPERATURES. THE PROBLEMS WERE CORRECTED BY USE OF SIX SEPARATE CASINGS AND LINER STRINGS, CHROME LIGNITE - CHROME LIGNOSULFONATE DRILLING FLUID, HIGH TEMPERATURE CEMENTS, DIAMOND BITS, 10,000 PSI WORKING PRESSURE BOP, CHOKE MANIFOLD EQUIPMENT WITH REMOTE CONTROLS (PICTURES AND WORKING DRAWINGS ARE GIVEN). THE INITIAL OPENING OF THE WELL WAS A 26-IN. HOLE DRILLED TO A DEPTH OF 750 FT AND SET WITH 20-IN. OD CASING. FOUR MORE CONCENTRIC HOLES WERE DRILLED WITH HOLE DIA (THE FIRST TWO WERE CASED) DECREASING WITH INCREASING DEPTH. THE FINAL HOLE WAS 6 5/8 IN. DIA AND 5,407 FT IN DEPTH WHICH TOOK 1,730 ROTATING HOURS. THE WELL WAS LINED TO A DEPTH OF 16,199 FT WITH 7 5/8 OD LINER WITH THE REMAINDER BEING LINED WITH 5 IN. OD LINER.

85-66-11001 SO WHO NEEDS WHEELS TO RUN A TRAIN (TUNNEL)
SULLIVAN, W. & NEW YORK TIMES
THE NEW YORK TIMES, NOV 4, 1966. THE LATEST EXPERIMENTAL DEVELOPMENTS IN WHEELLESS TRAINS ARE DESCRIBED FEATURING AIR CUSHION SUSPENSION AND VARIOUS FORMS OF PROPULSION. SOME PROPOSED SCHEMES INCLUDE VEHICLE TRANSPORT IN UNDERGROUND TUNNELS.

85-66-11002 VIENNA PEDESTRIANS GET A PREFAB TUNNEL (PRECAST HEAVILY-REINFORCED-CONCRETE-SECTIONS)
ENGINEERING NEWS-RECORD, 114, NOV 17, 1966. A 318 FOOT LONG PEDESTRIAN TUNNEL UNDER THE PRATERSTERN, VIENNA'S BUSIEST 6 LANE TRAFFIC CIRCLE WILL OPEN SOON. THE CONTRACTOR EXPECTS TO HALVE THE ONE YEAR SCHEDULE FOR CASTING THE CONCRETE IN PLACE BY INSTALLING PRECAST HEAVILY REINFORCED CONCRETE SECTIONS, 8 FEET LONG, 17 FEET WIDE AND 11 FEET HIGH. WALLS AND CEILING ARE 10 INCHES THICK. THE ARTICLE DESCRIBES THE CONSTRUCTION STEPS BEING USED.

85-67-04001 RAIL TUNNEL UNDERPASSES A RUNWAY IN HOLLAND (SITE-DRAINAGE SLURRY-TRENCH-METHOD TENSION-PILES
CHEMICAL-SOIL-STABILIZATION)
ENGINEERING NEWS-RECORD, (178) 42, APR 20, 1967. A 1640 FOOT LONG TUNNEL WILL CARRY TRAINS BENEATH A NEW RUNWAY AND TAXIWAY AT AMSTERDAM'S SCHIPHOL AIRPORT. A HIGH WATER TABLE MADE CONVENTIONAL SITE DRAINAGE METHODS IMPRACTICAL, FORCING A VARIETY OF OTHER TECHNIQUES. TWO-THIRDS OF THE TUNNEL USES WALLS BUILT BY THE SLURRY TRENCH METHOD. THIS IS A CONCRETE FLOOR CAST UNDERWATER WITH PRESTRESSED CONCRETE TENSION PILES DESIGNED TO RESIST UPLIFT. IN THE REMAINING SECTION THE CONTRACTOR USED DEEP-INJECTION CHEMICAL SOIL STABILIZATION TO SEAL THE AREA, MAKE EXCAVATION EASIER AND ELIMINATE NEED FOR TENSION PILES.

85-67-07001 BURNER CUTS CONCRETE LIKE BUTTER (CONCRETE-BURNING REINFORCED-CONCRETE)
ENGINEERING NEWS-RECORD, (179) 55, JULY 13, 1967. A SKINNY TUBE ATTACHED TO AN OXYGEN CYLINDER BURNS A 2 INCH DIAMETER HOLE IN 3 INCH STEEL PLATE IN 10 SECONDS AND IN A 10 INCH THICK REINFORCED CONCRETE WALL IN 2 MINUTES 20 SECONDS. BURNER TUBE CONTAINS 13 SMALL RODS PACKED TO LEAVE AIR POCKETS AND THE TUBE AND RODS ARE CONSUMED IN THE DRILLING. RODS ARE PRESUMED TO CONTAIN ALUMINUM AND MAGNESIUM IN THE COMPOSITION. PATENTS ARE APPLIED FOR IN 60 COUNTRIES.

85-67-07002 LASER BEAM GUIDES TUNNELERS LAYING OUT DRILL-HOLE PATTERNS (ADVANCE DRILLING BLASTING ALIGNMENT SAFETY)
CONSTRUCTION METHODS & EQUIPMENT, 58-61, JULY 1967. JAMES MCHUGH CONSTRUCTION CO. HAS A 62.4 MILLION DOLLAR CONTRACT FOR 3,100 FT. OF CONCRETE LINED HORESHOE TUNNEL WITH 12 1/2 FT. ROUGH (10 FT. FINISHED) DIMENSIONS AND WITH AN OCTAGONAL INTAKE STRUCTURE 54 FT. ACROSS AND 17 FT. HIGH. A PERKIN-ELMER MODEL 5600 TOOLING LASER IS BEING USED TO GIVE LINE AND GRADE. OUTPUT BEAM IS 0.4 INCH DIA AT THE INSTRUMENT AND 2 IN. AT A RANGE OF 1,000 FT. THE LASER RANGE IS 1,000 FT BUT IT MAY BE POSSIBLE TO USE IT FROM ITS ORIGINAL SETTING FOR ALL 3,100 FT. OF TUNNEL. THIS TUNNEL UNDER LAKE ONTARIO IS BEING CONSTRUCTED BY DRILLING AND SHOOTING, ON TWO 10 HOUR SHIFTS PER DAY, 5 DAYS A WEEK, WITH AVERAGE ADVANCE OF 24 FT., THREE ROUNDS, PER SHIFT. AN EXPLORATORY HOLE IS DRIVEN 16 FT. AHEAD OF THE WORKING FACE AT ALL TIMES TO GIVE ADVANCE WARNING OF PROBLEMS THAT MAY ARISE. A LASER BEAM ALSO GIVES ALIGNMENT FOR CONCRETE FORMS.

85-67-09001 PLASTIC SIGNS FOR TUNNELS
CONSULTING ENGINEER, SEPT 1967. RESULTS OF A STUDY OF INFORMATIONAL SIGNING FOR HIGHWAY TUNNELS FEATURING AN INTERNALLY ILLUMINATED PLASTIC SIGN MOUNTED HORIZONTALLY ON THE TUNNEL CEILING. OVER 80 PERCENT OF TEST GROUPS RATED SUCH SIGNS AS GOOD VS FAIR OR POOR.

85-67-11001 TUNNEL WILL STORE STORM RUNOFF
ENGINEERING NEWS-RECORD, (179) NOV 30, 1967. THE SOLUTION TO CHICAGO'S STORMWATER POLLUTION PROBLEM IS A BIG HOLE IN THE GROUND. $12.4 MILLION WILL BE SPENT ON A 4-MILE LONG, CONCRETE-LINED TUNNEL. DURING HEAVY RAINS THE OVERFLOW WILL GO TO THIS TUNNEL, THEN AFTER IT HAS STOPPED FLOODING OR BACKING UP THE SEWAGE WILL BE PUMPED OUT OF THE TUNNEL AND TREATED. THE TUNNEL WILL BE ABLE TO STORE 31.5 MILLION GALLONS OF WASTE WATER.

85-68-01001 BRUSSELS SUBWAY IS POTPOURRI OF TECHNIQUES (INTERLOCKING-WALL SHIELD SLURRY COST)
ENGINEERING NEWS-RECORD, (180) JAN 11, 1968. A $400 MILLION RAIL TRANSIT SYSTEM IS BEING DEVELOPED FOR BRUSSELS. THE CONTRACTORS REAL CHALENAGE LIES UNDERGROUND. HERE A MAZE OF UTILITY LINER, WATER AND WEAK SOILS DEMAND A VARITY OF COMPLICATED AND EXPENSIVE CONSTRUCTION TECHNIQUES. TO AVOID AN OPEN TRENCH COLLAPSING INTERLOCKING CAST-IN-PLACE CONCRETE PILES FORM A WALL. THE CONTRACTORS USED HEAVY PLASTIC TO INSULATE THE REINFORCING. WHEN THE SOIL IS WATER LOGGED THE SLURRY TRENCH METHOD IS USED DURING CONSTRUCTION. BENTONITE SLURRY IS USED. FINALLY TREMIE CONCRETE DISPLACES THE BENTONITE WHEN CONSTRUCTION IS COMPLETED.

85-68-08001 LASER CONTROLS: TASMANIA TUNNEL ALIGNMENT (WATER-TUNNEL)
AUSTRALIAN CIV. ENGR. (9) N 8, 33-35, AUG. 1968. USE OF LASER BEAM TO CONTROL TUNNEL ALIGNMENT IN WILMOT HEADRACE TUNNEL IN TASMANIA; TUNNEL WILL BE 14,000 FT LONG AND IS OF HORSESHOE SECTION, 7 FT 3 IN. FROM INVERT TO SPRINGING LINE AND 5 FT 3 IN. CROWN RADIUS; DURING DRIVING OF TUNNEL, ALIGNMENT IS CONTROLLED BY SPECTRA-PHYSICS STABILITE MODEL 122T-335, HELIUM-NEON GAS LASER; IT HAS CONTINUOUS UNIPHASE OUTPUT OF 0.003 W AT 6328 A; ATTACHED TO OUTPUT END IS TELESCOPE WHICH EXPANDS BEAM FROM DIA OF 0.7 MM TO 22 MM AND ALSO COLLIMATES LIGHT BEAM TO ITS DIFFRACTION LIMIT.

85-68-09001 TAPPING A COOL IDEA FOR POWER (SUPERCONDUCTIVITY UNDERGROUND-POWER-TRANSMISSION)
BUSINESS WEEK, 53-4, SEPT 7, 1968. SUPERMAGNETS ARE BEING USED BY A NUMBER OF COMPANIES AT 5 PERCENT THE NORMAL COST FOR MAGNETS. ATOMICS INTERNATIONAL, WESTINGHOUSE, UNION CARBIDE, NORTON CO., AVCO AND DYNATECH CORP. ARE ACTIVELY ENGAGED IN SUPERCONDUCTIVITY DEVELOPMENTS. HIGH VOLTAGE TRANSMISSION LINES CAN BE PUT UNDERGROUND. GENERATORS CAN BE BUILT MUCH SMALLER. SUPER CONDUCTING ALLOYS INCLUDE NIOBIUM-TIN, NIOBIUM-ZIRCONIUM, AND NIOBIUM-TITANIUM.

85-68-09002 EQUIPMENT TO MEET SPECIAL NEEDS (PUMPS SLURRY-PUMPING WATER-JET-DRILLING)
THE OIL AND GAS JOURNAL, (66) 111-113, SEPT 23, 1968. HIGHER PUMPING PRESSURES NEEDED FOR DEEPER OIL WELL DRILLING AND FOR NEW DRILLING METHODS WILL REQUIRE A PUMP THAT CAN RELIABLY TURN OUT 3000 HP AND MUD AT 12,000 TO 16,000 PSI. MOST LIKELY CANDIDATE IS THE TRIPLEX PUMP WHICH HAS BEEN IMPROVED CONSIDERABLY THE LAST FEW YEARS.

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BURGESS, R. P.	72-68-04001
BURGIN, L	03-61-01001
BURGIN, L.	03-60-08001
BURGIN, L.	03-61-02001
BURGIN, L.	12-61-03007
BURKE, H. H.	32-57-11001
BURKE, R. G.	25-64-05001
BURKE, R. G.	25-68-01001
BURT, C. R.	13-69-02001
BUTKOWIK, T. R.	12-59-07006
BYERLEE, J. D.	12-66-09002
BYLYNKA, G. K.	04-64-12003

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CAIN, P. A.	24-66-06001
CALDER, P.	12-65-06002
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CAMPBELL, W. C.	12-62-05016
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CAPLAN, B.	44-69-06001
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CHARLEWOOD, G. H.	24-67-01003
CHEATHAM, J. B., JR.	12-65-01002
CHEATHAM, J. B., JR.	12-66-09015
CHEATHAM, J. B., JR.	15-67-10001
CHEATHAM, J. B., JR.	22-65-06005
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CHEATHAM, J. B., JR.	22-66-10002
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CHIU, C. L.	42-68-03002
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CLEAVES, A. B.	12-58-05001
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CLOUGH, G.	53-67-02002

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COATES, D. F.	12-59-07004
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COHN, V.	55-68-09001
COLLIER, W. R.	54-65-03002
COLSON, G. P.	82-69-10001
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GANGAL, M.	12-66-09006
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GATLIN, C.	12-61-03017
GAUTHIER, G.	22-67-00001
GAYLORD, E. W.	28-67-12001
GAYNER, J. F. C.	34-68-10001
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GREGSON, V. G., JR.	23-69-01002
GREIGLEY, J. H.	12-62-05018
GRINE, D. R.	12-59-07005
GRONEBAUM, R.	44-66-10001
GROSVENOR, N. E.	32-57-04002
GROSVENOR, N. E.	32-66-00001
GROVE, G. W.	53-42-00001
GRUBA, V. I.	24-64-09008
GSTALDER, S.	24-66-08001
GUMENNIK, YA.	24-64-09009
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HAMBACH, P.	04-70-05004
HAMBURGER, R.	07-67-03001
HAMILTON, R. C.	84-64-08001
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HINO, K.	22-56-04006
HIRAMATSU, Y.	14-68-07001
HIRSCHFELD, R. C.	13-68-09001
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HOBBS, M. F.	25-64-10001
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HOBBS, M. F.	85-64-03001
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INADA, Y.	24-67-09001
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ISHCHUK, I. G.	24-65-03002
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IVANOV, V. V.	24-65-05002

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JACCON, A.	45-64-06001
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