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Progress Report
9a

INSTRUMENT RESEARCH AND DEVELOPMENT
QUARTERLY PROGRESS REPORT
FOR PERIOD ENDING JANUARY 20, 1951

OAK RIDGE NATIONAL LABORATORY
OPERATED BY
CARBIDE AND CARBON CHEMICALS COMPANY
A DIVISION OF UNION CARBIDE AND CARBON CORPORATION
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QUARTERLY PROGRESS REPORT
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Compiled by
W. E. Thompson

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1. CHEMISTRY DIVISION

A DIFFERENTIAL AND INTEGRAL PULSE-HEIGHT SELECTOR FOR THE A-1 AMPLIFIER

E. Fairstein

Introduction. The increased use of scintillation counters for the measurement of beta- and gamma-ray energy spectra has emphasized the need for an inexpensive differential pulse-height selector. Because of the wide use of the A-1 amplifier at this Laboratory, a unit small enough to replace the integral pulse-height selector now incorporated in it is most desirable. Such a unit should require a minimum of amplifier circuit change without appreciably sacrificing speed of operation or reliability.

A circuit which meets these requirements has been designed and built. There has been insufficient time for extensive reliability tests, but there appears to be no reason for early failure in the present unit.

Description of Circuit. The basic differential pulse-height selector consists of a pair of gate circuits followed by an anticoincidence circuit (Fig. 1.1). The difference in triggering level of the two gate circuits constitutes the slit width. The sensitivity of both gate circuits is varied simultaneously by the pulse-height selector control. The anticoincidence circuit accepts only those amplifier pulses whose peak amplitudes fall within the slit. Larger pulses are prevented from passing through.

Because of the finite rise and fall time of the signal pulse from the amplifier, the lower gate is triggered before the upper, and the upper gate recovers before the lower. It becomes necessary for proper operation of the anticoincidence circuit to delay the signal from the lower gate until the upper has triggered, and to store the signal from the upper gate until the lower has recovered. The delay is accomplished by using the differentiated trailing edge of the lower gate signal. Storage is accomplished by charging a small condenser through a diode.

T_1 through T_4 are the gate circuits. Western Electric 404A tubes are used because of their high figure of merit and reported long life. To get positive triggering on the fast pulses from the A-1, it is necessary to provide inductive compensation in the plate circuits of T_1 and T_3. Overcompensation

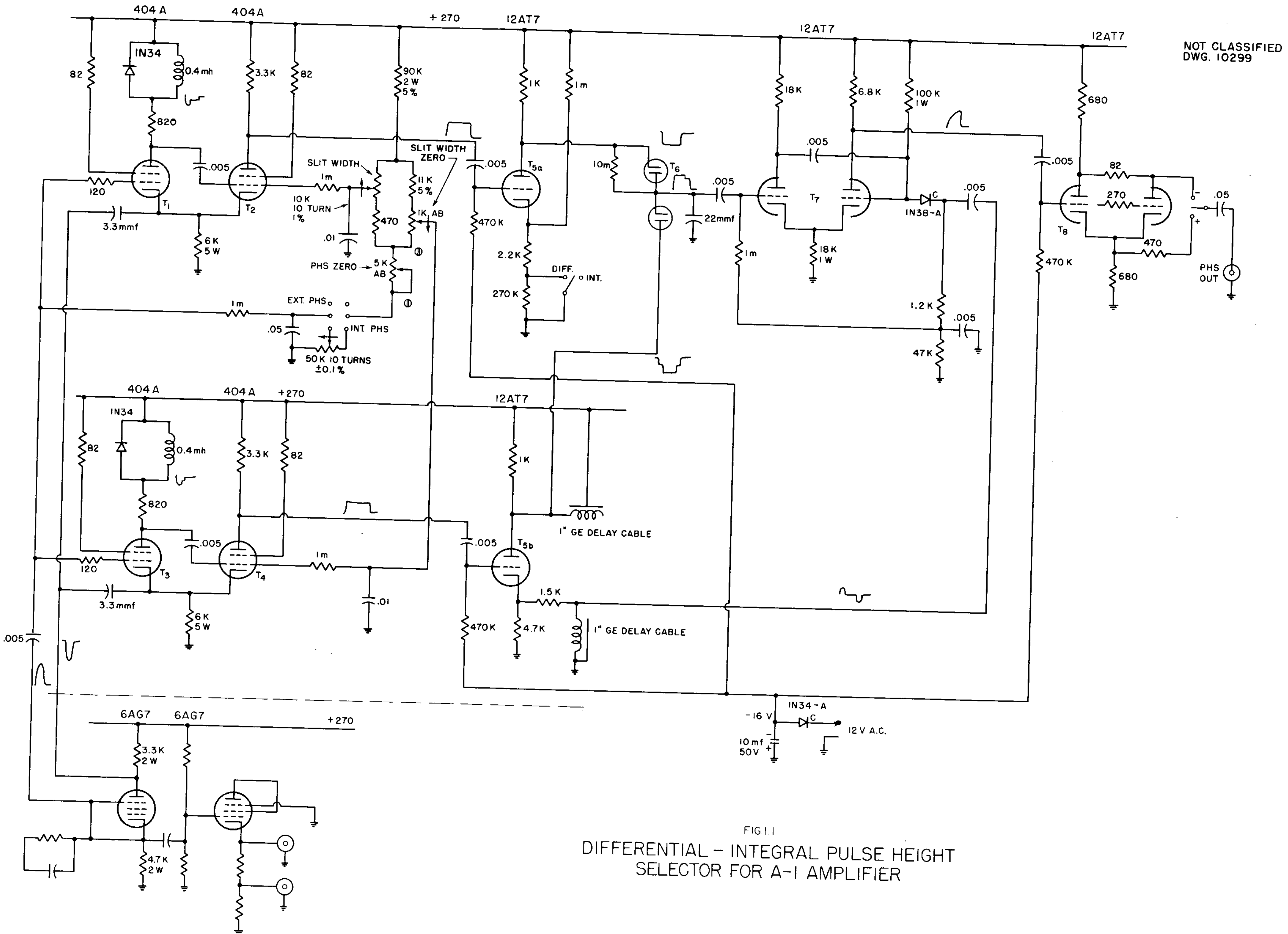

FIG.1.1

DIFFERENTIAL – INTEGRAL PULSE HEIGHT SELECTOR FOR A-1 AMPLIFIER is used for two reasons: (1) An increase in speed of triggering of nearly a factor of 2 results, and (2) the minimum recovery time is fixed at approximately 0.3 μsec. Ringing is prevented by the diode clamps.

The gate circuits are followed by two halves of a 12AT7 tube, each half being used as an impedance transformer and phase inverter. This tube is represented by T_{5a} and T_{5b} on the diagram. Both halves are biased to complete cutoff to conserve tube life and power drain.

The storage circuit is driven by one-half of a 6AL5 twin diode. The remaining half is used as a clamp to discharge the storage circuit at the end of a signal pulse. The clamp is driven by the plate circuit of T_{5b}, whose plate load is an open-end delay line. The clamp is opened by the leading edge of the signal from the lower gate circuit. It is not closed until after the lower gate has recovered and the differentiating circuit has been discharged.

T_7 is a combined anticoincidence circuit and pulse shaper. The pulse shaping is accomplished by connecting the tube as a univibrator. Its output pulse has an amplitude of about 30 volts and a duration of 0.6 μsec. It is triggered (in the absence of an inhibiting signal) by the trailing edge of the differentiated signal from the lower gate circuit. It is prevented from triggering by the inhibiting signal from the storage circuit.

T_8 is an impedance transformer used as the output stage for the circuit. It will feed a 13-volt 0.5-μsec pulse of either positive or negative polarity to an external circuit. Its source impedance is 680 ohms.

The grid-to-cathode capacity of the 404A tube results in a small signal being transmitted through the gate circuits even without triggering action taking place. The amplitude of the signal is dependent upon the rise time and amplitude of the output pulse from the A-1. This spurious signal is easily neutralized by feeding a negative signal equal in magnitude and shape to that of the normal output signal from the A-1 into the cathode circuits of the 404A. A coupling capacity equal to the grid-to-cathode capacity of the 404A must be used.

This negative signal can be obtained from the plate circuit of the output tube of the last feedback loop in the amplifier (see Fig. 1.1). This change and the replacement of the power transformer with one of higher power-handling capacity are the only changes needed in the wiring of the remainder of the A-1.

Miscellaneous Information. After the initial adjustments of the zero positions of the slit width and pulse-height-selector controls, no additional adjustments are necessary when it is used on the three available bandwidths. The maximum setting of the pulse-height-selector dial represents an actual pulse amplitude of about 85 volts. The maximum setting of the slit-width dial represents 10% of this value. The output of the pulse-height selector will drive an external scaler or count-rate meter. The minimum dead time of the circuit is about 1 μsec. Under no condition of operation will it limit the maximum counting rate which the A-1 can now tolerate. The minimum actual pulse amplitude it will accept is 2.4 volts. The linearity of the circuit is as good as that of the best obtainable helipot. Unfortunately, when the A-1 is set for the 2-megacycle bandwidth, the amplifier itself begins to saturate at about 60 volts. At full scale on the pulse-height-selector dial the error is 12%. The maximum errors for the 0.5- and 0.1-megacycle settings are 0.5 and 0.1%, respectively. The linearity is degraded with aging of the 6AG7 tubes in the amplifier.

FIELD-FORMING ELECTRODES IN CYLINDRICAL PROPORTIONAL COUNTERS

R. S. Stone and C. J. Borkowski

In energy measurements with proportional counters it is essential that ionizing events with equal energies should give rise to identical voltage pulses, regardless of location of the ionizing event within the active volume of the chamber. This means that the gas multiplication, and hence the electric field, must be constant for the entire length of the collection wire. It is proposed to investigate methods of achieving this in the case of the usual cylindrical counter.

An infinitely long cylinder with a uniform coaxial center wire would have a constant field of the type sought, but when end walls, sample holders, or other discontinuities are inserted, the field is found to be distorted. For example, an end wall which is at the same potential as the side walls will reduce the field in its vicinity by an amount proportional to exp $-kz/b$, where z is the distance from the end wall and b is the radius of the chamber.[1]

The usual means of dealing with this problem is to record only the events occurring in the uniform-field portion of the counter (one chamber radius or more from the ends). This is accomplished in various ways, one of the most

(1) N. M. Blachman, "The Counting Volume of a Cylindrical Ionization Chamber," *Rev. Sci. Instruments* 20, 477 (1949).

common of which is to increase the wire diameter near the ends so as to make the field there too low for gas multiplication to take place. This change in wire diameter will, of course, itself create a distortion in the field, but of a lesser degree and in a direction opposite to that introduced by the end wall. For the measurement of energies of gaseous radioactive nuclides such as H^3, C^{14}, I^{129}, and S^{35} it is important to maintain a uniform field throughout the chamber volume if possible.

An approach to this ideal could be obtained by making the end wall in the form of a number of concentric insulated rings, each held at the potential which would exist at that radius if the cylinder were infinite in length. This potential is

$$V = Vr \frac{\ln r/a}{\ln b/a}$$

where Vr is the total potential across the chamber and b, a, and r are the radii of the chamber, center wire, and point in question, respectively. With an infinitely large number of rings this device could duplicate perfectly the field of a chamber with no end walls, a finite number of rings giving a field only approximately uniform.

Another source of field distortion is a sample holder which projects into the chamber. Such a holder is useful in energy measurements of soft electrons, in which cases we wish the electrons from the sample to give up all their energy in the counter gas. To make this possible the source must be held a sufficient distance from the walls to ensure that no particles reach them. The same type of construction may be employed here as in the case of the end walls. The holder can be made in insulated sections and each held at roughly the correct potential for its position in the chamber.

In order to investigate the behavior of these devices, an electrolytic bath analogy was set up; the results are plotted in Figs. 1.2 through 1.6. Figure 1.2 shows the effect on the field of the conventional type of guard sleeve. It is seen that this type of correction straightens out the field considerably; moreover, pulses collected within this region have such low gas multiplication that they are not usually counted. To hold field distortion to a minimum, the wire enlargement should be no more than is necessary to cut the

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FIG. 1.2

FIELD PATTERNS FOR END WALL CORRECTING SLEEVES IN CYLINDRICAL COUNTER; AS DEDUCED FROM MEASUREMENTS IN ELECTROLYTIC TANK

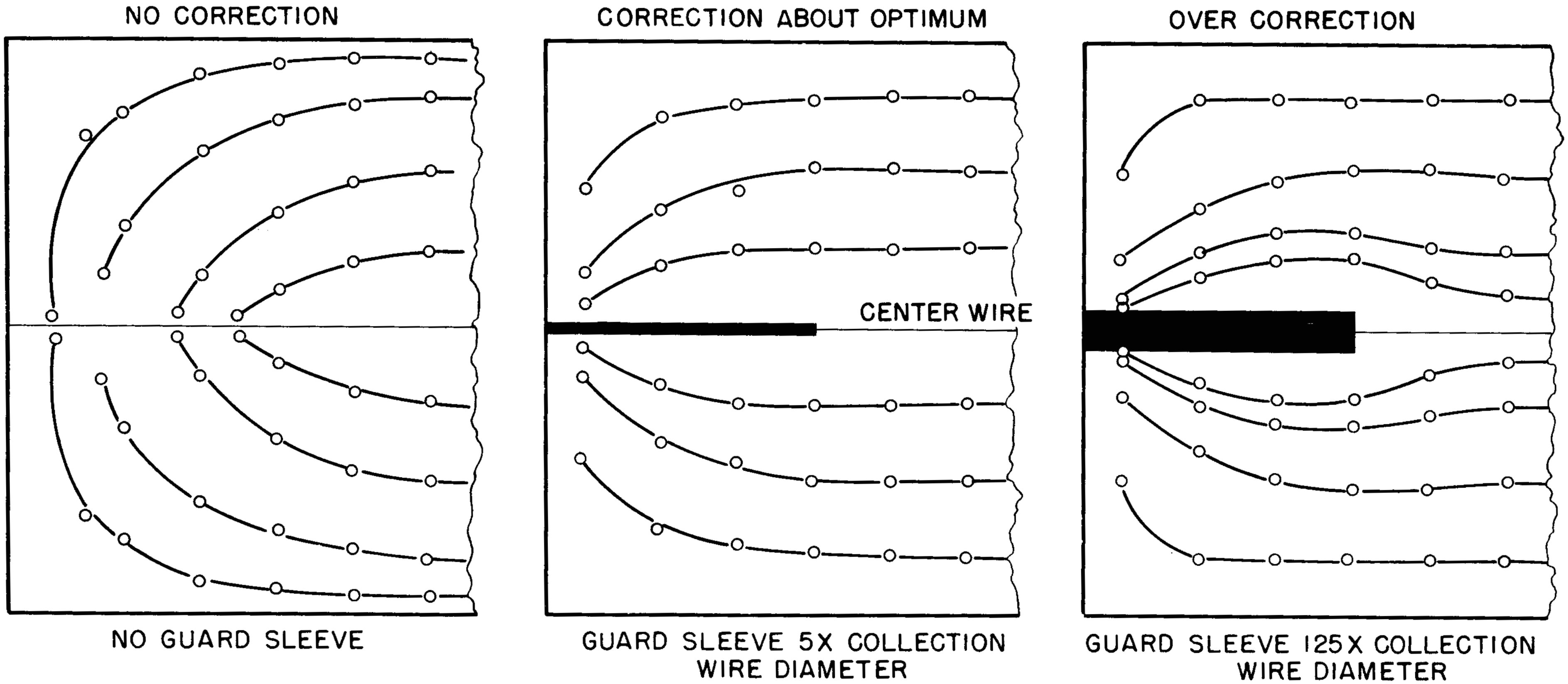

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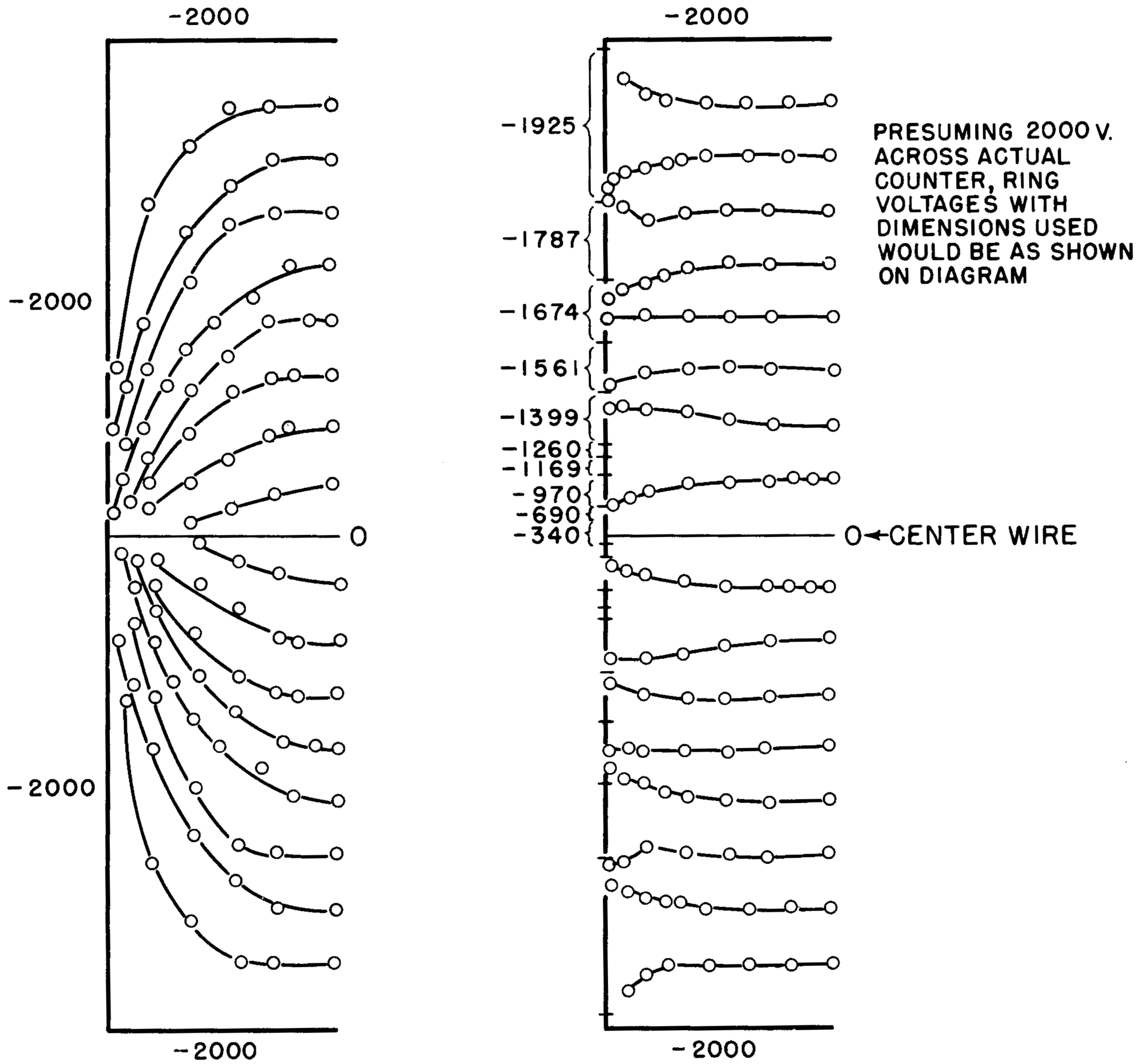
FIG. 1.3

FIELD PATTERNS FOR END WALL EFFECTS IN CYLINDRICAL COUNTER WITH AND WITHOUT RING-TYPE CORRECTION; AS READ FROM ELECTROLYTIC BATH MEASUREMENTS



END AND WALLS AT SAME POTENTIAL

END DIVIDED INTO RINGS WITH STEPWISE VOLTAGE VARIATION FROM CENTER WIRE TO SIDE WALLS

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FIG. I. 4

FIELD PATTERN FOR DISTORTION DUE TO INTERNAL SAMPLE HOLDER AT SAME POTENTIAL AS WALL-AS READ IN ELECTROLYTIC BATH

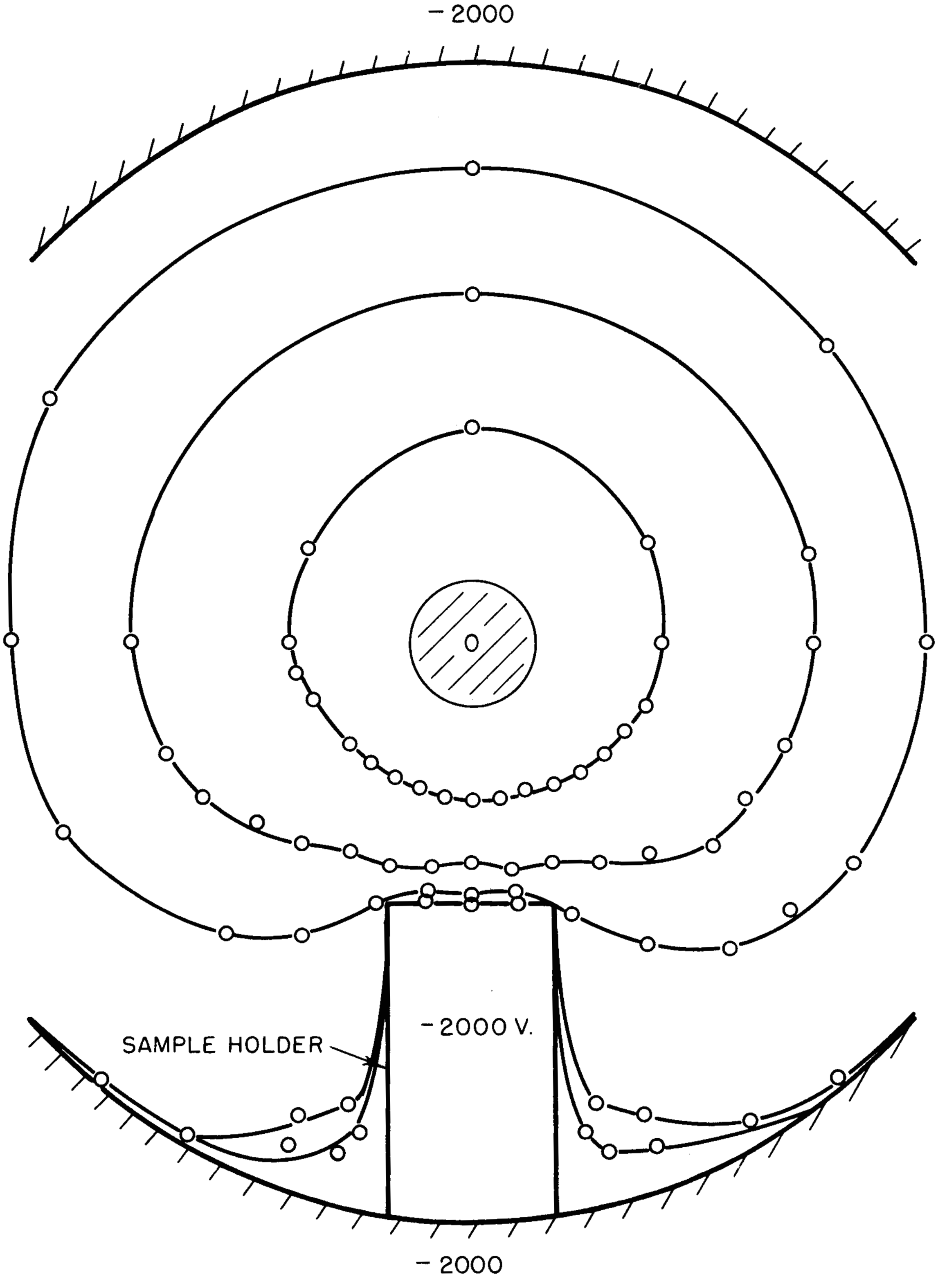

FIG. 1.5

FIELD PATTERN FOR DISTORTION DUE TO INTERNAL SAMPLE HOLDER WHOSE VOLTAGE IS HELD AT VALUE CORRECT FOR ITS INNERMOST POINT – AS READ IN ELECTROLYTIC BATH

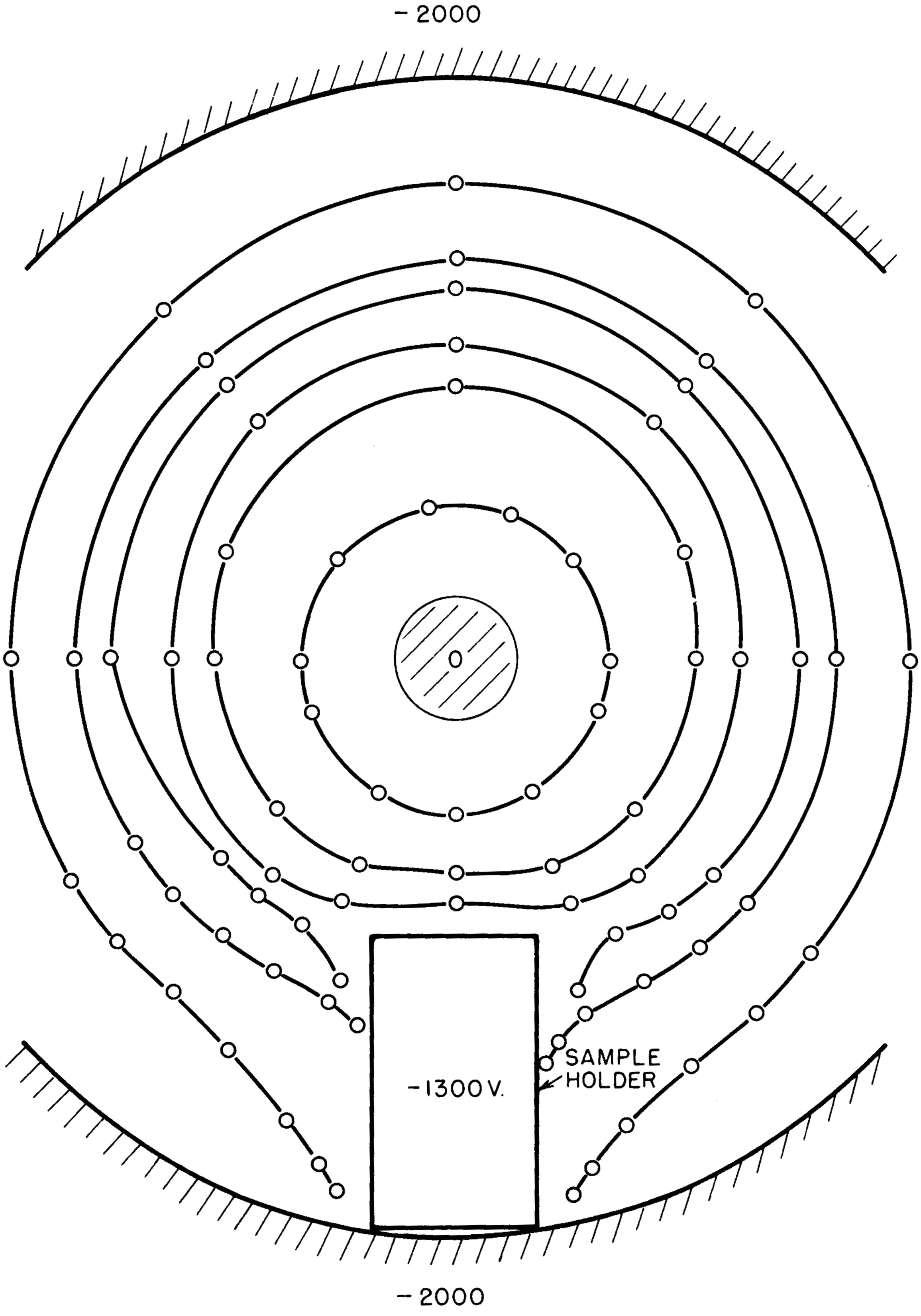

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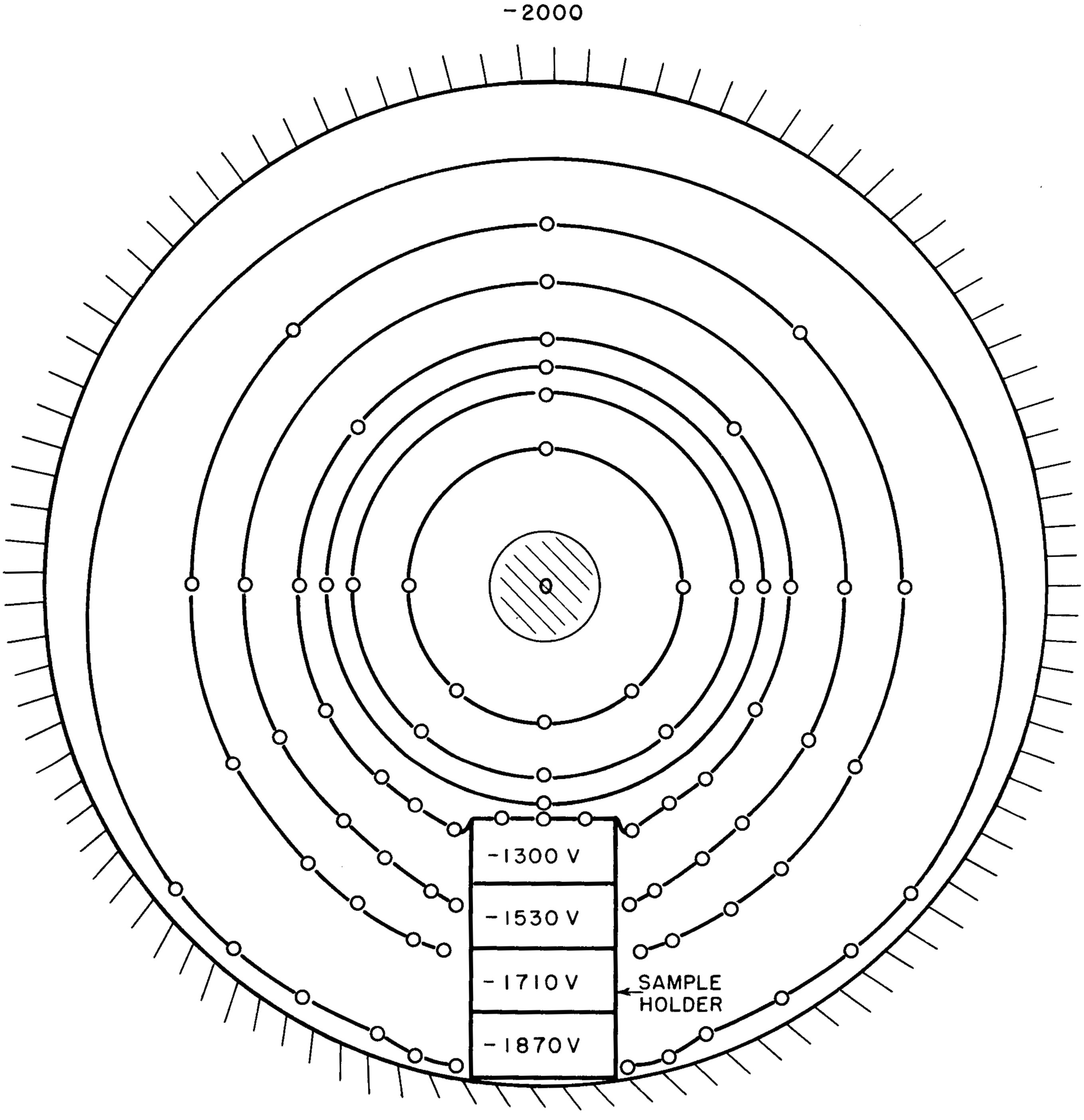
FIG. I.6

FIELD PATTERN FOR DISTORTION DUE TO INTERNAL SAMPLE HOLDER WITH FOUR VOLTAGE STEPS – AS READ IN ELECTROLYTIC BATH



gas amplification to a negligible value. Figure 1.3 indicates that the postulated ring type of end construction is capable of much better field correction than guard sleeves, permitting use of the entire counter volume. It is seen that more rings are needed near the center wire than further out, since the potential gradient is much greater near the center than in the vicinity of the side walls. This is as expected.

Figures 1.4 through 1.6 show the effect of sample holders held at various potentials. It is seen that an internal sample holder held at wall potential introduces bad field distortion (Fig. 1.4), but that by insulating the holder and applying proper voltages to it, either as a whole or in part (Figs. 1.5 and 1.6), its disturbing influence may be minimized. While segment type construction gives the best field smoothing (Fig. 1.6), it is seen that simply holding the whole structure at the potential correct for its deepest penetration into the chamber gives what is probably quite adequate correction (Fig. 1.5).

These investigations are felt to be encouraging enough to justify constructing a chamber with the above type of correction for end effects. In one scheme the end rings could be mounted on an insulating disk and connected by dropping resistors of the proper values; the whole assembly could then be mounted inside an overall gastight chamber envelope. It should be noted that to avoid introducing resistor noise into the output of the chamber, separate high-voltage supplies should probably be used for this correcting system and for the chamber potential source proper.

2. HEALTH PHYSICS DIVISION

W. M. Hurst

Constant Water Monitor. An increase in sensitivity of the system being designed has been obtained by surrounding a thin-walled beta counter with a vertical cylindrical wall of water having about 1/8 in. air gap between the water wall and the counter. The wall of water is almost ½ in. thick, and there is no spray or splashing to contaminate the counter.

The continuous-gas-flow discharge counter, 0.75 in. in diameter and about 2 in. in length, was constructed largely of 0.0005-in. sheet aluminum so as to have a beta window area approximately 90% of the total area of the counter. The counter, operated in the Geiger region, has a background counting rate of 11 c/min when shielded with 3 in. of lead. The beta window area is approximately 4.8 in.^{2}

A sample solution of Sr^{90} having an activity of 20 dis/cc/min was measured with the above apparatus with the following results: total counting rate, 32 c/min; background, 11 c/min; and net counting rate, 21 c/min; in this case the activity counting rate is closely equal to the dis/cc/min of the activity. A test of activity measurement for 8 hr resulted in no increase of background counting rate although some water vapor did condense into a fine film on the lower part of the counter and thereby forcibly demonstrate the lack of carryover of activity.

In brief, the work accomplished to date, although incomplete in fine detail, does indicate that a continuous water monitor can be constructed to have a significant reading (twice the background) where the activity of energetic betas is 11 dis/cc/min or more.

A modification of the instrument will permit rapid (10-min) measurements of beta activity in liquid solution of about 50 cc volume where the lower limit of activity is about 10 dis/cc/min. A desirable feature is in not having to reduce the activity to a solid. A disadvantage of the instrument is the counter shell which requires a beta energy of at least 45 Kev for penetration.

Fast-Neutron Survey Meter. In collaboration with the Physics of Radiation Dosimetry Section, design information is being assembled so that commerical production of this instrument may be discussed.

3. INSTRUMENT DEPARTMENT

Van de Graaff Accelerator Tubes (R. W. Lamphere). Three tubes 60 in. long with 1-in. modulus and stainless steel electrodes have been built using corrugated pyrex glass with vinyl acetate as the sealing agent. Two of these tubes have flat electrodes, one 3 in. in inside diameter and the other with a ½-in. inside diameter. The third tube has re-entrant electrodes 1¼ in. in axial length and 3 in. in inside diameter.

The first two tubes are being used to study electrical breakdown phenomena in long tubes under total voltages in excess of one million. The third tube will be used to some extent for this purpose but is designed primarily as a positive-ion accelerator.

Cockcroft-Walton Tubes (R. W. Lamphere). Two identical Cockcroft-Walton tubes have been built using Coors porcelain rings 12 in. in outside diameter and 2½ in. long. The electrodes are of spun aluminum (Dahlin Company of Chicago) with 5½ in. inside diameter and re-entrant to the extent that there is no direct line of vision from any point on the axis to the inside porcelain walls. Each tube has 15 porcelains and 14 electrodes and is designed for operation up to 400 kv. The large inside diameter is to afford ample pumping speed to permit operation with very high intensity ion beams.

Cockcroft-Walton Additions (R. F. King). Materials are either on hand or on order for a fourth voltage doubler stage which is to be added to the Cockcroft-Walton accelerator.

A voltage regulator has been ordered to regulate the 500-cycle alternator supplying power to the terminal of the Cockcroft-Walton accelerator tube. The failure of this generator to build up voltage upon starting has been a source of trouble and some lost time. Probe, lens, and Helmholtz-coil power supplies for the new Cockcroft-Walton accelerator tube have been built as a single unit, giving some saving in space over the old design as well as better appearance. Work has started on the installation of the new accelerator tube with its pumps, control panels, etc.

The 360-cycle motor-generator set for powering the Cockcroft-Walton accelerator has been tested with its voltage regulator. It has been ready for the past 30 days and awaits an opportune time to be put into service. A two-day shutdown is estimated as the time required for this.

Target Evaporator (H. Reese, Jr.). An evaporator was constructed for the purpose of evaporating targets for the Van de Graaff and Cockcroft-Walton accelerators. It contains the usual vacuum pumps and glass bell jar. In addition, there is a refrigerator baffle above the diffusion pump which is held at a temperature of 30°C and an appendage type liquid-nitrogen cold trap.

Refrigerated Baffles (H. Reese, Jr.). Refrigerated baffles have been installed on the Van de Graaff and Cockcroft-Walton accelerators. These baffles are cooled to about 70°C by Freon-22 which is compressed by two 1/3-hp compressors in cascade. The system has been very effective in keeping oil from the vacuum pumps out of the accelerator tubes.

Four-Terminal Voltage Regulator (B. M. Hildebrant). A voltage regulator that holds the voltage constant across an arbitrarily selected portion of the load was designed and constructed. Isolation from ground or other reference points was effected by a light-beam lever and photoelectric cells. Two ranges of voltage, 0 to 1 volt and 0 to 10 volts, with currents from 10^{-6} to 10^{-2} amp, were incorporated, though in principle the range of both currents and voltages can be extended. Present use of instrument is by the Physics of Solids Institute to measure conductance of germanium and the semiconductors when bombarded in the pile.

Magnetic-Induction Flowmeter (W. G. James). Since the last quarterly report (ORNL-924) the induction flowmeter has been successfully applied to the measurement of a 40 cc/min flow to within ±50%. The difficulty of no-flow signal was overcome by the use of a push-pull preamplifier and a voltage-bucking loop in the electrode assembly. Following the preamplifier there is a sharply tuned band-pass electronic filter which greatly reduces random noise. After further amplification the signal is rectified and sent to a vacuum-tube voltmeter which drives a panel meter and to an external Brown recorder. The recorder slide-wire voltage is derived from the current through the magnet in such a way that the recorded output is not affected by changes in magnet excitation. The magnet is supplied by an electronic power amplifier which is driven by a 11 c/sec Wein bridge oscillator.

All the B+ supplies are electronically regulated. The filaments of the preamplifier and amplifier are obtained from a constant-voltage transformer. The overall stability is such that a 15% change in line voltage causes a 5% change in the recorded output. The long-time stability has not been thoroughly checked, but during a 5-hr check with a flow of 40 cc/min of water the uncompensated panel meter gave readings always accurate to within ±5%.

The glass shop has succeeded in producing several satisfactory glass and platinum electrode assemblies. One complete detector assembly has been installed and another is ready for installation.

Reactor Simulator (C. G. Goss). A simulator, which is a direct extension of the one built by Bell and Straus in 1947 [*Rev. Sci. Instruments* **21**, 760 (1950)], has been designed and constructed for application to homogeneous reactors. Since most of the details are at present classified, a status report has been written for submission to the *Journal of Reactor Technology*.

Beta, Gamma Background Monitor (F. M. Glass). This monitor, Q1112, employs a 5819 photomultiplier tube and an anthracene crystal as the detector. It contains a nonoverload amplifier that permits monitoring low-energy gamma rays (50 Kev) without overloading on the high energies. A linear count-rate meter covers the ranges from 2000 c/min maximum to 100,000 c/min maximum in four steps and drives a 1-ma Esterline-Angus recorder. An additional range of 500 c/min maximum can be supplied. Its performance is summarized as follows:

Ranges	2000 c/min, 10,000 c/min, and 100,000 c/min
Linearity	±1% full scale
Stability = warm-up drift	1.5% of full scale for first hour, 0.1% for second hour, and 0.0 thereafter
Drift resulting from line voltage changes	0 from 104 to 130 volts
Overload factor of amplifier	2000
Physical size	Built on standard rack chassis

Electrometers (F. M. Glass). No further work has been done on the three improved electrometers mentioned in the last quarterly report (ORNL-924).

Gamma-Ray Spectrometer (H. N. Wilson). This instrument is being developed in conjunction with NEPA and the Bulk Shielding Facility Group for use in scanning a gamma-ray spectrum. It consists of three crystals and photomultiplier tubes mounted in such a way as to measure coincidences with either Compton electrons or a pair produced by a higher energy gamma ray. Activated sodium iodide crystals are used with RCA 5819 photomultiplier tubes.

Compton Coincidence-Anticoincidence Counter (R. K. Abele). For the Bulk Shielding Facility a special Geiger-Mueller counter arrangement was designed for use in detecting Compton electrons produced by gamma rays striking an aluminum absorber. The first counter, placed immediately in front of the absorber, has both entrance and exit windows of mica and acts as the trigger counter. The emerging electron passes into the second counter, which is placed in coincidence with the first. Electrons energetic enough to emerge from the second counter trigger a third counter built around the second and placed in anticoincidence with the first two.

Radiation Detectors (R. I. Luman). During the past quarter 24 special ionization chambers and 41 special counters were designed and built as well as the necessary standard type thin-walled glass- and mica-window counters.

Approximately 30 jobs were done in the vacuum coating unit, including some evaporation of beryllium.

Resonance Analyzer (W. G. Stone). During most of this last quarter work proceeded on the amplifier. The lengths of leads and the placement of parts were found to be very important. The mechanical difficulty of balancing the output to input capacities in the analyzer tube made it necessary to lower the overall gain of the amplifier. This means that either the mean free path in the analyzer tube must be made higher than anticipated by getting a better vacuum or the spacing of the plates must be decreased.

The amplifier appears to be working well enough now with an overall gain of about 3000 and negligible phase shift from 50,000 to 500,000 cycles.

Creep Test Laboratory Instrumentation (J. Lundholm, Jr.). The installation of the instrumentation for the new ORNL Metallurgy Division Creep Test Laboratory is nearing completion. Sixteen Leeds and Northup Speedomax strip-chart recorders equipped for electric proportional control, using the Duration Adjusting type unit, have received initial testing.

A special panel for controlling six mechanical and six oil diffusion pumps has been tested.

Another special control panel for monitoring each of the six vacuum systems is being assembled. It is equipped with indicators for both Hastings Instrument Company thermocouple vacuum gauges and Philips ionization gauges.

Special thermocouple panels with plugs and jacks are being fabricated by the Thermo Electric Company for mounting at each creep-test machine. Four thermocouples from each machine are carried via a large square duct to a 64-point precision indicator. A 12-point recorder may be used to monitor any of the 64 temperatures.

Temperature-Pressure Recorders (S. A. Hluchan). A multichannel unit for recording six temperatures and six pressures alternately on one record has been constructed and tested. An alarm system with appropriate switching delays for indicating high and low temperatures, high pressure, necessity for high- and low-range scale changes and for power-failure indication has been built into a separate unit which is synchronized with the recorder variable-selector switch. Alarm lights and sounding devices are activated from adjustable limit switches mounted in the recorder.

Five two-channel (one pressure and one temperature) units have been delivered to various users. These units have been giving satisfactory service on experiments which have run continuously as long as six weeks. There are some differences of design among these. One notable difference was that two units employed a-c voltage instead of d-c voltage for strain-gauge bridge pressure capsules and measuring circuit supply. The d-c system is preferred. The variable-selector switch interrupts potential leads only in the two measuring circuits.

Automatic Titrator (J. Horton and J. R. Tallackson). The Automatic Titrator, Model Q-945, is designed to provide a fast, precise chemical titration by giving a fast reagent-feed rate when the electrode potential remains constant and an intermittent feed when the electrode potential is changing. This type of feed is desirable in order to allow time for stirring to keep the solution homogeneous at all times, especially as the end point (point of rapid change in electrode potential) is reached.

The instrument is constructed in two parts: the recorder and control unit in a standard 19-in. rack cabinet and the reagent-feed drive unit in its own housing. The only connection between the two units is electrical, thus providing maximum flexibility in their placement. The recorder is a standard Brown Instrument Company Electronik strip-chart potentiometer modified as follows:

1. Measuring bridge replaced by a seven-range bridge, giving five voltage ranges of 1 volt each end covering the interval from -1.5 to +1.5 volts and two *p*H ranges covering the range from 0 to 14 *p*H units.

2. Input impedance increased to 100 megohms to accommodate glass calomel *p*H electrodes.

3. Chart drive motor replaced by a selsyn motor which is driven by a selsyn generator in the reagent drive unit so that the recorder plots electrode potential or *p*H against volume of titrating reagent.

4. Manual standardization is provided. Intermittent reagent feed is obtained by using a thyratron-relay circuit which is sensitive to recorder unbalance. The relay disengages a solenoid clutch in the reagent-feed drive unit. Intermittent reagent feed is thus established when the input signal unbalance indicates an excess of reagent. Reagent feed ceases until this momentary excess has vanished.

Power for the titrator is supplied by a 1/15-hp 1750-rpm motor connected to a Graham Company continuously variable speed transmission. Transmission output, after additional speed reduction, passes through the solenoid-operated clutch and then rotates a selsyn generator and, through additional gears, a vertical lead screw. A manually operated split nut on the lead screw drives the plunger of a hypodermic syringe which contains the titrating reagent.

A tachometer generator, driven by the output of the Graham transmission and connected to a meter, provides indication of titrating rate in inches per minute of the hypodermic syringe plunger.

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

Power supplies	3
Scalers	10
Magnet amplifier	6
BF_3 preamplifier	2
Sigma amplifier	13
Monitron preamplifier	19
Strain gauge unit	3

Fast-neutron counter	1
Remote analytical balance	1
Alpha-pulse analyzer	2
10-channel analyzer	1
Log *N* meter	1
Count-rate meter	2
Sigma bus	2
Ionization gauge control	2
Electrometers	7
Single-channel analyzer	4
Differential-pulse analyzer	3
1024 scaler	3
A-1 amplifier	14
Monitrons	3
Log-count-rate meter	2
Total	104

The ten scalers built were of the scale-of-eight type for the neutron time-of-flight spectrometer.

Besides the above work, five constant air monitors were modified for automatic range changing. Three atomic scalers were also modified to make them available for use at the laboratory. Twenty preamplifiers were built for use with various amplifiers and scalers. Also, 20 other instruments were built for various jobs throughout the plant.

The table below is a summary of Instrument Department services:

	NO. SERVICED	NO. OF FAILURES
October	237	697
November	198	516
December	207	517
Total	642	1730

A breakdown of instrument failures by type is as follows:

	% OF TOTAL
Transformers replaced	0.55
Geiger-Mueller tubes replaced	9.46
Filter condensers replaced	1.73
By-pass condensers	0.90
Resistors replaced	1.79
Vacuum tubes replaced	27.26
Instruments calibrated	3.64
Miscellaneous failures	54.67
	100.00

4. PHYSICS DIVISION

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Hollow-Crystal Spectrometer. The difficulties found upon occasion with the split-crystal spectrometer, caused solely by its property of converting all electrons emitted by the sample, cause some concern. As long as all particles are counted, coincident beta rays or beta rays and conversion electrons result in a distorted spectrum. The ordinary scintillation spectrometer, even when using anthracene, gives much poorer Kurie plots than the split crystal owing to the scattering out of beta rays before their whole energy is lost, thereby producing a small pulse where a larger one should be. This effect is prevented in the split crystal, and straight Kurie plots result.

An attempt has been made to get the same effect without leaving the source inside the crystal. A crystal ¾ in. thick and 1 in. in diameter was used. A flat-bottomed hole ¼ in. in diameter and 3/8 in. deep was drilled in the 1-in.-diameter face using a sharp end mill operated by hand. After being polished with toluene, the undrilled face was cemented to the standard light piper, and the crystal and piper were covered with 0.0002-in. aluminum foil except over the hole, where thinner foil of 0.2 mg/cm^2 was used.

A lucite collimator 5/16 in. thick was placed above the crystal and a P^{32} source on thin film was placed above the collimator so that the beta rays could fall only on the bottom of the hole. It was expected that few of the scattered beta rays would find their way out of the hole after once entering it.

A fairly good spectrum was obtained, as shown in Fig. 4.1. Experiments on this method of spectrometry are continuing.

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