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ALPHA PARTICLE COUNTING CHAMBERS

By: J. H. Parsons
9/14/44

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For The Atomic Energy Commission
H. R. Carnell
Chief, Declassification Branch

INTRODUCTION

During the First World War, Rutherford discovered transmutation by observing particles emitted from certain elements. Scintillations (light sparks) caused by these particles striking a zinc sulphide screen were counted. He was limited in his experiments by the human error in counting these scintillations, and in the speed at which he could count them. Today we have instruments that can count alpha particles with great accuracy and at speeds exceeding one hundred thousand per minute.

An alpha particle is a helium nucleus (mass 4, charge + 2) ejected from the nucleus of a disintegrating radio active atom with an energy of about two million electron volts. The range of an alpha particle (distance it will travel before it stops) varies with the molecular density of material through which it is passing. The range in air is about four centimeters, while a sheet of paper will stop nearly all alpha particles.

In order for an individual event to be recorded by electronic means, a voltage pulse that can be amplified must be produced. This is accomplished in the equipment now in general use by allowing the alpha particle to cause ionization in a gas. This is the primary action taking place in the chambers; the secondary action is the collection of the charges from these ionized products.

Ionization - General Mechanism

The alpha particle as it passes through the gas will pass within the fields of some of the molecules of the gas. The field of the alpha particle will strip electrons from the molecules it passes near. The alpha particle will encounter about 1.2×10^5 of these collisions before it is stopped. This means that it will produce 1.2×10^5 ion pairs (positive ion and an electron).

Collection

Whether charges from ions or electrons are collected depends on the gas. The mixture of the gas and electron affinity are the controlling factors. Oxygen has a high affinity for electrons, therefore, in air electrons cannot be collected because they combine with the oxygen to form negative ions. Both positive and negative ions can form large ion clusters. The low mobility (high collection time) [redacted] have high resolution

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loss. Below is a chart of collection products of various chambers:

TYPE	SIGN CHARGE COLLECTED	GAS	CHARGES COLLECTED FROM
Magnetic) Standard) Low Geom.)	+	Air	Positive ions (ionic clusters)
Methane Proportional Counter	—	CH_4	Electrons
Nitrogen Chamber	—	N_2	Electrons

The electronic charges, whether existing as ionic clusters or electrons produced in an electrical field will move to the electrodes depending on the direction of the field and polarity of the charges. The voltage change on the collecting electrode depends on the number of elementary charges collected and the capacity of the chamber. This voltage change also depends on the input impedance of the pre-amplifier.

The voltage pulse appearing on the collecting electrode of the various chambers is given below:

TYPE	OUTPUT
Standard) Magnetic) Low Geom.)	$\sim 10^{-4}$ volts
Nitrogen	3×10^{-3} volts
Methane Proportional Counter	10^{-2}-10^{-1} volts (depends on voltage field)

Counting Yield

For absolute measurements it is necessary to know what percentage of the number of alpha producing disintegrations are being counted by an instrument. Counting yield, number of events counted, can be given approximately as:

$$N = Gd/m\ (1 - R - A)$$

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where

N = number of events per minute counted from sample of disintegration rate d/m

G = Geometry factor (decimal)

d/m = disintegrations per minute in sample

R = Resolution factor multiplied by N

A = Absorbtion factor due to sample thickness

The geometry factor is a function of the mechanical design of the chamber. It is numerically equal to the number of particles entering the sensitive region of the chamber divided by the number of particles leaving the sample.

It would seem that the highest geometry obtainable would be one-half in the standard chamber since it appears as though one-half of the particles leave the sample in the direction of the hi-voltrode. Four percent of these "wrong way" particles are back-scattered into the sensitive region bringing the geometry to .52 or 52%.

Resolution factor is a function of collection time of charges and the parameters of associated circuits. The faster the charges are collected and the higher the frequency characteristics of the amplifier, in general, the lower the resolution factor.

Absorption factor is a function of self absorption due to surface mass of the sample. It amounts to about .136 (13.6%) per mg. per square centimeter in the standard chamber.

Since mechanical construction and operational details differ in each chamber, they will be taken up in a discussion of each unit.

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THE STANDARD CHAMBER

By: J. H. Parsons
9/14/44

The Standard Chamber is paralled plate chamber (figure 1) in which the ionizing gas is air. Principal parts include an outer shell housing for a pre-amplifier, a collectrode, and a hivoltrode which also serves as a sample holder. Other parts are a removable bottom for introducing a sample to be counted and supporting members for above mentioned components.

Assembly

The hivoltrode or sample holder can be removed by turning the bottom of the chamber one-sixth turn counter clockwise and lowering the sample holder.

The pre-amplifier and collectrode may be removed by taking out the small screws on the upper sides of the chamber. The screws on the top of the chamber should not be removed as these support the entire pre-amplifier. Removal of these screws might damage the wiring of the pre-amplifier.

The electrodes are separated by a distance of 8.4 mm. The high voltage electrode is held positive with respect to the collectrode by about 1250 volts. The magnitude and direction of this voltage are such that primary positive ion charges are collected on the collectrode, resulting in a positive pulse on collectrode, and no secondary ionization occurs.

Geometry

The standard chamber has a geometry of 52%.

Resolution

The resolution factor for the standard chamber and associated circuit is 10^{-5}. That is the resolution loss is about 1% per 1000 counts per minute.

Absorption

Absorption factor is approximately 13.6% per mg. per cm.

Beta Tolerance

The beta background tolerance is about 5×10^{6} disintegrations per minute.

SERVICING STANDARD CHAMBER

The basis for diagnosis of most troubles is the oscillograph which is an integral part of each circuit. The following table will serve as a general guide for trouble shooting:

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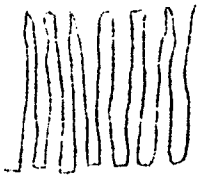
STANDARD CHAMBER

SCOPE PATTERN	DESCRIPTION	ISOLATION METHOD	RESULTS	CHECK	CAUSE	CURE
	Pattern responds to noise in the room. Termed: MICROPHONIC	Remove High Voltage	Stops	Foreign material in chamber	Hairs, lint vibrating causing changing field	Clean
				Loose electrode	Capacity change	Secure all parts of chamber. Embed in wax.
			Does not stop	Input tube		Replace 38
				Cables and connectors	Varying resistance of connection	Secure, clean or replace
				Mounting	Chamber not shock insulated	Suspend chamber with good rubber clear of all other parts.
	Regular pattern. No. response to noise of room Frequency 60 or 120 per second Termed: HUM	Remove High Voltage	Stops	Hi Voltage condenser	Open or not grounded	Replace or secure ground
				Hi Voltage Supply	Filter condensers open	Repair H.V. Supply
			Does not stop	Shielding and grounds	Induced A.C.	Secure grounds and shield cables, etc.
				Cables and connectors		Repair

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SCOPE PATTERN	DESCRIPTION	ISOLATION METHOD	RESULTS	CHECK	CAUSE	CURE
	Irregular Pattern Termed: NOISE	Remove H.V.	Stops	H.V. Condenser for Corona	Arcing or Shorting	Replace or insulate as indicated. Remove sharp points.
				Foreign material	Corona on particles	Remove lint, hair, or paper.
			Does not stop	Input tube		Replace 38
				Sample for Beta background	Beta background over tolerance	
				Components	Leaky condenser or resistor	Replace part
				Cables and connectors	Open or High resistance	Repair or replace
	High background Termed: HIGH HASH			Input tube		Replace 38
	Regular Pattern Any frequency Termed: Oscillations			Contact to H.V.	Hi Voltrode floating	Repair contacts. Place in correct position
				Grounding and shielding		Repair and secure
				Cables and connectors		Repair and secure
				Component parts	Open decoupling condenser or resistor	Replace

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SCOPE PATTERN	DESCRIPTION	ISOLATION METHOD	RESULTS	CHECK	CAUSE	CURE
	Short pulses (not all pulses are saturating)			HiVoltage	Low or Off	Restore correct HiVoltage
				Gain of amplifier	Operation below plateau	Repair amplifier or reset gain in plateau
				Sample	Self Absorption	
				Input tube	Low amplification factor	Replace 38
				Component parts	Low resistors. Open condensers.	Repair and replace
				Filament and plate batteries	Low	Charge or replace
	No pulses. No noise Non-microphonic Termed: DEAD			Batteries	Low or dead	Charge or replace
				Amplifier	Turned off or dead	Turn on or repair
				Input tube	Filament open	Replace 38
				Components	Shorted condenser. Open resistor	Replace part
				Wiring	Open wiring	Repair

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LOW GEOMETRY VACUUM CHAMBER

By: J. H. Parsons
9/14/44

It is often necessary to count alpha particles from a sample, the disintegration rate of which, exceeds the maximum counting rate of the standard alpha chamber and circuit. If the geometry of the chamber is reduced, i.e. reduce the area of the sensitive region of the chamber, we can count these samples at lower rates. The true rate may then be determined by multiplying the recorded rate by the reciprocal of the geometry factor.

The sample is held a distance away from a very thin mica window and only the alpha particles passing through this small mica window are counted. The geometry factor is controlled by the distance of the sample from the window and the area of this window. The space between the window and the sample is evacuated so that the sample can be a distance from the window that exceeds the range of the alpha particle in air. Since, as we have said earlier, the range of the alpha particle depends on molecular density of the substance through which it is passing, the range in a partial vacuum is much greater than it would be in air.

Removing the Sample Holder

The sample holder can be removed only when the vacuum above the tapered joint is released. This joint must be kept well greased with some good vacuum grease to prevent this joint from "freezing".

Removing Lower Assembly

The entire low geometry section of the chamber can be removed by turning the knurled upper supporting ring counter clockwise by about a sixth turn. Do Not try to turn by the side arm or the pyrex tube as these may break causing an injury.

Removing Pre-Amplifier

The pre-amplifier circuit is removed by taking out the screws on the upper sides of the chamber. Do Not remove the screws on the top of the chamber. Removal of these screws will release the supports holding this input circuit. The wiring may be damaged.

Servicing

Service notes applying to the Standard Chamber also apply to the low geometry chamber. Mechanical breakage of lower assembly should be repaired by a glass-blower. The mica window is cemented to the brass support by DeKhotinsky cement. This mica must be strong and free from

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imperfections, so that it will not break when the chamber is evacuated. The mica window is very thin (about 1 to 2 mg. per sq. cm.).

Resolution
Beta tolerance

The resolution factor of the low geometry chamber is the same as the Standard Chamber when referred to the recorded rate. The absorption factor and beta tolerance depend on the geometry of the chamber.

Geometry

The geometry factor of each sample holder is posted on the chamber with which it is used. Calibration of sample holder does not hold when the sample holder is used with other chambers.

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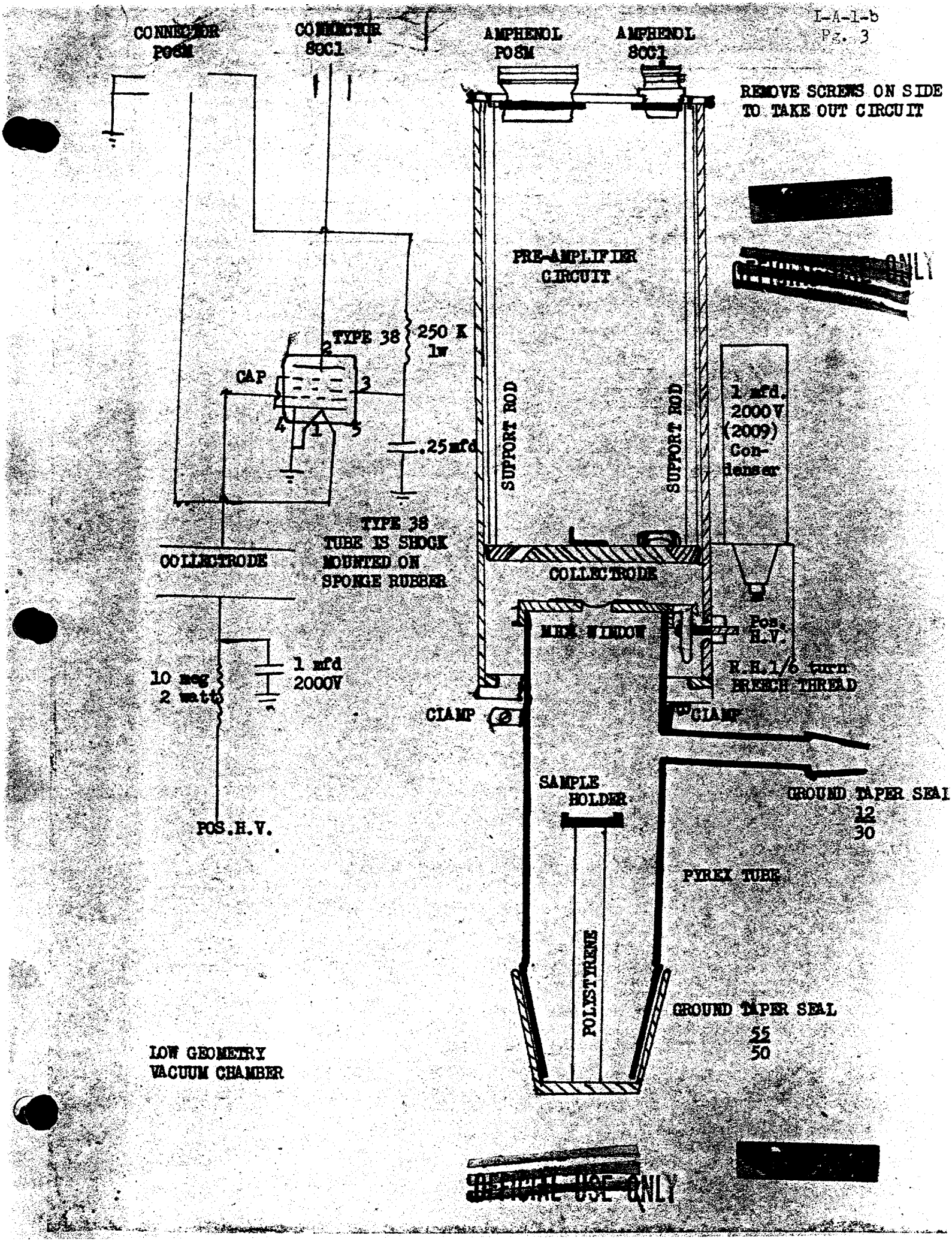
CONNECTOR
P08M
CONNECTOR
80C1
AMPHENOL
P08M
AMPHENOL
80C1
REMOVE SCREWS ON SIDE
TO TAKE OUT CIRCUIT
[redacted]
[redacted] ONLY
PRE-AMPLIFIER
CIRCUIT
TYPE 38
250 K
1w
CAP
2
3
4
1
5
.25mfd
SUPPORT ROD
SUPPORT ROD
1 mfd.
2000V
(2009)
Con-
denser
TYPE 38
TUBE IS SHOCK
MOUNTED ON
SPONGE RUBBER
COLLECTRODE
COLLECTRODE
MICA WINDOW
Pos.
H.V.
R.H.1/6 turn
BREECH THREAD
10 meg
2 watt
1 mfd
2000V
CLAMP
CLAMP
SAMPLE
HOLDER
GROUND TAPER SEAL
12
30
POS.H.V.
PYREX TUBE
POLYSTYRENE
GROUND TAPER SEAL
55
50
LOW GEOMETRY
VACUUM CHAMBER
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MAGNETIC IONIZATION CHAMBER

By: J. H. Parsons
9/14/44

It is frequently necessary to count samples which have a beta background exceeding the tolerance level of the Standard chamber. In the Magnetic chamber all particles, alpha and beta, must pass through a very strong magnetic field. This field strength is about 5000 gauss. The very light beta particles are bent in small arcs and do not enter the sensitive portion of the ionization chamber. The heavy alpha particles are not bent very much and can enter the counting region of the chamber.

Removing Sample Holder

The sample holder is removed by opening the door on the brass shield and pulling on the tab. The sample height is adjusted by turning a screw. Once adjusted for a given geometry this height should not be altered.

Removing Upper Housing

The upper housing which contains the pre-amplifier and the ionization chamber may be taken from the magnet by removing screws marked on diagram as number one (1).

Pre-amplifier Removal

Taking out screws marked number two (2) will allow pre-amplifier to be removed from the upper housing.

Magnet

Again, the notes on the standard chamber apply here. The magnet is the only thing that is new in this instrument. If the beta tolerance is reduced from accepted value (about 10^9 beta/minute), this may indicate a weak magnet. These magnets may be recharged. The field strength can reduce with age. This field strength goes down when the magnet is jarred or struck with a tool.

Tools

It has been estimated that each time a steel screw driver touches the magnet at the poles, the field strength drops by 2%. Copper berylium screw drivers should be used when working on or near the magnet.

Resolution Beta Tolerance

The resolution factor is the same as that on the Standard chamber (i.e. about 10^{-5}). The beta tolerance is about 10^9 betas per minute.

Geometry Factor

The geometry factor varies from chamber to chamber and is posted on each sample holder.

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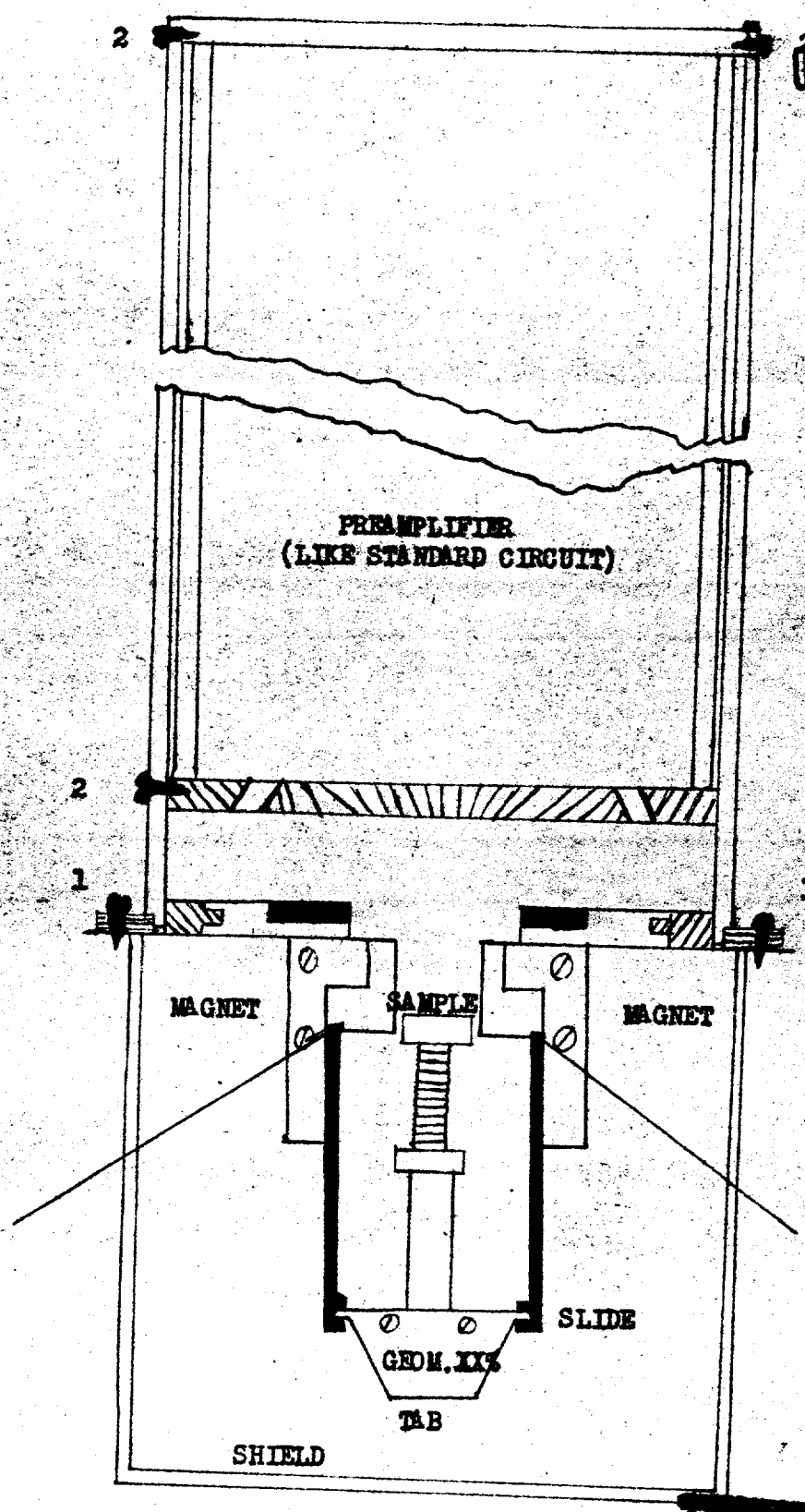

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NITROGEN CHAMBER

By: J. H. Parsons
9/14/44

The newest instrument in the field of alpha counters is the Nitrogen Chamber. The final model has not been made so this section will contain only a general description of the equipment.

Basically the nitrogen chamber is the same as the standard chamber in construction (i.e. it is a parallel plate chamber). Nitrogen is used instead of air as the ionizing gas. In air we saw that it was impossible to collect electrons because of the affinity of oxygen for free electrons. Only charges on positive or negative ion clusters could be collected. Nitrogen has a very small affinity for free electrons, therefore, electrons may be collected by the collecting electrode. These electrons may be collected in a very short time due to their high mobility.

This chamber, with its fast collection time is used with a high frequency amplifier. Together with a scaler, this forms a counting unit that can count to one-half million counts per minute at the same loss the standard chamber has at five thousand.

<u>Resolution</u>
<u>Beta Tolerance</u>

The resolution factor is about 7×10^{-8} which is to say .7% per hundred thousand counts per minute. The beta tolerance is 2.2×10^{10} beta/minute. This is referred to a beta with energy 7/10 mev.

<u>Geometry</u>
<u>Self Absorption</u>

The geometry of this type chamber is 52%; the same as the standard chamber. Self absorption amounts to 13.6% per mg. per cm^2, which is the same as the standard chamber.

It has been found that these chambers are not microphonic and the circuits are stable. Service notes will be added when more experience is built up on the instrument.

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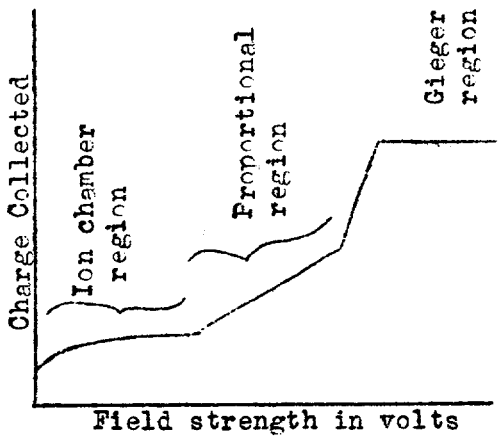
METHANE PROPORTIONAL COUNTER

By: J. H. Parsons
9/14/44

The standard chamber, the low geometry chamber, the magnetic chamber, and the nitrogen chamber are alike in one respect. In each of these, charges are collected from the primary reaction products only. The methane proportional counter collects the charge not only from the products of the primary reaction but also from secondary ionization products caused by collisions of the primary products on their way to the central wire.

This action is called secondary ionization or gas amplication. The electrical field strength in which the ionization products are moving determine whether we have gas amplification or not. Graph at left gives relationship between ion chamber region and proportional region. If the moving particle (ion or electron) is accelerated in a field so that in its free path it receives an energy that exceeds the ionization potential of the gas through which it is passing, it will ionize a molecule when it experiences a collision, thus increasing the total charge to be collected.



The central wire is kept positive with respect to the outer shell by about 2300 volts. The central wire is 2 mils. in diameter; therefore, the field strength is very great around this wire.

Plateau

This chamber operates on a voltage plateau. That is the number of counts will not vary, except for the statistical fluctuations, over a voltage range applied to the chamber. If the voltage is low, the counting rate will be low. High voltage will result in a high counting rate.

Spurious Counts

High Background

A high counting rate background is usually an indication of trouble in the chamber. This may be caused by contamination in the chamber. Cleaning should be done with petroleum ether or specially prepared solvent.

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Another cause of high background is corona discharge or leaking insulator. All insulators should be cleaned with care and coated with ceresin wax. Wires and connectors can be coated with glyptal to reduce corona discharge.

Gas Leakage

If the slide becomes scored or scratched, the gas will leak out of the chamber. The only way that scratches and digs may be removed is by grinding this surface on a surface grinder.

The counter will have a low counting rate if there is any air in the chamber. The chamber should be flushed for fifteen minutes at a fast gas rate after the gas has been off for a long time or the chamber has been opened before the counting rate can be accurate.

Slide

The slide may be moved only when the sample holder is in the down position. This sample holder may be lowered by the sample elevator knob on the bottom of the slide. Do not move the slide by pulling or pushing on the slide elevator. The slide may be removed by taking off the rear stop on the slide and moving the slide forward.

Lubrication

The slide should be well lubricated with Celvacene grease.

The resolution factor is about 10^{-7} which is about 1% per hundred thousand counts per minute. The beta tolerance is 10^{9} beta/minute. The geometry is 52% and absorption factor is 13.6% per mg. per cm.

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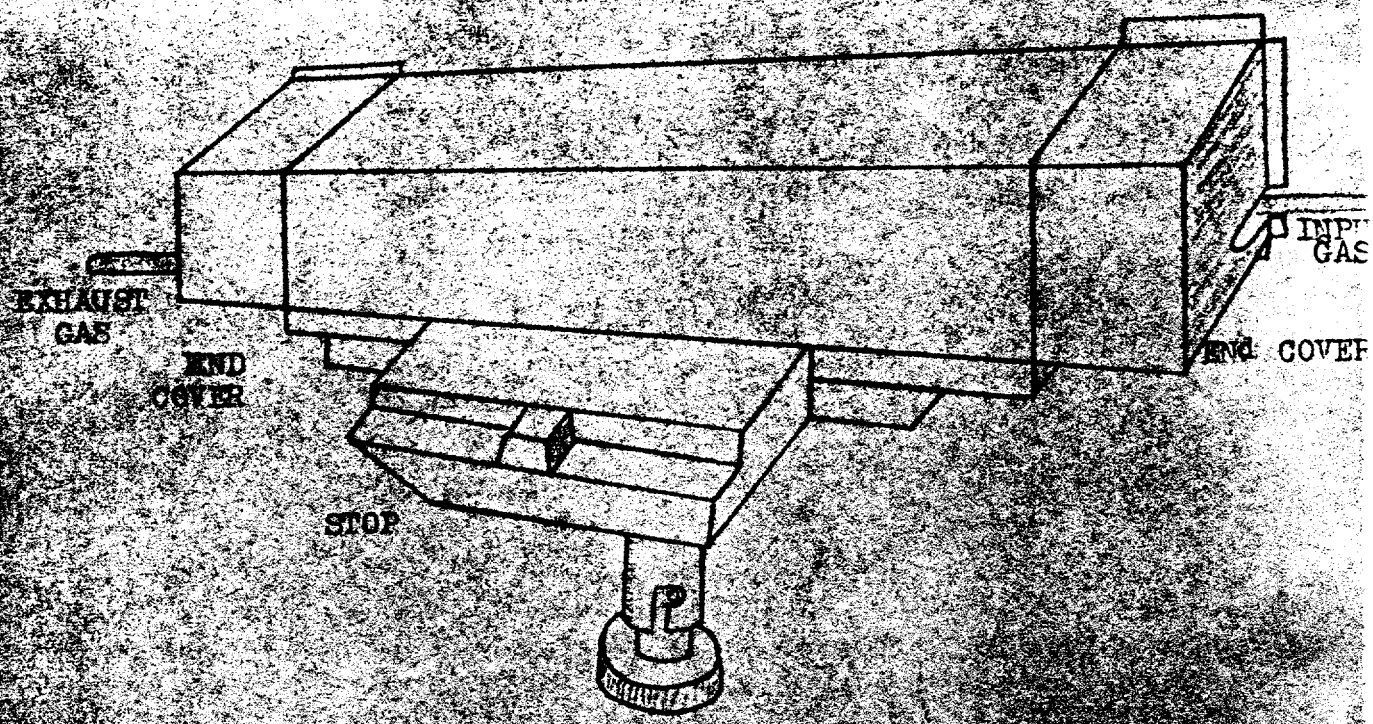

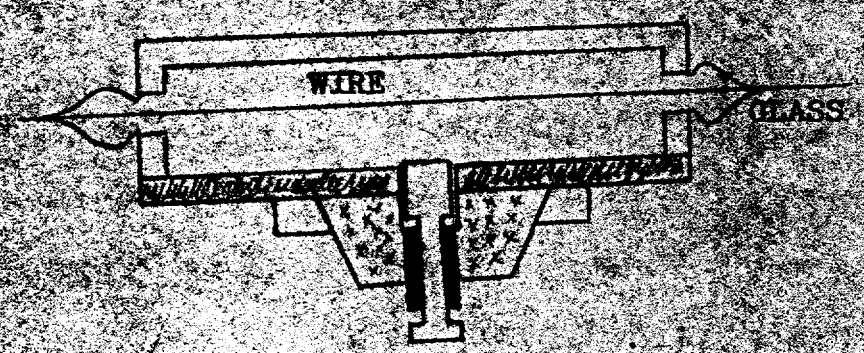

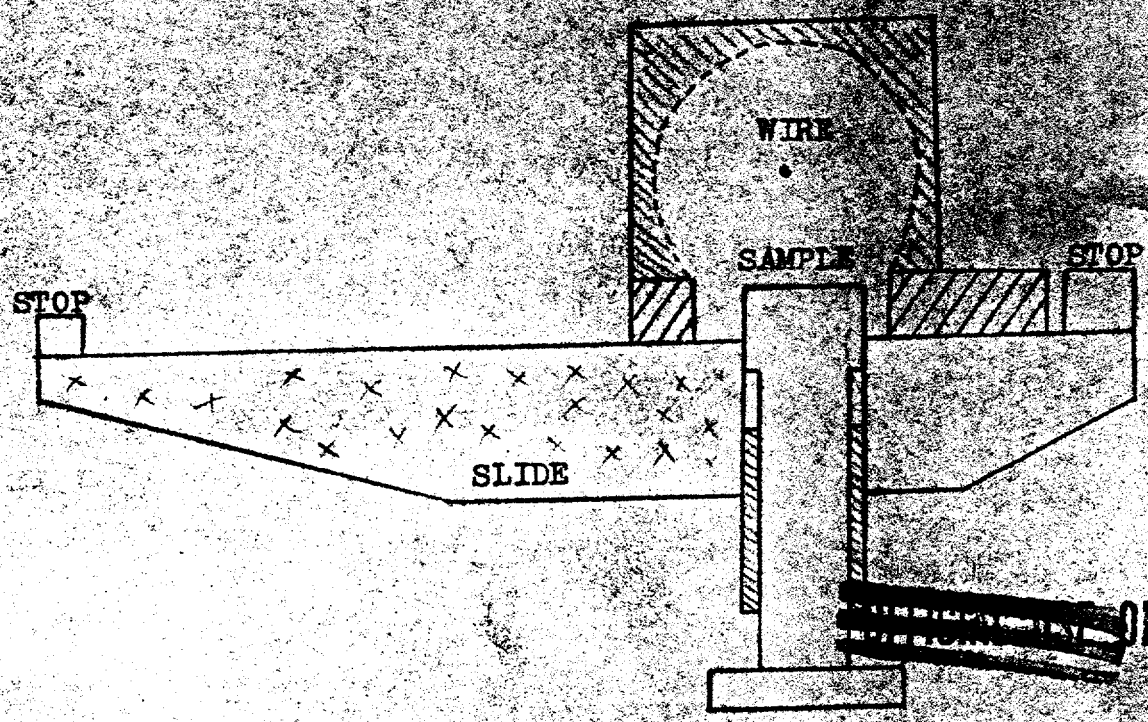

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BETA-GAMMA COUNTERS
Glass & Aluminum G-M Counters
Mica Window G-M Counters
Brass G-M Counters
By: W. B. Bennet
9/26/44

PRINCIPLE

The Geiger-Mueller (or G-M) counter is employed on this plant for counting beta and gamma rays. It consists of a cylindrical cathode with a concentric small diameter anode wire, in an atmosphere consisting of an inert gas and an organic vapor at a low pressure. The anode or collector electrode is at a high positive potential with respect to the cathode. An ionizing particle entering the counter gives rise to free electrons which are accelerated toward the anode. In the later part of their paths these electrons have enough energy to ionize the gas further, resulting in an "avalanche" of electrons which upon hitting the anode wire causes a momentary corona discharge. This discharge results in a negative voltage pluse which is amplified and transmitted to the first stage of a scaler. Thus a pulse results from each beta particle entering the counter.

DESCRIPTION

Three general types are in use: The thin wall type, which allows beta particles to enter through a thin cylindrical wall; the end window type, which employs a thin flat window for this purpose; and the thick wall brass type, used exclusively for gamma counting.

Thin wall counters are used to count beta particles of energies as low as 0.2 mev. Glass counters are about 3/4" in diameter, having a wall thickness of .006". The cathode is a thin coating of silver chemically deposited on the inner surface of this cylinder, and the anode is a concentric thin tungsten wire. Aluminum counters have a wall thickness of about .004", a diameter of 7/8", and have an axial anode of .005" diameter Kovar wire. The thin wall counters are generally used for foil counting and contamination detection.

The end-window (or mica window) counter consists of a flanged brass or copper cylinder (the cathode), with a thin sheet of mica waxed onto the flange. A glass dome waxed into the other end supports the anode, a thin tungsten wire, and is provided with a stopcock for sealing the counter after filling. The anode wire extends down the exis of the cylinder and is tipped with a small

[redacted]

[redacted] national [redacted] of the [redacted] Espionage Act [redacted] transmission [redacted] or the revelation of its contents in any manner to an unauthorized person is prohibited by law.

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[redacted]

[redacted]

glass bead to prevent corona discharge from the end of the wire. The mica window is about .0005" thick (approx. 4 mg./cm.^{2}) and admits beta rays as low as .02 mev. energy. This counter is used in radiochemical analysis.

Brass G-M counters in use at this plant have dimensions ranging from 3" long x 3/4" diameter to 18" long x 3" diameter. Wall thickness is generally about 1/16". The efficiency of a gamma counter depends on the absorption of the gamma ray energy and re-emission of electrons which will produce detectable pulses. The wall thickness is chosen so that as much as possible of the gamma ray energy is absorbed, yet a maximum number of the photo-electrons formed escape from the walls into the counter where they may be detected. Choice of the counter to be used thus depends on the energy of the radiation to be measured. Hard gammas are more efficiently counted with a thick walled counter, whereas soft gammas or a wide range of gamma energies may often be more efficiently counted with a thin wall counter.

PLATEAUS

A poor voltage plateau is the best indication of an unsatisfactory G-M counter. The plateau is run by recording counts per minute from the counter every 20 or 25 volts above the threshold (first voltage at which a count is obtained) until the counting rate begins to increase sharply or until 250 volts overvoltage (above threshold) has been reached.* If the counter "runs away", (goes into continuous discharge) the voltage must be cut down below threshold, as continuous discharge tends to pit the electrodes. A counter with pitted electrodes cannot be reclaimed. At least 10,000 counts should be made at each voltage to reduce the effect of statistical error.

The plateau is run in the following manner. The counting time which will give approximately 10,000 counts per plateau point is determined by a one minute count at about 60 volts above threshold; the counting time at this rate is then found in the accompanying table, and a count made for this length of time at each point. From the data obtained, a region which seems to be the plateau is chosen and the maximum difference in counts per minute over this plateau length is checked against the maximum allowable rise as shown in the table. Note that these minimum and maximum points do not necessarily occur at the beginning and end of the plateau. A sample plateau check is included in this report. It is not necessary to plot the plateau, but a sample graph is included to show some of the characteristics of a typical plateau. Note that the counting rate rises quite rapidly to the plateau, and that the slope of the plateau gradually increases as the voltage rises.

* Never go above this point.

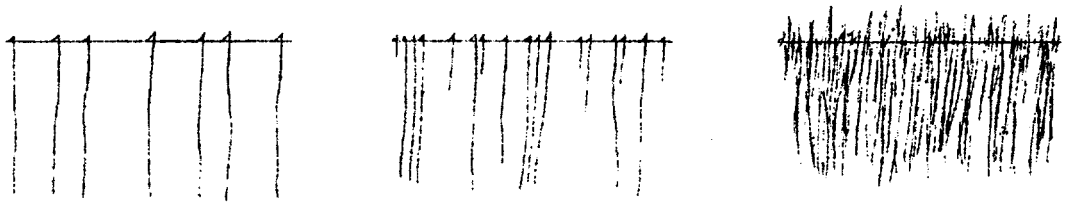
[redacted]

The plateau slope for a G-M counter is expressed as percent rise in counts per minute for a hundred volt rise in applied potential, regardless of the length of the plateau. Thus, the slope of an eighty volt plateau which over its eighty volt range rises 4.0% of the average counts per minute should be expressed as a slope of 5.0% per hundred volts (i.e., $4.0\% \times \frac{100\ V.}{80\ V.}$) even though the plateau does not extend a full 100 volts. Likewise the slope of a 120 V. plateau which has a 6.0% rise in counts over its range would be expressed as a 5.0% rise per 100 volts. The plateau slope is expressed in this manner so that a direct comparison of slopes of various plateaus may be made. The plateau of a good G-M counter will extend a minimum of 100 volts and will have a slope of 5.0% or less per hundred volts. The counter is operated at a voltage about the end of the first 1/3 of the plateau, since the slope or change in counting rate is generally less on the first portion of the plateau.

The plateau of any G-M counter tends to become shorter and steeper with age, and when it fails to meet the above specification, the counter should be replaced. Good glass G-M counters have an average life of two to three months. Mica window counters, which often show a tendency to leak at the wax seals, have an average life of two to three weeks.

SERVICE NOTES

When possible, the action of a G-M counter can best be observed on an oscilloscope, the vertical plates connected directly across the counter electrodes through a 50 mmfd. 5000 volt condenser. A good counter gives sharp, clear pulses of even height, with very few short or double pulses. If pulses are irregular in height, or



GOOD G-M PULSES SHORT & MULTIPLE PULSES CONTINUOUS DISCHARGE

occur in closely bunched groups, or if continuous discharge ("running away") occurs, the counter should be replaced and returned to the counter lab for examination.

If a glass G-M counter does not count, it is quite likely that the signal is being shorted to ground somewhere in the circuit. With a mica window counter this is also frequently true, although leaks around the wax joints will give the same symptoms.

An advancing threshold indicates leakage. However, the counter may generally be used until the plateau has vanished.

Some counters show a tendency to become photosensitive, counting at a high rate when light shines inside. Sometimes a glass counter may be corrected for photosensitivity by painting all non-silvered portions; however, all such counters should be replaced and returned to the counter lab for examination.

TEMPERATURE SENSITIVITY

Unfortunately, most of the glass counters now in use are temperature sensitive, showing a tendency for the threshold to advance with increasing temperature. It is hoped this condition may soon be corrected; in the meantime, it will be necessary for field groups to check with the counter lab before installing any counters in a room that is not air conditioned.

CARE IN HANDLING

G-M counters are very fragile. Glass and aluminum thin wall counters should be handled only by the ends, which are sturdy. They should be transported in soft packing material of some sort. Mica-window counters should always be laid on the side, being very careful not to loosen the stopcock plug. Never set the counter upright on any surface except when installing in a counter holder. Be careful not to strike the brass flange against the table - the window may very easily be loosened sufficiently to leak. Never touch the mica window. The wire is brittle, particularly at the wax seal. Use care in putting clip leads on during installation; clip the high voltage lead to the loop of wire which does not come from the wax seal. These counters are transported in thermos bottles which have the double advantage of a rounded bottom to protect the window and an even temperature to prevent wax seals from softening.

The metal-to-glass seal at the top of the brass counter is fragile; use care at all times not to strike it against anything. The type of wire used in the glass-to-metal seal is quite brittle and will often break under a small amount of flexing; use care in clipping or soldering this lead into place. Do not strike the evacuating tube against anything, as it is easily broken at the point where it is soldered into the body of the counter.

Always return a bad or broken counter to the counter lab for examination and refilling or reclamation, together with all available data on its past behavior.

COUNTING RATE (COUNTS/MIN.)	COUNTING TIME (MINUTES)	MAXIMUM RISE (C/M) ALLOWABLE FOR 5% PLATEAU OF THE FOLLOWING LENGTHS:							
		80V.	100V.	120V.	140V.	160V.	180V.	200V.	220V.
1000	10	40	50	60	70	80	90	100	110
1500	7	60	75	90	105	120	135	150	165
2000	5	80	100	120	140	160	180	200	220
2500	4	100	125	150	175	200	225	250	275
3000	4	120	150	180	210	240	270	300	330
3500	3	140	175	210	245	280	315	350	385
4000	3	160	200	240	280	320	360	400	440
4500	3	180	225	270	315	360	405	450	495
5000	2	200	250	300	350	400	450	500	550
5500	2	220	275	330	385	440	495	550	605
6000	2	240	300	360	420	480	540	600	660
6500	2	260	325	390	455	520	585	650	715
7000	2	280	350	420	490	560	630	700	770
8000	2	320	400	480	560	640	720	800	880
9000	2	360	450	540	630	720	810	900	990
10000	1	400	500	600	700	800	900	1000	1100
15000	1	600	750	900	1050	1200	1350	1500	1650
20000	1	800	1000	1200	1400	1600	1800	2000	2200

9/20/44

PLATEAU CHECKS

COUNTER NO. 17
REASON FOR CHECK Recheck
SCALER NO. 74
LEADS
SOURCE #3 Beta
THRESHOLD 840

DATE 9/20/44
OPERATOR WBB

(Preliminary 1 min. count @ 900 V. = 5341 counts)

2 min. counts.

VOLTAGE	RECORDER	CALCULATION	COUNTS/MIN.	VOLTAGE	RECORDER	CALCULATION	COUNTS/MIN.
850	2231:41 2103 128	8192 41 2 8233	4117	1025	3424:24 3245 179	11456 24 2 11480	5740
875	2398:02 2233 165	10560 02 2 10562	5281	1050	3602:38 3425 177	11328 38 2 11366	5683
900	2567:17 2399 168	10752 17 2 10769	5385	1075	3787:50 3603 184	11776 50 2 11826	5913
925	2734:61 2568 166	10624 61 2 10685	5343	1100	3985:12 3788 197	12608 12 2 12620	6310
950	2899:23 2735 164	10496 23 2 10519	5260				
975	3069:43 2900 169	10816 43 2 10859	5430				
1000	3244:22 3070 174	11136 22 2 11158	5579				

CALCULATIONS

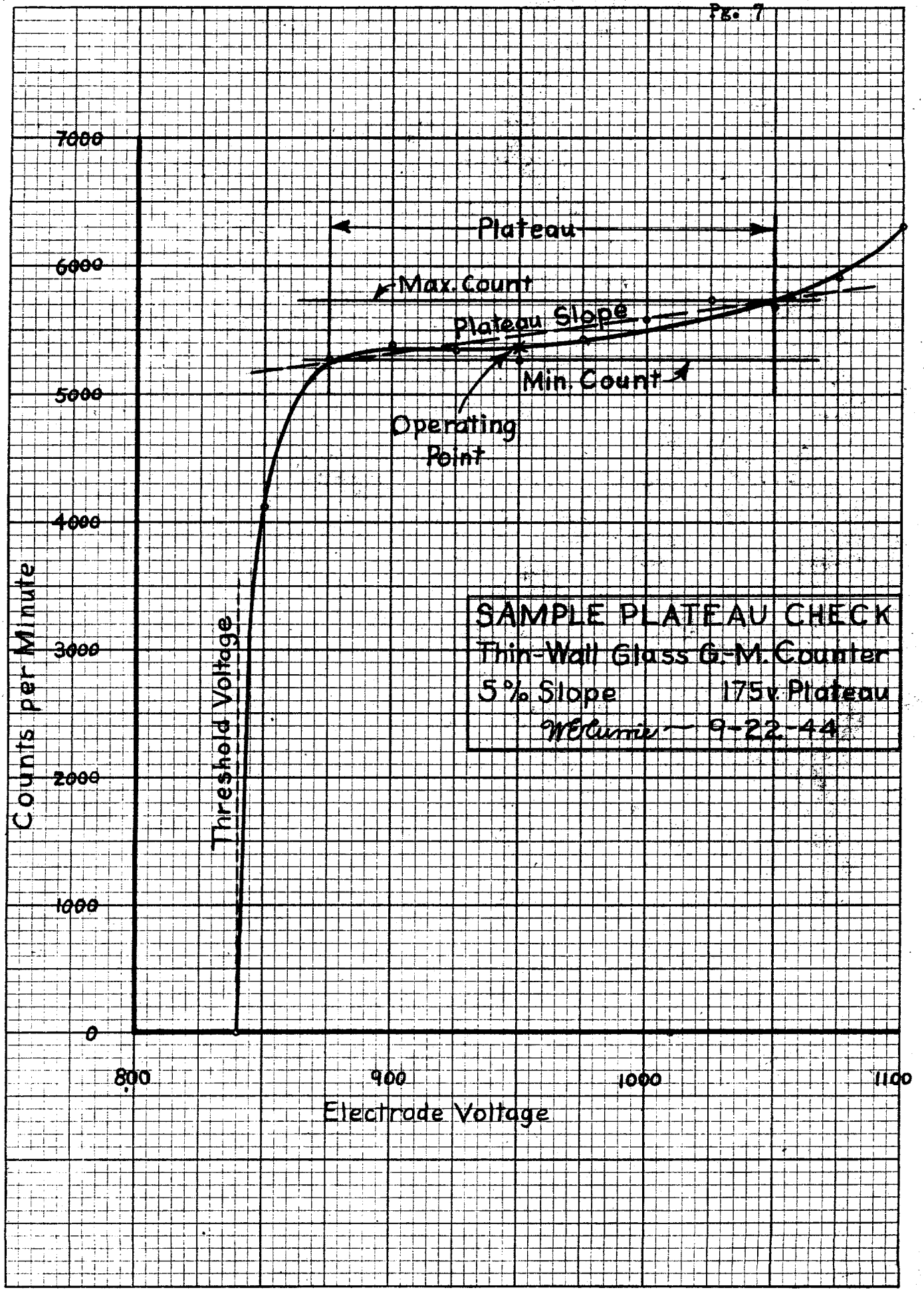
Apparent Plateau: 875 - 1050 V.
(175 Volts Length)

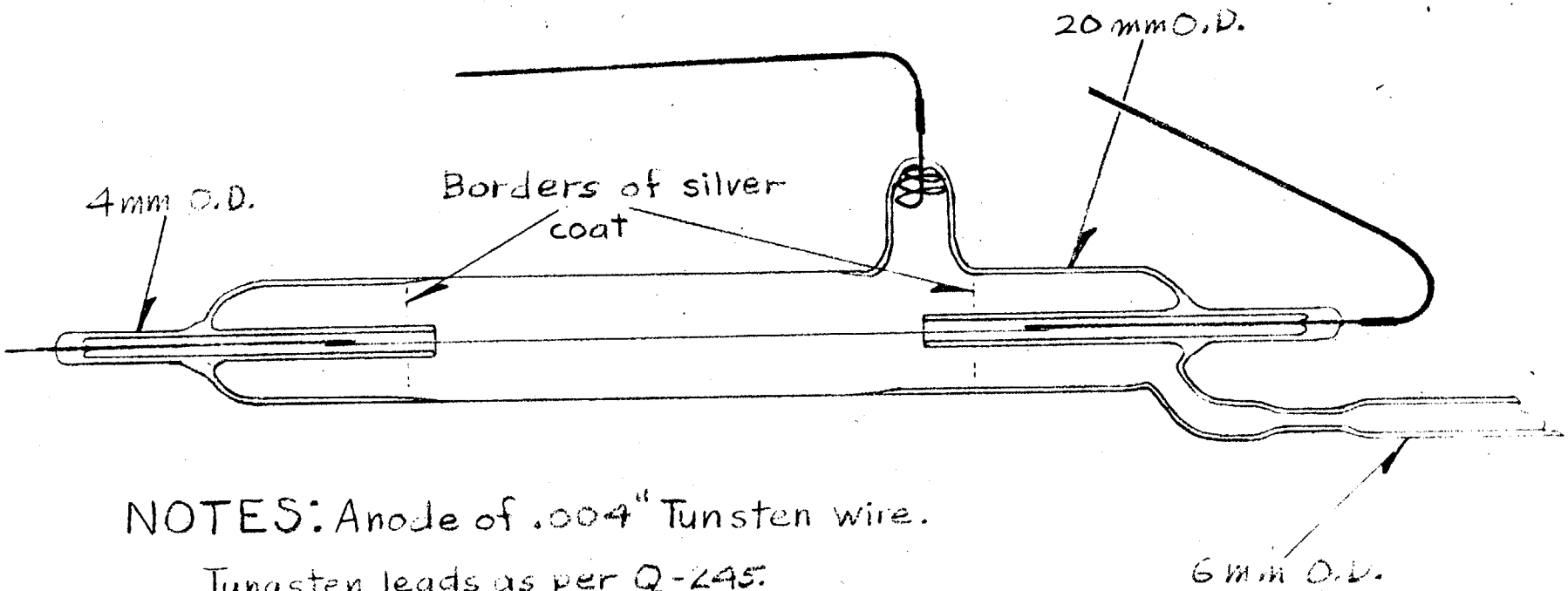
Rise in C/M
5740
-5260
480

Average C/M
5740
5260
2 11000 — 5500

% Rise Per 100 Volts:

$$\frac{480}{5500} \times \frac{100}{175} \times 100\% = 5.0\% \text{ per } 100 \text{ V.}$$


7000
6000
5000
4000
3000
2000
1000
0
Counts per Minute
800
900
1000
1100
Electrode Voltage
Plateau
Max. Count
Plateau Slope
Min. Count
Operating Point
Threshold Voltage
SAMPLE PLATEAU CHECK
Thin-Wall Glass G.-M. Counter
5% Slope
175v. Plateau
W. E. Currie — 9-22-44



NOTES: Anode of .004" Tunsten wire.

Tungsten leads as per Q-245.

Approx. .006" wall for approx. 3" at center.

Silver deposited inside thin wall and inside boss (to connect cathode with coiled contact spring).

Approx. dimensions may be scaled.

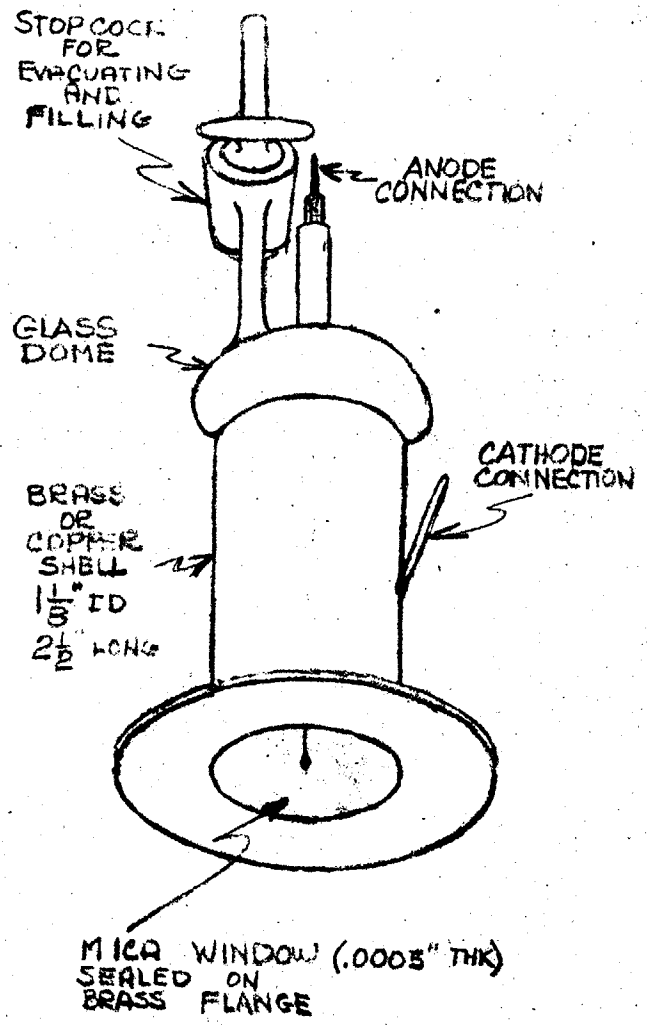
Envelope is of Pyrex glass.

INSTRUMENT SHOP BUILDING 717-B
CLINTON LABORATORIES

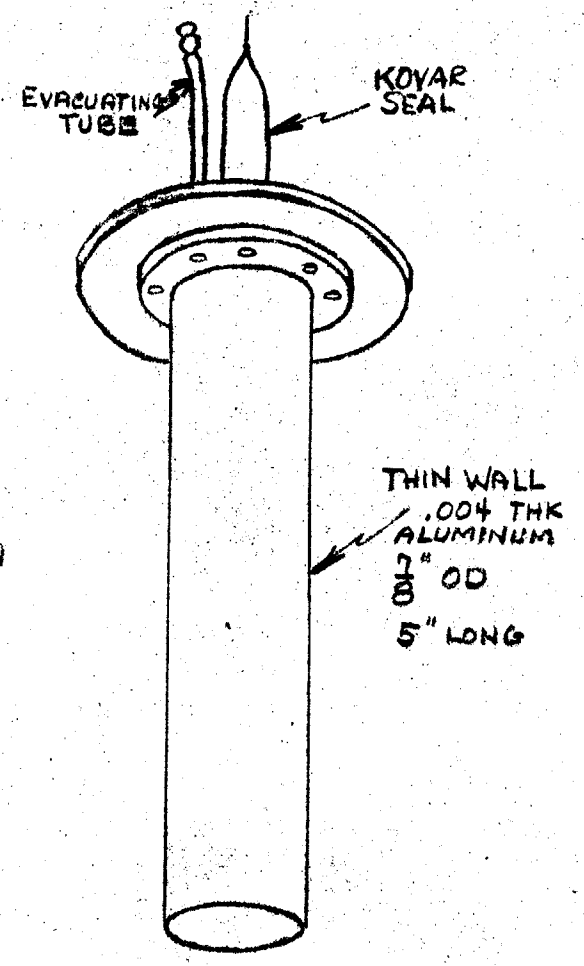
ECK & KREBS THIN WALL G-M COUNTER

REV. No.	REVISIONS	REV. DATE	DATE 12-23-44
			SCALE Full
			DRAWN WEC
			CHECKED

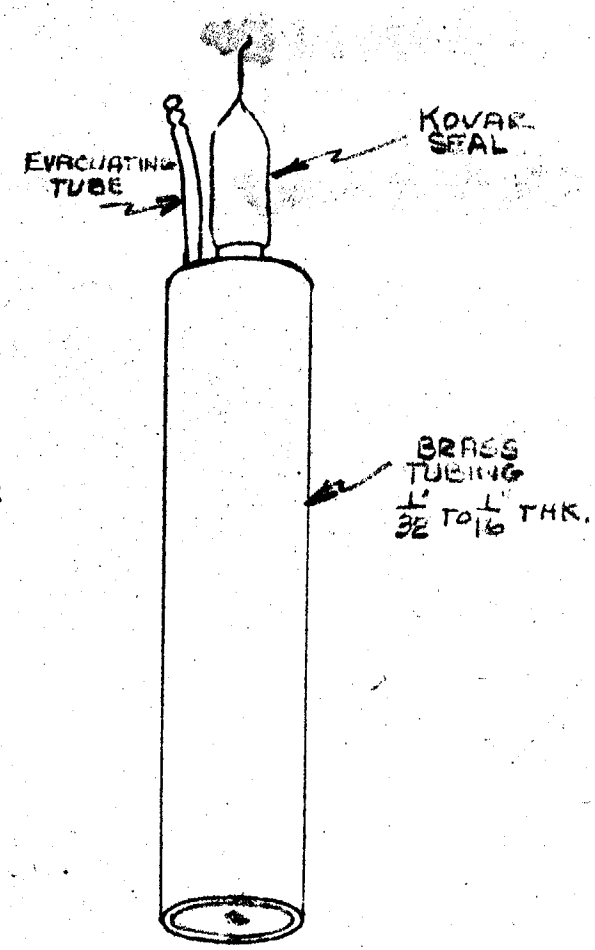
SKETCH # 257--717B



MICA WINDOW GM COUNTER



ALUMINUM GM COUNTER



BRASS GM COUNTER

INSTRUMENT SHOP—BUILDING 717-B CLINTON LABORATORIES			
GM COUNTERS			
REV. No.	REVISIONS	REV. DATE	DATE 2-2-45
			SCALE NONE
			DRAWN BY DRL
			APP'V'D BY DRL
SKETCH O-279-A			BLDG. No.

This document consists of 3 pages and 3 figures. No. 12 of 47 copies, Series A.

OFFICIAL USE ONLY

BF_3 NEUTRON PROPORTIONAL COUNTER

By: W. B. Bennet
9/27/44

CLASSIFICATION [redacted]
DATE FEB 11 6 4
For The Atomic Energy Commission
H. F. Carroll
Chief, Declassification Branch

DESCRIPTION

A BF_3 Neutron Proportional Counter is a cylindrical brass cylinder (usually 1" dia. x 7" long x 1/16" wall) with a thin concentric electrode wire. It is filled to about 12.5 cm. pressure with a 12% argon - 88% BF_3 mixture. Such a counter operates with about 1600 volts potential across the counter electrodes, the central wire positive with respect to the shell.

PRINCIPLE

The detection of slow neutrons depends on the reaction

$$B^{10}(N;\alpha)Li^7$$

and on the collection of electrons produced by ionization in the path of the alpha particle formed.

The proportional counter is so called because each pulse produced is proportional in size to the initial ionization. Each electron from the initial ionizing event is accelerated toward the anode wire, gaining enough energy in its path to cause considerable further ionization; hence an "avalanche" of electrons, proportional in size to the amount of primary ionization, reaches the anode. (The G-M counter's action differs in that a momentary corona discharge results when the avalanche reaches the anode, giving pulses of even height. No corona occurs in a proportional counter.) The importance of this proportional counting action is that the pulses from heavily ionizing particles such as alpha particles can be counted above a high background of relatively weak pulses due to beta and gamma ray ionization.

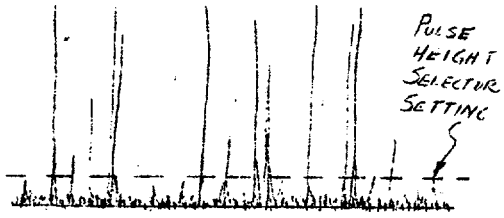
A more complete description of BF_3 counters may be found in report CP-1408.

DETAILS OF OPERATION

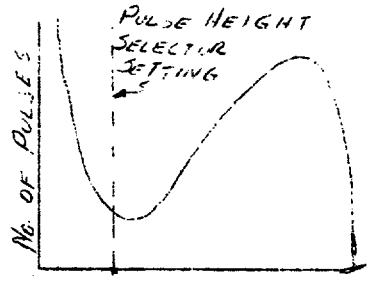
Some of the neutron counters at this plant are operated with negative high voltage on the shell, others with positive high voltage on the wire. In both cases a negative pulse is taken from the anode wire and amplified. [redacted]

[redacted]

An oscilloscope is always used in connection with the BF_3 counter. Pulse image should resemble the diagram and pulse size [redacted]



PROPORTIONAL COUNTER PULSE IMAGES



distribution should be somewhat like the accompanying curve. The scaler bias should be set at the point indicated on the curve, eliminating the low amplitude pulses which represent largely gamma ray "hash". Background count should not exceed 10 counts per minute when the counter is shielded with a 1/32" thick cadmium sleeve.

TESTING

Place the counter with leads and circuits properly connected in a flux of slow neutrons such as can be obtained with a 10 Mg. Ra-Be source in a block of paraffin.

Turn the amplifier gain up to near maximum and study the pulses obtained on the oscilloscope screen with a reasonable voltage on the counter. Make sure the pulses show the characteristic proportional counter distribution in size (see previous paragraph). Gamma ray hash should be just visible on the sweep line of the oscilloscope. Practically all these pulses should disappear when the source is removed.

Run the voltage versus counts per minute curve with the gain setting as above and a pulse height selector setting such that the scaler responds to practically all pulses above the gamma ray hash. This curve should exhibit a region or so called "plateau" of from 150 to 300 volts in width over which the counting rate increases not less than about 0.05% per volt and not more than about 0.5% per volt. The operating voltage is now chosen to lie near the end of the first third of the voltage range selected above. (See Figure 1.)

Plot a pulse height selector (bias) versus counts per minute curve with the voltage selected above and amplifier gain as in above paragraph. The operating pulse height selector setting is chosen such that the scaler responds to pulses which are one fourth of the maximum size. The one fourth is arbitrary, but eliminates picking up the gamma ray count. and hash without missing too many neutron counts. (See Figure 2.)

[redacted]

[redacted]NLY

The operating amplifier gain setting can now be rechosen if desired by plotting a gain versus count per minute curve. High voltage and pulse height selector settings should be kept as determined in 3 and 4. (See Figure 3) The proper setting should fall at about the end of the second third of the flat part of this curve.

The spurious background of the counter is now determined by removing the source and covering the counter with cadmium. Caution: Turn off voltage on counter before removing it from paraffin. If the background is greater than ten, the counter should be discarded. A good counter should have a background of one-half to five counts per minute.

CAUTION IN HANDLING

A number of neutron counters have been rendered useless when the central wire was broken off at the glass to metal seal on top. Since the wire which must be used in this seal is brittle, the counter must be handled carefully at all times, particularly when installing in or removing from a proportional counter shield.

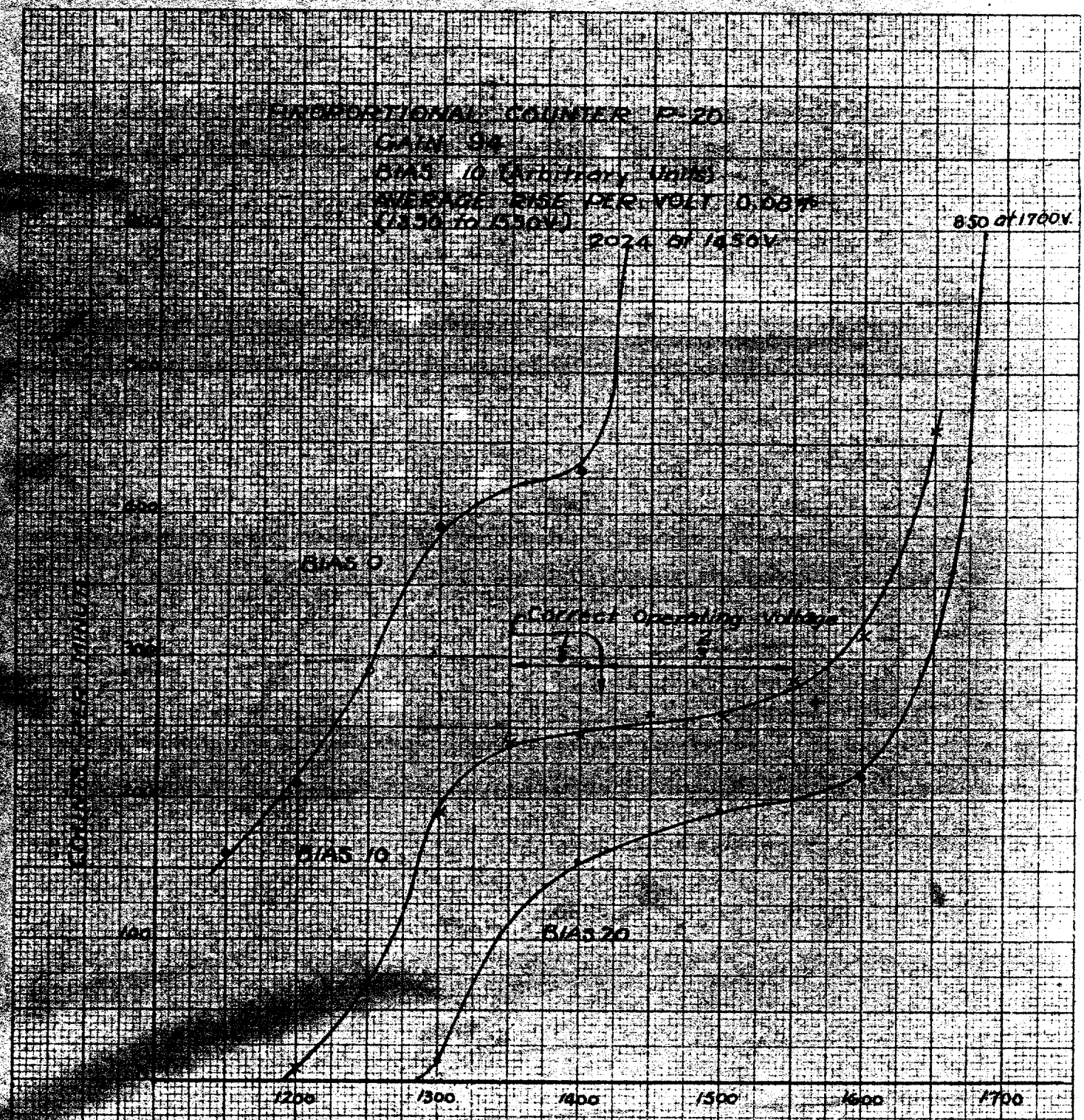


FIG 1 THE MIDDLE CURVE SHOWS HOW THE PROPER OPERATING VOLTAGE IS CHOSEN. 1400 VOLTS IS SELECTED AS IT IS THE NEAREST ROUND NUMBER. THE OTHER CURVES SHOW THE EFFECT OF IMPROPER BIAS SETTINGS ON THE SHAPE OF THE CURVE.

CL 717-B-3

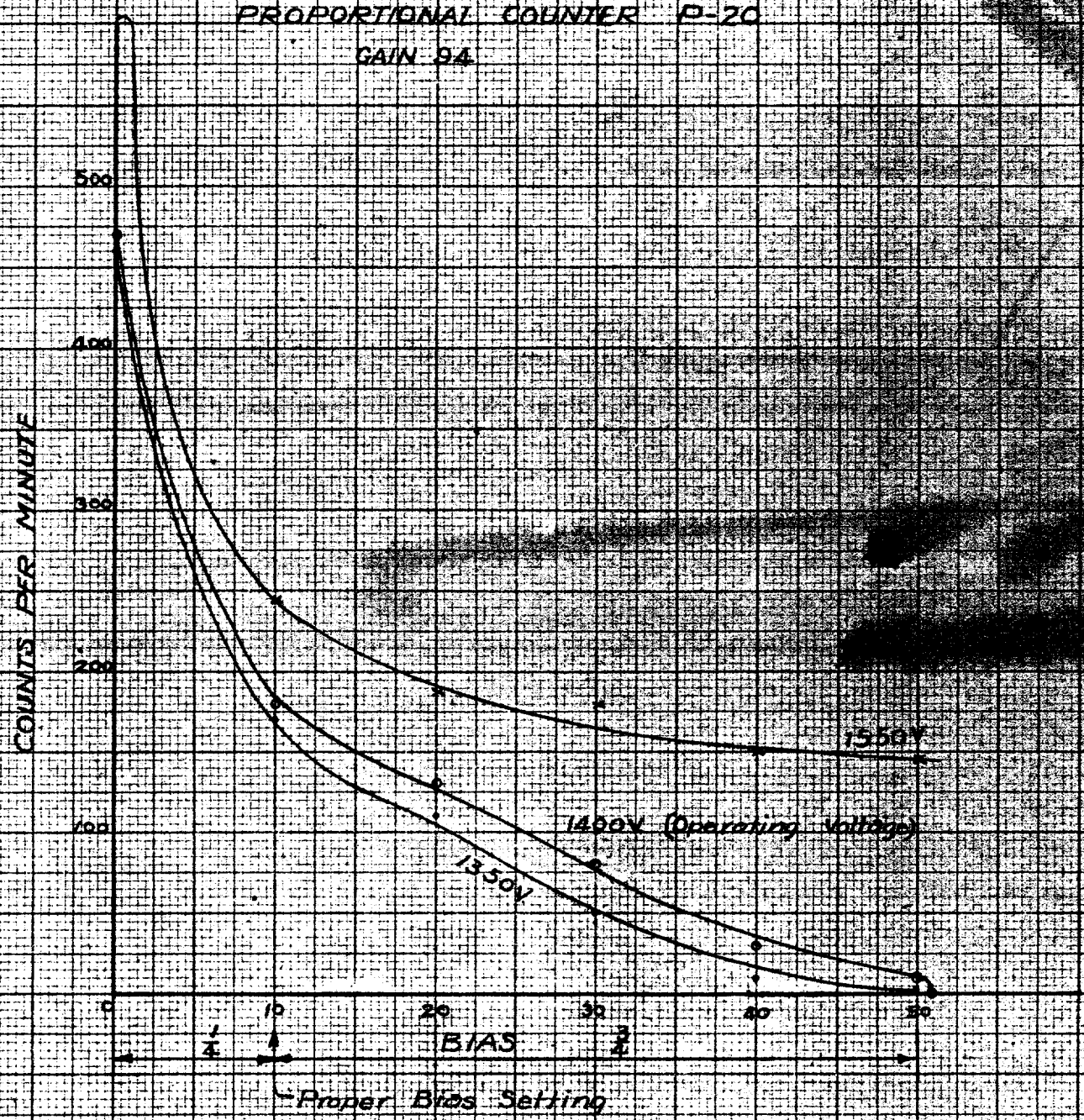


FIG 2. BIAS CURVES SHOWING HOW PROPER SETTING IS CHOSEN.

KEUFFEL & ESSER CO., N. Y. NO. 359-120
10 X 10 to the half inch, 10th lines heavy.
Engraving, 7½ X 10 in.
MADE IN U.S.A.

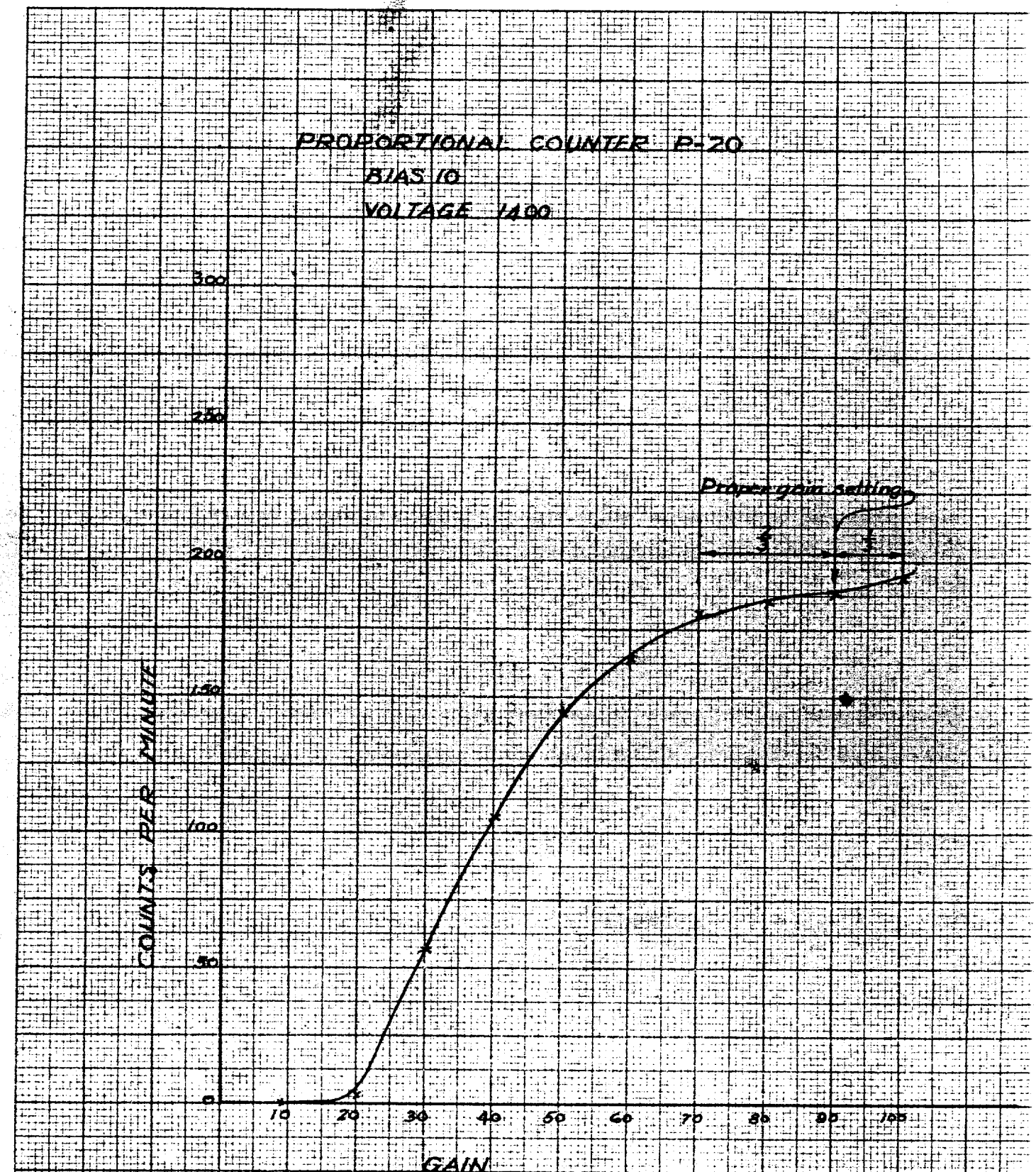


FIG. 3. CURVE FOR SELECTION OF PROPER GAIN SETTING

KEUFFEL & ESSER CO., N. Y. NO. 359-180
10 × 10 to the half inch, 10th lines heavy.
Engraving, 7½ × 10 in.
MADE IN U.S.A.

LABORATORY PRODUCTION OF ENRICHED BF_3 FROM $CaF_2 \cdot BF_3$

By: R. E. Zedler
R. I. Luman
6/13/47

INTRODUCTION:

Boron trifluoride (BF_3) is the gas commonly used in slow-neutron counters. As furnished by the AEC Isotope Branch, the boron in the complex $CaF_2 \cdot BF_3$, is 96% B^{10} as compared with the normally occuring B^{10} content of 20%. Since counter action results only on the slow neutron capture by B^{10}, counters 5 times as efficient may be obtained by filling them with enriched BF_3 generated from this complex.

The boron trifluoride gas is generated by heating the complex and collecting the gas in a closed evacuated system.

$$CaF_2 \cdot BF_3 \xrightarrow[\Delta\, 250^\circ C.]{} CaF_2 + BF_3 \uparrow$$

6.5 grams of the complex produce 1 liter (3 grams) of BF_3 at S.C.T.P.

EQUIPMENT:

The equipment is described in order from generator to receiving flasks. (See generating system sketch.)

The generator (see generator sketch) is a flanged lid stainless steel container. A 1/4" O.D. stainless steel thermocouple well is welded into the lid and extends nearly to the bottom of the chamber. A nichrome heating element (40 ohms) is wound around the generator, being insulated from the generator by mica. The unit is wrapped with asbestos to minimize heat loss. A thermocouple hooked to a Leeds & Northrup Micromax is used as the temperature measuring device.

The generator is connected to the glass system through a short length of copper tubing which is sealed to the glass with de-Kotinsky cement. A small copper can is soldered around the copper tube near the cemented joint. This is filled with cold water to keep the cement cool during the generation process.

Next in line are two glass traps and a glass wool filter in series to catch condensable impurities and entrained solids.

Following the traps is the capillary flow meter. The manometer legs on each side of the .5 mm capillary tube are about 80 cm long, and extend into a mercury reservoir. With the capillary by-pass stopcock closed, the difference in mercury levels in the two legs is an indication of the rate of flow. The height of mercury in either leg indicates the

Laboratory Production of Enriched BF_3 from $CaF_2 \cdot BF_3$ continued

R. E. Zedler
R. I. Luman
6/13/47

static pressure in the system. The flow meter also serves as a safety valve.

A four-way stopcock follows the flow meter. The bottom outlet goes to the vacuum pump through a cold trap. The four stopcock positions allow the following: 1) to evacuate the generator side of the system, 2) to evacuate the receiving side of the system, 3) to connect both parts of the system and isolate the vacuum pump, 4) to isolate all sections of the system from each other.

Following this stopcock are two outlets to which receiving flasks may be connected, one of which has a stopcock. A manometer is attached to the receiving system to enable the observation of static pressure readings and to act as a safety valve when the receiving system is isolated from the rest of the system. On a side arm is a liquifying chamber made from 30 mm pyrex glass tubing 1 foot long. BF_3 from the generating system is condensed in this at the end of the generating process.

The collecting flasks used are the standard two liter pyrex glass type in which spectroscopically pure gases are distributed.

PROCEDURE:

After introducing the complex in the generator, evacuate the entire system for several hours. The system is tested for leaks with a spark coil. The spark coil produces a pale blue glow in a well evacuated system and a purple glow in a poorly evacuated system. The thermos full of liquid nitrogen should be placed on the vacuum pump cold trap after an indication of a good vacuum has been obtained.

Place the thermos bottles of acetone-dry ice mixture on the generator cold traps and begin heating the generator (a variac is used to regulate the current through the heating coil). Continue evacuation of the system until the temperature reaches 170°C. at which temperature the vacuum pump is isolated by use of the four-way stopcock. Increase the current through the coil to maintain a steady temperature rise.

The BF_3 gas begins to generate in appreciable quantity at 250°C. When the temperature reaches 380°C. (after 3 hours from the starting time of the heating process), most of the BF_3 will have been evolved.

When the manometer indicates that there is 70 cm pressure in the first receiving flask, the flask is removed and the stopcock opened into the second flask. When all the BF_3 has been evolved (3 to 4 hours) a thermos of liquid nitrogen is placed on the liquifying chamber. This condenses all the BF_3 in the system. The generating system is isolated from the receiving system by means of the four-way stopcock and the thermos removed. The BF_3 vaporizes into the second collecting flask which is then removed.

Laboratory Production of Enriched BF_3 from $CaF_2 \cdot BF_3$ continued

R. E. Zedler
R. I. Luman
6/13/47

RESULTS:

The BF_3 thus collected should be 97.2% pure, 75% of the impurity being air. Final purification of the BF_3 is done on the system used to evacuate and fill counters. The process is simply that of solidifying the BF_3 in a liquid nitrogen trap in an evacuated system and then re-evacuating the system to remove the non-condensable air impurity from the solidified BF_3 .

This method, used at Clinton Laboratories, is essentially that given in an extract from SAM Report A-2121, but the system was modified to make the generation process simpler and safer.

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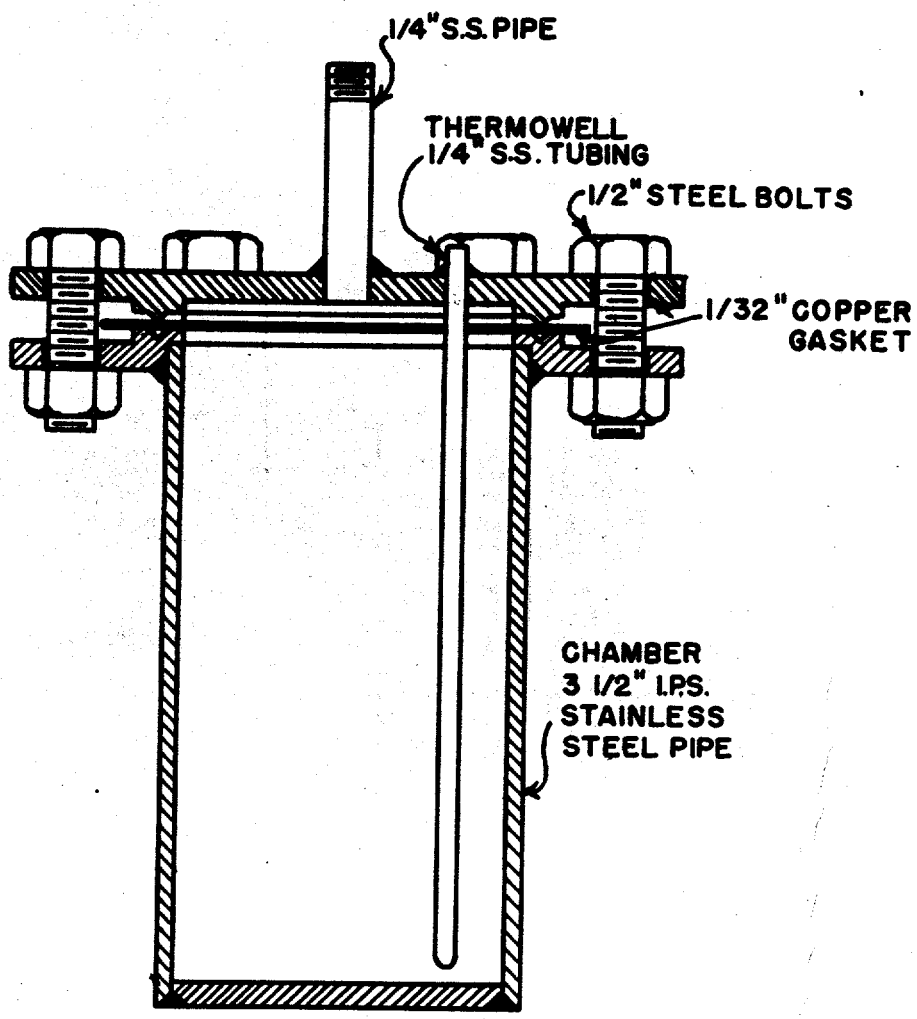
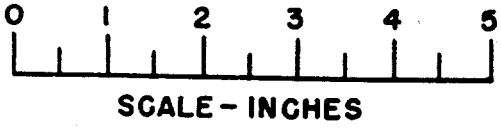


GENERATOR



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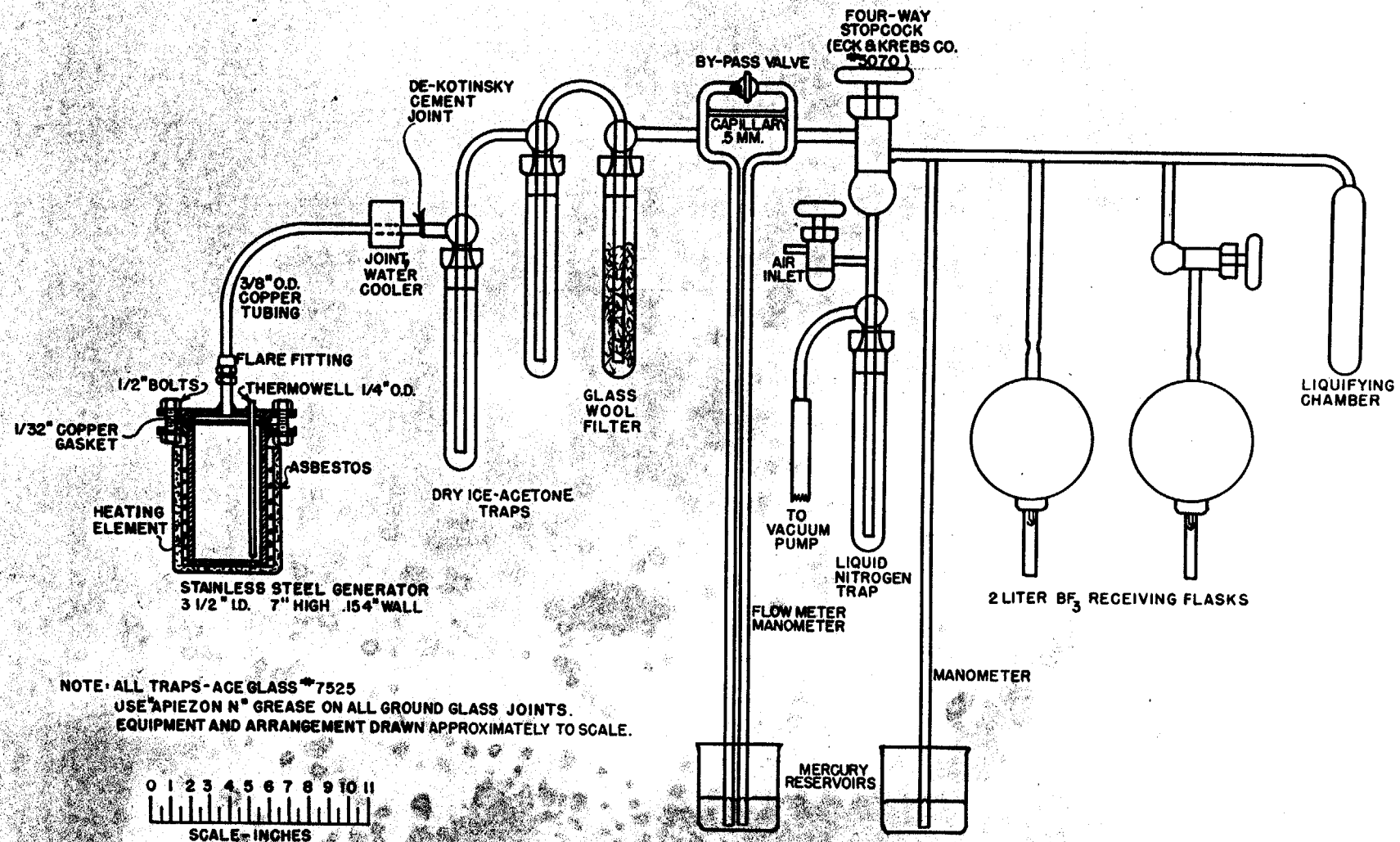
CLINTON LABS
INST. DEPT.
R.E.Z. 6-17-47



SYSTEM FOR GENERATING BF_3 FROM $CaF_2 \cdot BF_3$

0.592 A
CLINTON LAB.
INST. DEPT.
R.E. ZEDLER 6-16-47

[redacted]

HIGH VOLTAGE SUPPLY, 3000 VOLTS WITH 1500 VOLT SUPPRESSED ZERO

By: R. L. Quinn
10/2/44

This high voltage supply is designed to give a regulated direct current voltage that can be adjusted to any desired output voltage from 1500 to 3000 volts. It can be used as the high voltage power supply for any apparatus requiring a regulated D.C. voltage within this range and having a very low current drain. It is necessary to have a B+ supply voltage of approximately 300 volts available for the meter circuit.

The circuit (see Sketch Q-192) may be divided into the following components: 1) 110 V. to 2500 V. high voltage transformer, 2) half-wave rectifier circuit with condenser filter, 3) a voltage regulator circuit consisting of a two-stage inverse feedback circuit, 4) a voltage divider, 5) the suppressed zero meter circuit, and 6) another resistor-condenser output filter.

The voltage regulator will compensate for both changes of input voltage and of load current. An increase of the output voltage will decrease the negative grid voltage of the 6SJ7, and thus increase its plate current. This increase in the plate current will result in an increased voltage drop across the 5 megohm load resistor, lowering the plate voltage of the 6SJ7. The 6SJ7 and the 809 are direct coupled tubes, so the grid voltage of the 809 will become more negative as the plate voltage of the 6SJ7 is lowered. When the grid voltage of the 809 becomes more negative, its plate current becomes smaller, thus tending to reduce the output voltage. The output voltage may be varied by the 100 K. potentiometer. Because of the voltage dividing action of the potentiometer, only a portion of the output voltage change is applied to the grid of the 6SJ7. A 1 mfd. 2000 V. condenser is connected from the output to the grid of the 6SJ7 to improve regulation of transients.

This circuit is unusual in that the regulator operates on one-third of the output voltage. This is done in order to keep the plate voltage of the 6SJ7 down to a safe operating value. Thus, the maximum plate voltage is 1000 volts instead of 3000 volts. The difficulty encountered in doing this is that the cathode of the 6SJ7 is tied to the voltage divider resistor network, instead of being tied to a constant reference voltage. Thus, the cathode voltage of the 6SJ7 will swing up or down as the output and grid voltages swing up or down. The 45 V. reference standard battery must be well insulated from ground since it is at 2000 V. above ground with maximum output voltage.

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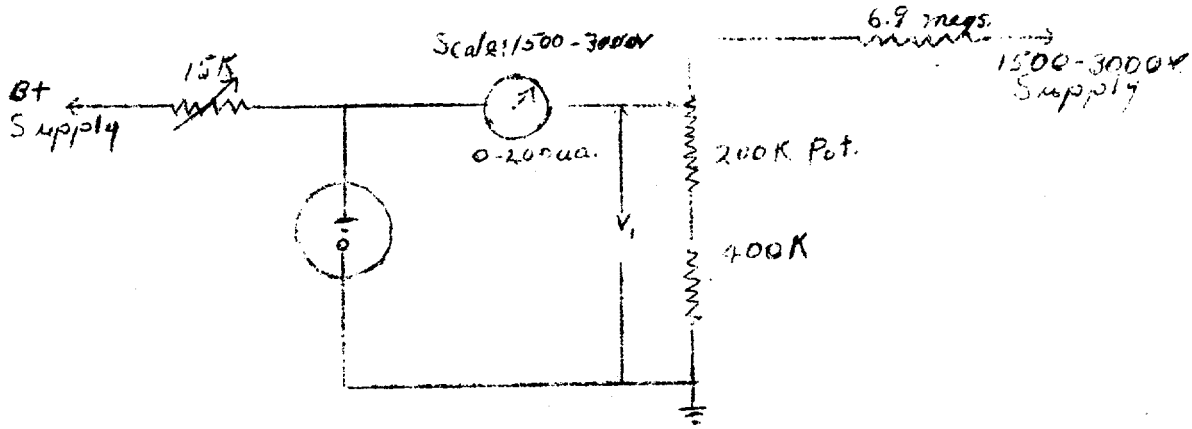
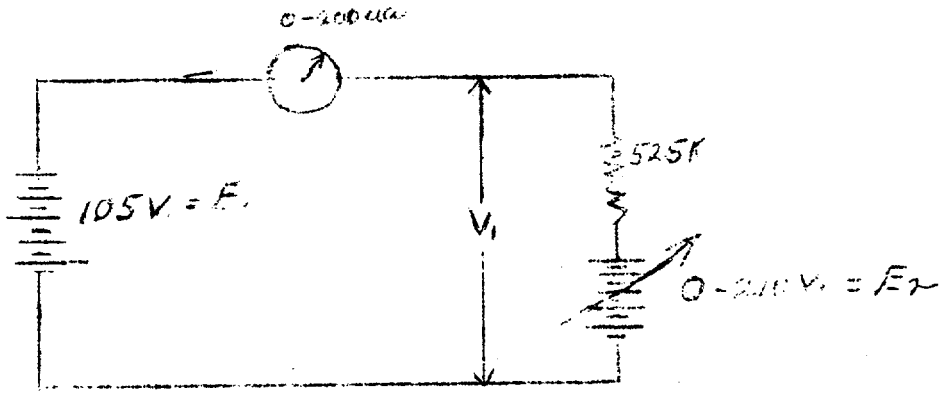
In the meter circuit, as shown below, a portion of the voltage divider is balanced against a constant reference voltage. The reference voltage is obtained from a separate "B" supply



voltage across a VR 105 tube. The 0 to 200 microampere meter, with a scale reading from 1500 to 3000 volts, is connected between the 105 volt reference voltage and a point on the voltage divider which is at 105 volts when the output voltage is 1500 volts. The circuit is essentially a variable D.C. voltage, a 525 K resistor, a 105 volt constant D.C. voltage, and a 200 microampere meter in series. The equivalent circuit can be shown as below, where the voltage (V) across the 525 K. resistor and variable D.C. voltage is equal to the voltage from the center tap of the 200 K. potentiometer to ground in the previous meter circuit. The proper values of the variable



Equivalent Meter Circuit

D.C. voltage and the series resistor may be calculated as follows:

[redacted]

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At 1500 volts output voltage, the meter must read zero, or no current must pass through the meter. Thus, the voltage (V) from the center of the potentiometer to ground must be 105 volts. Also the current through the voltage divider will be [redacted]

$$I = \frac{E}{R} = \frac{1500}{7.5 \times 10^{-6}} = 200 \times 10^{-6} \text{ amps.},$$

so from the center tap of the potentiometer to ground

$$R = \frac{E}{I} = \frac{105}{200 \times 10^{-6}} = 525{,}000 \text{ ohms.}$$

Now, if the wire going from the center tap of the potentiometer to the meter is disconnected, and the output voltage increased to 3000 volts; then the voltage from the center tap of the potentiometer to ground will be 210 volts. So, the possible variation of the variable D.C. voltage will be from 0 to 210 volts. If the wire from the center tap of the potentiometer to the meter is reconnected, then the equivalent circuit consists of a 210 volt and a 105 volt battery, connected opposing each other in series with the meter and 525 K. resistor. The current through the meter is thus limited to 200 microamperes, for

$$I = \frac{E_2 - E_1}{R} = \frac{210 - 105}{525{,}000} = \frac{105}{525{,}000} = 0.0002 \text{ amp. or 200 microamps.}$$

So, the meter will read full scale deflection at an output voltage of 3000 volts. Also, the meter is protected in case of a high voltage failure when there is no trouble in the reference voltage. In such a case, the variable D.C. voltage in the equivalent circuit is equal to zero, then

$$I = \frac{E_2 - E_1}{R} = \frac{0 - 105}{525{,}000} = 200 \text{ microamperes.}$$

Thus, the maximum current that would pass through the meter in the wrong direction in such a case, would only be of such a value as would cause full scale deflection of the meter. This would be sufficiently low, so as not to damage the meter.

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[redacted]

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The switching arrangement is not shown on the O-Sketch, but it should be such that it is never possible to turn off the high voltage supply without turning off the "B" supply.

There are three adjustments to be made in the circuit. There is a 15 K. variable resistor that should be adjusted to obtain the proper current flowing through the VR 105 tube, the 200 K. potentiometer is the adjustment by which the meter is calibrated, and the output voltage is regulated by the 100 K potentiometer.

The 45 volt battery will have to be replaced at periodic intervals. As there is practically no drain on the battery, its life will be a considerable length of time. However, as it ages, its voltage will drop. This will result in poor regulation of the output voltage; because the portion of the voltage divider, in series with the battery in the grid circuit of the 6SJ7, must be decreased as the battery voltage becomes lower.

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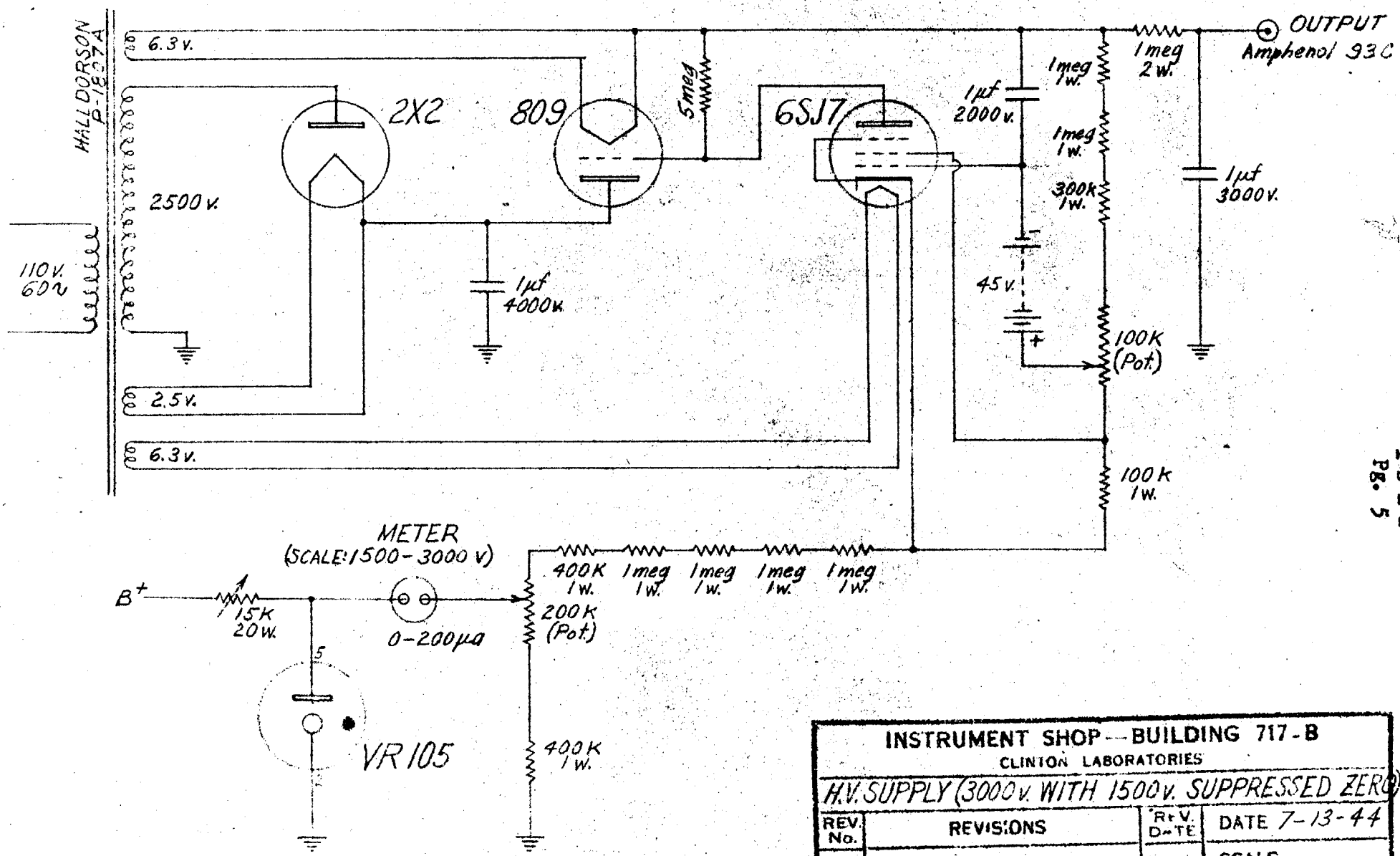

INSTRUMENT SHOP — BUILDING 717-B
CLINTON LABORATORIES

H.V. SUPPLY (3000 v. WITH 1500 v. SUPPRESSED ZERO)

REV. No.	REVISIONS	REV. DATE	DATE 7-13-44
			SCALE
			DRAWN BY M. Falls
			APP'V'D BY G. S. D...

BLDG. No.

SKETCH Q-192

[redacted]

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PROPORTIONAL COUNTER HIGH VOLTAGE SUPPLY

By: R. L. Quinn
9/18/44

The Proportional Counter High Voltage Supply is a regulated 2500 or 5000 V. power supply. The primary voltage across the H.V. transformer is regulated, instead of the D.C. voltage, as is done in the more common type regulated power supplies. The main purpose in doing this is to minimize the number of high potential connections.

The primary A.C. voltage is regulated by a magnetic voltage stabilizer. Output voltage can be adjusted by the variac in the circuit. The stabilizer consists of two transformers with the primaries in series, and the secondaries in series opposed. Like all magnet stabilizers, one transformer operates at high magnetic flux density. This transformer, with the higher saturation, has its secondary partially resonated by a condenser connected across it. Due to this partially resonated secondary as the transformer begins to become saturated, there is a phase shift that occurs between the two secondary voltages. By proper design the two secondary voltages add vectorially, so as to always give a constant A.C. voltage across the variac. This has been shown on the vector diagram which has been drawn on the following page.

On this diagram, and the circuit diagram above it, E_L represents the line voltage. E_1 and E_2 are the primary voltages. E_4 and E_5 are the secondary voltages, and E_3 is the output voltage. The voltages were measured on an actual circuit for different values of applied voltage, and the phase angles between E_L and E_1 and E_L and E_2 were calculated. E_5 was taken as 180° out of phase with E_1, E_4 would be in phase with E_2, and E_3 is the sum of E_5 and E_4 of the output voltage across the variac. E_3 should be constant and should fall on an arc around the point O. The arc has been drawn, and it can be seen that the sum of E_4 and E_5 does not always end on the arc, however, at no point does it depart by more than 4 volts. Under proper design, the stabilization will be within $\pm\frac{1}{2}\%$. * Transients which appear due to line voltage and load variations will disappear in 2 cycles, or approximately 0.02 sec.

A complete mathematical treatment of the operation of the regulator can be found under Technical Reports - General in the 717-B Files.

* Raytheon Voltage Stabilizers - Bulletin DL48-71L, March 1, 1943.

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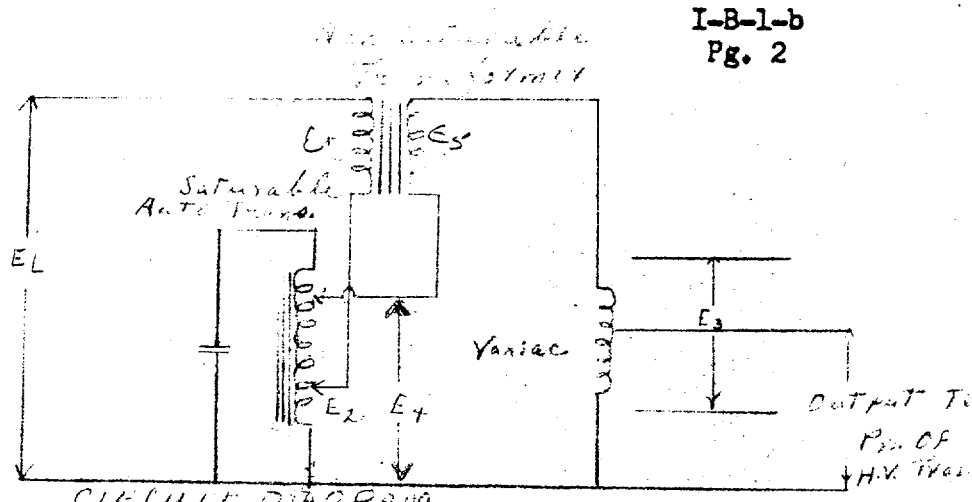
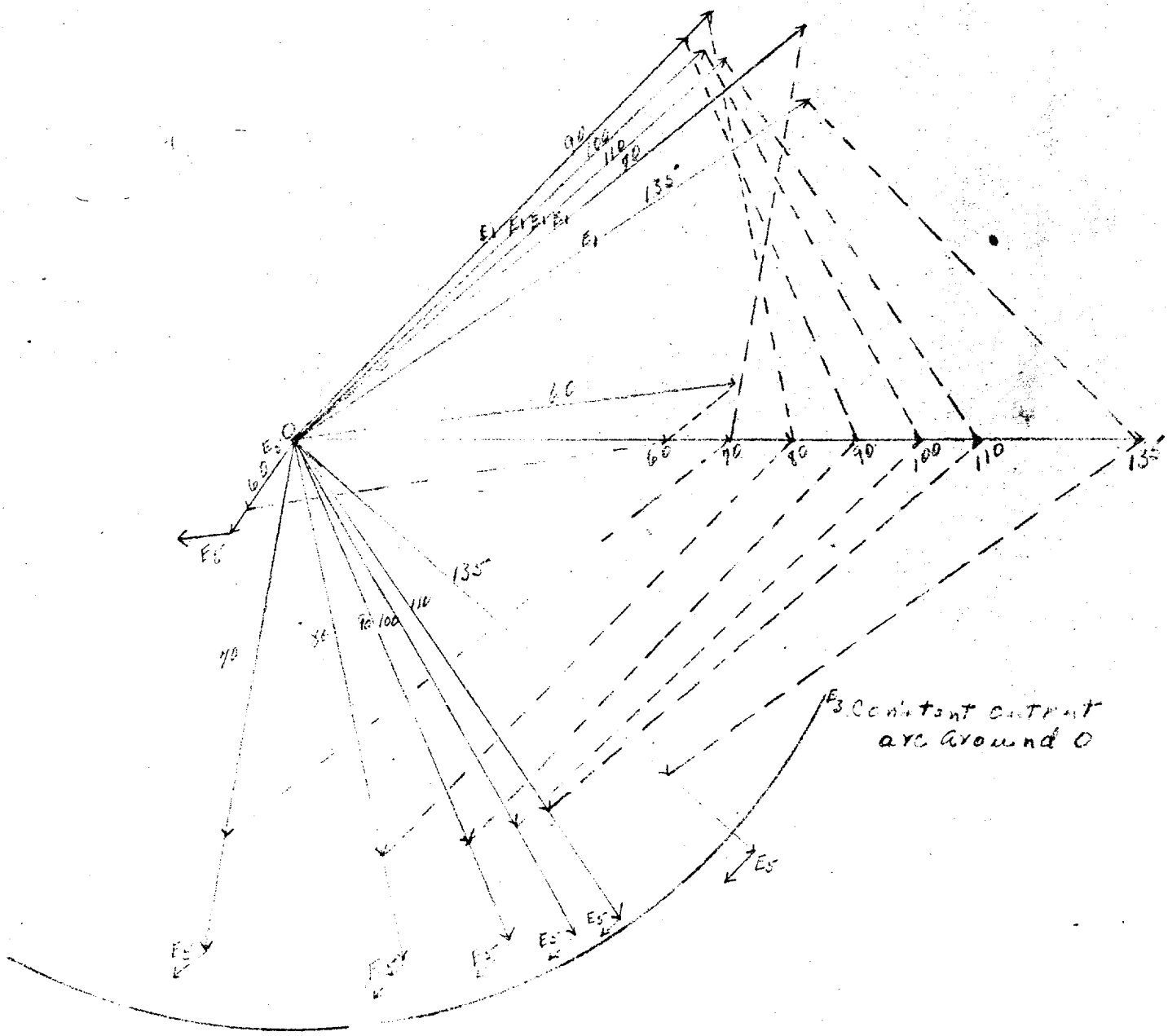


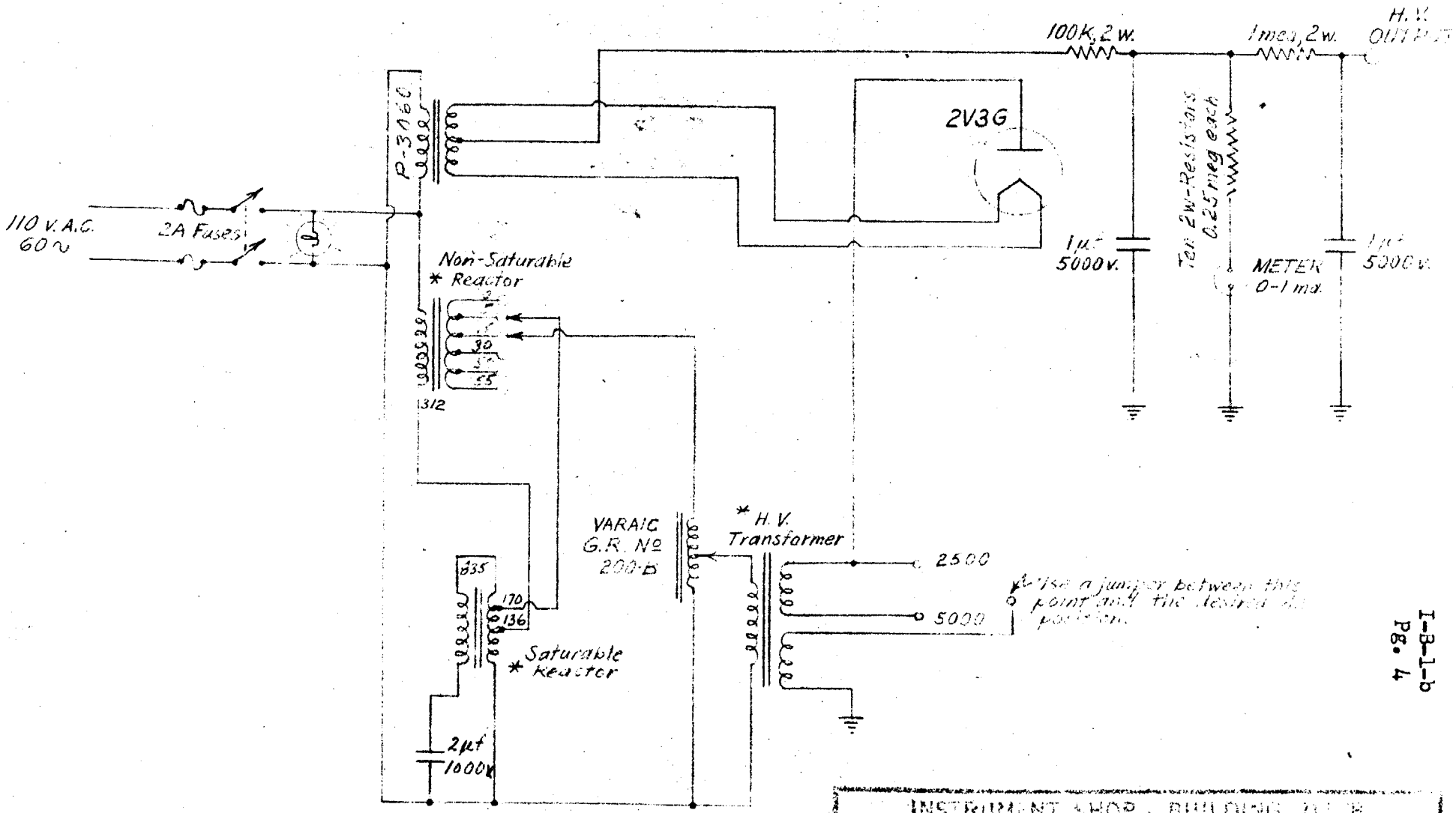
CIRCUIT DIAGRAM



[redacted]

The remainder of the H.V. Power Supply consists of a conventional half-wave rectifier with a two section resistor capacitor filter. (See Sketch Q-127-A.) The only two adjustments that will ordinarily have to be made are to adjust the primary voltage to the H.V. transformer with the variac, and to change the taps on the H.V. side of this transformer so as to obtain either a 2500 V. or 5000 V. power supply. However, the non-saturable transformer is also tapped so that E_5 may be increased or decreased. This voltage should not have to be changed, once it has been properly adjusted. It is also possible to change the output voltage of the stabilizer by changing the value of the condenser across the secondary of the saturable auto-transformer. The value of this condenser is not critical. The stabilizer works very nicely with either a 1 mfd. or a 2 mfd. condenser. It is also interesting to note that the stabilizer is not the limiting factor of the lower limit of the high voltage regulation. The lower limit of regulation is determined by the filament emission of the rectifier tube. This is due to the fact that the filament voltage is not regulated.

In case of any trouble in the H.V. supply, it most likely will be found on the H.V. side of the H.V. transformer. There is only a small probability of any trouble occurring in the stabilizer.



*Specially Wound By Boston Transformer Company.

INSTRUMENT SHOP - BUILDING 717-B
CLINTON LABORATORIES

PROPORTIONAL COUNTER H.V. SUPPLY (+2.5 & +5 KV)

REV No.	REVISIONS	REV DATE	DATE 6-16-44
1	Indicated taps and wire ings. N.R.E.	7/27/44	SCALE
			DRAWN BY M. Falls
			APPV'D BY

SLDG No.

SKETCH O-127-A

OFFICIAL USE ONLY

LINEAR AMPLIFIER

By: C. Clark IV
10/28/44

I PURPOSE

The linear amplifier is used as an intermediate amplifying unit in conjunction with an alpha counting chamber and one of the standard types of scaler. It is needed because the single pre-amplifying tube in the chamber does not supply amplification of the alpha pulses sufficient to actuate the scaler.

II GENERAL PHYSICAL DESCRIPTION

The linear amplifier is built into a 16" x 4" x 3" chassis, with its controls mounted on a 17" x 3" front panel. These controls consist of a ten-position selector switch for coarse gain adjustment, a 50 K potentiometer for fine gain adjustment, and two toggle switches through which the D.C. plate and filament voltages are applied.

The chassis is divided into three partitions, which serve to shield each amplification stage from each other.

III PRINCIPLE OF OPERATION

The pre-amplifying tube (usually a 38 tube) of the alpha counting chamber delivers a negative pulse to the control grid of the first amplifying stage (6J7 tube). The signal is then passed through the second and third stages, and into the input of the scaler as a positive pulse.

Gain control is effected at the grid of the second amplifier tube by varying the fraction of the available signal applied to this grid. A ten position selector switch provides coarse control in ten equal steps. A 50 K potentiometer across successively different portions of the coarse control divider provides a fine control. Schematically the circuit is as follows:

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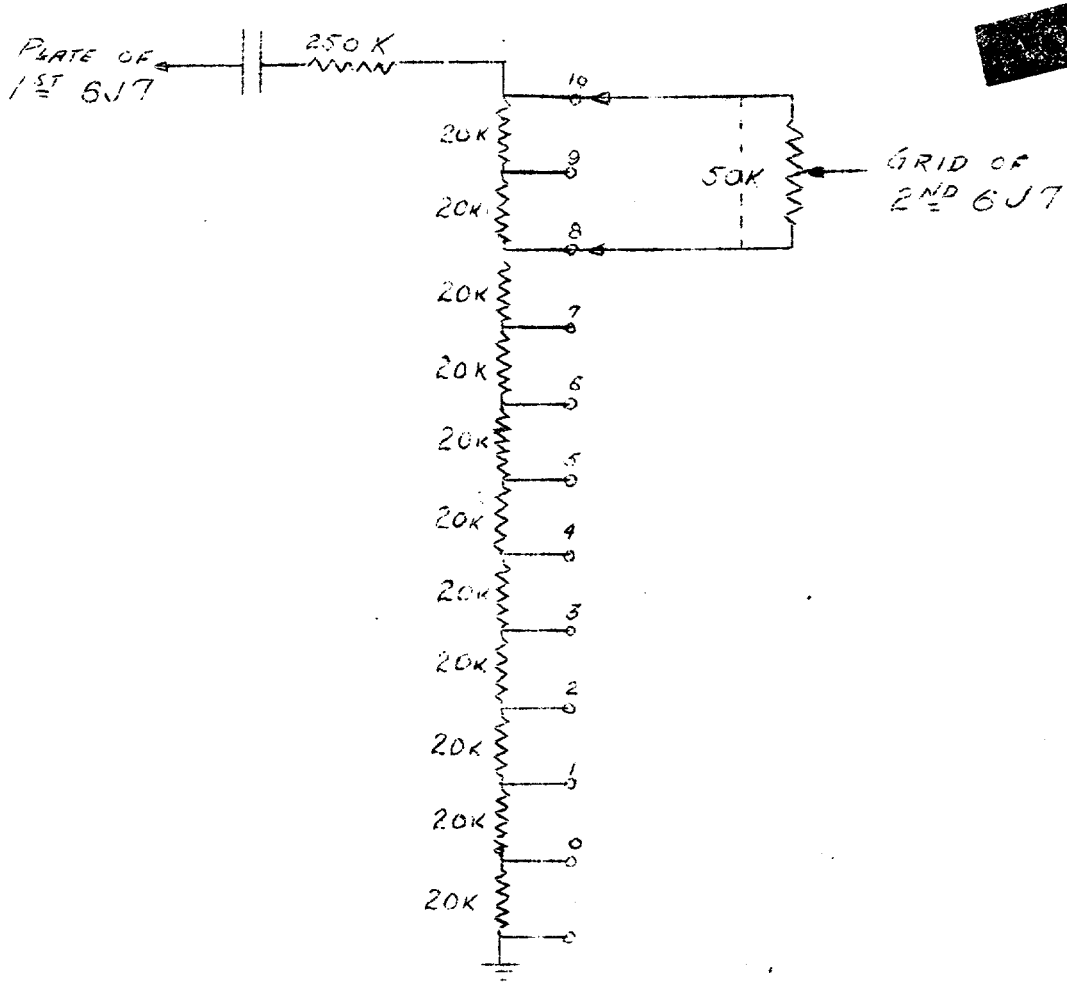

Plate voltage for the three stages is supplied from the scaler B+ and is RC filtered at each stage to prevent feed back from the power supply.

The amplification of the linear amplifier is dependent upon the frequency and strength of the input pulses. Although it is possible to obtain an amplification factor of 250,000 from the amplifier, in normal alpha counting applications its amplification is approximately 50,000. Since the scaler requires a minimum pulse of approximately 50 volts, the minimum input pulse to the linear amplifier is approximately 5 millivolts.

IV PROCEDURE FOR TESTING

Since the linear amplifier is used solely for the purpose of amplifying negative pulses supplied to its input, the most conclusive test of its functioning is a trial under actual operating conditions. This entails introducing negative pulses to the input of the amplifier, and observing these pulses on a cathode-ray oscilloscope at the output of the amplifier. These input pulses may originate from either a pulse generator, or an alpha counting chamber with a chemical sample.

[redacted]

V SYMPTOMS OF FAILURE & CORRECTIVE STEPS

Failures of the linear amplifier are characterized, in general, by a complete failure to transmit pulses, or by a distortion of the oscilloscope pattern.

Complete failure to transmit pulses is generally caused by faulty tubes or broken leads. These may be located by applying a signal from a pulse generator, and tracing, with an oscilloscope, this signal through the amplifier to the point at which it disappears.

A distorted 'scope pattern may be caused by faulty tubes, or by A.C. pick-up. If the trouble lies in the tubes, it may be eliminated by replacement of the faulty tube. A.C. pick-up in the linear amplifier is caused generally by the practice of grounding one side of the A.C. filament voltage to the last two amplifier tubes. This trouble may be eliminated by not grounding either side of the filament voltage, and by separating these A.C. leads from all other leads in the amplifier.

VI CIRCUIT DIAGRAM

(See Sketch Q-63)

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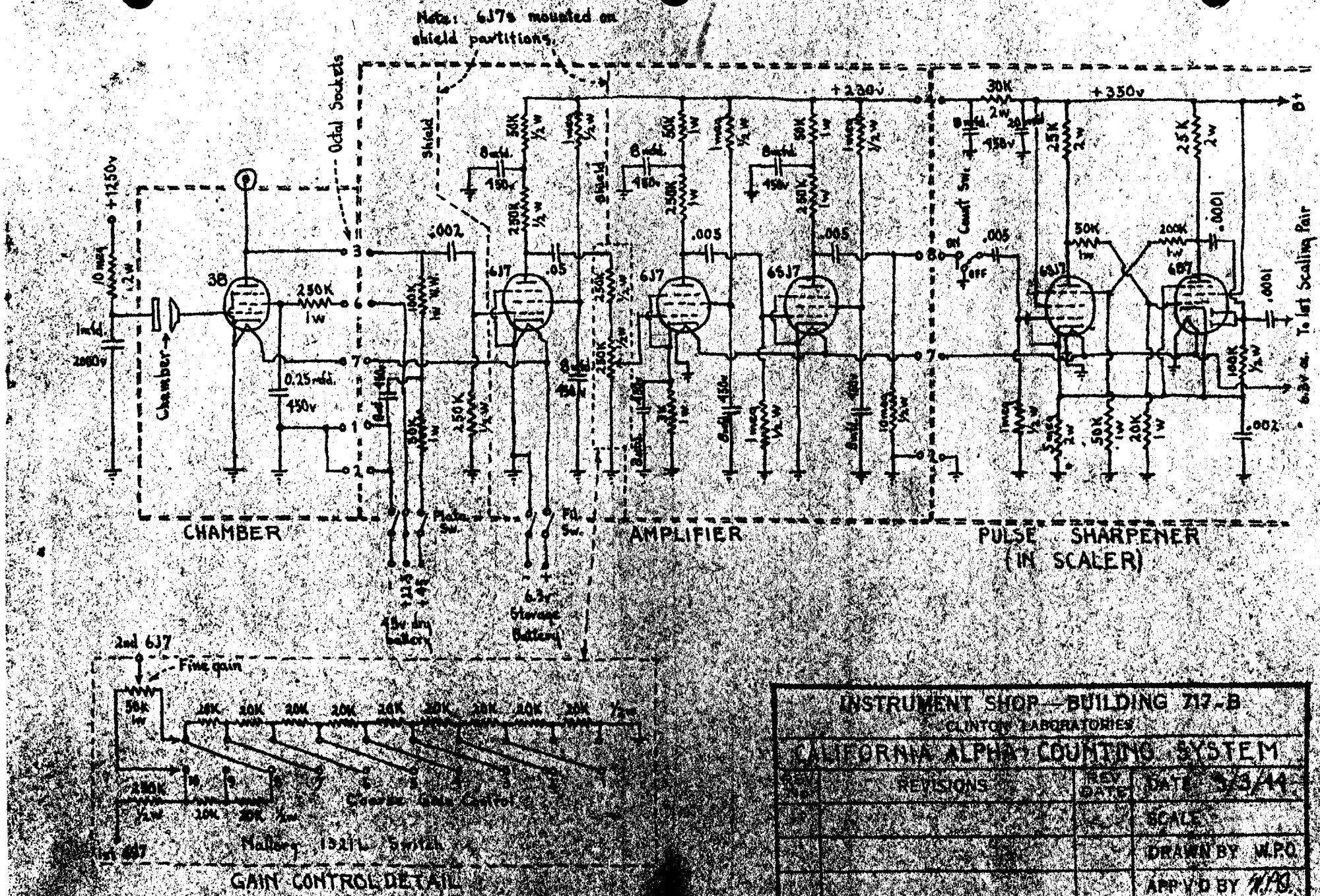

INSTRUMENT SHOP — BUILDING 717-B
CLINTON LABORATORIES

CALIFORNIA ALPHA COUNTING SYSTEM

REV. No.	REVISIONS	REV. DATE	DATE 5/3/44
			SCALE
			DRAWN BY W.P.O.
			APP'V'D BY W.P.O.

BLDG. NO.

SKETCH Q-63

[redacted]

PROPORTIONAL COUNTER AMPLIFIER

By: W. M. Mathis
10/31/45

[redacted]

PURPOSE

This amplifier is used with a BF_3 proportional counter tube to amplify its pulses to sufficient strength for scaler operation. The particular amplifier used in the 105 Building feeds both a 512 Scaler and a Counting Rate Meter, whose outputs are used for an indication of the operating level and neutron flux density.

PHYSICAL DESCRIPTION AND OPERATION

The amplifier consists of three separate units: a pre-amplifier, which is mounted with the BF_3 tube, main amplifier and power supply (B+ and B-).

PRE-AMPLIFIER

The pre-amplifier is a 12SF5, high mu triode, which acts as an impedance match for the 25 ft. leads to the amplifier. These leads allow positioning of the counter tube within the shielding or pile for various operating levels and are combined in three cables: (1) signal lead, (2) hi voltage from saturable reactor for BF_3 tube potential, (3) B+ and B- in two conductor cable. The heater of the 12SF5, together with the heaters of the first two amplifier tubes, are DC operated from the B- supply to eliminate AC pick-up on the tube.

AMPLIFIER

The main amplifier is mounted on a 16" x 10" x 3" chassis and has five tubes which can produce a gain of approximately 5×10^5.

The first two stages use 12SF5 tubes, D.C. operated, and the plate of the second tube is fed back to the cathode of the first tube to provide degeneration and increase frequency response. This amplifier will satisfactorily handle counts of 10^5 per minute which is the maximum of the counting rate meter.

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[redacted]

CLASSIFICATION CANCELLED
DATE FEB 11 6 4
For The Atomic Energy Commission
H. R. Carnell
Chief, Declassification Branch

The plate circuits of these tubes contain grounded 20 mfd. condensers which reduce B+ ripple and prevent oscillation.

Following the second 12SF5 is a step-attenuator of 10 positions. Normal operation is in the middle range.

The third and fourth tubes are high mu pentodes, 6AC7's, which are AC operated. These tubes also use degenerative feed back and have grounded 8 mfd. de-coupling condensers in plate supplies.

The output tube is a 6L6, which uses the B- supply for grid bias of about -40 volts. The plate load is a VM-0 United Transformer of 2500 ohms, whose secondary matches a 500 ohm line to the scaler where a second VM-0 transformer matches into a 2500 ohm load. In this way exact duplication of pulses are transferred over a long lead wire of approximately 150 ft.

POWER SUPPLY (B+ and B-)

The power supply consists of two separate transformers, rectifiers and choke input filter systems mounted on a second 16" x 10" x 3" chassis. (The rectifiers used are 5Z3 rather than 80 as shown on print.) Both supplies have high current ratings and the B+ for amplifier plates can be tapped from a dividohm and is usually held at 225 volts. B- supply to amplifier is approximately -45 volts.

SYMPTOMS OF FAILURE AND CORRECTION

The most common causes of trouble with this amplifier have been (a) weak or poorly filtered B+ or B-, which can usually be corrected by replacement of the 5Z3 or filter condensers, (b) weak tubes.

The amplifier circuit is shown on the attached drawing CL-717-B-20.

The scaler circuit is shown on the attached drawing CL-717-B-21.

A similar amplifier is now commonly used for experimental purposes and is shown on Sketch Q-177.

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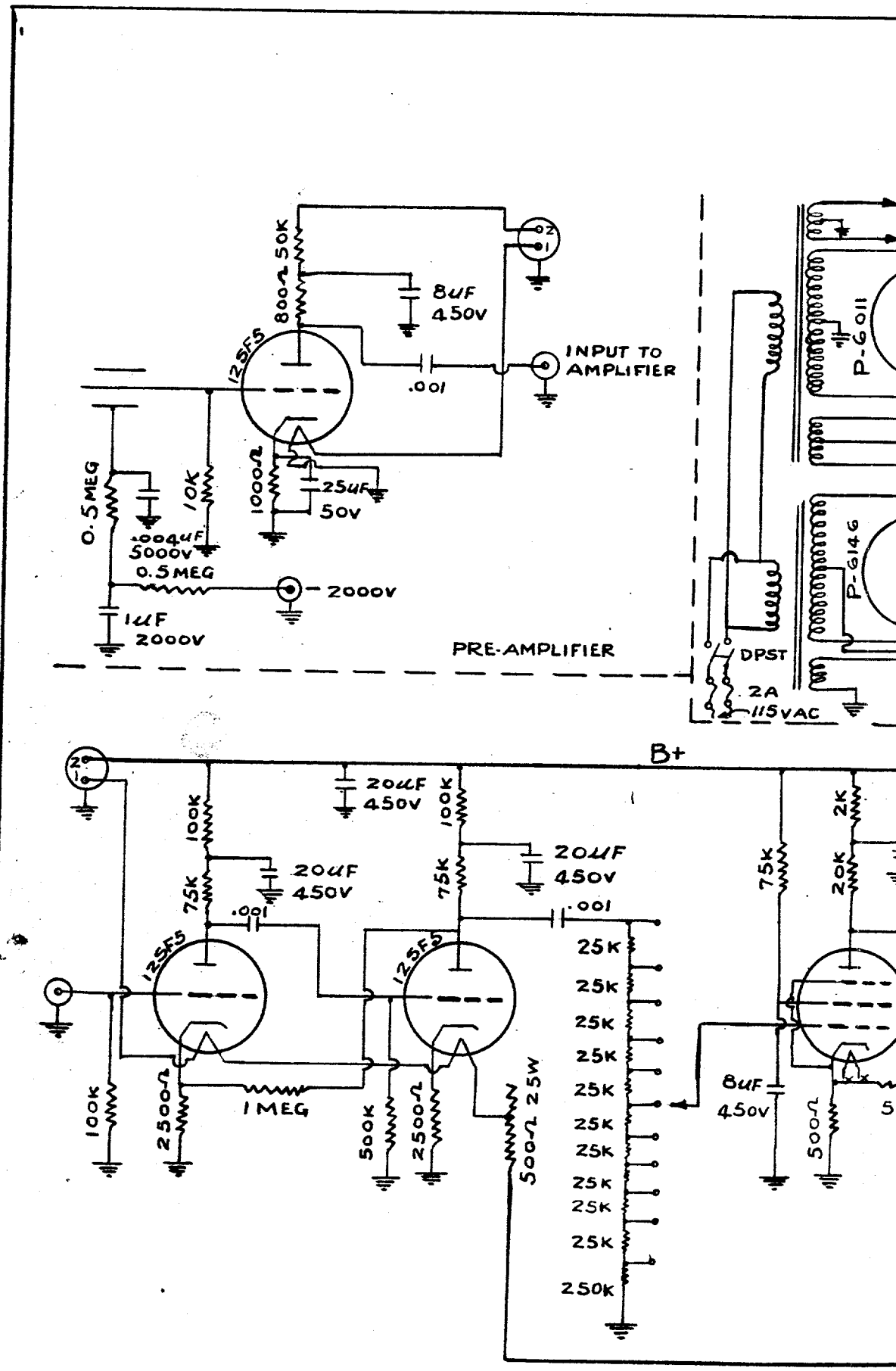
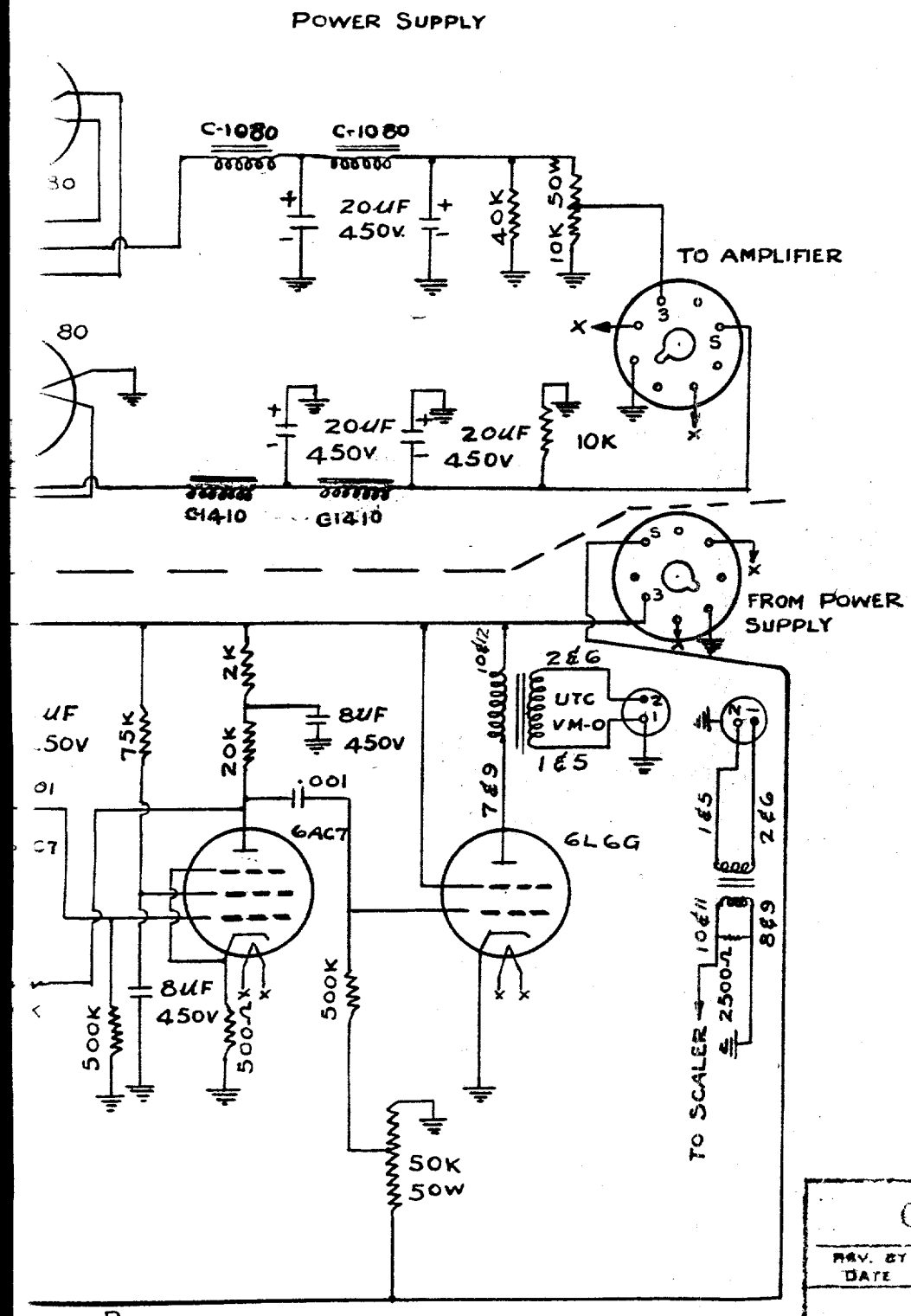


PROPORTIONAL



B-

COUNTER AMPLIFIER

CLINTON LABORATORIES		
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		SCALE NONE
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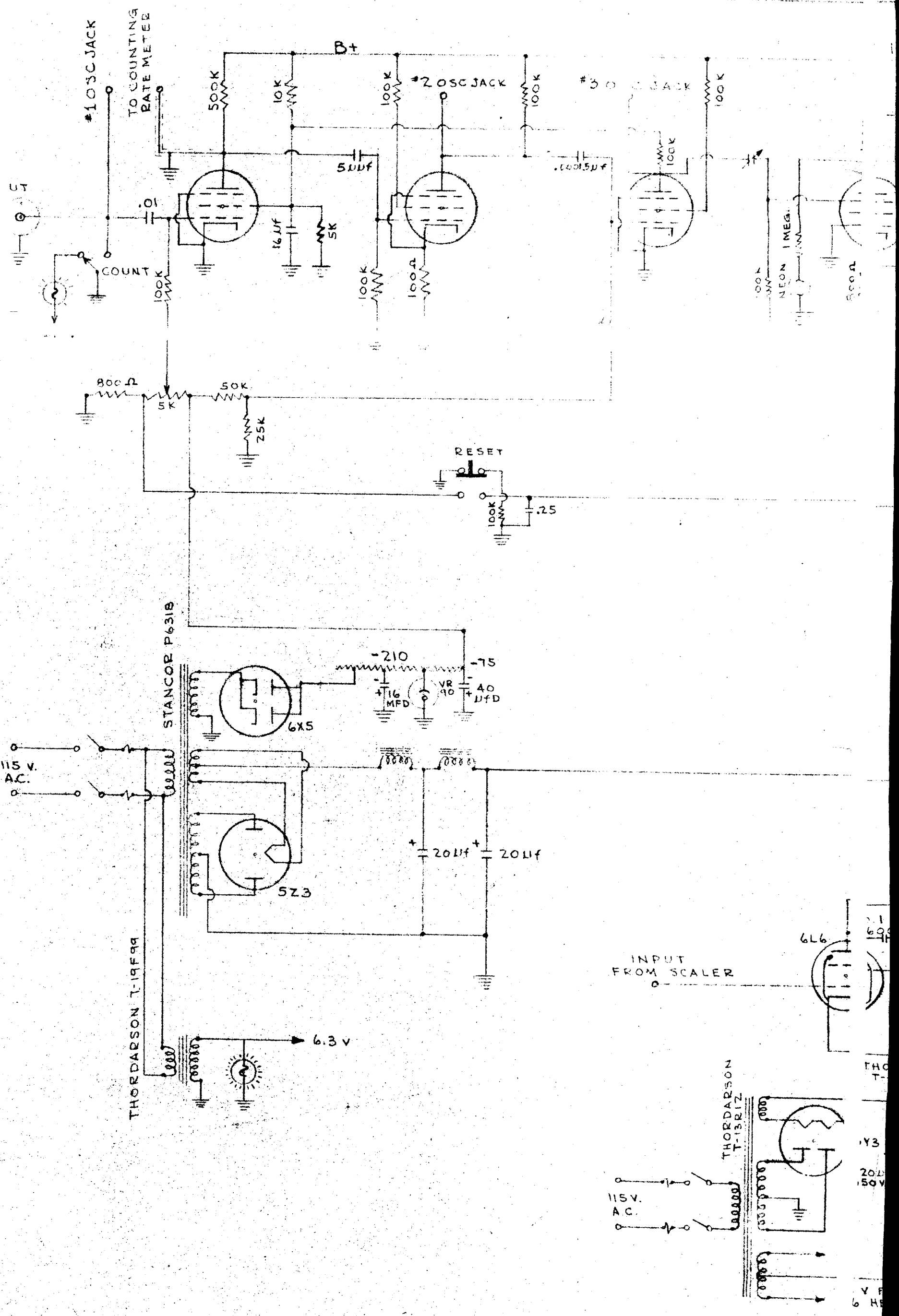
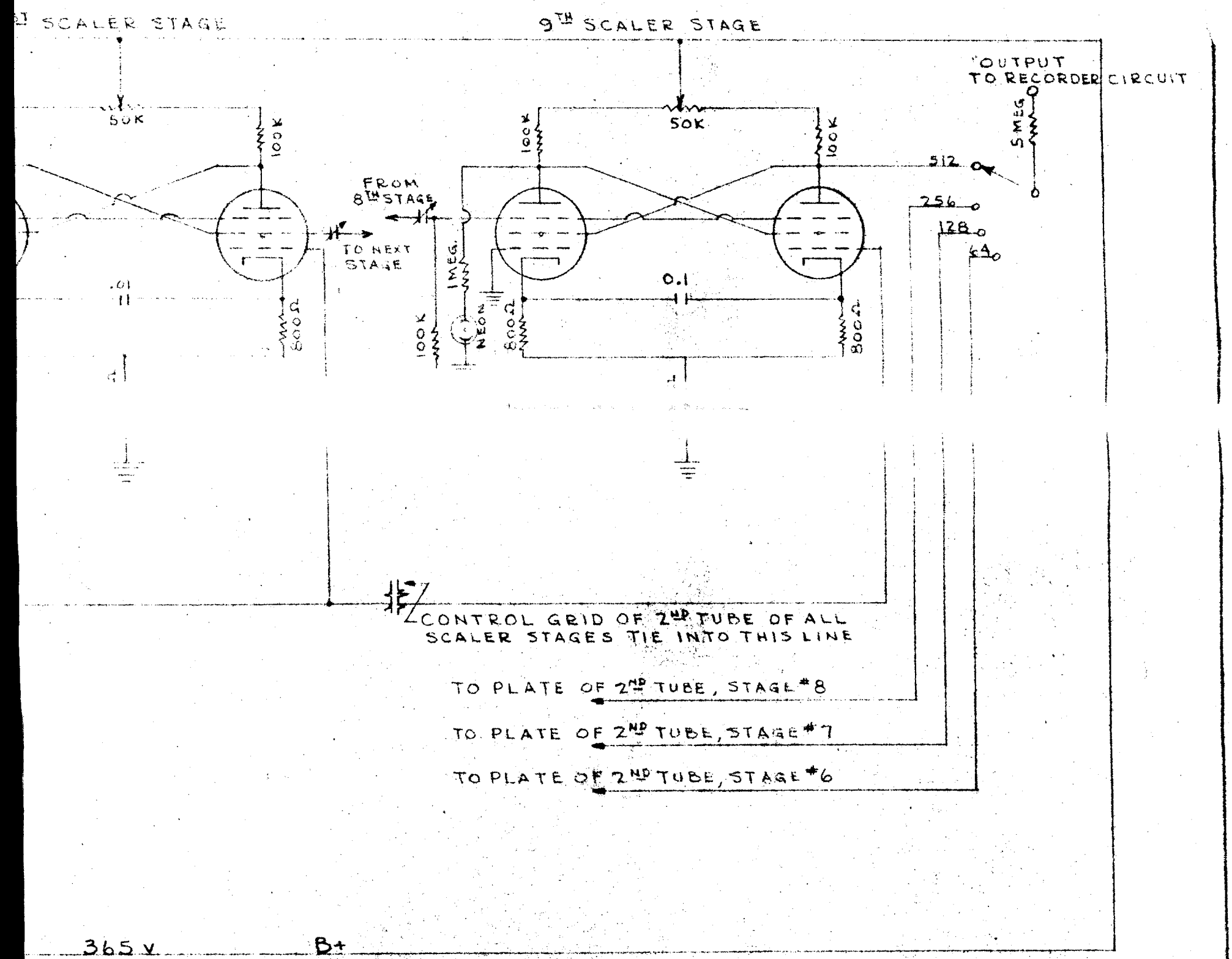
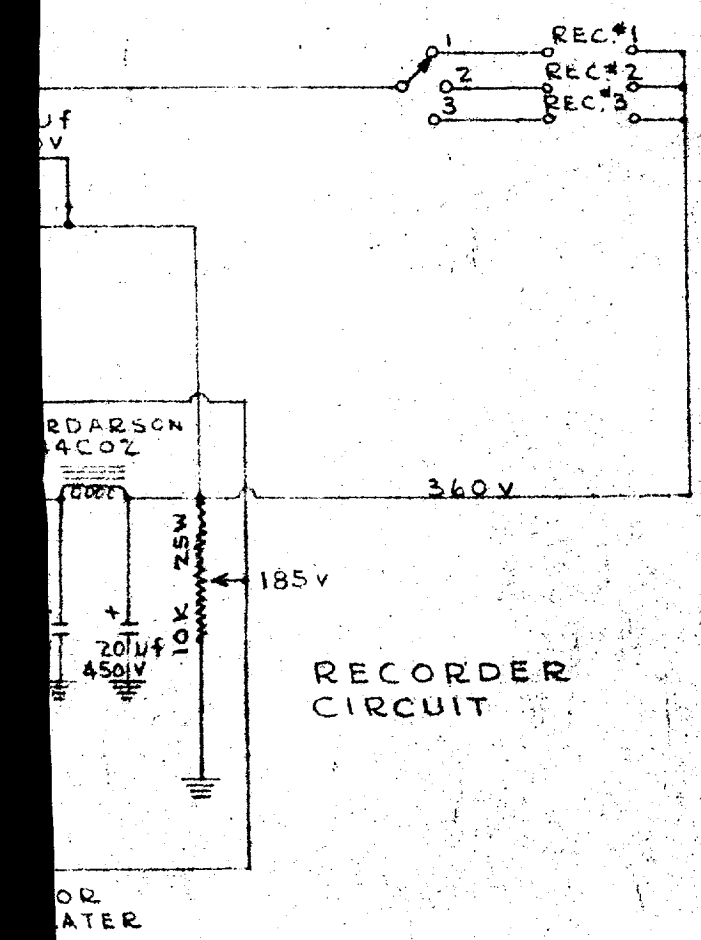
		APPROVED M[illegible]
		PROJECT No. 9[illegible]
		CL-717-B-2[illegible]



#1 OSC JACK
TO COUNTING RATE METER
B+
500K
10K
100K
#2 OSC JACK
100K
#3 OSC JACK
100K
5μμf
.0015μf
100K
UT
.01
16μf
5K
COUNT
100K
100K
100Ω
100K
NEON
1 MEG.
800Ω
5K
50K
25K
RESET
100K
.25
STANCOR P6318
-210
-75
16 MFD
VR 90
40 μfD
6X5
115 V. A.C.
20μf
20μf
5Z3
THORDARSON T-19F99
6.3 V
6L6
INPUT FROM SCALER
THORDARSON T-13R12
115 V. A.C.



STAGE NO.	COND. IN μf
1	.01
2	.03
3	.05
4	.05
5	.05
6	.05
7	.05
8	.05
9	0.1



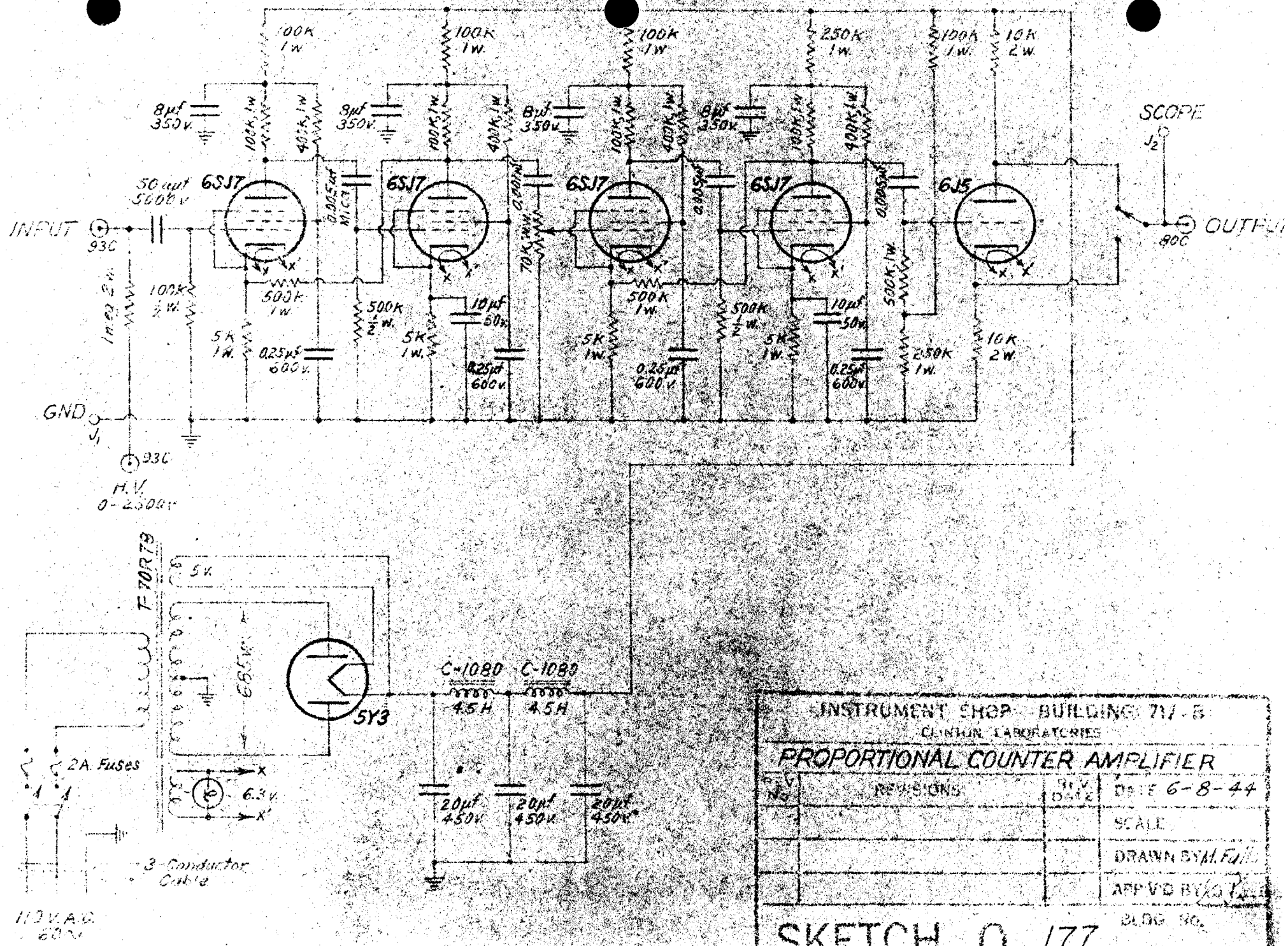
'SCALE OF 512 SCALER'

CLINTON LABORATORIES

REVISIONS	REV. BY DATE	REFERENCE DRAWINGS

DATE 3-24-44
SCALE NONE
DRAWN BY Blackstock
APPROVED M.S.S.
PROJ. No. 9733

CL-717B-21



INSTRUMENT SHOP BUILDING 717-B
CLINTON LABORATORIES

PROPORTIONAL COUNTER AMPLIFIER

REV. No.	REVISIONS	REV. DATE	DATE 6-8-44
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			DRAWN BY M. Falls
			APP'VD BY [illegible]

BLDG. No.

SKETCH O-177

This document consists of 2 pages and 1 figures.
No. 12 of 47 copies, Series A

[redacted]NLY

ALPHA PROPORTIONAL COUNTER AMPLIFIER

By: A. R. Simpson
12/11/44

[redacted]

The pulse produced by an alpha particle in a proportional counter using methane gas is of the order of one one-hundreth volt. The purpose of the alpha proportional amplifier is to take pulses from the proportional counter and amplify them sufficiently to operate a scaler.

John Simpson developed this method of counting, so the instruments are known as Simpson proportional counters. Reference may be made to other parts of the system as follows:

Proportional Alpha Counter - Pg. 1-A-1-b
Higinbotham Scaler - Pg. 1-B-6-c
High Voltage Supply - Pg. 1-B-1-a

Specifications of the amplifier are as follows:

1. Input

   a. Comparatively low impedance, 100,000 ohms.
   b. Approximately .01 volt pulses.

2. Gain

   a. Approximately 10^2 up to trigger pair.
   b. Usable overall maximum about 3×10^3.
   c. Nearly constant due to use of degeneration.

3. Frequence response

   a. Sine wave response good from 20 K.C. to above 100 K.C.
   b. 60 cycle response is negligible.
   c. Will differentiate between pulses less than 10^{-5} seconds apart.

4. Output

   a. Uniform height pulse for any input above the minimum necessary to trip trigger pair.
   b. Pulse height approximately 30 volts.

CLASSIFICATION CANCELLED
DATE FEB 11 6 4
For The Atomic Energy Commission
Chief, Declassification Branch

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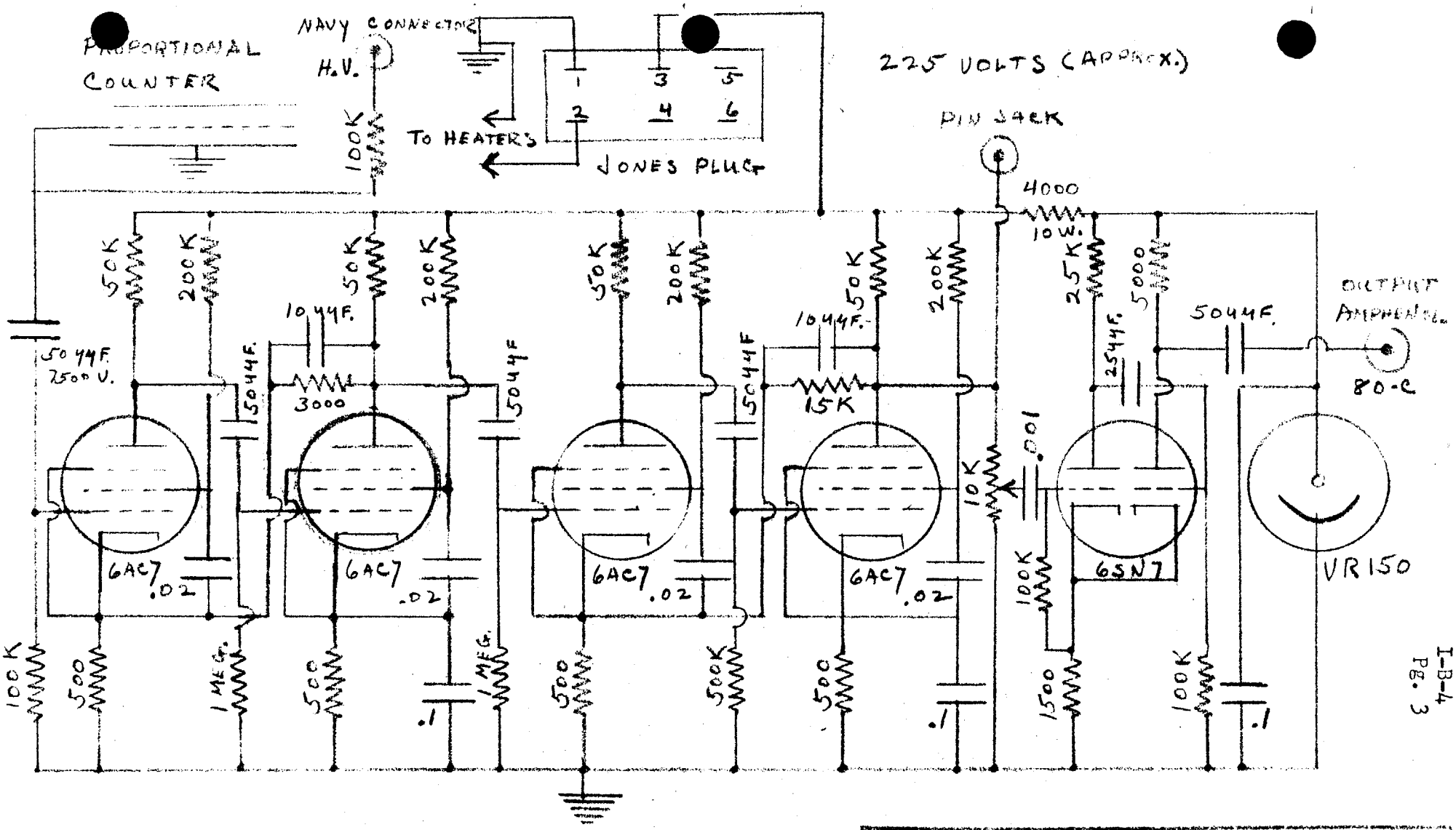
The circuit employs four 6AC7 tubes in a degenerative amplifier which has been designed for high frequencies. Degeneration is used to insure that the gain remains nearly constant and to minimize effects from line voltage change, ageing of tubes and tube replacements. A VR tube is used to hold the "B" supply to the 6SN7 trigger pair constant which gives a uniform output pulse.

Pulses produced by alpha particles in the counter may be difficult to observe on a scope due to their short duration. Use a five inch scope with a good high frequency amplifier (such as Dumont 208). Some patience will be necessary in adjusting the gain and synchronizing controls so the pulse can be seen. The exact procedure, of course, will depend on the pulse generator and scope used. One generator synchronized with the 60 cycle line has been found useful because the scope can be synchronized from the same source giving a positive lock-in.

The values of some parts in the 6SN7 trigger pair are critical and should be carefully checked if trouble is experienced in this circuit. One thing to note is that this tube should definitely trigger. Up to about .4 volt input to this tube, the signal will be amplified slightly but above the critical value at which it triggers the output will suddenly jump from, say, one-half volt to thirty volts and remain constant for any further increase in input voltage. If oscillation is experienced, it may indicate that the cathode resistor has changed value.

Special precautions should be observed in the input circuit to reduce spurious counts. Be sure the 50 micro-micro-farad mica input condenser is good and that the outside of the condenser is clean. Surface leakage will cause spurious counts. All insulators used in the high voltage circuit should be clean. The high voltage should be well filtered with no leakage thru the filter condensers. By unsoldering the wire leading to the counter chamber, one can tell whether the extra counts are caused by the chamber or the amplifier, however, the high voltage must be on as most of the extra counts are caused by leaks from there to grid or to ground. With proper care in the counter chamber as well as here, the overall background count can be held to the order of five counts per minute or less.

The amplifier stages are straight forward except for the large amount of degeneration used. The gain per stage will vary but in any case is very low. Values of parts should not be changed from those shown, since proper operation depends on holding the gain fairly close to its original value.



HIGH VOLTAGE 1800-2700

ALL RESISTORS 1 WATT UNLESS MARKED.

INSTRUMENT SHOP BUILDING 717-B CLINTON LABORATORIES			
SIMPSON P.C. AMPLIFIER			
REV. No	REVISIONS	REV. DATE	DATE 12-28-44
	REPLACES Q194		SCALE NONE
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SKETCH Q-194-A			BLDG. NO. 706A

This document consists of 2 pages and 1 figures.
No. 13 of 17 copies. Series A

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NEHER-HARPER QUENCH CIRCUIT

~~OFFICIAL USE ONLY~~

By: R. E. Toucey
8/31/44

Neher-Harper quenching is a method of stopping the discharge in a G-M counter by effectively acting as a shorting switch across the G-M tube. This quenching method is necessary with tubes which do not contain organic vapors in their filling but is also useful in prolonging life and improving characteristics of organic vapor tubes.

There are two types of Neher-Harper circuits in use at Clinton Laboratories. One is produced by Cyclotron Specialties Company using a Type 6J7 tube and is intended for use with the California Scaler. The second type produced by Clinton Laboratories uses a Type 6SJ7 tube and is intended for use with Columbia Type Scalers. Essentially any sharp cut-off pentode will work in a Neher-Harper, but in these two the method of obtaining cut-off bias for the pentode is different. The California type uses negative voltage impressed upon the grid, while the Clinton type uses positive cathode bias.

To adjust any Neher-Harper, the G-M tube is not connected. A high resistance voltmeter is connected from plate to ground and the bias control is set to the point where the plate voltage just reaches its maximum. This setting should be done with the H.V. set approximately at the operating region of the G-M tube.

When the G-M tube is attached, its wire is connected to the Neher-Harper plate and its cylinder to the grid of the Neher-Harper tube grid, With the G-M tube non-conducting, the Neher-Harper plate voltage is equal to the H.V. Supply and the Neher-Harper grid resistor has no voltage drop across it. When the G-M tube begins to conduct, it closes the circuit from the H.V. through the load resistor of the Neher-Harper tube, through the G-M tube, through the Neher-Harper grid resistor to ground potential. This voltage division, when the tube is conducting, thus impresses a fraction of the H.V. on the grid of the Neher-Harper tube causing it to become conducting, dropping the plate voltage in so doing. With the low potential across the G-M tubes, the ions recombine making the G-M tube again a non-conductor.

The G-M tube, being no longer conducting, allows the grid of the Neher-Harper to return to its original value and the tube becomes non-conducting, allowing the plate voltage to rise to the operating voltage of the G-M tube, where upon, it is ready to detect another ionizing event.

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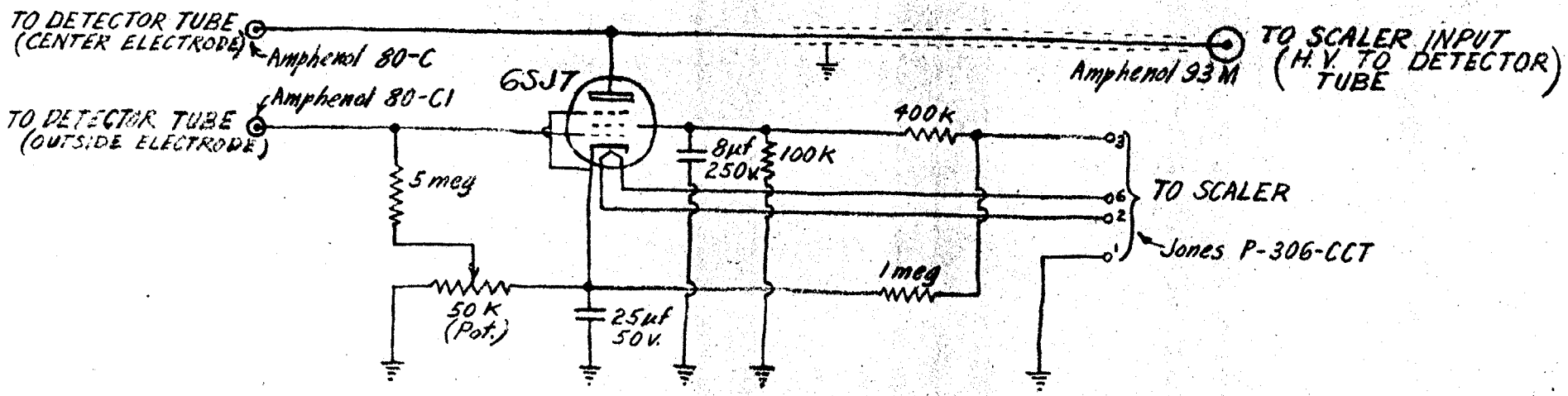
When a Neher-Harper is used with a Columbia type scaler, the input must be made less sensitive in order to prevent double counting. This is best accomplished by connecting the first input tube cathode to ground and setting the second input tube cathode to a larger voltage than usual, approximately + 12 volts.

The schematic diagrams of the two Neher-Harper circuits can be found in Sketch Q-83-A and in Dwg. CL-717-B-12. (I-B-5, Pg. 3) (I-B-6-b, Pg. 9)

It has been found that a combination of inductance and resistance in the Neher-Harper grid circuit produces more uniform output pulses than a resistance alone. The values used in this circuit are included in Q-83-A.



NOTE:
Mount the 6SJ7 tube in a low-loss socket such as Millen 33008.

SPECIAL NEHER-HARPER ARRANGEMENT

1. Plate load 3 meg, replacing 1 meg.
2. Grid circuit load of Neher-Harper 100 k resistor in series with a 10 mh. choke, replacing a 5 meg resistor.

INSTRUMENT SHOP — BUILDING 717-B CLINTON LABORATORIES			
NEHER-HARPER CIRCUIT FOR COLUMBIA SCALER			
REV. No.	REVISIONS	REV. DATE	DATE 7-25-44
			SCALE
			DRAWN BY M Falls
			APP'V'D BY
SKETCH O-83A			BLDG. No.

OFFICIAL USE ONLY

THE COLUMBIA SCALER

By: E. H. Lusebrink
M. P. Falls
9/28/45

CLASSIFICATION CANCELLED
DATE FEB 11 6 4
For The Atomic Energy Commission
H. F. Canese
Chief, Declassification Branch

INTRODUCTION

The pulses emitted from G-M tubes in counting circuits are of small amplitude, of small time duration, and can be of rather high frequency. These factors render any form of direct mechanical counting useless; thus an instrument is needed that will count these pulses accurately, and still meet the above requirements.

The Clinton Columbia scaler is an improved model of the Offner Columbia scaler. These scalers register one count on a Wizard recorder per 64 input pulses. The scaler divides the number of impulses by a factor of 2^6; hence the title "Scale of 64". The instrument can be divided into five sections, all included in one basic unit. They are

(1) Pre-amplifier and pulse leveller,
(2) Six scale-of-two stages,
(3) Recorder driver stage,
(4) Unstabilized B+ supply for above sections, and
(5) Stabilized High Voltage supply, for G-M tubes or other use.

EXPLANATION OF THE VARIOUS SECTIONS

Pre-Amplifier

Negative input pulses are required to operate the scaler. The first tube is a type 6SJ7, used to amplify the small input pulses. The input pulses are fed to the amplifier tube grid through a 50 mmfd capacitor, and a 100K ohm grid leak. The pulse (viewed on an oscilloscope) on the grid side of the input capacitor may be both positive and negative in sign, due to resistance-capacitance differentiation. The pulse should be more negative than positive, however. The pulse on the plate of the amplifier should appear as it did on the grid of the same tube, except greatly amplified (approximately 40 times) and inverted. Due to the 180° inversion, the pulse is now more positive than negative. This pulse is then coupled to the next tube, (leveller) through a 0.001 mfd mica coupling or blocking capacitor.

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Inverter and Leveller

Since the scaling pairs trip with a negative pulse, a means of inverting the positive pulse must be provided. This is accomplished by the inverter tube. The second function of this tube is to provide even sized (amplitude) output pulses, even though the input pulse amplitude should vary considerable. The bias potentiometer on this tube is set to furnish a cathode potential of approximately +12 volts, which is beyond cutoff value of the tube. The plate supply voltage is regulated to +75 volts by a VR-75 tube, while the screen operates at +100 volts. The plate load resistor is slightly high, being 500M ohms, The positive input signal is large enough to drive the tube from cut-off to saturation. This results in even output pulses, usually not amplified and of negative sign to feed the scaler stages. If the leveller tube input signal is too large, the tube will conduct for a small period of time, resulting in a square wave. If the bias of this tube is set too low, a positive and negative output pulse will result, due to the tube not being at cutoff, with zero grid signal. The negative output pulses are taken from the plate of this tube, passed through a variable 0-30 mmfd capacitor, to the first scaling pair.

Scaling stage

Let us consider the left hand tube (on drawing) as tube (1), the right hand tube as (2). Tube (2) contains a neon light in its plate circuit. These two tubes constitute one scaling stage, or scaling pair.

The scaling pair is stable in one of two conditions only:

(a) with (1) conducting and (2) at cutoff

or

(b) with (2) conducting and (1) at cutoff.

Assume (1) is conducting and (2) is cutoff. If a positive signal is applied to the suppressor grids, nothing happens. If a negative signal is applied, it will cutoff both tubes, equalizing plate and screen voltages. Since (1) was conducting, its cathode is more positive to ground than is (2) cathode. The memory condenser has charged correspondingly. (Pulse duration is much shorter than the discharge time of this condenser.)

Since (2) cathode is less positive to ground than (1), when the negative pulse on the suppressor grid leaks off, the plate of (2) will draw more current than (1). As (2) conducts, its plate

voltage will drop. This plate is tied to the screen of (1), tending to shield (1) plate, further reducing (1) plate current. This decrease of (1) plate current causes a plate voltage increase. The (1) plate is tied to (2) screen, causing (2) plate current to increase still further. This process continues till (1) is cutoff and (2) conducting. The drop in (2) plate current emits a negative pulse into the next scaling stage, actuating it. On the next negative pulse input, tube (2) puts a positive pulse into the next stage, which does not actuate it. This action results in an output of 1/2 of the number of negative input pulses to the stage, and six stages give us a dividing factor of 2^6. The (2) tube control grid of each scaling pair is tied to a common line which terminates at a SPDT switch (reset switch). When in normal position, this switch grounds the common or reset line, grounding all (2) control grids. When it is in "reset" position, a positive 100 volts is applied to (2) control grid of each scaling pair, causing it to conduct thereby cutting off (1) tubes of all pairs. Since all neon lamps are on (2) tubes, all lights will be extinguished, as (2) tubes will be conducting.

Recorder Driver

This unit consists of a triode connected 6L6 tube, a VR-105 tube and Wizard mechanical counter. The VR tube is connected between the 6L6 cathode and ground, resulting in +105 volts on the 6L6 cathode. The 6L6 grid is tied to the plate of the (1) tube of the last scaling pair. This tube of the pair must be used in order that the register will trip on the 64th pulse. On the 64th pulse, (2) tube will conduct, shutting off the (1) tube of the pair, causing a rise in its plate voltage. This will place a large positive voltage on the 6L6 grid, which will cause it to conduct, tripping the register one count. Thirth-two pulses later the (1) tube of the last scaling pair will conduct, dropping the 6L6 grid potential, cutting the tube off. The register armature will then fall back into normal position, ready to register another count 32 pulses later.

The register is shunted by a 0.1 mfd paper condenser, which opposes the counter emf of the register solenoid when its current stops flowing. This not only enables faster register counting, but eliminates disturbing pulses into the B+ system.

B+ Supply

This is a standard full wave π filtered (condenser input) supply, using a 5Y3 type rectifier tube. The power transformer furnishes 350-0-350 volts to the rectifier plates, and the filtered B+ output is approximately 400 volts at 85 ma. The bleeder network consists of a 25K resistor (Dividohm) and a VR-75 tube in

series, acting as a voltage divider between B+ and B- (ground). A tap on the Dividohm is set to +100 volts, and is used to supply the screen potential of the amplifier and leveller tubes, as well as the reset network. The +75V tap at the VR tube is used to supply the leveller tube plate, and is also used as the stabilization reference point for the 1N5 tube, in the separate HV supply, that will be explained in more detail later. The 6L6 register driver tube receives its B+ supply directly from the rectifier cathode (filament). This is necessary in order to eliminate excessive intermittent currents flowing through the filter choke, which would result in B+ fluctuations.

HV Supply

The HV system of the Columbia scaler delivers a regulated DC potential, variable from approximately 600 to 1500 volts. The system includes a high voltage transformer, a type 2X2 half-wave rectifier tube, a regulator tube, type 809, and a regulator driver tube, type 1N5.

The transformer develops 1600 volts RMS, on the HV secondary, which is rectified by the 2X2. A 2 mfd 2500 volt filter condenser is connected between the 2X2 filament (B+) and ground (B-). The 809 is placed in series with the HV positive line, its plate (cap) is tied to the 2X2 filament and the 809 filament being the HV output terminal. From this point a bleeder network also passes to ground, consisting of 5 - 200K resistors, a 50K potentiometer, a 60K resistor and an 0-1 ma meter, all in series. The 809 tube regulates by the amount of bias on its grid, which is developed by the 1N5 as follows:

The plate of the 1N5 is tied to the high voltage output through a 5 megohm load resistor. The 1N5 grid is tied to a point on the high voltage bleeder and the tube is biased by the VR-75 in the cathode circuit. A drop in the output high voltage will result in a negative signal on the grid of the 1N5 causing the tube to become less conducting. The plate voltage accordingly rises putting a positive signal on the 809 grid. This causes the 809 to conduct more current and thus raises the high voltage back to its original value. If the output voltage tends to rise, the 809 becomes less conducting in the same way and the output voltage is restored to its original value. Voltage regulation is thus effected. A capacitor between the high voltage and the 1N5 grid aids in filtering by impressing ripple on the 1N5 grid. This ripple will be inverted by the 1N5 and will then appear on the 809 grid. The system thus acts as a filter as well as a regulator. The output voltage can be adjusted by varying the point on the high voltage bleeder at which the 1N5 grid is connected. This is accomplished by connecting the grid to the arm of a potentiometer in the high voltage bleeder.

The 1N5 and 809 regulating tubes are quick heating types, while the 2X2 is slow heating, in order to insure regulation as soon as DC is obtainable from the rectifier.

Due to high potentials, extreme care and good judgement should be exercised while repairing this section of the scaler. While repairing other sections of the scaler, the HV master switch should be thrown to the "off" position.

An outline of the procedure for testing and servicing is appended on the following pages.

APPENDIX

SERVICE OF COLUMBIA AND OFFNER SCALERS

1. Check visually for improper wiring; faulty connections; leaking condensers; overheated transformers, chokes and resistors. Correct these. Make all changes agree with C. L. Columbia type scaler (DWG. CL-717-B-27).

2. If the scaler has mica trimmer capacitive coupling between scaling stages, replace with variable air trimmer condensers where space permits.

3. Check all tubes. Use tube tester where applicable. Match the tubes (using aged tubes) in scaling stages as to G_m.

4. With AC supplied to the set check the power supply voltages, both the B+ section and the HV section. These voltages should be made to agree reasonably (within 10%) with the voltages indicated on the drawing. If the HV meter does not agree with the HV as measured by a Simpson test meter, provide the necessary shunt for meter calibration. The HV output should be variable from six or seven hundred volts to fifteen hundred volts, and regulate 700 - 1500V within 1% over AC line variation 90 - 135V.

5. Balance the plate voltages at individual scaling pairs by adjustment of the cathode or plate balancing potentiometer, whichever may be provided. If balancing potentiometers are not provided, plate and cathode resistors will have to be matched closely. It may be necessary sometimes to balance the plate or cathode resistors even when balancing potentiometers are provided. The plate voltages or individual scaling pairs should agree in any case within 10% of the plate (approx. 20V.) voltage.

6. Supply the input to the amplifier with negative pulses of any size between 2 and 10 volts. Adjust the cathode bias potentiometer to the 2nd tube of the amplifier input so that no positive tail is observed on an oscilloscope screen with the signal taken from the plate of the 2nd tube of the input stage. The bias voltage will be approximately 12 volts.

7. Turn all trimmer condensers to minimum capacity.

8. With the count switch on, adjust the first trimmer condenser until pulses of size 2 to 10 volts and frequency 3 c.p.s. to 12,000 c.p.s. trip the first stage properly. Observation may be made by visual inspection of the first interpolate light and by the picture on the oscilloscope screen with the signal taken at either cathode of the first scaling pair. Square waves will appear on the screen.

   NOTE: Taking the signal from the plates of scaling tubes will load the scaling pairs improperly.

9. Adjust next the trimmer condenser to the second scaling stage until the stage is scaling properly. Observation may be made of the second interpolate light and the picture on the oscilloscope screen with the signal taken from either cathode of the second scaling pair.

10. Advance with similar procedure to the succeeding scaling pairs.

11. With the oscilloscope signal taken from either cathode of the last scaling pair adjust the pulse generator to deliver pulses of frequency such that a single square wave is observed on the screen. Now, if the scaler is scaling properly, two square waves will appear when the signal probe is moved to either cathode of the preceding scaling pair; four square waves at the next preceding pair; eight square waves at the next; sixteen; and thirty-two. Sixty-four pulses should appear at the input to the first scaling pair.

12. After the scaler is made to scale properly over the frequency range of the pulse generator at a negative pulse input of 2 to 10 volts, turn off the count switch, connect a wizard recorder to the output, adjust the pulse signal to 2V size and known frequency. Check the scaling over an interval of time. Repeat for various frequencies of pulse input.

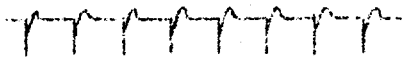
13. When the scaler is operating properly on -2 volt pulses from a pulse generator, the oscilloscope patterns will be as shown on the following page.

14. When the scaler scales properly with a 2V input pulse and over the frequency range of the pulse generator it should scale properly with G-M tube pulses. Try it.

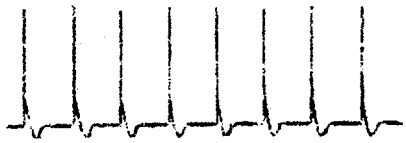
COLUMBIA SCALER OSCILLOSCOPE PATTERNS

(1) At input of scaler

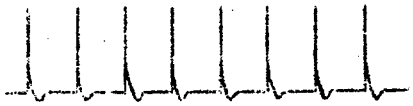
(2) At grid of first 6SJ7 (input tube)



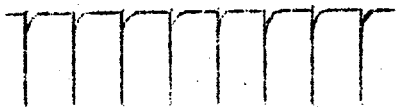
(3) At plate of first 6SJ7 (input tube)



(4) At grid of second 6SJ7 (leveller tube)



(5) At plate of second 6SJ7 (leveller tube)



(6) At suppressor grid of 1st scaling pair

(7) At cathode of either tube 1st scaling pair

(8) At cathode of either tube 2nd scaling pair

(9) Successive scaling stages have same pattern. Number of waves reduced by a factor of two at each stage.

This document consists of 8 pages and 2 figures.
No. 12 of 47 copies, Series A.

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THE CALIFORNIA SCALER

By: R. G. Jackson
9/13/44

[redacted]

The scale of eight, triode scaler as manufactured by the Cyclotron Specialties Co. is known as the "California" scaler. A high speed Cyclotron impulse register is used with this circuit.

The scaler may be divided into the following sections:

1. Input stage.
2. Scaling stages.
3. Output stage.
4. Low voltage power supply.
5. High voltage Power Supply.

In the two types used here, the only differences are in the input stages. The type "A" scaler is designed to take pulses from a Geiger-Mueller counter. The type "B" takes pulses from the alpha amplifier described in Chap. I-B-2.

The following equipment is needed for trouble shooting in the California scaler:

1. Tube tester.
2. Oscilloscope.
3. Pulse generator.
4. Test meter (Simpson #260, Volt-Ohmyst Jr., etc.)

Any trouble shooting should begin by testing the Power Supply Voltages. The B + should read 330 - 370 volts. The B - should read 320 - 380 volts.

TYPE "A" INPUT

Description

The input stage of the type A scaler consists of two tubes, 6SJ7 and 6C5. A negative pulse from the G-M tube of 20 volts or greater is fed through a 50 mmfd. 5000 V. condenser to the grid of the 6SJ7. This tube is operated at zero bias and is designed so that all pulses from the G-M tube will cut it off. It functions as an amplifier and pulse leveler. The following tube (6C5) is cut off by a grid bias of 40 volts. Positive pulses from the 6SJ7 cause it to conduct, sending a negative pulse to the first scaling pair. With the count switch in the off position, the grid of the 6SJ7 is grounded.

[redacted]

The input signal is also fed to a 6C5 which amplifies and decouples it for oscilloscope observations.

Trouble Shooting

1. Check tubes in tube tester.
2. Check the voltage drop across the plate resistors. It should be 100 - 150 volts for the 6SJ7 and 0.0 volts for 6C5.
3. Check grid to cathode bias. Should be 0.0 for 6SJ7 and - 30 to - 40 for 6C5.
4. Apply negative pulse of at least 20 volts to input condenser. Trace pulse through input with scope by observation on plate and grid of each tube.
5. Most common troubles.

   (a) Bad tubes.
   (b) Bad coupling condensers.

TYPE "B" INPUT

Description

The input of the type B scaler is of the multivibrator type, consisting of two tubes. Tube #1 is a pentode (6SJ7 or 6C6) and tube #2 is a duplex-diode pentode (6B8 or 6B7). The cathodes of these two tubes are returned to ground through a common resistor. Tube #2 is made conducting by a dropping resistor to its grid from the plate of tube #1. Tube #1 is biased so that it is not conducting. A positive pulse applied to the input causes tube #1 to conduct, sending a negative pulse to tube #2. Regenerative feedback from the plate of tube #2 to the suppressor of tube #1 strengthens the pulse. This cumulative action continues until the pulse saturates tube #1. It will appear on the plate of tube #2 as a square wave whose width is determined by the circuit constants. This is differentiated by a .0001 mfd. condenser into a positive and a negative pulse. The positive pulse is shorted to ground through the diode in tube #2. The negative pulse is fed into the first scaling stage.

Trouble Shooting

1. Check tubes.
2. Check voltage drop across plate resistors. Should be 0.0 volts for 6SJ7 or 6C6. Should be 200 - 250 volts for 6B8 or 6B7.
3. Apply positive pulse of at least 25 volts to input. Trace pulse through input with scope.
4. Most common causes of trouble.

   (a) Bad tubes.
   (b) Bad coupling condensers.

SCALING STAGES

Description

Each of the three identical scaling stages consists of two triodes (6C5's). Each stage is coupled to the next stage by a 6C5 which is biased at - 40 volts and feeds a negative pulse to the following scaling stage.

If all of the condensers in and around the scaling pair are neglected, it is seen that there are two dropping resistor networks from B + to B -. With the tubes removed the approximate voltages along either of these networks are as follows: B +, + 350 volts; plate of tube, + 310 volts; grid of opposite tube, + 10 volts; B -, - 65 volts. Since the cathodes are grounded, if one tube is inserted (call it tube #1) it will have a positive bias and will conduct strongly. Its plate voltage will be about + 70 volts which will drop the grid of tube #2 to - 40 volts, so that tube #2 will not conduct when inserted. It is seen that both tubes of the scaling pair cannot be conducting simultaneously, and that one of the tubes must be conducting. If one of the tubes is made to conduct, the other will immediately be cut off. Or, if one tube is forcibly cut off, the other will conduct. This action is aided by cross-coupling condensers from the plate of each tube to the grid of the other. When tube #1 is forcibly cut off, a positive pulse is transmitted to the grid of tube #2, causing it to become conducting. This causes a negative pulse to be transmitted to the grid of tube #1, causing it to be cut off still further.

The negative pulse from the input is fed through a condenser to the grid of both tubes in the first scaling pair. It cuts off the conducting tube, causing the other tube to conduct as described above. The next pulse reverses the tubes again.

The plate resistor of tube #2 is divided and the signal is taken to the interstage 6C5 from the division point. A negative pulse has no effect since the tube is already cut off. A positive pulse causes it to conduct sending a negative pulse to the next stage. In this way only one of every two pulses entering a scaling stage will be transmitted to the next stage.

The cathode of tube #2 is grounded through a 200 ohm potentiometer and the reset switch. With the switch in the reset position the cathode of tube #2 is open, forcing tube #1 to conduct.

The three potentiometers in parallel with a meter are used to provide interpolation. When the set is first reset, tube #1 of each stage is conducting and no current flows through the potentiometer. When the first pulse comes in, tube #2 of stage 1 conducts and the potentiometer of this stage is adjusted so that the interpolate meter deflects one division. On the second pulse, tube #2 of stage 1 is cut off and tube #2 of stage 2 is conducting and its potentiometer is adjusted so that the interpolate meter deflects two divisions. On the third pulse tube #2 of both stages are conducting, giving an interpolate reading of 3. The effect adds up until 7 is reached on the interpolate meter, the meter returning to zero on the eighth pulse.

PULSE	1st. STAGE TUBE 1	TUBE 2	INTERPOLATE CURRENT	2nd. STAGE TUBE 1	TUBE 2	INTERPOLATE CURRENT	3rd. STAGE TUBE 1	TUBE 2	INTERPOLATE CURRENT	INTERPOLATE READING
0 (after reset)	C	N	0	C	N	0	C	N	0	
1	N	C	1	C	N	0	C	N	0	1
2	C	N	0	N	C	2	C	N	0	2
3	N	C	1	N	C	2	C	N	0	3
4	C	N	0	C	N	0	N	C	4	4
5	N	C	1	C	N	0	N	C	4	5
6	C	N	0	N	C	2	N	C	4	6
7	N	C	1	N	C	2	N	C	4	7
8	C	N	0	C	N	0	C	N	0	0

N = Non-conducting

C = Conducting

Interpolate Current = The potentiometer for each stage is adjusted to give this reading on meter.

[redacted]

Trouble Shooting

1. Check tubes.
2. Check plate, cathode, and grid voltages of scaling pairs as follows:

	Plate Voltage	Grid Voltage	Cathode Voltage
Tube conducting	+ 70 ± 10	+ 1 ± 3	+ 2 ± 1 or 0.0
Tube not conducting	+ 315 ± 10	- 40 ± 5	0.0
Both tubes of scaling pair removed *	+ 320 ± 10	+ 15 ± 10	0.0

* If these voltages are off, check resistance of grid resistors, plate resistors, and cross-coupling resistors.

3. Voltage drop across plate resistors of interstage 6C5 should be 0.0 volts. Grid to cathode bias should be - 30 to - 45 volts.
4. Any properly operating stage may be triggered by grounding the grid of the tube that is not conducting with a screw driver (or test lead).
5. Apply pulse to input with pulse generator. Put scope on plate of any scaling tube. A square wave indicates proper operation.
6. Most frequent causes of trouble.

   (a) Bad tube.
   (b) Low B + or B - voltage.
   (c) Resistance of .4 meg. resistors may rise
   (d) Mica coupling condensers. Check with oscilloscope.

OUTPUT STAGE

Description

The output to the recorder consists of a 6C5 set at zero bias and an 884 thyratron. The thyratron is normally cut off by a negative grid bias of 60 - 100 volts. Negative pulses from tube # 1 of the last scaling pair are inverted and amplified by the 6C5. The positive signal on the grid of the 884 causes it to conduct, discharging the 0.1 mfd. condenser. The recorder and a 7500 ohm

resistor are in the plate circuit, and the current flow through them drops the plate voltage low enough to cut off the plate current. Current continues to flow through the recorder until the 0.1 mfd. condenser is recharged. The action of the condenser is to increase the duration and quantity of current flow through the recorder. This current flows through the coils of an electromagnet within the recorder, starting a mechanical action that drives the recorder dial.

Trouble Shooting

1. Check tubes in tube tester.
2. Grid to cathode bias should be 0 volts on the 6C5 and - 60 to - 100 on the 884. The grid of the 6C5 is very slightly negative due to grid current.
3. Plate voltage of 6C5 should be + 60 to + 90 volts. Plate voltage of 884 should be + 225 to + 275 volts, depending on the B + supply.
4. Most frequent causes of trouble.

   (a) Bad tubes (especially 884).
   (b) Paper condenser from plate side of recorder to ground may be too small or too large. A spare .05 mfd. paper condenser is included in most sets and may be connected in parallel with 0.1 mfd. condenser if needed.

STABILIZED HIGH VOLTAGE SUPPLY

Description

The operation of the high voltage supply can be best understood by reference to the circuit diagram. The plate voltage of the rectifier can be controlled by the variac marked "STABILIZE". This produces a D.C. voltage across which are the 50 K VOLTAGE pot, a 50 K resistor and several resistors adding up to 1.7 megs. The positive side of the voltage pot is tied to ground through the control tube (47). The amount that the negative side of the supply is below ground depends on the drop across the VOLTAGE pot, which depends on the setting of the VOLTAGE pot and on the amount of current flowing through the 47 tube.

Assuming that the voltage is stabilized at some point, the action to compensate for some change which tends to lower the positive output voltage is as follows:

1. Reduction in output positive voltage reduces the voltage drop through the dropping network, bringing the cathode of the control tube closer to the negative supply voltage.
2. The grid of the control tube is held at the same voltage relative to the negative supply voltage by the neon bulb.

3. The resulting decrease in negative grid bias causes the control tube to conduct more, causing a lower voltage drop across the VOLTAGE pot and bringing the minus supply nearer to ground.
4. As the minus side of the high voltage comes nearer to ground the positive side becomes more positive tending to compensate for the decrease in output voltage.

Stabilization is accomplished by varying both the STABILIZE and VOLTAGE dials to give the desired voltage until flipping the TEST switch results in no change in the high voltage. This is done by trial and error.

The SUBTRACT pot is across a VR 150 and provides a means of varying the HV output by 150 volts without affecting the stabilization.

Most common causes of trouble.

1. High voltage output zero or very small.

   (a) Check 2X2 and 47 tubes on tube tester.
   (b) Remove 2X2 and 47 tubes and check A.C. output of windings of HV transformer and HV filament transformer. If these are too low, either the transformer is bad or the leads coming from it are shorted.
   (c) Check all high voltage leads, resistors, and condensers for shorts.
   (d) Be sure that the plate of the 47 tube is grounded through the SUBTRACT pot.

2. High voltage fluctuates or cannot be reduced from its maximum value.

   (a) Try a new 47 tube.
   (b) Try a new neon bulb.
   (c) Resistors from neon bulb to positive side of high voltage may have increased in value so the neon bulb won't light. Measure them and replace if necessary.

3. Meter cannot be adjusted to read correctly.

   (a) Measure resistors in series with meter.

4. High voltage introduces jagged 60 cycle wave into scope picture of Type B counter.

   (a) Replace pyranol condenser.

"CALIFORNIA" SCALERS CONSTRUCTED AT CLINTON LABORATORIES

A number of California type scalers have been constructed at Clinton Laboratories. The three major changes in the circuit are as follows:

1. There is no B - supply. Positive cathode voltages are used to accomplish the same purposes.
2. The high voltage supply is the same as that used in the Offner scalers described in Chap. I-B-6-a.
3. In some cases interpolation is accomplished by neon lamps instead of by means of a meter. The operation of all parts of the circuit except for the high voltage is essentially the same as for the Cyclotron Specialties' scalers.

[redacted]

C. L. HIGINBOTHAM SCALER

By: W. Q. Gulley
11/1/44

The Higinbotham Scaler is a scale-of-64 scaler which is operated by negative pulses from a G-M tube or amplifier. The pulses from the output stage are recorded on a Wizard Recorder.

When properly constructed, the tune-up adjustments are not too critical and the scaler will give comparatively trouble free operation.

The following sections cover the construction, tune-up, and operation of each stage:

INPUT STAGE

The input tube is a Type 6SN7 double triode arranged to act as a trigger pair rather than as an amplifier. All negative pulses larger than a certain critical value, when applied to the grid of the input triode, will produce very large negative pulses at the plate of the second triode, which are substantially independent of the size of the input pulse. For input pulses smaller than the critical or tripping height, the tube acts as a two stage amplifier.

The size of pulse required to trip the trigger pair can be adjusted by means of the 5000 ohm potentiometer in the cathode circuit of the tube. This bias potentiometer should be set slightly beyond the cut-off point of the second triode. With this setting, negative input pulses larger than the tripping height will produce uniform size negative pulses to drive the first scaling stage.

B+ voltage for the first triode of the input 6SN7 is regulated at 105V by a VR-105. The count is stopped by grounding the grid of the second triode of the input 6SN7 through the "COUNT" - "STOP" switch.

SCALING STAGES

The scaling stage of the Higinbotham scaler is a double triode tube, Type 6SN7, so arranged that it is stable in either of two conditions as follows: (1) with the left hand triode conducting and the right hand triode cut off or (2) with the left hand triode cut off and the right hand triode conducting.

[redacted]

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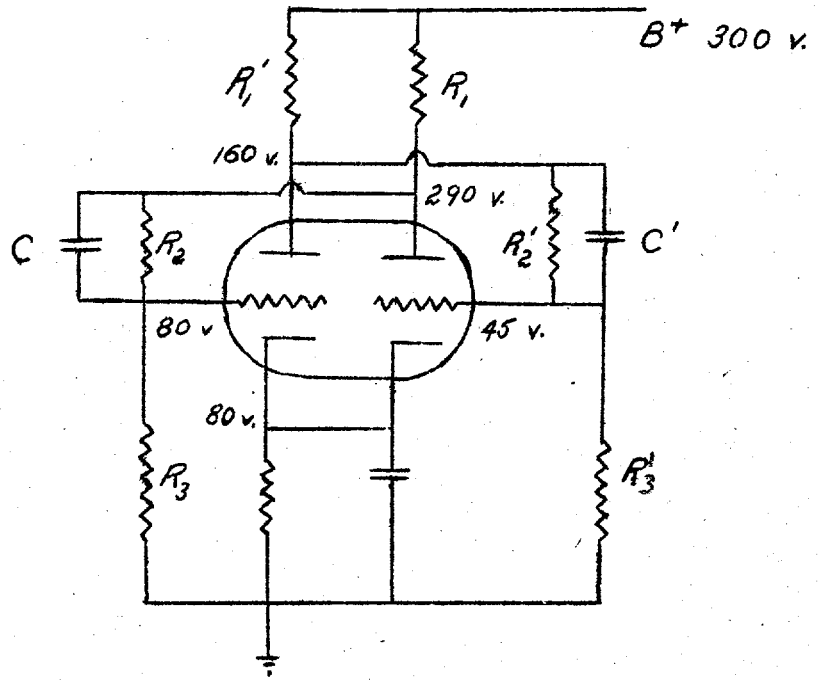
[redacted]

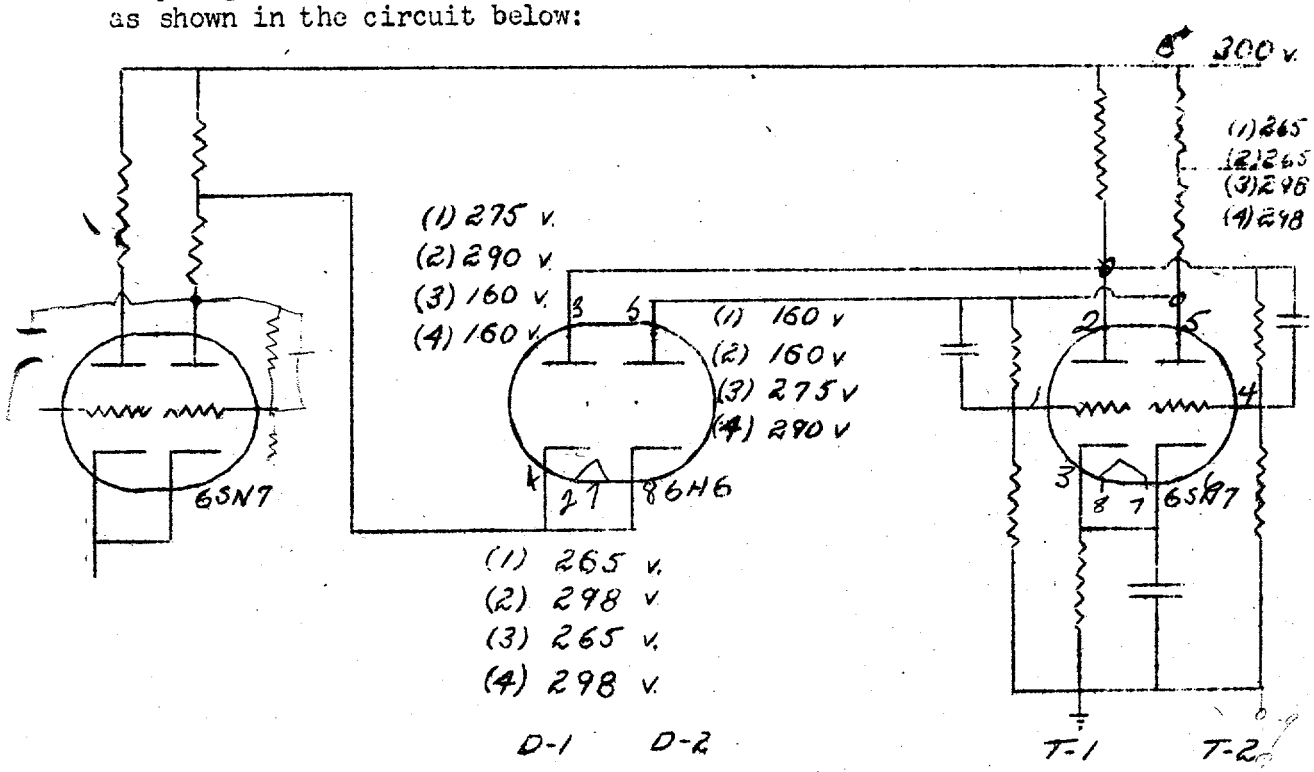
This is accomplished by means of the resistor networks R_1, R_2, R_3 and R_1', R_2', R_3' shown in the circuit diagram below. The voltages shown on the diagram are typical (but vary considerably between sets) values when the left hand triode is conducting.



If a negative pulse of sufficient size is applied to the conducting (left hand) triode, the effect will be to reduce the plate current of this tube causing a positive pulse at its plate. This plate is coupled to the grid of the non-conducting (right hand) triode by condenser C^1. The result is a positive pulse on this grid causing the tube to become conducting, and lowering its plate voltage. The negative pulse thus produced is coupled to the grid of the left hand triode and adds to the effect of the original input pulse. The pair again become stable but now the left hand triode is cut off and the right hand triode is conducting. It is now necessary to apply a negative pulse to the right hand (conducting) triode to again trigger the stage. It can thus be seen that two negative pulses coming into the scaler stage will produce one negative and one positive pulse at the plate of the second triode.

In order to use this scaler stage in a practical instrument, it is necessary to couple the stages together in such a

way that positive pulses from one stage will not be transmitted to the following stages and so that negative pulses from one stage will be fed only to the conducting triode of the following stage regardless of which triode of the pair is conducting. This coupling is accomplished by a double diode, Type 6H6, connected as shown in the circuit below:



The voltages shown in the circuit are for four successive steps in the scaling action. The action of the scaler is described in the table below. The symbol, ●, indicates plate current flowing and, O, indicates tube cut off.

	TUBE D-1	TUBE D-2	TUBE T-1	TUBE T-2
(1) With the scaler in the reset condition, tube D-1 is conducting since its plate voltage exceeds the cathode voltage; D-2 is cut off since the plate voltage is less than the cathode voltage; T-1 is cut off and T-2 is conducting as described above.	●	O	O	●

	TUBE D-1	TUBE D-2	TUBE T-1	TUBE T-2
(2) When the previous stage is tripped, the cathodes of D-1 and D-2 rise in potential to 298 volts. Since this is higher than either plate, neither of the diodes can conduct. Cutting off diode D-1 causes a slight reduction in the current through the load resistance and hence a small voltage increase at its plate. This appears as a small positive pulse at the grid of T-2, but this tube is already conducting and the positive pulse has no effect. Hence the diode has effectively blocked the passage of a positive pulse from the previous stage.	0	0	0	●
(3) Tripping the previous stage again reduced the diode cathode voltage to 265V. The plate of D-2 is less than 265 volts. Hence, it cannot conduct. Diode D-1 starts to conduct since its plate is at 290 volts. This added current through the load resistor produces a negative pulse at the plate of D-1 which also appears at the grid of T-2. This pulse is of sufficient size to trip the stage as described above. Voltages will then be as shown in the third step of the diagram. The increased plate voltage of D-2 causes it to become conducting. In this case the coupling diode has directed the negative pulse to the conducting triode.	0	●	●	0

	TUBE D-1	TUBE D-2	TUBE T-1	TUBE T-2
(4) When the previous stage is tripped again, the cathode of the diode rises to 298 volts. As shown in (2) above, the only effect of this is to cut off the conducting diode, in this case D-2.	O	O	●	O
(5) The next time the previous stage trips, the cathode of the diode falls to 265 volts. As described in (3) above, this trips the scaler stage and returns it to the reset condition.	●	O	O	●

It can be seen from the above that four "trips" of the previous stage have caused two "trips" of the stage under consideration and the scale of two has been accomplished.

The scaling stages are reset by breaking the grid resistor to ground connection of the second triode of each stage with the reset switch. This raises the grid potential of this tube and causes it to conduct regardless of other influences on the stage.

The neon interpolate light for each stage is connected, in series with a 1 meg. resistor, from B+ to the plate of the first triode. When the scaler is reset, the first triode of each stage will be cut off and the interpolate lights will be out.

All Higinbotham scalers built here have an adjustable common cathode bias for all scaling stages. The only adjustment necessary to tune-up properly constructed scaling stages is proper adjustment of the common cathode bias. All stages will scale properly over a wide range of bias adjustment, however, the bias should be set as high as is consistent in order to reduce B+ drain and heat generation.

In order to insure that the stages do not become unbalanced because of shifting resistors, all IRC load (5K and 15K), plate to grid (200K), and grid resistors (100K) should be stabilized before using by heating at 100° - 120° C. for 48 hours. The stabilized resistors are then "balanced" for each stage by selecting grid resistors of the same value, plate to grid resistors of the same value, and by balancing the sum of the 5K and 15K "IRC" load resistors against the 20K "Brown Devil" load resistor for each stage. These resistors should be balanced within 3%. All

replacements of these components should be stablized and balanced in the same manner.

The actual values of these components are not too critical, however, in order to insure continued satisfactory performance, 10% tolerance parts should be used.

In wiring the scaling stages, it is necessary to observe one precaution in regard to the B+ line carried on the 6H6 heaters. Each scaling stage must be fed off the same side of the filament winding in order to have the ripple in phase on both sides of the scaling stage. If this is not observed, difficulty may be encountered in getting the set to scale dependably.

OUTPUT STAGE

The output stage uses a triode connected 6L6 biased beyond cut-off with a VR-105 from cathode to ground. VR-tube bias has been used in the output stage of all Columbia and Higinbotham scalers recently built here. The use of VR-tube bias eliminates degeneration in the cathode circuit and gives a negative square wave to the Wizard recorder.

The output stage operates on a positive pulse from the first plate of the 6SN7 in the last scaling stage. The two neon lamps which couple the last scaling stage to the output 6L6 allow the grid to vary from ground potential to a more positive potential than the cathode. This is accomplished by a 150V subtraction (approx.) from the scaler plate voltage which normally varies from 280 to 150 volts. With 105V cathode bias, the 6L6 grid to cathode potential varies from -105V to +25V. Grid current through the 1 meg. stopping resistor actually causes the grid to rise only slightly above cathode potential.

An increase in the tension of the Wizard counter restoring spring will permit the recorder to be driven at a much higher counting rate.

HIGH VOLTAGE SUPPLY

High voltage is supplied by the 1600V secondary of the Hallordson P-1806A transformer. One end of the secondary is grounded and the other connected to the plate of a 2X2 half-wave rectifier. The cathode of the 2X2 is connected to the plate of an 809 triode and to a 2 mfd. 2500V filter condenser.

The voltage drop across the 809 tube, and consequently the output voltage, is regulated by means of a 1N5 regulator tube which controls the 809 grid bias. The H.V. supply is stabilized against a 75V standard provided by a VR-75 from the 1N5 filament

to ground. The grid of the 1N5 is connected to the center tap of the 70K H.V. adjusting potentiometer which is located near the low end of the H.V. divider.

To show how the regulator operates, let us assume a rise in 809 plate potential. As the 809 plate rises in potential, the cathode potential will also tend to increase. This rise in cathode potential will be reflected through the high voltage divider to give a small but proportional voltage rise to the 1N5 grid. This makes the 1N5 more conducting, which lowers the 1N5 plate voltage and the voltage of the 809 grid, which is connected to it. As the 809 grid becomes more negative, the voltage drop across the 809 increases and the output high voltage (809 cathode) is reduced to its original value. A decrease in output voltage will result in the opposite effect. The output high voltage is R.C. filtered.

COUNTING RATE METER FOR BETA - GAMMA

G-M COUNTERS Q-463-A

Purpose:

The purpose of this instrument is for counting Beta and Gamma radiation with a calibrated meter while employing Geiger Muller tubes.

General Operation:

The set is operated from a 60 cycle 110 volt AC source. After switching the AC on, allow the set to warm up for about 60 seconds. Then switch the high voltage on and bring up moderately to the desired voltage. When using voltages over 1100 volts, be sure the G-M tube is not plugged in.

The double pole double throw switch will enable you to determine the high voltage or the rate of counts per minute.

The counting rate meter is calibrated to read full scale on four different ranges. The ranges are:
0 - 200 counts per minute
0 - 1000 counts per minute
0 - 5000 counts per minute
0 - 20000 counts per minute
Curves with the meter ranges are supplied with this write up.

The scaler connector, oscilloscope jack, micromax jack and high voltage connectors may be plugged in at will for checking various voltages, characteristics, etc.

The high voltage subtract pot. is located conveniently on the front and will vary the high voltage over a 150 volt range.

The bias adjustment for the thyratron is a screw driver adjustment to be set when the instrument is tuned up.

With a high voltage supply that will go 3,000 volts both positive and negative, at the same time, approximately 6,000 volts may be realized from the supply by tapping in on the high and low side of the supply (connectors in the back of the chassis).

An amplifier gain control is also used in the second stage.

Since this instrument was designed for experimental work, it also has another input connector for plugging in either Neher-Harper or Neher - Pickering quenching circuits. This connector has a two thousand volt condenser on the input to protect the input tube grid.

Tune Up Procedure:

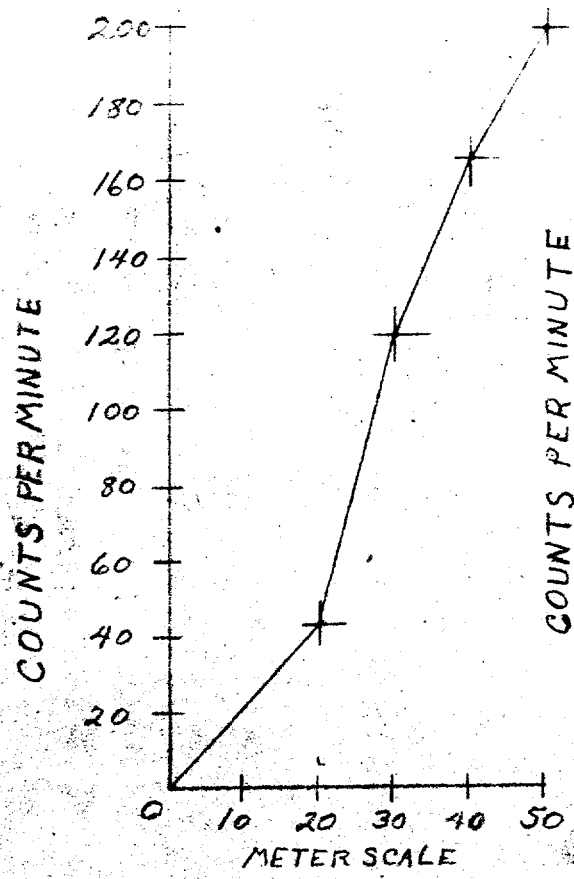
The tune up procedure is relatively simple barring any bugs in the circuit. Should there be any, a routine check-up of the circuit should be made.

The bias on the 2D21 tube should be set at about 30 volts.

All rate meter ranges are calibrated with a pulse generator and scaler. The potentiometers and condensers in parallel with the meter that are thrown in and out of the circuit with the selector switch are very critical.

Any changes in the pots. will throw the calibration off.

POS. #1



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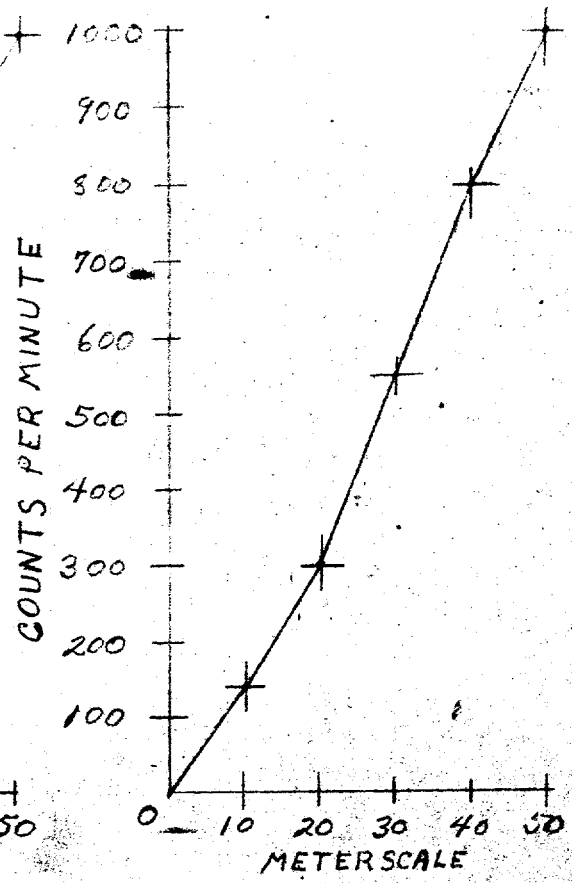

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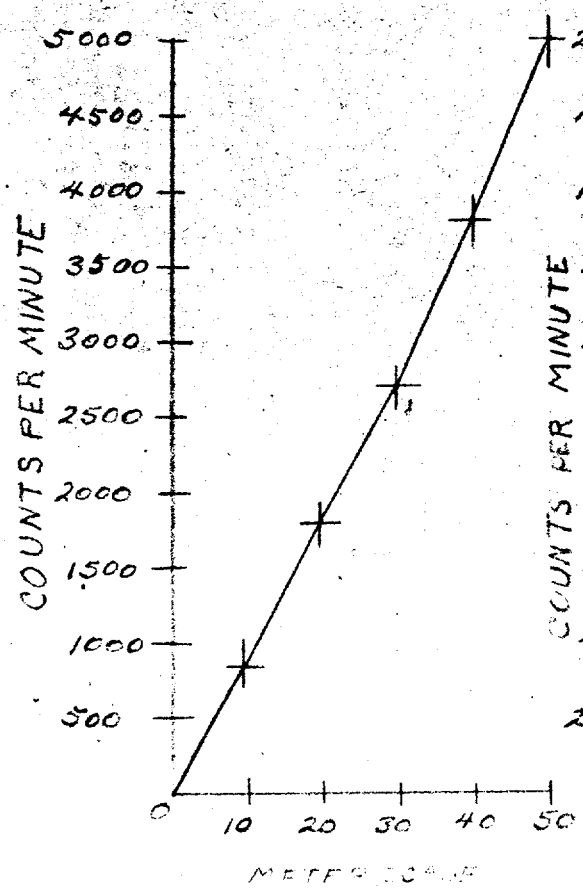

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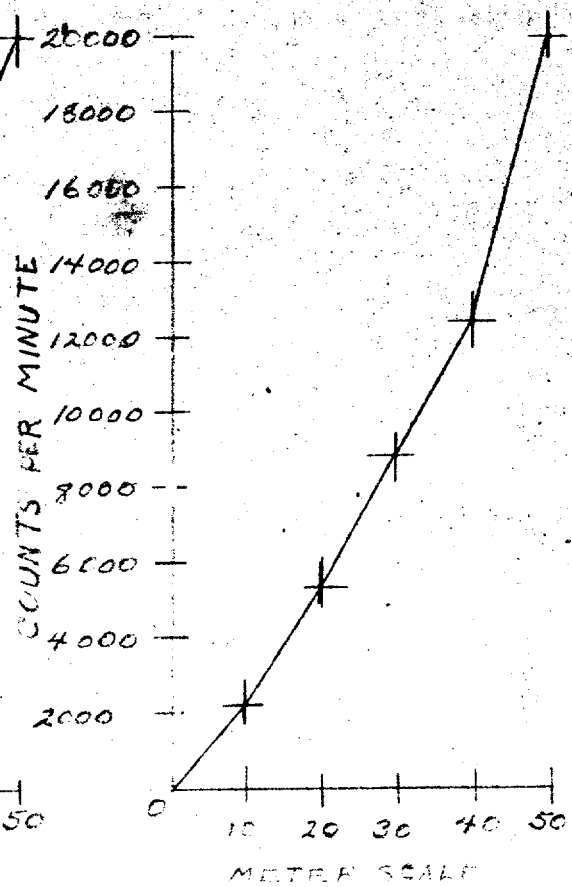
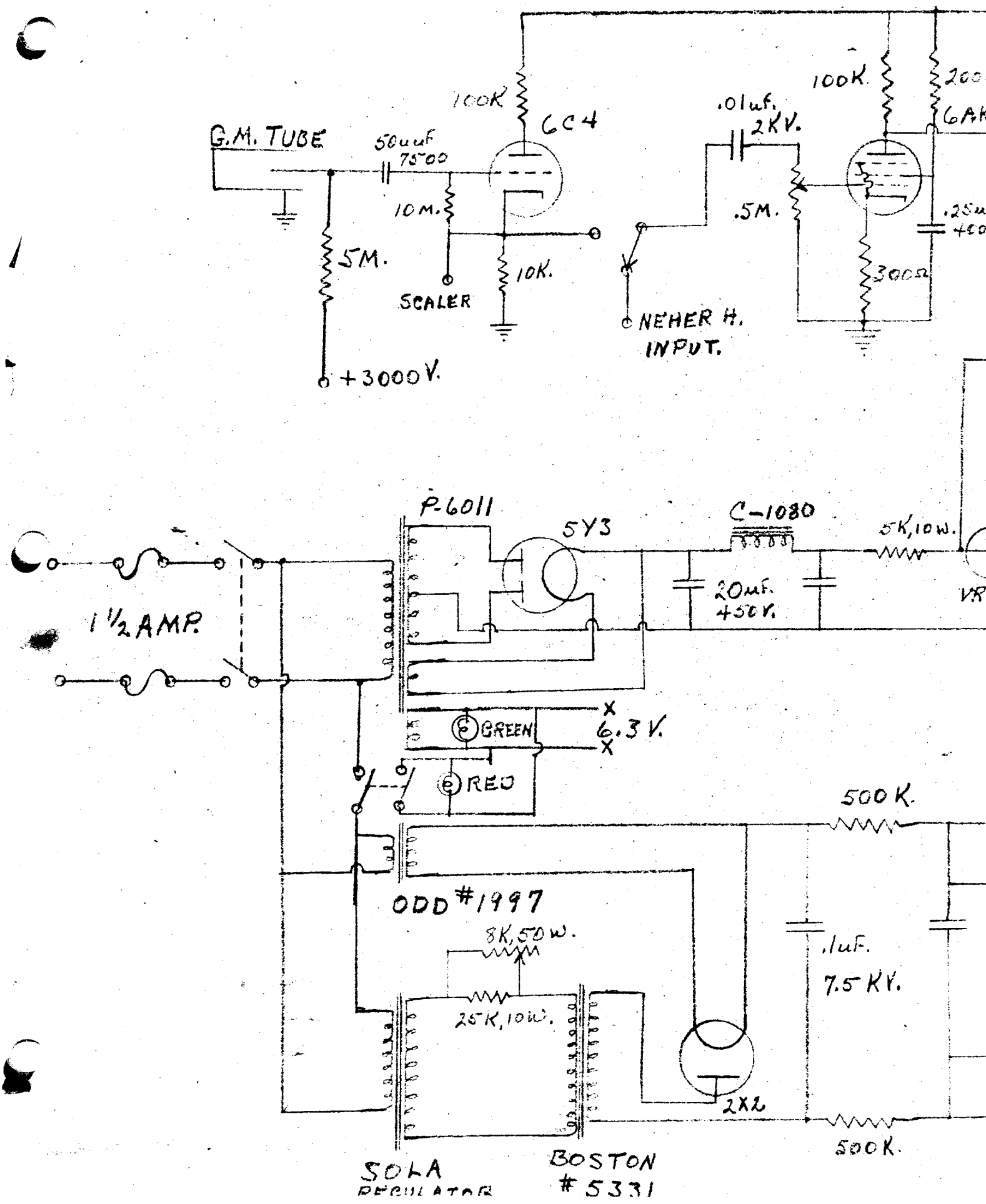
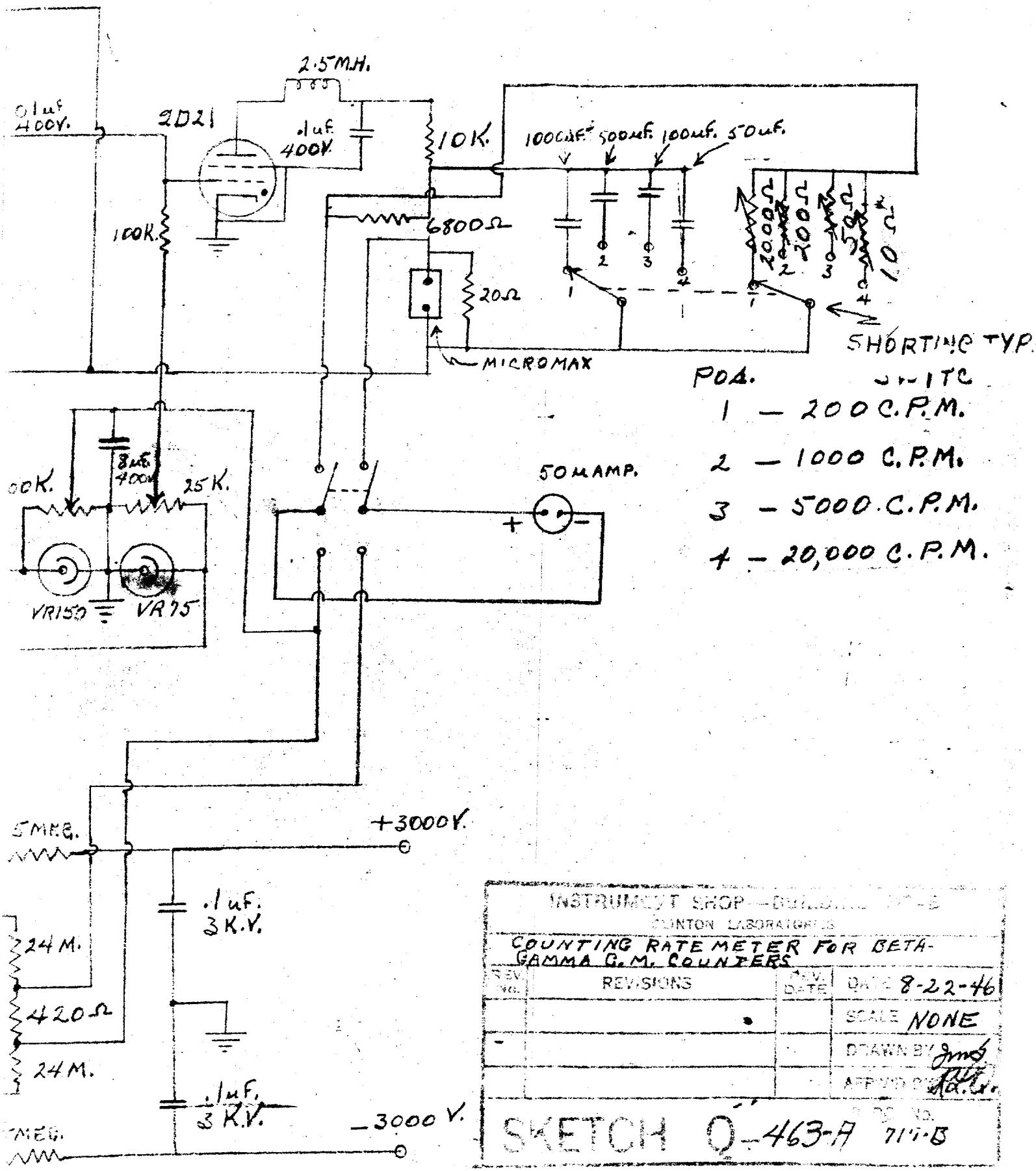



G.M. TUBE
50uuf
7500
100K
6C4
10M.
5M.
10K.
SCALER
+3000V.
.01uf.
2KV.
.5M.
NEHER H.
INPUT.
100K.
6AK
300Ω
P-6011
5Y3
C-1080
5K,10W.
20uf.
450V.
1 1/2 AMP.
GREEN
RED
6.3 V.
500K.
ODD #1997
8K,50W.
25K,10W.
.1uF.
7.5 KV.
2X2
500K.
SOLA
BOSTON
#5331


2.5 MH.
.01 uf 400V.
2D21
.1 uf 400V.
10K.
1000uf 500uf. 100uf. 50uf.
100K.
6800Ω
20Ω
MICROMAX
2000Ω 200Ω 50Ω 10Ω
SHORTING TYP.
POS.
1 — 200 C.P.M.
2 — 1000 C.P.M.
3 — 5000 C.P.M.
4 — 20,000 C.P.M.
8uf 400V
25K.
50 μAMP.
VR150
VR75
5MEG.
+3000V.
.1 uf. 3K.V.
24 M.
420Ω
24 M.
.1 uf. 3 K.V.
-3000 V.
MEG.
INSTRUMENT SHOP — BUILDING
CLINTON LABORATORIES
COUNTING RATE METER FOR BETA-GAMMA G.M. COUNTERS
REV. NO.
REVISIONS
REV. DATE
DATE 8-22-46
SCALE NONE
DRAWN BY
APPV'D BY
SKETCH Q-463-A
717-B

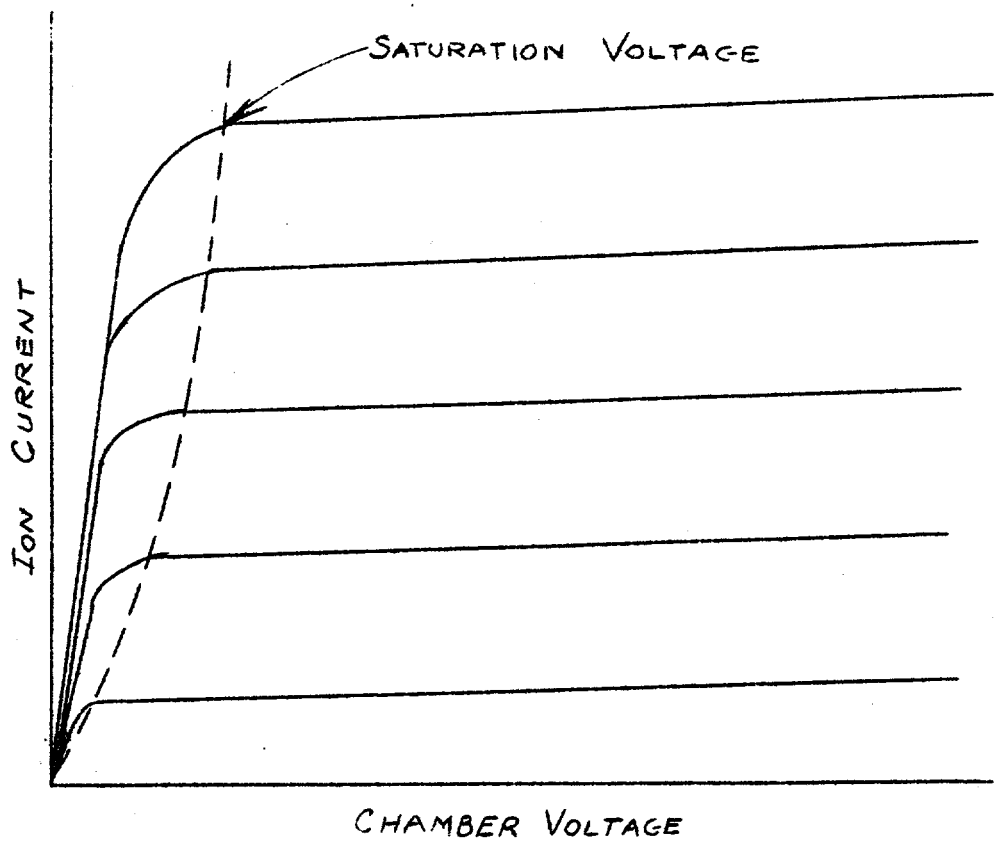


FIGURE 1

The ion current developed in chambers of reasonable size is of the order of 10^{-7} to 10^{-11} amps. Thesefore, the current must be measured by a galvanometer, or must be amplified before measuring with less sensitive instruments.

[redacted]

SERVICING

Ionization chambers are sturdy reliable instruments and under normal conditions last for years. About the only thing that fails is the insulation and this should be checked immediately when a chamber shows signs of failure or erratic behavior. Ninety percent of the time failure will be found in the cables or connectors rather than in the chamber itself. However, if a faulty chamber is found, it should be returned to the Detection Instrument Group for repairs.

The insulation required for satisfactory operation is shown below.

High Voltage electrode to ground .. 10 megohms
Collecting elect ode to ground ... $>10^{12}$ ohms
Collecting electrode to High
Voltage electrode ..... $>10^{12}$ ohms

[redacted]

[redacted]

ESTIMATING ION CURRENT

By: D. R. Luster
10/19/44

[redacted]

Since the process of producing ionization in a chamber varies with the different types of radiation, the methods of estimating ion current will be discussed separately for each type of radiation.

GAMMA RADIATION

Since Gamma rays have neither mass nor charge they cannot produce any direct ionization. However, they have the property of reacting with matter to produce energetic free electrons. These electrons can then ionize and be detected. The unit of intensity of Gamma radiation is the Roentgen, which is defined as that amount of Gamma radiation whose secondary electrons in air will produce 1 esu of charge per cc of air.

From this definition it can be seen that if we wish to estimate the amount of ion current developed in a chamber of known volume in a known amount of Gamma radiation, we need only multiply the volume of the chamber in cc by the amount of radiation in Roentgens to obtain the charge collected in esu. Converting to standard units, the equation becomes

$$I = \frac{VR}{86.4} \times 10^{-12}$$

where

I = Ionization current in amperes

V = Effective volume of chamber in cc

R = Intensity of radiation in Roentgens per 8 hours

It should be noted that this equation holds only for chambers filled with one atmosphere of air. If a chamber is filled with some other gas or to some other pressure the equation must include correction factors. A more general equation is:

$$I = \frac{V\ R\ C\ P}{86.4} \times 10^{-12}$$

[redacted]

where

I = Ionization current in amperes

[redacted]

V = Effective volume of chamber in cubic centimeters [redacted]

C = Gas coefficient (1.6 for Argon. 3.35 for Freon 12.)

P = Pressure in chamber air (atmosphere)

R = Intensity of radiation in Roentgens per 8 hours

This equation neglects the absorption of gamma rays and the emission of secondary electrons which takes place in the chamber walls. The error thus introduced depends on the material and thickness of the walls. However, for chambers of common construction the error is less than 10%.

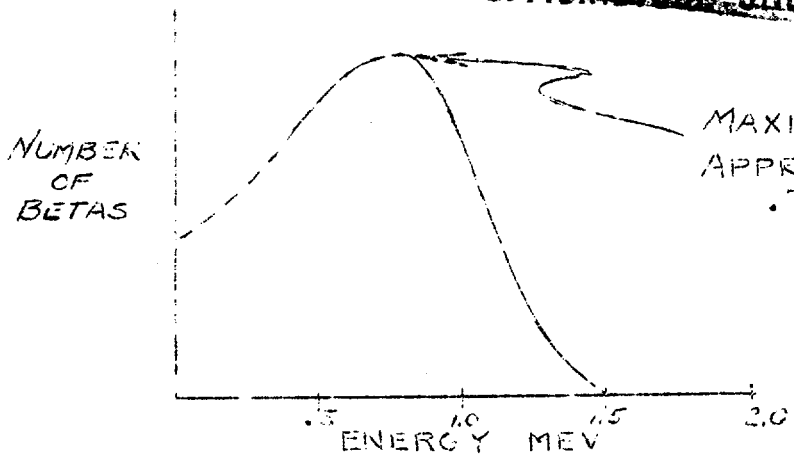
BETA RADIATION

The term beta ray is used in discussions of radioactivity to describe those fast electrons which are ejected from nuclei in radioactive transformations. Becuase they are charged particles, their path through matter is greatly affected by the planetary electrons in the atoms of the material. By this interaction between the beta particles and the atomic electron, the beta particles lose their energy and are finally absorbed. This effect is approximately proportional to the mass of matter traversed and for that reason the thickness of beta ray absorbers is generally specified in grams per square centimeter. If a piece of material with a cross-sectional area of one square centimeter weighs one gram, it is said to have a thickness of one gram per square centimeter. Water 1 cm. thick has a thickness of 1 gram per sq. cm.; steel .128 cm. thick, lead .088 cm. thick, aluminum .391 cm. thick, air 773 cm., all are 1 gm. per square cm. thick.

In many applications we are interested in measuring beta activity of energies of less than .25 MEV. The thickness of material that will completely stop a .25 MEV. beta (see chart) is .07 grams per square centimeter (54 cm. of air, .027 cm. of aluminum, or .009 cm. of steel). Thus, the absorption of beta rays in the walls of chambers cannot be neglected.

Another property of beta radiations that must be remembered in estimating ion currents is that not all beta particles emitted from a so called 1.5 MEV. beta source possess 1.5 MEV. energy. The particles are actually ejected at all energies below 1.5 MEV, the specified energy merely indicating the maximum. The distribution of beta particles from a 1.5 MEV. source is shown in Fig. 2, the maximum occurring at about half the specified energy.

[redacted]



[redacted]

FIG. 2

Beta sources are generally measured in Millicuries; a one millicurie source being one that emits 3.7×10^7 beta particles per second. Since the beta particles from a source are emitted in all directions, the geometry of a particular set-up must be taken into account in the estimation of ion current. If the source is entirely surrounded by the chamber, all the beta particles will be effective in producing ionization and the geometry will be 100%. However, if the source is on a table and the chamber is placed above it, only half of the betas will be effective (those ejected upward from the source) and the geometry will be 50%.

It can be seen from the above discussion that no single simple formula can be used to estimate the ionization current in a beta chamber. However, the problem breaks down into two parts; first, estimating the number of beta particles actually getting into the chamber and second estimating the ionization produced by these particles. The following formula can be used for the first step.

$$N = 3.7\ R_M\ A\ E \times 10^7$$

where

N = Number of beta particles entering chamber per second

R_M = Intensity of source in millicuries

A = Fraction of particles getting through chamber walls

This factor is determined by calculating thickness of chamber walls in gms/cm^2 and determining, from Chart I, the energy of beta that will be absorbed. Using this figure and the maximum energy of beta source find "A" on Chart II.

[redacted]

E = Estimated geometry of set-up

After determining the number of particles entering the chamber the following formula can be used to estimate ion current.

$$I = \frac{N\ K\ D\ C\ P}{6.3} \times 10^{-18}$$

where

I = Ion current in amperes

N = Number of beta particles entering chamber per second.

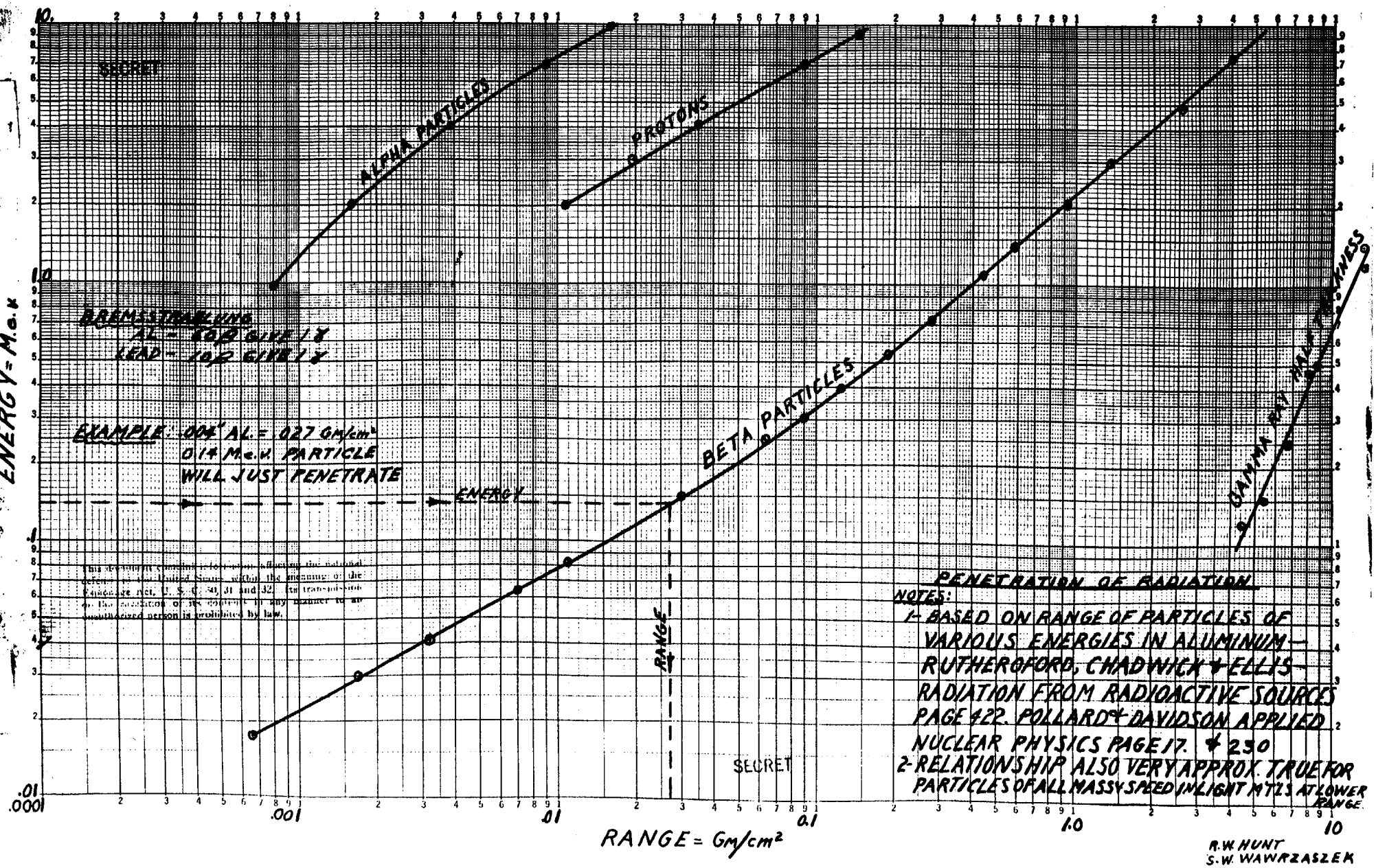
K = Number of ion pairs produced by a beta particle per centimeter path in the chamber. Using an estimated average energy of the betas entering chamber - find "K" on Chart III.

D = Average length of beta particle path in centimeters (estimate). In large chambers a check should be made to be sure that D is not larger than the range of the betas.

C = Gas coefficient. (1 for Air, 1.6 for Argon. 3.35 for Freon 12.)

P = Pressure in chamber in atmospheres

It will be noted that several of the factors in the above equations are almost "pulled out of thin air". It is not quite as bad as that. Estimates of sufficient accuracy for most applications can be obtained if a little common sense is coupled with a fair understanding of the nature of beta radiation.



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R.W. HUNT
S.W. WAWRZASZEK
9-27-44
Drawing No.

KEUFFEL & ESSER CO., N. Y. NO. 359-5
10 × 10 to the inch.
MADE IN U. S. A.

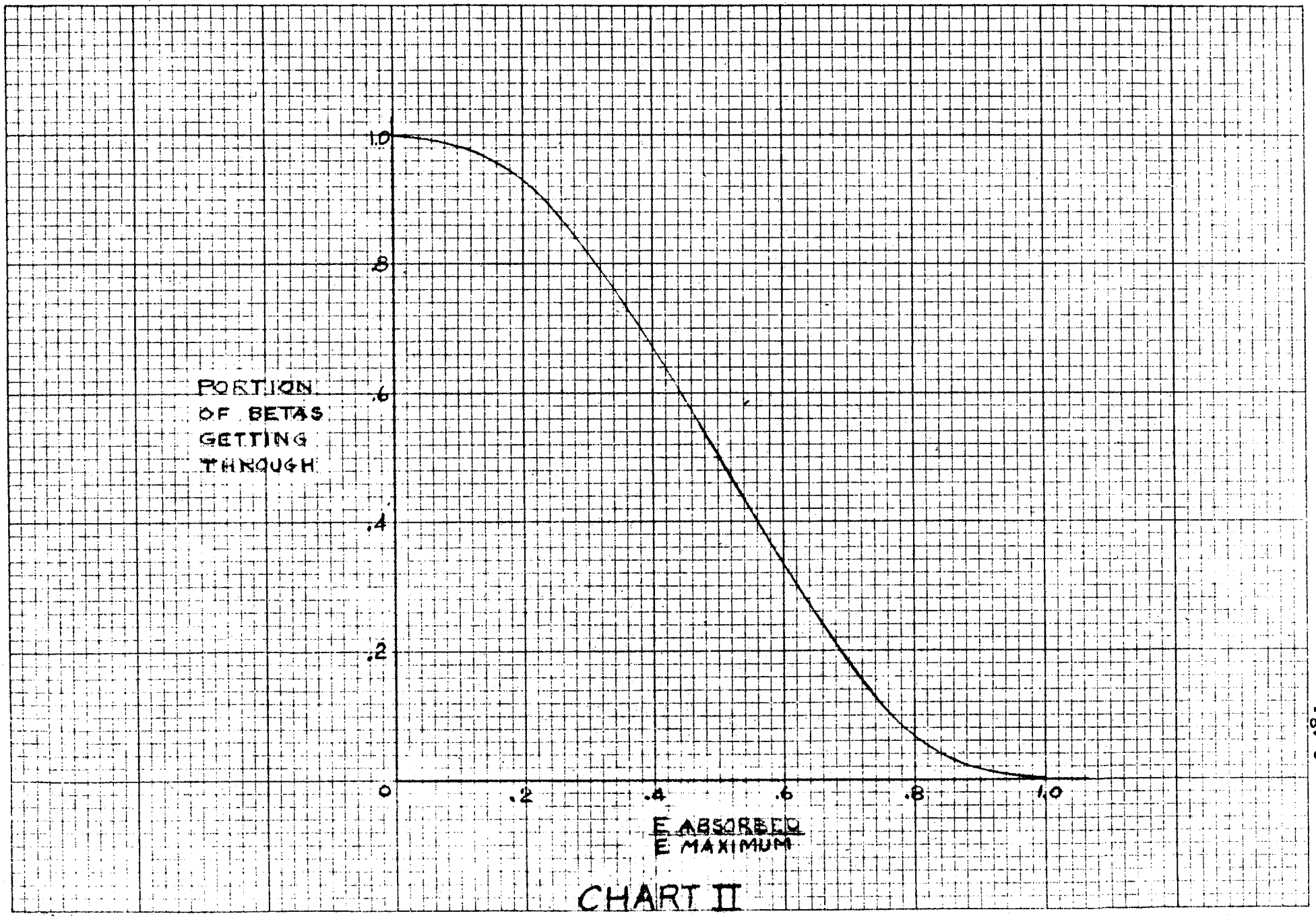

CHART II

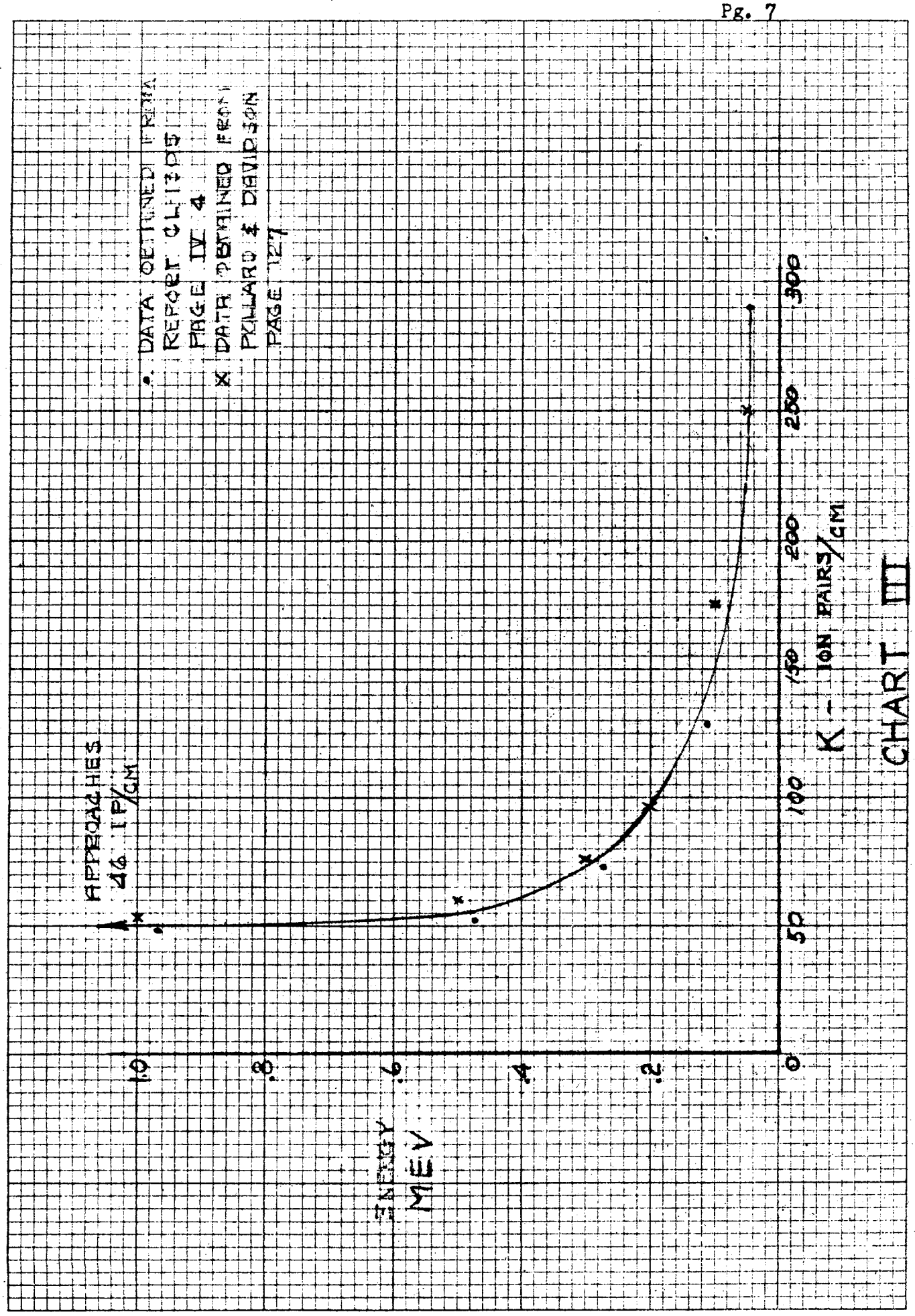

CHART III

KEUFFEL & ESSER CO., N. Y. NO. 359-8
10 X 10 to the inch.
MADE IN U.S.A.

OFFICIAL USE ONLY

ION CHAMBER CALIBRATION

By: D. R. Luster
10/24/44

[redacted]

Ion chambers are generally used with a circuit similar to that shown in Figure 1. A positive high voltage is placed on

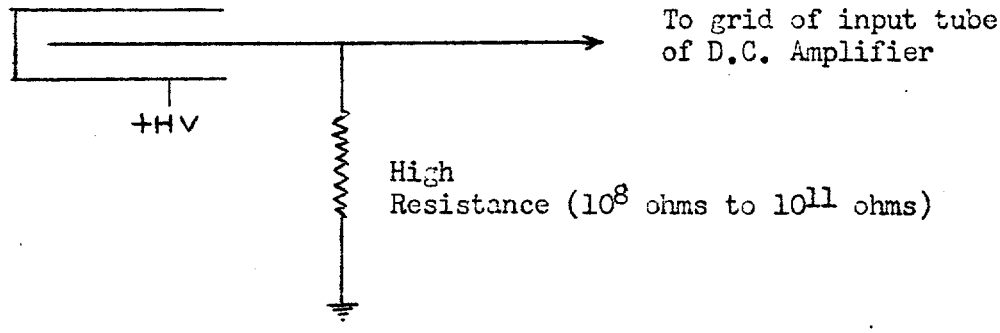

Fig. 1

the outer electrode and the collecting electrode connected to ground through a high resistance. Ion chambers will operate equally well with either positive or negative high voltage on the outer electrode, but positive high voltage is generally used, since most amplifiers are built to operate on a positive signal.

In order to calculate what deflections on the meter or recorder connected to the amplifier mean in terms of radiation, the following equation is used.

$$F = \frac{V}{RI}$$

where

F = Full scale deflection of meter or recorder in Roentgens/hour

V = Voltage sensitivity of amplifier, volts full scale

R = Input resistance, ohms

I = Ion Current developed in chamber, Amperes/Roentgen/hour

[redacted]

[redacted]

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The values of I are determined experimentally by the Detection Instrument Group and are given below: [redacted]

8" G. E. Gamma Chamber 3.6×10^{-9} amps/r/hr

Mack Chamber 3×10^{-10} amps/r/hr

Clinton Gamma Chamber 8.7×10^{-11} amps/r/hr

For information on other chambers, contact the Detection Instrument Group.

SAMPLE CALCULATION

Assume that a Clinton Gamma Chamber is used with an amplifier having a voltage sensitivity of 1.2 volts full scale and input resistors as shown below:

RANGE	INPUT RESISTANCE
1	1.1×10^{11}
2	9.5×10^{9}
3	1.3×10^{9}

The calibration of this set would be as follows:

RANGE	$\frac{V}{RI}$	RADIATION FULL SCALE
1	$\frac{1.2 \text{ Volts}}{1.1 \times 10^{11} \text{ ohms} \times 8.7 \times 10^{-11} \text{ amps/r/hr}}$	.125 r/hr or 125 mr/hr
2	$\frac{1.2 \text{ Volts}}{9.5 \times 10^{9} \text{ ohms} \times 8.7 \times 10^{-11} \text{ amps/r/hr}}$	1.45 r/hr or 1450 mr/hr
3.	$\frac{1.2 \text{ Volts}}{1.3 \times 10^{9} \text{ ohms} \times 8.7 \times 10^{-11} \text{ amps/r/hr}}$	10.6 r/hr

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This document consists of 1 pages and 1 figures.
No. 12 of 17 copies. Series A

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G. E. GAMMA CHAMBER

By: D. R. Luster
10/31/44

The G. E. gamma chamber is shown in Sketch Q-232 attached. It consists of a welded, gas tight steel shell 8" in diameter in which are supported two electrodes. The high voltage electrode is a steel cylinder $7\frac{1}{4}$" O.D. isolated from the shell by six porcelain insulators (three at each end) as shown. The collector is 3/4" O.D. steel tubing supported at one end by a large glass insulator. The connection to the high voltage electrode is brought out through a small metal to glass seal. The chamber is filled with one atmosphere of Freon 12.

This chamber is sensitive only to gamma radiation and produces 3.6×10^{-9} amperes for each roentgen/hour of radiation. It is used to measure the level of gamma radiation inside the 200 area chemical separation cells. A Harvey B+ amplifier is generally used with it.

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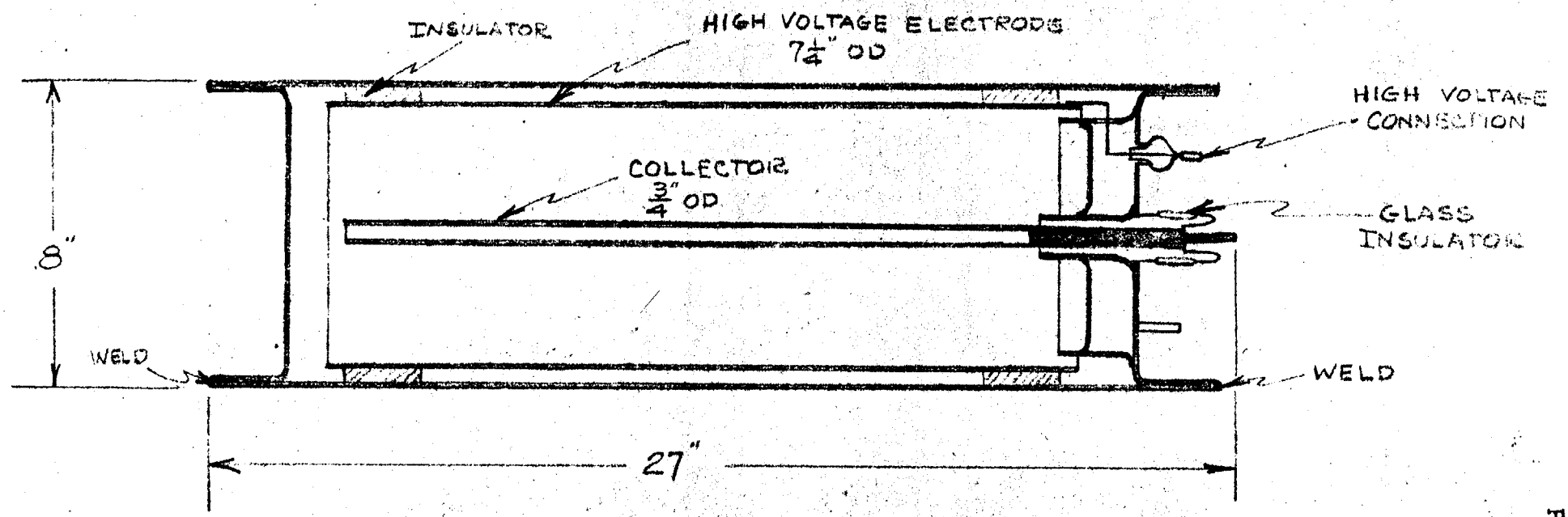

FILLED WITH 1 ATMOS. OF FREON-12

INSTRUMENT SHOP—BUILDING 717-B CLINTON LABORATORIES			
8" GE GAMMA CHAMBER			
REV. No.	REVISIONS	REV. DATE	DATE 10-24-44
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			DRAWN BY DRL
			APP'V'D BY
SKETCH O-232			BLDG. NO.

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12-47 A

[redacted]

G. E. NEUTRON GAMMA CHAMBER

By: D. R. Luster
10/31/44

The G. E. Neutron Gamma Chamber is shown in Sketch Q-233. It consists of a welded, gas tight steel shell 8" in diameter in which two electrodes are supported. The high voltage electrode is a steel cylinder 7¼" O.D. isolated from the shell by six porcelain insulators (three at each end) as shown. The collector is 6-1/8" O.D. steel tubing supported at one end by a large glass insulator. The connection to the high voltage electrode is brought out through a small metal to glass seal. The chamber is filled with one atmosphere of Argon.

This chamber is sensitive to both slow neutrons and gamma rays. The detection of slow neutrons, in the thermal range requires the production of some secondary ionizing particle since slow neutrons lacking both charge and speed cannot ionize directly. Of the various neutron reactions capable of producing ionizing particles, one of the most effective is the Boron neutron reaction which produces 2 MEV alpha particles. The ionization by these alpha particles is directly proportional to the original neutron flux. In the G. E. neutron gamma chamber neutrons are detected by the above reaction, the boron being provided in the form of boron-carbide on the surfaces of the electrode. Gamma radiation is detected as described in section II-A-2. Therefore, the ion current produced is proportional to the sum of the neutron flux and the gamma radiation present.

This chamber is used to measure the neutron and gamma radiation from the pile chain reaction. It is used in connection with the shim rod and safety rod trip circuits.

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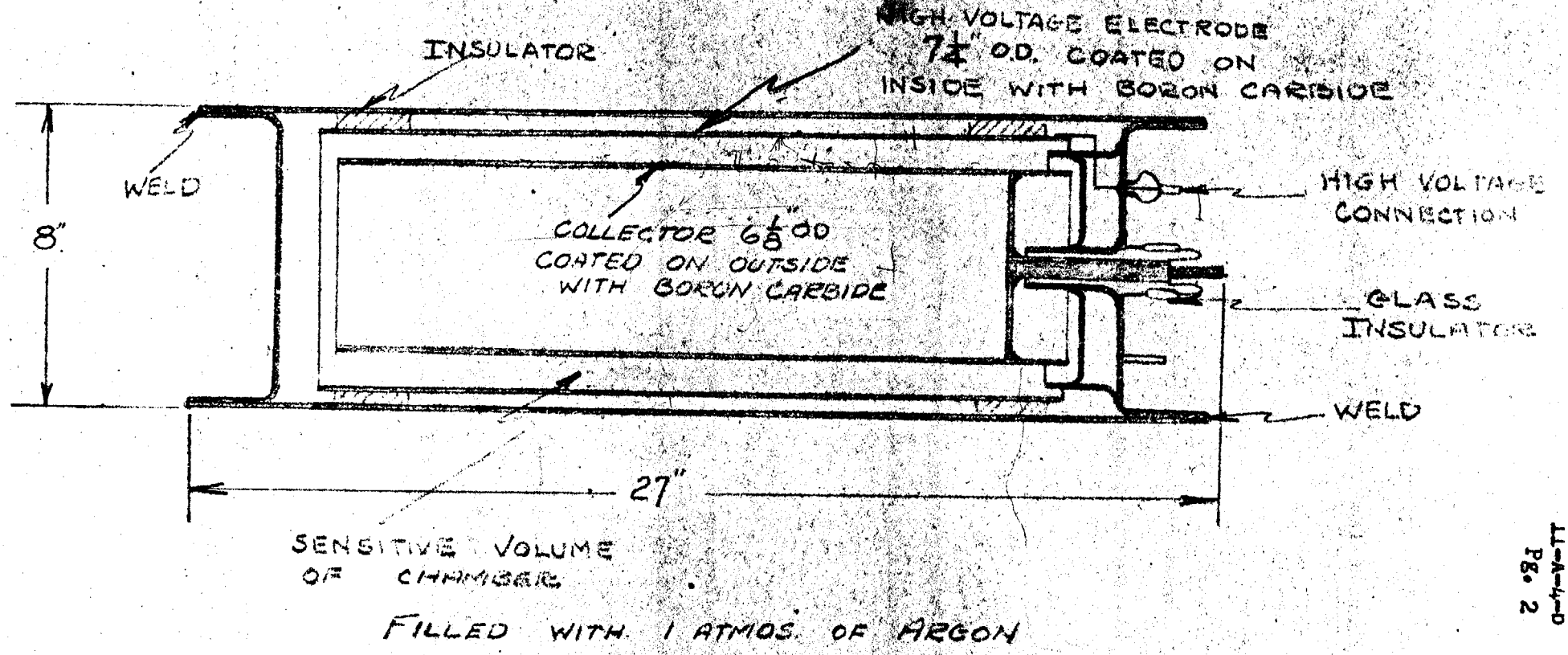

FILLED WITH 1 ATMOS. OF ARGON

LT-A-4-0
Pg. 2

INSTRUMENT SHOP--BUILDING 717-B CLINTON LABORATORIES			
8" G.E. NEUTRON GAMMA CHAMBER			
REV. No	REVISIONS	REV. DATE	DATE 10-24-44
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12 47 A

G. E. DIFFERENTIAL NEUTRON CHAMBER

By: D. R. Luster
10/31/44

[redacted]

The G. E. Differential Neutron Chamber is shown in Sketch Q-234. It consists of a welded, gas tight steel shell 8" in diameter in which three electrodes are supported. The positive high voltage electrode is a steel cylinder 7¼" O.D. isolated from the shell by six porcelain insulators (three at each end) as shown. The collector is 6-1/8" O.D. steel tubing supported at one end by a large glass insulator. The connection to the positive high voltage electrode is brought out through a small metal to glass seal. A negative high voltage electrode is also provided supported by a second large glass insulator in the other end of the chamber shell. The chamber is filled with one atmosphere of argon. The inner surface of the positive high voltage electrode and the outer surface of the collector are coated with boron carbide.

The G. E. Differential Neutron Chamber is then essentially two chambers, one inside the other, the collecting electrode being common to both chambers. The outer chamber is a neutron gamma chamber (See Section II-A-4-b) and the inner chamber is a straight gamma chamber (See Section II-A-2). Since the high voltage electrodes of the two chambers are of opposite sign the ions collected from the chambers will be of opposite sign. The resultant signal from the chamber is proportional to the neutron flux only and is independant of the gamma radiation present.

This neutron chamber is used to measure power level for the control of the chain reacting pile. It is used with the galvanometer circuits.

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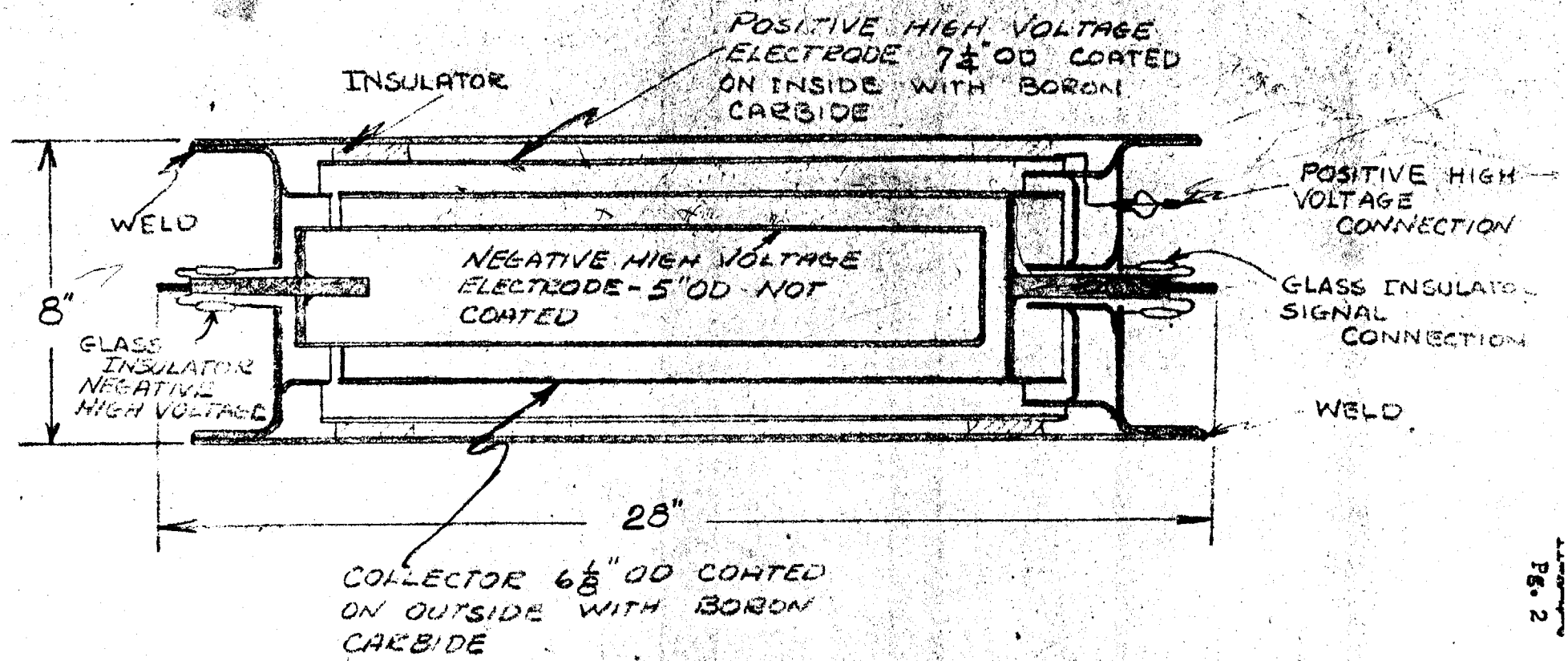

FILLED WITH 1 ATMOS OF ARGON

INSTRUMENT SHOP--BUILDING 717-B CLINTON LABORATORIES			
8" G.E. DIFFERENTIAL CHAMBER			
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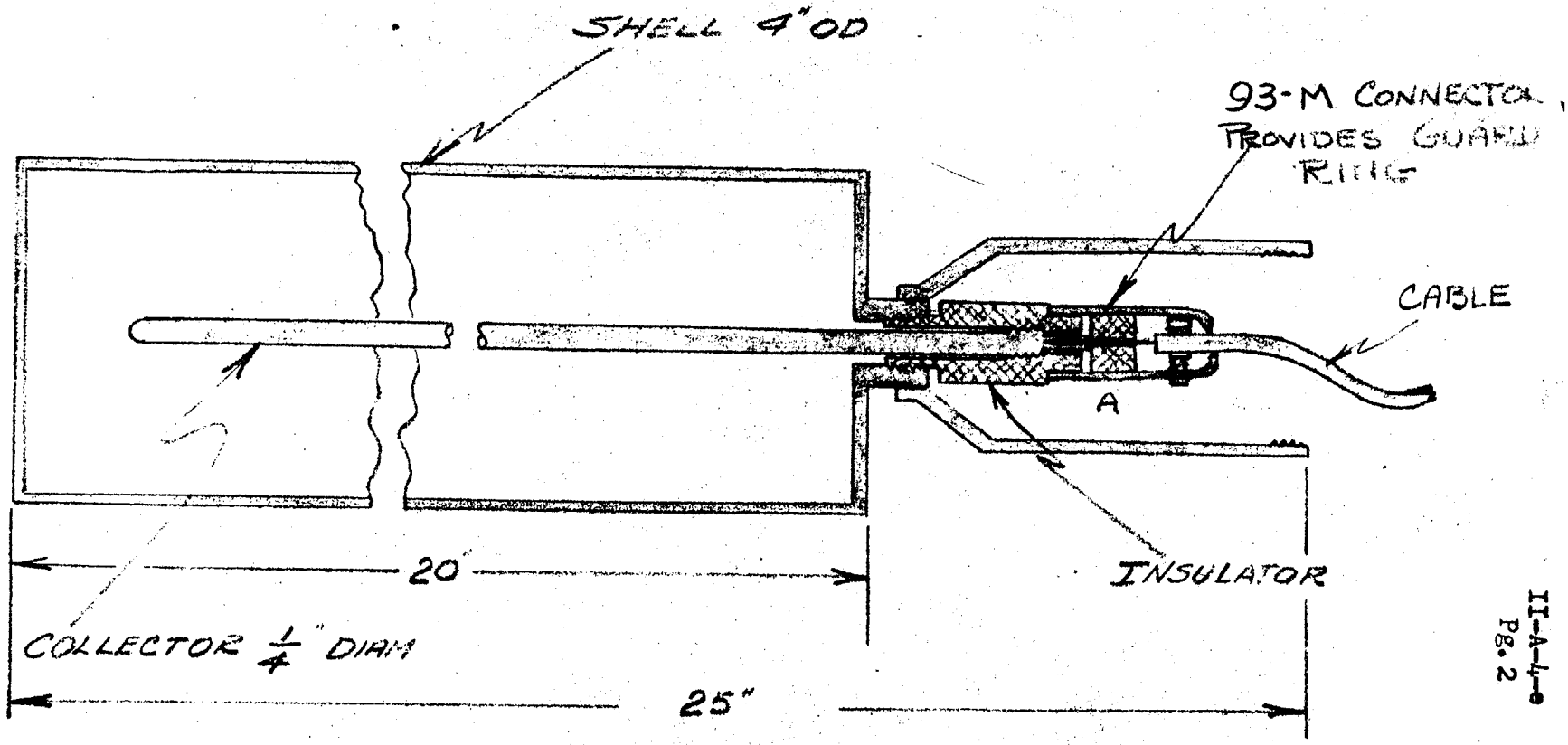
SKETCH Q-234			BLDG. No.

Pg. 2



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MACK CHAMBER			
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SKETCH 0-125			BLDG. NO.

II-A-4-e
Pg. 2

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12 47 A

CLINTON GAMMA CHAMBER

By: D. R. Luster
10/31/44

[redacted]

The Clinton Gamma Chamber is shown in Sketch Q-25 attached. It consists of a brass shell 3-7/8" O.D. in which two electrodes are supported. The high voltage electrode is 2-7/8" O.D. brass tubing supported at one end by three insulators as shown. The high voltage connection is brought out to an 80-C connector in the shell. The collector is 1/8" brass rod supported at one end by an insulator. The collector connection is made to a 93-C connector. The chamber is not gas tight and is, therefore, filled with one atmosphere of air.

This chamber is sensitive only to gamma radiation and produces 8.6×10^{-11} amperes for each roentgen/hour of radiation. It is used to measure gamma intensity in the chemical separation cells in the Semi-Works and various other places on the plant. It is generally used with a Beckman or Q-31 amplifier.

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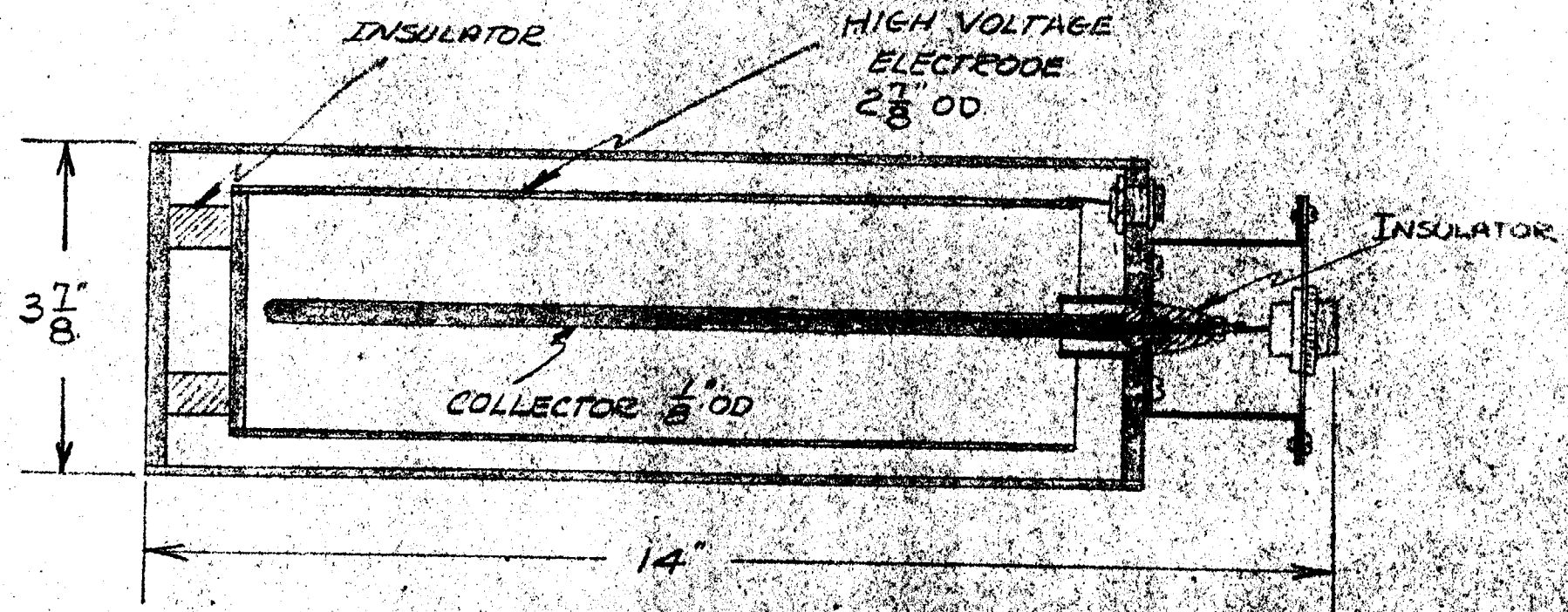

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INSTRUMENT SHOP — BUILDING 717-B CLINTON LABORATORIES			
CLINTON GAMMA CHAMBER			
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			BLDG. No.

SKETCH O-25

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MACK CHAMBER

[redacted]

By: D. R. Luster
10/31/44

The Mack Chamber is shown on Sketch Q-235 attached. It consists of a steel shell 4" O.D. in which a collecting electrode 1/4" O.D. is supported. A guard ring is provided on the collector insulator as shown. The chamber is filled with one atmosphere of dry air.

In operation a negative high voltage supply is used connected to the collector. The input tube of the amplifier then floats at this negative voltage. This permits the use of a single electrode to carry the high voltage and also collect the ionization while the outer shell of the chamber is grounded. The guard ring is also connected to the negative high voltage supply to reduce electrical leakage.

This chamber is sensitive only to gamma radiation and produces 3×10^{-10} amperes for each roentgen/hour of radiation. It is used in the 200 area to measure the radiation in certain of the chemical separation cells. A B- Harvey amplifier is used with it.

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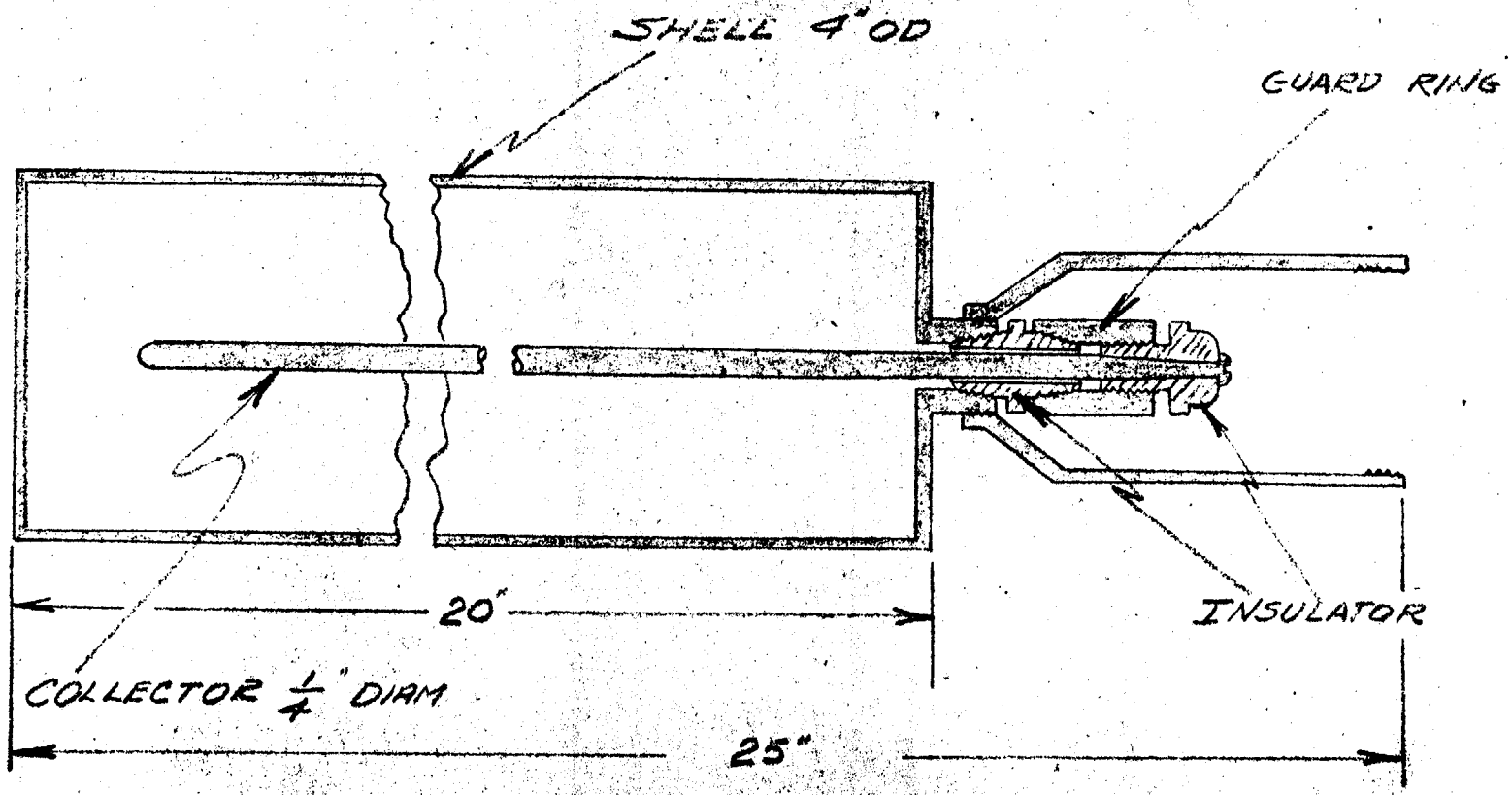

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INSTRUMENT SHOP--BUILDING 717-B
CLINTON LABORATORIES

MACK CHAMBER

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SKETCH O-235

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GAMMA COUNTER

By: W. R. Woodruff
3/26/45

[redacted]

INTRODUCTION

The gamma counter for determination of "Decontamination Factor" in product separation in Bldg. 205 consists essentially of an ionization chamber and a Lindemann electrometer.

PHYSICAL AND ELECTRICAL LAYOUT

The ionization chamber is a "steel cylinder 13" in diameter, 14" long and walls 3/8" thick to which a top end plate 3/4" thick has been welded. A spun steel thimble 1/32" thick, 8" long and 1-7/8" inside diameter is welded to the top end plate ..."(1) for sample insertion. An aluminum insert has been placed inside the steel thimble to facilitate decontamination in case one of the Pyrex tubes is broken while being inserted in the thimble. "The bottom of the chamber is closed with a 1" steel plate which is bolted onto the cylinder and made air tight with a rubber gasket." (1)

The chamber, which has been tested at a pressure of 100 atmospheres, is filled with 30.5 atmospheres of argon for increased ionization. The chamber is surrounded with four inches of lead shielding (1-1/2 - 2 tons) to cut down background due to local radiation and cosmic rays. The high voltage (180 volts) is supplied to the walls of the chamber by four heavy duty Burgess 45 volt batteries.

The Lindemann electrometer is of standard design with the electrical charge being impressed on a sputtered quartz fiber which is suspended between two U shaped plates. The electrometer is handled as a unit and in case of damage should be sent back to the Cambridge Instrument Company, Ossining, New York.

The gamma radiation from the sample in the well causes ionization of the argon in the chamber. The positive ions are collected on the central wire. The resulting current is carried on a brass rod through, and insulated from, a 2-1/4" diameter piece of brass tubing to the electrometer connection. This connection from the brass rod to the electrometer is made with a

(1) Chicago Pressure Ionization Chamber for Gamma Ray Measurement. F. R. Shonka & R. J. Stephenson - MUC-RJS-2 - 11/15/44.

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piece of bare wire to eliminate the possibility of a high resistance leakage path to ground.

The quadrant leads from the quadrant plates to the resistor network are also bare wires for the same reason.

The potential on the quadrants is supplied from two 45 volt batteries and balanced as shown in Sketch Q-301-A.

For calibration a known source of potential is supplied by a Leeds and Northrup 0-1 volt portable potentiometer.

A microscope with an internal scale is supplied to view the electrometer.

The grounding key and the constant potential lead are combined as shown in Sketch Q-301-A.

REPLACEMENT OF THE LINDEMANN ELECTROMETER

Before working on the electrometer shut off the quadrant voltage and close the grounding key.

To replace the electrometer the five brass screws on the underside of the brass body are removed. This allows the bottom of the body containing the electrometer to drop down. It will be held from coming completely out by the three bare wire connectors, which are tied to both quadrants and to the quartz fiber leads. These are glass insulator projections and may be easily broken. The bottom comes down far enough to allow the insertion of one or two fingers into the brass body so that the knurled nuts may be removed, disconnecting the three bare wire leads from the electrometer. This allows the bottom assembly to be removed. The three positioning screws are loosened and electrometer removed. The new electrometer is inserted and the reverse procedure followed.

The quadrant connectors may be checked with a Simpson Test Meter for ground. If they are found to be shorted to ground, the assembly will have to be lowered and the bare wires moved so as not to contact the case.

It is desirable that the quartz fiber appear around 15 - 25 on the 0-100 microscope scale and perpendicular to the viewer. This is the mechanical zero. It is usually necessary to adjust the electrometer position several times to arrive at the desired point. It is well to remember that in using the microscope an inverted image is seen and the electrometer should be moved to the right to move the fiber to the left on the scale.

ZERO SETTING AND CALIBRATION

The instrument should then be ready for electrical zero setting and calibration. The battery supply to the resistor network for the quadrants should be turned on and allowed to warm up. The fiber should be watched since an unbalanced distribution of potential on the quadrants will throw the fiber off the scale.

The electrical zero is positioned by the 1000 ohm "Zero Set" potentiometer to coincide with the mechanical zero. Fifteen minutes should be allowed for the fiber to come to rest. If enough adjustment is not available in the 1000 ohm potentiometer, one of the fixed resistors may be changed.

After balancing the Leeds & Northrup potentiometer, use it to place a few millivolts on the quartz fiber to bring it up scale to some convenient position, 3 to 10 divisions above the mechanical and electrical zero. Then add exactly 100 millivolts from the Leeds & Northrup potentiometer and adjust the fine and coarse "Sensitivity Potentiometers" to bring the fiber to some convenient point up-scale - say 50 divisions above the previous setting. This will then give a sensitivity of 2 millivolts per division. Since the electrostatic capacity of the chamber and the electrometer is approximately 80 micro-micro-farads the current to be measured for a sample which takes 50 seconds to 50 divisions would be

$$I = C \frac{\Delta V}{\Delta t}$$

$$= \frac{80 \times 10^{-12} \times 100 \times 10^{-3}}{50}$$

$$= 1.6 \times 10^{-13} \text{ amperes}$$

It is possible to vary the sensitivity from 1 - 1000 divisions per volt.

The 100+ millivolts is removed from the fiber and the instrument is now ready to be used to determine background and gamma content of samples.

To run background on the instrument, the grounding key is opened which allows the ionization current to flow to the fiber instead of being shorted to ground. The fiber starts to drift and when it passes the point at which the 100 millivolts was applied for calibration, the clock is started. When the fiber passes a point 50 divisions higher, the grounding key is closed, the clock is stopped and the time read in seconds. Since the

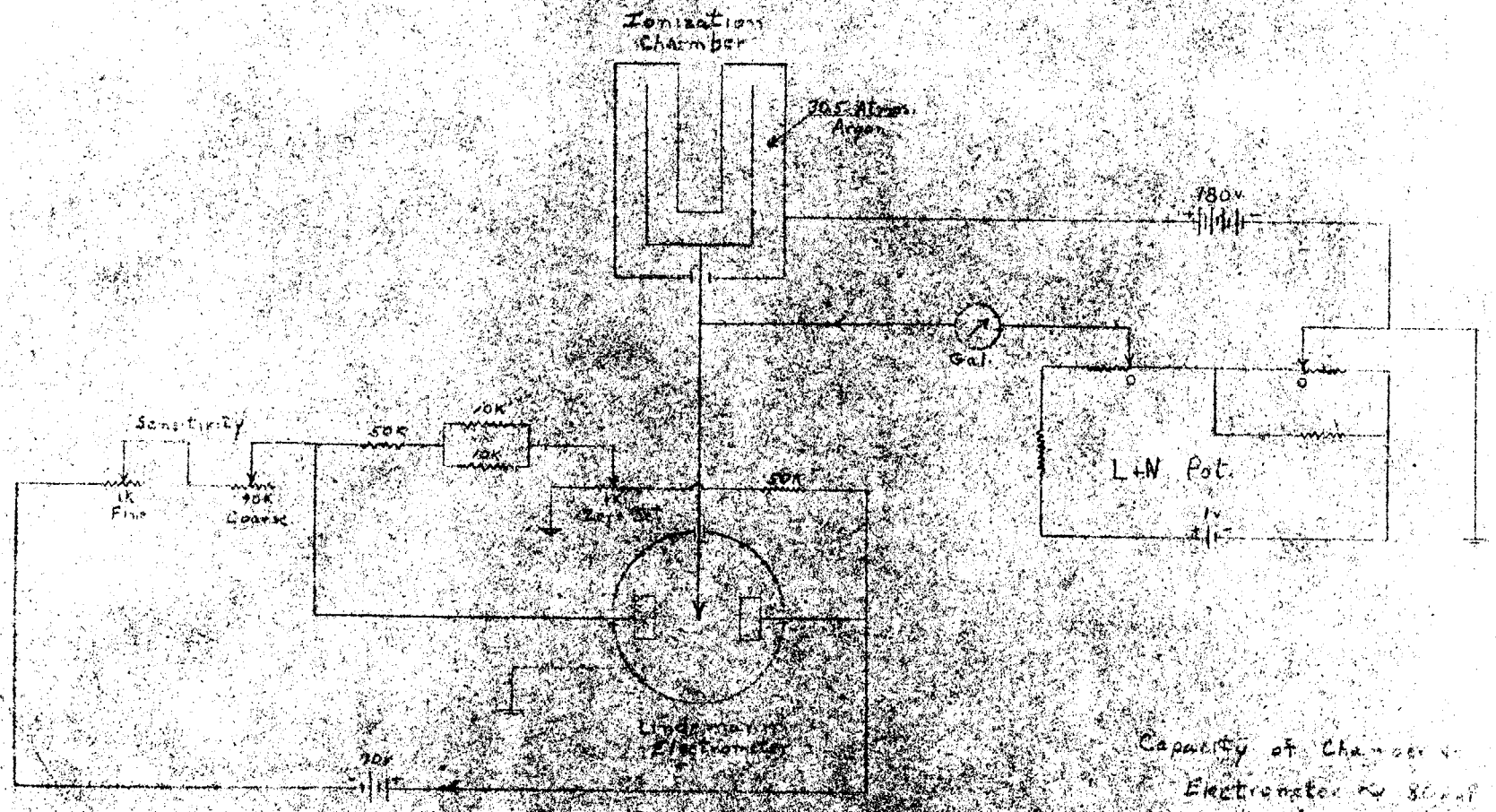
electrometer fiber travel is not linear, this method runs the sample over the same section of the scale as the original calibration.

If the grounding key is not closed, the fiber will continue to travel and may hang up. If when the grounding key is closed the fiber does not return to sight, turn off the voltage to the quadrants and this may bring it back into view. If not, tap the side of the case gently with the voltage off. If all else fails, with the voltage off, the quadrant leads may be disconnected, the voltage turned on, reverse the leads and touch them to the connectors. It is wise in the last step to observe the scale through the microscope because this procedure may take the fiber out of sight on the opposite side.

MISCELLANEOUS

The 45 volt batteries supplying the quadrant voltage should be checked once a month. One battery was found which checked 45 volts but apparently had a very slight variation in supply which made the fiber fluctuate seriously.

Grounded leads should be studiously avoided. No difficulty was experienced with chamber leakage. Standard samples should be investigated for content with particular reference to half-life as the sample may change appreciably after a few months.



Capacity of Chamber ~
Electrometer ~ 80 mf

INSTRUMENT SHOP - - B'LD'G 7176 CLINTON LABORATORIES		
"G" Counter		
SCALE: None	DATE: 3/1/45	
Woody D'WN	C'K'D	APP'D
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AUTOMATIC AUXILIARY SCALER - Q-590-A

By: D. S. Zachry
6/18/47

The Automatic Auxiliary Scaler is designed to provide a compact unit, with no external wiring, for accurately indicating the time required to count a selected number of pulses. Selection is provided by a switch with positions numbered 1, 2, 4, 8, 16, 32, and 64. This number is multiplied by 64 - the number of pulses required to give one output pulse from the main scaler - to get the number of pulses counted during the time interval.

OPERATION:

1. Plug into 3-connector 115V AC line.
2. Connect the 2-connector input cable to the "Recorder" output of the main scaler.
3. Turn on main scaler. Throw switch to "Count".
4. Set clock to zero position by small knob to left of clock face.
5. Set selector switch to desired number of counts.
6. Turn on power toggle switch.
7. Press "Start" button and release - being sure clock is at zero time position.
8. For each succeeding operation, reset timer hand and depress, then release "Start" button.
9. To stop scaler and timer at any point in the cycle, press "Stop" button.
10. Set input bias (red knob behind panel, right side) to optimum value for the particular main scaler and set starting circuit bias (red knob at back, left corner) at best operating value for the main scaler used.

POWER SUPPLY:

There is no high voltage supply in this scaler. In addition to the 322 volt B+ supplied by a 5Y3 and filtered with a condenser input network, there is a 255 volt B+ taken off across the series-connected VR-150 and VR-105. This regulated voltage furnishes plate and screen voltages for the amplifiers and thyratrons controlling the relays. Decoupling is required to isolate the plate of the stopping circuit from the plate of the starting pulse amplifier (6AK5), which shows a positive pulse for each count. In this case an RC filter is used.

A second voltage supply is the -150 volts grid bias voltage for the thyratron grid potentiometers. This is furnished by a VR tube regulated, filtered 6X5 output.

Filaments are supplied from one winding of the power transformer and a 6 amp. filament transformer.

SCALER:

This is the conventional Higinbotham scaling circuit with a modified input circuit designed to receive the output pulse of a main scaler having #1 output lead at B+ voltage. Pulse height selection is provided by a 5000 ohm potentiometer in the cathode circuit of the 6SN7 input tube. For true counting over a wide frequency range this bias setting is critical. A value of +44 volts from cathode to ground gives a frequency response equal to that of the main scaler. Because of the double pulse output characteristic of the Higinbotham, too low a setting will cause a tendency to double count. Too high a bias will cause the tube to refuse pulses at high counting rates. This value must be adjusted for each particular scaler when first connected and may vary from 30-45 volts.

RELAY CIRCUITS:

The negative input pulse is used to perform the functions of resetting the scaler, starting the clock, stopping the clock, and opening the reset line. The pulse is fed through an amplifier onto the grid of a thyratron biased (-10 volts) to cutoff, where it appears as a positive pulse large enough to fire the tube. The 10,000 ohm Clare relay in the plate circuit is picked up, actuating a microswitch which 1) grounds the reset line in the scaling section and 2) closes the starting circuit to the electric clock.

The stopping circuit utilizes the negative pulse taken from the plate of any scaling stage through a selector switch and amplifier to the grid of a 2D21. When the selected pulse reaches the thyratron biased to about -49 volts, it fires the tube, picking up relay #2. Microswitches on this relay open the clock circuit and open the reset line causing the scaling action to stop.

TROUBLE SHOOTING:

A. Scaler does not scale:

1. Check polarity of input terminals.
   #1 must be B+.
2. Check bias setting of input 6SN7.
   44 volts optimum.
3. Check bias setting of starting 2D21.
   10 volts optimum.
4. Depress "Start" switch and release - see if relays are picked up.

B. Scaler starts, but stops after one pulse.

1. Stopping bias is too low. Set to 45 - 49 volts.
2. If bias setting will not stop the firing on first pulse without also stopping firing on the desired pulse, one scaler stage is unbalanced. Observe the grid of 2D21 for "hash" on first pulse. If

it appears, the 100K grid resistors in that stage must be better balanced. Remove one and test several resistors in its place. When "hash" disappears, upon the first pulse tripping the scaler, re-adjust grid bias and test cut-off action.

C. Scaler does not cut off:

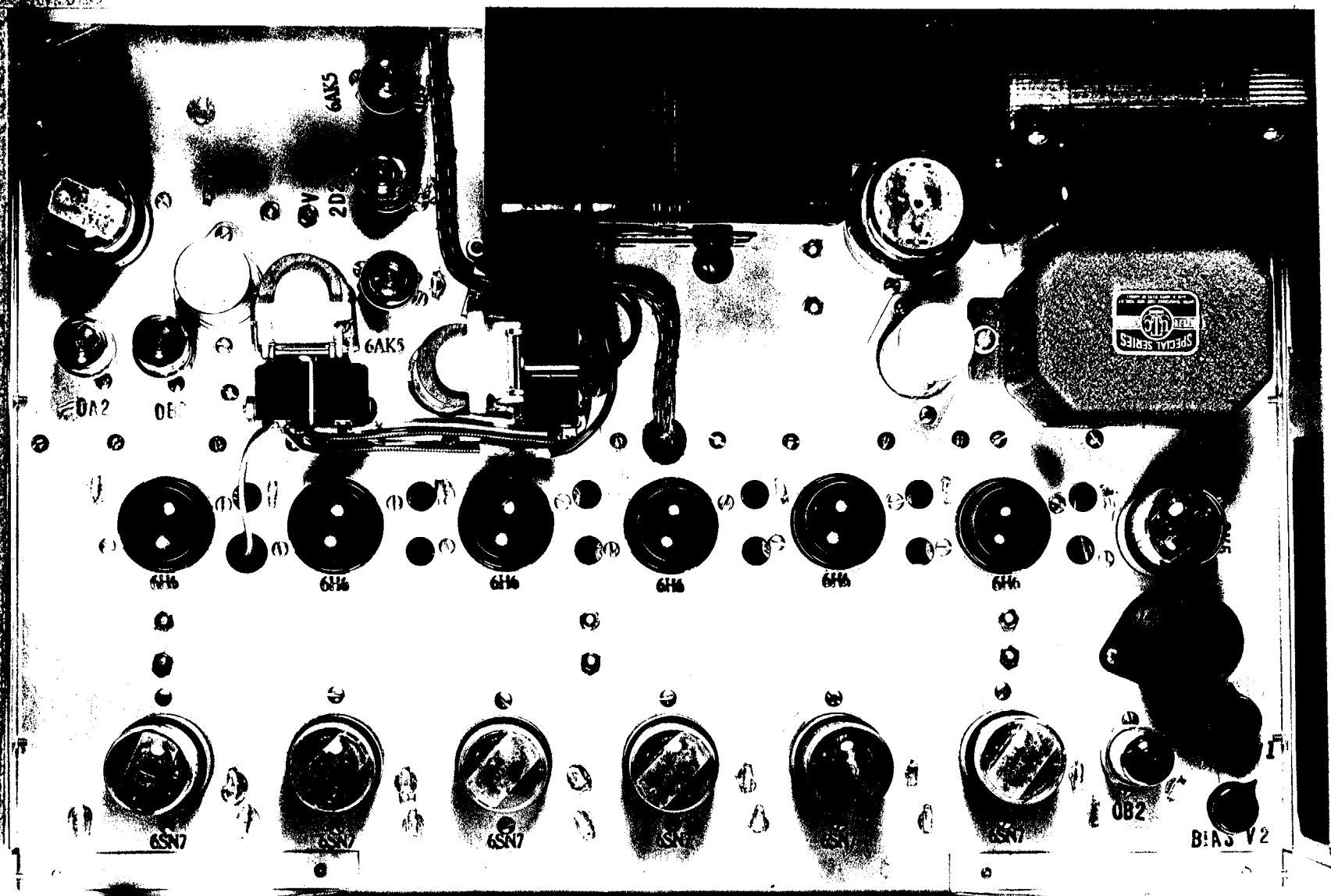
1. Lower cut-off bias on 2D21 until each stage operates the cut-off circuit.
2. If scaler now cuts off at other than number selected, check input condenser (.01 mfd.) to grid of 2D21.

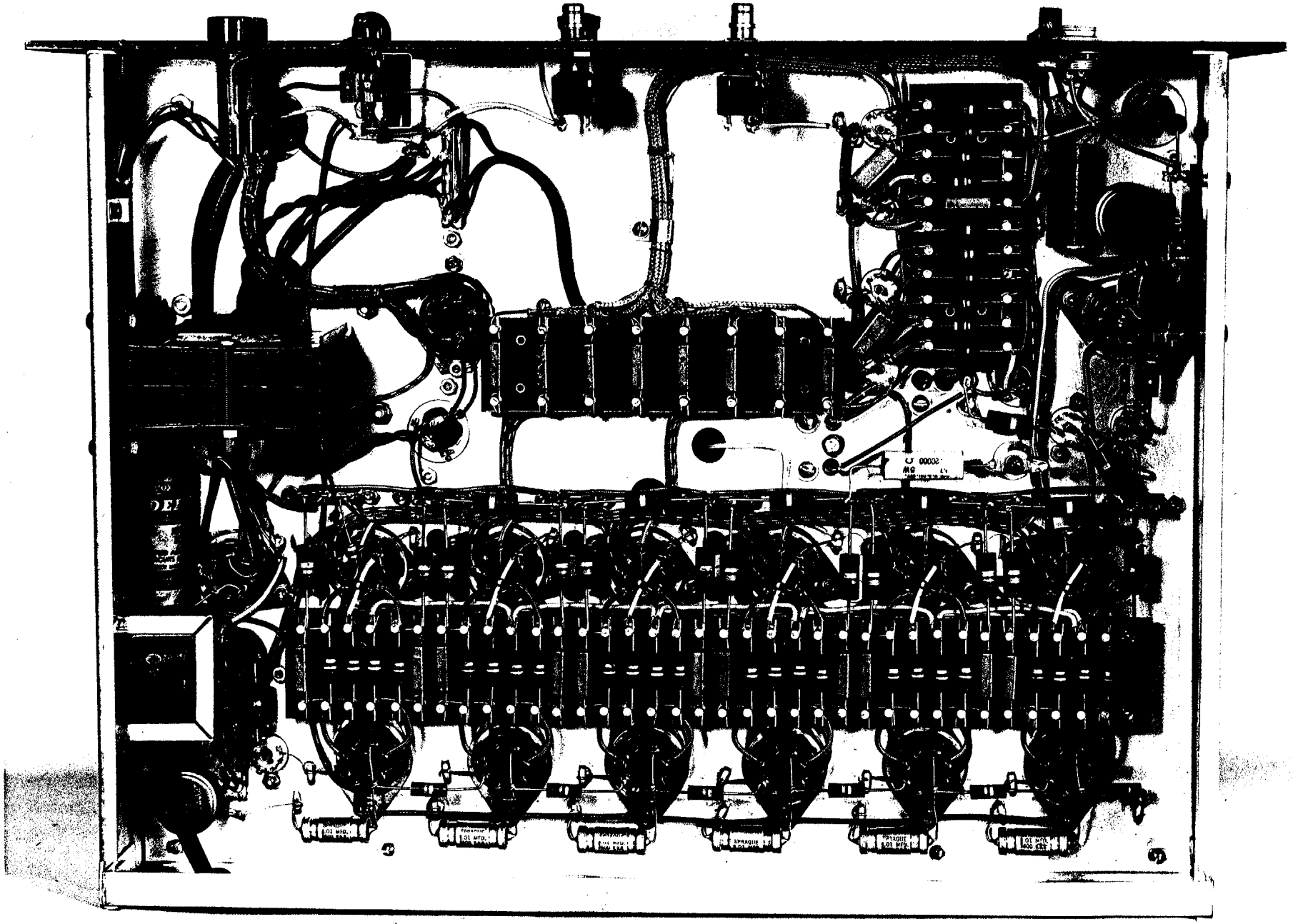
D. Scaler starts on other than 64th count of main scaler:

1. Raise input bias so that 64th count only will fire 2D21 in #1 relay circuit. -10 volts should be enough bias.

DSZ:vaj

1
2
4
8
16
32
LINE
ON
OFF
START
STOP
INPUT


6AK5
6AK5
6H6
6H6
6H6
6H6
6H6
6H6
6SN7
6SN7
6SN7
6SN7
6SN7
6SN7
OB2
BIAS V2
SPECIAL SERIES



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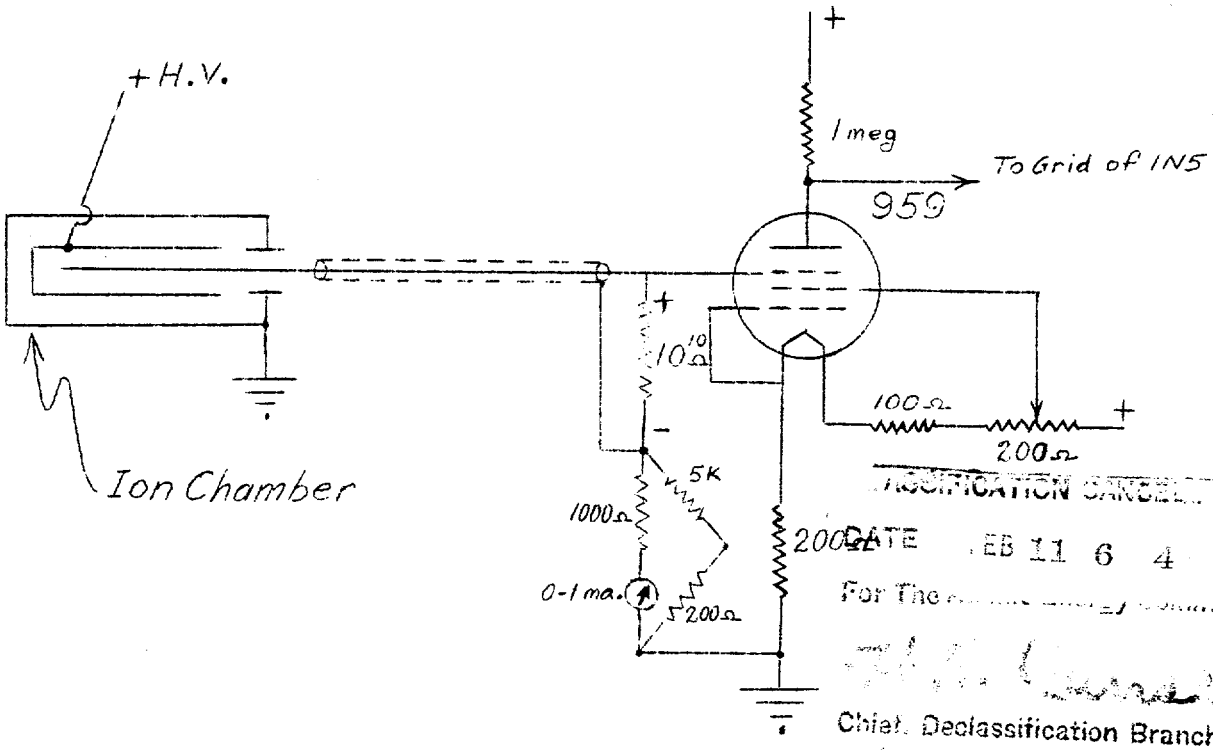
Q-31 AMPLIFIER
(Beckman Replacement)

By: R. L. Quinn
9/26/44

The purpose of this amplifier is to amplify the small ionization current of an ion chamber to such a value that it can be measured with an ordinary zero to one milliampere meter. The input circuit is as shown in the sketch below.



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[illegible]
Chief, Declassification Branch

As radioactive rays pass through the ion chamber, positive ions are produced which will be attracted to the center electrode. This is true because of the electric field between the center electrode and outer cylinder to which the high voltage is applied. As the positive ions come in contact with the center electrode, electrons are required to neutralize the charge that they possess. The source of these electrons is the ground. So, by placing a high resistance of the order of 10^{10} ohms between the grid and ground connection, a voltage will be developed across the resistor that is proportional to the number of electrons flowing through the resistor. This is true from Ohm's law, where E = IR. The number of electrons flowing through the resistor depends on the number of positive ions which come in contact with the center electrode. Thus, as the ionization is increased in the chamber, the electron flow through the resistor is increased, and the voltage applied to the grid of the 959 becomes more positive. That briefly describes the input circuit.

[redacted]

[redacted]

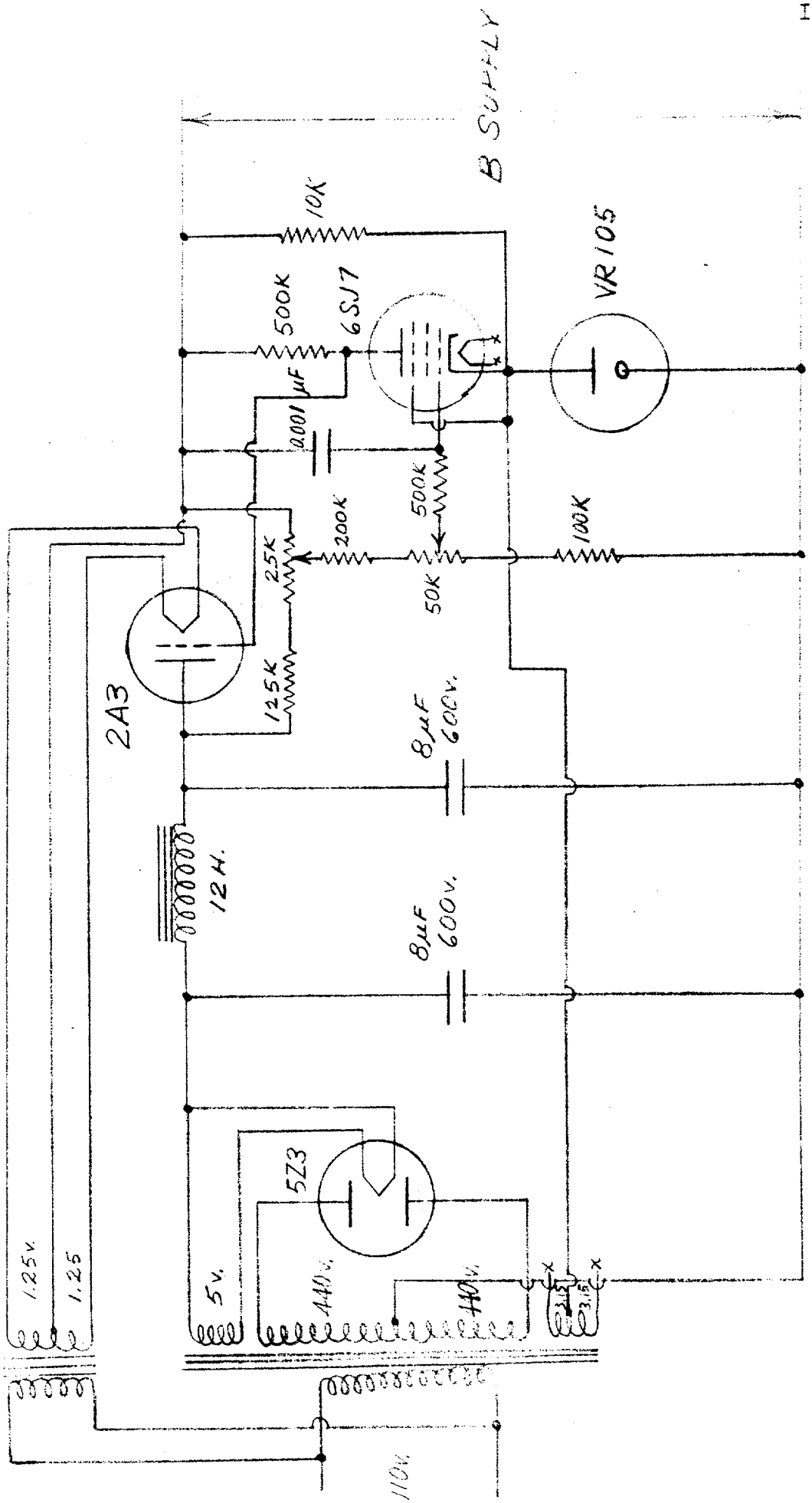
RESTRICTED

The operation of the amplifier circuit and the output circuit can best be explained by re-arranging the circuit diagram shown on Sketch Q-31 so as to better show the bridge circuit. This is done on the following page.

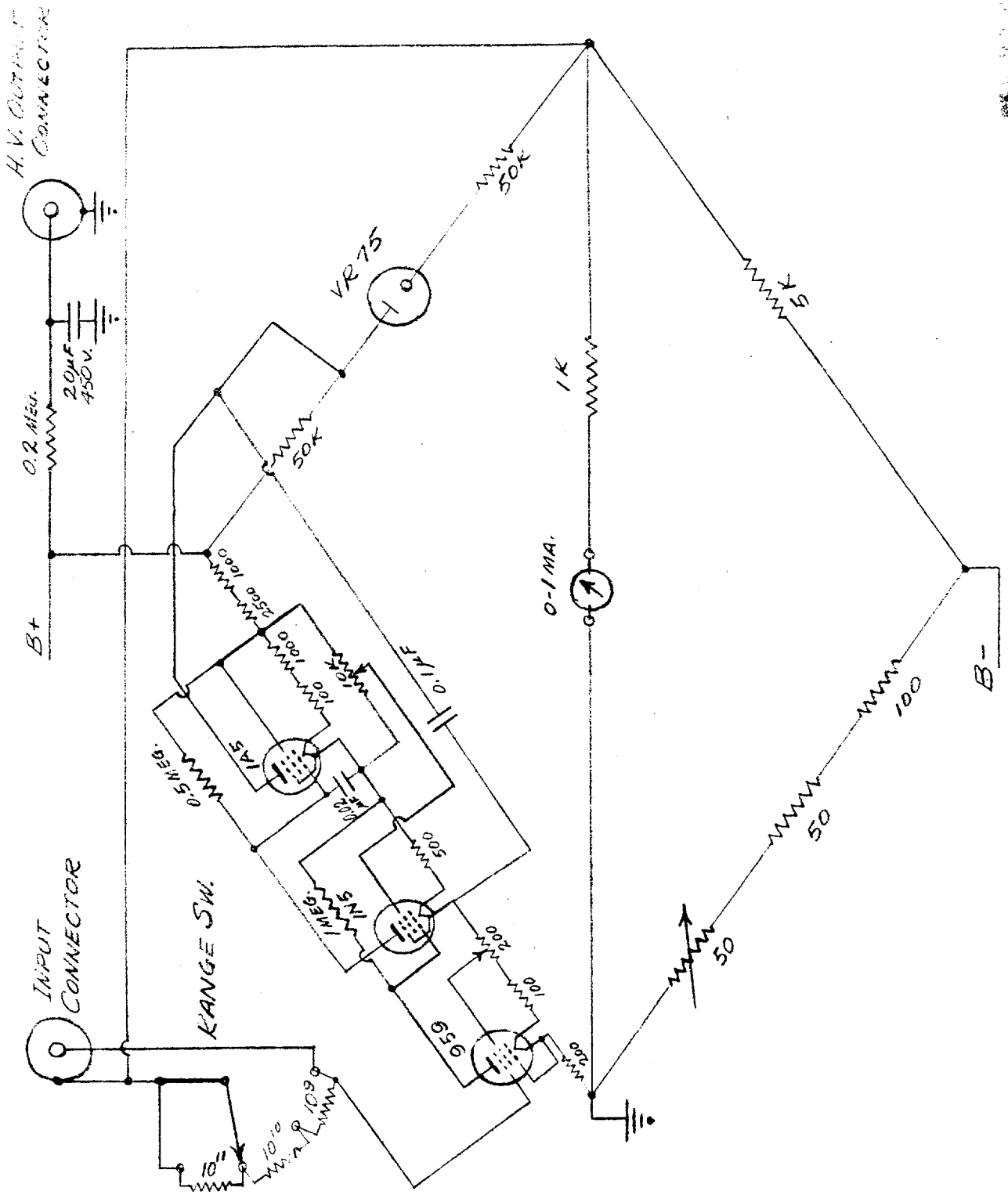
The B Supply can be regulated, as will be shown later, so that 50 ma. will flow through the filaments of the tubes. Then with the last tube of the amplifier passing no current, the bridge can be balanced by adjusting the 50 ohm potentiometer (see tune-up procedure).* When the bridge is properly balanced, the meter reads zero. Now as a positive voltage is applied to the grid of the first tube of the amplifier, as explained in the input circuit, the tube will allow more current or electrons to pass through it. This will increase the drop across the 1 megohm plate resistor, making the plate of the tube drop to a lower voltage. The amplifier is a direct coupled amplifier with the grid of the second stage tied directly to the plate of the first tube, so the grid voltage of the tube in the second stage (the 1N5GT) will become more negative. This will decrease the plate current of that tube, and raise its plate voltage and the grid voltage of the last stage tube. The tube in the last stage (the 1A5GT) will then pass more current, increasing the voltage drop across its plate resistor. But this resistor is in the bridge circuit of the output meter, so the bridge becomes unbalanced and the meter will read up scale. The bridge circuit and degenerative feedback are used to increase the stability of the instrument.

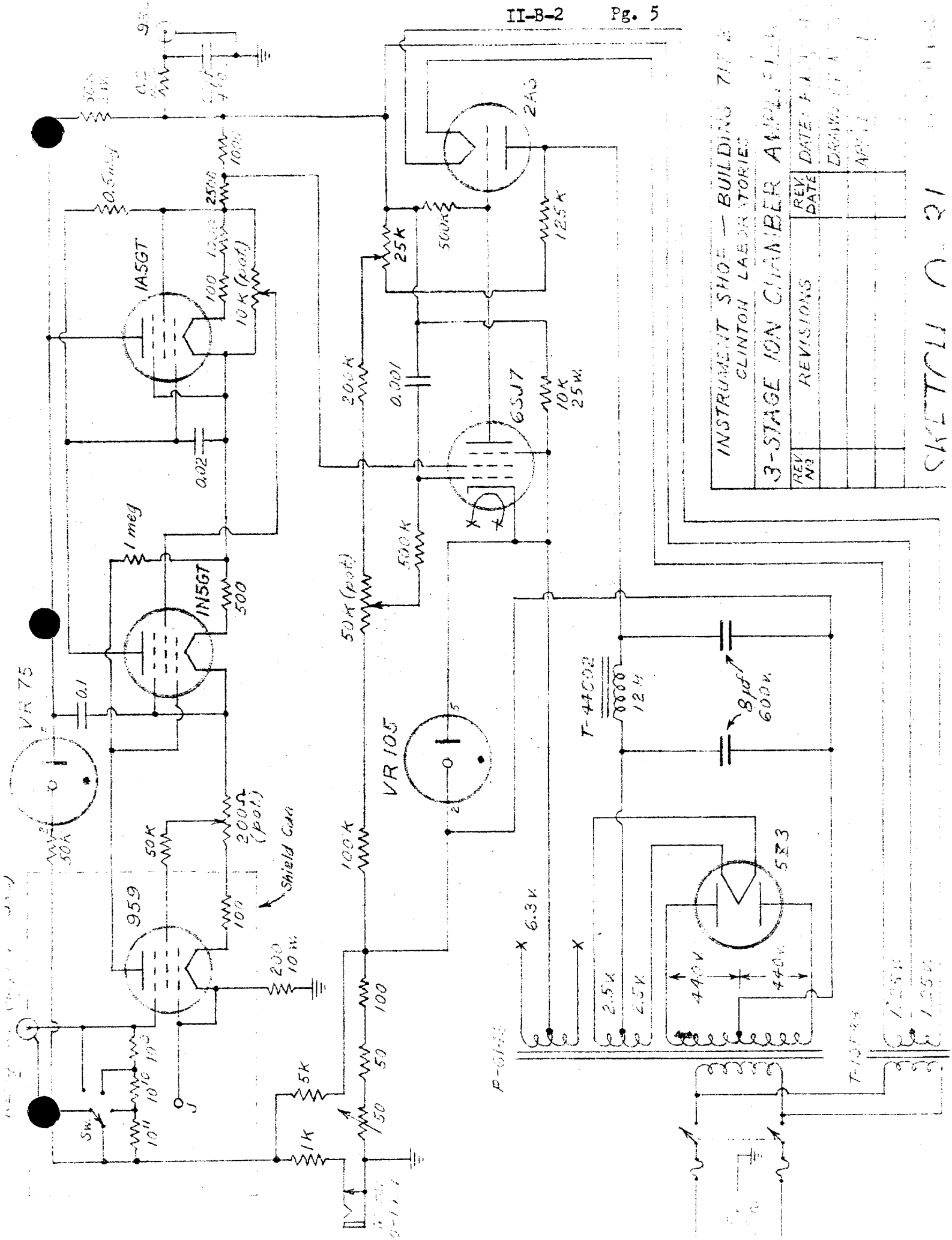
The power supply is a regulated supply that can be adjusted to give the proper filament current for the tubes as mentioned previously. The regulator consists of a two stage degenerative amplifier with the 2A3, or second stage tube, acting as a variable resistor in series with the load. The input voltage to the 6SJ7 is taken from a voltage divider, and may be adjusted by the 50K potentiometer. The 25K potentiometer, which is in series with a 125K resistor across the 2A3, is used to control the regulation, so that the regulator will neither over now under regulate. The VR 105 is used to obtain the proper constant reference bias voltage on the 6SJ7. The circuit is shown on page four.

* Page 6



OFFICIAL USE ONLY


H.V. OUTPUT CONNECTOR
0.2 MEG.
20μF 450V.
B+
VR 75
50K
50K
1K
5K
0-1 MA.
B-
100
50
50
1000
2500
1000
100
10K
0.1μF
0.5 MEG.
1A5
0.02 μF
500
1 MEG.
1N5
200
100
959
200
INPUT CONNECTOR
RANGE SW.
10¹¹
10¹⁰
10⁹


INSTRUMENT SHOP — BUILDING 717
CLINTON LABORATORIES
3-STAGE ION CHAMBER AMPLIFIER
REV. NO
REVISIONS
REV. DATE
DATE
DRAWN
APP'D
SKETCH NO. 21
1A5GT
1N5GT
959
VR 75
VR 105
6SJ7
2A3
5Z3
T-44C02
12 H
8 μf 600 v.
6.3 v.
2.5 v.
440 v.
Shield Can
0.5 meg
1 meg
10 K (pot.)
200 K
0.001
25 K
500 K
125 K
10 K 25 w.
50 K (pot.)
100 K
200 Ω (pot.)
50 K
200 10 w.
5 K
1 K
Sw.
J

PROCEDURE FOR ADJUSTING BECKMAN REPLACEMENTS

RESTRICTED

1. Adjust D.C. voltage regulator, so that it will not over or under regulate, with the 25K pot.

2. Adjust the D.C. regulated voltage to such a value that the filament current for the 959, 1N5GT and 1A5GT tubes is 50 ma. The filament voltage on the 959 should then be 1.2 to 1.25 volts approximately.

3. Set the output meter at zero by adjusting the 50 ohm pot. when the grid resistor of the 959 tube is shorted by the sensitivity switch and the filament of the 1A5GT is shorted with a clip lead.

4. With the clip lead removed adjust the screen voltage of the 959 tube with the 200 ohm pot and the screen voltage of the 1N5GT tube with the 10K pot until the following conditions exist:

   a. The grid voltage of the 1N5GT is approx. -0.5V.

   b. The grid voltage of the 1A5GT is approx. -7.0V.

   c. The meter reads zero.

5. Check to see if the instrument is linear by applying input voltage 0 - 1.0 voltage, and plot output meter reading in m.a. against input voltage.

6. Check the stability of the instrument by connecting to ion chamber and Micromax and leaving it for several hours with a source near enough to give approximately half-scale deflection on the chart. The input resistance to the grid of the 959 should be 10^{11} ohms during this check.

R. L. Quinn
7/29/44

SECRET

HARVEY AMPLIFIER

By: C. Clark IV
10/6/44

DATE FEB 11 6 4
For The Atomic Energy Commission
Chief, Declassification Branch

I PURPOSE

The Harvey Amplifier is an electronic instrument which amplifies the ionization current output of an ionization chamber to such an extent that it may be recorded on a standard 0 - 1 MA. recording milliammeter.

Two types of Harvey Amplifiers are in use on this project: The B+ and the B- circuits. The B+ amplifier is used in conjunction with the General Electric ionization chambers, and the B- amplifier is used with the Mack ionization chambers.

In the case of the General Electric chamber, the ionization current is of the order of magnitude of 10^{-10} amperes. With the Mack chamber, the ionization current is approximately 10^{-11} amperes. In either case, the Harvey instrument amplifies these ionization currents to the extent that the recording milliammeter receives currents of from 0 to 1 milliamperes.

The output current of the Harvey amplifier may then be calibrated to read directly in roentgens per hour of radiation received at the ionization chamber.

II GENERAL PHYSICAL DESCRIPTION

The Harvey amplifier is built on a 17" x 13" x 3" chassis; and its controls and meter are mounted in a 19" x 9" front panel. The usual arrangements of components on the chassis are shown in Figure A. The front panels of the amplifiers are labeled completely enough to be self-explanatory.

III PRINCIPLE OF OPERATION

The Harvey amplifier, electronically, consists of two main parts: a full-wave rectifier power supply, with electronic voltage regulation; and a two stage amplifier in which the input stage is a 959 tube whose suppressor grid is operated as the control grid, and the output stage is a 1A5 tube with a 0 - 1 MA. meter connected from 1A5 plate to a point of equal potential on the voltage-dividing network.

[redacted]

The power supply consists of an 800 volt center-tap transformer feeding onto the plates of a 5V4 full-wave rectifier. The 5V4 filament feeds through a filter circuit of four 4 mfd. condensers to the voltage regulating circuit. This voltage regulating circuit consists of a 2A3 tube, a 6J7 tube, a VR 150/30 tube, and a network of resistors acting as a voltage divider. The unregulated voltage from the filter circuit is applied to the plate of the 2A3 and also on the 1 megohm resistor of the voltage divider network. A fluctuation in the output voltage from the 2A3 filament introduces a corresponding fluctuation in the control grid voltage of the 6J7 tube, since this grid is connected to the voltage divider by the 200 K potentiometer, and the 6J7 cathode is held at constant voltage by the VR 150/30. This regulates the 6J7 plate current in proportion to the output voltage fluctuation. The 6J7 plate is connected directly to the 2A3 grid, which regulates the voltage drop across the 2A3 tube in proportion to the output voltage fluctuation. The output of the voltage regulator circuit is taken from the filament of the 2A3 tube, and applied directly to the series network of wire-wound resistors supplying operating voltages for the amplification stages. The output of the voltage regulator circuit may be adjusted by the 200 K potentiometer (Voltage Control #2).

Ionization current from the chamber flows to ground through the input resistor and range selector switch, thus, developing a positive signal voltage at the suppressor grid of the 959 tube. This increases the 959 plate current, and correspondingly lowers its plate voltage. Since the 959 plate is connected directly to the 1A5 grid, the 1A5 receives a negative signal. Its plate current decreases, causing an increase in plate voltage and, therefore, an increase in meter current. The meter reading is, thus, a measure of the ion current and of the radiation at the chamber.

The operating voltages of the 1A5 filament and control grid, as well as, that of the 959 filament and screen grid, are supplied directly from the series network of wire-wound resistors across the output of the voltage regulator circuit.

IV PROCEDURE FOR TUNE-UP

A. Necessary Equipment

1. "Simpson" test meter.
2. "Variac" with adequate connectors to insert in A.C. supply line to Harvey.
3. Small screw driver.
4. Two leads with pin plugs on ends.
5. Two leads connected into Mallory #75N phone plug. (Positive to tip of plug.)
6. Clip lead.

B. Current Adjustment

1. With all tubes in sockets and recorder terminals open, turn set on and allow to warm up for one hour.
2. Set "Zero Set" potentiometer in the middle of its range; and sensitivity selector switch to "Zero Check" position.
3. Set "Simpson" test meter to read 100 MA. full scale. Attach meter leads to phone plug leads.
4. Switch set off; insert phone plug into phone jack in front panel; switch set on again. Set is switched off while inserting phone plug to avoid overloading circuit while the jack breaks contact momentarily.
5. Adjust "Voltage Control #2" until "Simpson" reads 50 MA. This is the filament current through the 959 and 1A5 tubes.
6. Using pin plugs inserted into the lucite pin jacks in the front panel, check the 959 filament voltage. Since the correct voltage is between 1.00 volt and 1.75 volts, it is suggested that the 2.5 volt full scale setting of the Simpson be used. In the event that the 959 filament foltage falls outside of these limits, while the other values to be checked and adjusted remain correct, the 959 tube is faulty and should be replaced.

C. Bias Setting of 1A5 Tube

1. Using "Simpson" on 50 volts full-scale, read voltage across red and black pin jacks on top of chassis. The "Simpson" is set on 50 volt scale in order to supply a high enough resistance to prevent overloading of the circuit.
2. Adjust 70,000 ohm potentiometer on top of chassis for 5 volt reading. Leave Simpson connected.
3. Re-connect recorder, or short recorder terminals with clip lead.
4. Adjust slide on 3000 ohm, 50w Dividohm so that panel meter reads zero. Re-adjust 70,000 ohm potentiometer to 5 volts, if necessary. Balance these two adjustments so that Simpson reads 5 volts and panel meter reads zero simultaneously.
5. Disconnect Simpson and re-adjust 70,000 ohm potentiometer so that panel meter again reads zero. This sets the 1A5 bias at 5 volts.

NOTE: On certain of the Harvey amplifiers in use on this project, it will be found that the

3000 ohm, 50w Dividohm has been replaced by a potentiometer of similar characteristics. This has been done simply to facilitate tune-up; and alters step #4 merely to the extent that this potentiometer is to be adjusted so that the panel meter reads zero.

D. Voltage Regulation

1. Insert "VARIAC" in A.C. Supply line, and allow set to warm up for one hour.
2. Adjust "ZERO SET" potentiometer so that panel meter reads approximately mid-scale. Set front panel sensitivity "SELECTOR SWITCH" to "0".
3. While rotating "VARIAC" between 105 volts and 125 volts, adjust "VOLTAGE CONTROL #1" Potentiometer in front panel so that panel meter needle shows minimum fluctuation.
4. Set "SELECTOR SWITCH" to "100,000" and repeat step #3.
5. Re-check filament current through 959 and 1A5 tubes as in "CURRENT ADJUSTMENT, step #4".

V PROCEDURE FOR CALIBRATION

A. Voltage Sensitivity

1. Allow Harvey set to warm up for one hour. Set "SELECTOR SWITCH" to "1".
2. Connect to the Harvey (as shown in Figure B) a source of battery potential variable between 0 volts and 3 volts.
3. With no voltage applied to Harvey, adjust "ZERO SET" potentiometer so that panel meter reads zero.
4. At various convenient increments, read the simultaneous values of battery voltage and panel meter reading.
5. Plot a curve showing the relation of voltage input and panel meter reading. (This curve should be essentially a straight line.) The voltage sensitivity (expressed in volts per milliampere), is the voltage which must be applied to the input of the amplifier in order to obtain full scale (1 MA.) deflection of the panel meter.

B. Measurement of Input Resistance

This procedure is a practical utilization of the following formula for voltage across a condenser in discharge:

$$E_1 = E_o e^{\frac{-T}{RC}}$$

in which:

R = Resistance (in megohms) through which condenser is discharged.

E_o = Voltage to which condenser is charged initially.

E_1 = Voltage to which condenser remains charged after T seconds of discharge.

T = Time (in seconds) during which condenser is discharged.

e = 2.71828 (Base of Naperian logarithms)

C = Condenser capacity in mfds.

Thus, setting $\frac{T}{R\,C} = 1$,

$$E_1 = E_o e^{-1}$$

or

$$E_1 = \frac{E_o}{e} = 0.368\ E_o$$

This gives us the convenient relationship that $\frac{T}{RC} = 1$, when E_1 is 0.368 of its initial value E_o.

This relationship is used to calculate the input resistances of the Harvey amplifier in the following steps:

1. Connect condenser of known capacity and of variable battery potential to Harvey set as shown in Figure C. Short recorder terminals.
2. Allow one hour for Harvey to warm up.

3. Set "SELECTOR SWITCH" to scale whose input resistance is to be calculated. Adjust "ZERO SET" potentiometer for zero on panel meter.
4. Close switch "S" (See Figure C).
5. Adjust battery potential so that panel meter reads slightly beyond full scale.
6. Open switch "S".
7. Note time required for panel meter reading to drop from exactly full-scale to 0.368 of full-scale. An electric timer is recommended for this step.
8. Repeat steps 4, 5, 6 and 7 if increased accuracy is desired.
9. Using capacitance bridge, observe input capacity of the Harvey set.
10. Add this capacity to the known capacity of the condenser before substitution in the equation.
11. Calculate the Input Resistance:

$$R \text{ (in megohms)} = \frac{T \text{ (in seconds)}}{C \text{ (in microfarads)}}$$

A table of typical data collected by means of this condenser discharge method of input resistance determination is given below:

SENSITIVITY SCALE	CONDENSER CAPACITY (MFD.)	DISCHARGE TIME: T	INPUT RESISTANCE
100,000	$1.1427 \cdot 10^{-3}$	96.1 sec.	$0.841 \cdot 10^{5}$ meg.
10,000	$1.1427 \cdot 10^{-3}$	16.6	$1.451 \cdot 10^{4}$
1,000	$1.0 \cdot 10^{-2}$	9.6	$0.96 \cdot 10^{3}$
100	1.00	155.5	$1.555 \cdot 10^{2}$
10	1.00	16.3	$1.63 \cdot 10^{1}$
1	By Megohm Bridge		$1.01 \cdot 10^{0}$

C. Calculation of Full-Scale Equivalents

Knowing the voltage sensitivity and input resistances of a particular Harvey amplifier, the radiation equivalent to full-scale deflection may then be calculated. This is done by means of the formula:

$$R./HR. = \frac{V}{K\ A}$$

in which,

R./HR. = Roentgens per hour equivalent to full-scale meter deflection.

V = Voltage sensitivity of Harvey amplifier (in volts per milliampere).

K = Input resistance in ohms.

A = Ionization current developed in accompanying chamber by 1 R./HR.

The following values of A have been established by the Detection Instrument Section:

TYPE OF CHAMBER	A
Mack	$3 \cdot 10^{-10}$ Amps./R./HR.
General Electric Gamma	$3.6 \cdot 10^{-9}$ Amps./R./HR.

VI SYMPTOMS OF FAILURE & POSSIBLE CORRECTIVE STEPS

As is the case with practically any electronic instruments, there are certain predictable symptoms of failure, and recommended corrective steps thereof. This does not include such obvious troubles as blown fuses, failure to plug into A.C. supply, bad pilot lights, et cetera.

Among the more probable symptoms of Harvey amplifier failure are the following (not listed in order of probability of occurrence):

1. Meter drifts off zero.

   This is a characteristic of this type of amplifier, and is usually corrected by re-setting the zero once each 8 hr. shift. Any drift of more than 10% of full-scale, however, may be due to actual failure.

2. Insufficient range in "ZERO SET" potentiometer.

   This may be corrected by setting the "ZERO SET" potentiometer in mid-range, and then adjusting the 70,000 ohm potentiometer on top of the chassis until the meter reads zero.

3. Filament current through 959 and 1A5 tubes is not 50 MA.

   This may be corrected by adjusting "VOLTAGE CONTROL #2" potentiometer in front panel.

4. General erratic behaviour of panel meter.

This may be caused by shorted and/or open circuits in the high voltage and/or signal leads between Harvey and Ion Chamber. To check this, disconnect these leads and observe the meter behaviour. Another cause lies in the 959 tube. Current leakage across the glass of this tube will cause a high plate current to flow. The range of acceptable plate current in this tube is 124 - 225 microamperes, with plate voltage of +15 volts, screen voltage of +10½ volts, and grid bias of -7½ volts (with respect to the cathode). This can be checked by the Circuit Construction Room and, if found to be outside of limits, a new 959 tube should be used.

5. Meter reads counter-clockwise with increase in output current.

The meter polarity has not been observed.

6. Filament voltage of 959 tube is outside of 1.00 to 1.75 volt limits.

If other tune-up adjustments are correct and 959 filament voltage is incorrect, replace 959 tube.

7. No Power Supply (B+ or B-) voltage.

This may be caused either by failure of the 5V4 rectifier tube, or a filter condenser, or the 2A3 tube, or failure of one of the other components of the voltage regulator circuit.

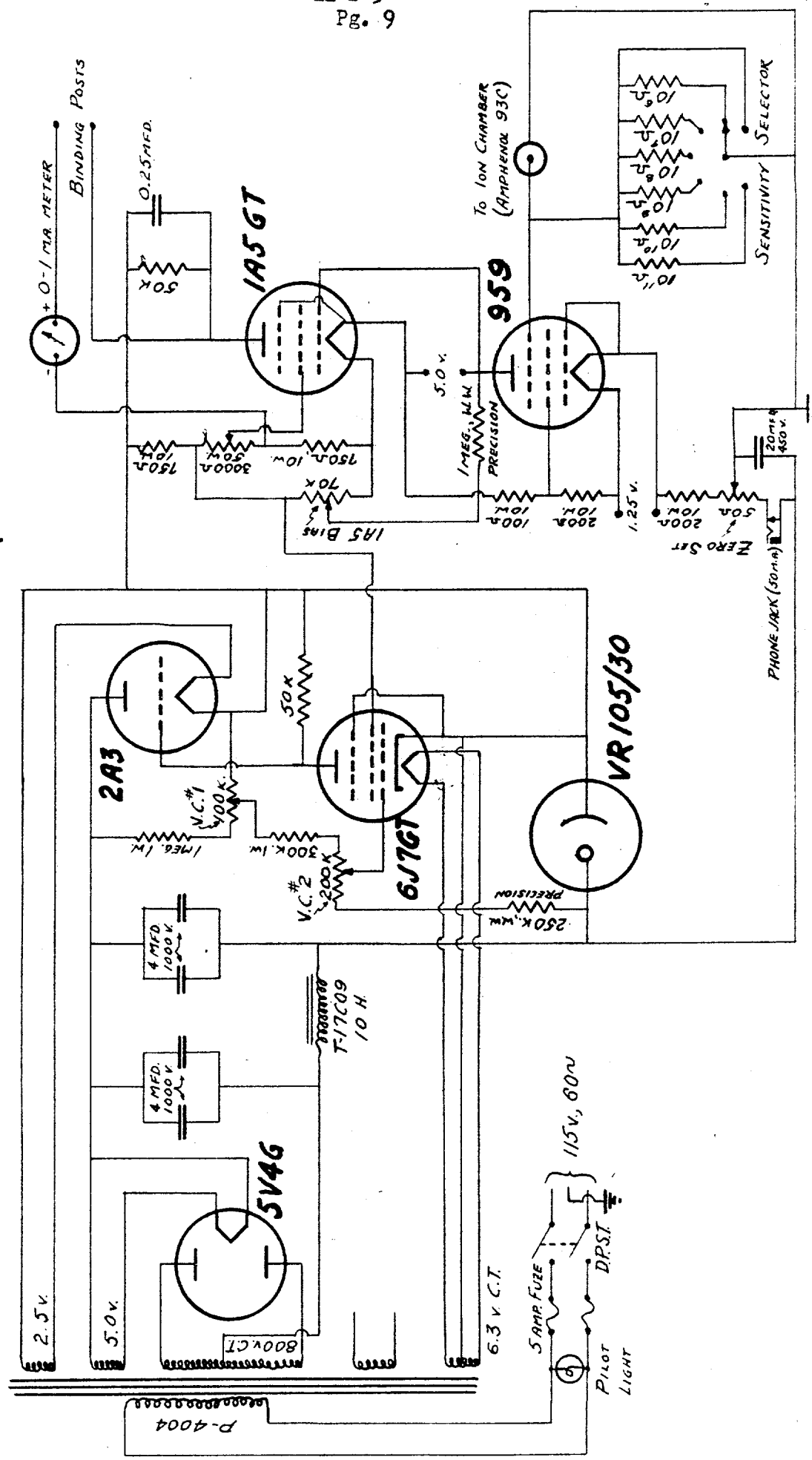
8. Voltage across the VR 105/30 tube is not 105 volts.

In this case, the VR tube is bad, or else it is not a VR 105/30

After the replacement of either the 959 tube or the 1A5 tube, or the changing of any of the tune-up adjustments (except the 70,000 ohm potentiometer on top of the chassis), the set should be tuned up anew. The replacement of the 959 tube will necessitate the re-establishment of the voltage sensitivity of the amplifier.

HARVEY D.C. AMPLIFIER
B+ CIRCUIT
(FROM SKETCH Q-103)

10-13-44



USUAL PHYSICAL LAYOUT OF HARVEY D.C. AMPLIFIER
(CHASSIS TOP)

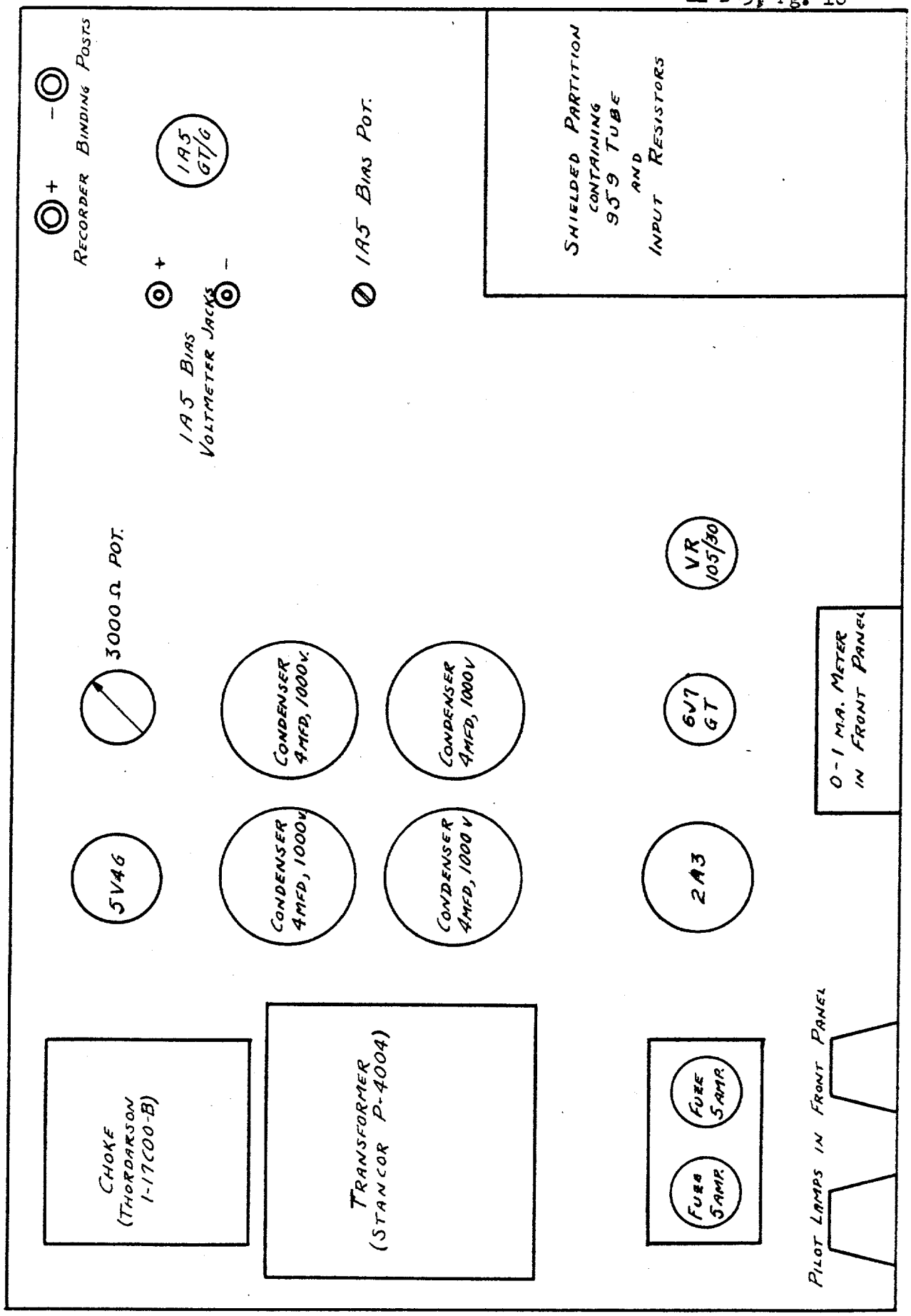


FIGURE A

Clark
10-7-44

FIGURE B

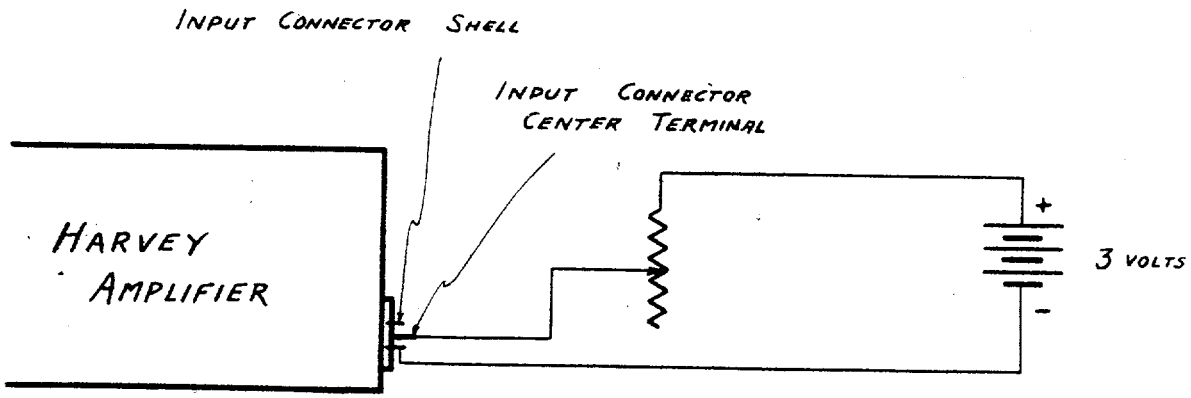
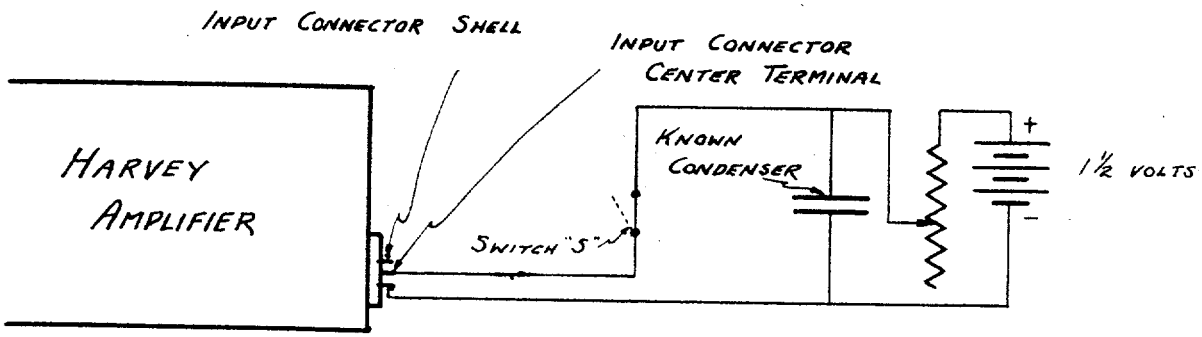


FIGURE C



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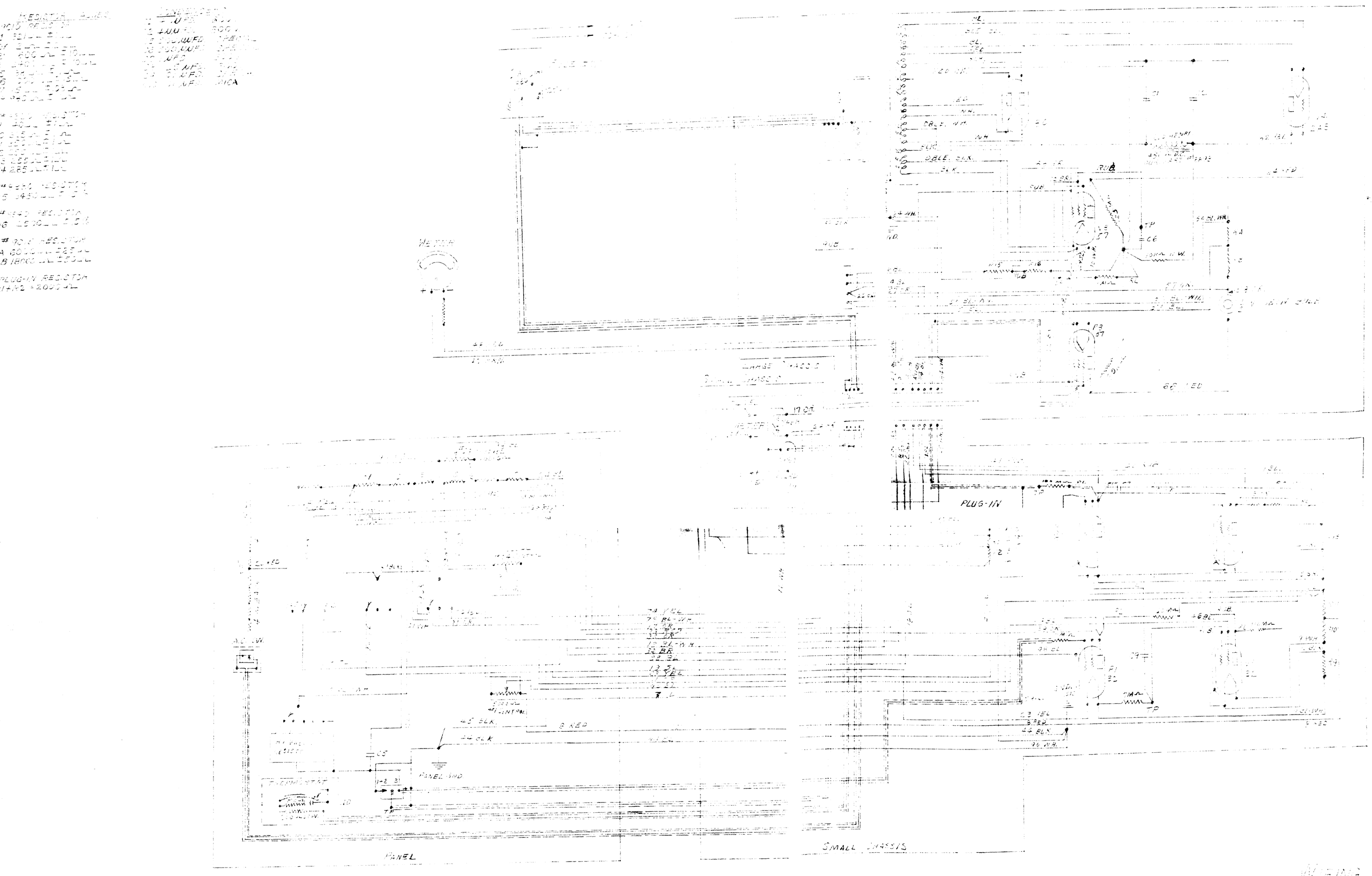

Wiring Diagram
For UU Ammeter

#3436

CLINTON LABORATORIES			
REVISIONS	REV. BY DATE	REFERENCE DRAWING	DATE 11-23-43
			SCALE NONE
			DRAWN BY T.O.G.
			APPROVED M.O.S.
			No. 9733

BECKMAN MICRO-MICROAMMETER - MODEL RXD

By: A. R. Simpson
8/25/45

1. SPECIFICATIONS

Voltage sensitivity	400 millivolts
Full-scale deflection with 10^{11} input resistor	4 micro-microamperes
Full-scale deflection with any input resistor	400/input resistor in thousands of megs
Power input	115 volts 60 cycles
Fuses	2 ampere cartridge type
Drying agent	Drierite
Recommended cable	Polyethylene, aquadag coated. Amphenol #21B - 285 - 7/26XV

2. ADJUSTMENTS (IN BRIEF)

No. 1 - Control switch, Pos. #1	Adjust for meter reading of 5.00
No. 2A - Control switch, Pos. #2	Adjust for zero.
No. 2B - Control switch, Pos. READ (chamber voltage disconnected)	Adjust for zero.

3. MOUNTING

The micro-microammeter is regularly supplied with mounting lugs attached to the back of case for wall mounting. For panel-board mounting the lugs may be removed and the instrument supported from the flange at front of case. Mount with panel vertical in a location not subjected to severe vibration. After mounting, remove plate from left-hand side of case to expose terminal connections.

4. DRYING AGENT

It is necessary to employ a drying agent in the lower compartment. Remove the square plate on left-hand side of compartment and lift out the box which is attached. Half fill box with the drying agent "Drierite", and install it in the instrument. The drying agent should be replaced or regenerated (by heating to 180° C. (365° F.) for two hours) at regular intervals. Drierite has a deep blue color, normally and turns to light pink after use.

5. POWER SUPPLY

The Micro-microammeter is supplied to operate on 115 volts, 50/60 cycles. Line voltage fluctuations of 10% will not affect the instrument operation, but the life of electronic tubes will be impaired if operated continuously above 120 volts. Before connecting power supply, turn switch to "OFF". Bring in power leads through hole in top of case and connect to upper terminals on the 2 amp. fuse block.

6. GROUNDING CONNECTIONS

The case containing the chassis must be grounded either to the conduit carrying the power leads, or by connection to a water pipe by means of the "Ground" Terminal on the electrode terminal panel.

7. "RECORDER" TERMINALS

These terminals are for connection of a potentiometer type recorder or controller. No connection is made otherwise. The recorder used should have uniform chart graduations, with the left-hand graduation corresponding to zero voltage input to potentiometer. It is desirable that no temperature sensitive element, such as cold-junction temperature compensator, be connected in the potentiometer circuit.

The Micro-microammeter is designed to operate with a recorder having a millivolt range as shown on the plug-in resistor located on top of the lower compartment. The plug-in resistor may be changed to adapt the Micro-microammeter for use with a recorder having a different millivolt range. In ordering a new resistor, specify the millivolt range of recorder.

8. "METER" TERMINALS

These terminals are for connection to an auxiliary meter when instrument readings are needed at a remote location. The terminals must be shorted when an auxiliary meter is not used.

The auxiliary meter should have a full-scale sensitivity of 1000 milliamperes and a resistance, including the circuit wiring, of less than 100 ohms. However, if Model 8005 controller is not used, the resistance may be as much as 1500 ohms.

9. "RESISTANCE THERMOMETER" TERMINALS

The special 4000 ohm dummy resistance thermometer must be securely attached to the terminals on the electrode panel.

10. "250 VOLTS" TERMINAL

The upper terminal panel has a binding post which supplies a regulated potential of about 250 volts with respect to the ground terminal. A protective resistance of one megohm is included in the circuit.

11. CONTROLLER CONNECTIONS

The plug receptacle between fuse block and terminal strip is for connection of No. 8005 Controller unit -- see instruction sheet supplied with Controller. No connections are made to the receptacle if No. 8005 Controller is not used.

12. INPUT CONNECTIONS

The Micro-microammeter is designed for operation with a current source (an ion chamber for example) having an internal resistance greater than one hundred times the value of the input resistor selected. The current source must be connected to the "Input" terminal of the Micro-microammeter by a highly-insulated, (polyethylene) well-shielded cable. The cable shield must be attached to the outer shell of the "Input" terminal or to the "Guard" terminal. Any other circuit elements having capacity coupling to the highly-insulated lead wire must be connected so as to have a stable potential with respect to the "Guard" terminal; where possible, such circuit elements should be connected directly to the cable shield or the "Guard" terminal.

13. ADJUSTMENTS

Three preliminary adjustments are required before the instrument is ready for operation. The No. 1 control adjusts the power supply regulator to provide the correct current and potentials for the operation of the instrument.

The No. 2A adjustment serves to bias the input stage of the current amplifier at the correct point, so that zero current gives zero meter reading.

The No. 2B adjustment reduces the grid current of the input tube to zero. The care with which this adjustment is made will determine the degree to which transients which accompany changes of the input resistance selector switch may be minimized.

All adjustments will drift quite badly during the first hour or so that the instrument is connected, while the thermostat in the lower chassis assembly warms up to operating temperature. Subsequent drift of the No. 1 adjustment should be negligible, and need be checked only when changing tubes. Drift of the No. 2A adjustment should be small after the first day, but the No. 2B adjustment may require re-setting several times per day for the first week, and once each day thereafter. The No. 2A adjustment should be checked each time the 2B adjustment is made.

a. Meter

With the control switch in the "OFF" position, the meter needle should indicate exactly zero. (Tap it with a pencil.) Any adjustment required may be made by means of the screw on face of meter.

b. Voltage Regulator (Adjustment No. 1)

Turn the control switch to position No. 1, which connects the power. The meter needle will oscillate across the scale for about ten seconds. After it has come to rest, turn screw adjustment No. 1 until the meter reads 5.00.

c. Amplifier (Adjustment No. 2A)

Advance the control switch to position No. 2 and adjust control No. 2 until the meter reads zero.

d. Grid Current Elimination (Adjustment No. 2B)

Remove high voltage from ion chamber and ground the high voltage electrode. With the control switch in position READ, set the input resistance switch to the "100 Thousand Megohms" position, and adjust control No. 2B until the needle position is zero, on the average. A small amount of random fluctuation of the needle is normal to the operation of the instrument in this position. It is due to resistor and tube noise and should not exceed one dial division.

14 OPERATION

With the high voltage applied to the ion chamber, which is attached to the Input terminal, turn the resistance selector switch to "O" and the control switch to "READ". After allowing sufficient time for the dielectric absorption currents from the circuit insulation to be dissipated, turn the selector switch to the desired resistance value.

If dielectric absorption currents are negligible, the final reading of the meter should be closely approached within about ten seconds, despite an input capacity of as much as 5,000 micro-microfarads and an input resistance of 100,000 megohms.

Make sure that all connections to the terminal strip are secure and replace the side cover plate.

15. ELECTRONIC TUBES

IMPORTANT! If faulty electrical operation is indicated, do not handle tubes or wiring without first turning the switch to "OFF", as dangerous voltages are present. The five upper tubes may be satisfactorily tested in radio test-sets, but such tests are not necessarily conclusive on the No. 32E tubes. Actual trial replacement should be made in case of trouble with a No. 32E tube.

Occasional tube replacement may be necessary when adjustments in switch position No. 1 and No. 2 cannot be made. The four special No. 32E tubes in lower compartment and the special neon tube at right center should normally function satisfactorily for years. Should damage result to these special tubes, replacements must be obtained from the National Technical Laboratories. The No. 32E tubes are accessible after removing the front bakelite panel. Hold the panel in place by hand as the last screws are removed, then carefully pull straight out as far as possible to avoid bending the assembly which carries the high value resistors. The instrument will not operate properly if the resistors or their leads touch anything except their polystyrene insulators. The panel may be pushed aside far enough to remove the cast aluminum isothermal shield which surrounds the tubes. Separate the power plug to the right and unscrew its base. Then remove the nuts from the casting mounting studs and the grid clip from the lower left-hand tube. Push the casting downward to clear the plug-in resistor base, then pull clear.

Only the lower left-hand No. 32E has its envelope guard terminal attached to the binding post alongside it. On the others it is soldered to one of the large pins in the tube base. In ordering replacement tubes specify which type of guard is required.

Do not allow the grid wire to touch the shield at any point even though it is insulated. Be sure all tubes are seated properly, with grid connections tight, before replacing casting.

If the No. 2A adjustment cannot be made after changing the lower left-hand 32E tube, it is an indication that the new tube requires a different bias voltage than the old. A tapped resistor is provided for the purpose. It is located just above the right-hand switch on the panel. If the needle cannot be brought on scale from the left, the red wire should be moved one pin to the left. Each small section of the resistor corresponds to about two turns of the control knob.

The No. 2A3 voltage regulator tube, No. 80 rectifier tube and the two No. 57 amplifier tubes are standard types. These tubes are operated well below their normal rating and should function satisfactorily longer than one year. However, where uninterrupted service is desired, it is recommended that No. 57 and No. 2A3 be replaced each year and No. 80 every two years.

16. TESTING

IMPORTANT: Turn switch to "OFF" before handling tubes or wiring.

By observing the action of the meter needle while making adjustments outlined in paragraph 13, it should be possible to locate the source of any electrical trouble which may be encountered.

a. If no needle action results when switch is turned to No. 1 position, check the meter connection, test power supply through the 2 amp. Little-fuses and observe if the filaments glow in the five upper tubes. If all filaments glow, it is probable that one of the No. 32E tubes in lower compartment is in trouble.

b. If the needle comes on lower part of scale with switch in No. 1 position but does not rise properly, it is likely that the power supply is below 100 volts. The instrument may be started on low voltage by fastening an insulated wire to the ground terminal and touching the grid cap of the upper No. 57 tube for about 15 seconds.

c. With switch in position No. 1, if the needle rises to upper part of scale but cannot be brought back to the proper point, it is probable that the upper No. 57 is faulty.

d. If proper operation per paragraph 13b is obtained in switch position No. 1, and the needle goes off either end of scale when switches are turned to No. 2 position, it is probable that the lower No. 57 tube or the neon tube is at fault. It is also possible that one of the left-hand No. 32E tubes could be deficient.

e. If the Micro-microammeter performs properly during adjustments 1 and 2A but adjustment 2B cannot be made or is excessively unstable, trouble is indicated with the 32E tube in the lower left-hand corner or with the insulation of the circuit leading from the grid of this tube to the resistance selector and control switches. Be sure that the drying agent is fresh and active. Because of the crowded condition of this compartment, it is possible to cause trouble of this type by careless manipulation in removing the panel. If the mounting bracket of the high-value resistor assembly is accidentally bent, a portion of this highly-insulated circuit may come into contact with one of the tube envelopes or grid leads or with the input condenser next to the highly-insulated section of the control switch. To check, loosen all the panel screws and move the panel slightly, then hold still while trying adjustments 2A and 2B. If a location can be found in which the instrument performs satisfactorily, remove the panel and adjust by bending the resistor assembly bracket slightly. If no satisfactory location can be found, it is probable that the lower left-hand tube is defective, and a new one, especially selected for this model instrument, should be obtained and tried.

f. Faulty operation will result if a ground exists in the recorder or external meter circuits, since the recorder terminal is grounded in the instrument. Check these circuits if the instrument operates properly when they are completely disconnected at the terminal panel and the meter terminals shorted.

g. As a check on the feedback circuit, including the resistance thermometer connection, and to detect serious departure of the signal amplifier from linearity, adjust the meter to some point up on the scale instead of to zero, by means of adjustment No. 2A. Then open the large door and remove the plug-in resistor from its socket. The meter reading should decrease by exactly one-half.

h. To check the thermostat circuit, turn the power off external to the instrument, and connect an AC ammeter in series with the red lead at the upper terminal panel. It should read about 1/2 ampere when first connected and until the thermostat reaches 50° C., when it should be intermittently interrupted. The lower compartment should feel quite warm after operating for an hour or so.

i. The voltage sensitivity cannot be tested by applying known voltages between input and ground, as the feedback circuit will be bypassed and full-scale deflections produced by less than 1 millivolt, instead of the rated 400 millivolts. A temporary wire may be brought out from the low side of the input resistors and a known voltage, preferably from an L & N potentiometer, applied across the input resistors. The front panel must be replaced and the instrument allowed to warm up for an hour or more before the measurement is made. The true voltage sensitivity will then be indicated.

j. To measure the input resistance the same temporary wire mentioned in (i) may be used. Use a standard condenser with good insulation and known capacitance. Connect the condenser between the temporary wire as the ground side and the input terminal. Keep the wire to the input terminal very short. Charge the condenser such that the meter reads slightly greater than full-scale. Use a timer to time the interval between full-scale reading and .368% of scale. The input resistance R is then given by $R = \frac{T}{C}$ where R is in megohms, T is in seconds and C is in microfarads.

17. SPECIAL PRECAUTIONS IN SERVICING

a. Cable

Use only the recommended cable for best results. Copalene cable may cause drifts and transients due to voltages generated when the cable is moved. The aquadag coating on the polyethylene cable reduces these effects to a minimum.

Fittings should be polyethylene or polystyrene insulated. Clean carefully before using. Do not touch the insulators with the fingers after cleaning.

The cable should be permanently fastened in place wherever practical. This will prevent movement of the cable while in operation and thus prevent errors. Rigid conduit is good.

Probably 75% of the service troubles on these Beckman instruments are traceable to the cable and fittings.

b. Internal wiring

The original rubber cable which runs from the input connector to the switch, then to the grid of the 32E tube has been changed in some cases to polyethylene cable. This is a worthwhile change. Use extreme care in cleaning, and in keeping clean, all parts in the input circuit. Dress signal wiring away from other wires and parts, including the container for the drying agent. If it is necessary to change the input resistors, use as little rosin flux as possible, then clean carefully. Be sure no fingerprints are left to cause leakage. See that the mounting is in proper position when inserted back in the heat shield,that is,when the front panel is replaced.

c. General

We cannot urge too strongly the exercise of extreme care with the instrument in operation and in servicing it. A fingerprint, a wire looped over a metal part, a screw left out, any of these or similar things may cause erratic readings.

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CELL NOISE AMPLIFIER

By: W. R. Woodruff
9/18/44

Since the process in the 205 cells is by remote control, the information normally available to operators through the medium of operational noises is absent. As this information is helpful in carrying out this type of chemical process, steps were taken to transmit these noises from the cell to the operator's gallery.

An amplifier and speaker, built by the Astatic Corporation of Youngstown, Ohio, working off a vibration pick-up microphone were originally employed. All later installations consisted of a Masco amplifier, built by Simpson Company, and a separately mounted University booster speaker, which were found to be more satisfactory.

The Masco amplifier employs a 7C7, a pentode detector amplifier, a 7B4 which is a high mu triode, a 6L6 which is a beam power amplifier. The B+ voltage supply for the amplifier is a conventional B+ supply with choke condenser filter. The full wave rectifier is a 5Y3. The transformer, also supplies 6.3 heater voltage for the set, and rectifier filament voltage of 5 volts.

The signal from the vibration pick-up microphone is impressed on the grid of the first amplifying tube, the 7C7. The amplified signal goes to the center tap of a 0.4 megohm potentiometer, one end of which is grounded. This acts as the gain control. The signal is then passed through a tone control. This control consists of a .005 mfd. condenser and 0.4 megohm variable resistor to ground that will filter out high frequencies. The signal is then passed through the 7B4 to the grid of the 6L6 and, thence, to the output transformer.

To test the amplifier, it is hooked up to a vibration pick-up microphone and checked by tapping the surrounding structure.

The main operational difficulty is that no noise is heard when the amplifier is turned on. The following items should be checked in the following order:

1. Power
   - A. 110 A.C. plug in and power coming to the amplifier.
   - B. Power switch on.
   - C. 5Y3 warm.
   - D. B+ on.

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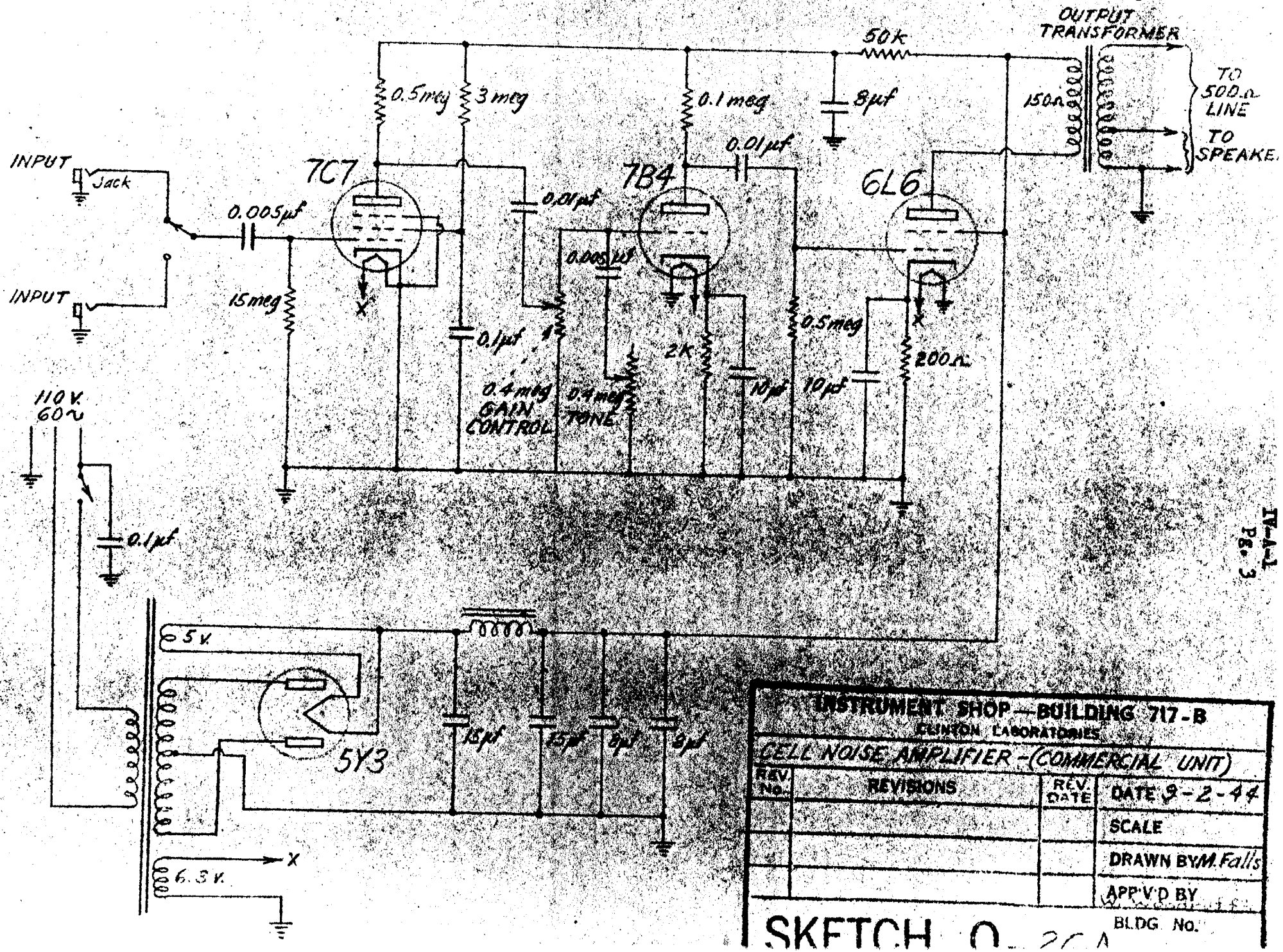
2. Signal
   A. Microphone leads not shorted.
   B. Phone jack from signal leads making contact.
   C. 7C7, 7B4 and 6L6 check good on tube tester.
   D. No broken leads.
   E. Signal leads not interchanged.

[redacted]

[redacted]


INPUT
Jack
INPUT
0.005μf
15meg
7C7
0.5meg
3meg
0.1μf
0.01μf
0.005μf
0.4meg
GAIN CONTROL
0.4meg
TONE
7B4
0.1meg
0.01μf
2K
10μf
50K
8μf
0.5meg
10μf
6L6
200Ω
OUTPUT TRANSFORMER
150Ω
TO 500Ω LINE
TO SPEAKER
110V. 60~
0.1μf
5V.
5Y3
15μf
15μf
8μf
8μf
6.3V.
X
INSTRUMENT SHOP — BUILDING 717-B
CLINTON LABORATORIES
CELL NOISE AMPLIFIER - (COMMERCIAL UNIT)
REV. No.
REVISIONS
REV. DATE
DATE 9-2-44
SCALE
DRAWN BY M. Falls
APP'V'D BY
BLDG. No.
SKETCH

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CLASSIFICATION CANCELLED
DATE FEB 11 6 4
For The Atomic Energy Commission
H. R. Canaan
Chief, Declassification Branch

THE LAURITSEN ELECTROSCOPE

By: W. J. Chelgren
10/11/43

PURPOSE

The Lauritsen Electroscope is a portable, independent instrument that directly detects and measures radiation. It utilizes a quartz fiber sputtered with gold as the indicating leaf. This fiber is uneffected by gravity, and the elastic quality of the fiber is used as the restoring force.

DESCRIPTION

The instrument essentially consists of a microscope to which a small aluminum cylindrical chamber is attached. Inside of the chamber and insulated from it is is a small metal frame with the quartz fiber attached. So that the end of the fiber may be seen through the microscope, a "T" is made by fastening a second piece of quartz fiber to the end of the longer quartz fiber. The fiber can then be seen coinciding with a scale mounted in the microscope. The frame and fiber are charged by pressing a switch which makes contact between the fiber and the frame. Releasing the switch leaves the system in a charged state.

When the system is charged, the quartz fiber is repelled from the frame which is towards the "zero" end of the measuring scale. The fiber will remain in this position until the instrument is placed near a radiation source. Electrons entering the cylindrical chamber will cause ionization in surrounding air. The ions in the air are attracted to the fiber, tending to neutralize its charge. The fiber then moves up the scale towards its original "uncharged" position. The rate of travel of the fiber across the scale in divisions per minute is a measure of the ionization current. The ionization current in turn is a measuring of the incoming electrons from the radiation source.

OPERATION AND USE

Connect the wires from a charging source to the red and black buttons on the instrument. The charging voltage is 250 volts. A vacuum tube power pack, a set of "B" batteries, or a friction charger may be used in charging the instrument. When using the vacuum tube power pack or a set of "B" batteries, a one megohm protective resistor must be placed in series with each side of the unit to protect the charging switch.

[redacted]

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To charge the unit depress the red button as far as it will go towards the aluminum can. Releasing the button will isolate the quartz fiber with its electrical charge. When thus charged, the fiber will be at "zero" on the scale of the instrument. In the normal, uncharged position, the fiber is slightly off scale to the right.

To bring the fiber into correct focus, loosen the thumb screw on top of the microscope tube. Looking through the telescope, move the thumb screw back and forth until the position is found putting the fiber into best focus. Tighten the thumb screw at that point.

In measuring radiation, start a stop watch at the moment the charging button is released. At the end of one minute, note and record the deflection of the fiber on the scale. This reading will then be a measure of the radiation present. There is a normal "background" discharging of the instrument due to cosmic and other stray radiation. This background amounts to approximately three divisions per hour. For a correct reading, the background should be deducted from the actual reading.

CALIBRATION AND SENSITIVITY

The sensitivity of the Lauritsen Electroscope is stated in Scale Division Per Minute Per Millicurie at One Meter.

For use here in the plant, these electroscopes will be calibrated in Roentgens or fraction of Roentgens. To do this each instrument will be calibrated using a standard radium source at a standard distance.

On a representative electroscope, the sensitivity is given as: 2.2 division deflection per minute for one millicurie of radium at one meter distance. We want to convert this reading to roentgens per eight hour day to give us a more usable figure.

Now 1 millicurie of Radium = 8.6 r/hr at 1 cm.

$$= 8.6 \times \frac{1}{100^2} \text{ r/hr at 1 meter}$$

$$= \frac{8.6}{60} \times \frac{1}{100^2} \text{ r/min at 1 meter}$$

$$= 1.43 \times 10^{-3} \text{ r/min at 1 meter}$$

Since 1 millicurie = 2.2 division/min. at one meter

2.2 divisions/min. = 1.43×10^{-3} r/min.

1 division/min. = $\frac{1.43}{2.2} \times 10^{-3}$ r/min.

[redacted]

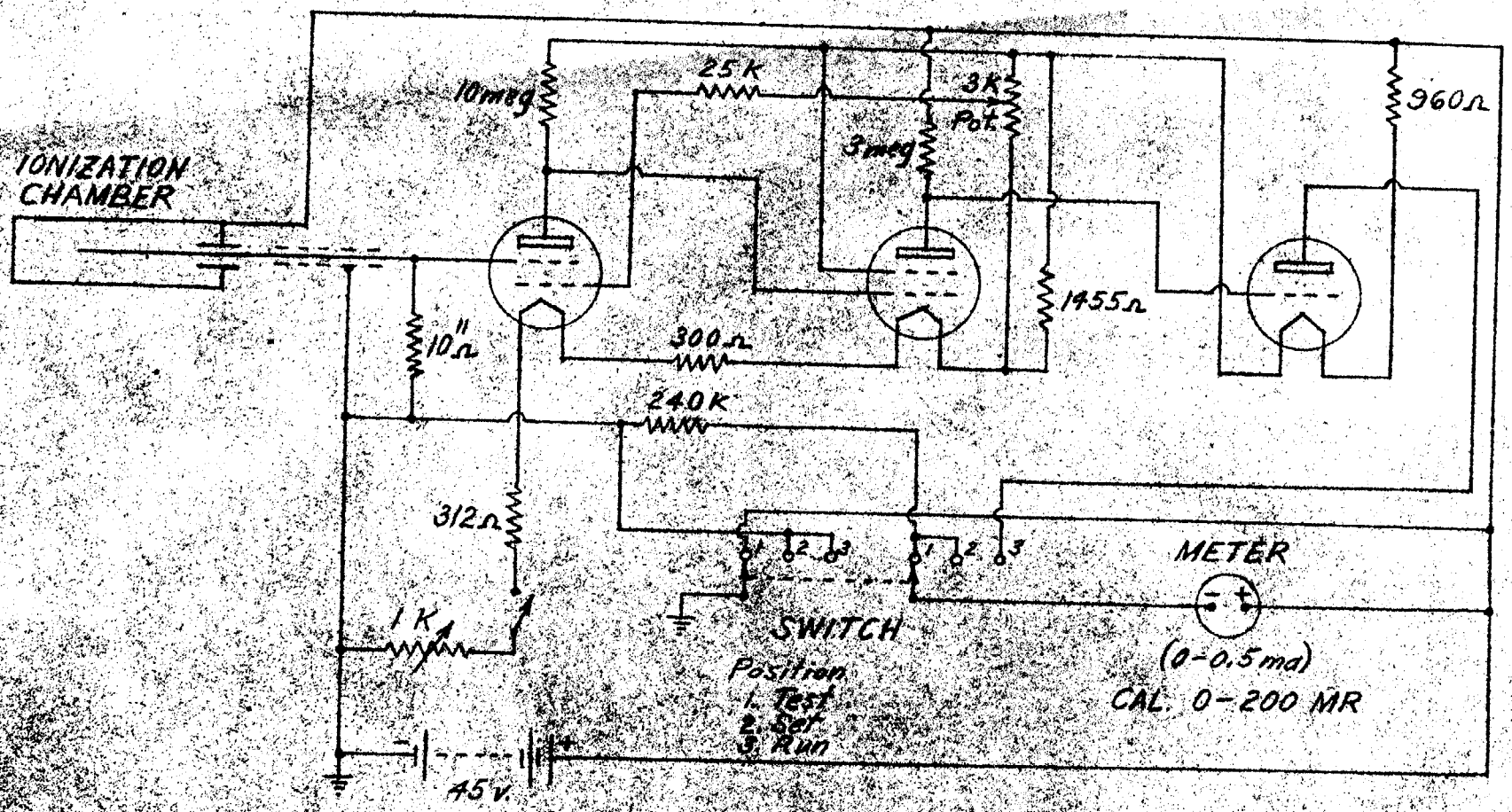
= 0.00065 r/min.

= .312 r/8 hr day

CARE

While this instrument is unusually rugged, simple care should be exercised in its handling. Sudden turning or jarring may tangle the quartz fiber around the frame. If the fiber cannot be brought into view by the normal charging procedure, the fiber is usually tangled, and the instrument should be repaired.

The aluminum cylinder should never be removed from the instrument. In so doing, the quartz fiber may be bent, the gold coating may become broken, or dust may be admitted into the chamber, all of which are undesirable.



INSTRUMENT SHOP — BUILDING 717-B CLINTON LABORATORIES		
VICTOREEN SURVEY METER		
REV.	REVISIONS	REV. DATE	DATE 10-11-44
			SCALE
			DRAWN BY M. Falls
			APP'V'D BY
SKETCH O-228			BLDG. No.

This document consists of 2 pages and 1 figures.
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ALPHA "PLUTO" SURVEY METER

By: W. Ragan
9/18/44

The Pluto was developed at the Metallurgical Laboratory and has since been produced by Hallicrafters in Chicago and the Clinton Laboratories Instrument Shop.

This instrument was developed and produced for the purpose of checking alpha contamination, primarily on table tops. Due to large counting rates encountered in spillage, individual particle counting is unnecessary. A D.C. Amplifier and Chamber can be used. The Volume of the Chamber can be small because added depth of Chamber produces no increase in ionization, since alpha range is small. Increased area is also useless because spills are small and the localizing effect of small chamber area is a useful feature.

Due to the qualitative use of the instrument it is not important that it have extreme stability. Speaking from a health standpoint, the value of the Pluto is that of a qualitative contamination locator. It should not be relied upon to determine tolerance from its readings.

CIRCUIT OPERATION

A 959 tube and a 1A5 tube, when connected as shown in Sketch Q-181, has a voltage sensitivity of approximately 0.5 volts for full scale deflection of the meter. With a chamber attached and using an input grid resistor of 2×10^{11} ohms, the ionization current from a sample which counts 6000/min. in a standard chamber produces about half-scale deflection. Fluctuations produced by bending of the Chamber screen should kick the meter but the meter will restore when capacitance remains constant. Random fluctuation indicates improper operation usually associated with the 959 tube.

The potentiometer on the screen of the 959 tube is adjusted so that the meter reads "0". When alpha particles enter the chamber, ionization occurs and a positive signal is impressed on the suppressor grid of the 959. This will cause the 959 to conduct more and, hence, drops its plate voltage making the control grid of the 1A5 tube more negative causing its plate current to decrease; therefore, its plate voltage rises and a voltage is impressed across the meter; current will now flow through the meter causing it to read up scale.

[redacted]

[redacted]

[redacted]

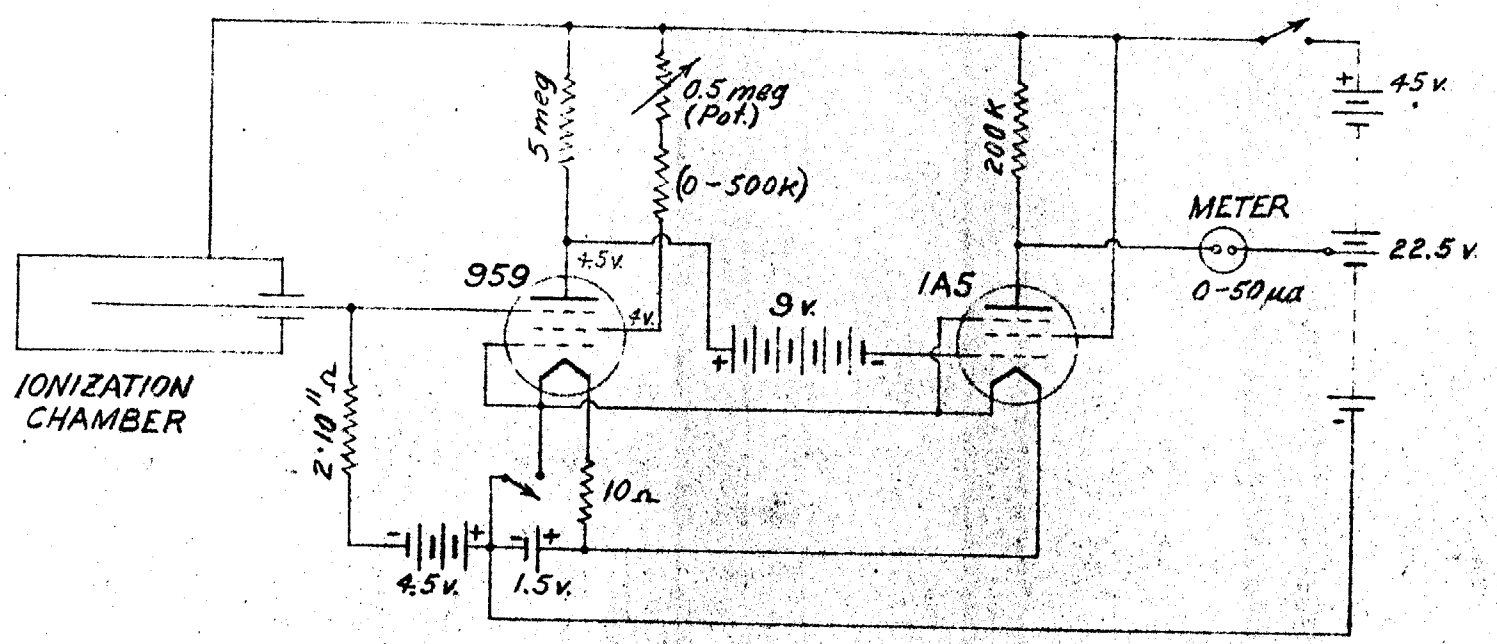
MAINTENANCE

Many troubles are caused in the Pluto by the improper opening of the instrument. The Hallicrafter's model should be opened by removing only the hex head screws along the lower edge of the instrument. Do not remove the screws underneath the cabinet because these screws hold the batteries and component parts in the chassis. The Clinton Laboratories' model should be opened by removing the screws along the top edge and then the top is turned straight back pivoting about the edge nearest the meter until the top rests on the handle. Do not pull straight up because the cable is attached to the top and also to the chassis.

The point causing most trouble is the input of the 959 tube. High grid current will render it impossible to zero the set with a high input resistor such as the 2×10^{11} ohms. If the 959 emission is either high or low, the bias conditions prescribed are not satisfactory and the set cannot be zeroed. Altering the 1A5 grid bias can frequently be used as a means of bringing it into a usable condition. In checking for trouble, the cathode to plate and cathode to screen voltages of the 959 measured with a Junior Volt-Ohmyst are very useful since they are both to be in the order of + 4 volts. The 1A5 grid to cathode voltage should be approximately - 5 V. Adjusting this by changing the 9 V. bias battery has cured many troubles.

Extreme care should be taken in handling the waxed 959 and the input resistor. The input lead to the 959 suppressor grid must be supported only at the 959 pin and the polystyrene insulator leading to the chamber.

Photosensitivity of the 959 makes it necessary to perform all tests on the circuit with a high input resistor with the case closed. Shorting the input resistor makes it possible to check the circuit with light shining on the 959.



INSTRUMENT SHOP—BUILDING 717-B CLINTON LABORATORIES			
ALPHA SURVEY METER (PLUTO)			
REV. No.	REVISIONS	REV. DATE	DATE 6-12-44
			SCALE
			DRAWN BY M. Falls
			APP'V'D BY
SKETCH Q--181			BLDG. No.

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[redacted]

PORTABLE 959 SURVEY METER

By: W. Ragan, Jr.
9/27/44

The first survey meter of this type was nothing more than a paint pail attached to a bread board chassis. This model was followed by two different models. Both were in lucite housings, the only difference being that the first had only one input resistor and the second has three sensitivity ranges.

The 9" x 9" chamber is too large to measure small beams or sources close by accurately. The 10 to 20 sec. response times on the 20 mr/hr sensitive scale, handicaps the instrument for scanning. Reproducible results and linearity up to 1500 mr/hr, however, make this an excellent instrument for many applications. Usable readings up to 6400 mr/hr can be obtained.

The small rate of drift of this instrument makes it desirable for use where time is not available for frequent zero setting. Its 20 sec. warm up period insures an instrument ready for emergencies, as well as saving valuable time.

In order to reset zero in a radiation field, switch the "H.V." into the "OFF" position and wait for the meter to stabilize and reset zero. This procedure can be done very quickly if the zero check is made on the low sensitivity range of the instrument, since the time required for stabilization of the collecting electrode potential due to capacitative effect of switching the "H.V." either "ON" or "OFF" is 100 times shorter on this range than on the most sensitive range.

CIRCUIT OPERATION

The circuit when connected as shown on Sketch Q-66 will operate as follows: Switch the "Fil. Check Switch" to the "Oper." position and turn the "Fil." and "H.V." on, and adjust the 50 K potentiometer till the meter reads zero. When radiation enters the chamber causing ionization, a positive signal is placed on the suppressor grid of the first 959 tube, it's plate current will increase thereby dropping the voltage at the plate and a voltage is impressed on the meter causing current to flow through the meter and making it read up scale.

Both 959 tubes used should have approximately the same conductance for proper operation. The reason for the two 959 tubes is to nullify the effect of changes in battery conditions.

[redacted]
unauthorized person is prohibited by law.

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The voltage sensitivity of this instrument should be approximately 1.5 V. for full scale deflection. In order to observe grid current, switch from one sensitivity range to another, if there is no appreciable grid current, the meter will not change over two or three divisions between each range. Grid current will naturally show up between the two most sensitive ranges.

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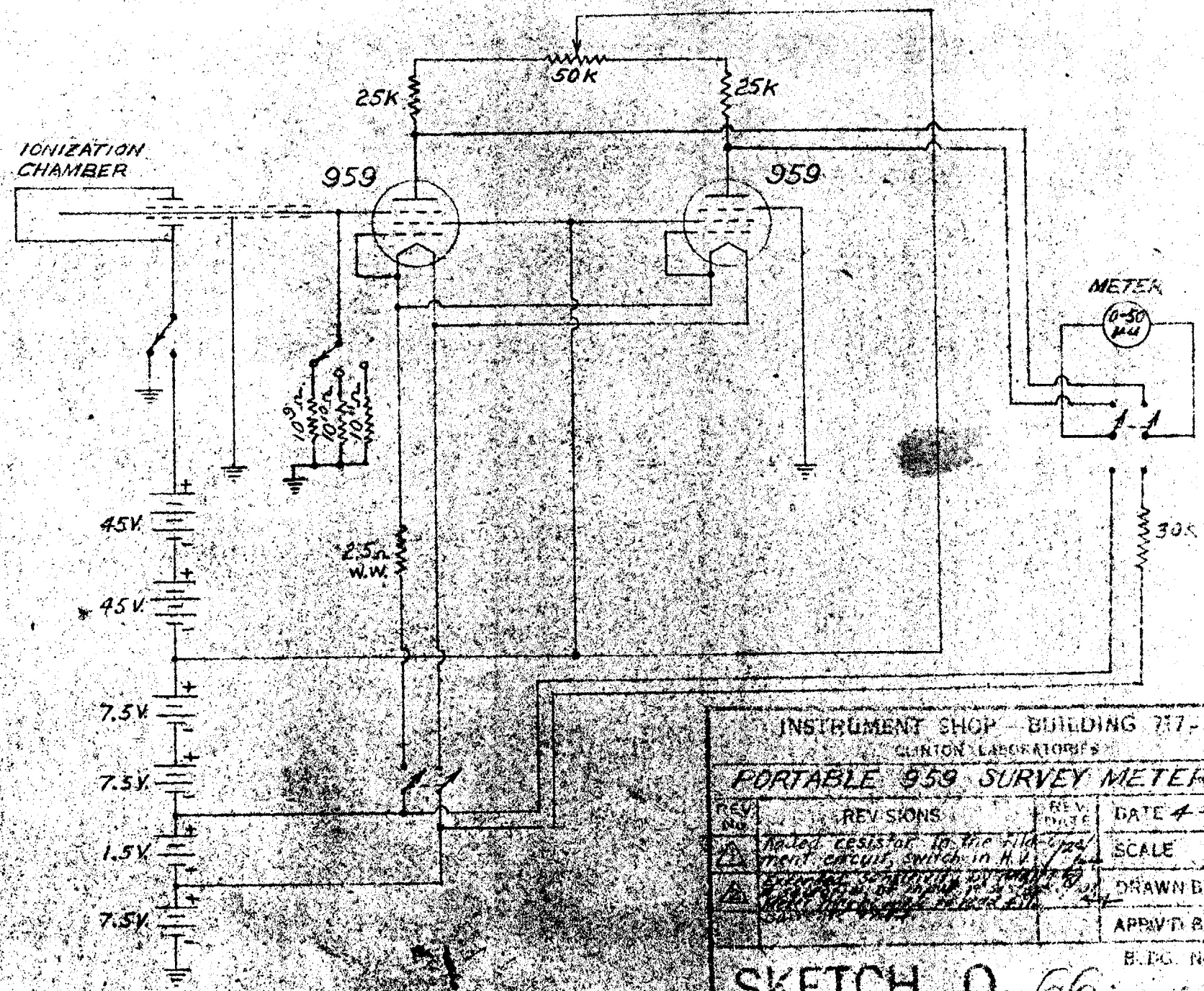
IONIZATION CHAMBER
959
959
25K
50K
25K
METER
0-50 μa
30K
45V.
45V.
7.5V.
7.5V.
1.5V.
7.5V.
2.5Ω W.W.
10Ω
10Ω
10Ω
INSTRUMENT SHOP BUILDING 737-B
CLINTON LABORATORIES
PORTABLE 959 SURVEY METER
REV. No.
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REV. DATE
DATE 4-22-44
SCALE
DRAWN BY M. Falls
APPV'D BY RWH
BLDG. No.
SKETCH Q-66

CLASSIFICATION CANCELLED
DATE FEB 14 1964
for The Atomic Energy Commission
Declassification Br

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CUTIE PIE

By: C. O. Ballou
8/17/45

[redacted]

"Cutie Pie" is a portable survey meter sensitive to beta and gamma radiations. The amplifier circuit has a full-scale voltage sensitivity of .25 to .30 volts. The radiation sensitivity is approximately 0-50, 0-500 and 0-5000 mr/hr on the three ranges. Each instrument must be calibrated to determine accurately its full-scale radiation sensitivity.

It consists of the following electrical components:

1. A combination beta and gamma chamber.

2. A current amplifier consisting of one Victoreen V-32 tube with appropriate switching and input resistors. This portion of the circuit is vacuum enclosed to reduce leakage and spurious response.

3. A 20 microampere indicating meter and four batteries.

I CIRCUIT

The single Victoreen tube is the only electronic amplification used. It is operated with $7\frac{1}{2}$ volts on the plate, and another identical battery (W5BP Burgess) is used to obtain both bias voltage and meter balancing current. When the meter is balanced, the current drain from both the B and C batteries is the same. Consequently, the two batteries should run down at the same rate and should be replaced at the same time.

II BATTERY REPLACEMENT

B and C batteries should be replaced when their voltage drops to 7 volts or less. These batteries should last at least 600 operating hours; probably a year in intermittent use. To replace the B and C batteries, remove the A battery and the 45 volt hearing aid battery.

[redacted]

To remove the A battery, rotate the container cap to release the bayonet pins and remove the battery from the container. In removing the batteries do not complete an electrical circuit thru your hands between the battery and the case of the instrument. To complete such a circuit, even thru the high resistance of your hand, will pass

[redacted]

sufficient current thru the meter to damage it or even burn it out.

After removal of the A battery, the 45 volt hearing aid battery should be removed by rotating it against the vacuum enclosure and lifting it from the front of the case. Remove the connector from the battery. Until both the A and the 45 volt batteries have been removed and disconnected is all danger of meter burn out eliminated. [redacted] Remove the A battery container by removing the 8-32 screw projecting outside of the case.

The B and C batteries can now be easily disconnected for replacement. Reverse the above procedure for installing the 45 volt and $1\frac{1}{2}$ volt batteries, again being careful of completing a circuit to the case of the instrument thru the hands.

The A battery should be replaced when it reads 1.4 volts or less. The 45 volt battery should last between one and two years but should be replaced when it reads 42 volts or less.

III ELECTRICAL TROUBLES

Troubles, other than battery replacement, will probably be found in high resistance leakage of the 93-C connector and/or the glass Kovar connector on the tube compartment. Leakage at either of these points will manifest itself in causing the meter to read up-scale when the selector switch is changed from the "0" position to the 10^{11} position. To correct such leakage, the insulators must be completely and thoroughly cleaned. Carbon tetrachloride is preferable for cleaning the glass insulator, but will damage the polystyrene in the 93-C connector. Alcohol is the only solvent that can be safely used on polystyrene.

Make certain that such solvents are clean and not contaminated with other chemicals before using them. Do not contaminate the bottles by handling the pouring lips or by pouring any used liquid back into the bottle. It is much better to dispose of used solvents than spend hours trying to correct a supposedly clean insulator with circuit changes.

The 20 microampere meters used in this instrument are fragile instruments. They are wound with #60 wire only .001" in diameter. They will safely stand about ten times their current rating of 20 microamperes but will fail with much more than one milliampere passing thru them.

Meter failure is indicated when the meter will not read below zero when the instrument is first turned on. [redacted]

Other electrical troubles will probably be a short or grounded connection at the battery lugs, potentiometer lugs or tube chamber lugs. It is also possible, due to shock or a fall, to

bend components in the tube compartment and establish a short circuit.

IV TUBE COMPARTMENT

The tube, switch and resistors are in an evacuated compartment. This has been found to be the only satisfactory way to prevent surface leakage, particularly during moist weather.

It has also been the only satisfactory way to eliminate spurious response. Spurious response manifests itself by giving instrument readings when the chamber is disconnected or when the selector switch is in the zero position, with the instrument in a radiation field.

In the Cutie Pie, the enclosure is at 54 volts positive with respect to the grid of the tube. If air is in the compartment, it will be ionized when subjected to radiation. The grid and associated wiring will collect the ions and produce a reading on the meter. If the air is removed from the chamber, no ionization can occur and no meter response is obtained. Consequently, it is possible to determine if air has leaked into the enclosure. Place a 10 mg. Radium source against the cabinet, or if the cover plate is off, against the enclosure itself. With the input switch in the zero position, no deflection of the meter should be observed. If any deflection is obtained, the enclosure should be evacuated.

To evacuate the chamber, remove the cover plate which will expose the valve. The valve screw should be backed off about two turns with an Allen wrench. Connect the vacuum line to the opening through the bottom of the case and pump until 29" of vacuum is obtained.

If it is not possible to obtain 29" of vacuum, it is probable that the valve screw is leaking. This can be remedied by the application of a small amount of Apezion stop-cock grease to the threads of the screw. On new units or units which have been opened, pumping for an hour or so may be required to evaporate all moisture from the components.

V REMOVAL OF TUBE

The tube should give several thousand hours of service. Replacement of the tube requires complete disassembly of the vacuum compartment.

Remove the A battery, its container, the 45 volt battery, and the B and C batteries. Remove the index knob and the hexagonal nut on top of the case. Unsolder the leads to the 93-C connector. Swing the compartment toward the front of the case and remove it as far as the leads will permit. Disconnect the four leads and remove the compartment.

OFFICIAL USE ONLY

Release the vacuum by opening the valve. Remove the 6 screws which hold the two bulkheads in place. If the vacuum is not released before removal of these screws, the amplifier unit may be sucked down, breaking the tube, resistors and switch.

Heat the unit with a gas flame around the central bulkhead sufficiently to soften the Picien wax and then pull the unit out of the enclosure.

Handle the unit in such a way that the switch and resistors are not contaminated by handling. If the switch should in any way become contaminated with finger marks, soldering rosin, or acid, it should be thoroughly cleaned with first, G. E. Thinner, No. 1500, and after complete drying, it should be immersed in carbon tetrachloride.

There is no such thing as a chemically clean surface, although such a surface is desirable. Some approximation can be obtained by repeated dilutions of contamination by repeated washings in solvents which are renewed for each washing. The G. E. Thinner (probably Xylol) will disolve rosin and stearic acid found in soldering compounds. It is also a powerful solvent for organic oils and waxes such as are found in perspiration. Carbon tetrachloride and alcohol disolve organic chemicals found in perspiration and soldering chemicals.

The evacuation of the switch and tube surfaces contributes to the elimination of leakage from moisture, but does not eliminate leakage due to dirty or poor workmanship.

VI REPLACEMENT OF TUBE ASSEMBLY

Warm the compartment with a flame sufficient to soften the wax. Insert the tube and index assembly and align the screw holes and terminals. Replace the screws which hold the bulkheads in position.

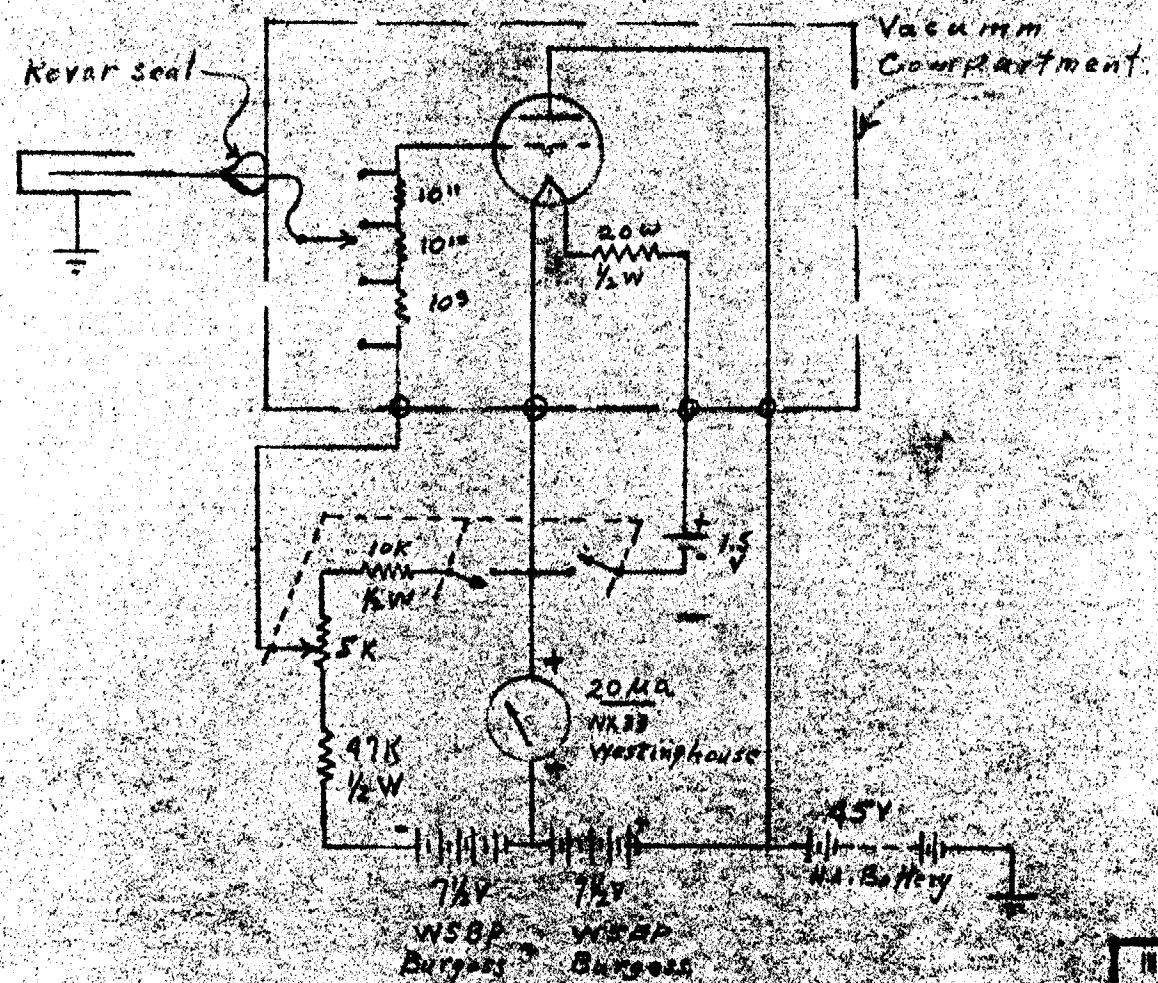
Heat the compartment quite hot so as to get the Picien wax into a semi-fluid condition. Make certain that the wax wets the surfaces of the compartment and bulkhead. Also make certain that the screw heads are wetted and sealed with wax. When the chamber has cooled so that the wax is still plastic it should be placed on a vacuum line to pull the plastic wax into small leaks.

The seal around the shaft is Neoprene tubing. Under ordinary conditions this material will out live the rest of the instrument. However, if it should become punctured or leaky, it should be replaced. To remove the old piece, take the two 4-48 nuts off the top of the indent mechanism. Cut the two banding wires around the Neoprene tube and pull on the indent mechanism; the tube will stretch and come off the shaft or bushing.

OFFICIAL USE ONLY

Cut a piece of 1/4" tubing to $1\frac{1}{4}$" length and slide on the shaft of the indent mechanism. Seal with Picien wax and heat, then band with a piece of #20 copper wire (hook up wire) about 1/16" to 1/8" from the indent plate. Work a small amount of Lubriseal grease between the tube and shaft. Place the indent mechanism in position and start the shaft through the brass bushing. Make certain that the shaft key is in proper position to enter the slot in the ceramic wafer. Also make certain that the contact arm is wiping through the contacts connected to the Hi-meg resistors, when the indents are properly located. Push the indent mechanism down, rotating the shaft slightly in each direction, so that the shaft key will enter the ceramic wafer without breaking it. This will also work the Neoprene tube onto the 3/8" tapered bushing. Replace the 4-48 nuts. Apply Picien wax to the Neoprene tube and 3/8" bushing, heat the wax and bulkhead to obtain a seal and band with wire. Do not over heat or else the Kovar seal, bushing, and wires may come unsoldered.

In closing, it should be pointed out that considerable trouble has occurred in the past, due to grid to plate leakage of the V-32 tubes. It is recommended that these tubes, after solvent cleaning, be immersed in hot ceresin wax. This eliminates surface leakage sufficiently to permit measuring the internal leakage of the tube. This leakage path can be rapidly checked by twisting the filament and plate leads together and clipping to a lead connected to the ground side of the Megohmeter. The grid lead should then be touched to the R_x terminal. Leakage any worse than 10^{12} ohms makes the tube unfit for use as an input tube. 10^{13} ohms is desirable but tubes this good cannot always be found.



INSTRUMENT SHOP - BLD'G 717B
CLINTON LABORATORIES

"Cutie Pie" #2

SCALE: None | DATE: 5-10-45

COB D'WN | COB C'K'D | COB APP'D

SKETCH NO Q-319-B | BLDG. NO. 717-B

A STUDY OF "CUTIE PIE"

Submitted by: H. B. Frey, Jr.
Approved by; R. L. Quinn
9/16/46

The object of this report is to summarize an investigation of Victoreen tubes type VX-32 as they are used in "Cutie Pie" portable beta and gamma radiation measuring instrument. It was suggested that specially selected tubes could be purchased from the manufacturer if such a request would be justified.

The difficulty encountered is that of maintaining the required sensitivity on the most sensitive range of the instrument, while at the same time keeping the construction and maintenance costs at a minimum. The Health Physics Division wants a sensitivity of at least 50 mr/hr full scale in order that a tolerance of 12.5 mr/hr can be read with some degree of confidence. This requirement can be met by closer control of the circuit elements. Two components which show the widest variation are the 10^{11} ohm resistor and the VX-32 tube. These two parts are also the ones that determine the gain of the circuit.

The "Cutie Pie" is built around a single triode, type VX-32. A 7.5 volt plate battery is used with a 1800 ohm, 0-20, microammeter on the filament side of the battery as a load. The tube normally draws between 100 and 160 microamperes of plate current, most of this, however, bipassing the meter through a bucking circuit connected across the meter. Bias for the grid is also supplied by the bucking circuit (see ref. 1). With the instrument switched to its most sensitive range, a 10^{11} resistor is positioned between the bias portion of the bucking circuit and the grid of the tube, the grid also being connected to the center electrode of the associated ionization chamber. The outer electrode is grounded. The positive side of a chamber voltage source is grounded, and the negative side is connected to the plate of the triode.

Radiation causes chamber to be drawn through the 10^{11} resistor in the grid circuit, thereby causing the grid to become more positive and plate current to increase.

The grid resistors in use at the present time are Victoreen Hi-meg Vacuum Sealed Resistors. They are inclosed in a glass tube with pig tail leads projecting from each end. All high value resistors, however, are sensitive to temperature, humidity, voltage, and dirt. Eight 10^{11} resistors picked at random were measured, and their actual values were found to vary by as much as 25% from those marked on the resistor. A 15% change was measured from a

rainy day to a clear day in the same resistors. It is therefore difficult to measure and select certain ones before installing. Heat from a soldering iron while connecting adjacent parts can change the resistance of a unit after it is mounted. We are forced to assume, therefore, that a resistor purchased as 10^{11} ohms may actually be as low as 0.75×10^{11} ohms in the circuit.

According to ref. 2 the "Cutie Pie" circuit was intended to operate with an 864 cc ionization chamber producing 4×10^{-12} amperes with 50 mr/hr radiation, but the chamber actually used has only 662 cc volume. Therefore by volume calculations only 3.1×10^{-12} amperes can be expected. One chamber was tested and found to produce 0.9×10^{-12} amperes with 12.5 mr/hr radiation, or approximately 3.6×10^{-12} amperes with 50 mr/hr. Since volume calculations can not always be depended upon and chambers are quite uniform, it seems safe to assume that at least 3.3×10^{-12} amperes will be produced with 50 mr/hr radiation.

A minimum grid signal of 3.3×10^{-12} amperes $\times$ 0.75×10^{11} ohms = 0.25 volts should be available with 50 mr/hr radiation, requiring an actual tube gain of 80 micromhos. When the instrument was originally designed the tube was found to have a gain of 80 micromhos with -1.0 volt bias (see ref. 3). According to characteristics established by Victoreen Instrument Co., grid current on the type VX-32 passes through zero at about -1.3 volts. This current, however, does not seem to be objectional in "Cutie Pie" until the grid voltage is less than -0.75 volts. It is therefore suggested that the triodes be operated with a grid bias of -1.1 volts, allowing the signal to reduce this to -0.85 volts. The gain of the circuit is too low with a higher bias. With a lower limit of 80 micromhos in the circuit, about 75% of the VX-32 tubes received are expected to be satisfactory for use in "Cutie Pie".

APPENDIX

TESTER

A test was requested which would indicate tubes acceptable for satisfactory operation of the instrument. A modification of the "Cutie Pie" circuit as in the attached diagram can be used as a tester. First adjust filament current to the maximum available, as this is a condition under which the tube will be operated. Current should not be less than 10 milliamperes. Second, note the difference in plate current between grid voltages of 0.85 and 1.1. Plate current should change 20 microamperes or more, less than 20 microamperes (80 micromhos) indicating insufficient gain. Third, leakage and grid current can be checked by setting the grid voltage to 1.1 and noting any difference in plate current when a switch shorting the grid resistor is opened and closed. Allow

time for the current to settle down when the switch is open. A good tube will have no noticeable change in plate current, as much as one microampere indicating excessive grid or leakage current.

RELAY

It is an interesting fact that little protection is being offered by the use of a Victoreen VX-10 thermal relay as shown in ref.1. These relays are rated at 12.5 milliamperes maximum heater current, and they are drawing about 24 milliamperes in the circuit shown. After one or two hours of service the heater element burns out and the contacts freeze closed. This condition can be remedied by placing 80 ohms in series with pin 4 as shown in the Tester circuit. It is, however, doubtful whether any relay is required when the Victoreen tubes are operated in such a low gain circuit. The cost of the instrument would be reduced by $12.50 if the relay were eliminated.

RESISTOR CHART

In order to maintain the correct grid bias and bucking current, it is suggested that the attached chart be used for selecting resistors "A" and "B" in ref. 1. On the graph, I_p is the plate current indicated on the tester with 1.1 volts on the grid of the tube and maximum filament current. Using resistor values from the chart, the meter on "Cutie Pie" should zero with the 5000 ohm potentiometer at midscale and the grid of the tube at -1.1 volts. The resistance of "B" will be found to be more critical than that of "A".

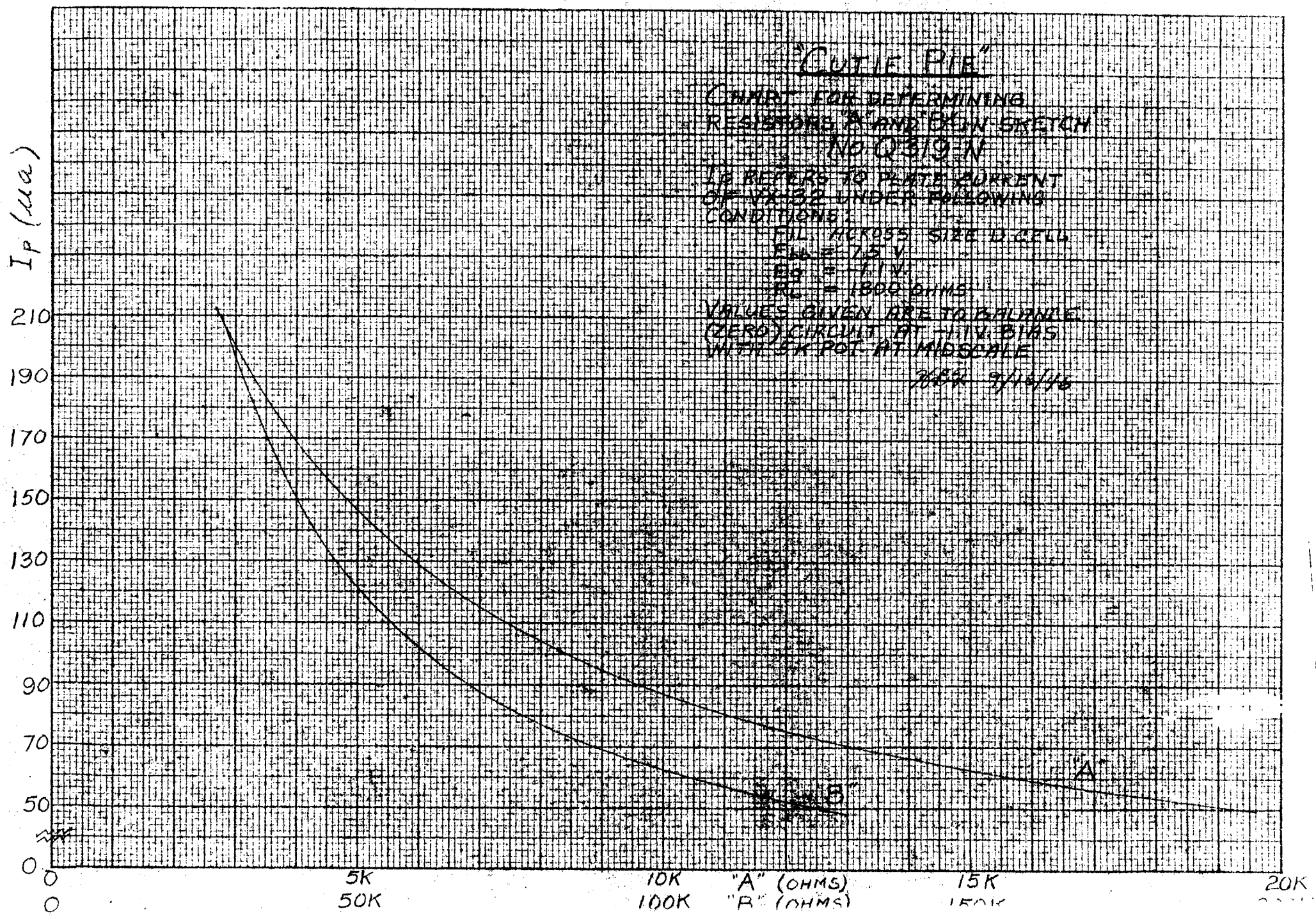
References:

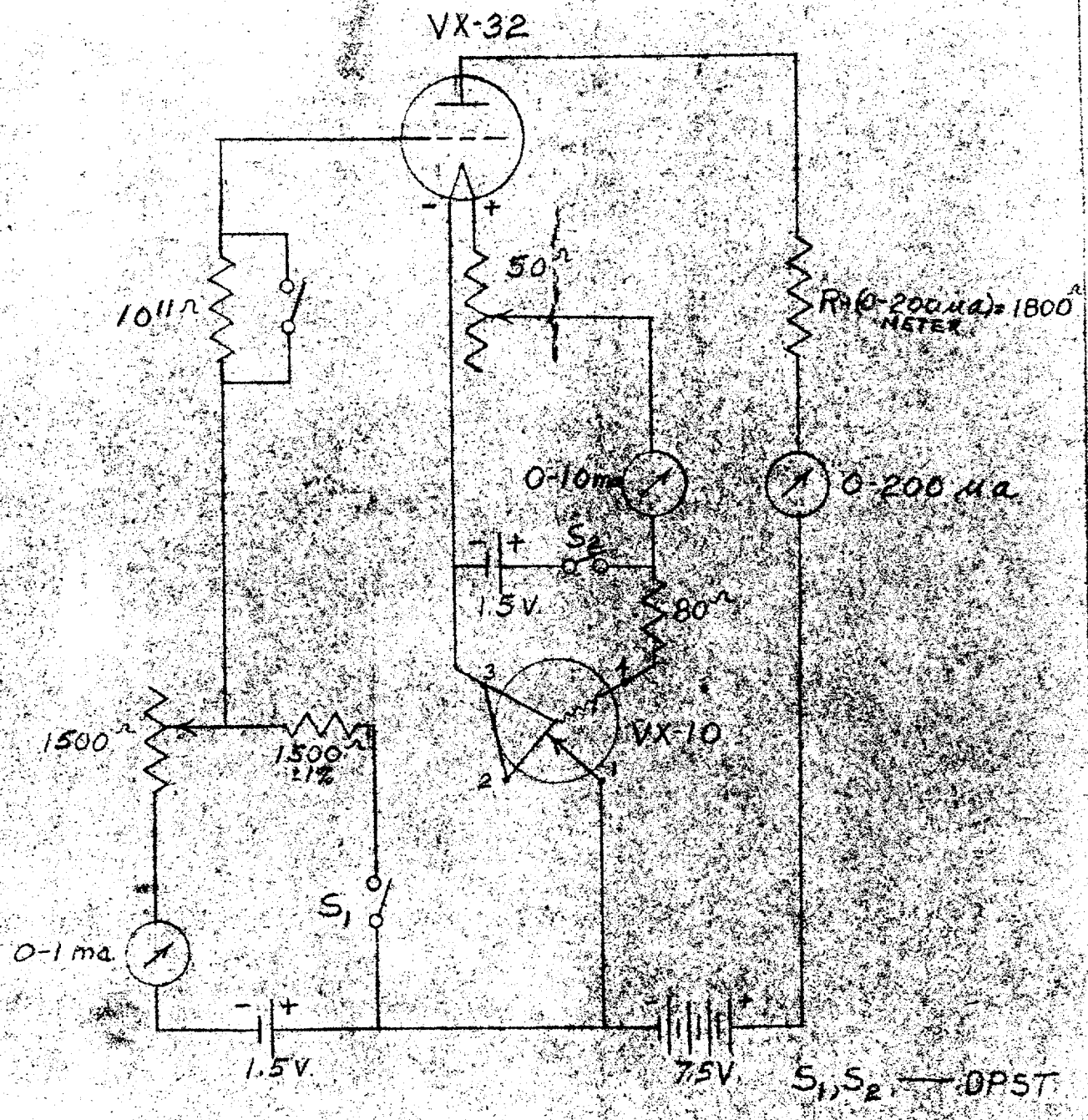
1. Sketch No. Q-319-N

2. Report Mon P-19, "Cutie Pie", 9/22/45

3. C.O. Ballou's Notebook, CL 344

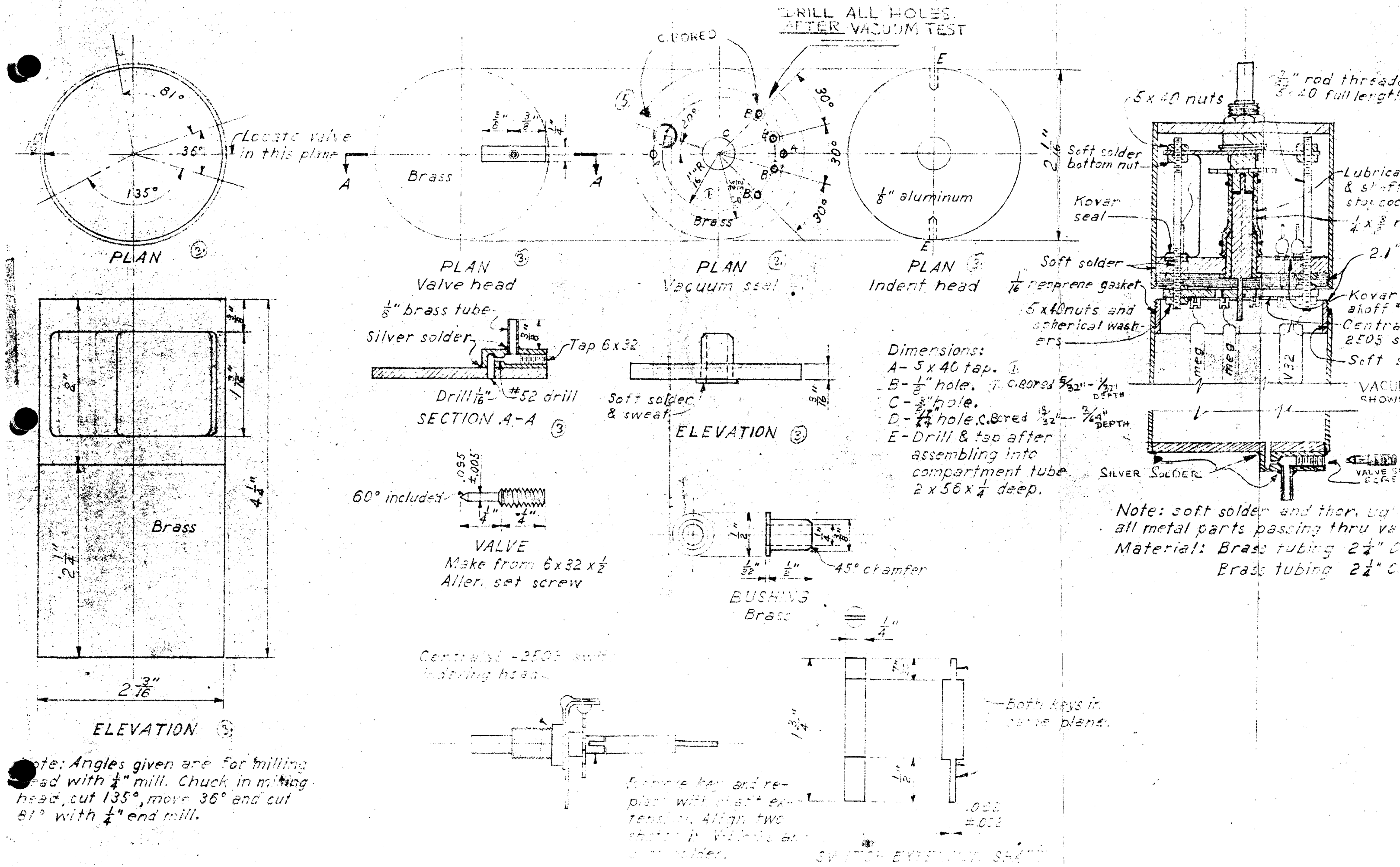
KEUFFEL & ESSER CO., N. Y. NO. 359-11
10 × 15 to the ½ inch, 6th Block accented.
Engraving 7 × 10 in.
MADE IN U.S.A.



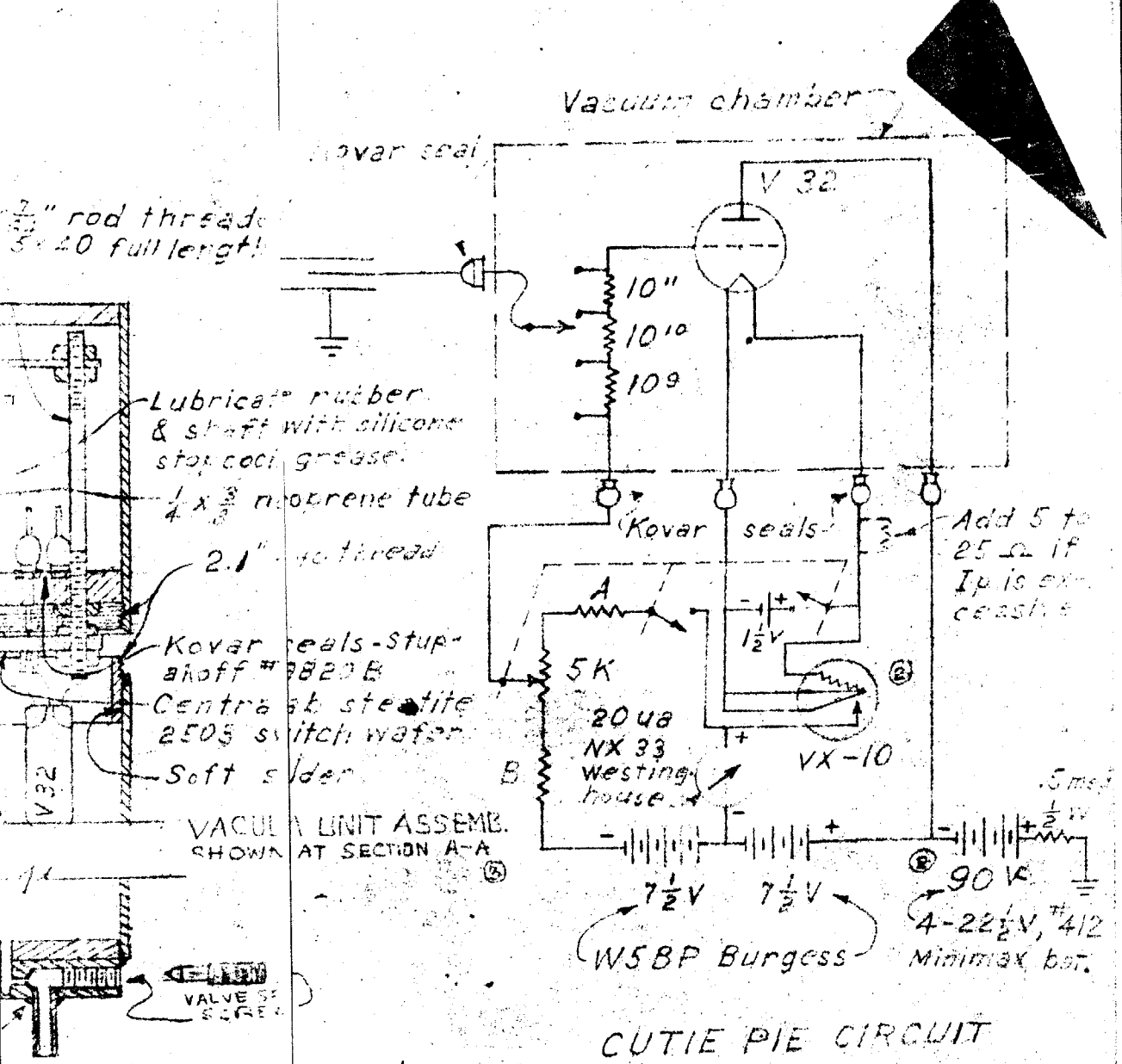


INSTRUMENT SHOP — BLDG 7173 CLINTON LABORATORIES		
VX-32 TUBE TESTER		
SCALE: NONE	DATE: 9-18-46	
H&F D'WN	C'KD	APP'D
SKETCH NO. Q 472-A	BLDG. NO.	

HBF 9/16/46



Note: Angles given are for milling head with 1/4" mill. Chuck in milling head, cut 135°, move 36° and cut 81° with 1/4" end mill.



REVISION--APPROVAL--DATE	NO.
1-7-46	1
2-4-46	2
3-15-46	3
	4

INSTRUMENT SHOP -- B'LD'G 7170
CLINTON LABORATORIES

CUTIE PIE CIRCUIT & VACUUM UNIT

SCALE: Full | DATE: 9-26-45

D'WN | C'K'D | APP'D

SKETCH NO | BLDG. NO

CRITICAL OPERATIONS IN THE ASSEMBLY OF THE CUTIE-PIE

12/23/46

ASSEMBLY OF "CUTIE-PIE" IONIZATION CHAMBER

All references to items refer to parts as numbered on Drawing D-1749.

1. The .001" pliofilm is cemented to surface "Y" on plug (Item 2) using a solution of Apiezon "W" wax in benzene. After a drying time of thirty minutes, the surface "Z" of the plug is coated with aquadag as well as the side of the pliofilm which will face the inside of the chamber. An area of about one-half an inch is left uncoated around each of the tapped holes in surface "Z".

The housing shell (Item 1) is aquadaged on the inside, leaving a half inch area around each of the screw holes with no aquadag. An aquadag coating is also placed on the chamber electrode (Item 8), being sure to have a good electrical connection from the plastic rod to the adjoining brass nut.

Aquadag is applied on the roughened surface "A" to "B" on chamber insulator (Item 7), leaving a one-half inch around the three 4-40 holes. The coating is placed to the edges of the #27 holes.

Parts are then assembled as shown in sketch of assembly on Dwg. D-1749.

2. Before assembling the selector switch, and the components that are mounted on it, the following things must be done:

A. Clean the ceramic switch deck thoroughly with xylene cleaner using a small clean brush. Shake excess cleaner from switch deck, taking care not to touch any part of the ceramic deck with the hands. Hold the selector switch by the shaft in a vertical position and immerse in clean ceresin wax at 130°C. Immerse switch into wax just far enough to cover the ceramic deck and allow switch to remain in the wax until all air and moisture have been driven from the ceramic deck. Air and moisture are indicated by small bubbles leaving surfaces of ceramic deck. Remove switch from wax and shake off surplus wax. Allow to stand on clean surface, shaft up, until wax hardens.

CAUTION: At no time during this operation, should the

switch deck be touched by the hands or any object that might leave dirt, lint, metal particles, etc., imbedded in the wax coating.

B. Solder tube and resistor support (Item 14) in place on switch. Solder Victoreen resistors (Items 20, 21, 22) in place and fasten Victoreen VX-32 tube (item 23) in place with small rubber band. Clean all Victoreen resistors and brass support with xylene cleaner and small brush. Shake off excess cleaner, then paint coating (approx. 1/64") of ceresin wax on all surfaces of brass supporting rod, Victoreen resistors, and VX-32 tube.

CAUTION: When cleaning resistors and rod, hold assembly in vertical position so cleaner does not run down on waxed switch deck. Do not touch VX-32 tube near base where element wires come out.

3. Before mounting the ionization chamber (item 1-8) on the case, the following things must be done:

A. Remove insulator (Item 7) from bakelite chamber. Hold insulator so that finger prints and other foreign particles can not mar surface bounded by circular grooves. Wash the unaquadagged surface on both sides using small clean brush dampened with alcohol.

CAUTION: Do not use xylene cleaner on this insulator.

Mount this insulator on case making certain that in the process nothing soils the clean surfaces and re-attach the ionization chamber to the insulator. In this operation care should be taken to prevent chipping of aquadagged surfaces. In mounting the insulator (Item 7) to the case, make sure to use the fibre washers (item 36) inside and outside of case, to insulate aquadag from case.

4. General.

A. When connecting VX-32 tube into circuit, allow sufficient length in tube leads so that there will be ample clearance between element leads. Also take care that no lead is pulled so tight that the glass seal at the base of the tube cracks.

B. Before fastening case cover (Item 9) on case, cut strips of 1/8" x 3/8" sponge rubber for a gasket and cement to cover.

ARC INDICATION HV SUPPLY FOR PRECIPITRON

Q-514-B, C, D, E

By: D. S. Zachry
5/28/47

To give an indication at the power supply of the arcing voltage in a remotely located precipitron, and to furnish a voltage variable from 0 to 14,000 volts, a specially modified power supply was necessary.

Line voltage is fed through a 1 amp. variac to the primary of a 115-5000V step-up transformer, loaded with two 5600 ohm 2 watt resistors. This 5000V RMS is the input to a voltage doubler network consisting of two 1Z2 tubes, two Plasticon Glassmike condensers rated at 10,000 and 15,000 volts, and a special filament transformer built by Sway-Nelson Company. This transformer has two secondary 1.25 volts @ 300 MA windings, insulated between windings at a minimum of 20,000 volts. The output voltage is put across a resistor bank consisting of 38 20 megohm 1/2 watt Allen Bradley resistors, and voltage in kilovolts read from a Microammeter connected across the last resistor of the bank. Voltage across each resistor is approximately 360 volts.

When the voltage begins to break down in the precipitron, the meter needle dips sharply, indicating to the operator that he has reached the proper voltage. The needle will begin slowly falling when corona occurs.

SERVICE NOTES:

1. Keep hands out of instrument. The 15,000 volt condenser charge will bleed off to ground, but the 10,000 volt condenser charge has no low impedance path through which to discharge. It should be discharged with an insulated probe before servicing.

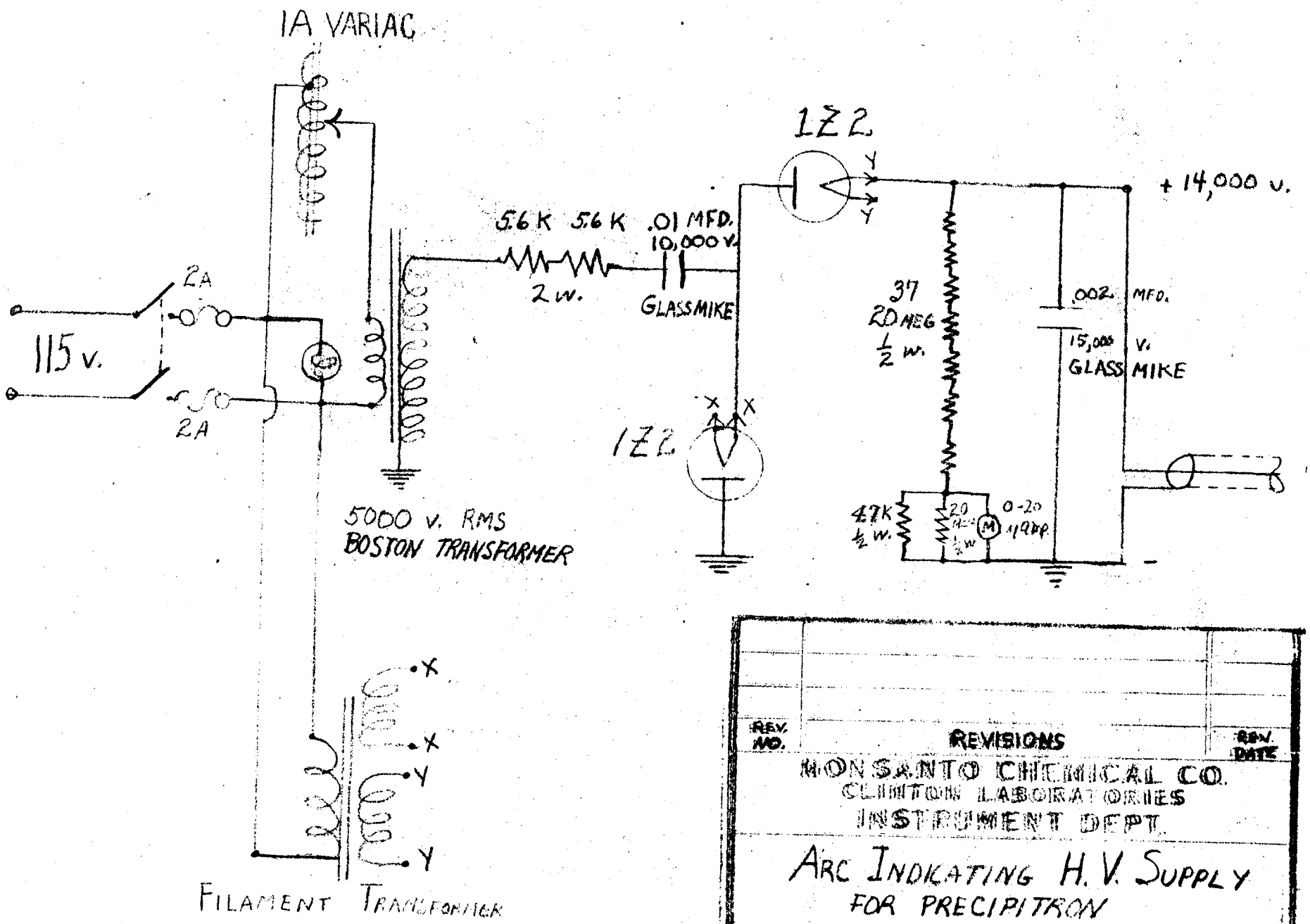
2. Constant arcing is hard on condensers. A popping noise can usually be traced to an internal arc through the film of a Glassmike condenser.

3. The meter is calibrated by the 4,700 ohm paralleling resistor to give a direct kilovolt reading.

4. The power transformer could be replaced by a more powerful one to get higher voltages to the doubler circuit.

5. The resistor board and all high voltage parts are wax-dipped to prevent moisture collection.

DSZ:vaj

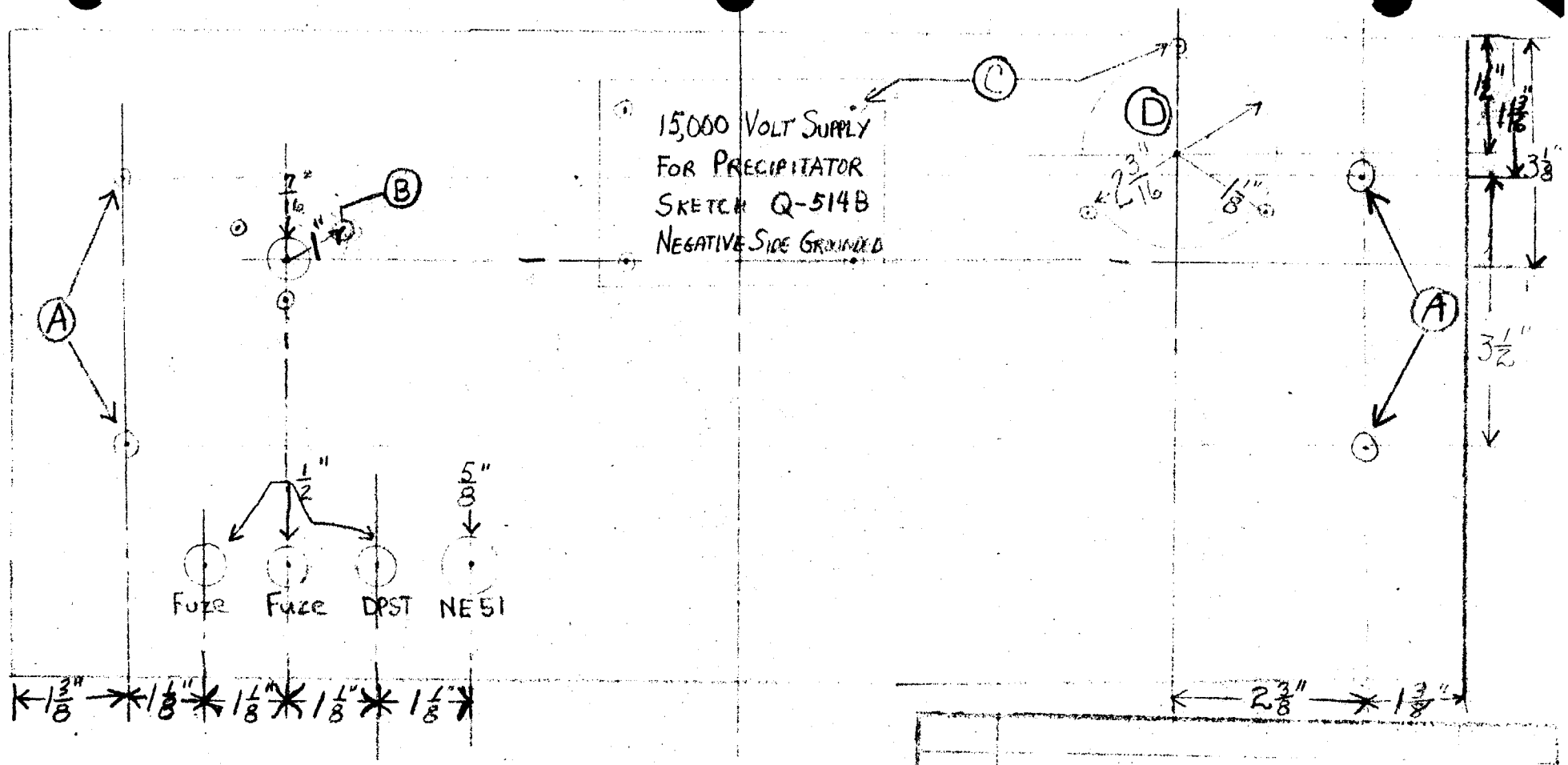


REV. NO.	REVISIONS	REV. DATE

MONSANTO CHEMICAL CO.
CLINTON LABORATORIES
INSTRUMENT DEPT.

ARC INDICATING H.V. SUPPLY
FOR PRECIPITRON

DESIGNED DRAWN CHECKED
27 MAY 1947
DATE SCALE SHEET OF



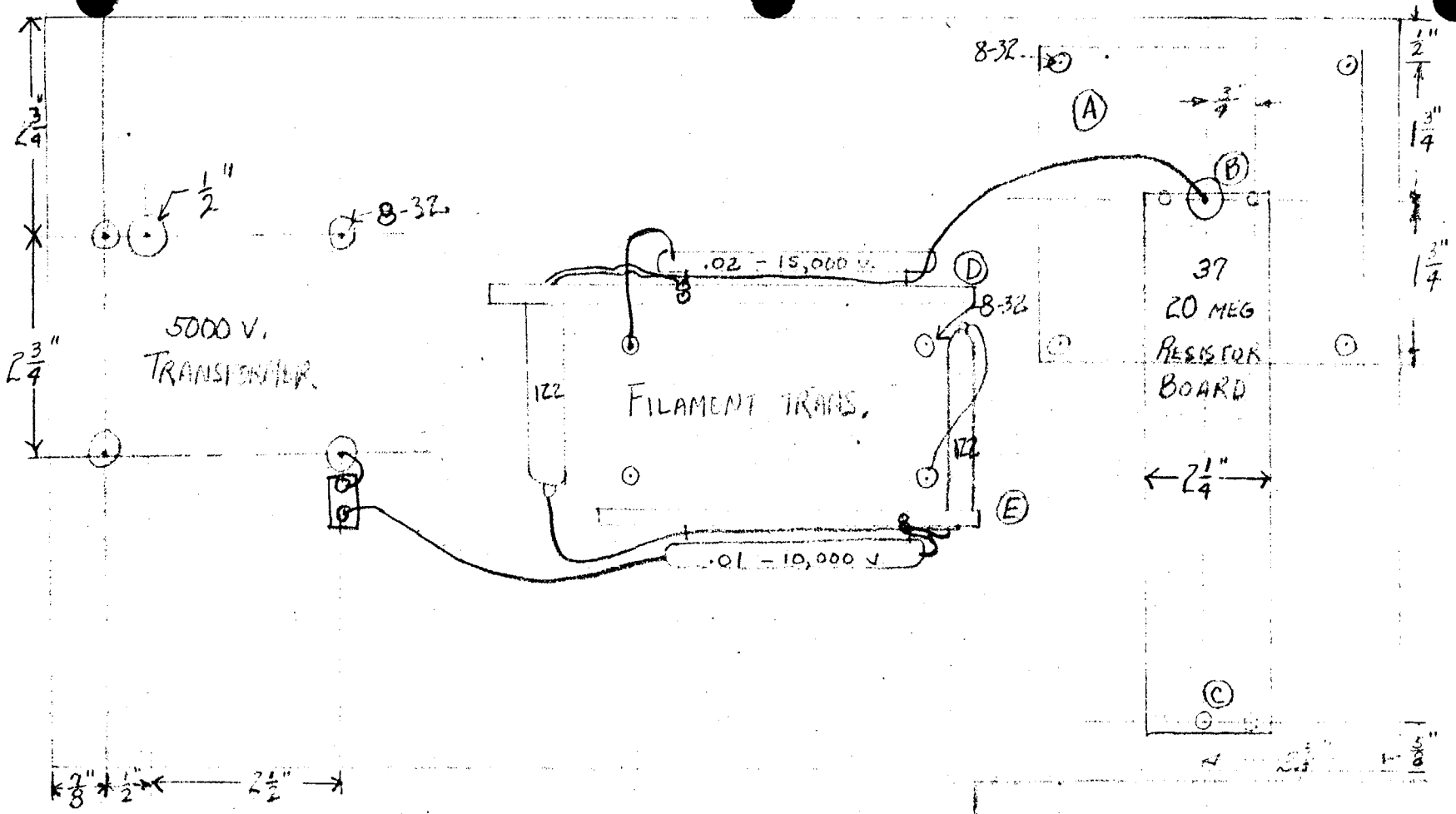
A. Drill and tap for #8 machine screw.
B. " " " " #6 " " .
C. " " " " #4 " " .
D. Westinghouse 0-20 Microammeter.

REV NO. REVISIONS DATE

MONSANTO CHEMICAL CO
CLINTON LABORATORIES
INSTRUMENT DEPT

PANEL LAYOUT
H.V. SUPPLY FOR PRECIPITRON

DESIGNED DR DRAWN DRZ
27 MAY 1947 SCALE 1/2
SKETCH Q-514-C



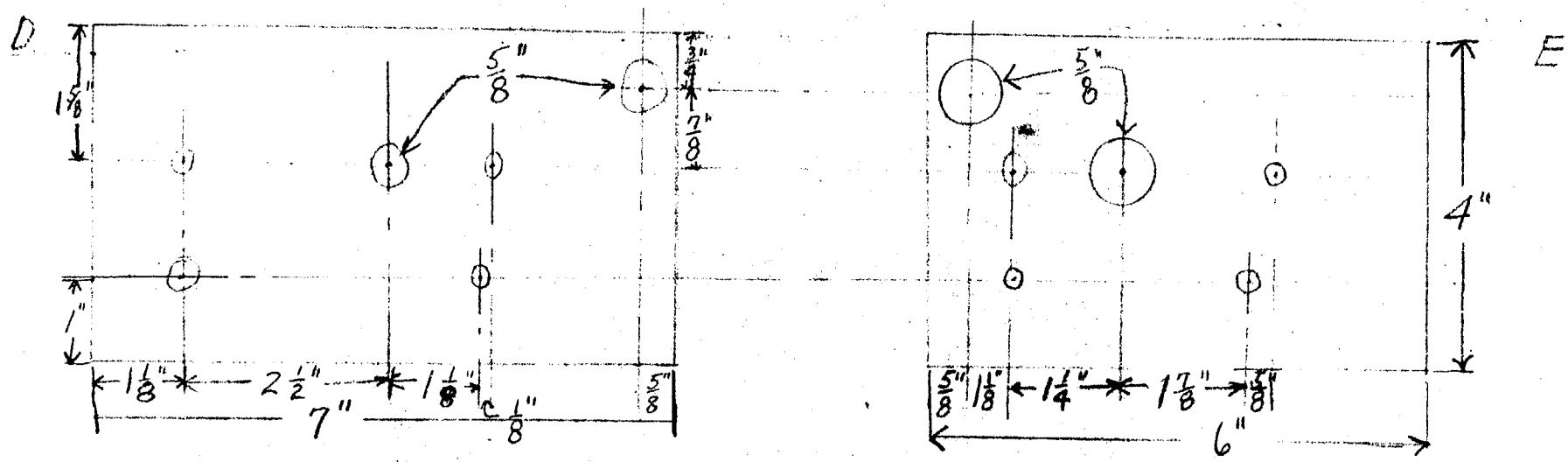
(A) POLYSTYRENE 4"×4"×3/16"
(B) " LEAD-THRU INSULATOR
(C) STAND OFF
(D) Q-514-E
(E) Q-514-E

REV. NO.	REVISIONS	REV. DATE

MONSANTO CHEMICAL CO.
CLINTON LABORATORIES
INSTRUMENT DEPT.

CHASSIS LAYOUT
10"×17"×3"

DESIGNED	DRAWN	CHECKED
DATE	SCALE 1/2	SHEET OF SHEETS



ALL HOLES FOR #8-32 SCREWS, EXCEPT THOSE MARKED.

POLYSTYRENE PANELS FOR H.V. SUPPLY

DBZ DBZ

27 MAY 1947 1/2

0-514-E

DUST PRECIPITRON
Q-587-A

By: K. H. Kline
6/18/47

The primary advantages of the new Precipitron, Q-587-A are: 1) a better fan powered by an alternating current induction motor resulting in a more constant air flow; 2) a timer is incorporated in the circuit so that a sample may be taken for a definite predetermined period; 3) the high voltage supply is of the voltage doubling type fed by the secondary of a 6800V R.M.S. transformer. The magnitude of the high voltage is controlled by a one ampere variac in the primary of this transformer.

On the front panel are four controls: a power toggle switch, a high voltage control knob, a timer setting knob, and a three-position switch labeled "Automatic", "Off", and "Manual". The front panel also has three pilot lights: one each red, yellow, and green.

OPERATION:

The Precipitron is plugged into a standard 3-prong 115V AC outlet. Put the three-position switch in the "off" position and turn the toggle switch to the "on" position. The yellow pilot light will now come on. At this point the rectifier filaments (1Z2's) will be lit but no high voltage will be applied to them.

With the timer set to some time up-scale, the three-position switch is now turned to the manual position. In this position the fan is on and the high voltage may be advanced to the point of corona discharge by advancing the high voltage adjusting knob in a clockwise direction. In the manual position the timer is not operating.

The timer is now set for the interval the operator wishes to collect a sample (from 3 to 60 min.). The three-position switch is now turned to the "off" position. An insulated handle screwdriver or similar tool is used to discharge the Precipitron head, and the collecting foil is inserted. The three-position switch is now turned to the automatic position and the run started. In this position the timer is running and will stop the fan motor and high voltage when it reaches zero. This condition is indicated by the green light coming on. The red pilot light is on anytime the high voltage is available.

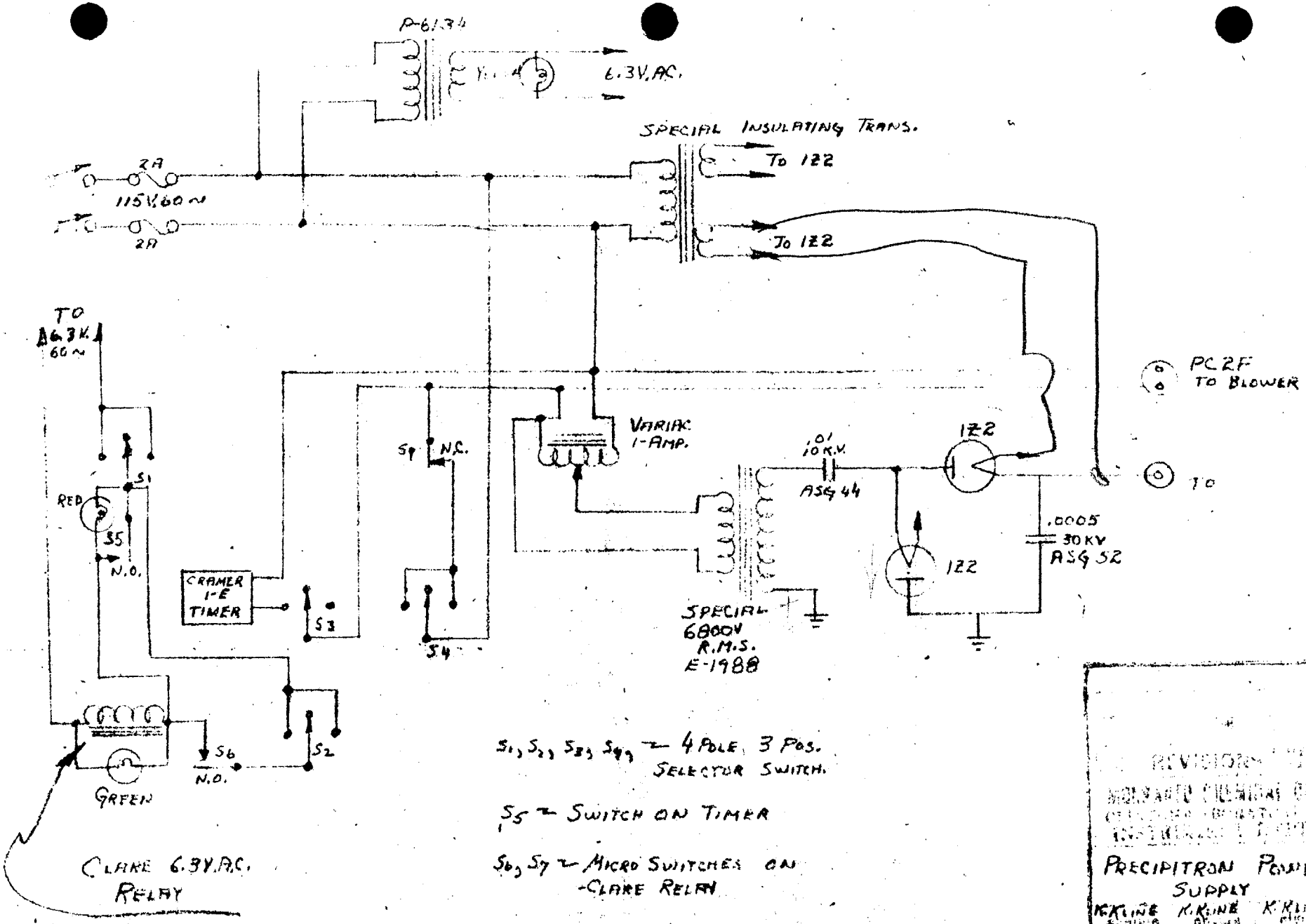
SERVICE HINTS:

The most probable place for failure is in the high voltage rectifier circuit. The circuit is a voltage doubler employing two

1Z2 rectifier tubes and two plastic "Glassmike" condensers built around a special insulating filament transformer for the 1Z2's. Although the condensers used are the best available, they should be cleaned and wax coated to discourage surface leakage. 1Z2 rectifier tubes are quite rugged for their size and should give little trouble. They are rated for a maximum current of 1 ma. and a maximum of 40KV inverse voltage.

The cable leading from the supply to the Precipitron head is Amphenol RG-7/U which will stand 50 kilovolts DC. Amphenol RG-6/U may be used with equal results.

KHK:vaj



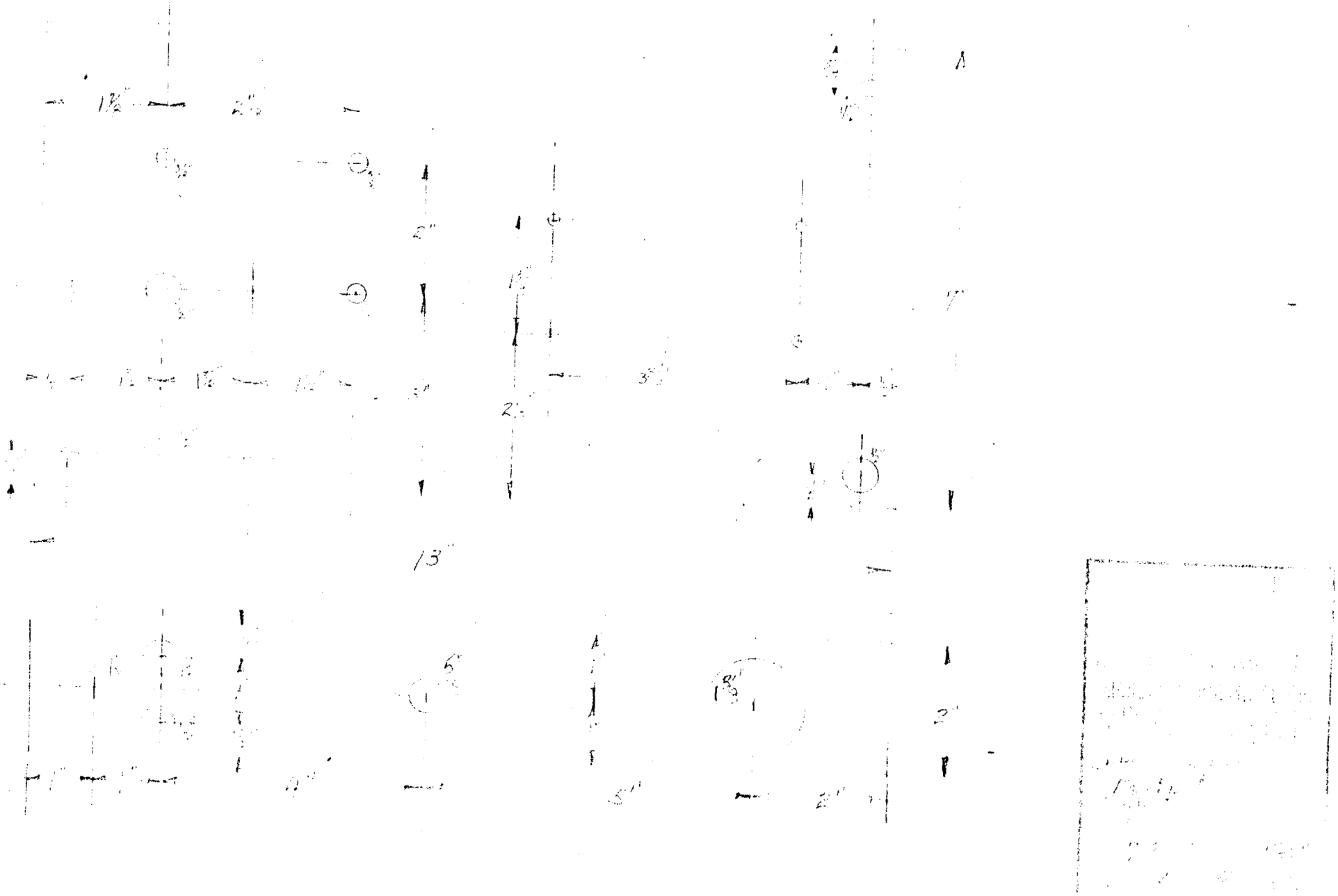
REVISIONS

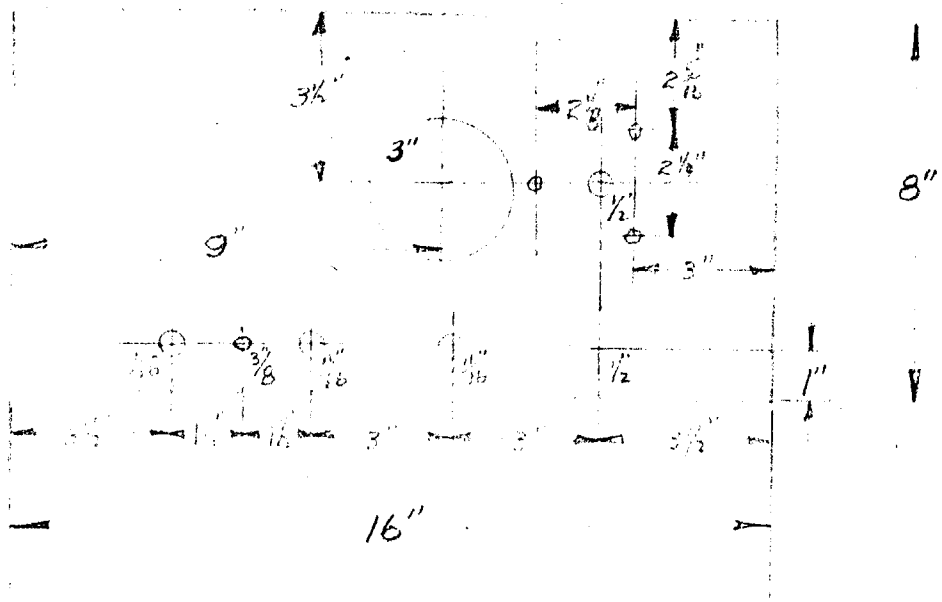
PRECIPITRON POWER SUPPLY

K.KLINE K.KLINE K.KLINE

6-16-47 NONE

-587-A





PANEL

PARTS LIST DUST PRECIPITRON

Q-587-D

Ref: V-A-7-a Pictures Nos. 1048, 1064

1	Chassis 7" x 13" x 2" Bud #CB1194
1	Cabinet 8" x 8" x 16" Bud #1190
1	6800V RMS Transformer. Allied Radio #E-1988
1	6.3V @ 1.2A Transformer. Stancor #P-6134
1	Insulating Fil. Trans. for 1Z2's. S.N.C. Mfg. Co. #P-1339
1	C. P. Clare 6.3V AC Relay #A-19914
1	1 Amp. Variac. General Radio 200B
1	3 to 60 min. timer. R. W. Cramer Co. Type 1-E
2	1Z2 tubes
3	Pilot lights - 1 each red, yellow and green
1	4-pole 3-position selector switch. Mallory #3243-J
1	Toggle Power switch
1	Plasticon condenser .0005 mfd. 30KV type ASG-52
1	Plasticon condenser .01 mfd. 10KV Type ASG-44
1	25KV output terminal. Amphenol AN-3102-24-8355
1	Type PC2F Connector. Amphenol.
2	Extractor Fuse Posts
1	Power cord
1	6" x 4" x 5" box. Bud #CU-729
1	Blower. F. A. Smith Mfg. Co. type 50745

REV NO	REVISIONS	REV DATE

MONSANTO CHEMICAL CO.
CLINTON LABORATORIES
INSTRUMENT DEPT.

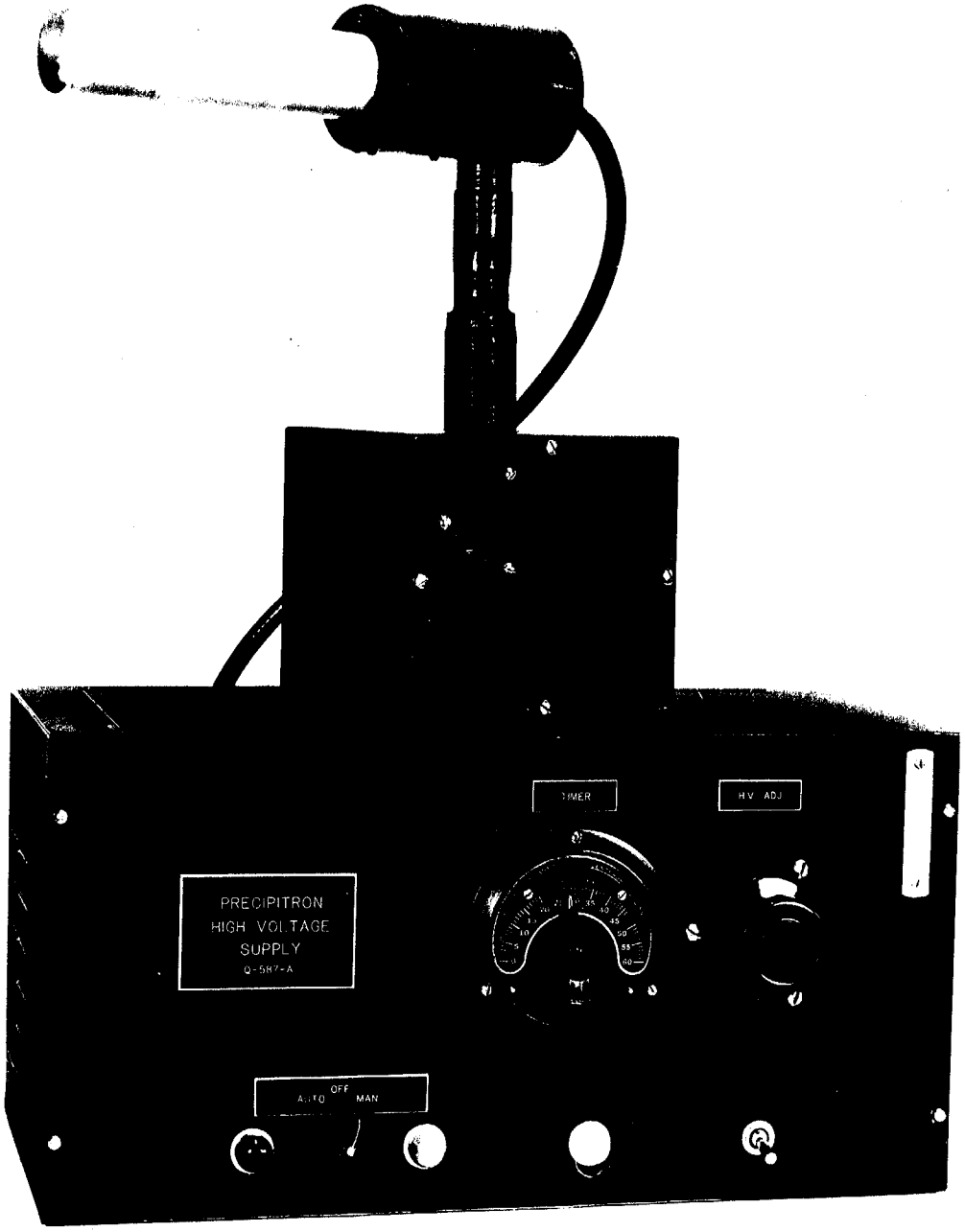
PARTS LIST
PRECIPITRON

KHK DES'N'D | DRAW'N | KHK CK'D

DATE 7/8/47 SCALE

SHEET 4 OF 4 SHEETS

SKETCH Q-587-D


PRECIPITRON
HIGH VOLTAGE
SUPPLY
Q-5H7-A
TIMER
H.V. ADJ
AUTO
OFF
MAN

ADJUSTABLE TRANSFORMER
VARIAC

OFFICIAL USE ONLY

12 47

[redacted]

VICTOREEN INTEGRON

By: M. P. Falls
10/11/44

The integron is a type of recording instrument designed to give, unattended, the continuous integration of radiation over an interval of eight hours. To accomplish its work, the integron employs an ionization chamber and an electrostatic generator, an A.C. amplifier and associated rectifier, a meter circuit, a charging mechanism, and a power supply.

A. IONIZATION CHAMBER

The ionization chamber has a collecting electrode normally free from any connection to the circuit and well insulated. The walls of the chamber are coated with aquadag and are at ground potential. Manually or automatically, the chamber may be given an initial charge with the collecting electrode at a positive potential of 300 V. (aprox.) with respect to ground. The integron is designed to give a meter indication of "0" with the collector at 300 V. and full scale when the collector voltage has dropped to 100 V. (approx.). This change in voltage is the change of voltage which would result when ionization corresponding to an integrated value of 100 milli-roentgens has occurred. Ionization of the air inside the chamber as a result of radiation will reduce the voltage on the collector. Since chamber leakage will also result in reduction of the collector voltage, the leakage resistance must be kept very high as demonstrated in the following calculations.

With

Voltage sensitivity of instrument = 300 - 100 = 200 V. for full scale deflection of the meter,
Chamber capacity = 120 statfarads,
Permissible drift = 5% of full scale for 8 hrs. = 10 V.,

$$V_t = E_o e^{-\frac{t}{RC}}$$

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DATE FEB 11 6 4
For The Atomic Energy Commission
Chief, Declassification Branch

Where

E_o = initial charging voltage = 300 V.

V_t = voltage at time t (sec.) after charging = 300 - 10 = 290 V.

[redacted]

OFFICIAL USE ONLY

[redacted]

t = time in seconds after charging = 8 · 3600 = 28800 sec.

C = chamber capacity (farad) = 120 · 1/9 · 10^{-11} = 133.3 · 10^{-12} farads

R = allowable leakage resistance in ohms

[redacted]

$$290 = 300\, e^{-\frac{28800}{R \cdot 133.3 \cdot 10^{-12}}}$$

$$e^{-\frac{216 \cdot 10^{12}}{R}} = \frac{290}{300}$$

$$R = \frac{216 \cdot 10^{12}}{\ln \frac{300}{290}} = 6450 \cdot 10^{12} = 6.37 \cdot 10^{15} \text{ ohms}$$

It may be of interest to note that the resistivity of polystyrene is 10^{17} ohms/cm^3. Experience has shown that surface leakage is a source of more trouble than volumetric leakage. To remedy this in part, visible silica gel in a container at the top of the integron chamber acts as a drying agent and indicates moisture adsorption by the color of the crystals. The crystals are blue at first and turn pink with the adsorption of moisture. By removing the crystals and baking them, the blue color will be restored and the crystals may be used again.

The collecting electrode is electrically connected to the stationary plates of the electrostatic generator (motor-driven variable condenser). The rotating plates are connected to the input grid of an amplifier tube. When the chamber is exposed to radiation, ionization current flows and the collector voltage drops. Measurement of the collector voltage is made without drawing any current from it. Any current which flows in the input grid resistor is due to capacity current by the electrostatic generator and not to electron flow to the collecting electrode. The capacity current may be expressed as:

$$i = \frac{E_o}{\sqrt{R^2 + \frac{1}{\omega C}^{\,2}}}$$

[redacted]

[redacted]

where

E_o = collector voltage

R = equivalent grid circuit resistance

W = 2 π times the frequency at which C changes being determined by the motor speed and the shape of the condenser plates. (f = approx. 450 cycles/sec).

C = equivalent capacity of the grid circuit plus the capacity of the electrostatic generator.

The reactive term varies with time, so i varies periodically, thereby, producing an alternating signal on the input grid of the amplifier. If the collector voltage drops, the amplitude of the signal becomes less, being directly proportional to the collector voltage.

In concluding the discussion of the chamber, it may be well to list two factors as largely responsible for undesirable changes in the signal to the grid:

(1) Motor speed.

(2) Leakage resistance (either in the chamber or across the rotating condenser).

B. AMPLIFIER AND RECTIFIER

The amplifier consists of two stages resistance - capacitance coupled and having moderate gain. The output of the amplifier drives a transformer whose secondary is center-tapped and used for impressing the output signal on a full-wave rectifier. The output of the rectifier operates the meter and also furnishes the signal for a Micromax Recorder across a 10 ohm resistor in series with the meter. A potentiometer is connected in shunt with the 10 ohm resistor and is used for obtaining meter tracking.

C. METER CIRCUIT

A milliammeter in the cathode circuit of the rectifier is used to measure the output current. The meter scale is made to read inversely with the current through its coils, and is calibrated to read from "0" to a value corresponds to 100 milli-roentgens. Full deflection of the meter corresponds to zero integral of intensity and zero deflection corresponds to an integrated value

of 100 milli-roentgens. The latter does not correspond to complete discharge of the collector but only to a reduction of charge to a point where there is insufficient voltage (100 V. approx.) across the chamber for proper collection of ions.

D. CHARGING MECHANISM

The meter has contacts which close at a meter reading of "100". The closing of these contacts de-energizes a relay which in turn energizes a thermal relay whose contacts then close energizing the charge relay and, thereby, impressing a charging voltage (B+) on the collector. Then the meter current increases, the scale reading changes from "100", and the meter contacts open. This action is followed by the breaking of the charge relay contacts, leaving the collector free from electrical connection to the circuit and the chamber is charged at a voltage E_0 (300 V. approx.).

In addition to the automatic recharging described above, the chamber may be given as initial charge by a timer equipped with contacts which close every eight hours. A third method of recharging, is provided in the Manual Recharge Push Button.

E. POWER SUPPLY

The power supply transformer furnishes A.C. for the tube filaments, the thermal relay, the induction motor to drive the variable condenser, and the plate voltage for the rectifier supplying B+. The B+ supply has a condenser input filter and the output is regulated by glow tubes.

ACTUAL OPERATION OF THE INTEGRON

With the 110 V. line switch open, the B+ supply is off, the relays are de-energized, the meter contacts are closed, and the chamber is assumed to be initially uncharged. By closing the 110 V. line switch the action of the circuit is as follows: As the B+ voltage rises, the 1400 ohm relay remains de-energized and its contacts closed, thereby energizing the thermal relay (6H05) and operating the buzzer. The thermal relay passes current and becomes hot enough to close a set of contacts which permits current to flow in the charge relay whose contacts then close impressing B+ (300 V. approx.) on the collector. The variable condenser is being driven by the induction motor. Now it becomes an electrostatic generator and furnishes the signal necessary to obtain meter current. When the signal amplitude becomes large enough to obtain a meter current of 2 ma. (approx.) the meter contacts open energizing the 1400 ohm relay and opening its contacts, thereby de-energizing the thermal relay and the buzzer. The thermal relay is hot so its

contacts remain closed for some time though it has been electrically de-energized. This slow action is desirable so that ample time will be provided for charging the ionization chamber to B+ (approx. 300 V.). The chamber is now ready to receive radiation.

As the amount of radiation to which the chamber has been subjected increases, the voltage on the variable rotating condenser lessens and likewise the signal to the input grid of the A.C. amplifier. The meter reading increases. When ionization corresponding to an integrated value of 100 milli-roentgens has occurred, the meter pointer indicates "100" and the meter contacts close. Now the recharging procedure previously described takes place.

RADIATION SENSITIVITY

The volume of the chamber affects the radiation sensitivity in that it presents a fixed volume for radiation. Change of the chamber capacity is accomplished by the adjustment of polystyrene thimbles inside the chamber. The chamber capacity has been set at 120 statfarads by the manufacturer to obtain optimum results from the A.C. amplifier and associated circuit. With the volume of the chamber fixed and the capacity fixed, the Standardization Adjustment is followed in setting the gain and compensating for drift.

STANDARDIZATION ADJUSTMENT

NOTE: Normally the following procedure is necessary only when installing a new instrument or when placing an instrument in service after repair. In such cases the Health-Physics Section should be notified promptly of the new installation so that any desired checks may be made, including a calibration with a source.

1) Turn "Zero Adj." in the rear full counter-clockwise.

2) Turn "Run Test" switch in the rear to "Test" position. Observe the position of the meter pointer on the scale.

3) Return "Run Test" switch to "Run" position.

4) Push in the button on the rear of the timer to charge the instrument.

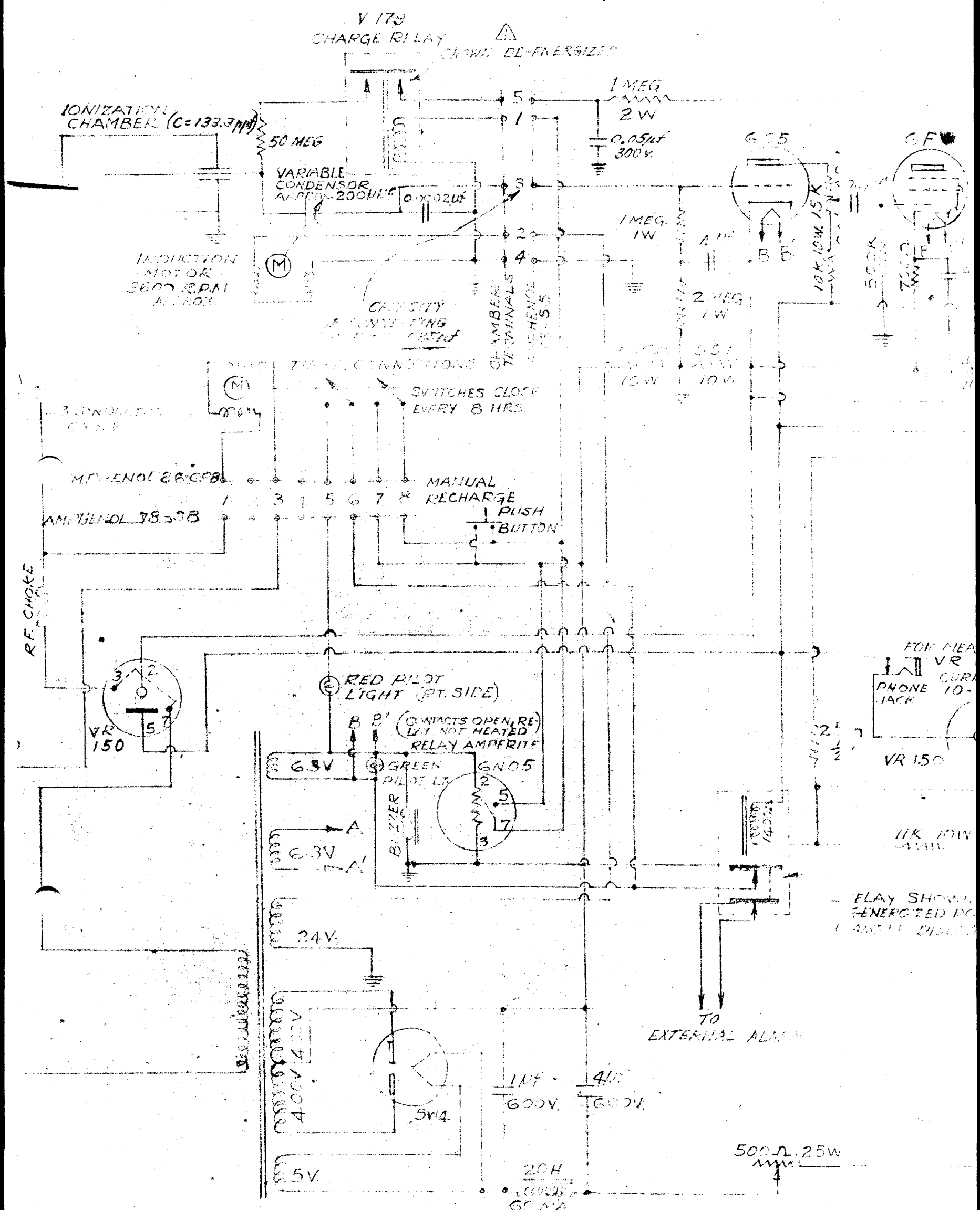
5) Turn "Cal. Adj." in rear and rotate until the pointer is in the same position as previously described in (2).

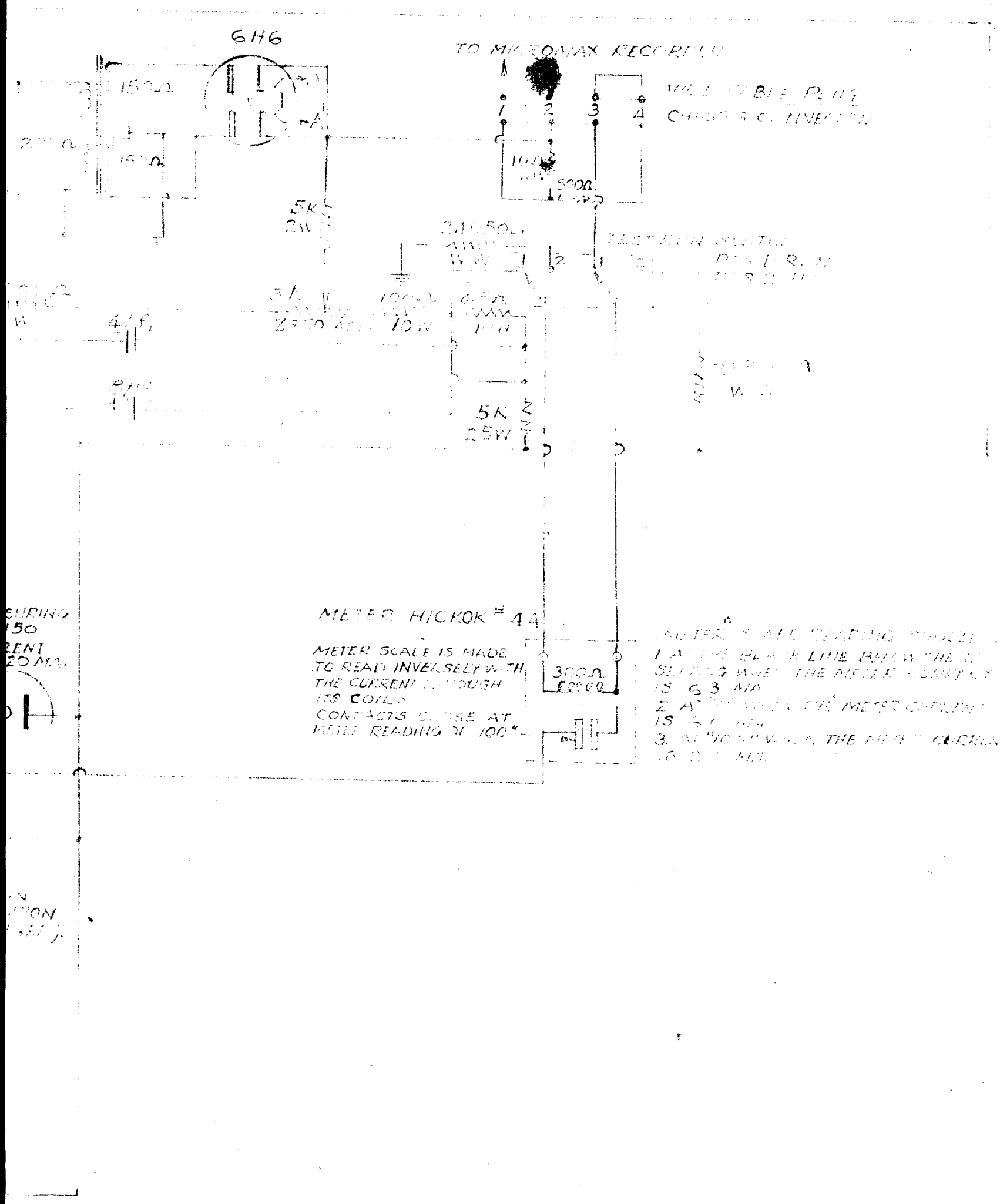
6) Repeat (2) to (5) until the pointer is at the same place in either the "Test" or "Run" position.

7) Set "Test Run" switch to "Run" position.

8) Rotate "Zero Adj." until the meter pointer is balanced at "0" on the scale.

Reference Dwg. CL-717-B-42


V 179
CHARGE RELAY
CHOWN DE-ENERGIZED
IONIZATION CHAMBER (C=133.3μμf)
50 MEG
VARIABLE CONDENSOR APPROX. 200μμf
0.0002μf
INDUCTION MOTOR 3600 R.P.M. APPROX.
CAPACITY OF CONNECTING
CHAMBER TERMINALS
1 MEG 2W
0.05μf 300v.
1 MEG. 1W
2 MEG 1W
10K 10W 15K
6F5
6F
SWITCHES CLOSE EVERY 8 HRS.
MANUAL RECHARGE
PUSH BUTTON
AMPHENOL 78-SB
RF. CHOKE
VR 150
RED PILOT LIGHT (PT. SIDE)
(CONTACTS OPEN, RELAY NOT HEATED)
RELAY AMPERITE
6.3V
GREEN PILOT LT.
6N05
BUZZER
24V.
400V
5W4
5V.
1μf 600V.
4μf 600V.
20H
60 MA
500Ω 25W
TO EXTERNAL ALARM
PHONE JACK
VR 150
11K 10W



VICTOREEN INTEGRON

CLINTON LABORATORIES				
REVISIONS		REV. BY DATE		DATE 8-31
△	Corrected meter [illegible] description of [illegible]	12/10/44		NONE
△	Overall Changes to Agree with Factory Model. M.F.E.	11/29/44		A
				PROJ. NO. CL
				CL-717

CLASSIFICATION CANCELLED
DATE FEB 11 6 4
For The Atomic Energy Commission
H. A. Carroll
Chief, Declassification Branch

RESTRICTED

By: C. O. Ballou
8/31/44

Small particles found in quiet air are so small that they pass thru conventional dust filters: viz., smoke particles. Roughly speaking, if particles are sufficiently small to obey Stokes Law, they will be difficult to filter. If the particles are of sufficient size to obey gravitational laws, they remain in the air for only a very short time. Consequently, the electrostatic filter or precipitator fulfills the needs for collection of minute particles suspended in the air, as they attain high efficiency for particles which obey Stokes Law.

The present device is an adaptation of the Cottrell precipitation process used for the collection of smoke, and of volatilized rare metals in chimney gases.

Charged particles, in an electrostatic field are repelled or attracted, depending upon the polarity of the field.

Intense electrostatic fields can be obtained by relatively high voltages applied to small conductors. Under conditions in which a corona discharge is observable, intense electrostatic fields are present. In the operation of electrostatic precipitators, it is desirable to bring about conditions that will give corona.

In the present device a corona discharge is obtained by applying from 12 to 15,000 volts between a "collector tube" and a central electrode consisting of a small steel wire. By this means an intense field is produced that charges particles and also collects them.

Charging of the particles occurs as the air is drawn thru the intense field produced by the small radius central electrode. In back of this area the radius of the central electrode is increased to reduce the electrostatic gradient. This area is considered as the collecting area.

In practice it has been found that collection of particles occurs a very short distance back from the tip of the wire. The particles become so strongly charged in the first part of the tube that they are attracted to the outer or negative terminal before they move back into the normal collecting zone.

CLASSIFICATION CANCELLED
FEB 11 [illegible]

This document contains information affecting the national defense [illegible] of the Espionage [illegible] mission or the revelation [illegible] any manner to an unauthorized person is prohibited by law.

The device consists of the following essential parts:

1. An electrical circuit for producing direct current at potentials of about 15,000 volts.

2. A collecting tube thru which air is passed for collection of dust particles.

3. A system capable of moving a given quantity of air through the collecting tube.

The electrical circuit consists of a transformer which supplies power for the vibrator reed, the spark coil primary circuit and a fan motor. In addition a 2.5 volt winding, insulated for the high potentials encountered, is used to heat the cathode of a rectifier tube.

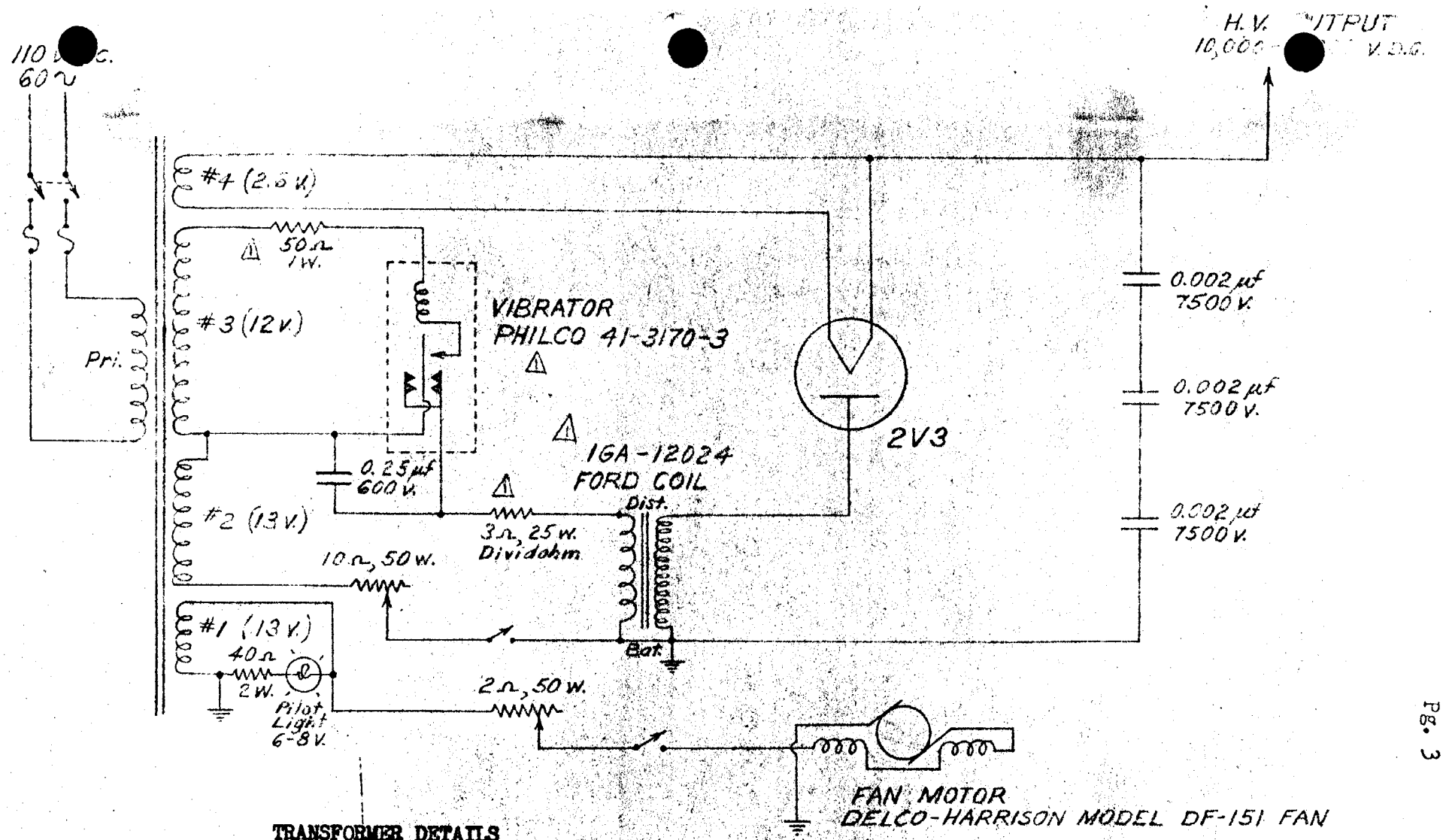
The high voltage is developed by a spark coil which with a moderate turn ratio develops high voltages due to the high ratio of $\frac{di}{dt}$ produced by the opening of the vibrator contacts aided by a 0.25 mf. condenser. This condenser prevents arcing of the vibrator contacts. If this arcing were not prevented, the high $\frac{di}{dt}$ ratio could not be realized as the energy stored in the coil primary would be dissipated in the arcing of the contacts.

This system is far from ideal, as the contacts of the vibrator are interrupting the primary circuit at various portions of the applied sine current wave and thus produces large momentary fluctuations in voltage. However, the fluctuations are appreciably reduced by the condenser in the high voltage circuit.

The collecting tube has been discussed, and other than a short circuiting switch to prevent shock upon removal of the outer collecting tube, requires no comment.

The air moving system was an adaptation of materials which could be quickly obtained. The fan is a Cheverolet heater and defroster fan made by Delco Harrison and has a capacity in the arrangement used of about 12 cubic feet of air per minute. For non-quantitive results, the fan is run at any convenient speed and the pressure in the system compared to other observations, by means of a static pressure "U" tube. For more precise measurements, an impact and static pressure differential Manometer is calibrated by means of a "Rotometer", thus giving precise calibration. It has been found that an inclined Manometer is required, as the differential between impact and static pressures is quite low.

In use, a band of aluminum foil is slipped into the outer collecting tube. The charged particles collect upon this foil which is removed for insertion into an alpha chamber of proper design and determinations of air contamination are made by the alpha count.



TRANSFORMER DETAILS
(Rebuilt Thordarson T-19R32)

1. Strip and use original primary at first tap.
2. Secondary windings:
   - No. 1 - 32 turns of #16 enamel-covered wire.
   - No. 2 - 32 turns of #16 enamel-covered wire.
   - No. 3 - 30 turns of #24 enamel-covered wire.
   - No. 4 - 7 turns of #16 enamel-covered wire.

   Insulate the No. 4 winding from the core and from the other windings with ten layers of 0.006 in. varnished cambric.
3. Fill the case with Cenco Plicene Cement No. 11441.

INSTRUMENT SHOP — BUILDING 717-B
CLINTON LABORATORIES

DUST PRECIPITATOR

REV. No.	REVISIONS	REV. DATE	
1	Changed vibrator type. Added resistor in vibrator coil circuit. Added resistor in coil	8/30/42 pri	DATE 5-29-4[illegible]
			SCALE
			DRAWN BY M. Fall
			APP'V'D BY [illegible]

BLDG. NO.

SKETCH 0-165

ADJUSTMENT OF THE MODULATED AMPLIFIER

By: C. O. Ballou
2/10/45

OPERATION

Due to the unorthodox method of amplification employed in this instrument, some description of its operation is required to understand servicing problems.

The input Victoreen 124 tubes are connected in a conventional bridge circuit. They are, however, employed in an unconventional manner. In addition to the D.C. plate supply voltage, an alternating current is superimposed upon the plate supply. When the two tubes are in balance, the same alternating current component, having identical phase relationship should exist between the two plates, thus, no differnece in potential exists between the plates. When the voltage of the grid to the input tube is changed, the alternating component on the plate of that tube is changed and a difference in A.C. potential will exist between the plates of the tubes, which is amplified, rectified and metered.

The amplifier which follows the input tubes is a resistance coupled audio amplifier which calls for no comment other than the fact that shielding against A.C. hum pick up is required.

The amplified A.C. is rectified by means of a 6H6 rectifier. The rectified current is measured by means of a milliameter, and to meet the requirements of the multipoint Micromax, the current is dropped across one of two switch selected 25 ohm precision resistors shunted with 500 ohm potentiometers to permit tracking between the Micromax and panel instruments.

The sensitivity of the instrument is adjusted on each of the two ranges by means of 70,000 ohm potentiometers, each one connected into its proper range by means of an auxiliary switch which functions as the range switch is moved. The same switch also connects the proper Micromax shunt to the instruments and also connects the alarm and signal system according to a pre-arranged schedule.

ADJUSTMENTS

A. Zero Balance.

Due to the fact that the meter is actually measuring the unbalance of an alternating current bridge, it is incapable of determining the phase relationships or direction in which the bridge circuit

is unbalanced. Consequently, instead of reading below and above zero, the meter will go from an up-scale reading down to zero and then back up-scale as the balance control is rotated. The point of balance is that point which gives the minumum reading on the meter.

B. Voltage Sensitivity Adjustment.

Voltage sensitivity adjustments will be required after changing any tube in the set. Assuming that the input resistors never change value after the chamber is calibrated, the instrument can be brought into calibration by using a 1½ volt battery with a potentiometer and an accurate voltmeter. The voltage from the battery and potentiometer should be connected with the positive lead to the input connector and negative to ground. The sensitivity for both ranges will be determined at the time of calibration and will be posted on each set. After setting the Voltmeter to the posted voltage, select the proper range and adjust the appropriate potentiometer on the chassis for full-scale reading of the panel meter. A more precise method of calibration would be to use an L & N potentiometer capable of delivering about 1 volt.

C. Instrument Tracking.

The zero balance adjustment is capable of giving an instrument deflection of better than half-scale and can be used to adjust the tracking of the Micromax and panel instruments.

Set the panel instrument to half-scale or any other convenient point by means of the Zero Balance with the range switch on the low or high sensitivity position. Observe the Micromax reading and adjust the appropriate potentiometer on the instrument chassis to bring the Micromax into agreement with the panel meter. Scale tracking can be observed by changing the instrument readings with the Zero Balance, remembering a tracking agreement of 20 Microamperes is all that can be hoped for, as the 3" panel instruments are accurate to only 2% of the full-scale reading.

D. Alarm Circuit.

The alarm is to be adjusted for operation at 12.5 mr/hr. as the meter is going up-scale. Once the alarm relay is pulled in, it will not release at the same value of voltage but will require that the voltage shall drop to a lower value than the pull-in voltage. The circuit employed for the relay in this instrument has been designed to release the relay with a minumum of "pull-in" - "drop-out" differential. A 10,000 ohm shunting resistor connected through relay contacts controls this differential. However, if the "pull-in" - "drop-out" differential is decreased too much the relay will "hunt" just as it pulls in.

To adjust the relay "pull-in", the input selector switch is set to the high sensitivity range. The Zero Balance control is rotated until the meter indicates 12.5 mr/hr. The alarm potentiometer on the chassis is slowly adjusted till the relay just closes. Check the adjustment by lowering the meter reading with the zero balance control and then coming up-scale on the meter reading. Observe the reading when the relay pulls in and refine the adjustment if required.

E. Tubes and Balance Control.

Replacement of any tube or tubes will call for rebalancing of the input circuit because the amplification of either side of the push pull amplifier will be affected. A small amount of amplifier unbalance can be corrected by means of the balance control, but to keep the AC Modulating voltage on the linear range of the input tubes excessive unbalance should not be corrected at the balance control. In general, about 15° plus or minus from the center position of the front panel balance control for zero meter indication will be satisfactory.

The balance controls are incorporated in the input circuit. The one on the back of the input tube shield is for equalizing the emission of the input tubes. This adjustment is required to reduce harmonic generation at balance. Failure to balance properly in this control will cause a high zero reading. The zero balance on the front of the panel obtains equal operating ranges for each of the input tubes.

Proper balancing procedure is as follows:

1. Set the input selector switch to "O" position.

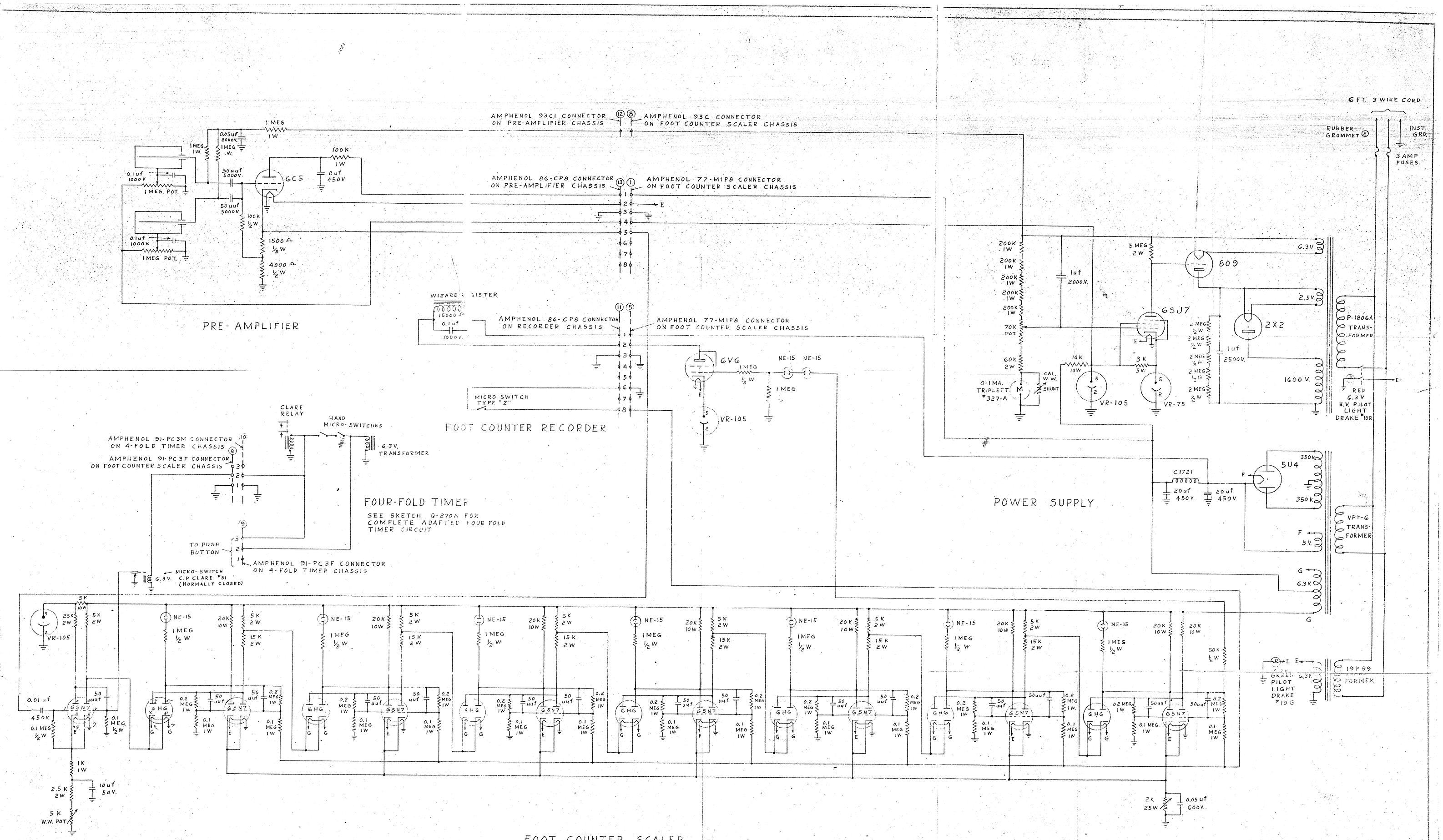
2. Manipulate the two balance controls for the lowest possible zero reading on the meter.

3. Turn the high sensitivity voltage adjustment potentiometer to give maximum meter deflection.

4. Repeat step 2 moving the controls through rather small increments till the meter gives minimum zero indication.

CAUTION: Due to the extreme sensitivity of the instrument, with the voltage sensitivity potentiometer turned all out, the final adjustments must be carefully made through small ranges or else the meter may be damaged.

5. Reset the voltage sensitivity as outlined in #B.



NOTE:
CONNECTOR NUMBERS REFER TO SKETCH Q-269-A SHOWING CHASSIS CONNECTOR AND CABLE LAYOUT.

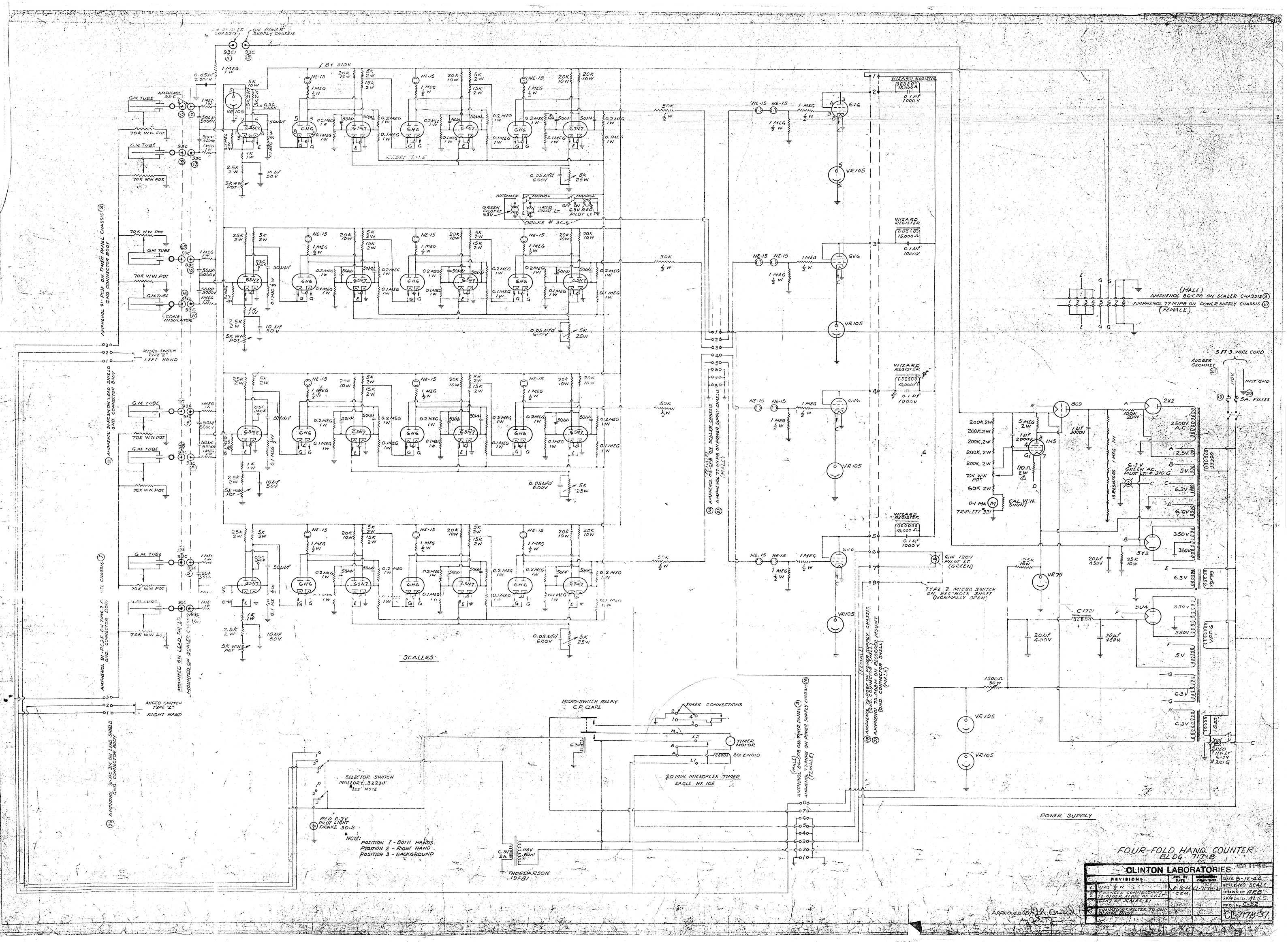
FOOT COUNTER
WIRING DIAGRAM

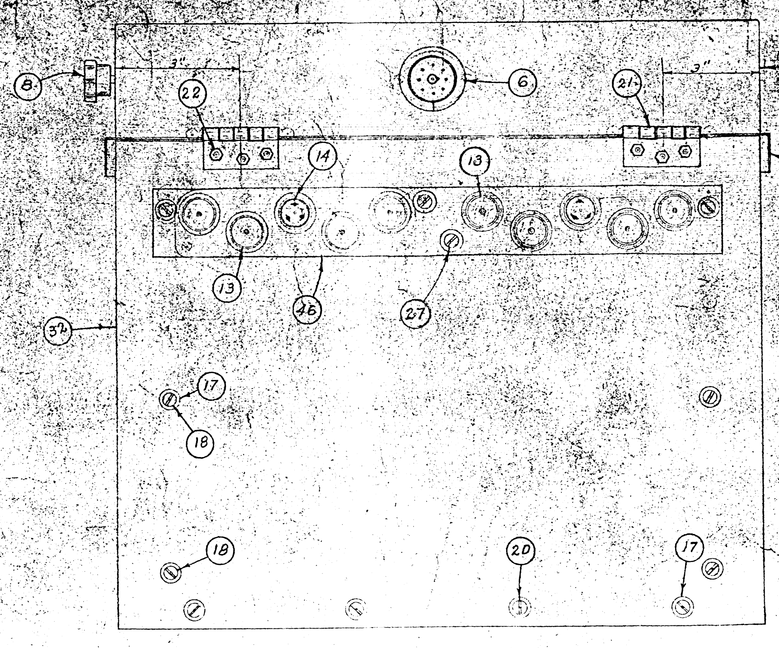
CLINTON LABORATORIES

BLDG. 717-B CIRCUIT

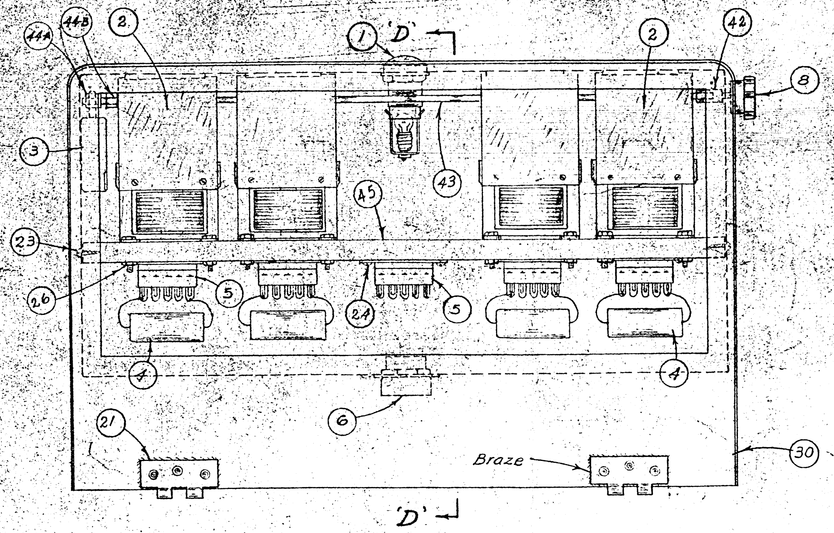
DATE 4-20-45
PROJ. NO. None
SCALE None
DRAWN BY JEM
DRAWING NO. CL-717B-50

#3426

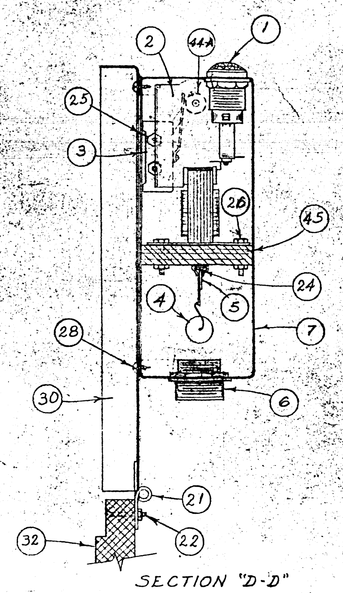

ON SCALER CHASSIS
ON POWER SUPPLY CHASSIS
B+ 310V
G.M. TUBE
70K W.W. POT.
AMPHENOL 93-C
AMPHENOL 91-PC3F ON TIMER PANEL CHASSIS (12) GND. CONNECTOR BODY
AMPHENOL 91-PC3M ON LEAD SHIELD GND. CONNECTOR BODY
AMPHENOL 91-PC3F ON TIMER PANEL CHASSIS (7) GND. CONNECTOR BODY
MICRO SWITCH TYPE "Z" LEFT HAND
MICRO SWITCH TYPE "Z" RIGHT HAND
MOUNTED ON LEAD SHIELD
MOUNTED ON SCALER CHASSIS
CONE INSULATOR
SCALERS
AUTOMATIC
MANUAL
GREEN PILOT LT. 6.3V
RED PILOT LT.
6.3V RED PILOT LT.
DRAKE # 30-S
WIZARD REGISTER
15,000 Ω
0.1 µf 1000V
AMPHENOL 86-CP8 ON SCALER CHASSIS (5)
AMPHENOL 77-MIP8 ON POWER SUPPLY CHASSIS (17)
(MALE)
(FEMALE)
5 FT. 3 WIRE CORD
RUBBER GROMMET (21)
INST. GND.
5A. FUSES
TYPE Z MICRO SWITCH ON RECORDER SHAFT (NORMALLY OPEN)
6W 120V PILOT LT. (GREEN)
CAL. W.W. SHUNT
0-1 MA
TRIPLETT #321
10 REGISTERS 1 MEG 1W
6.3V GREEN AC PILOT LT. # 310 G
RED 6.3V PILOT LT. # 310 G
POWER SUPPLY
MICRO-SWITCH RELAY C.P. CLARE
TIMER CONNECTIONS
TIMER MOTOR
SOLENOID
20 MIN. MICROFLEX TIMER EAGLE HX 10E
SELECTOR SWITCH MALLORY 3223J *SEE NOTE
RED 6.3V PILOT LIGHT DRAKE 30-S
*NOTE: POSITION 1 - BOTH HANDS
POSITION 2 - RIGHT HAND
POSITION 3 - BACKGROUND
THORDARSON T5F51
AMPHENOL 86-CP8 ON SCALER CHASSIS (5)
AMPHENOL 77-MIP8 ON POWER SUPPLY CHASSIS (17)
AMPHENOL 86-CP8 ON TIMER PANEL (3)
AMPHENOL 77-MIP8 ON POWER SUPPLY CHASSIS (16)
AMPHENOL 70-PC8F ON POWER SUPPLY CHASSIS (GND. CONNECTOR SHELL)
AMPHENOL 70-PC8M ON RECORDER MOUNT (GND. CONNECTOR SHELL)
FOUR-FOLD HAND COUNTER
BLDG. 717-B
CLINTON LABORATORIES
MAR 31 1945
REVISIONS
1. WAS ½ W
2. CHANGED CONNECTIONS TO OTHER PLATE OF LAST HALF OF SCALER #1
3. CHANGED RC FILTER TO CONVERTER
DATE 8-17-44
SCALE NO SCALE
DRAWN BY ARB
APPROVED M.S.S.
PROJ. NO. C.L.S.
CL-717B-37
APPROVED BY R. B.
#3426



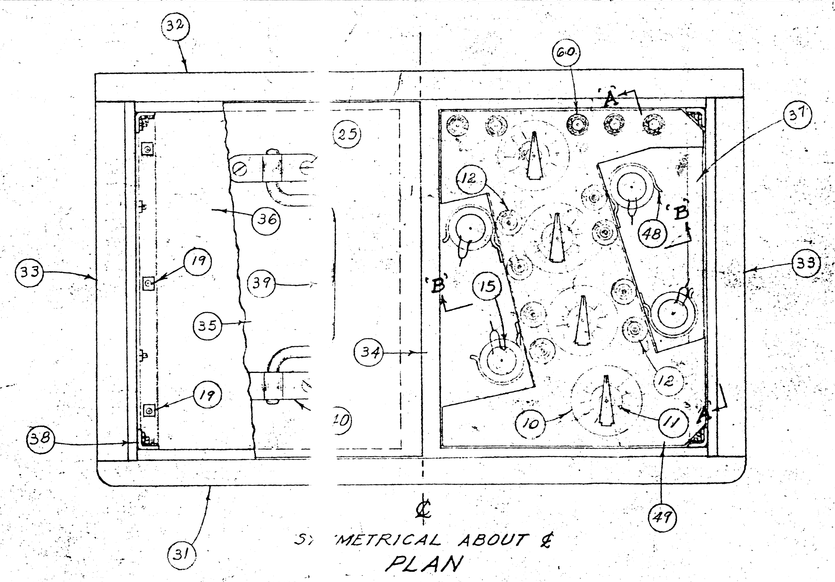
REAR VIEW



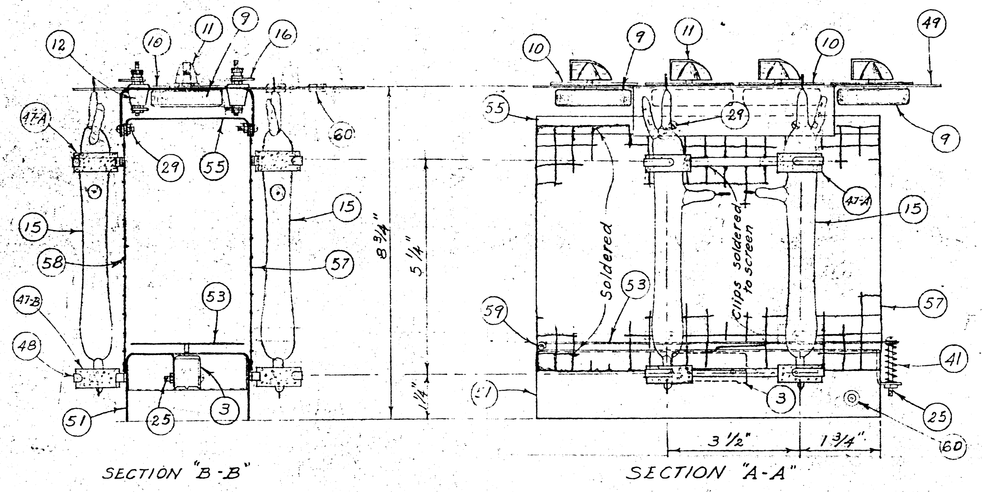
SECTION "C-C"



SECTION "D-D"

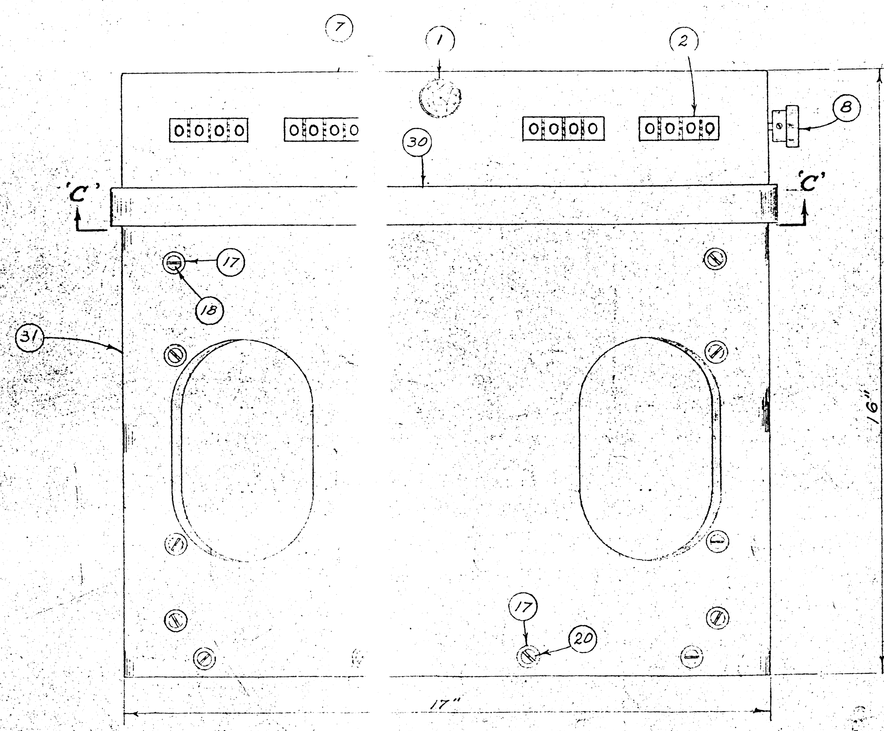


SYMMETRICAL ABOUT ℄
PLAN

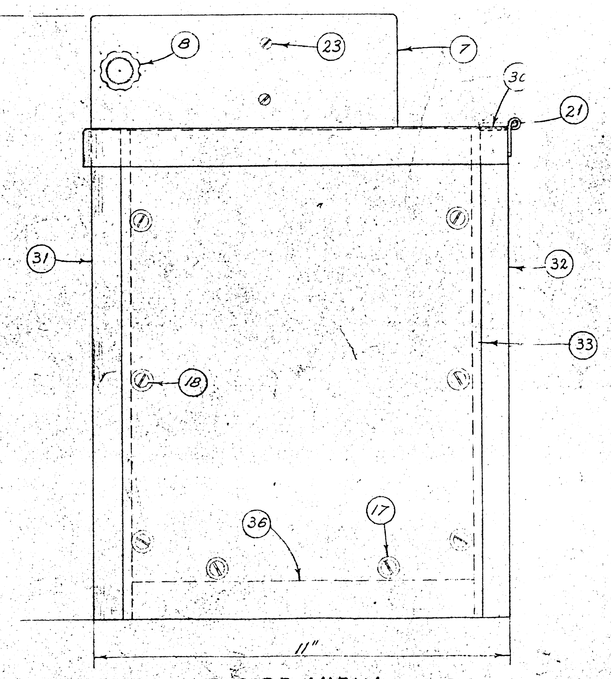


SECTION "B-B"

SECTION "A-A"



FRONT VIEW



R. SIDE VIEW

LIST OF PARTS

PIECE NO.	NAME	QUAN.	MATERIAL
1	PILOT LIGHT ASSEMBLY - 1.- NEWARK 52-501 (GREEN)	1	
2	WIZARD RECORDER	4	
3	MICRO SWITCH TYPE "Z" (NORMALLY OPEN)	3	
4	CONDENSERS .1 MFD - 1000V	4	
5	TERMINAL STRIPS 5 LUG # 2005	5	
6	MALE ARMORED OCTAL CHASSIS CONNECTORS P08M	1	
7	3"X 7"X17" CABINET (DETAILED)	1	
8	GENERAL RADIO KNOB 1 3/8" DIAM.	1	
9	POTENTIOMETERS 70 K Ω	8	
10	DIAL PLATE 0-100	8	
11	BAR KNOBS 1 1/4"	8	
12	CONE FEED THROUGH INSULATOR BUD I-435	16	PORCELAIN
13	CHASSIS CONNECTORS 93-C (1 CONDUCTOR)	8	AMPHENOL
14	CHASSIS CONNECTORS 91-P03M (3 CONDUCTORS)	2	AMPHENOL
15	G.M. TUBE	8	GLASS
16	SOLDERING LUGS, BIRNBACH # 98 1435	32	
17	CUP WASHERS RW-7161 N.P.	40	STEEL
18	#10-24 OVAL HEAD SCREW 1 1/2" LONG AND 1 STD. NUT	30	STEEL
19	#10-24 FLAT HEAD SCREW 1 1/2" LONG AND 1 STD. NUT	6	STEEL
20	#10 OVAL HEAD WOOD SCREW 2" LONG	8	STEEL
21	2"X 2" LOOSE PIN 6 HOLES BUTT HINGE	2	STEEL
22	#6-32 FLAT HEAD SCREW 1" LONG AND 1 STD. NUT	6	STEEL
23	#6-32 ROUND HEAD SCREW 3/4" LONG	4	STEEL
24	#6-32 ROUND HEAD SCREW 3/4" LONG	10	STEEL
25	#6-32 ROUND HEAD SCREW 1 1/4" LONG AND 1 STD. NUT	15	STEEL
26	#6-32 ROUND HEAD SCREW 3/4" LONG AND 1 STD. NUT	16	STEEL
27	#10 OVAL HEAD WOOD SCREW 3/4" LONG	2	
28	#6 SHEET METAL SCREWS 1/2" LONG	8	STEEL
29	#6-32 ROUND HEAD SCREW 1/4" LONG AND 1 STD. NUT	8	STEEL
30	TOP (DETAILED)	1	SHEET STEEL
31	FRONT (DETAILED)	1	LEAD
32	REAR (DETAILED)	1	LEAD
33	SIDE (DETAILED)	2	LEAD
34	PARTITION (DETAILED)	1	LEAD
35	CAP (DETAILED)	2	LEAD
36	BOTTOM (DETAILED)	1	LEAD
37	R. 1/2" ANGLE (DETAILED)	1	STEEL
38	L. 1/2" ANGLE (DETAILED)	1	STEEL
39	HANDLE (DETAILED)	2	STEEL
40	HANDLE BRACKET (DETAILED)	4	STEEL
41	#22 GAGE 20 COILS (18 LIVE 2 DEAD) .23" O.D. FREE LENGTH 1 1/4" SPRING	2	STEEL
42	COUPLING (DETAILED)	1	STEEL
43	RECORDER SHAFT (DETAILED)	1	STEEL
44A & B	CAM AND STOP COLLAR (DETAILED)	1 Ea.	STEEL
45	RECORDER BRACKET (DETAILED)	1	BAKELITE
46	REAR MOUNTING PLATE (DETAILED)	1	SHEET STEEL
47-A & B	TUBE GUARD (DETAILED)	8 Ea.	SPNGE-RUBBER
48	TUBE BRACKET (DETAILED)	8	BRASS
49	R. TOP PLATE (DETAILED)	1	SHEET STEEL
50	L. TOP PLATE (DETAILED) (NOT SHOWN)	1	SHEET STEEL
51	R. BOTTOM PLATE (DETAILED)	1	SHEET STEEL
52	L. BOTTOM PLATE (DETAILED) (NOT SHOWN)	1	SHEET STEEL
53	R. SWITCH PLATE (DETAILED)	1	SHEET STEEL
54	L. SWITCH PLATE (DETAILED) (NOT SHOWN)	1	SHEET STEEL
55	R. HAND SHIELD PLATE (DETAILED)	1	SHEET STEEL
56	L. HAND SHIELD PLATE (DETAILED) (NOT SHOWN)	1	SHEET STEEL
57	2X2 MESH 19 GAGE. GALVANIZED WIRE (6" X 8 3/4")	2	STEEL
58	2X2 MESH 19 GAGE. GALVANIZED WIRE (6" X 7 3/4")	2	STEEL
59	1/8" DIA. X 4" PIN	2	STEEL
60	3/8" GROMMET	12	

THIS DOCUMENT CONSISTS OF 1 PAGES
NO. 31 OF 41 COPIES
SERIES B

SECRET

FOUR FOLD HAND COUNTER
LEAD SHIELD
BLDG 717-B

Approved J. R. Oppenheimer 6/15/44

CLINTON LABORATORIES APR 13 1945

	REVISIONS	REV. BY DATE	REFERENCE DRAWINGS
1	GENERAL REVISION	8/23/44	CL717-B39

DATE 8-12-44
SCALE 1/2-SIZE
DRAWN BY E.L. Hutto
APPROVED R.S.S.
PROJ. No. C-22
CL-717B-38
CP-7/44

#3426

[redacted]

THE FOUR-FOLD HAND COUNTER & FOOT COUNTER

By: W. Q. Gulley
3/24/45

A. FOUR-FOLD HAND COUNTER

I PURPOSE

The Four-Fold Hand Counter is designed for the automatic rapid determination of Beta and Gamma contamination of the hands. Its main advantages over previous instruments are: (1) it checks both sides of both hands simultaneously, (2) it improves geometry by the use of two G-M tubes for each side of each hand, (3) no operator is required, and (4) it reduces the chance of error by means of automatic timing.

II PHYSICAL DESCRIPTION

The Four-Fold Hand Counter consists of four scale-of-eight Higinbotham scalers, each receiving pulses from two G-M tubes, a single high voltage supply and an automatic timing circuit.

The eight G-M tubes, two for each side of each hand, are mounted in a lead shield having 1" walls. A 1" lead shield also separates the right and left hand sections. The hands are inserted through holes in the front of the shield and rest on trays. Coarse mesh wire screen protects the tubes from accidental breakage.

The four Wizard recorders are housed in a cabinet resting on top of the lead shield, and are oriented to agree with the source of the four readings. The individual shafts of the four recorders have been replaced by a single shaft so that all recorders can be reset to "zero" by means of one knob.

A single cabinet with three chassis contains all of the electronic circuits. A transparent door, provided with a lock, prevents tampering with the controls. The lower chassis houses the high voltage supply, the B+ supplies, and the output stages for the four scalers. The middle chassis contains the four Higinbotham scale-of-eight scalers. The top chassis contains the timer and related controls. Detachable cables connect the various units to the instrument from the rear.

[redacted] ONLY

This docu[redacted] information affecting the national [redacted] of the [redacted] transmission [redacted] in any manner to an [redacted] prohibited by law. [redacted]

CLASSIFICATION CANCELLED
DATE FEB 11 6 4
For The Atomic Energy Commission
H. R. Carraway
Chief, Declassification Branch

The mechanical design and chassis layouts are shown by the following drawings:

Power Supply Chassis and Panel Layout CL-717-B-34
Scaler Chassis and Panel Layout CL-717-B-35
Lead Shield Assembly CL-717-B-38
Lead Shield and Recorder Details CL-717-B-39
Interconnection Cable Layout Q-195
Control Circuit Diagram Q-195-A
Control Circuit Description Q-195-B

[redacted]

III CIRCUIT OPERATION

The complete schematic circuit diagram is shown in Dwg. CL-717-B-37.

a. Voltage Supply for G-M Tubes

The high voltage supply for the G-M counters is conventional in design with a few exceptions. The high voltage A.C. is supplied by the 2500V. secondary of a #33390 transformer. In order to reduce the plate voltage of the 809 tube, a 100K 20W resistor was inserted between the 2X2 cathode and the 809 plate. The bleeder serves also to discharge the 1 mfd. 3000V condenser.

The "H.V. On - Off" switch controls only the primary of the #S-55 filament transformer for the 809 regulator tube; thus the input condenser and rectifier are at high potential when the "Line" switch is on regardless of the position of the "H.V." switch. For safety reasons, this should be remembered when servicing the set. In order to protect the G-M tubes against high voltage surges before the 1N5 regulator assumes control, it is important that the high voltage switch be turned on after the A.C. switch has been turned on.

Since there was no 1.5V secondary, the filament voltage for the 1N5 regulator tube was reduced from 7V by inserting a 110 ohm resistor in series with the 1N5 filament.

In order to provide individual voltage adjustments for the G-M tubes, a regulated potential from the B+ supply, adjusted by a potentiometer at each counter, is applied to the outer shell of the counter.

[redacted]

b. Scalers and Register Power Supplies

Because of the heavy power requirements, four transformers were used in the power supply.

The 5U4 rectifier supplies condenser input filtered B+ to the scalers. The center tap of the 6.3V secondary of the VPT-6 transformer is tied to this B+ supply and B+ is supplied to the scalers through the 6H6 filament lines. This impresses a 3V A.C. ripple on the scaler B+ but does not adversely effect operation. In wiring the scaling stages, it is necessary to feed each scaling stage off the same side of the filament winding in order to have the 3V ripple in phase on both sides of the scaling stage.

The 5U4 rectifier also supplies 210 volts, regulated by two VR-105 tubes connected in series, for the cylinder voltage of the G-M tubes.

The 5Y3 rectifier supplies R.C. filtered B+ to the four Wizard recorders.

The heavy 6SN7 filament current (approximately 10 amps.) is provided by a separate transformer.

c. Scalers

The four scale-of-eight Higinbotham scalers are essentially conventional in design, therefore only the deviations from standard design will be covered here. For information on scaler operation see "The Higinbotham Scaler", Volume I, Section B, Chapter 6-c, this manual.

Each of the scalers receives pulses from two G-M tubes which scan one side of one hand. Since pulses are fed into the first grid of the input 6SN7 from two G-M tubes, the oscilloscope, when plugged into the jacks on the front of the panel, does not distinguish between the pulses of the two G-M tubes.

The H.V. RC filter is located in the scaler chassis near the input stage of scaler #4. Filtered high voltage is supplied to a common high voltage line. Each of the four input stages receives pulses from two G-M tubes through two 50 mmfd. condensers, each input condenser being connected to the common

high voltage through a 1 meg. resistor.

Common B+ for the first triodes of all four input 6SN7's is regulated at 105V by means of a VR-105 tube.

The scaling stages are of conventional design except in two respects. One, previously mentioned, is the method of distributing the B+ voltage supply. The second departure from standard design is the method of starting and stopping the scaling action. This is normally accomplished by means of a switch which in the "stop" position grounds the input grid. The scaling action can be and is in this case, started and stopped by means of the switch normally used for resetting the scaler. To start the scalers, the reset line is grounded either manually by means of the switches marked "Manual", or automatically through the timer circuits. The scalers are stopped and automatically reset when the reset line to ground connection is broken (either manually or by the timer), allowing the grids to go positive. Consequently the neon lights cannot be used for interpolation. This method of starting and stopping is satisfactory because the interpolator readings are not of interest in this application. The neon lights are provided for checking the operation of the scalers.

In order to insure that the stages do not become unbalanced because of shifting resistors, all IRC plate load (5K, 15K), plate to grid (0.2 meg.), and grid (0.1 meg.) resistors were stabilized before using by heating at 100 - 120° C. for 48 hours. The stabilized resistors were then "balanced" for each stage by selecting grid resistors of the same value, plate to grid resistors of the same value, and by balancing the sum of the 5K and 15K plate load resistors against the 20K Brown Devil load resistor. When any of these components are replaced, the replacements should be stabilized and balanced in the same manner. The actual resistance values of the above components is not too critical. However, the use of 10% tolerance components is recommended.

Some difficulty was experienced with inter-wire capacity in the cable carrying the scaler output signal to the output stages located in the power supply chassis. When the 1st triode of the last

stage of any scaler became conducting, a negative pulse was transmitted to the grid of the second triode in the last stage of each scaler causing those which were conducting to become non-conducting, thus "flipping" the stage. A positive pulse pick-up had no affect. This trouble was eliminated by introducing a 50,000 ohm resistor in each scaler output signal line at the last stage.

The output stages of the four scalers are biased beyond cut-off by means of VR-105 tubes instead of resistors in order to eliminate degeneration in the cathode bias circuits.

d. Timer and Controls

The scalers can be operated with automatic timing or by manual control. For manual operation, the scaling is started and stopped by a toggle switch which grounds or opens the reset line. Automatic timing is accomplished by means of a Micro-Flex Timer manufactured by the Eagle Signal Corp., Moline, Illinois. The timer contains a magnetic clutch, a synchronous motor, and two independent switch assemblies. The contact assemblies operate in the following relation to the timer clutch and motor operation:

CLUTCH SOLENOID POWER	MOTOR POWER	SWITCH CONTACT ASSEMBLY #1	#2
Off	Off	Open	Open
On	Off	Closed	Closed
On	On during timing interval	Closed	Closed
Off at end of timing interval	On	Open	Open

The sequence of operations for automatic control is as follows:

1. During the operation of resetting the recorders to "zero", a cam on the common recorder shaft momentarily closes a micro-switch in a 110V line actuating the timer clutch solenoid, and lights the green pilot light in the recorder chassis which indicates when the solenoid power is on.

2. Actuation of the clutch solenoid closes both switch contact assemblies. Contact assembly #1 holds the solenoid actuated and maintains the green pilot light on the recorder mount. Contact assembly #2 completes the reset line from ground to the C. P. Clare micro-switch relay in the timer chassis but it is still open from ground at the micro-switch relay.

3. When the hands depress both trays in the lead shield, thus closing the two micro-switches located under the trays completing a 6.3V circuit, the micro-switch relay in the timer chassis is actuated. This relay completes the 110V power line to the timer motor and simultaneously completes the grounding of the reset line, starting the scalers.

4. At the expiration of the interval for which the timer had been set, contact switches #1 and #2 open, de-energizing the clutch solenoid, and opening the reset line.

The 6.3V transformer for the micro-switch relay circuit is located in the timer chassis.

Three means are provided for starting the count using the automatic timer. Control is accomplished by means of a Selector Switch on the Timer Panel as follows:

<u>Position 1</u> - The micro-switches under the trays are series connected so that both must be closed to start the counts. This is the normal position for counting both hands.

<u>Position 2</u> - The left hand micro-switch is shorted out so that only the right hand tray need be depressed to start the count. This position is used for counting one hand only.

<u>Position 3</u> - In this position, both micro-switches are shorted out so that counting begins immediately when the selector switch is thrown to position 3 provided the recorders have been previously reset to "zero". This position is useful for running background counts.

e. Lead Shield - G-M Tubes

As previously mentioned, the Lead Shield is divided into two sections, each section containing four G-M tubes. The central wires of these G-M tubes are supplied with the positive high voltage indicated by the meter on the power supply panel. Adjustment of the voltage applied to each individual tube is obtained by connecting the shell of the G-M tube to the center tap of a potentiometer connected between regulated B+ (210V) and ground. These potentiometers are located next to the G-M tubes which they control and are arranged so that the voltage on the shell of the tube is decreased, and consequently the voltage across the G-M tube is increased, as the potentiometer is turned from 0 to 100.

The bottom sponge rubber bushing for supporting the G-M tube is cemented in place while the top bushing is removable. This permits the G-M tubes to be replaced without removing the wire screens.

The central wires of the G-M tubes connect to the outer terminals and the shells to the inner terminals.

The following procedure has been found most satisfactory for adjusting the eight G-M tubes to their proper operating voltage:

1. Turn all potentiometers to zero. This puts 210V on the shell of the tubes.

2. Increase the high voltage by means of the control knob on the power supply panel until one scaler starts counting.

3. Adjust each tube to its proper operating voltage by running a plateau on each tube using the potentiometer adjacent to each tube to vary the voltage applied across that tube. These voltages must lie within a 200V range. Since two G-M tubes are connected to each scaler, the plateaus can be run only in groups of four. A G-M tube can be disconnected by either disconnecting the H.V. cable to the tube, or by disconnecting the central wire of the tube.

f. General Specifications

The approximate voltage and current specifications of the circuit are as follows:

B+ drain for scaler supply (5U4) ..... 225 ma.
B+ voltage for scaler supply ..... 300 volts
B+ drain for register output supply ..... 70 ma.
B+ voltage for register output supply ..... 360 volts
Line drain @ 110 volts ..... 3.0 amps.
Line fuse size ..... 5.0 amps.

Scaler operating conditions (voltages to ground):

Plates	150	290
Grids	80	40
Cathodes	70	70

B. FOOT COUNTER

I PURPOSE

The Foot Counter is designed for the determination of Beta and Gamma contamination of the shoes. While it is a complete unit in itself, the Foot Counter can be used to best advantage in conjunction with the Four-Fold Hand Counter for simultaneous rapid automatic determination of Beta and Gamma contamination of the hands and shoes.

II PHYSICAL DESCRIPTION

The Foot Counter consists of a power supply and a Scale-of-128 Higinbotham scaler mounted in one chassis, a floor stand equipped with two G-M tubes feeding into a single stage pre-amplifier, and a single Wizard recorder mounted in a separate chassis.

All controls, except for a push button "count" switch, are located on the back of the scaler in order to make them comparatively inaccessible to unauthorized persons.

The Foot Counter floor stand frame is made of wood and is expendable upon contamination. A steel grating rests on the wood frame and is covered by thin paper fed from an attached roll which prevents dirt from the shoes of the person being checked from falling through the grating onto the G-M tubes located underneath the grating. Further protection from dirt and contamination is provided by a paper covered tray mounted underneath the steel grating and over the G-M tubes. A partial wall of 1½" x 3" x 6" lead bricks offers some shielding for the G-M tubes.

III CIRCUIT DESCRIPTION

The pulses from the two G-M tubes are fed into a common single stage pre-amplifier. The pulse is taken off the cathode of the 6C5, thus delivering a negative pulse to the scaler.

The scaler is a standard scale-of-128 Higinbotham scaler provided with a standard power supply. For information on the operation of this circuit, see "The Higinbotham Scaler", Volume I, Section B, Chapter 6-c, this manual.

The Foot Counter, when used in conjunction with the Four-Fold Hand Counter, uses the timer circuit of the Four-Fold Hand Counter to start and stop the scaling action. The scaler is started and stopped in the conventional manner by breaking the ground connection, or grounding the second grid of the input triode

respectively. This is accomplished by means of a C.P. Clare micro-switch relay located in the Foot Counter scaler chassis. The 6.3V A.C. circuit for this relay is made and broken by the timer circuit in the Four-Fold Hand Counter timer chassis.

In order to use the Four-Fold timer circuit to time the operation of the Foot Counter, some changes are necessary. 6.3V A.C. for the Foot Counter "Start - Stop" relay is obtained by running a line from the high side of the C. P. Clare relay in the Four-Fold Hand Counter timer chassis, thus placing the two relays in parallel. In order for the Foot Counter to be stopped at the expiration of the time interval (at the same time that the Four-Fold scalers are stopped and reset), it was necessary to connect a spare set of Microflex timer switch contacts in series with the two micro-switches in the Lead Shield. With this change, the 6.3V A.C. line is broken by the timer at the expiration of the time interval, thus de-energizing the two relays and stopping the Foot Counter. In addition, a normally open push button switch is wired in parallel with the two micro-switches in the Lead Shield, but not in parallel with the timer contacts in the 6.3V A.C. line; therefore when testing with radiation sources, the count (both Four-Fold and Foot Counter) can be started by pressing the push-button switch, provided the Four-Fold recorders have been reset to close the timer contacts. At the expiration of the time interval, both the Foot Counter and the Four-Fold Hand Counter are stopped automatically.

The Foot Counter is reset in the conventional manner by breaking the common connection to ground for the grids of the second 6SN7 triodes of all stages. This is accomplished by means of a type "Z" micro-switch and a cam on the Foot Counter recorder reset shaft. The Foot Counter recorder chassis is mounted above the Four-Fold recorder chassis, and the recorder shafts are connected by means of a chain and sprockets so that all recorders can be reset in one operation.

The relation of the various components of the timer circuit for automatic operation of the Foot Counter and Hand Counter is shown in the following table:

RECORDERS	MICRO-SWITCHES IN LEAD SHIELD	MICRO-SWITCHES IN RECORDER MOUNTS		CLUTCH SOLENOID POWER	TIMER MOTOR POWER	TIMER SWITCH ASSEMBLIES		C. P. CLARE RELAYS	
		HAND COUNTER	FOOT COUNTER			#1	#2	IN FOOT COUNTER	IN HAND COUNTER TIMER CHASSIS
Recorders not reset	Open	Open	Closed	Off	Off	Open	Open	Closed	Open
Knob turned to reset Recorders	Open	Closes momentarily (Supplies clutch solenoid power)	Opens Momentarily (Resets scaler)	On	Off	Closed	Closed	Closed	Open
Recording	Closed	Open	Closed	On during timing inter-val	On during timing inter-val	Closed	Closed	Open	Closed
End of timing interval recorders stopped	Closed	Open	Closed	Off	Off	Open	Open	Closed	Open
Not Recording	Open	Open	Closed	Off	Off	Open	Open	Closed	Open

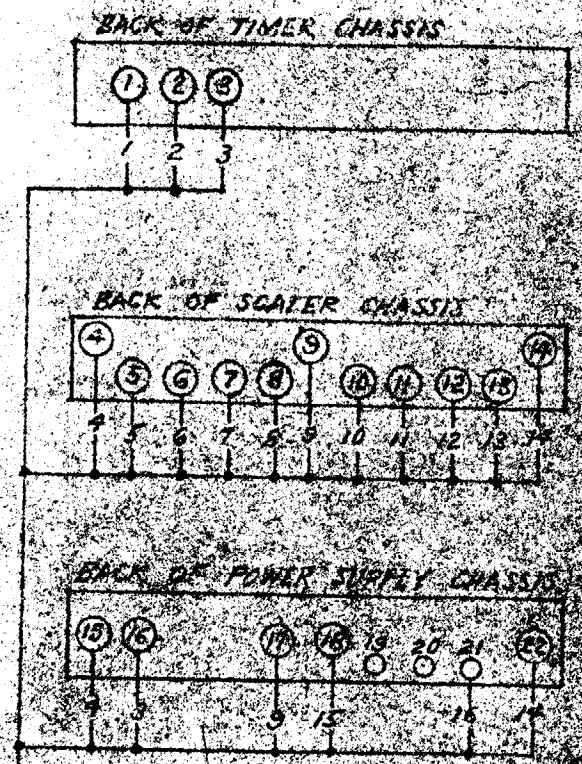
High voltage is supplied to the control wires of the two G-M tubes from a common high voltage line. Adjustment of the voltage applied across each individual tube is obtained by connecting the shell of the G-M tube to the center tap of a 1.0 meg. potentiometer connected between 105V, regulated by a VR-105 tube, and ground. A 0.1 mfd. filtering condenser is connected between the center tap of the potentiometer and ground.

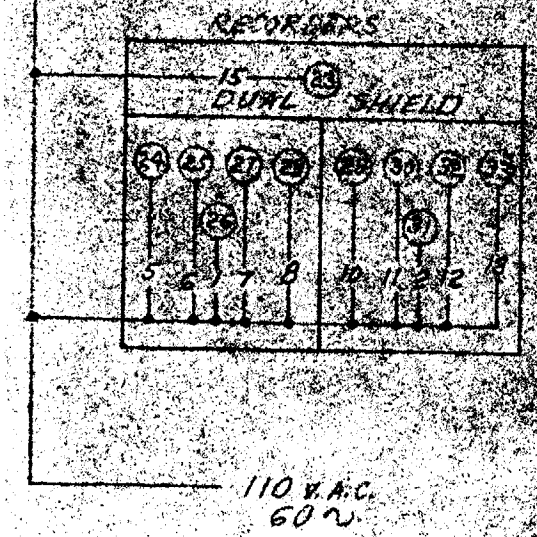
To run plateaus on the tubes, the potentiometers are turned to give full 105V on the shells of the tubes. The high voltage is then increased until one tube begins counting. Plateaus are then run on one tube at a time, the other tube being disconnected, by adjusting the potentiometers. The operating voltages of the two tubes must be within 105V of each other.

The circuit diagram of the Foot Counter are shown by the following prints:

Circuit Diagram CL-717-B-50
Four-Fold Modified Timer Q-270-A
Layout - Chassis Connectors & Cables ... Q-269-A

CP-2188
V-C-1





CABLE NO.	CONNECTOR	CABLE	LENGTH	CONNECTOR
1	Amphenol 91-MC3M	3-Conductor Shielded, Belden 8423	30 In.	Amphenol 91-MC3F
2	Amphenol 91-MC3M	3-Conductor Shielded, Belden 8423	30 In.	Amphenol 91-MC3F
3	Amphenol 79-PT8	7-Conductor Shielded, Belden 8427	30 In.	Amphenol 86-PM8
4	Amphenol 93-M	1-Conductor Shielded, Alpha 1249	18 In.	Amphenol 93-M
5	Amphenol 93-M	1-Conductor Shielded, Alpha 1249	32 In.	Amphenol 93-M
6	Amphenol 93-M	1-Conductor Shielded, Alpha 1249	32 In.	Amphenol 93-M
7	Amphenol 93-M	1-Conductor Shielded, Alpha 1249	32 In.	Amphenol 93-M
8	Amphenol 93-M	1-Conductor Shielded, Alpha 1249	32 In.	Amphenol 93-M
9	Amphenol 78-PT8	7-Conductor Shielded, Belden 8427	16 In.	Amphenol 86-PM8
10	Amphenol 93-M	1-Conductor Shielded, Alpha 1249	32 In.	Amphenol 93-M
11	Amphenol 93-M	1-Conductor Shielded, Alpha 1249	32 In.	Amphenol 93-M
12	Amphenol 93-M	1-Conductor Shielded, Alpha 1249	32 In.	Amphenol 93-M
13	Amphenol 93-M	1-Conductor Shielded, Alpha 1249	32 In.	Amphenol 93-M
14	Amphenol 78-PT8	7-Conductor Shielded, Belden 8427	16 In.	Amphenol 86-PM8
15	Amphenol 79-08M	8-Conductor Shielded,	36 In.	Amphenol 79-08F1
16		3-Conductor Rubber Covered,	60 In.	Hubbellock Plug

CHASSIS CONNECTORS

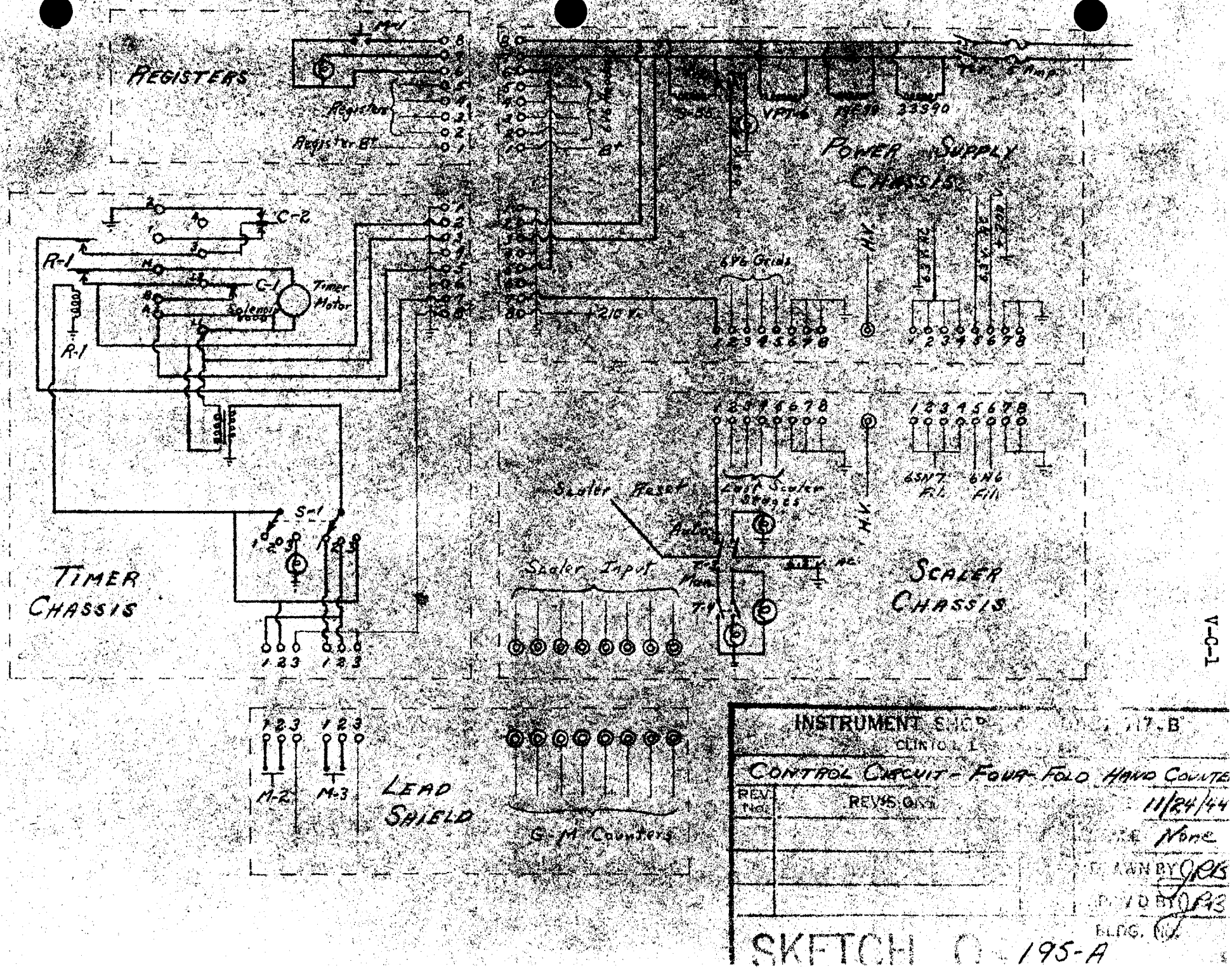
TYPE	CONNECTOR NO.
Amphenol 93-01	4
Amphenol 91-PC3F	1,2
Amphenol 91-PC3M	26,31
Amphenol 86-PM8	3,9,14
Amphenol 79-PT8	16,17,22
Amphenol 79-[illegible]	18
Amphenol 79-[illegible]	
Amphenol 93-C	5,6,7,8,10,11,12, 13,15,24,25,27, 28,29,30,32,33
Extractor Fuse Post	19,20
Rubber Grommet	21

REFERENCE DWG. CL-7178-39
FOUR-FOLD BAND COUNTER

INSTRUMENT SHOP — BUILDING 717-B
CLINICAL LABORATORIES
CHASSIS CONNECTORS & CABLES — LAYOUT & LIST

REV. No.	REVISIONS	REV. DATE	DATE 8-7-44
1	Zero Time Lamp Res.	7/24/44	SCALE
2	Channel Ref. Dwg. MPR		DRAWN BY M. Falls
			APP'V'D BY [illegible]
			BLDG. No.

SKETCH O-195


REGISTERS
M-1
Registers
Register B+
POWER SUPPLY CHASSIS
VPT-6
33390
B+
+210 V.
6V6 Grids
H.V.
C-2
R-1
C-1
Timer Motor
Solenoid
TIMER CHASSIS
S-1
Scaler Reset
Last Scaler Stages
Auto
Scaler Input
Man
T-4
6SN7 Fil.
6H6 Fil.
SCALER CHASSIS
M-2
M-3
LEAD SHIELD
G-M Counters
INSTRUMENT SHOP
CONTROL CIRCUIT - FOUR-FOLD HAND COUNTE
REV. No.
REVISIONS
11/24/44
None
DRAWN BY
APPD BY
BLDG. NO.
SKETCH
195-A

V-C-1

1. Close "Line Switch T-1	1. Provides plate voltage for all rectifiers and filament voltage for all tubes except Type 809. Hence there is no high voltage beyond this regulator tube.
2. Close "H.V." Switch T-2	2. Provides filament voltage for 809 tube. This completes H.V. circuit.
3. Throw "Auto.-Man." Toggle Switch T-3 to "Man."	3. Removes entire automatic timing circuit and provides for manual control.
4. Close "On-Off" Switch T-4	4. Grounds scaler reset lines, thus starting the scaling.
5. Open "On-Off" Switch T-4	5. Opens scaler reset lines from ground, thus stopping scaling and resetting lights to zero.
6. Throw "Auto.-Man." Toggle Switch T-3 to "Auto."	6. Connects automatic timing circuit to scaler reset line.
7. Reset registers to "zero"	7. Cam momentarily closes micro-switch M-1. This momentarily energizes clutch solenoid of timer Switch contacts C-1 and C-2. Contact C-1 holds the solenoid actuated. Contact C-2 completes reset line to this point but is still open from ground at relay R-1.
8. Set Selector Switch S-1 to Position 1	8. Arranges Micro-switches M-2 and M-3 in series.
9. Press trays in lead shield	9. Closes Micro-switches M-2 and M-3 and energizes relay R-1. This closes A.C. circuit to motor and also completes grounding of reset line starting scaler.
10. Hold trays until timer completes cycle for which it is set.	10. At expiration of interval for which timer is set Contact Switches C-1 and C-2 open, de-energizing clutch solenoid, opening power circuit to timer motor, and opening reset line.
11. If Selector Switch S-1 is set to Position 2	11. Micro-switch M-3 is shorted out and Relay R-1 is actuated by closing only Micro-switch M-2.
12. If Selector Switch S-1 is set to Position 3	12. Both Micro-switches M-2 and M-3 are shorted out and relay R-1 is actuated at once.

DESCRIPTION OF CONTROL CIRCUIT
REFER TO Q-SKETCH 195-A

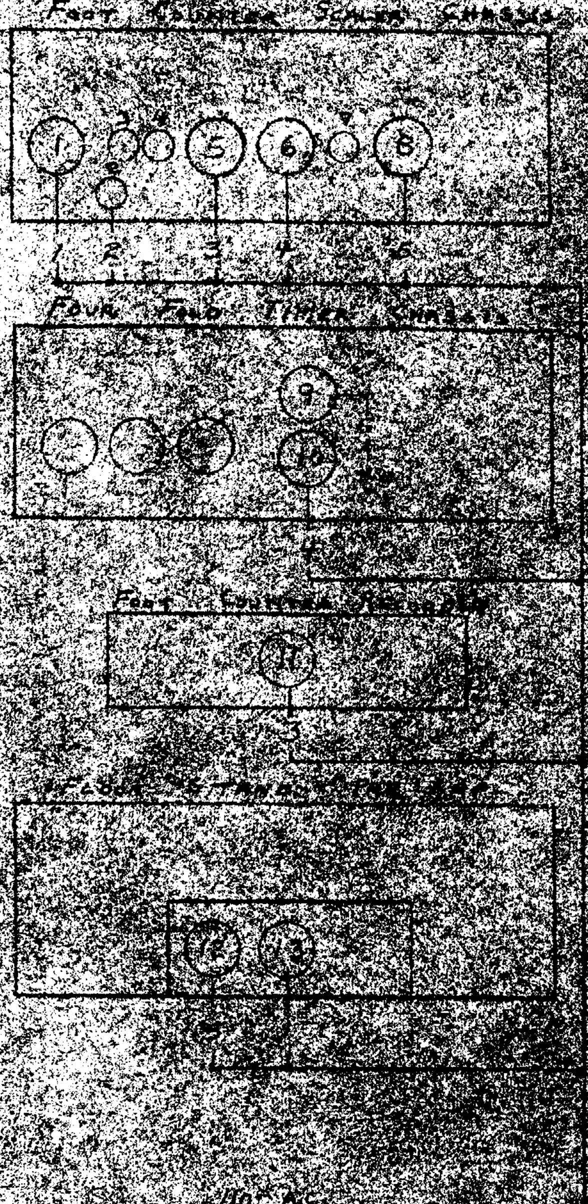
FOUR-FOLD HAND COUNTER

11/25/44

J.R.B.

JRB

SKETCH Q 195-B



CABLE NO.	CONNECTOR	[illegible]	LENGTH	CONNECTOR
1	[illegible]	[illegible]	9 ft	Amphenol 86-PM8
2	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	Amphenol 86-PM8
4	[illegible]	[illegible]	[illegible]	Amphenol 91-MC3F
5	[illegible]	[illegible]	[illegible]	Amphenol [illegible]
6	[illegible]	[illegible]	7 ft	Amphenol 91-MC3F

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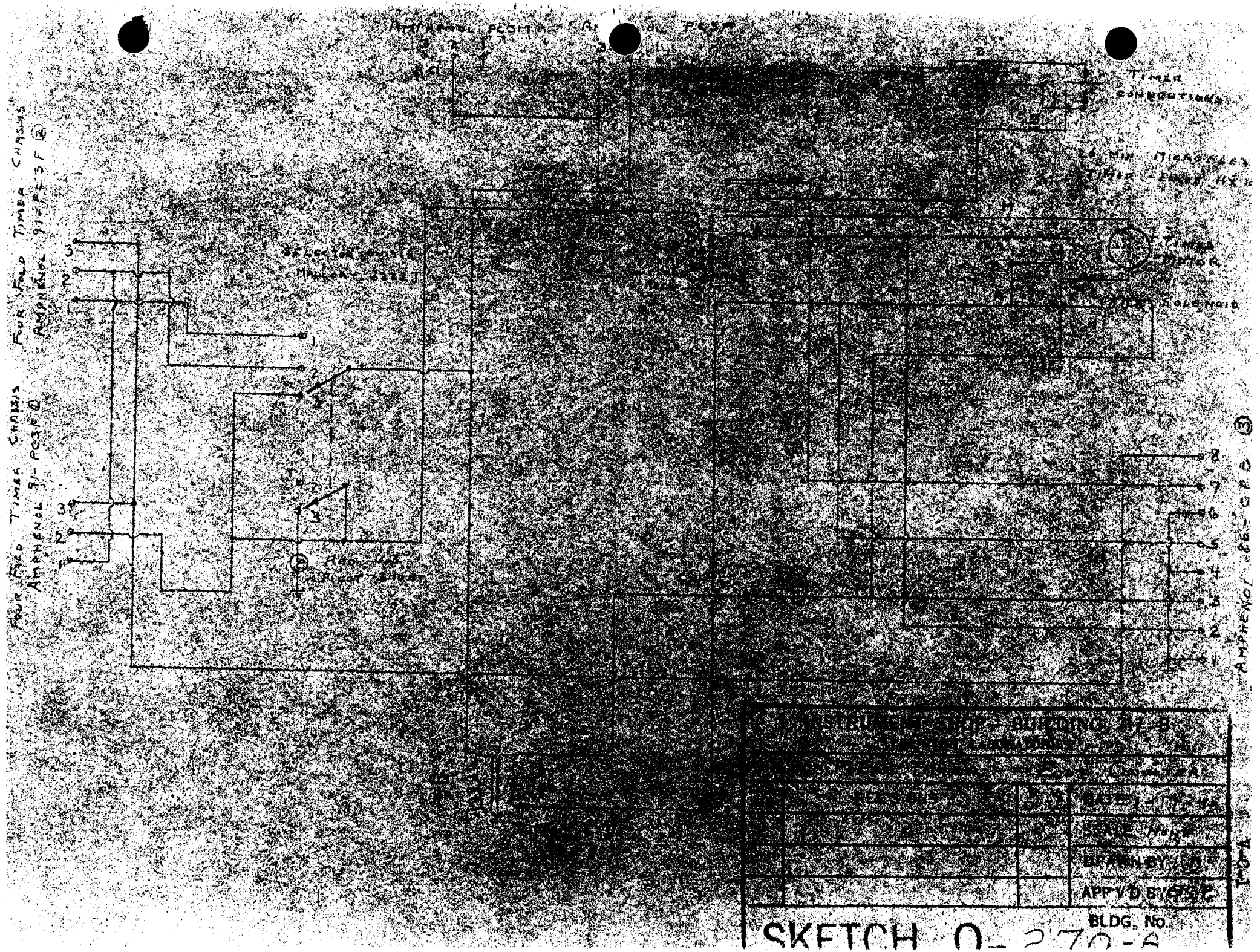
SKETCH Q-



Four Fold Timer Chassis
Amphenol 91-PC3F ②
Four Fold Timer Chassis
Amphenol 91-PC3F ①
Amphenol PC3M
Timer Connections
Timer Motor
Solenoid
Amphenol 86-CPB ③
INSTRUMENT SHOP - BUILDING 217-B
REVISIONS
DATE
SCALE None
DRAWN BY
APP'V'D BY
BLDG. No.
SKETCH O-270-A

MonP-329

Contract No. W-35-058 eng 71

* * *

PLANT INSTRUMENTS

C. F. Foster, Area Engineer.

* * *

THE HAND & FOOT COUNTER MONITOR

6-12-47

C. W. Reed & C. F. Foster

Received: 6/24/47 Issued: 6/24/47

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94-95. University of Rochester

I

Since 1945 the Health-Physics Department has been making daily tests of the Hand & Foot Counter equipment. These tests and subsequent calculations are based on a memorandum from R.R. Coveyou to K. Z. Morgan, Re: "Testing of Counter-Scaler Units for statistics, dated Jan. 1, 1945.

In this article Coveyou has developed an equation which has proven of great value to Health-Physics in determining the condition of their health protection equipment. Likewise it has proven a useful tool in Instrument Maintenance in keeping the equipment in proper repair for best operating conditions.

The equation as derived by Coveyou and used by Health-Physics is

$$K = Q\left(\frac{\sum (X_i - \bar{X})^2}{\sum X_i}\right)$$

which can be converted into a more usable form

$$K = Q\left(\frac{\sum X_i^2}{\sum X_i} - \frac{\sum X_i}{M}\right)$$

where K = the Factor.
X_i = the result of the ith count.
M = the number of counts taken.
$\bar{X}$ = the average of M counts.
Q = the Scaling Factor.

It is remarkable that, within the limits imposed by the use of the LaPlace approximation the distribution of the values of K (individual Factors for the Hand & Foot Counters) depend only upon the number of determinations of the counting rate used in its calculation and is independent of the actual counting rate. Of course, in a given counter, K may depend on the counting rate; i.e., the counter may work more satisfactorily at one counting rate than at another. Within practical limits this is at no serious consequence, for with existing test procedures we use an input circuit capable of fulfilling these conditions.

If the unit is working properly, the Factor will be approximately unity and the divergence of the Factor from Unity will be a measure of the statistical reliability of the scaling unit.

The probability that $K \leq a$, for 20 determinations is shown in the table below.

a	$P(K \leq a)$	a	$P(K \leq a)$	a	$P(K \leq a)$	a	$P(K \leq a)$
.1	$\sim 10^{-7}$	.6	.0840	1.1	.6595	1.6	.9567
.2	$\sim 5 \times 10^{-5}$	.7	.1695	1.2	.7576	1.7	.9739
.3	.0011	.8	.2834	1.3	.8342	1.8	.9846
.4	.0081	.9	.4126	1.4	.8906	1.9	.9911
.5	.0318	1.0	.5421	1.5	.9301	2.0	.9950

There is appended a graph giving the values of the probability that K lie in the interval $\pm .05$, as a function of a, and with $M = 20$.

From the above table, we see that the Factor should fall between the limits of 0.6 & 1.6 about 87% of the time. If the scaling units are in good working condition Factors of 0.4 or under should rarely occur & Factors above will occur about 1 in 200.

II

Health-Physics have radiation sources or samples made up which fit snugly into the hand counter openings & a similar source to be placed on the foot counter. The sources in the main are Beta & Gamma emitters. When placed in position, the sources are not touched for the duration of the test. Twenty consecutive counts are made and recorded for each hand & foot counter. Either the Microflex Timer or a stop watch may be used for timing the intervals. The latter method yields better factors but it has not been found necessary for daily checking.

There is appended a Daily Hoople Counter Test Sheet, which includes 20 Consecutive counts, calculations, factors and remarks, typical for each hand & foot counter.

III

What are the conditions for producing bad factors. An interesting case is the detection of an oscillatory condition in a scaling circuit, detected by the otherwise unexplainable circumstance that the value of K was low or abnormally low. All other circumstances affecting the value of K, being irregular, will have the tendacy to increase K^o. Common sources of trouble could be:

1. GM tubes not properly adjusted to their plateaus.

2. Poor scaling action.

3. GM tubes discharging.

4. Recorders jamming.

5. Loose connections in cables, wiring, etc.

6. H.V. not properly controlled causing fluctuation of GM tube voltage.

7. Output circuit to recorders not operating correctly.

8. Timer not operating properly, e.g. factors of 2.0 or more. Should be checked weekly with stop watch.

9. H.V. circuit arcing or discharging (not very common).

Unusual sources of trouble.

1. (4 of 7) Intersection pulsing across VR105 tube which supplies plate voltage to 1st section of each 6SN7 input tube. Eliminated by 8 mfd. condenser connected across the VR tube.

2. (2 of 7) One section recorder would not record when adjacent recorders were drawing current. Cable connecting recorder assembly and scaler chassis had a high resistance leakage path between pins was cause of trouble.

IV

What procedures should we use in detecting these troubles? It is imperative that the average count be known in addition to the factor. One of the two GM tubes could be inoperative and still yield a good factor.

When factors as high as 20 or above are recorded, the cause is obvious. No recheck of the factor is necessary for factors higher than 3.00, because with the instrument in good condition and according to the law of probability this condition is extremely remote.

In order to eliminate troubles in advance a weekly check on GM tube operation is advised. A simple method of adjusting the GM tubes can be used although objections may be raised that this method is not as accurate as individual plateaus.

There are two forms of Hand & Foot Counters now in use, the "Original Model" and the "Modernized Model". The methods are as follows:

Original Model.

1. Reset all H.V. pots to zero and reduce common H.V. so that all GM tubes are below their thresholds.

2. With a source in place, adjust the common H.V. source to a value just below the threshold on any of the GM tubes.

3. Increase the H.V. on one GM tube using the H.V. pot in shield until the threshold is reached. Note the reading on the pot and reduce pot setting to zero.

4. Repeat for all GM tubes.

5. Set GM tube pots so that each GM tube is at its threshold as determined from preceding steps.

6. Using the Main H.V. control and meter, increase the H.V. common to all tubes 60 to 70 volts.

7. Check operation of the Hand & Foot Counter with a standard source.

Modernized Model.

1. Reset all H.V. pots to zero and reduce common H.V. so that all GM tubes are below their thresholds.

2. With a source in place, adjust the common H.V. source to a value just below their thresholds.

3. Place all switches in under side of Register Mount to "On" position. Place one switch in "Operate" position. Increase the H.V. on the GM tube using the H.V. pot. until the threshold is reached. Place switch in "On" position.

4. Repeat for all GM tubes.

5. Place all switches in "Operate" position.

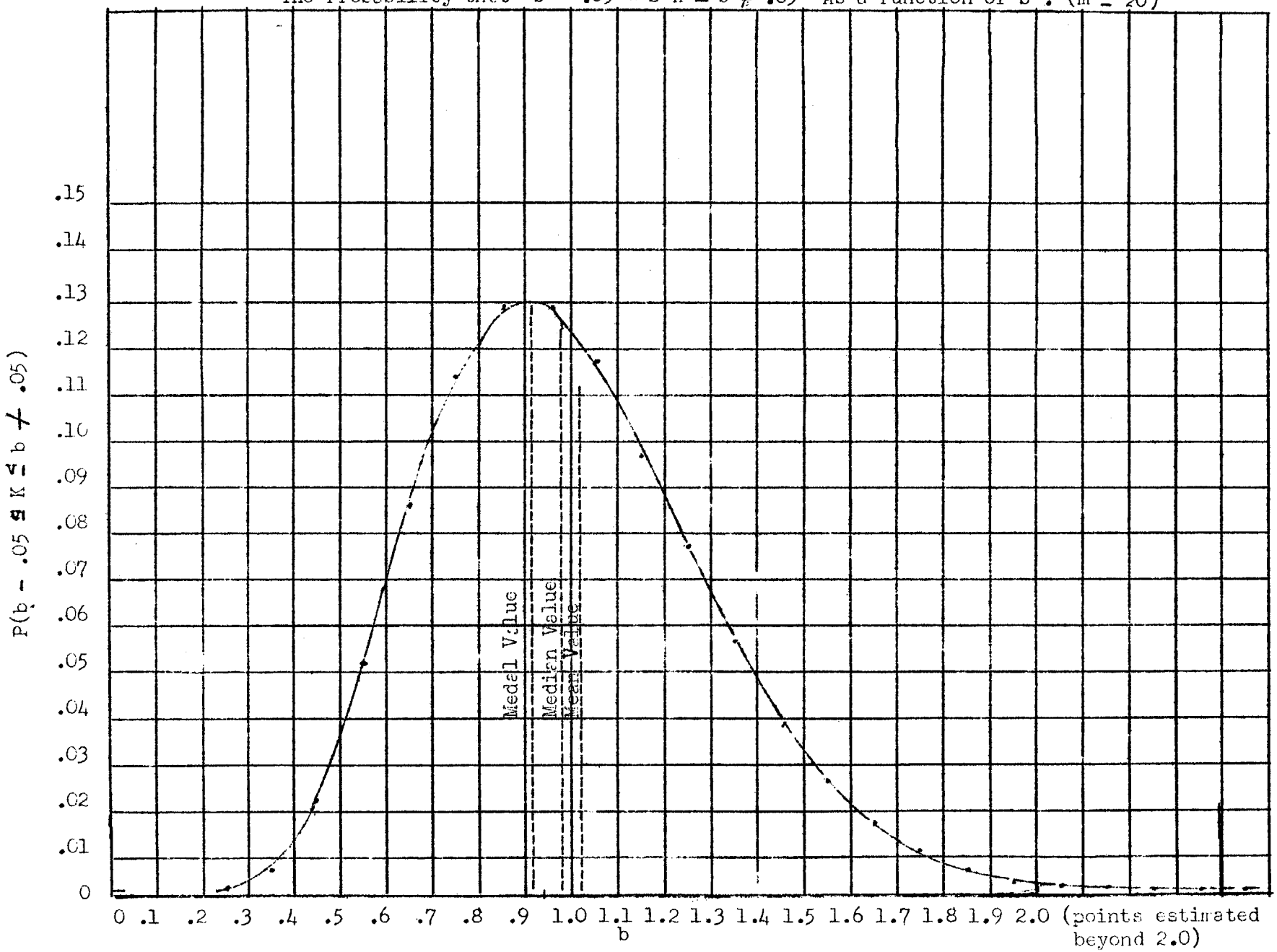
6. Using the Main H.V. control and meter, increase the H.V. common to all tubes 60 to 70 volts.

7. Check operation of the Hand & Foot Counter with a standard source.

If after completing above procedure a particular section counts low, then each of the two GM tubes should be checked individually for plateaus. If the count is high, then in all probability one or both tubes may be discharging. It is assumed that the bias for each input stage of each section has been properly adjusted before setting the GM tubes on their plateaus.

It is hoped that the above summary will be useful in explaining the meaning of the factor and that the factor will be useful tool in using and servicing the Hand & Foot Counter equipment.

The Probability that $b - .05 \leq S\ K \leq b + .05$ As a Function of b . ($m = 20$)



FORM NO. B-284

DAILY HOOPLE COUNTER TESTS

BUILDING 706-D

DATE: 1/21/46

COUNTER NO. 7-924

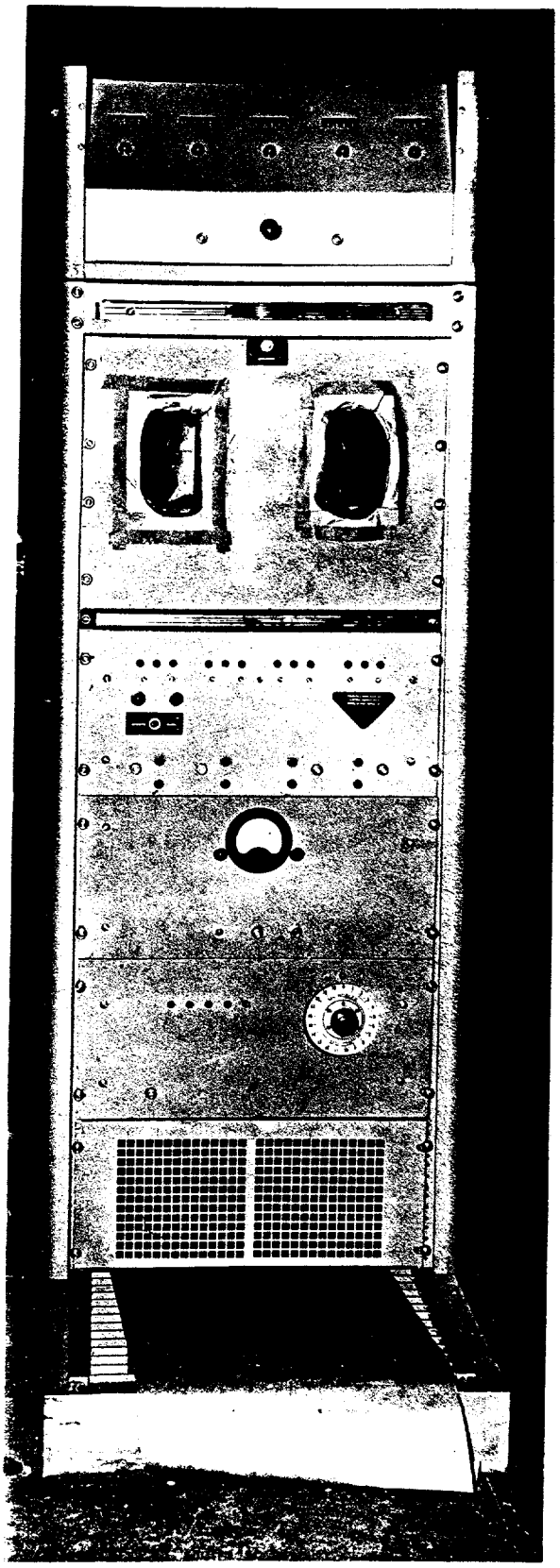
BY: R. Slattery

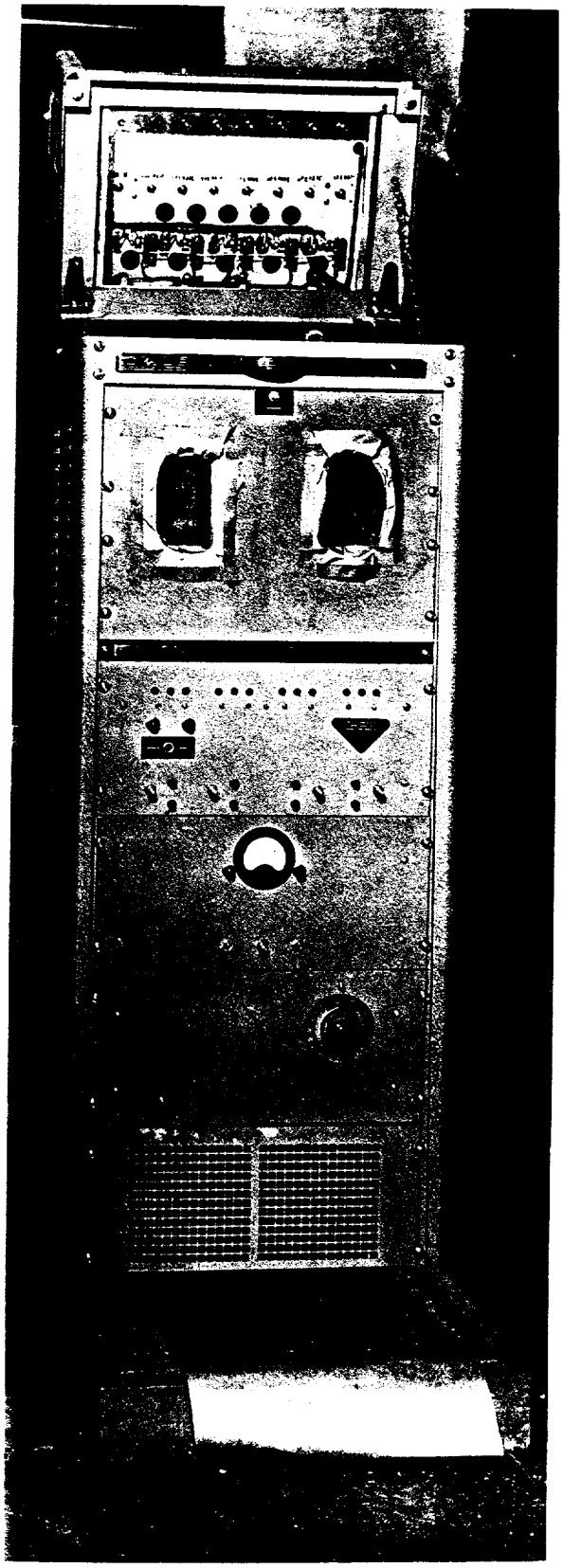
LB	LP	RP	RB	FC	Background: LB 9 LP 7 RP 6 RB 11 FC 7
					Factors:
110	103	78	124	61	LB
					221684 105.363
105	104	74	120	62	2104 105.2
					.163 x 8 = 1.304
104	100	75	125	61	
107	106	76	125	60	
					208943 102.272
109	100	79	122	61	LP 2043 102.15
100	105	75	127	60	.122 x 8 = .976
109	101	75	113	58	
106	99	78	130	61	
105	108	72	121	60	
					116848 76.471
106	105	77	123	62	RP 1528 76.4
106	96	78	123	59	.071 x 8 = .568
100	106	81	127	62	
98	94	80	122	59	
					311733 124.943
98	104	74	137	61	RB 2495 124.75
104	102	78	130	60	.193 x 8 = 1.544
104	98	79	125	62	
110	103	74	131	63	
					73361 60.578
103	100	75	123	58	FC 1211 60.55
115	106	76	127	61	.028 x 128 = 3.584
105	103	74	120	60	

Remarks:

LB
LP
RP
RB
FC

High Background





BECKMAN QUARTZ SPECTROPHOTOMETER Model DU

By: A. V. Novak
2/28/47

The Model DU Beckman Quartz Spectrophotometer is an instrument used for the identification and determination of various chemical substances. This is accomplished by passing a monochromatic beam through the sample and noting the percent transmission or light absorption as a function of wave length. The monochromatic beam is produced by passing light through a quartz prism by means of a system of mirrors and apertures. Detailed specifications on this unit are presented in Beckman's Bulletin #134-B.

The purpose of this write-up is to present a logical sequence of tests and adjustments to put a spectrophotometer into firstclass condition. Beckman's Bulletin #150-A is helpful in locating specific difficulties and should be studied in detail. However, it cannot be overemphasized that a complete tune-up as presented below should be made upon a unit whenever it is brought in for repair. Only in this way can confidence be built and maintained in the repair jobs made.

Shop Tune-up Procedure:

1. Remove the light source housing, the sample cover, and the sample holder. Turn the unit with the meter face down. For this purpose, it is convenient to make a small "U"-shaped block that will rest next to the wave length knob and near the ammeter in such a way as to keep the unit from resting on the control knobs.

2. Remove the 6 small screws holding down the base plate and test the 6 $7\frac{1}{2}$-volt batteries located under the plate. Check the battery connections against Dwg. # CD-25C as shown on page 10 of Bulletin #150-A. Be sure the battery terminals do not ground out by touching the frame. Note that it is sometimes necessary to move the wire terminal of the #3 battery to another point on battery #2, depending upon the characteristics of the vacuum tubes. This change is seldom necessary other than when tubes are changed.

3. Under battery #2 is located a desiccant box. This should be refilled at least <u>every three months</u> whether the unit is in use or not. <u>Warning</u>: Do not use calcium chloride as a desiccant. Drierite or silica gel is satisfactory.

4. Remove the 6 screws located in the battery compartment that hold the top cover in place. Replace battery cover and hold in place with 2 screws. Turn the instrument right side up and remove the slit knob, the wave length knob, and the top cover.

5. Clean both scales with art gum.

6. Check cross-hair on wave length dial to make sure it is "square" with the lines on the scale.

7. Check the wave length dial for wobble on its vertical axis. If any rocking should be present, it can be removed by adjusting the locked screw on top of the wave length shaft. The proper adjustment is the point where no wobble exists and a minimum binding is felt.

8. The inner cast iron housing should normally never be entered, as it is sealed off to prevent dirt and moisture from entering.

9. The adjustment on the long arm movement controlling the prism motion is very critical and should normally never be changed. If, however, a wave length dial calibration (explained in step #21) checks at one point but not at another, this adjustment has been tampered with and must be corrected. A rough adjustment can be made on this by making all of the following distances equal:

(a) Distance from the vertical prism axis to the cross-hair on the wave length dial.

(b) Distance from the vertical prism axis to the knob that rums in the scroll under the wave length dial.

(c) Distance from the vertical prism axis to the center of the vertical axis holding the wave length dial.

From here on, it is definitely a trial and error method of changing the arm length and rotating the prism housing. After each setting two points with the mercury lamp must be checked. Needless to say, this is a very involved procedure, often taking days to complete. It is, therefore, advisable not to move this adjustment unless absolutely necessary.

10. Replace the top cover, but do not screw in place.

11. Remove the light housing and note the condition of the concave mirror. If any dust or dirt is present on the mirror, try cleaning it as follows: Dip a large wad of cotton into a solution of Dreft and drag the cotton across the surface of the mirror while holding the mirror in a horizontal position. Do not use any pressure on the cotton - let only the weight of the wet cotton do the job. After several wipes with the cotton, wash the mirror off under running tap water and finally rinse with distilled water and blow dry. If this treatment fails to clean the mirror, replace it.

12. Check the lamp. Wash it if dirty, or replace it if it shows any signs of being black inside. Take special pains to make the screw contacts holding the lamp secure. Note that the lock nuts on these screws are tight.

13. Check the switch on the lamp housing with an ohmeter to make sure no resistance occurs across this switch.

14. Check all storage battery wiring for good connections.

15. Remove the phototube housing and the block containing the plane mirror in front of the slit block. Check this mirror and clean with Dreft or replace if necessary. Normally only one filter (center) is used in the filter block slide. This filter can be cleaned with lens paper as it is made of hard glass. The window covering the lower slit is flat while the one over the upper slide is a 10 cm. lens with its flat side out. These lenses are made of quartz and can be cleaned with lens paper.

16. Replace the lamp housing, turn on the lamp, and make a preliminary focus by means of the 3 screws on the back and side of the lamp housing. A rough focus is indicated by getting a sharp image on a card held perpendicularly to the beam just at the centerline of the lower slit. The edge of the image should be just at the edge of the metal surface next to the slit block.

17. Replace the filter block. Turn the wave length dial to some visable range (556 mu) and observe the action of the slit as the slit control is moved. It is normal for the slit dial to move to a point less than zero. At this point no light should be seen through the slit. Now slowly open the slit and observe the point at which the slit first opens, that is, the first ray of light is seen. This point should be reached before approximately 1/3 of the distance between zero and the first mark on the scale is reached. If the slits fail to operate properly, the condition may be corrected by removing the windows in front of the slits and blowing through them with dry, clean air. Much care must be used in dealing with the slit mechanism. If the mechanism itself is damaged, there is little that can be done in the field as a special jig is required. Since this trouble is rarely experienced, it is advisable to return the slit mechanism to the factory for repair when required.

18. Remove the cover from the phototube housing and replace the desiccant. Note general wiring conditions within the housing. Wipe clean the black ring around the grid cap of the two amplifier tubes. This area should never be touched with bare hands. Note sliding contact under the phototubes. Note condition of insulators. Replace cover and re-install housing.

19. Balance dark current: To do this, connect storage battery, turn lamp switch on, turn selector switch to "check", turn switch on phototube housing to "off". Set the wavelength dial at 500, pull the phototube selector rod "out", and bring the meter to zero by rotating the "dark current" knob.

20. Zero Balance: Starting with all conditions as in # 19, turn the switch on the phototube housing to "on", and bring the meter back to zero by adjusting the slit width. The "sensitivity" pot can be used as a fine adjustment after the slit width is set fairly close to the desired value. The sensitivity pot is normally operated at a position about 2 turns from its extreme clockwise position.

If steps 19 and 20 cannot be completed, a systematic recheck of battery voltages, connections, and tube conditions must be made. Reference to Beckman's Bulletin #150-A may aid in spot checking specific trouble. It is not the intent of this report to repeat the trouble shooting suggestions given in this bulletin.

21. Calibration of wavelength dial: This calibration is done by means of a mercury discharge lamp which replaces the tungsten lamp ordinarily used. It is convenient to have one such mercury lamp already mounted in a space lamp housing to be used for calibration purposes only. It might be pointed out that the mercury lamp looks exactly like the hydrogen lamp except for the metallic mercury that can be seen inside of the envelope.

In the following table is the listing of the main bright lines in the mercury spectrum and the corresponding tolerances allowable on the wavelength scale:

Millimicrons	± Millimicrons on scale
1014.0	3.0
690.8	1.0
579.0	0.6
577.0	0.6
* 546.1	0.2
491.6	0.5
435.83	0.4
407.8	0.4
404.7	0.4
365.0	0.2
334.1	0.2
313.2	0.2
312.6	0.2
302.15	0.15
296.7	0.15
289.36	0.15
280.35	0.12
275.3	0.12
265.2	0.1
* 253.6	0.1
248.27	0.1
239.94	0.1
237.83	0.1
222.47	0.1

In calibrating the instrument it is customary to use two points on the spectrum, namely, 546.1 and 253.6. To calibrate the instrument the wave length dial is set at 546.1 and brought to balance as stated in #20, except that the sensitivity pot should be turned completely clockwise. Now carefully turn the wave length dial to either side of 546.1 and note if the meter can be made to move further to the left. If a maximum left reading is obtained at other than the 546.1 setting on the dial, the dial is out of calibration and must be reset. To do this, reset the dial at 546.1. Insert a screw driver in the hole at the left side end of the instrument and turn the screw very slightly in one way or the other until the maximum left reading is again reached. Care must be taken not to move the screw too far so as to bring another spectrum line into play.

When this setting has been made it is next necessary to check if the scale is linear throughout its length. To do this, set the wave length dial at 253.6 (choose the proper phototube) and check to see if a maximum deflection to the left has been reached at this point by carefully turning the wave length dial slightly to either side of the 253.6 mark. If the maximum point is reached within the allowable limits the scale can be assumed to be linear. If further checks are of interest, use any of the other values given in the above table.

If the second setting does not come within allowable limits, the scale is non-linear and an adjustment of the prism and prism arm must be made. This procedure is discussed under item #9.

A spot check of the wave length dial can be made by means of the hydrogen discharge lamp by using the 656.3 millimicron line. Since the hydrogen lamp gives only one usable line, it is recommended that a mercury lamp always be used for shop testing. It may be convenient, however, to use the hydrogen lamp as a spot field check.

22. Maximum light intensity or final focus: Up to now, the lamp has been given only a rough focus and at this point it is well to focus it to obtain maximum light intensity. This must be done on the tungsten lamp and also on the hydrogen lamp if used.

A. Tungsten lamp final focus: Turn the lamp switch on, the selector switch to check, the wave length dial to 500 mu, the sensitivity knob to the full clockwise position, the phototube selector slide "out", the switch on the phototube housing to "off", and balance the dark current. Turn the switch on the phototube housing to "on" and balance the meter by adjusting the slit width only. With the instrument set as indicated above, a balance must be reached with a slit width at least as small as 0.04 mm and preferably as small as 0.02 mm. If this cannot be done, the focus is not correct and should be corrected. This is done by adjusting each of the four focusing screws one at a time until the smallest slit possible for balance has been reached. The four adjusting screws are located as follows: 2 are on the back side of the lamp housing and control the setting of the lamp; 1 is located on the left side of the lamp housing and controls the position of the concave mirror; the 4th is located on the front of the instrument and controls the position of the flat mirror located in front of the lower slit opening. Since each adjustment will affect the others slightly, it is well to set each adjusting screw to its maximum and then repeat the adjustments until no further change is found on any screw. Faulty mirrors or a dirty lamp will greatly cut down the light intensity. The condition of the concave mirror is especially critical.

B. Repeat the above with the other phototube and the wave length set at 900 mu.

C. Hydrogen lamp final focus: Balance the dark current with the phototube selector "out". Turn the sensitivity pot completely clockwise, open the slit to its maximum, turn the switch on the phototube housing to "on", and bring the meter to balance with the wave length dial somewhere in the region of 220 to 270 mu. If

a balance can be obtained at 230 or less the instrument has acceptable transmission. If a reading as low as 230 cannot be reached, re-focus the lamp and mirrors in exactly the same manner as was done with the tungsten lamp. The condition of the mirrors is extremely important in the short wavelength region.

23. The contacts on the selector switch and on the phototube housing switch are rather important and should be checked at this time. This is done by balancing the unit and preparing it for operation (use any lamp). Take each switch and turn it slightly, enough to move the contacts but not enough to move to the next position. While doing this, note the meter to see if any motion occurs. If so, it is sometimes possible to clean the contacts by switching the contacts back and forth for about a dozen times to remove the surface film. If such action does not clear up the situation, replace the switch.

24. A similar check should be made on the 2 helipots. This procedure is known as "running the pots". To do this, the instrument is brought into balance as is done for normal operation. The balance is then upset slightly by turning either the sensitivity or dark current pot, noting whether or not the meter moves smoothly across the dial. The balance is then alternately restored with the slit knob and upset again with the pot under test. If a rough spot exists on the pot, it will show up as an unsteady motion of the meter. Frequently these rough spots can be removed by rotating the pot several times past the bad area. If this does not clear up the situation, replace the pot.

25. Zero set of transmission dial: When the selector switch is on "check", the circuit is automatically locked in for 100% transmission and the setting of the transmission dial will have no effect upon the reading. With the instrument balanced as for normal use, set the transmission dial at 100% and turn the selector switch from "check" to position 1. There should be no appreciable change in the meter reading. If a change occurs, it can be corrected by moving the contact that rides on the slidewire drum in the proper direction. This slidewire should be cleaned with a cloth damp with benzene.

26. In using the instrument, the ultra-violet sensitive phototube (rod pulled "out") should be used for wavelengths less than 625 mu. For wavelengths less than 350 mu, the hydrogen lamp should be used.

ALIGNMENT OF FLUOROPHOTOMETER

MODEL II

By: C. B. Pickle
5/7/47

References: Q-475-S (3 sheets) attached.

To open optical housing: Remove only the left side of the housing, the left side being the operators left when he is facing the front of the fluorophotometer.

Reflectors: Reflectors used are silvered surface automobile head light reflectors made by General Motors. Have 1-7/8 inch diameter holes cut in center of back of reflector.

Mounting ultraviolet filter and fresnel lens: Place filter on 1-7/8" holes in reflector, completely and entirely covering the hole. Reflector is shown at A and filter at B. Glue in place with Amphenol coil dope; dope should not enter the opening of the reflector. When dope is hard, place fresnel lens on top of filter. Lens is shown at C. Fasten to filter with Amphenol coil dope. When dope has hardened, cover the dope or the exposed surface of the dope with "Carbonoid A".

Components inside optical housing: All such components beneath reflector A that are metal (the silvered reflector surface excepted) should be coated with "Carbonoid A".

Sample slide: Thoroughly coat with "Carbonoid A".

Light shield at D: Make from 1/64" sheet brass, funnel shaped, open at both ends, length is 2-1/4", large opening is 1-7/8" in diameter, small opening is 1/2" in diameter. Coat

inside and out with "Carbonoid A". Place in position as shown, such that all light passing through lens and filter at C and B must pass through the funnel, and none can escape around the funnel at the point of attachment to the reflector. Attach with "Carbonoid A".

Multiplier phototube cable outlet: Shown as E. Bring the eleven conductor cable through the outlet, then pack strips of wool felt inside the outlet, between the outlet wall and the cable. Pack tightly to make light-tight.

Filter turntable shown at F: This turntable provides holders for four sets of filters. The filters are placed on the table, outside the housing, and the table must be rotated 180° to place that particular filter or set of filters over the window of the photomultiplier tube. At point of contact between the turntable housing and the optical housing, Apiezon "W" wax should be used to make the housing light-tight.

Focusing: With a sample in position for measurement, move the mercury lamp G through the X, Y, and Z planes until a maximum meter indication is obtained. With lamp in position of maximum indication, tighten lamp bracket H.

Adjusting sensitivity of the electronic section of the Fluorophotometer: The overall sensitivity of the instrument, with any given combination of filters over the window of the photomultiplier tube is a function of the intensity of the excitation lamp (mercury lamp), sensitivity of the photomultiplier tube, voltage applied to the photomultiplier tube, and the

resistive load in the plate circuit of the photomultiplier tube.

Limitations on maximum sensitivity are: 1) Maximum voltage that can be applied without breakdown at or within the tube or spasmotic leakage currents flowing, 2) Sensitivity and stability of the photomultiplier tube, 3) Range of light intensities to be measured.

All photomultiplier tubes tested became very unstable when the recommended maximum of 1250 volts was exceeded. Several tubes broke down at less than 1250 volts. By decreasing voltage, the overall sensitivity of the instrument can best be decreased. As voltage is decreased the overall stability and, hence, overall accuracy of the instrument increases. Dark currents (which fluctuate and account for a high percentage of the total instability of the instrument) decreases with decrease in the applied voltage, and become insignificant at about 900 volts.

Photomultiplier tubes tested have shown differences in sensitivity as great as 400%. As the sensitivity of the tubes increases, the variation in dark currents increase directly and at a ratio greater than one. Tubes, therefore, should be chosen for their sensitivity and stability.

The lower the level of light intensities to be measured, the higher the value of plate load resistance in the plate circuit of the photomultiplier that can be used. The higher the value of load resistance, the greater the sensitivity will

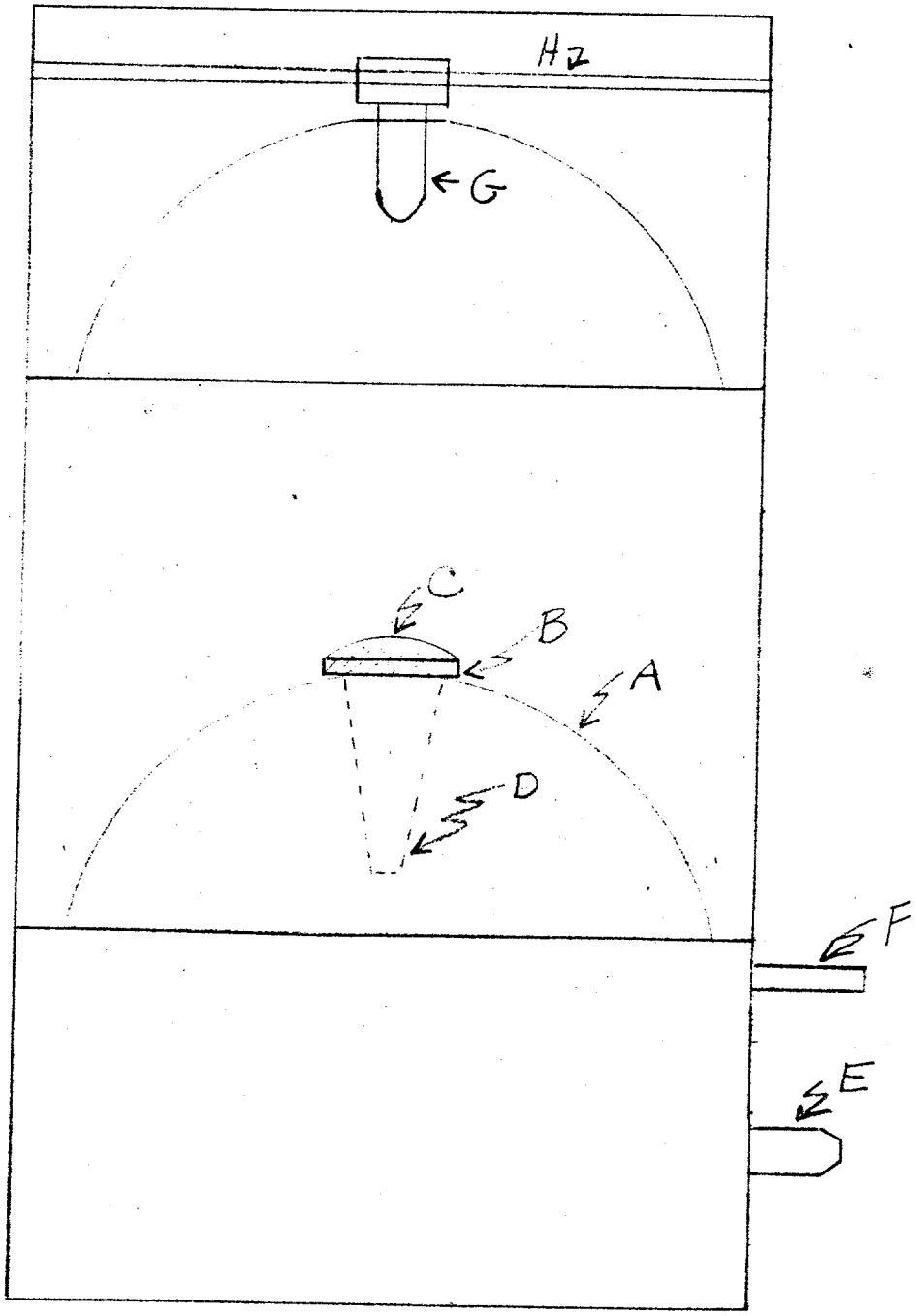
be. With any value of load resistance used, a certain range of light intensities can be measured with linear instrument response. At some maximum intensity the photomultiplier tube will saturate, and for still further increased intensities, the instrument reading will not increase. When this occurs, the value of load resistance must be decreased.

For a relatively narrow range of light intensities a fixed load resistance can be used, and the sensitivity should be varied by variation of the voltage to the photomultiplier tube. For a broader range of light intensities the load resistance should be variable.

The ideal arrangement for sensitivity adjustment for the broadest range of light intensities involves variation of the applied voltage, in fixed steps, using a selector switch, and variation of the plate load resistance in fixed steps by a switch and fixed resistors.

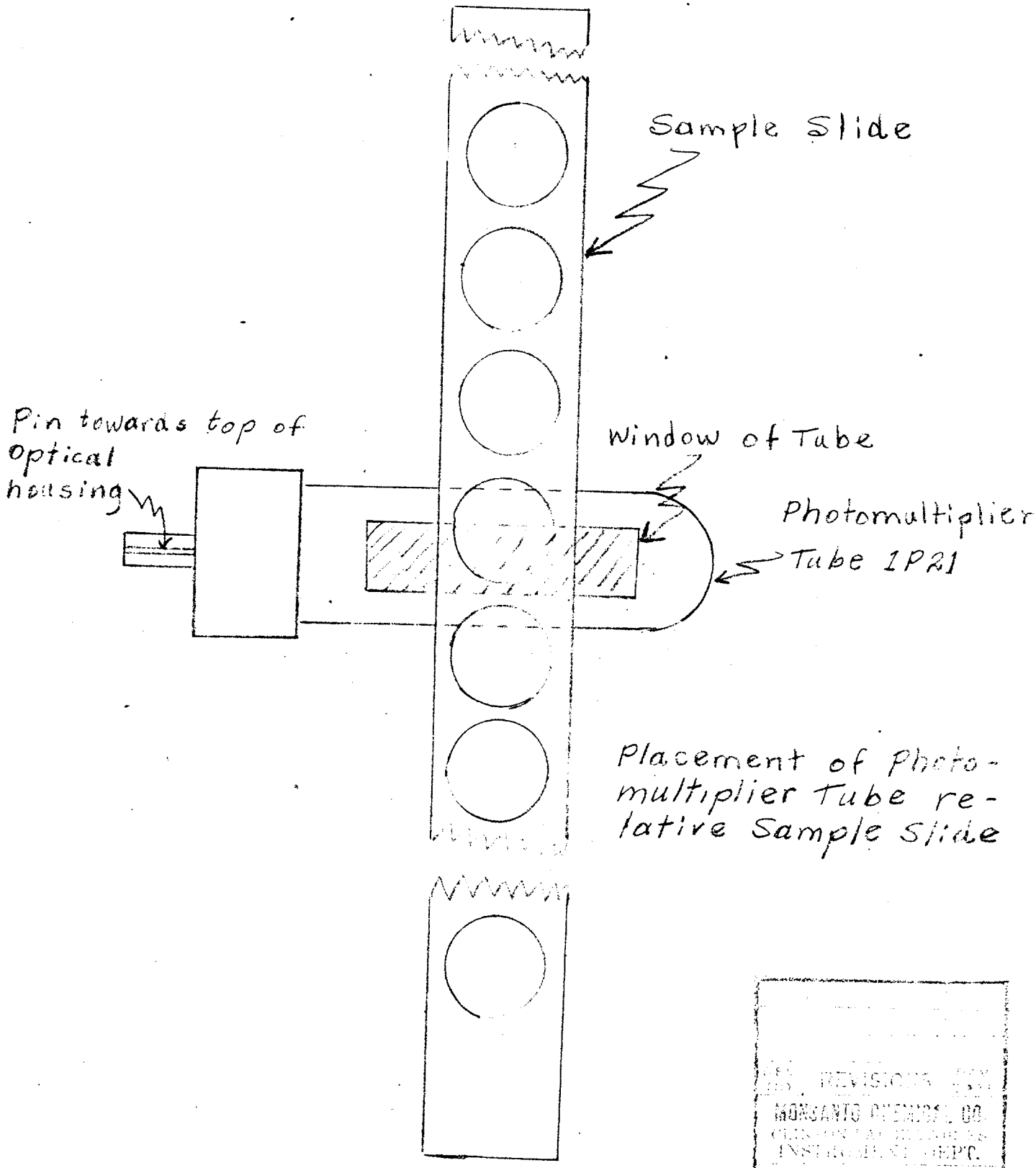
The balancing provision, incorporating a potentiometer and battery for bucking the photomultiplier dark current, should be set for the minimum bucking that will permit zero adjustment of the microammeter with the balancing potentiometer in the plate circuit of the balanced 6K6 amplifier. When the bucking voltage has been adjusted, it should remain undisturbed.

CBP:vaj

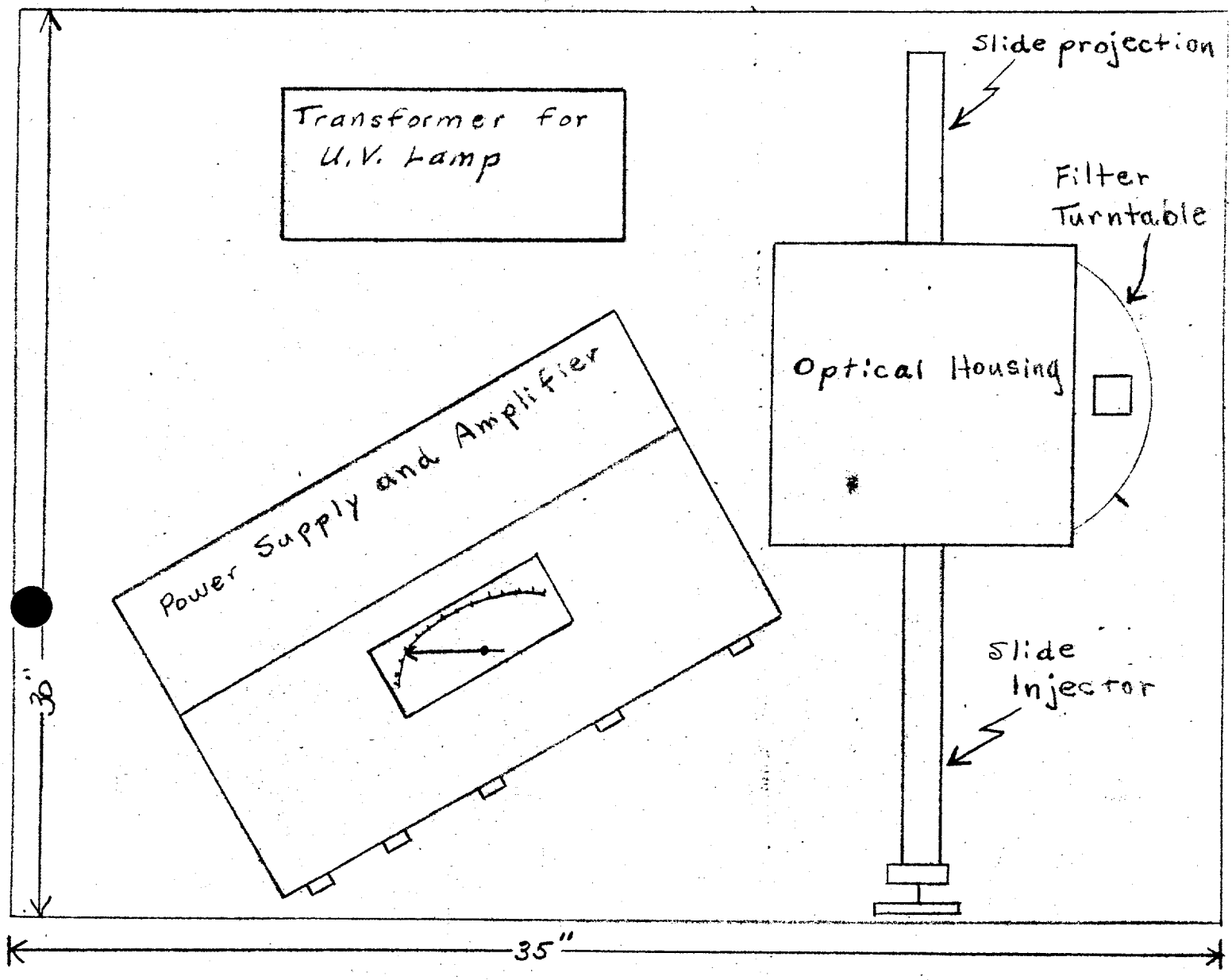


OPTICAL HOUSING

MONSANTO CHEMICAL CO.
CLINTON LABORATORIES
INSTRUMENT DEPT.
Fluorophotometer
-Description-
CBP DES'N'D CBP DRAWN CBP CK'D
DATE 5-7-47 SCALE —
SHEET 1 OF 3 SHEETS
SKETCH Q-4755



REVISIONS
MONSANTO CHEMICAL CO
INSTRUMENT DEPT.
Fluorophotometer
- Description -
DATE 5-7-71 SCALE —
SHEET 2 OF 3 SHEETS
SKETCH C-4755



Layout on Bread board Mount.

Board: 35 by 30 inches

REV. NO	REVISIONS	REV. DATE

MONSANTO CHEMICAL CO.
CLINTON LABORATORIES
INSTRUMENT DEPT.

Fluorophotometer
- Description -

DES'N'D	DRAWN	CH'K'D
GBP	GBP	GBP

DATE 5-7-47 SCALE -

SHEET 3 OF 3 SHEETS

SKETCH Q-475S

COUNTING RATE METER FOR PRESSURE CONTROL
Q-572-A

By: C. B. Pickle
5/21/47

OPERATING INSTRUCTIONS:

1. Plug-in to 110 Volts AC.

2. Connect GM tube.

3. Connect relay output.

4. Turn "Off" HV switch if same is in the "On" position.

5. Turn "On" the line switch.

6. After the instrument has warmed up for 30 minutes, adjust the Counting Rate Meter to zero by following method:

   On top of chassis are 3 screw driver potentiometers headed "OADJ". Opposite each is the full-scale counting rate for which they adjust the meter to "O". With the front panel "Counting Rate Adjust" selector in each of its full-scale ranges, set the meter to zero by adjustment of corresponding potentiometer on top of chassis. While making this adjustment, the "Count-reset" switch should be pressed to the "reset" position.

7. Turn "On" the HV switch.

8. Adjust HV indicator to 25 by means of HV adj. knob.

   This indication of 25 is for furnishing the 1180 volts required by the Victoreen tube furnished, and if a different tube should ever be used, the meter setting should be determined with a test volt meter, and by means of the meter adjust control on top of chassis, the meter can be adjusted to indicate correct voltage with a meter setting of 25.

9. The count rate meter will now indicate counting rate, if the "Count-reset" switch is in the "Count" position. If the meter goes off scale, set the "Counting rate adjust" selector switch to the next higher counting rate.

10. The HV switch should be turned to "Off" when operations are complete.

11. The Line switch should remain "On".

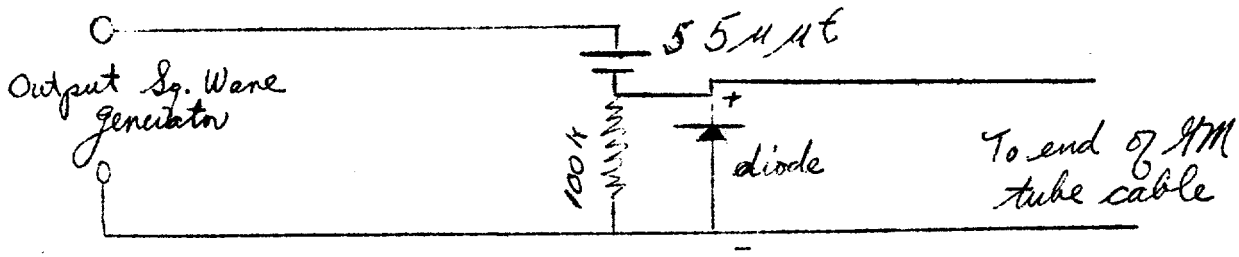
12. Each morning check the zero adjustment of the count rate meter on each of its three scales, until it is found that the "zero" is holding true from day to day.

CALIBRATION:

Calibrate with negative pulses 5 microseconds wide, 1 volt or higher at peak.

The instrument requires pulses 1 volt in peak, and the reading is unaffected by pulses greater than 1.0 volt high (tested to 75 volts).

The pulses should be feed into the GM tube cable, and if a square wave generator is used, it should be connected as shown:

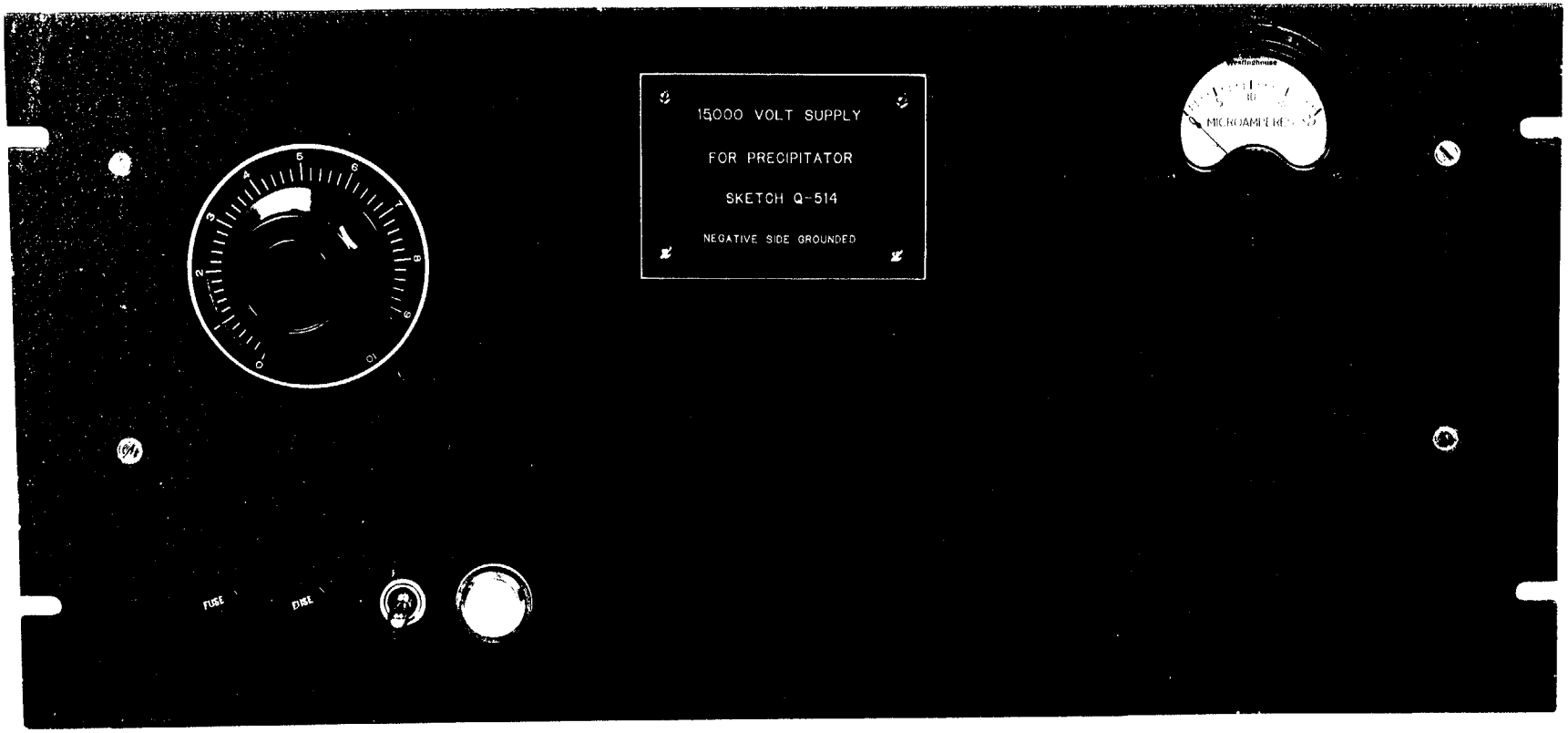


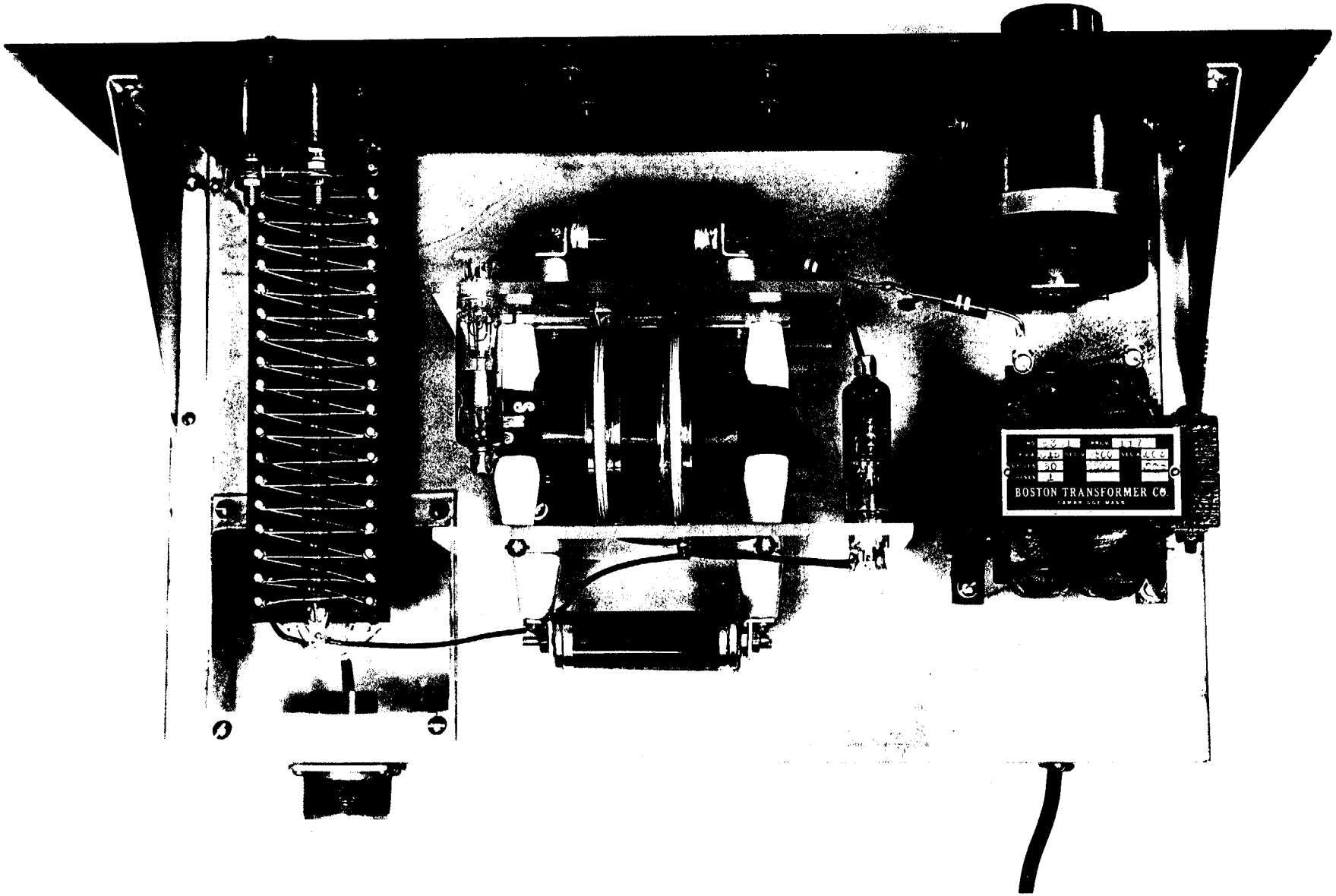
For 5000 counts per minute the generator should be set for 83 cycles per second. For 10,000 counts per minute the generator should be set for 166 cycles per second, and for 20,000 counts per minute, set the generator for 333 cycles per second.

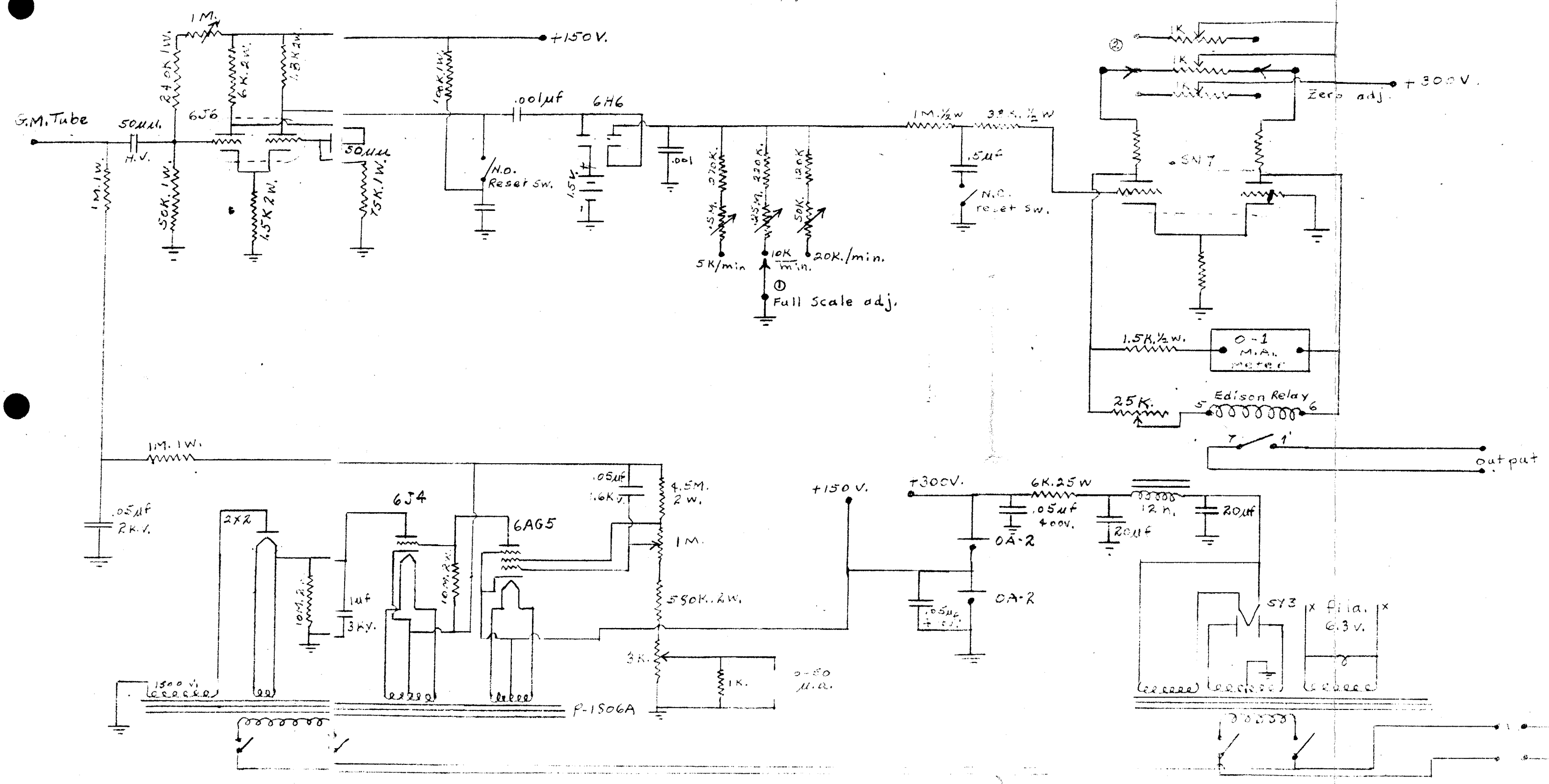
With the meter adjusted to zero before calibration procedure is started, then with correct frequency on input for the scale being calibrated, adjust correct potentiometer on top of chassis until the counting rate meter gives full-scale deflection.

Additional adjustment: Should greater stability be required or if a longer time constant is permissible for some particular operation, the .5 mfd. condenser in the integrator should be increased in size.

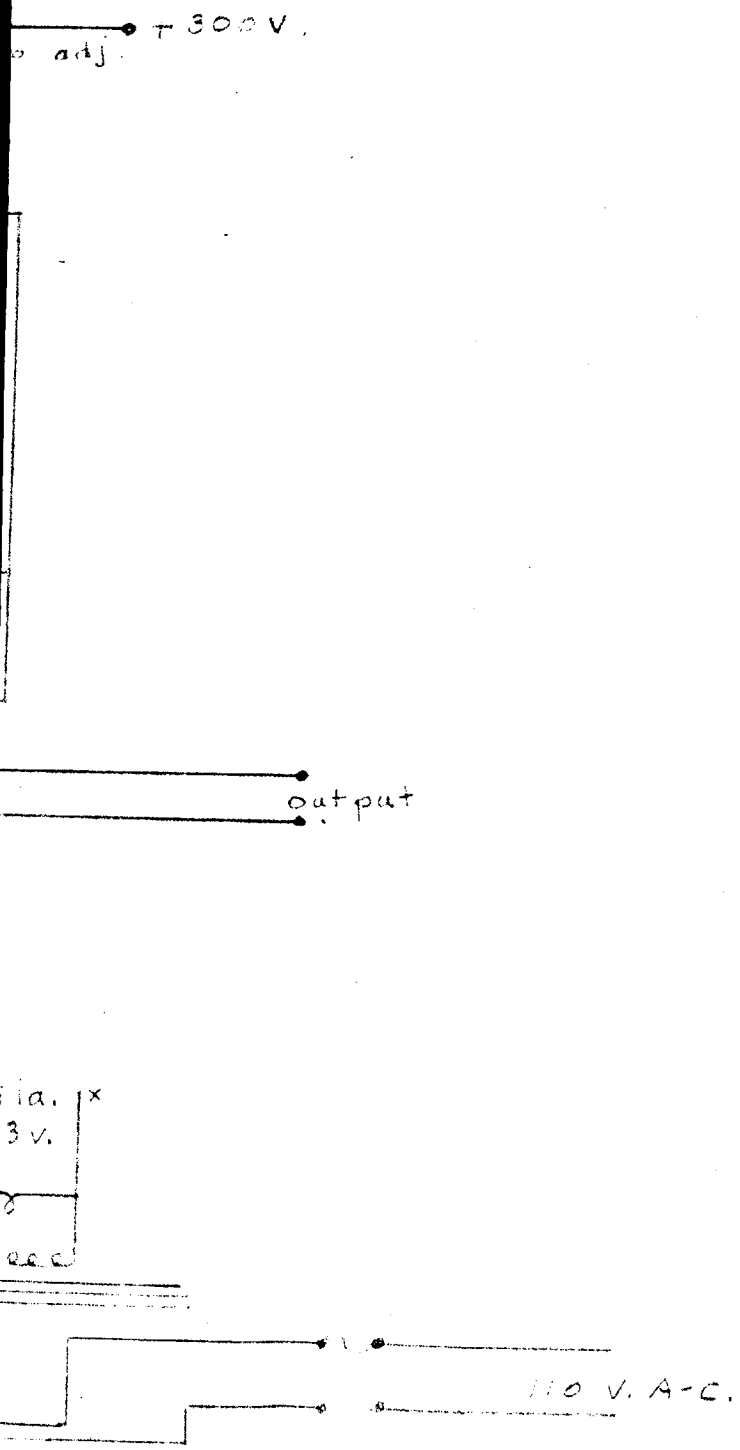
CBP:vaj


15000 VOLT SUPPLY
FOR PRECIPITATOR
SKETCH Q-514
NEGATIVE SIDE GROUNDED
Westinghouse
MICROAMPERES
FUSE
FUSE


BOSTON TRANSFORMER CO.



G.M. Tube
50μμ.
H.V.
1M.
240K 1W.
6K. 2W.
1.8K 2W.
6J6
50μμ.
1.5K 2W.
75K. 1W.
1M. 1W.
50K. 1W.
+150V.
100K 1W.
.001μf
6H6
N.O. Reset Sw.
1.5V.
.001
270K.
220K.
120K
.5M.
.25M.
50K.
5K/min
10K/min.
20K./min.
Full Scale adj.
1M. ½W
33K. ½W
.5μf
N.O. reset sw.
1K
1K
1K
+300V.
Zero adj.
6SN7
1.5K. ½W.
0-1 M.A. meter
25K.
Edison Relay
5
6
7
1'
output
1M. 1W.
.05μf 2K.V.
2X2
6J4
6AG5
.05μf 1.6K.V.
4.5M. 2W.
1M.
550K. 2W.
3K.
1K.
0-50 μ.a.
10M. 2W.
1μf 3KV.
10M. 2W.
1500 V.
P-1506A
+150 V.
+300V.
6K. 25W
.05μf 400V.
20μf
12 h.
20μf
0A-2
0A-2
.05μf
5Y3
Fila. 6.3 V.



REV. NO. | REVISIONS | REV. DATE

MONSANTO CHEMICAL CO.
[illegible]
INSTRUMENT DEPT.

Count Rate Meter
for
Pressure Control

CBP DES'N'D | CBP DRAWN | CBP CK'D

DATE 5-14-47 SCALE None

SHEET 1 OF 1 SHEETS

SKETCH C-572 A

IMPEDANCE BRIDGE AMPLIFIER (Q-584-A)

By: M. P. Falls
6/17/47

The Impedance Bridge Amplifier described herein was designed for the metallurgical group to indicate changes in length of a heated specimen. Full-scale deflection on a 1 ma. meter may be adjusted for any value of change between 0.002 in. and 0.250 in. Briefly, the unit consists of a bridge circuit, a local oscillator, an amplifier, a detector, a vacuum tube voltmeter, and a self-contained power supply.

The bridge circuit is a somewhat generalized form of Wheatstone's Bridge. For the general equation for the condition of balance see "Electricity and Magnetism" by S. G. Starling, pp. 380 - 381. An oscillator supplies the bridge with a sine wave voltage of good form at a frequency of approximately 2500 cycles per second.

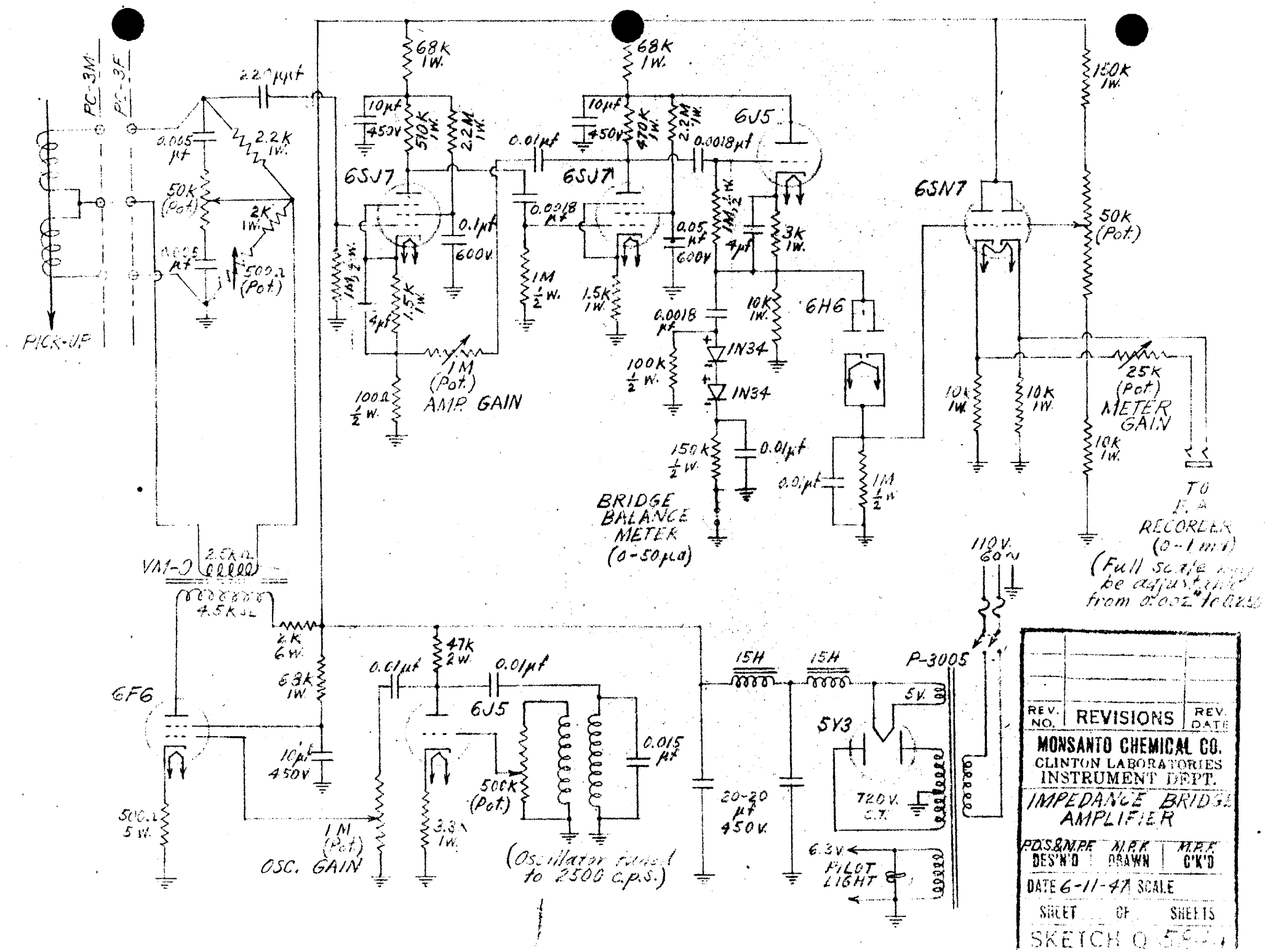
A magnetic pickup made of two inductances with a moving iron core and pointer attached forms two arms of the bridge. A crystal diode detector is employed for indication of bridge balance; i.e. for zero setting of the pickup. A displacement of the iron core along the axes of the inductances changes the impedance ratio and subsequently unbalances the bridge. The unbalanced signal is amplified by an AC amplifier of voltage gain adjustable between approximately 100 and 10,000. A vacuum tube diode serves as a detector developing a DC voltage across a RC tank. This voltage is applied to one grid of a balanced vacuum tube voltmeter. The output meter is a commercial type inking recorder with a 1 ma. meter movement (Esterline-Angus).

SERVICE NOTES:

1. The oscillator wave form must be good. The presence of harmonics in the input or their production in a non-linear impedance within the bridge may obscure the fundamental balance. Adjustments are available at both the oscillator and the power stage following the oscillator for permitting sufficient excitation and not over-excitation which results in operation of the tubes into an increased non-linear range. The wave form may be studied with the aid of an oscilloscope.

2. Residual noise level of the oscillator and amplifier may mask the null balance. Reduction of noise and hum is possible with the aid of shielding, feedback, and an oscilloscope.

MPF:vaj


PICK-UP
PC-3M
PC-3F
220 μμf
0.005 μf
2.2K 1W.
50K (Pot.)
2K 1W.
0.005 μf
500Ω (Pot.)
68K 1W.
10μf 450V
510K 1W.
2.2M 1W.
6SJ7
0.1μf 600V.
1M ½ W.
1.5K 1W.
4μf
1M (Pot.)
AMP. GAIN
100Ω ½ W.
0.01μf
0.0018 μf
1M ½ W.
68K 1W.
10μf 450V
470K 1W.
2.2M 1W.
6J5
0.0018μf
6SJ7
0.05 μf 600V
1.5K 1W.
1M ½ W.
4μf
3K 1W.
10K 1W.
6H6
0.0018 μf
100K ½ W.
1N34
1N34
150K ½ W.
0.01μf
BRIDGE BALANCE METER (0-50μa)
0.01μf
1M ½ W.
6SN7
150K 1W.
50K (Pot.)
10K 1W.
10K 1W.
25K (Pot.)
METER GAIN
10K 1W.
TO E.A. RECORDER (0-1 ma)
(Full scale may be adjusted from 0.002" to 0.250)
VM-9
2.5KΩ
4.5KΩ
2K 6W.
68K 1W.
6F6
10μf 450V
500Ω 5W.
1M (Pot.)
OSC. GAIN
0.01μf
47K 2W.
0.01μf
6J5
500K (Pot.)
3.3K 1W.
0.015 μf
(Oscillator tuned to 2500 c.p.s.)
15H
15H
20-20 μf 450V.
P-3005
5V.
5Y3
720V. C.T.
6.3V.
PILOT LIGHT
110V. 60~
REV. NO.
REVISIONS
REV. DATE
MONSANTO CHEMICAL CO.
CLINTON LABORATORIES
INSTRUMENT DEPT.
IMPEDANCE BRIDGE AMPLIFIER
P.D.S.&M.P.F. DES'N'D
M.P.F. DRAWN
M.P.F. C'K'D
DATE 6-11-47 SCALE
SHEET OF SHEETS
SKETCH Q-5

TIME BASE OSCILLATOR (Q-556-B)

By: M. P. Falls
6/16/47

The time base oscillator described herein is a device for marking on paper tape intervals of 0.1 second and 1.0 second. In addition to the time base channel there are two other channels: One serves as a start-stop indicator; the other, as a record of a number of events.

A Gaertner Scientific Tape Chronograph is used for the recording device (recording pens and wax coated tape). An electronic section was built to furnish the time base and to drive the recording elements of the chronograph.

The recording elements of the chronograph consist of an electro-magnet, a reed type armature, and the pen. The reed of high magnetic permeability and small mass permits a complete cycle of operation in less then 0.01 second during which time the pen may move back and forth across the paper removing the wax coating and leaving a distinct record. A governor controlled electric motor drives the tape and permits adjustable speeds between 12 mm. and 60 mm. per second.

The oscillator furnishing the time base is built into the electronic section. Light from a pilot lamp passes through a perforated disc driven at synchronous speed and is received by a phototube thereby developing a voltage pulse across the phototube load. These pulses are amplified and a power stage is used to drive the recording element of the chronograph. The disc has 10 holes spaced 36° apart on a circle near the edge of the disc. One of these holes actually consists of three separate holes closely spaced. The disc is driven by a 60 r.p.m. Telechron motor; hence, one second and one-tenth second markers are obtained.

The time base oscillator and recorder described has its application in determining decay curves for radioactive materials, particularly for those of short half lives in the order of a few seconds. Removal of a sample from a nuclear pile closes a micro-switch and immediate counting by a scaling circuit begins. Simultaneous recording of the start-stop, time base, and scaler output makes possible radioactive decay curve determination.

Attached to this report are pictures of the chronograph and the electronic section containing the oscillator. An electrical schematic is included also.

SERVICE NOTES:

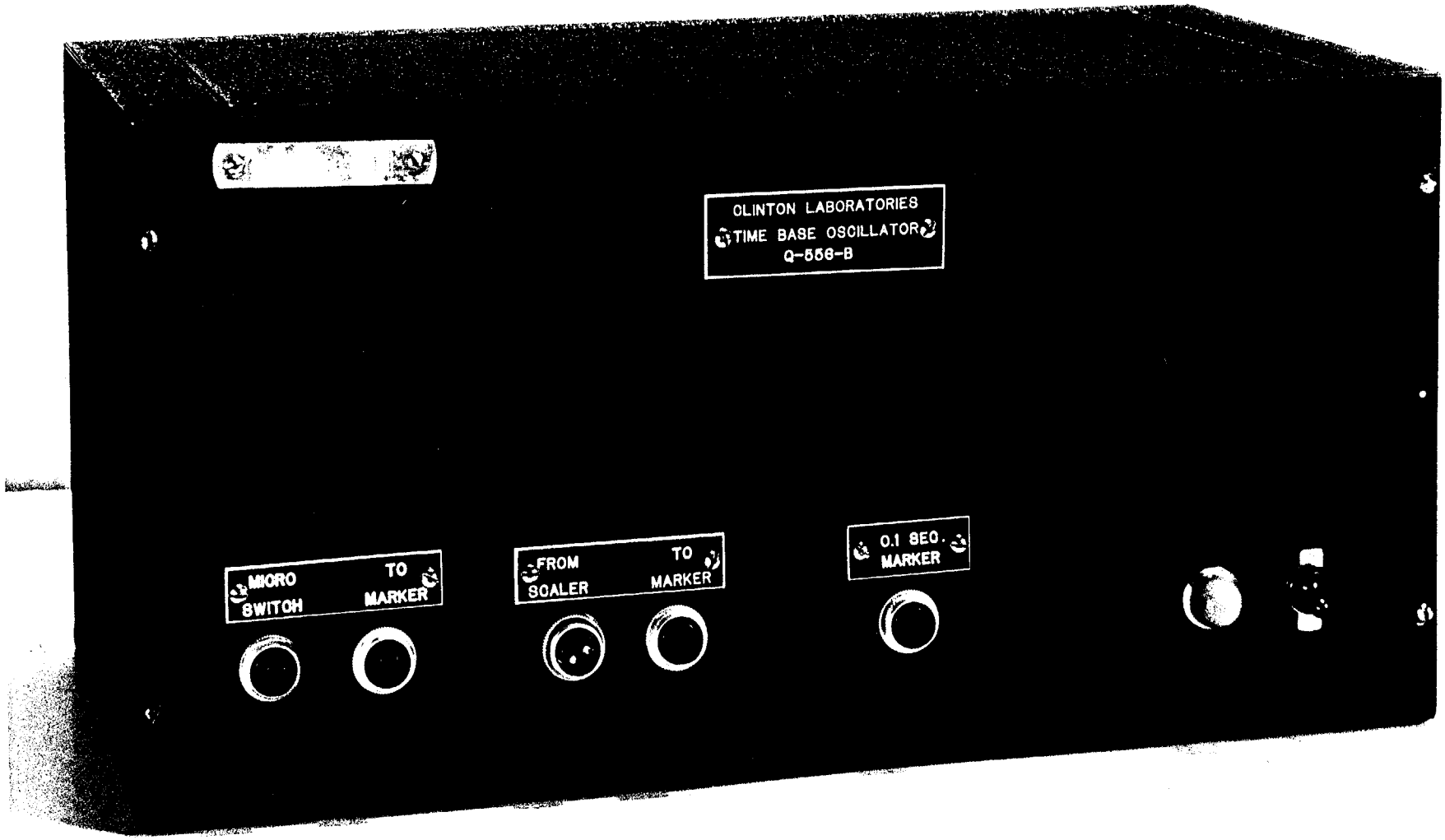
1. Proper alignment of the light source, disc, and phototube window is essential. In order to readily align the system an oscilloscope should be used, observing the pulse size and shape at

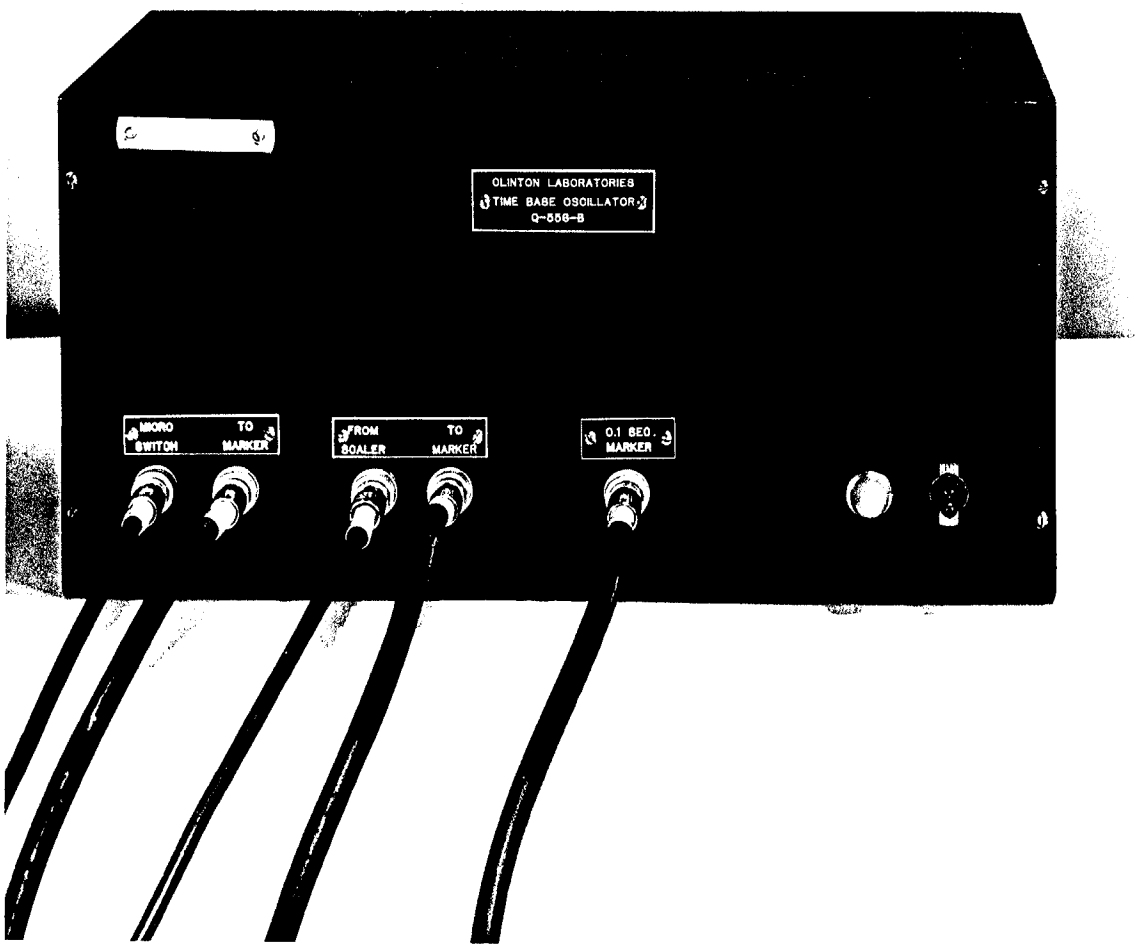
the 6C4 grid. Adjust for optimum conditions. Lock the phototube in place by the adjusting screws at the base.

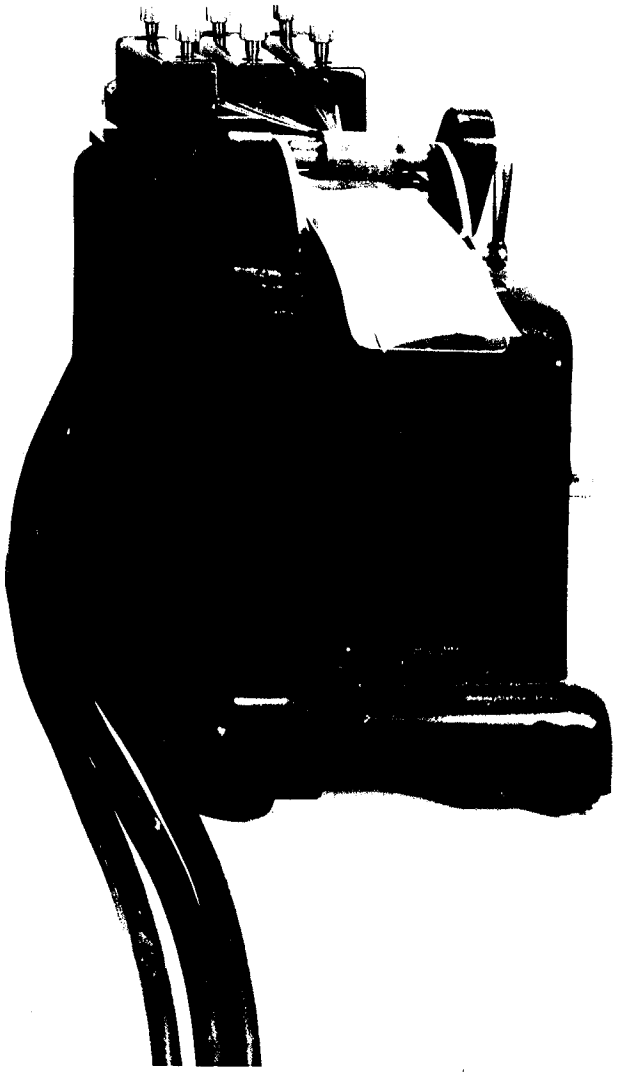
2. The 6C4 tube in the scaler channel is used as a discriminator for proper shaping the pulse from the scaling stage. The step which exists in a scaling pulse must be eliminated or diminished to the extent that the 6V6 tube recognizes only one pulse per scaling pulse.

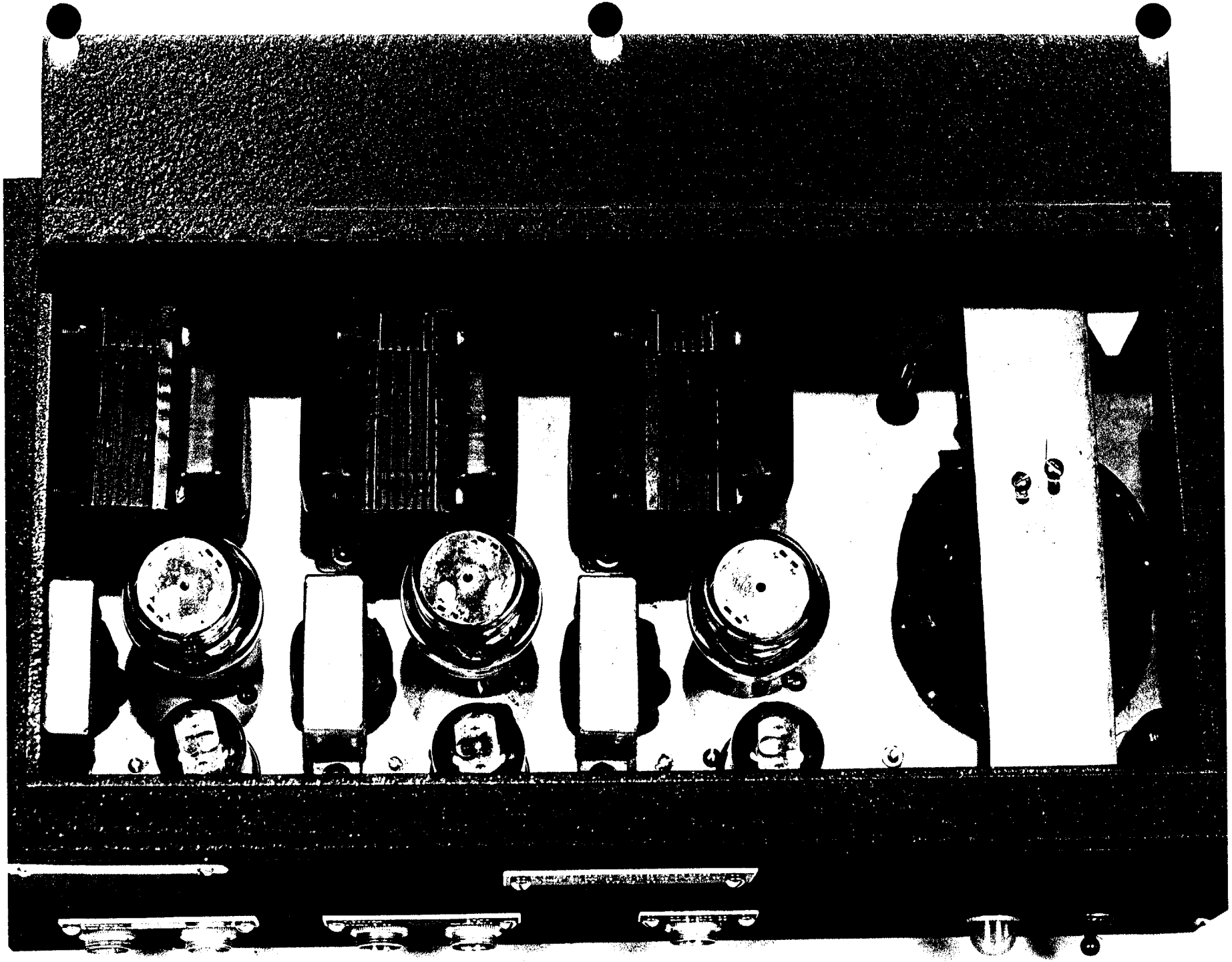
3. The pens and the recording elements of the chronograph require attention for proper operation. Thumb screws are available for this purpose.

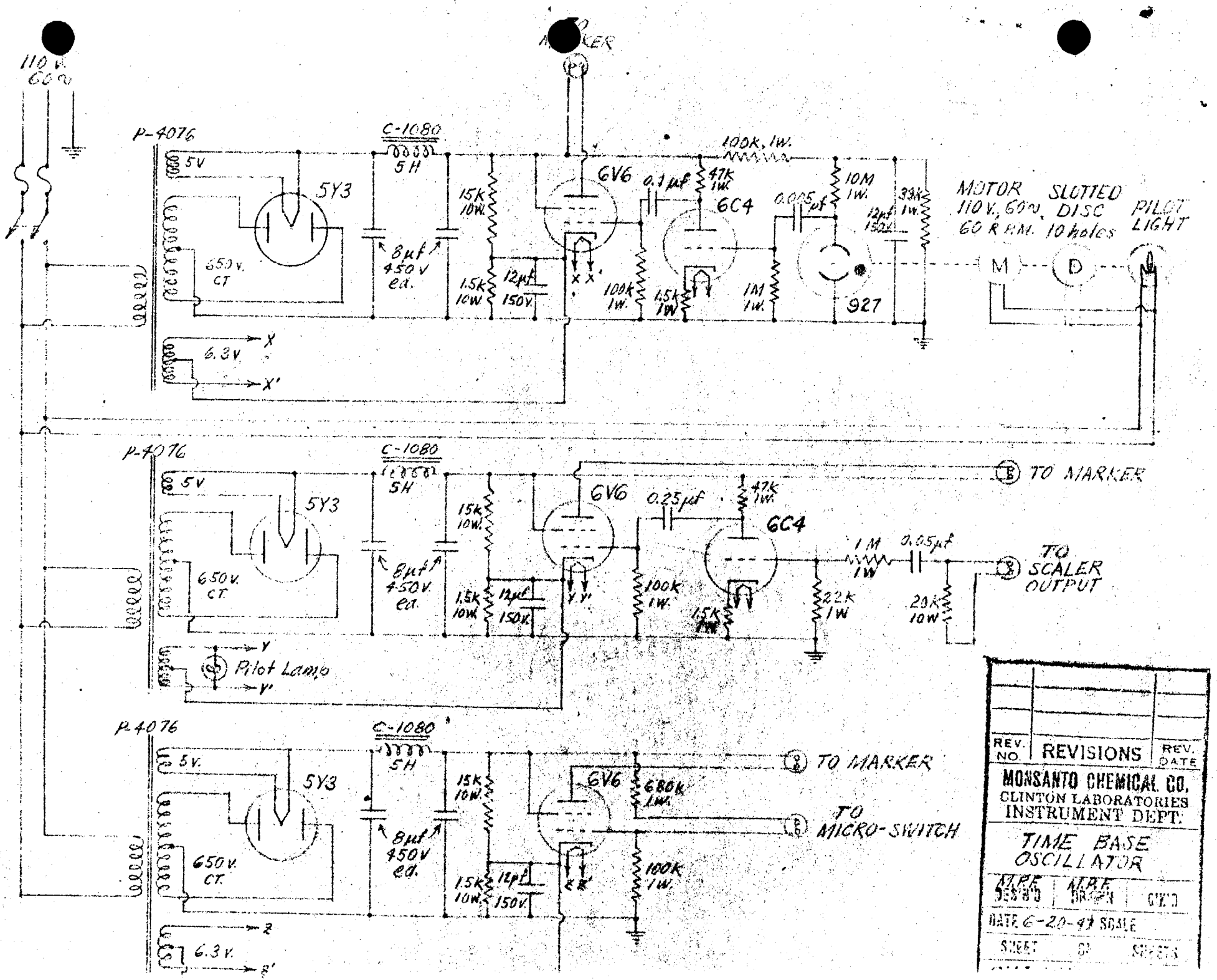
MPF:vaj


CLINTON LABORATORIES
TIME BASE OSCILLATOR
Q-556-B
MICRO SWITCH
TO MARKER
FROM SCALER
TO MARKER
0.1 SEC. MARKER


CLINTON LABORATORIES
TIME BASE OSCILLATOR
Q-556-B
MONO SWITCH
TO MARKER
FROM SCALER
TO MARKER
0.1 SEC. MARKER






110 V. 60 ~
P-4076
5V
5Y3
650 V. CT
6.3 V.
X
X'
C-1080
5H
8μf 450 V ea.
15K 10W.
1.5K 10W
12μf 150V.
6V6
0.1μf
100K 1W.
47K 1W.
6C4
1.5K 1W
100K, 1W.
0.005μf
1M 1W.
10M 1W.
12μf 150V.
33K 1W.
927
MOTOR 110 V., 60 ~, 60 R.P.M.
SLOTTED DISC 10 holes
M
D
PILOT LIGHT
TO MARKER
0.25μf
1M 1W
0.05μf
22K 1W
20K 10W
TO SCALER OUTPUT
Y
Y'
Pilot Lamp
TO MARKER
680K 1W.
TO MICRO-SWITCH
Z
Z'
REV. NO.
REVISIONS
REV. DATE
MONSANTO CHEMICAL CO.
CLINTON LABORATORIES
INSTRUMENT DEPT.
TIME BASE OSCILLATOR
DATE 6-20-47 SCALE
SHEET OF SHEETS