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INSTRUMENT RESEARCH AND DEVELOPMENT

QUARTERLY PROGRESS REPORT

FOR PERIOD ENDING JULY 20, 1951

OAK RIDGE NATIONAL LABORATORY • U.S. ATOMIC ENERGY COMMISSION

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INSTRUMENT RESEARCH AND DEVELOPMENT QUARTERLY PROGRESS REPORT

PHYSICS DIVISION

Hollow-Crystal Spectrometer (P. R. Bell, R. C. Davis, J. E. Francis, and Judith Cassidy). Work with the hollow-crystal spectrometer, reported in a previous quarterly report[1] has been continued, and very good results have been obtained. Figure 1 shows a diagram of the arrangement showing the source, the collimator, and the hollow crystal itself mounted on the photomultiplier. Electrons entering the hole in the crystal are not readily scattered out since the solid angle of the hole is small at the place where the electrons strike. The layer of air between the crystal and the source causes considerable difficulty both absorbing and scattering soft electrons and spoiling the resolution.

Figure 2 shows some curves obtained using a Ca^{45} β-ray source and various conditions of the apparatus. The lower curve shows the results obtained with air at atmospheric pressure between the crystal and source. Without moving the source, hydrogen was introduced into the container and resulted in the intermediate curve. Very many more electrons, even of considerable energy, are apparent. The container holding the crystal and the source was then evacuated and the upper curve obtained. As you can see, it was only slightly different, and so hydrogen is customarily used now in preference to vacuum, as handling the apparatus under these conditions is much easier.

Figure 3 is a Kurie plot obtained with this instrument for the radiations of Ca^{45}. A good Kurie plot was obtained and the end point at 245 Kev agrees with the work of Ketelle. The deviation below the line at 50 Kev is still partially unexplained. Part of the deviation is caused by the 1/10 mg/cm^2 aluminum reflector window over the crystal, and part of it is probably due to the uncertainty in the curvature of the pulse height vs. energy curve for anthracene. A correction has been applied to the data for this curvature according to the work of Hopkins, but the data is insufficient to get an accurate correction and further work must be done to get good corrections in the low-energy region. With proper correction curves there seems to be no reason why Kurie plots could not be obtained which are straight down to the order of 10 Kev at least.

The hollow-crystal spectrometer is now being used for studying the β-γ coincidence spectra from I^{131}.

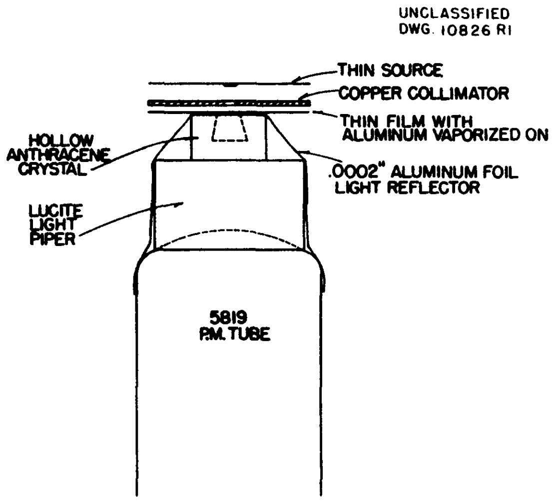

Fig. 1. Hollow Crystal Spectrometer.

[1]P. R. Bell, J. M. Cassidy, R. C. Davis, and G. G. Kelley, "Investigations with the Scintillation Spectrometer. Hollow-Crystal Spectrometer," *Physics Division Quarterly Progress Report for Period Ending December 20, 1950*, ORNL-940, p. 36 (March 15, 1951).

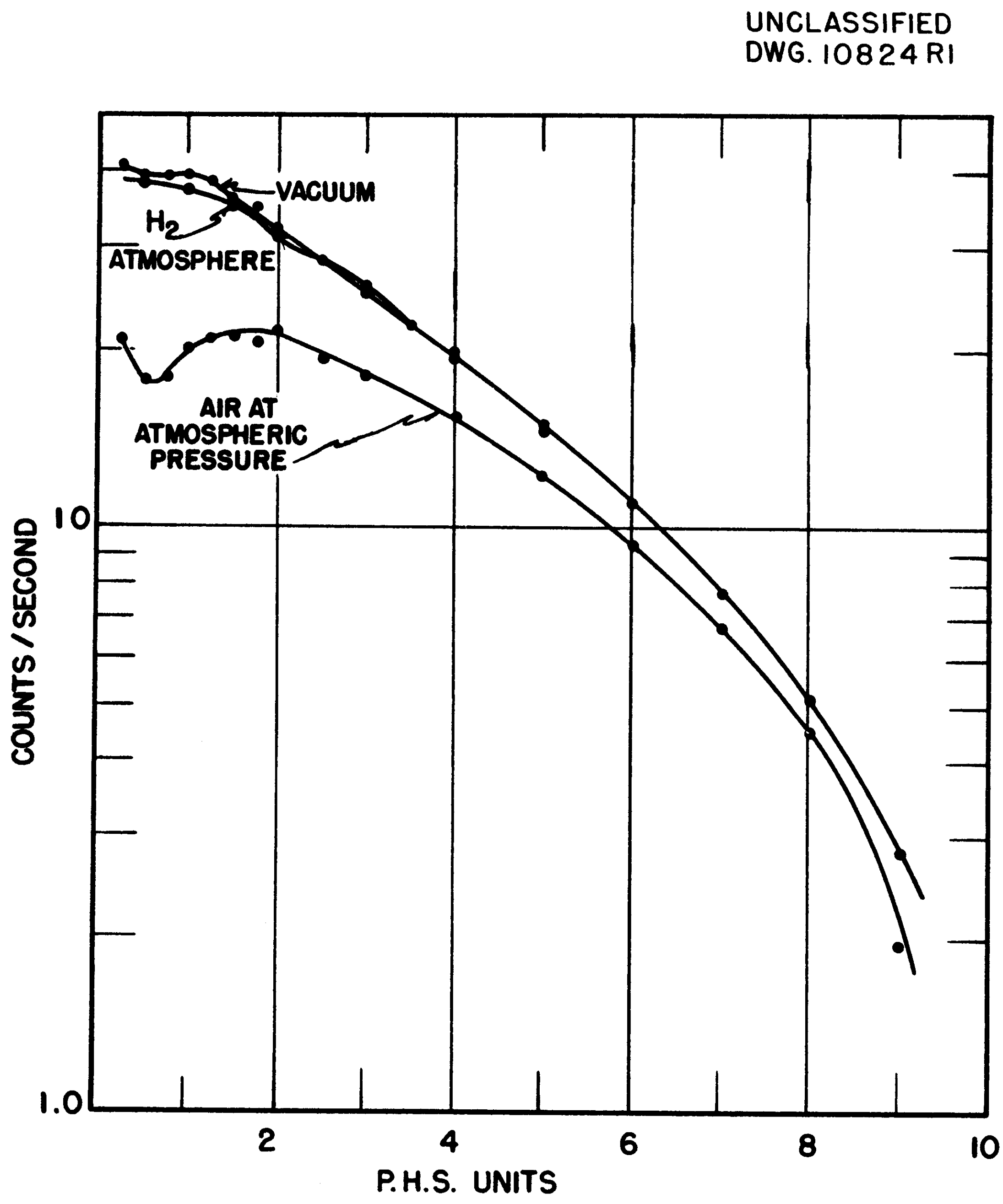

Fig. 2. Ca^{45} Collimated by .030-in. Copper Sheet on Hollow Anthracene Spectrometer.

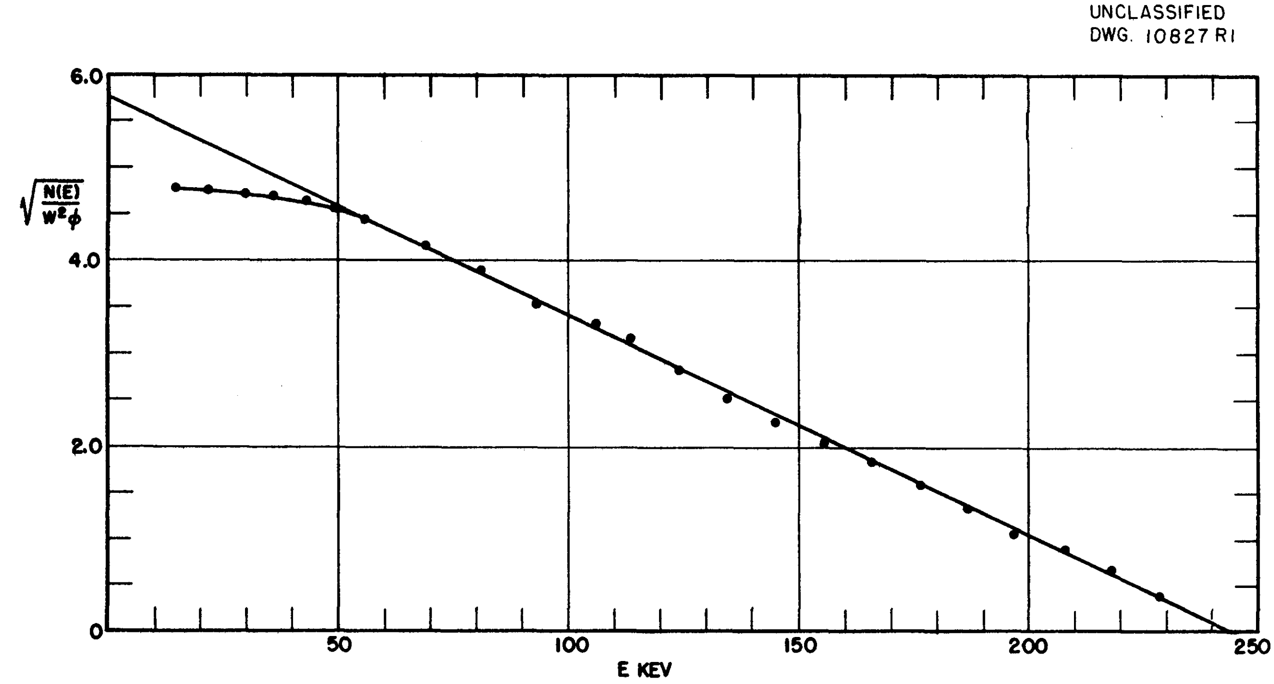

Fig. 3. Kurie Plot of Ca^{45} Using Copper Collimator on Hollow Anthracene Spectrometer.

Improvement of Resolution of Scintillation Spectrometers (P. R. Bell, R. C. Davis, J. E. Francis, Judith Cassidy). In an effort to improve the resolution of the scintillation spectrometer and optical absorption of the materials used in the spectrometer has been studied at some length. A Beckman Model DU quartz spectrophotometer was used for measuring the absorption of samples of anthracene, sodium iodide, mineral oil, and Canada balsam. The absorption spectra are shown in Fig. 4. It is interesting to notice that the anthracene absorption is extremely sharp and sets in abruptly at 4450 A and is essentially complete at 4250 A. The absorption of sodium iodide, however, shows a distinct step in the absorption, being only partially absorbing from 3250 to 3450 A. This sample, nearly 1 cm thick, would show poor resolution for any light emitted in the partially absorbed region since then the pulse would vary in size depending upon where in the crystal the similar light flashes were produced. The data for Canada balsam show a strong absorption dip in an important region for the light from sodium iodide. This sample was a 10% solution of Canada balsam in xylene and was 1 cm in thickness, equivalent to 1 mm of Canada balsam. In using Canada balsam layers of various thicknesses between the sodium iodide crystal and the photomultiplier, a considerable change in resolution was actually observed, there being an optimum thickness for the best resolution.

It appears that a filter constructed of a material having a sharper cut-off than Canada balsam would thus improve the resolution of sodium iodide if inserted in the proper amount between the crystal and the photomultiplier. A substance which appeared to be a possible filter for the light from

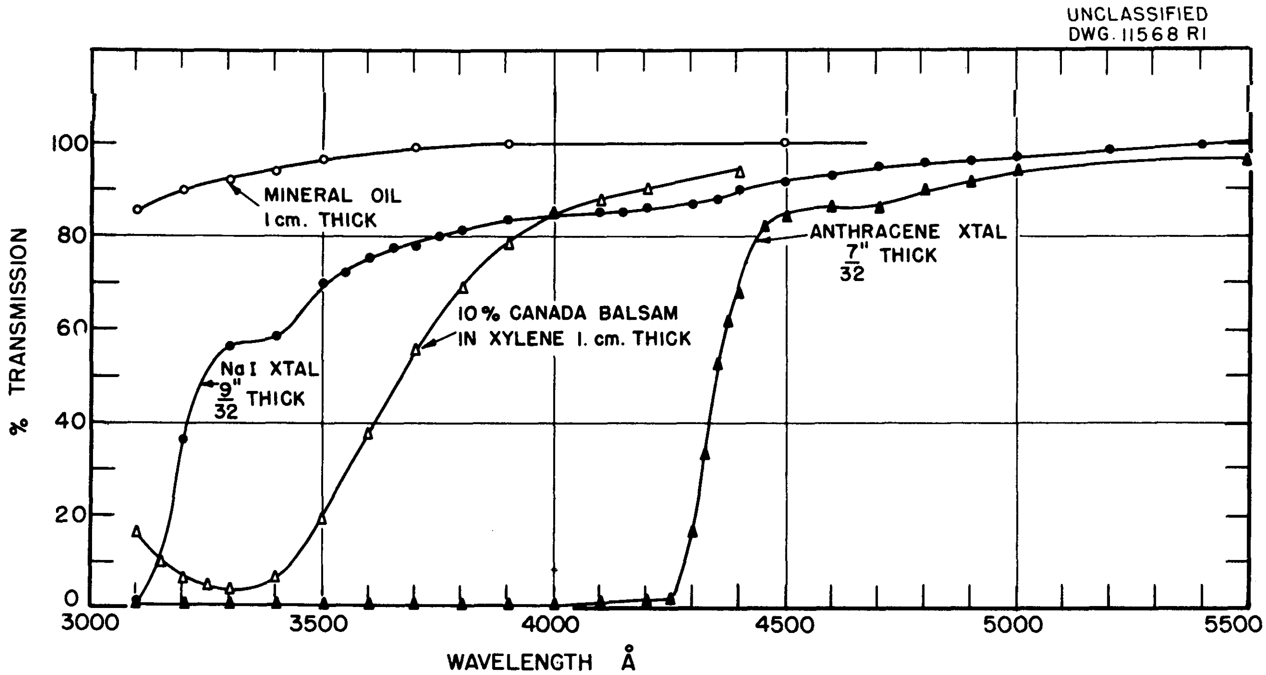

Fig. 4. Transmission Spectra of Substances Used in Scintillation Spectrometry.

sodium iodide is a saturated solution of potassium nitrate. The curve for it is shown in Fig. 5. This curve is extremely steep and cuts off near the low-frequency edge of the absorption shelf in the sodium iodide.

It was observed that several samples of lucite being used for light pipers for these crystals differed in their performance with the crystal and samples of ultraviolet transmitting lucite and ultraviolet absorbing lucite were run as shown in Fig. 5. Some of the ultraviolet absorbing lucites have quite different absorption curves than others. This particular one cuts off at approximately the correct place. The ultraviolet absorption of mineral oil (see Fig. 4) and Dow-Corning 200 make them quite satisfactory liquids to join the sodium iodide crystal to the light piper. Poly-*a*-methyl styrene was also measured and found to absorb considerable near the short wavelength end of the sodium iodide emission spectrum.

The absorption curves for other scintillation phosphors were measured. *p*-Terphenyl in a solid clear crystal, *p*-terphenyl in *m*-xylene, and a clear trans-stilbene crystal were also measured and their curves are shown in Fig. 5. Solid *p*-terphenyl seems to show some absorption far from its sharp cut-off and solid trans-stilbene shows an absorption step of considerable depth near its cut-off. The fluorescent light from these materials has not been measured well enough to ascertain the effect upon the scintillations as yet. Some measurements of the emitted light from sodium iodide and anthracene have been made in the Chemistry Division by J. A. Ghormley. These measurements, after being corrected for the transmission of the spectrometer on which they are made, are reproduced here in Fig. 6. These

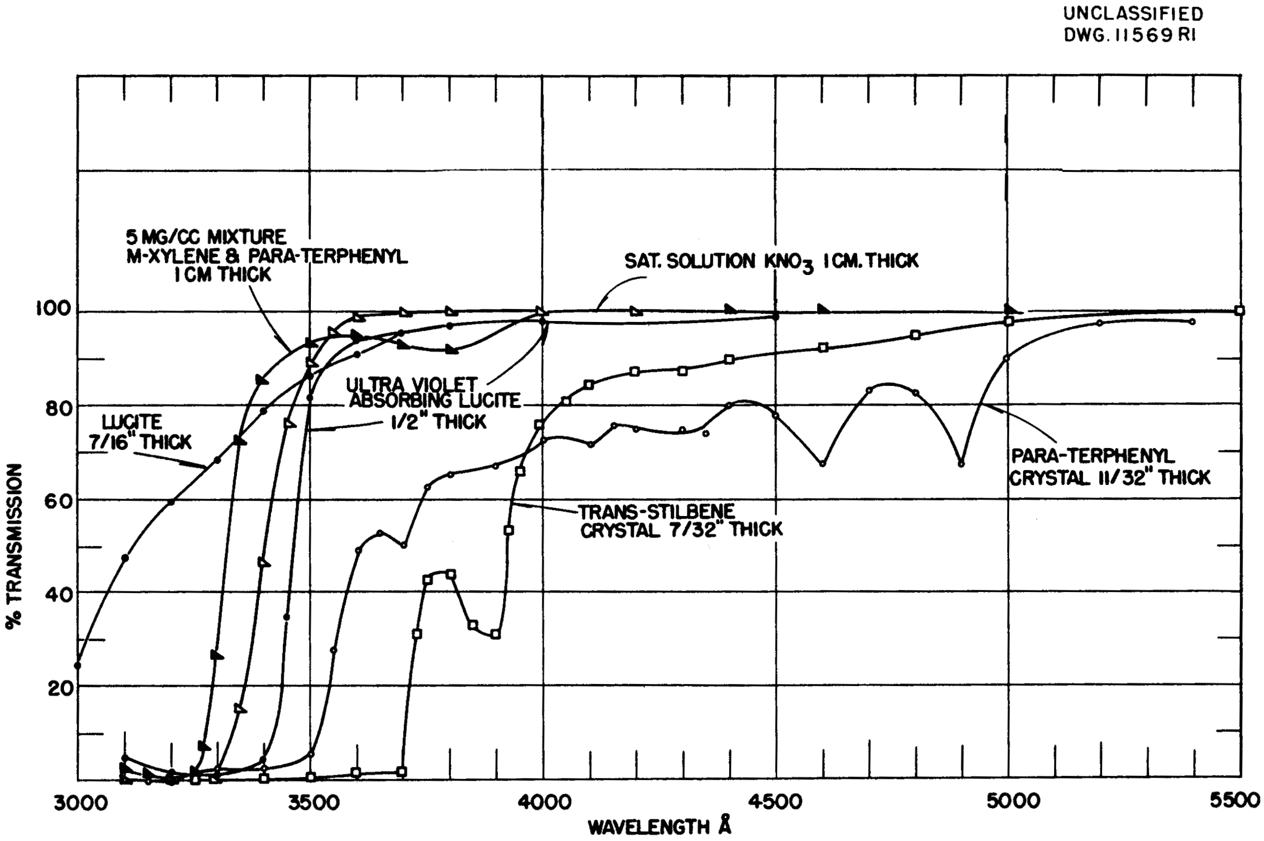

Fig. 5. Transmission Spectra of Various Crystals and Solutions.

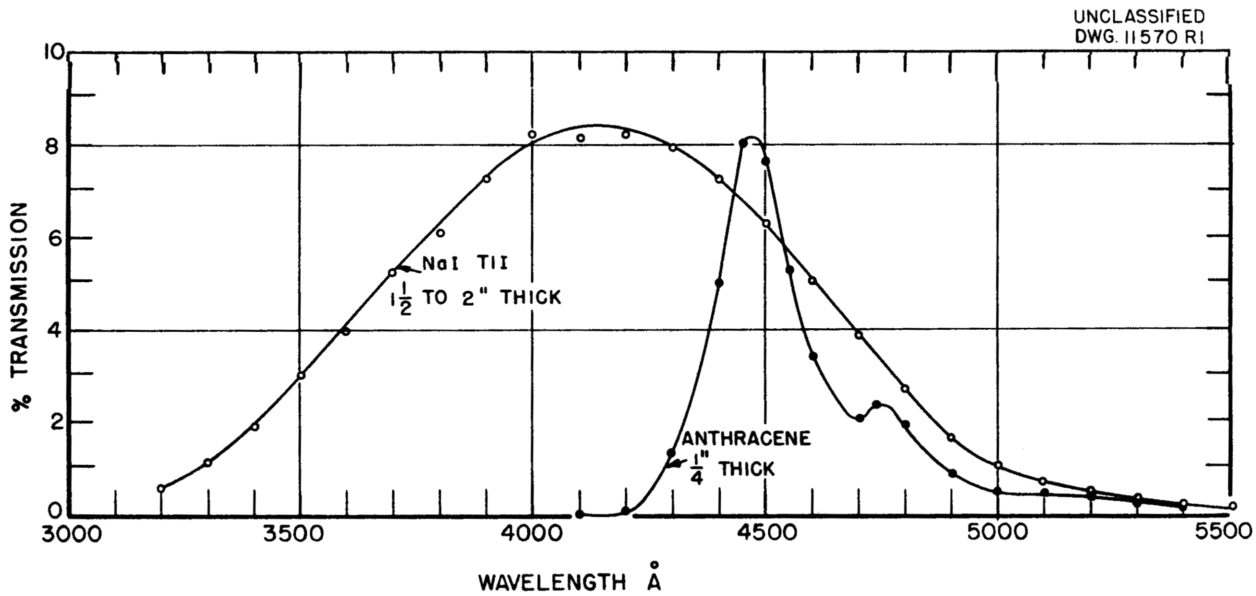

Fig. 6. Emission Spectra of Anthracene and Sodium Iodide Activated with Thallium.

curves are not the true curves of the emitted light since the entire crystal is illuminated in each case and the fluorescent light was partially absorbed in the crystal. Had the crys-been illuminated on one face so that the light would be completely absorbed or completely unabsorbed by the crystal material, they could be directly interpreted. Further measurements of this type would be extremely helpful and should be done. It can be seen that the short wavelength side of the anthracene emission curve coincides with the sharp absorption edge in the solid material. Should a similar condition be obtained with trans-stilbene, this would account for the poor energy resolution always obtained with good crystals of trans-stilbene.

The energy resolution of sodium iodide scintillation counters has been considerably improved by optical treatment of the crystal and the reflector. It was found that the previously used solvent-polishing method using alcohol or acetone was producing an ultraviolet absorbing layer on the surface of the sodium iodide crystals. By removing these layers by abrasion, in essence preparing the crystals only by grinding in extremely dry conditions in a dry box, the resolution was very much improved. A crystal which on solvent polishing gave a peak-to-valley ratio of approximately 10 with the 0.661-Mev γ ray of Cs^{137} was improved to give a ratio of approximately 25 merely by grinding and dry-polishing the surface. The resolution of a highly polished crystal was much improved by grinding the entire outside with 320 Carborundum. The ratio was decreased again merely by wetting the surfaces with mineral oil, thus restoring some degree of polish.

The ratio was also much improved by surrounding the crystal with highly polished aluminum foil which produced a better reflecting surface than the polish put upon the aluminum container by the shops. With such an arrangement the peak-to-valley ratio on Cs^{137} has exceeded 40. The resolution obtained with this ratio is between 8 and 9 percent for the full width at half maximum of the cesium peak at 661 Kev. To obtain these high ratios, the voltage ratio between the photocathode and the dynodes of the photomultiplier must be adjusted. The voltage ratios giving the best result appear to be 5.0, 0.85, 1.2, 1, 1, 1, etc., starting with the photocathode. When a high peak-to-valley ratio was obtained it was observed that there appeared to be an optimum total photomultiplier voltage. The ratio of 37 obtained with the total photomultiplier voltage of 620 volts was reduced to 19 by raising the total voltage to 860 volts. This ratio could be restored to 37 by defocussing dynode 6 or 7. This appears to be a saturation or space charge limiting effect in the photomultiplier. The peak current in the photomultiplier for the sodium iodide pulses at which saturation appears to begin is approximately 30 μa. The sodium iodide was replaced with an anthracene crystal whose pulse duration is approximately 10 times shorter; it was then found that a pulse 10 times smaller must be obtained from the photomultiplier before the maximum resolution was obtained, further confirming the belief that this is space charge limitation. Because of the low peak current at which it occurs, further work is being done to make sure this is a space charge limiting effect.

High-Speed Synchroscope (G. G. Kelley and R. R. Hall). A new synchroscope is in the process of development for the study of circuits and components to be used in very fast counting equipment and for the investigation of various discharge phenomena. The instrument will be at least five times as fast as the one developed here previously.[2]

It is intended that the vertical amplifiers used will have a rise time of about 1 mμsec. This figure is certainly within a factor of 2 of the fastest response that can be achieved with presently available tubes and to this extent represents a compromise with expediency. A low-frequency analog distributed amplifier has been constructed and studied as an aid to design. It is a 10-tube stage with parasitic grid and plate capacities increased to 950 μμf and uses Miller 0.5-mh choke coils as the half-section inductive elements. These have been disassembled and coupled together in pairs to give the required value of negative mutual inductance for an "*m* derived" line with $m = 1.27$. By calculation R_0, the low-frequency impedance of the line, is 1.16 K-ohms. The best value determined experimentally is 1.21 K-ohms. This analog circuit has demonstrated that with an optimum "*m* derived" line in grid and plate circuits, the rise time is equal within 10% to twice the calculated (and measured) delay per section (approximate mean value of the delay in the pass band is $1.265\sqrt{LC}$) or

$$t_{\text{rise}} = 2.54\sqrt{LC} = 2.0\,R_0C'$$

where L and C are the equivalent full-section "constant *k*" impedances, R_0 is the low-frequency impedance of the line, and C' is the actual circuit shunt capacity ($C' = mC$).

The measured delay per section of the analog amplifier is 1.15 μsec, and the rise time of the 10-tube stage is 2.3 μsec when terminated with a "constant *k*" half section of the same impedance and cut-off frequency. The rise time increases very slowly as the number of tubes in a stage is increased. It is only a few percent greater in the 10-tube stage than when only half the tubes are used. The overshoot, however, does increase significantly as the tubes per stage are increased. It is about 4% at the unterminated output of a 10-tube stage and appears to increase about 0.4% per tube. Very much improvement can be made by phase correcting condensers from grid to grid. The overshoot has been decreased to less than 1% by this means. It has been found experimentally from the analog that when the grid line is driven from a current generator, whose parasitic capacity equals the line shunt capacity, best pulse fidelity is obtained if the current is applied directly at the mid-series point of the first section of this line. Best open circuit plate line terminations is a "constant *k*" half section of equal impedance and cut-off frequency. The standard practice of using an "*m* derived" half section with $m = 0.6$ followed by a resistor equal to the low-frequency impedance of this line provides a very good termination with regard to pulse reflection.

(2)G. G. Kelley, "A High Speed Synchroscope," *Rev. Sci. Instruments* 21, p. 71 (1950).

INSTRUMENT RESEARCH AND DEVELOPMENT REPORT

CHEMISTRY DIVISION

Edward Fairstein and Frank Porter

Pulse Generator. A mercury-relay pulse generator for testing amplifiers and other equipment (Fig. 7) has been designed and tested which has some advantages over other types now in use at this laboratory. The advantages of the unit are:

1. It is small and light; its dimensions are 5 by 6 by 9 in.

2. It contains no batteries.

3. It is designed for an external terminating resistance of 100 ohms or less. This is advantageous in that long lengths of low-impedance connecting cable may be used with no degradation of the pulse shape. The voltage calibration is independent of the terminating resistance, for resistances of 100 ohms or less. Low-impedance uncompensated attenuator boxes may be used with the unit.

The voltage calibration of the generator may be checked with an external d-c voltmeter or potentiometer (the generator load must be removed when making this test). The warm-up drift is less than 0.05%. The long-time stability has not been checked.

The rise time is less than 0.007 μsec. If there is ringing present, it has a period which is less than this figure. With a 100-ohm load, the fall time is about 1700 μsec. The fall time is directly proportional to the load resistance. External loads of greater than 100 ohms will cause a voltage calibration error.

Contact potential differences between the relay contacts cause spurious pulses as they make and break. The connections as shown in the diagram appear to be optimum. The spurious pulses from a new relay are usually less than 1 mv in amplitude.

Single-Channel Differential Discriminator. The single-channel discriminator previously described[1] has been in operation for a sufficient length of time to obtain new information about its performance.

It was found necessary to replace the diodes in the shunt-compensating circuits of the trigger pairs with 4.7K damping resistors. It was also necessary to slightly increase the dead time of the lower trigger pair by means of a powdered iron slug in the compensating inductor. These changes materially improved the circuit operation at very high counting rates (3×10^6 counts/min).

The circuit has unfortunately proved to be unstable for long periods of operation. Both random and uniform drifts occur in the slit width. The trouble is caused by the extremely close-grid-to-cathode spacing in the 404A tubes. Intermittent shorts cause randomly spaced drifts of large magnitude. Slow drifts are apparently caused by slow changes in the grid-to-cathode spacing. It is expected that an aging program for the tubes will materially improve the reliability of the circuit by making it possible to install sets of tubes with closely matched drift rates and by weeding out those tubes which develop shorts. An aging rack is now being constructed.

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[1] E. Fairstein, "A Differential and Integral Pulse-Height Selector for the A-1 Amplifier," *Instrument Department Research and Development Quarterly Progress Report for Period Ending January 20, 1951*, ORNL-1021, p. 7 (June 25, 1951); also in *Chemistry Division Quarterly Progress Report for Period Ending December 31, 1950*, ORNL-1036, p. 65 (Sept. 10, 1951).

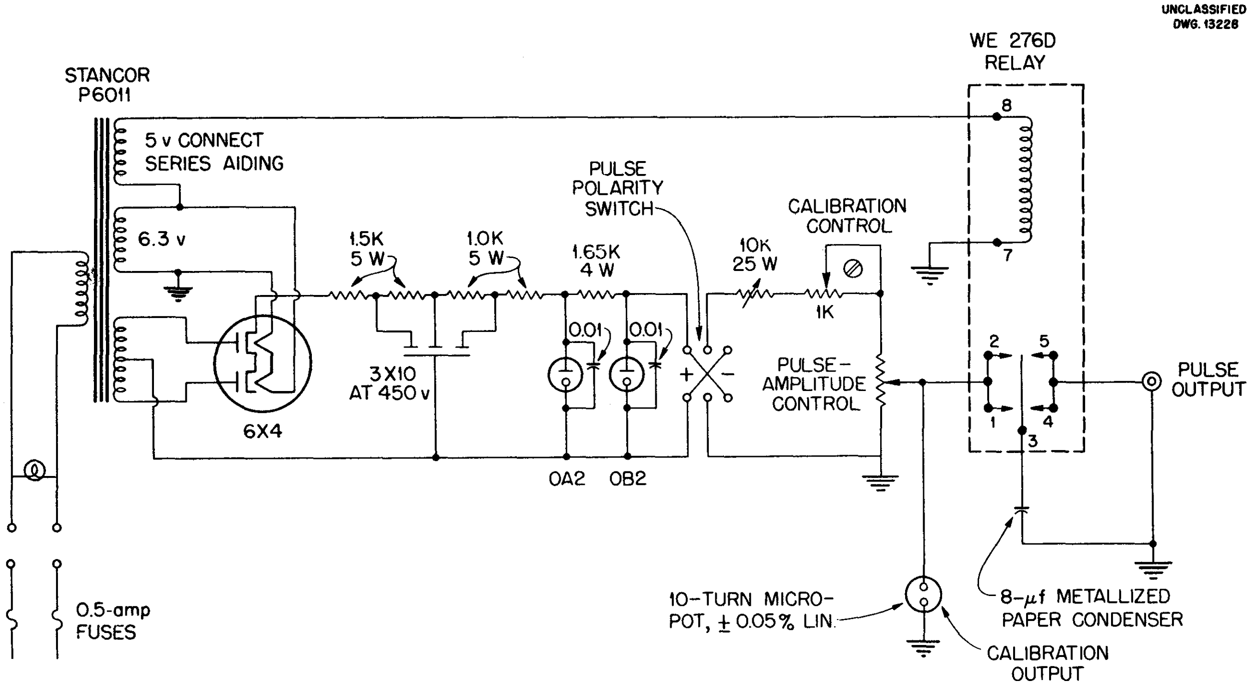

Fig. 7. Mercury-Relay Pulse Generator.

Other tube types are also being investigated with the hope that a desirable substitution can be made.

Twenty-Channel Energy Analyzer. A 20-channel pulse-height analyzer has been designed and is now under construction. The unit is expected to be a general-purpose energy analyzer, adaptable to all the types of energy measurements now being made by differential discriminators.

The basic circuit is that of the single-channel unit described above. The analyzer will be used with a window amplifier similar to that used in the Physics Division, to minimize channel width drift.

A condenser storage circuit will be substituted for the usually used scaler circuit. This will result in a considerable saving in space and cost and an increase in flexibility of operation. The data will be automatically plotted in the form of a histogram by a strip-chart recorder.

Ten-Channel Energy Analyzer. The Allen B. Du Mont Laboratories have made available a 10-channel gating tube for pulse-height analysis applications. The tube type is K 1059, and the original development work was sponsored by the University of California. The claims for it are high. If the tube meets specifications, it should be possible to construct a very stable, relatively inexpensive energy analyzer. An experimental circuit using this tube has been designed and is now under construction.

High-Voltage Power Supplies. Two power-supply designs are being considered with the hope that these will eventually become standard equipment for the Chemistry Division. One has an output adjustable between 500 and 1500 v for use with scintillation counters, and the other will be adjustable between 500 and 5000 v for proportional counters. Emphasis is being placed on those design factors which result in stable operation for long periods of time.

INSTRUMENT RESEARCH AND DEVELOPMENT REPORT

HEALTH PHYSICS DIVISION

EXPERIMENTAL RADIATION MEASUREMENTS

Background Instrumentation. A test probe for measuring slow neutrons in drill holes is being built in cooperation with the U. S. Geological Survey. The counter is of the enriched boron trifluoride type. The slow-neutron density should be higher near uranium ore as a result of spontaneous fission and should also be specific for uranium. Tests will be made at Grand Junction, Colorado on a simulated test hole made up of layers of concrete and uranium ore. Although the expected count will not be high enough to serve as an efficient ore-detecting device, the instrument may serve as a check on holes that have been logged with a gamma-ray probe and give further information as to whether or not the radium and uranium are in equilibrium.

A sodium iodide scintillation probe is also being constructed to test the feasibility of this type of probe on the simulated drill hole. The possible advantages of the scintillation probe are greater sensitivity and the possibility of gaining further information from energy distribution curves. Knowledge of the energy distributions may make it possible to differentiate between a near, small source and a distant, large source.

Development of equipment used in the U. S. Geological Survey airplane for radiation measurements is still in progress. The light-piping from the 4-in.-dia, 2-in.-thick sodium iodide crystal to the 5819 photomultiplier tube has been improved by making the Lucite light-piper as short as possible. The next step in improvement will be to mount the crystal directly onto the phototube.

An improved recording-rate meter has been utilized, which has no memory effect, obviates the use of scalers, and has a resolving time of the order of 2 microseconds. The device uses a small condenser, which is discharged by each count and then recharged from a large (1 μf) condenser. The voltage on the large condenser is measured at the end of a counting interval, with a recording electronic voltmeter circuit, after which the condenser is recharged. Two large condensers are used alternately so that the voltage on one condenser is being recorded while the other is being discharged by the count. At the end of the counting interval, a switch reverses the connections so the condenser whose voltage was being recorded is charged and becomes the one to be discharged, and vice versa. The time interval of the switch is controlled by a Bodine motor with a relay so that the time interval used is 1 second. Ceramic wafer switches mounted on a rotary solenoid did not stand up under continuous use. A new type of switch is being constructed that may remove this difficulty.

Work on radiation-absorption measurements is under way to find the perturbations introduced into White's[1] results by the presence of cylindrical air cavities of various diameters surrounding the detector.

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(1) G. R. White, "The Penetration and Diffusion of Co^{60} Gamma Rays in Water Using Spherical Geometry," *Phys. Rev.* 80, 154 (1950).

INSTRUMENT DEPARTMENT

Cockcroft-Walton Generator (R. W. Bennett and R. F. King). It was decided to operate two accelerators from the Cockcroft-Walton generator to make efficient use of the high voltage available. One of these accelerators will be operated by G. E. Evans' group, Physics of Solids Division, and the other by W. M. Good's group, Physics Division. The No. 2 accelerator set was completed and put in operation during this period.

It was found desirable to increase the maximum potential available from the Cockcroft-Walton generator by the addition of a fourth stage. This additional stage has been completed and put in operation. Maximum ratings on this generator are now approximately 20 ma at 450 kv.

Van de Graaff Generator (R. W. Lamphere). Work continued on the conversion of the Van de Graaff generator to the acceleration of positive ions. All of these major projects involved a host of minor ones. For example, the conversion of the Van de Graaff involved the addition of a system of controls for the equipment, which operates on the high-potential terminal of the generator. These controls are actuated by driving Variacs from slave selsyns through long insulating rods; the transmitter selsyns then control and indicate the equipment operated at high potential.

Constant-Current or Constant-Voltage Power Supply (B. Hildebrant). When the instrument is used as a constant-current source, it operates to maintain a constant voltage across a precision resistor in series with the load. A Leeds & Northrup potentiometer (0 to 1.11 v) is used as an adjustable reference voltage. The difference voltage between the reference resistor and the potentiometer is applied to the input of a Brown amplifier motor, which drives two ten-turn, ganged helipots controlling the load current. For use as a constant-voltage source it is only necessary to short across the "load" terminals and put the load across the "reference resistor" terminals.

Liquid-Waste Monitoring and Metering System (I. D. Groves). This monitoring and metering system is designed to detect activity in water (or other liquids, with proper modifications), record the total amount of activity on a four-digit meter, provide a continuous record of the activity level at any time, record the total amount of water disposed of, and sound an alarm when the amount of radioactivity reaches some predetermined level. Using a 30-mg/cm^2, Mark 1, Model 11, Radiation Counter Laboratories beta-counter tube, the instrument will detect activity of 2×10^{-6} μc/ml of water. This level of activity is 20 times the tolerance for drinking water.

The counting-rate meter contains a dual-channel input whereby the background radiation is subtracted from the monitored level before recording. The differential counting rate is multiplied by the rate of flow of liquid, and the product is integrated by a watt-hour meter. The final reading on the watt-hour meter is calibrated in units of total activity discharged. In addition to the monitoring equipment there is a pump that obtains a very accurate but small sample of water for chemical analysis. The pumping rate is proportional to the rate of flow of the water being monitored.

Viscosimeter, Q-1164 (K. H. Kline). A device has been constructed and is now in service for measuring the viscosity of liquid metals. This is done by electronically timing the rate of fall of a radioactive (gamma) sphere through the liquid metal. Timing begins and ends as the ball successively passes two G-M counters placed a predetermined distance apart.

Powder Metallurgy Laboratory (J. Lundholm, Jr.). The Applications Section has recently completed the installation of instruments in the powder-metallurgy laboratory for the Metallurgy Division. A central instrument-panel board was installed for two Leeds & Northrup Micromax-DAT indicator-controllers, six Brown Pyrovane millivoltmeter controllers, two Brown Protectovane overtemperature protection units, and a 20-kw saturable-reactor temperature controller for a special G-E molybdenum furnace. Special contactor and thermocouple patch boards were installed to allow use of the Micromax-DAT controllers with different furnaces. This is the first installation in the Laboratory of a commercially available saturable-reactor unit equipped with electric droop correction or automatic reset to maintain the temperature precisely at the desired value. Naturally this excludes errors in temperature measurement. Long-time runs have shown the unit to give excellent control and it is satisfactory in all respects. Temperature records are essentially straight-line.

Recording Extensometer (J. Lundholm, Jr.). Development work is in progress to design a recording extensometer for use by the Metallurgy Division in their 16-machine creep laboratory. The extensometer should have a stability, sensitivity, and accuracy of 50 μin. or better over a period of 6 to 12 months of continuous uninterrupted operation. For much of the creep laboratory work, it will be necessary to operate the extensometer inside the furnace vacuum chamber. It is contemplated that a plenum chamber will be added to the bottom end of the furnace to house the unit. This will allow the extensometer to be placed in a comparatively cool zone, and it will be necessary for only the push rods to enter the high-temperature zone of the furnace. Various sensing elements such as linear differential transformers (Microformer and Atcotran), strain gages, capacitance gages, ultrasonic circuits, mechanical dial indicators, and electric-contact motor-driven micrometers have been considered.

Present information shows that the electric-contact motor-driven micrometer will be most satisfactory. It is the only unit that has the desired sensitivity and is capable of a 1-in. span. It works on the principle of driving a geared micrometer head with a small Bodine 200- to 600-rpm motor until an electric contact is made. As the specimen elongates, the contacts separate and an electronic relay closes, causing the motor to again drive the micrometer to make contact. The reading of a Veeder-Root revolution counter vs. time gives the desired data. The recording of the revolutions of the motor vs. time may be printed by a Streeter-Amet automatic printer. For this, the motion of the motor shaft will be transmitted outside the vacuum chamber with the aid of a selsyn transmitter. In order to achieve sufficient power to actuate the seven-dial revolution counter used on the Streeter-Amet printer, it will be necessary to employ an electronic-servomechanism to operate the printer dials and selsyn receiver.

A second way to record the revolutions vs. time is by actuating the pens of an Esterline-Angus operational recorder. A special Veeder-Root counter is constructed to actuate a microswitch that gives a pip on the chart for each 0.1 revolution of a particular dial. If a five-dial counter is used, then a five-pen operational recorder is needed. It is planned to have models using both types of recording under test in the very near future.

Tests of Leeds & Northrup DAT '50 Speedomax Controller (J. Lundholm, Jr.). A Leeds & Northrup DAT '50 Speedomax controller driving a Variac for controlling the temperature of a small, light furnace has been tested. This is the new Leeds & Northrup controller utilizing a d-c network of resistors and condensers to achieve automatic reset and rate action. Unfortunately, the convolutions of a Variac cause the temperature to continually cycle 1 to 2°C. A change of 0.25 v is about the smallest one can obtain from a 115-v Variac. Since power is proportional to E^2, this is an appreciable change in power input to the furnace.

A special contact was added to the standard unit to open a contactor in the furnace line in case the temperature rises 0.25 in. above the set point. This is to prevent a serious rise in temperature should the electric drive mechanism for the Variac fail or stick. Future units will be ordered with the contact as a special feature installed at the factory.

For a small, light furnace where continuous power input is required, the DAT '50 driving a Variac is simpler than a saturable-reactor unit, but it does not give quite as close control. It may be roughly stated as being a 2°C variation compared to a 1°C cycle for a properly designed saturable-reactor unit.

Precision Constant-Temperature Salt Bath (S. A. Hluchan). Equipment and controls have been designed and put into service for maintaining a moving pressure vessel at constant temperature to permit precise pressure measurements. The circulated bath fluid is a salt eutectic and has been used up to 400°C. The temperature recorder-controller has a full scale span of 1.6°C. Proportional and reset control actions were obtained by use of a DAT unit. The primary control element was a special fast-response nickel resistance thermometer. Temperature measurement was made by means of a platinum resistance thermometer and a Mueller Bridge. Temperature drifts during any daytime period of testing were less than 0.02°C.

NaK Cycler (H. J. Stripling). This device was designed by the ORNL Instrument Department and built for the ORNL Metallurgy Division in cooperation with this division and the California Research and Development Company personnel. The NaK cycler thermally cycles metal samples between arbitrary temperature limits by alternate immersion of the samples in two temperature-controlled liquid NaK baths.

The sample rack holding 18 samples is transferred from bath to bath by means of cams. Cycling is controlled by thermocouples in the baths and by a thermocouple in a dummy sample in the sample rack. This allows a close approach to the optimum cycling rate determined by heat-transfer rates. The control circuit is so interlocked that cycling will not take place if the NaK baths are at temperatures that would nullify the data. The temperatures of the NaK baths are controlled by Wheelco indicating controllers. Dummy-sample temperature is continuously recorded on a Brown recording potentiometer. The hotter NaK bath contains direct immersion-type electric heaters in stainless steel sheaths. The cooler NaK bath contains similar heaters, and in addition is submerged in an oil bath containing cooling coils with circulating water. This enables the cooler bath to operate at temperatures above and below ambient air.

The sealed enclosure above the baths is filled with an inert gas (helium is currently being used) at a slight positive pressure. The cam-driven shaft that transfers the samples passes into this enclosure through a Graphitar-washer and asbestos-graphite seal. The shaft is hollow to provide passage for a thermocouple and a smaller shaft that rotates the samples in the baths to increase the rate of heat transfer. Over six runs of 1000 cycles each have been made between temperatures of 100 and 350°C. This is a total of over 120,000 sample cycles.

Gamma-Ray Spectrometer Shield, Q-1132 (R. M. Farnham). The gamma-ray spectrometer shield is a 2½-ton lead box enclosed in steel plate and lined with boron-aluminum alloy. Under the top access plug, multiple scintillation counters and preamplifiers are located precisely with respect to a collimating aperture and operate under 10 psig of dry air pressure supplied through the signal-cable sheath. The shield is supported at scanning height on a steel pipe tripod equipped with a leveling jack screw. Positioning and leveling of the shield can be accomplished by an operator approximately 20 ft above scanning height. A design modification will permit azimuth adjustments up to 90 deg from the horizontal.

Instrument Construction and Maintenance (W. J. Ladniak). The following instruments were built in the instrument fabrication shop for use in research work:

Servo amplifiers	2
Magnet amplifiers	27
A-1 amplifiers	44
Power supplies	19
Preamplifiers	41
Pile period meter	1
Tube ager	1
Log count-rate meter	1
Monitrons	2
Single-channel analyzer	2
Beta-gamma poppy	7
Differential pulse-height selector	2
Ten-channel analyzer	1
Electrometers	10
Survey meters	5
Ionization gage control	5
Total	170

The preamplifiers built were used with BF_3 counters, linear amplifiers, servo amplifiers, and G-M counters. The power supplies built were negative high-voltage supplies, magnet power supplies, ion-chamber power supplies, and straight power supplies for various uses.

The following is a summary of Instrument Department services:

	NO. OF SERVICES	NO. OF FAILURES
April	187	515
May	234	843
June	198	658
Total	619	2016

A breakdown of instrument failure by type is as follows:

	PERCENTAGE OF TOTAL
Transformers replaced	0.78
Geiger-Mueller tubes replaced	8.63
Filter condensers replaced	2.87
By-pass condensers replaced	1.64
Resistors replaced	1.79
Vacuum tubes replaced	39.61
Instruments calibrated	4.33
Miscellaneous failures	40.35
Total	100.00