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INV. 62

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AEC RESEARCH AND DEVELOPMENT REPORT

LABORATORY RECORDS 1954

INV 70

ELECTROMAGNETIC RESEARCH DIVISION

QUARTERLY PROGRESS REPORT

Part II

For Period Ending June 30, 1952

CLASSIFICATION CANCELLED (DOE Review Order) DATE JUL 10 1979

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1954

ELECTROMAGNETIC RESEARCH DIVISION

QUARTERLY PROGRESS REPORT

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For Period Ending June 30, 1952

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Index No. ORNL-1346
This document contains 19 pages
This is copy 29 of 53, Series A

Subject Category: Technology - Materials Testing Accelerator

ELECTROMAGNETIC RESEARCH DIVISION

Robert S. Livingston, Director

QUARTERLY PROGRESS REPORT, PART II
for Period Ending June 30, 1952

Edited by F. T. Howard

OAK RIDGE NATIONAL LABORATORY
Operated by
Carbide and Carbon Chemicals Company
A Division of Union Carbide and Carbon Corporation
Oak Ridge, Tennessee

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ABSTRACT

The production of polonium 208 with the 86-inch cyclotron has been discontinued. In the final production run proton bombardment totaled 147 milliampere-hours and yielded 1.45 curies of polonium 208; at 23 Mev, the specific yield averaged 9.8 millicuries per milliampere-hour.

A grid-type ion source using a convex arc electrode and a flat accelerating electrode produces over one-half ampere of lithium ions per square inch with distinct isotope separation at the face of the collector.

The resistance thermal cycler was used to determine the cyclic thermal stress conditions under which alpha-rolled uranium rods fail.

[redacted]

PREVIOUS QUARTERLY REPORTS

Quarterly reports have been issued by the Electromagnetic Research Division for the periods ending:

September 30, 1949		Y-495
December 31, 1949		Y-548
March 31, 1950		Y-584
June 30, 1950		Y-637
September 30, 1950		Y-676
December 31, 1950		Y-722
March 31, 1951		Y-767
June 30, 1951		Y-795
September 30, 1951,	Part I	ORNL-1173
	Part II	ORNL-1235
December 31, 1951,	Part I	ORNL-1269
	Part II	ORNL-1270
March 31, 1952,	Part I	ORNL-1339
	Part II	ORNL-1315

REPORTS PREPARED DURING LAST QUARTER

Harmatz, B. et. al., Enrichment of Uranium 236, ORNL-1169.

Livingston, R. S. and Boch, A. L., The 86-Inch Cyclotron, ORNL-1196.

Livingston, R. S., Martin, J. A., and Murray, R. L., The Cyclorator: A Device for the Separation of Isotopes of Time-of-Flight in a Magnetic Field, ORNL-1309.

[redacted]

TABLE OF CONTENTS

	page
POLONIUM PRODUCTION	6
PLASMA CONTROL STUDIES	11
THERMAL CYCLER	15
OPERATIONS SUMMARY	17

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POLONIUM PRODUCTION*

Internal changes in the 86-inch cyclotron completed during the recent shutdown increased the proton energy of the machine to 23 Mev while retaining the previous high output. Improved methods of determining the target exposure together with more accurate theoretical yield data have led to higher and more consistent polonium yields. Grazing incidence targets were developed which are capable of dissipating 25 kw, or 1.1 milliamperes at 23 Mev, without damage to the bismuth surface.

New Yield Data

After a recent visit to Oak Ridge, E. L. Kelly of the University of California Radiation Laboratory reviewed the existing Po 208 yield data. He found that the published yields were based on the preliminary cross sections given in the report UCRL-453 and were about 10 percent too high. It was his conclusion that the best cross section measurements are based on his data obtained with the Berkeley linear accelerator in March 1950. The new thick target yield curves are given in Figure 1.

Production Summary

After modification of the cyclotron was completed, several short runs were made to determine the beam characteristics and to verify the higher yield expected with the 23 Mev beam. The first bismuth bombardments were made at low current and were of short duration to minimize contamination of the machine. When it was certain that the machine was properly adjusted, long runs at high

* This program was terminated July 30, 1952, and a final report (ORNL-1392) is being prepared.

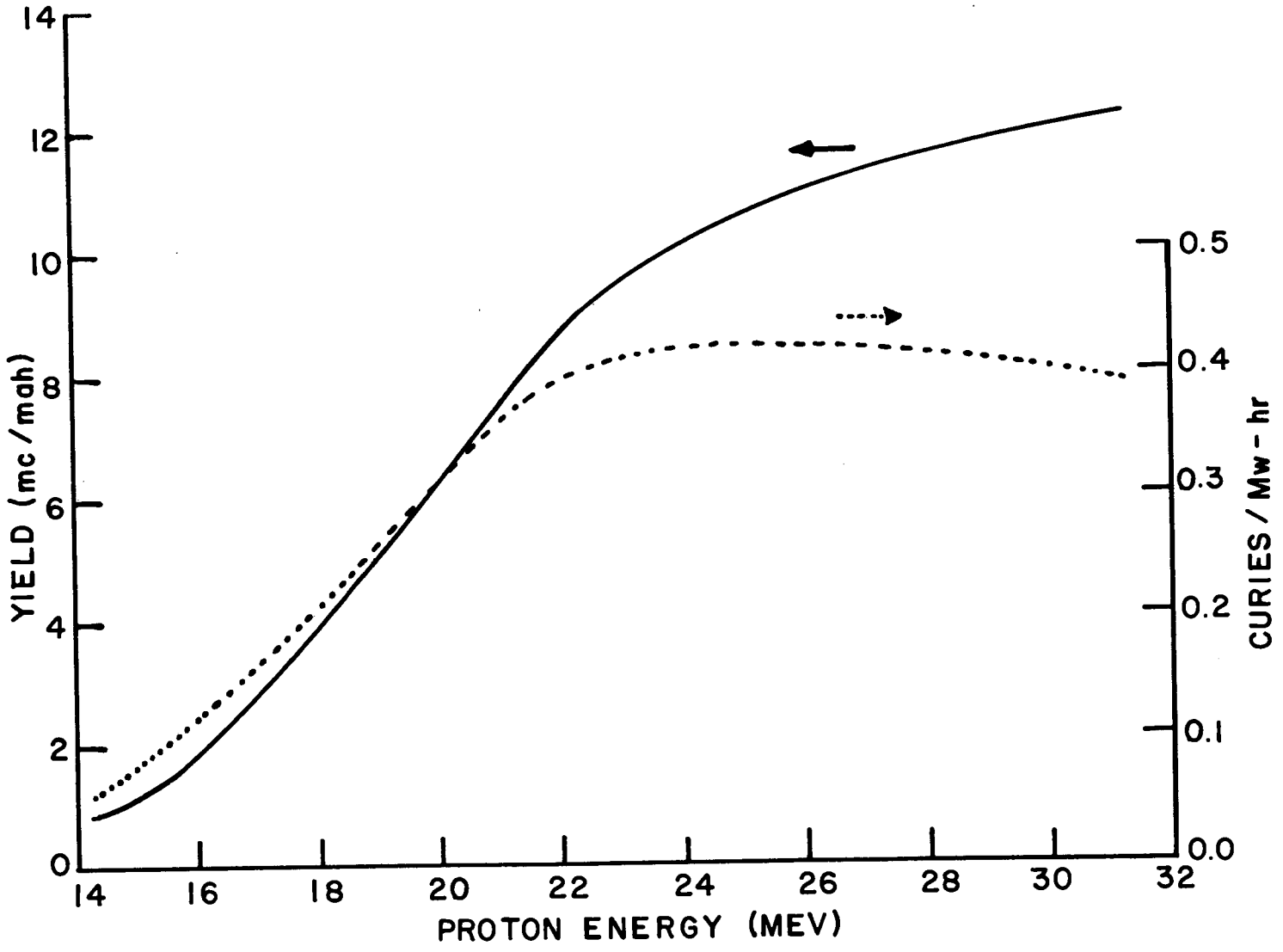


FIGURE 1. THICK-TARGET YIELD

current were begun, culminating in the best run of the program in which a target was bombarded for 147.5 milliampere-hours yielding 1.452 curies of Po 208.

During the present period, 17 bismuth targets were bombarded for a total production of 4.3 curies of Po 208. The data for these runs are given in Table I.

Radiation Protection

The improved target handling facility has been operated satisfactorily with only minor modifications to improve reliability. Targets containing 50 to 75 curies of Po 207 (5.7 hr, 1.3 Mev gamma) were removed from the cyclotron with only a 10 to 20 mr exposure to operating personnel. The dispersal of alpha activity into the air of the cyclotron pit has also been greatly reduced. The airborne contamination level in the pit is presently 10 to 15 dis/min-m^3, compared with 100 to 120 dis/min-m^3 just prior to the January shutdown. At the entrance to the pit and outside of the enclosed areas the level is negligible. The gloved-box facility was modified to allow the processing of larger radioautographs.

Target Development

The slotted-plate target design was standardized during the period. Both 6" by 10" and 6" by 14" targets of this type were used. The 6" by 10" targets are capable of dissipating 21 kw and the larger targets 25 kw. Facilities were installed to allow vacuum testing of target assemblies prior to their installation in the machine.

Initial attempts to use the rotating target resulted in vacuum seal failures after 10 to 15 minutes of operation. It appears that the presently used dual seal will be unsatisfactory. The use of a bellows seal such as that manufactured by the Crane Company is being investigated.

Target Number	Date	Average Beam (μa)	Bombardment Time (μah)	Assayed Yield (mc)	Observed Yield (mc/mah)	Cumulative Activity (mc)
106	4/11/52	168	160	1.4	8.62	4958
107	4/24/52	156	148	2.0	13.72	4960
108	4/25/52	177	235	1.4	6.1	4961
109	5/3/52	269	1,319	12.0	9.1	4973
110	5/4/52	286	1,459	12.8	8.8	4986
111	5/10/52	226	2,060	17.3	8.4	5003
112	5/12/52	214	4,238	26.2	6.2	5030
113	5/18/52	244	3,045	35.7	11.7	5065
115	6/3/52	574	37,742	333	8.54	5388
114	6/9/52	661	51,075	446	8.73	5834
116	6/14/52	666	27,829	256	9.19	6090
117	6/18/52	614	15,714	101	6.43	6191
119	6/23/52	549	19,972	184	9.21	6375
120*	7/2/52	604	41,280	388	9.40	6763
118	7/8/52	747	52,192	405	7.75	7168
121	7/15/52	641	55,600	623	11.20	7791
123	7/27/52	771	147,459	1452	9.84	9243

* This summary is extended beyond the end of the regular quarterly period to include the conclusion of the polonium production program.

TABLE I: POLONIUM PRODUCTION RUN SUMMARY

The target power can now be measured from the control desk of the cyclotron. The change in temperature of the target cooling water is measured by a bridge circuit with resistance thermometers in conjunction with a modified Leeds and Northrup potentiometer. A substitutive method for calibration is provided by a 0-30 kw electric heater in series with the target cooling water. The total energy delivered to the target during a bombardment can be determined by integrating the chart of the differential temperature indicator and multiplying the result by the calibration factor obtained by using the electric heater.

Polonium 208 Costs

During the last bombardment of the program, Po 208 was produced at a cost of $5000 per curie. A final report in preparation, ORNL-1392, revises downward the cost estimates given in ORNL-1192 and describes practical means whereby this cost may be sharply reduced.

PLASMA CONTROL STUDIES

Intense beams of lithium ions have been obtained from grid-type ion sources; newly designed arc and accelerating electrodes stabilize the arc and beam plasmas and permit sharply focused ion beams.

Electrode Shapes

In previous work the arc electrode and the accelerating electrode have been either both flat or both curved. With either of these arrangements it was possible to operate intense arcs yielding large ion beam currents. At the higher intensities, however, the arc plasma appeared to be forced through the grid openings along the mid-line, and the beam became badly defocused. In a new arrangement a convex arc grid provides the focusing effect while a flat accelerating grid tends to hold the arc boundary more stable at high intensity; well focused beams are obtained.

Focal Pattern of Beam

The stability of the arc and beam plasmas is determined from the geometric pattern of the beam focus. The beam is scanned at the focal plane through a 1/32" slot moved across the face of a collector plate. The focusing effect of various arrangements of ion source electrodes is evaluated in this manner. The convex grids provide better focusing than plane grids. With the convex-plane grid arrangement isotope separation is distinct, Figure 2. In this test the convex grid was one inch wide and two inches long; 575 ma of beam was obtained from the one square inch of arc surface.

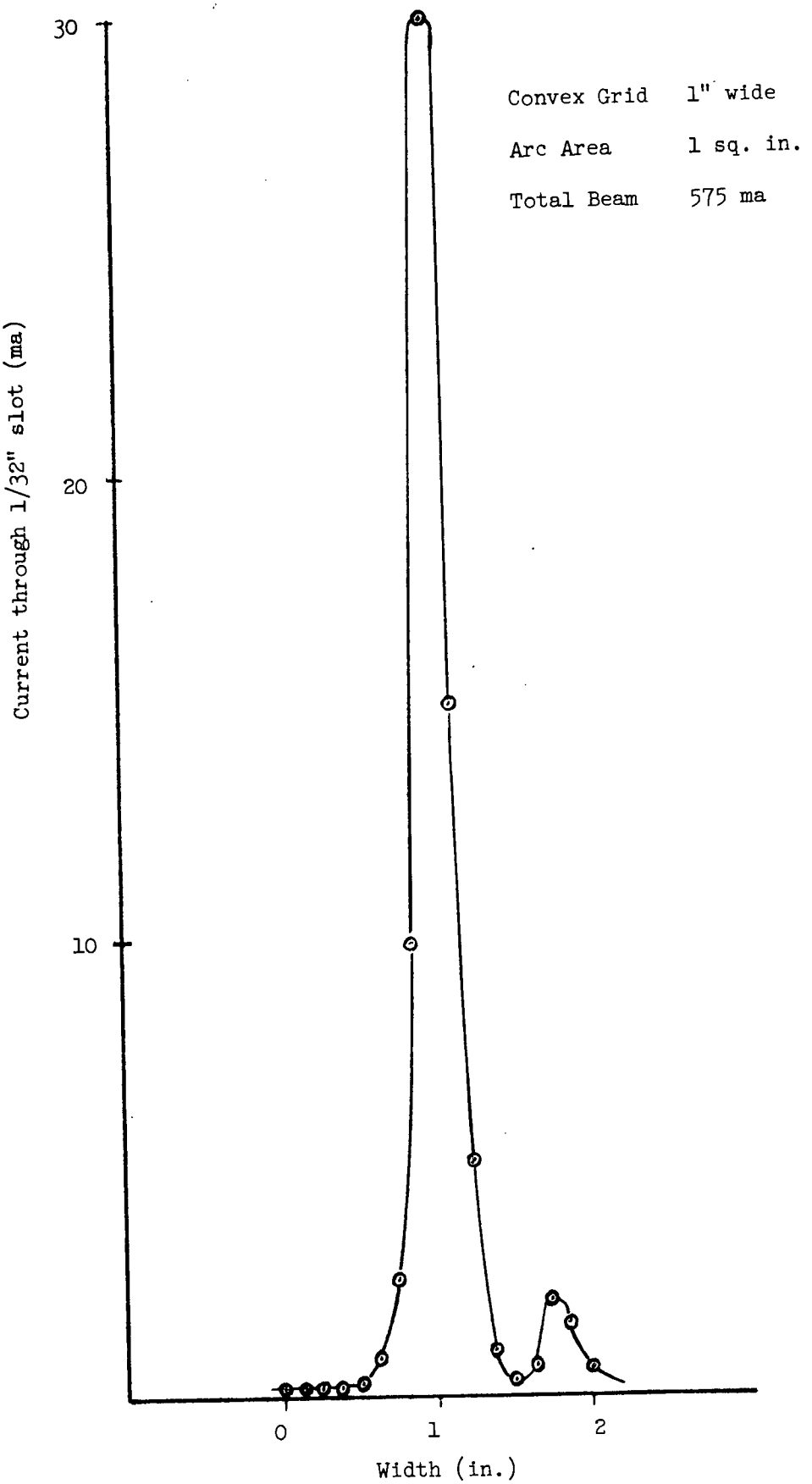


Figure 2. Focal Pattern of Beam at Collector Face

Beam Stability at Collector

For some time it has been observed that an ion beam is much better focused and more stable on a flat-plate collector than when directed into collector pockets. This observation has been verified by calorimetric measurements of the energy transferred by the target-cooling water. Two possible contributing factors are being investigated. First, the flat plate presents to the beam a uniform electric field while the deep pockets with insulated monitoring probes introduce asymmetrical field forces which may permit instabilities to arise. Secondly, atoms deposited on the flat plate are readily vaporized and can return to the beam plasma where they may again be ionized and contribute to the ion density; in the deep water-cooled pockets ions are trapped and removed from the beam.

In experimental investigations of these differences collector pockets have been made to "look like" flat plates. Fine tantalum wires across the collector pocket opening produce a more uniform field, and, becoming incandescent, emit electrons into the beam plasma; the measured ion current in the pocket then approached that normally obtained on a flat plate. Again, when no water cooling was used and the pocket was permitted to run very hot the metered current increased. In a similar test a thermally insulated graphite plate was placed in the collector pocket as a target. As the plate became hot, atoms deposited on it were vaporized and tended to increase the vapor pressure and collision rate within the collector pocket. This also increased the beam current into the pocket but reduced collection efficiency. The objectives of collector design is, of course, to permit the focus of all ions into the pockets and also to retain the deposited material.

Ion Source Development

For determining the practicability of longer arcs, an ion source with 8-inch arcs, four square inches of arc area, has been operated. With convex grids, a beam current of 2.5 amperes has been monitored on a flat-plate collector. It appears that output increases approximately linearly with arc length. In a unit using a low positive potential on the ion source and a negative potential on the beam-path liner, the ratio of current to collector versus current to liner is 5:1; development of this arrangement could result in reduced power requirements.

THERMAL CYCLER

The resistance thermal cycler was used in testing alpha-rolled uranium to determine the cyclic stress-time conditions under which this material may be used. Five uranium rods were tested at average power densities ranging from 25 to 47.5 kw/in^3, in continuation of the "B" series. The rods were cooled by a water flow of 11 gpm and surface velocity of 17.7 fps. The power was pulsed 400/min with a 33.3% duty cycle. A summary of the five tests is given in Table II.

A modification was made in the test procedure for runs B-21, B-22, and B-24 so that the power density was kept constant from day to day during the run. This was accomplished by reducing the current daily to compensate for the increased resistance of the sample and to maintain I^2R constant. During previous tests it was assumed that the sample resistance remained constant and therefore the current was held constant during the run. Typical examples of the increase in sample resistance are B-19, which increased in resistance from 0.854×10^{-3} ohms to 1.152×10^{-3} ohms in 8.07×10^5 cycles at 30 kw/in^3 and B-21 for which the resistance increased by a factor of 1.6 during the first 1.8×10^6 cycles, at 25 kw/in^3. The resistance of Sample B-21 increased by a factor of 3.25 during the test period of 2.15×10^6 cycles at which time the specimen was badly splintered although it did not melt.

The work of this quarter completes the program at Oak Ridge National Laboratory and the equipment is being moved to the installation operated by the California Research and Development Company, at Livermore, for the Atomic Energy Commission. A final project report, ORNL-1386, will be issued in the near future.

TABLE II

Test No.	Av. Power Density (kw/in^3)	Total Cycles	Comments
B-19	30.0	8.62×10^5	Spines appeared at 262,000 cycles. Rod was badly splintered but did not melt in two.
B-20	47.5	1.39×10^5	First crack noted at 15,000 cycles. Failed near middle after becoming badly splintered.
B-21	25	2.13×10^6	Power reduced at start of each shift to keep power density approximately constant. Rod did not melt but was badly splintered.
B-22	30	3.08×10^6	Power density held constant by reducing input. Rod failed in clamp.
B-24	35	6.42×10^5	Power density held constant. First cracks noted at 16,000 cycles. Test terminated.

TARGET TEST SUMMARY

OPERATIONS SUMMARY

A summary of operations in Buildings 9201-2 and 9204-3 for the months of April, May, and June include the following experimental runs:

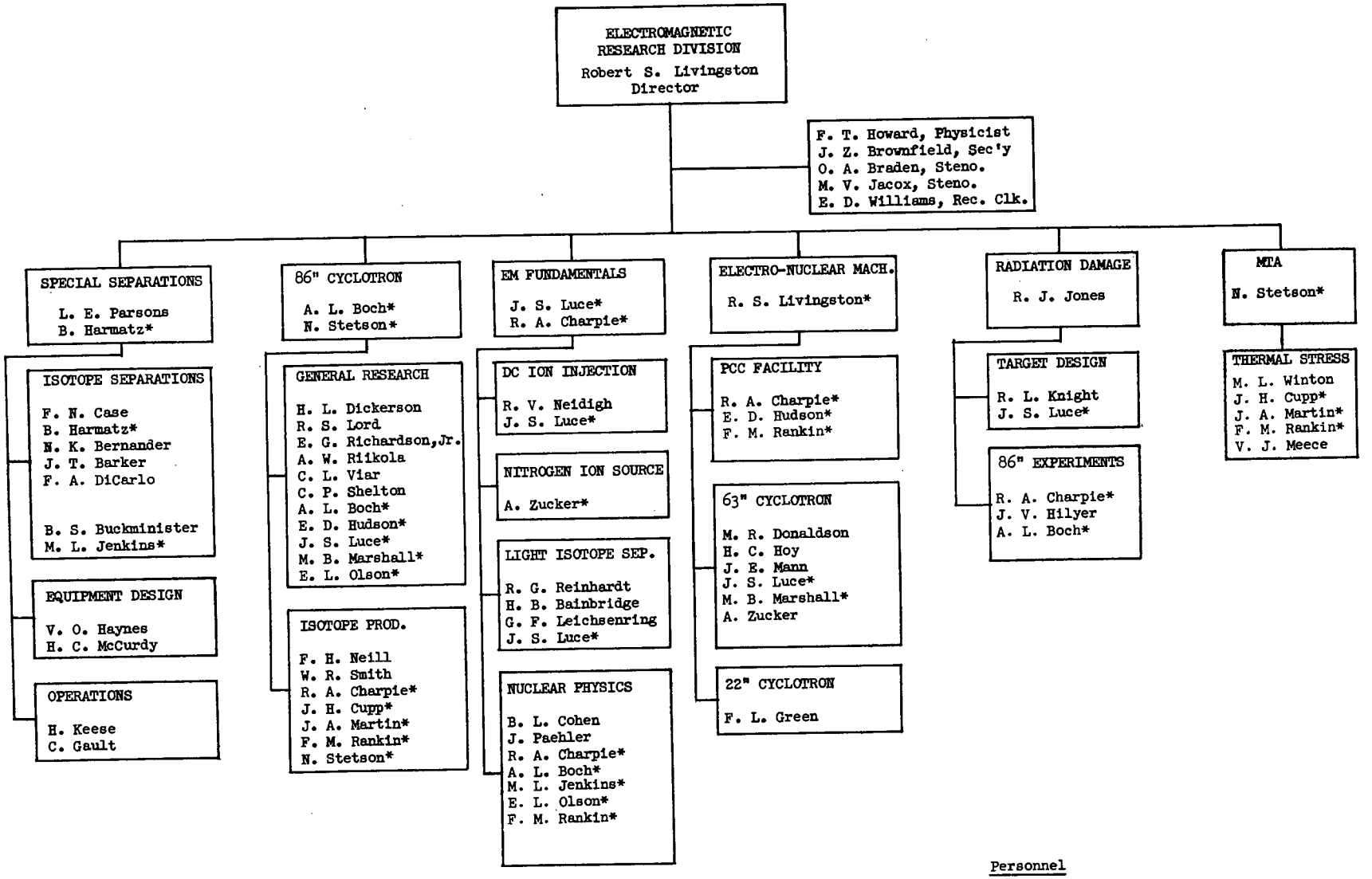
Special Separations	25
Electromagnetic Fundamentals	96
Electro-Nuclear Machines	42
86-Inch Cyclotron	
Experimental	41
Isotope Production	31
Nuclear Physics	72
Radiation Damage	16

Distribution of shop time charged to each of the various projects is given in Table III.

Assignment of personnel to various projects is indicated by the personnel chart on page 19.

		Mechanical Service		Machine Shop - Carbon		Machine Shop - Metal	
		Hours	% Used	Hours	% Used	Hours	% Used
33-238	Special Separations	1357.5	12.7	330.0	30.1	42.0	1.5
33-240	U 236 Separation	322.5	3.0	22.0	2.0	20.0	0.7
		1680.0	15.7	352.0	32.1	62.0	2.2
34-595	86" Cyclotron Operation	2670.8	24.9	46.0	4.2	302.5	10.5
34-596	86" Cyclotron Special Targets	1415.1	13.2	1.0	0.1	664.0	22.9
34-597	86" Cyclotron Development	164.0	1.5	27.0	2.4	140.0	4.8
		4249.9	39.6	74.0	6.7	1106.5	38.2
36	Electromagnetic Fundamentals	1846.0	17.2	489.5	44.6	528.4	18.2
37	Electro-Nuclear Machines	1493.0	13.9	121.5	11.1	331.0	11.4
38	Radiation Damage Research	497.0	4.6	-	-	137.0	4.7
3550-366	MTA Target	8.0	0.1	-	-	6.0	0.2
4900-132	Plutonium Laboratory Facilities	339.0	3.2	56.0	5.1	-	-
4900-161	The 63" Cyclotron	163.0	1.5	-	-	4.0	0.1
4900-217	Target Handling Facilities, 86" Cyclotron	354.0	3.3	2.0	0.2	589.0	20.3
4902-282	DC Injector and Hot Cathode Source, 63" Cyclotron	43.0	0.4	2.0	0.2	118.0	4.1
43204-1	Building Maintenance Service	53.0	0.5	-	-	16.0	0.6
	TOTAL	10,725.9		1,097.0		2,897.9	

TABLE III: TIME DISTRIBUTION - MECHANICAL AND MACHINE SHOPS
April 1 through June 30, 1952



* Dual Capacity
R. L. Quinn on loan to Protective Equipment Evaluation Program

Personnel

38 Monthly
12 Weekly
50 Total

July 1, 1952