THE DESIGN, BUILDING, AND CALIBRATING OF BOTH ARGON ALCOHOL AND ARGON CHLORINE GEIGER COUNTERS

By

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PREFACE

The purpose of this study was to devise a method of producing Geiger counters suitable for cosmic ray research to be done at A. & M. College. The equipment necessary to construct Geiger counters was designed and built. Also designed and built were three sets of counters which differed in size and design. Data were taken on the number of counts per minute at various voltages and curves correlating counts against voltages were drawn from these data. Visual counting by use of an oscilloscope was the method of collecting data used in determining these curves. The voltages were obtained from a regulated power supply.

ACKNOWLEDGEMENT

I wish to express my gratitude to Dr. Malcolm Correll for his expert guidance in this work. I also wish to thank Dr. Frank Durbin for his assistance in constructing the necessary glass work.

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CHAPTER I

GEIGER COUNTER THEORY

The essentials of a Geiger counter are: (a) two conductors separated by a dielectric which can be ionized; (b) a means of establishing a potential between the two conductors; (c) a device capable of detecting changes of this potential. To have a counter that is at all flexible the three elements above should be adjusted so that different types of radiation can be detected under various conditions. The geometry of the two conductors can vary but concentric cylinders are most used. The composition of the dielectric can be easily changed and the potential across the dielectric should be variable. A detecting mechanism should be designed that will give a record of the number of counts the counter has produced. This may be a very complex electronic device or a simple circuit depending on the events to be counted.

Cylindrical construction was used in this work. This type of construction consists of a metal cylinder with a taut wire down the axis of the cylinder. The cylinder serves as a container for the gas used, and may be referred to as the cathode. The central wire will be referred to throughout this work as the central wire, the wire, or the anode. In most of the literature on counters a standard terminology is used in describing counters and counting action. Korff[1] has supplied the following list of terms and definitions suitable for discussion of Geiger counters which have cylindrical construction.

"Ionization. The act or the result of any process by which a neutral atom or molecule acquires a charge of either sign, or by which electrons are liberated.
Radiation. Electromagnetic or corpuscular radiation being detected.
Ionizing Event. Any event in which ionization is produced, such as the passage of a charged particle through the counter.
Primary Ionizing Event. The ionizing event which initiates the count.
Pulse. A change in voltage of the central wire system of the counter. This change in voltage is usually abrupt and is a result of the collection of ions produced in the gas of the counter.
The Characteristic Curve of a Counter. The curve of the counting rate against voltage, all pulses counted being greater than a certain minimum size, determined by the sensitivity of the detecting circuit.
Plateau. The more or less horizontal portion of the curve of counting rate as a function of voltages.
Operating Voltage. The voltage at which a counter is operated. This is the voltage across the counter measured between the cathode and anode. Symbol V_o.
Starting Potential. The voltage which must be applied to a counter to cause it to count, with the particular recording circuit which may be attached. This potential is not necessarily the same as, and indeed is, in general, not equal to the Geiger threshold. Experimentally, this potential is that at the foot of the "plateau" curve of a Geiger counter and has often been called the "threshold" in the literature. ...
Threshold Voltage for Geiger Counting Action. The lowest voltage at which all pulses produced in the counter by any ionizing event are of the same size, regardless of the size of the primary ionizing event. Symbol V_g.
Overvoltage. The difference in voltage between the operating potential and the threshold for Geiger counting action. (Over-voltage $= V_o - V_g$.)

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1 Serge A. Korff, Electron and Nuclear Counters, pp. 14-17.

"The Gas Amplification in a Counter. The number of additional ions produced by each electron produced in the primary ionizing event as it travels to the central wire. Symbol A.

The Proportional Region. The part of the characteristic curve of pulse size versus voltage in which the pulse size is proportional to the number of ions formed in the initial ionizing event. In this region, A is constant for all pulses at any one voltage.

The Region of Limited Proportionality. The part of the characteristic curve of pulse size versus voltage in which A depends on the number of ions produced in the initial ionizing event, and also on the voltage.

The Geiger Region. The part of the characteristic curve of pulse size versus voltage in which the pulse size is independent of the number of ions produced in the initial ionizing event.

Spurious Counts. A spurious count is one which is caused by any agency whatever other than the entity which it is desired to detect, or the normal contamination or cosmic-ray background.

Life (Time) of a Counter. The life or life time of a counter is the number of counts which that counter is capable of detecting before becoming useless due to internal failure for any reason (e. g., gas decomposition or wire pitting, etc.). The life is not a time but a measure of the amount of use.

Quenching. The process of terminating the discharge in a counter. A quenching circuit is a circuit which causes the discharge to cease, and the term "selfquenching" as applied to counters refers to those in which the discharge ceases due to an internal (atomic) mechanism within the counter.

Avalanche. If an ion produces another ion by collision and the new and original ions produce still others by further collisions, an avalanche of ions (or electrons) is said to have been produced. The terms "cumulative ionization" and "cascade" are also used to describe this process.

Predissociation. Ordinarily an atom, or simple molecule, if it absorbs radiation, and is not immediately involved in a collision, will lose the absorbed energy by reradiation. A complex molecule (four or more atoms) will usually predissociate before it has an opportunity to radiate.

Cross Section. The cross section of an atom or molecule, usually expressed as an area in square centimeters, is the area obscured by that particle. The cross section of a process (e. g., a collision cross section or capture cross section) is a measure of the probability that that process will occur."

The theory of counter action is relatively simple from a qualitative standpoint. The quantitative rigorous mathematical explanation is long and difficult. A book[2] developed by the U. S. Atomic Energy Commission in connection with the present atomic energy program presents a treatment of this subject. The qualitative explanation is adequate for this work and will be used.

Consider a free electron, which was produced by an ionizing event, just inside the counter wall. This electron will be accelerated toward the central wire by a field that varies inversely as the distance from the wire,

$$E = v/r \text{ Log } r_c/r_a,$$

where r is distance from the central wire, r_c is radius of cathode, r_a is radius of anode, and v is applied voltage. If a gas is present in the counter there is a probability of the electron's colliding with a gas atom or molecule and as more gas is introduced in the counter the probability of such a collision increases. When the collision cross section is equal to, or greater than, 1 a collision will take place. This collision will result in ionization of the gas atom or molecule if the electron has acquired sufficient energy through acceleration toward the central wire. The energy acquired by the electron will depend on the field intensity and length of the path travelled before the collision.

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2 Rossi and Staub, Ionization Chambers and Counters.

Since the field inside the counter increases more and more rapidly as the distance from the wire decreases, an electron which has enough energy to ionize an atom at a point x from the wire will acquire more than enough energy to ionize in each subsequent mean free path, which lies between x and the wire. When the point of the first ionization is one mean free path from the central wire, the gas amplification factor is 2 and the pulse on the wire will be twice as large as a pulse due only to the electrons formed by the primary ionizing event. As the voltage, V_o, is increased the electron which has come from the region near the counter wall will start the avalanche farther out and the pulse will be larger. The pulse size will depend on the total number of electrons which the original electron starts toward the central wire. Furthermore, a primary ionizing event which produces more ions will give a larger pulse. This means that the pulse will be proportional to the energy of the radiation entering the counter.

Increasing the voltage will cause the first ionization point to move farther and farther out and a point will be reached where the electrons will have acquired more than enough energy to ionize an atom while traversing a mean free path and the excess energy will be used to excite the atom or even doubly ionize it. If an ion in an excited state drifts toward the wall of the counter an electron may be pulled from the wall and a new avalanche will be formed. A less likely situation would be for the metastable atom or ion to radiate, giving off a photon which would eject a photo-electron on striking the counter wall.[3,4] Still another method of emitting electrons is the possibility of recombination with the emission of a high energy photon.[5,6] Montgomery and Montgomery[7] suggest that these high energy photons may eject photo-electrons from other atoms as well as the metal parts of the counter. The recombination theory seems to be the most likely when considering that the mobility of an electron is about 1,000 times that of a positive ion and that in the case of fast counters the pulse is of about 10^{-5} seconds duration, along with the pulse shape which has a very sharp rise, indicating that within the counter considerable ionization is produced in a very short time. This time is of the order of 10^{-6} seconds[8].

If no provision was made to stop this discharge it would continue indefinitely. Either by lowering the impressed potential or by absorbing the photons the discharge can be quenched. To lower the voltage a large resistor may be placed in series with the central wire so that a pulse

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[3] Serge A. Korff, op. cit., p. 66.

[4] James M. Cork, Radioactivity and Nuclear Physics, p. 40.

[5] Pollard and Davidson, Applied Nuclear Physics, p. 27.

[6] James M. Cork, op. cit., p. 40.

[7] C. G. Montgomery and D. D. Montgomery, Physical Review, Vol. 57, (1940), p. 1030.

[8] Serge A. Korff, op. cit., p. 87.

flowing through the resistor causes the voltage across the counter to drop by the amount Ri. The photons may be both absorbed and eliminated at the source by adding an organic vapor, such as alcohol, which has a low ionizing potential (about 11.3 volts) and broad absorption bands. The argon ions, whose ionization potentials are 15.7 volts with radiation potentials of 11.57 volts, collide with the alcohol molecules and excite the alcohol. The difference between the ionization potential for argon (15.7 volts) and the 11.3 for alcohol is radiated as a photon and then absorbed by the alcohol. The same is also true if an excited argon atom with 11.57 volts transfers this energy to the alcohol except the photon will be of longer wave length. To neutralize, the alcohol dissociates into smaller organic molecules[9], rather than radiates, and quenches the discharge. Many other gases accomplish the same purpose. The quenching gas molecules upon dissociating are no longer of much value for quenching. The life of a counter using an organic vapor has been found to be limited to about 10^{10} counts[10].

The positive ion space charge will be nearly all organic ions due to the collisions and as these ions move to the anode they will recombine with any electrons that by chance still exist in the volume of the counter, so that upon the outward sweep the positive ion sheath will, in effect,

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[9] Serge A. Korff, op. cit., p. 99.

[10] Serge A. Korff, op. cit., p. 100.

"sweep" the counter of all electrons leaving a charge free space ready for the next count.

CHAPTER II

CONSTRUCTION

The problems of Geiger counter construction are not always readily apparent. To elaborate on this view, I quote:[1]

> "It is in place here to discuss the practical side of Geiger-counter construction. Probably no apparatus in modern physics has had more study from the technical side or appeared in more diverse successful forms than the Geiger counter. At the Massachusetts Institute of Technology the visitor is shown a Geiger counter consisting of a fork and spoon in a partially evacuated space. It works! On the other hand the reader may well intentionedly make up a Geiger counter after the best instructions and fail to make it work.
> ...
> In the first place there is, particularly for the inexperienced, a considerable amount of trial and error about counter construction. Of three similar counters, one may completely fail to operate for no clear reason. If, however, one thinks of the manner of operation of the counter this behavior is to be expected to some extent, for the counter must be such that it will discharge at a certain voltage when "tripped" by an entering electron and yet extinguish when the applied voltage falls by a hundred volts or so. Since the nature of the discharge in the counter depends greatly on the surface of the electrodes any dirt may or may not change the behavior of the counter in a radical way. Moreover, the gas used for filling plays an important role and must be chosen with care. There is, therefore, in the authors' opinion, no infallible set of rules which when followed will guarantee perfect operation of a counter. ... In several laboratories as many as fifty counters are in operation at one time, giving no trouble, so that they are not uncontrollably temperamental."

The counters built for this experiment were constructed as concentric cylinders. The central wire was 5 mil tungsten. The only preparation used on this wire was flashing

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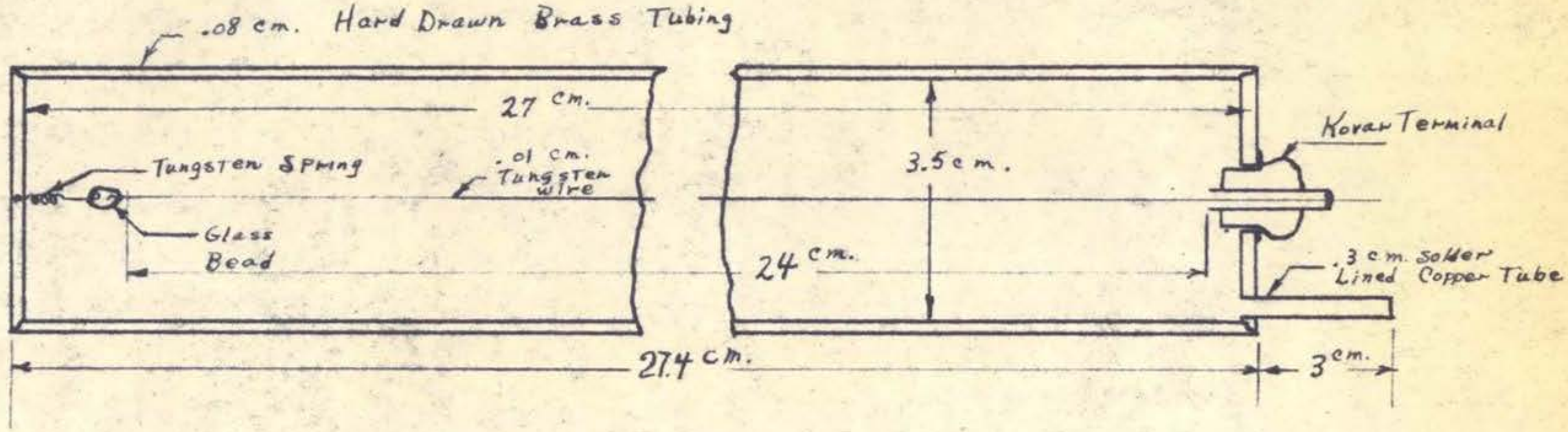
1 Pollard and Davidson, op. cit., pp. 28-30.

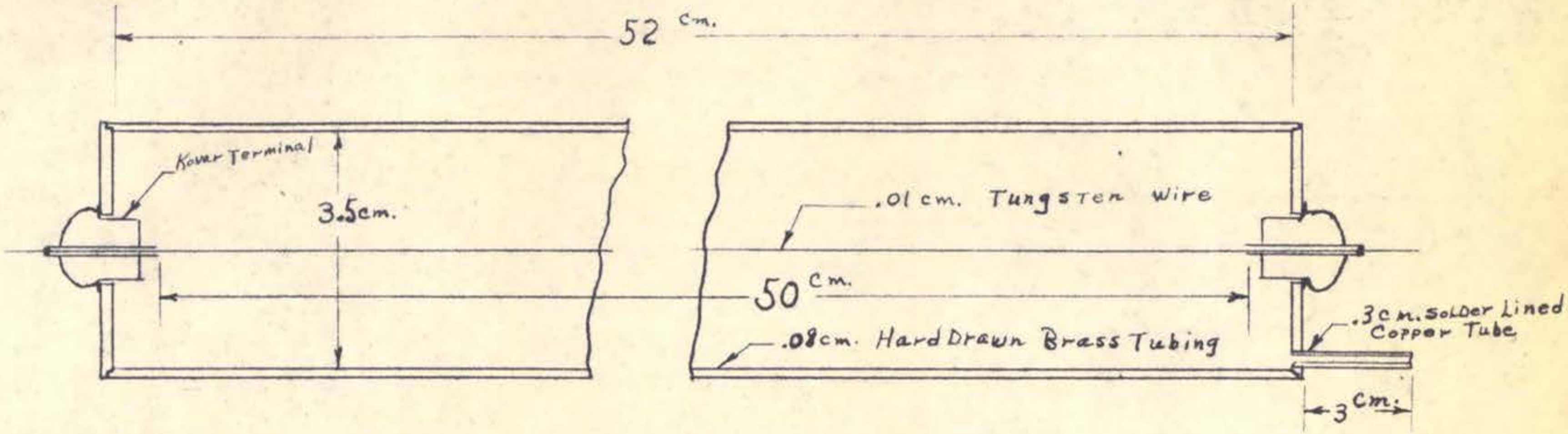
in a gas flame to eliminate any die marks and assure a smooth surface. The springs used on four of the counters were made of the same wire. The outside cylinder in the first four cases was made of hard drawn brass tubing of .032" wall thickness and 1¼" diameter. .020" would have been slightly better for Beta ray activity but this tubing was not available at the time. Steel wool and emery cloth were used to remove irregularities and to polish the inside of the tube. The inside polishing was done with a turned piece of oak with a ½" strip cut lengthwise out of the center and each of the rounded sections covered with fine emery cloth.

End plugs were made out of cold rolled brass and fitted with Stupekoff insulators for electrical connections. The tube, wire, and plugs were cleaned with warm nitric and hydrochloric acid to remove any oil on these surfaces. They were then rinsed with dilute hydrochloric acid and flushed with distilled water. An attempt was made to use silver solder to secure the plugs and the insulators but the heat necessary to work the silver solder caused the insulators to crack. This necessitated the use of soft solder. The plugs were machined to a press fit and there was very little need for great mechanical strength. The method of securing the wire was different in each set of counters. Plates I, II, and III demonstrate how the wire was connected. In counters 1, 2, 5, and 6 a spring was used to hold the central wire taut. After trying tungsten, phosphor bronze and stainless



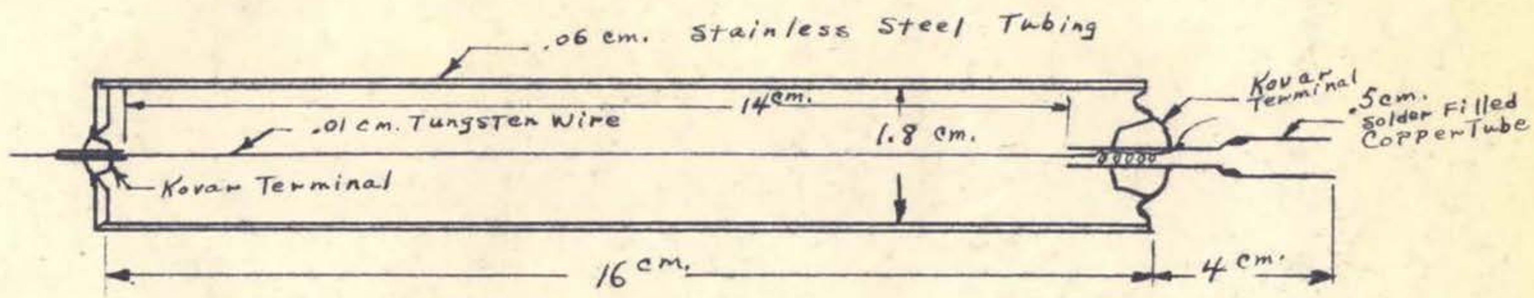
COUNTER # 1 + 2

Plate No. 1



COUNTER # 3 + 4

Plate No. 2



COUNTER # 5 + 6

Plate No. 3

steel, tungsten was selected. It's elastic qualities were adequate and sealing it to the pyrex bead in counters 1 and 2 was easier. When soldering tungsten, special care must be taken to make a vacuum tight connection. A 10% solution of hydrochloric acid makes an adequate flux. In this experiment a high soldering temperature produced the best seals.

The pumping tube was quite a problem. The method used was to drill out a small brass tube until the walls were very thin, then fill the hole with solder and redrill to a smaller diameter. This leaves a small hole lined with solder which can be pinched off with a blunt pliers and heated to form a vacuum tight seal. On the last two counters this tube was attached to the insulator and pumped through the insulator tube.

The gases used to fill the counters were commercial argon, 99.6% pure, and 99% pure ethyl alcohol. One purpose of this project being to compare counters of different design, a pumping manifold of glass was constructed so that all counters could be filled independently or at the same time. A manometer in the system gave a constant check on pressure. The pressure was lowered to .5 mm. and held there for 48 hours. During this time, the counters were heated with a bunsen burner to out gas them three times. Then they were flushed with argon, which was pumped out after about eight hours, and refilled with various pressures of argon and alcohol to determine the opportune values for a long plateau and low voltages.

The power supply was constantly variable from + 800 to + 1600 volts. It was regulated first by a constant voltage transformer and after rectification by a series of voltage regulator tubes. It was made by the Research and Development Department and was a very satisfactory piece of equipment.

The vacuum was produced by a mechanical pump, which was connected to a small dry ice trap, through a rubber pressure tube. The dry ice trap was connected through a flexible tube to a pyrex pumping manifold, which had stoppered connections for two types of gas, four counters and the manometer. This arrangement made it easy to fill or exhaust the counters at the same time but still allowed them to be controlled one at a time. The manifold itself was made of a $\frac{1}{2}$" pyrex glass tubing 2 ft. long.

An oscilloscope was used to study the action of the counters. It was connected to the negative end of a 1 meg. ohm resistor through a 20 micro farad ceramic condenser. Figure I is a schematic drawing of this circuit.

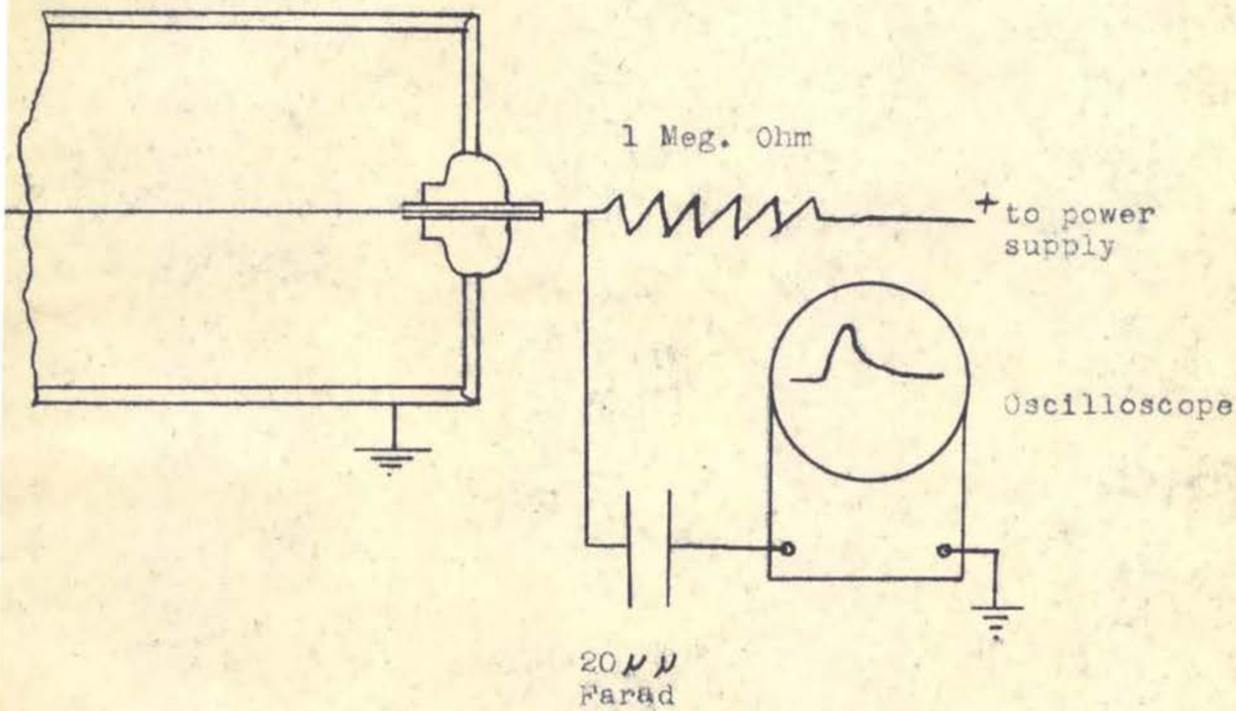


FIGURE I

CHAPTER III

CALIBRATING THE COUNTERS

The counters were filled to various pressures and the voltage increased until the counters began to count. The voltage was increased by about 20 volts, (see Graph No. 5), until the counters either began to oscillate or go into a continuous discharge. The applied voltage as recorded is the voltage indicated by the built in voltmeter and should be corrected by use of Graph No. 5 for true voltage. At each increase in the applied voltage the average counts per minute was taken. The following is a record of this procedure:

March 20, 1950
Counter No. 1 - At a pressure of 13 cm. Hg of argon and 1.3 cm. Hg of alcohol vapor.

Voltage	Counts per Minute	Remarks[1]
1200	11	1
1220	24	1
1240	28	2
1260	33	3
1280	40	
1300	51	
1320	64	
1340	71	
1360	73	
1380	74	

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[1] LEGEND OF REMARKS:

1. The pulse size varied by a factor of about 100 between largest and smallest pulse.

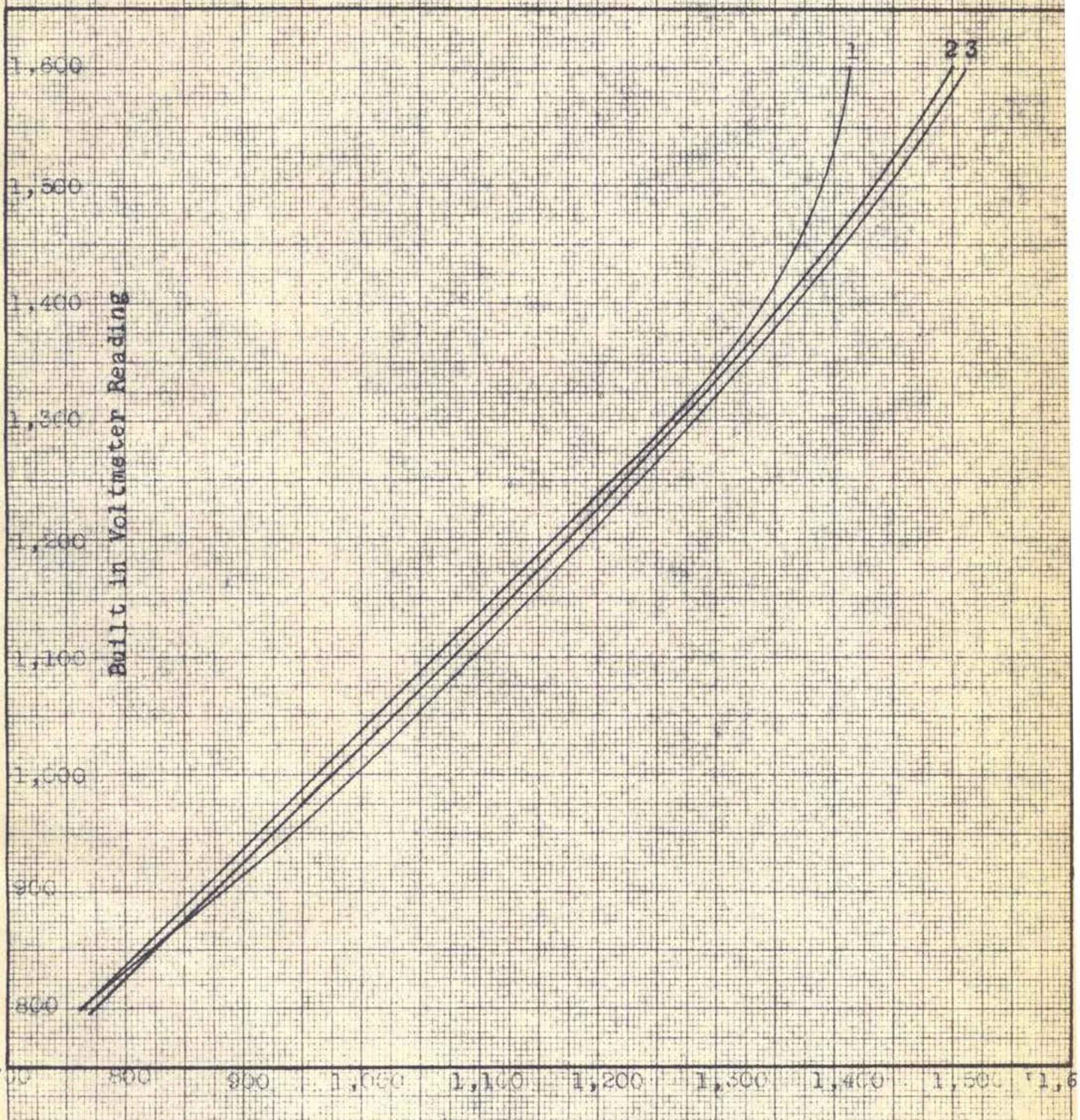
2. The pulse size varied by a factor of about 2 between largest and smallest pulse.

3. The pulse size varied by a factor of about 1.25 between largest and smallest pulse.

No number indicates pulses were all the same height.

CALIBRATION CURVE FOR POWER SUPPLY

No. 1 input of 40 volts
No. 2 input of 80, 90, 100 or 110 volts
No. 3 input of 60 or 120 volts



VOLTAGE AS MEASURED BY A VACUUM TUBE VOLTMETER

Graph No. 5

March 20, 1950 (Continued)
Counter No. 1 - At a pressure of 13 cm. Hg of argon and 1.3 cm. Hg of alcohol vapor.

Voltage	Counts per Minute	Remarks
1400	75	
1420	76	
1440	79	
1460	96	

March 24, 1950
Counter No. 1 - At a pressure of 12 cm. Hg of argon and 1.2 cm. Hg of alcohol vapor.

Voltage	Counts per Minute	Remarks
1160	14	1
1180	20	1
1200	29	1
1220	38	3
1240	50	3
1260	63	
1280	65	
1300	68	
1320	69	
1340	70	
1360	72	
1380	83	

March 26, 1940
Counter No. 1 - At a pressure of 11 cm. Hg of argon and 1.1 cm. Hg of alcohol vapor.

Voltage	Counts per Minute	Remarks
1100	12	1
1120	21	1
1140	32	1
1160	40	2
1180	55	3
1200	59	
1220	62	
1240	63	
1260	64	
1280	68	
1300	80	
1320	91	

March 27, 1950
Counter No. 1 - At a pressure of 10 cm. Hg of argon and 1 cm. Hg of alcohol vapor.

Voltage	Counts per Minute	Remarks
1040	9	1
1060	24	1
1080	39	1
1100	49	2
1120	58	3
1140	60	
1160	61	
1180	64	
1200	65	
1220	68	
1240	79	
1260	86	

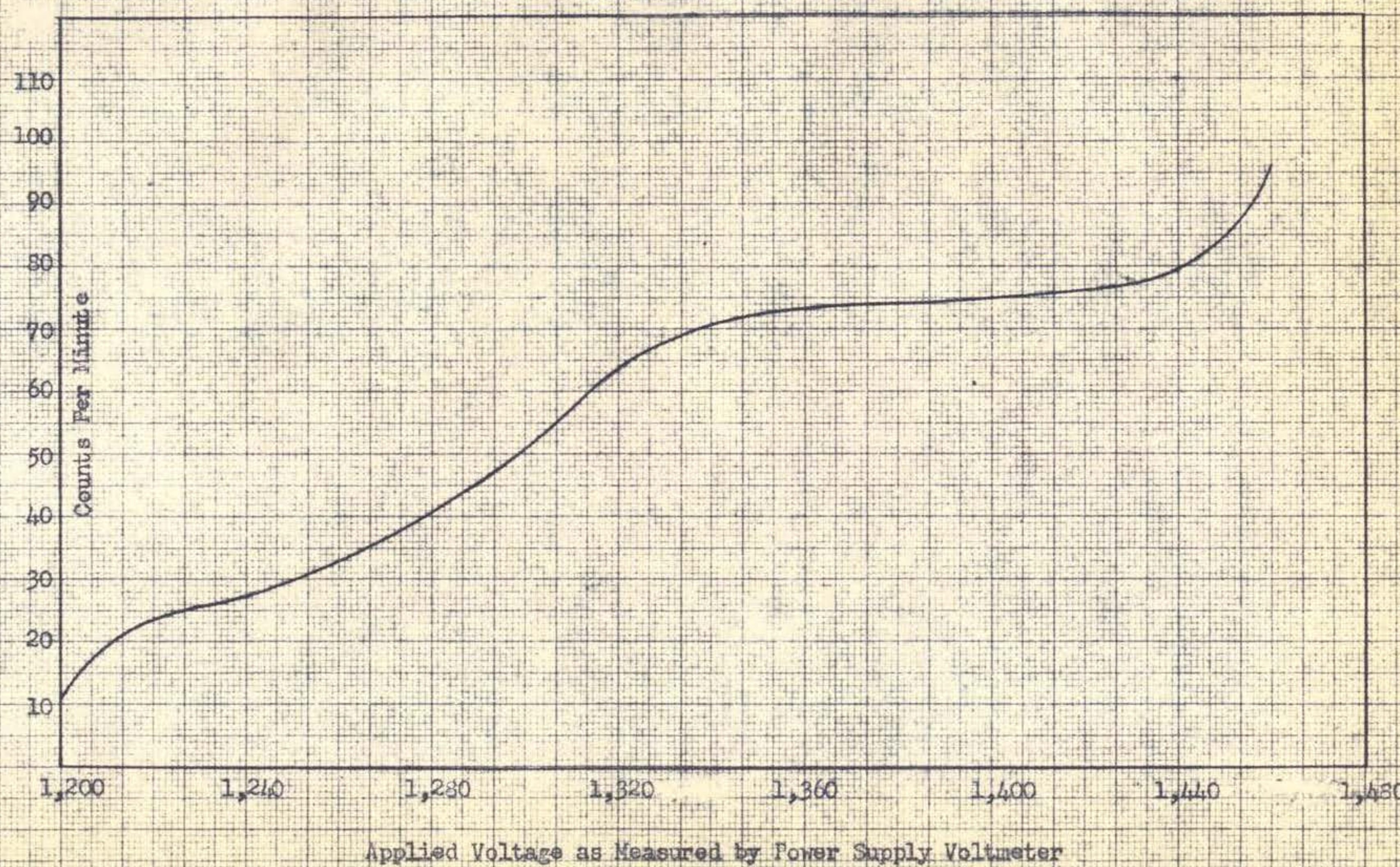
April 1, 1950
Counter No. 1 - At a pressure of 9 cm. Hg of argon and .9 cm. Hg of alcohol vapor.

Voltage	Counts per Minute	Remarks
1000	8	1
1020	16	1
1040	21	2
1060	32	2
1080	40	3
1100	51	
1120	60	
1140	61	
1160	63	
1180	70	
1200	78	

April 1, 1950
Counter No. 1 - At a pressure of 8 cm. Hg of argon and .8 cm. Hg of alcohol vapor.

Voltage	Counts per Minute	Remarks
960	3	1
980	19	1
1000	29	2
1020	54	
1040	62	
1060	63	
1080	69	
1100	76	
1120	89	

Operation Curve for Counter No. I at 13 cm. Hg Argon and 1.3 cm. Hg Alcohol Vapor



Curve No. 1

March 20, 1950
Counter No. 2 - At a pressure of 13 cm. Hg of argon and 1.3 cm. Hg of alcohol vapor.

Voltage	Counts per Minute	Remarks
1200	16	1
1220	25	1
1240	35	1
1260	39	2
1280	46	3
1300	53	
1320	65	
1340	71	
1360	73	
1380	75	
1400	76	
1420	78	
1440	90	
1460	112	

March 20, 1950
Counter No. 2 - At a pressure of 12 cm. Hg of argon and 1.2 cm. Hg of alcohol vapor.

Voltage	Counts per Minute	Remarks
1160	8	1
1180	25	1
1200	29	1
1220	38	3
1240	56	
1260	70	
1280	71	
1300	69	
1320	73	
1340	73	
1360	74	
1380	88	

March 26, 1950
Counter No. 2 - At a pressure of 11 cm. Hg of argon and 1.1 cm. Hg of alcohol vapor.

Voltage	Counts per Minute	Remarks
1100	8	1
1120	18	1
1140	28	1
1160	36	2
1180	56	3
1200	60	
1220	62	
1240	62	
1260	64	
1280	66	
1300	70	
1320	86	

March 27, 1950
Counter No. 2 - At a pressure of 10 cm. Hg of argon and 1 cm. Hg of alcohol vapor.

Voltage	Counts per Minute	Remarks
1040	7	1
1060	16	1
1080	31	1
1100	38	2
1120	48	3
1140	59	
1160	60	
1180	63	
1200	68	
1220	74	
1240	76	
1260	89	

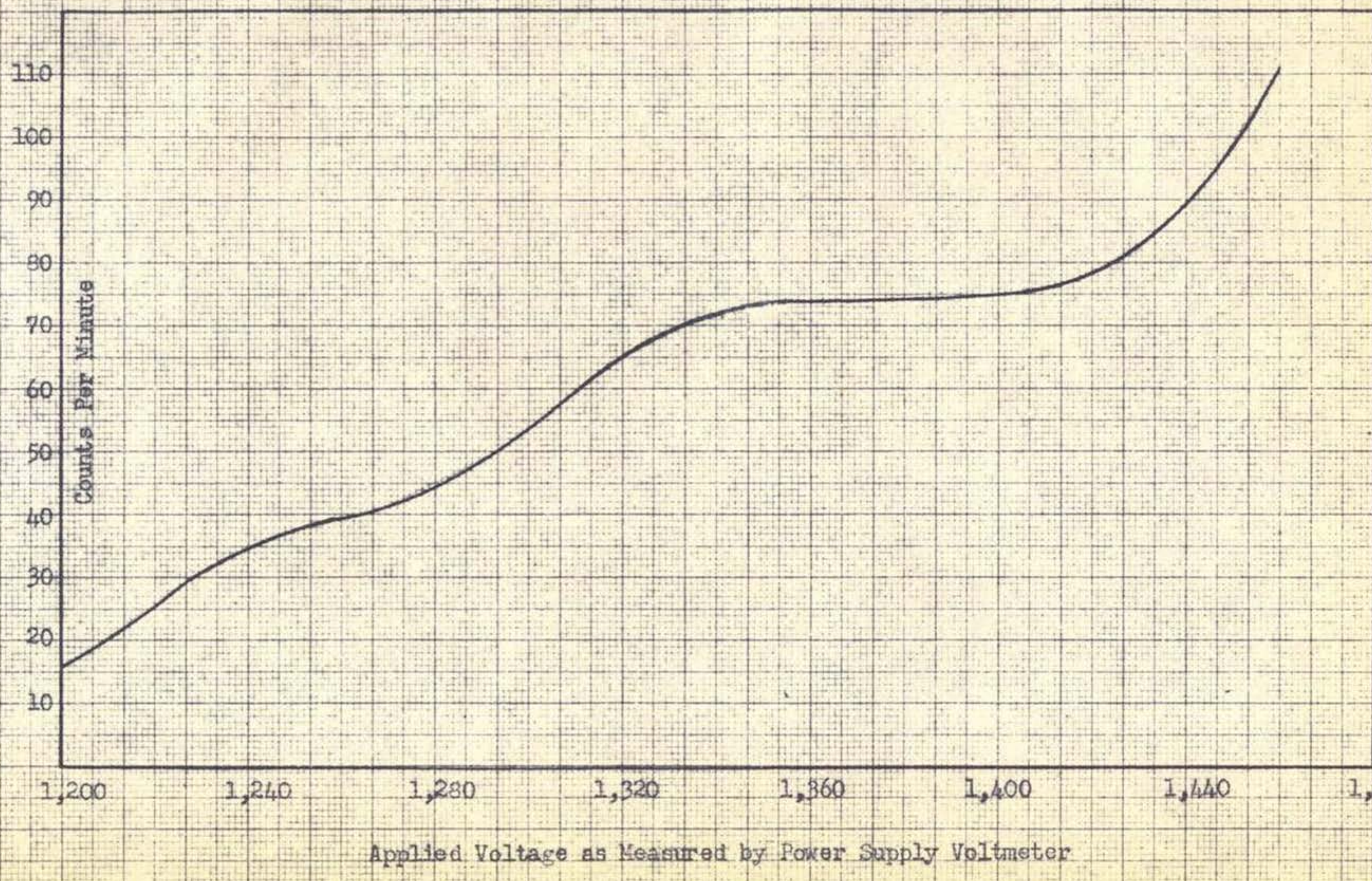
April 1, 1950
Counter No. 2 - At a pressure of 9 cm. Hg of argon and .9 cm. Hg of alcohol vapor.

Voltage	Counts per Minute	Remarks
980	4	1
1000	28	1
1020	36	2
1040	51	3
1060	59	
1080	60	
1100	61	
1120	63	
1140	66	
1160	74	
1180	89	

April 1, 1950
Counter No. 2 - At a pressure of 8 cm. Hg of argon and .8 cm. Hg of alcohol vapor.

Voltage	Counts per Minute	Remarks
940	8	1
960	26	1
980	39	2
1000	51	3
1020	58	
1040	59	
1060	60	
1080	61	
1100	73	
1120	83	

Operation Curve for Counter No. 2 at 13 cm. Hg Argon and 1.3 cm. Hg Alcohol Vapor



Curve No. 2

March 25, 1950
Counter No. 3 - At a pressure of 12 cm. Hg of argon and 1.2 cm. Hg of alcohol vapor.

Voltage	Counts per Minute	Remarks
1460	32	1
1480	50	1
1500	69	1
1520	90	2
1540	120	3
1560	149	
1580	156	
1600	159	
1620	161	
1640	162	
1660	164	

March 25, 1950
Counter No. 3 - At a pressure of 11 cm. Hg of argon and 1.1 cm. Hg of alcohol vapor.

Voltage	Counts per Minute	Remarks
1400	6	1
1420	31	1
1440	56	1
1460	86	2
1480	125	3
1500	148	3
1520	159	
1540	160	
1560	161	
1580	163	
1600	164	
1620	185	

March 28, 1950
Counter No. 3 - At a pressure of 10 cm. Hg of argon and 1 cm. Hg of alcohol vapor.

Voltage	Counts per Minute	Remarks
1400	22	1
1420	44	2
1440	43	2
1460	80	3
1480	130	3
1500	150	
1520	160	
1540	159	
1560	163	
1580	164	
1600	180	

March 28, 1950
Counter No. 3 - At a pressure of 9 cm. Hg of argon and .9 cm. Hg of alcohol vapor.

Voltage	Counts per Minute	Remarks
1360	6	1
1380	27	2
1400	39	2
1420	71	3
1440	119	3
1460	149	
1480	158	
1500	161	
1520	162	
1540	164	
1560	175	

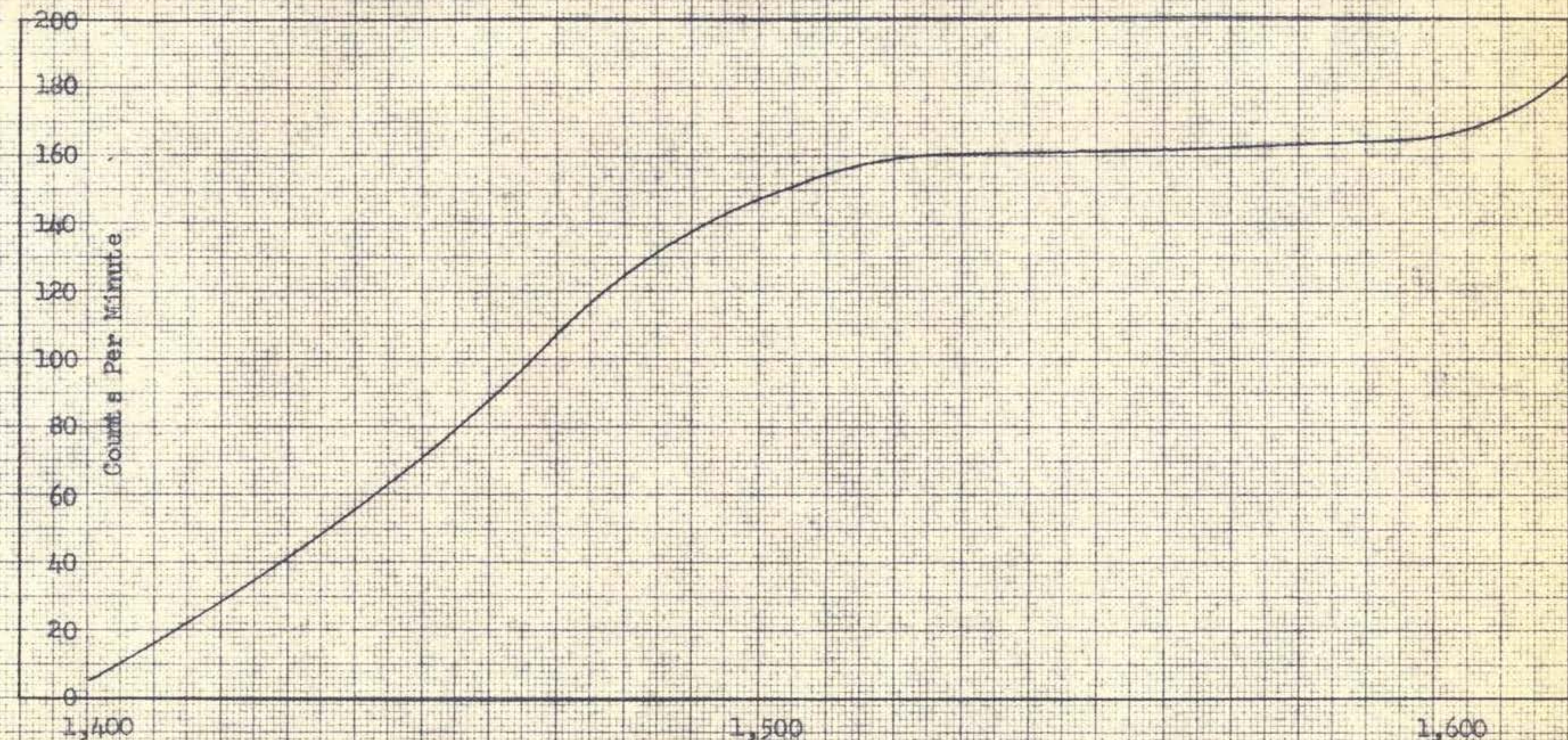
April 1, 1950
Counter No. 3 - At a pressure of 8 cm. Hg of argon and .8 cm. Hg of alcohol vapor.

Voltage	Counts per Minute	Remarks
1300	24	1
1320	43	1
1340	67	2
1360	102	3
1380	148	3
1400	156	
1420	158	
1440	160	
1460	162	
1480	163	
1500	164	
1520	180	

April 1, 1950
Counter No. 3 - At a pressure of 7 cm. Hg of argon and .7 cm. Hg of alcohol vapor.

Voltage	Counts per Minute	Remarks
1240	9	1
1260	31	1
1280	57	2
1300	186	2
1320	121	3
1340	156	
1360	158	
1380	158	
1400	159	
1420	160	
1440	162	
1460	179	

Operation Curve for Counter No. 3 at 11 cm. Hg Argon and 1.1 cm. Hg Alcohol Vapor



Applied Voltage as Measured by Power Supply Voltmeter

Curve No. 3

March 25, 1950
Counter No. 4 - At a pressure of 12 cm. Hg of argon and 1.2 cm. Hg of alcohol vapor.

Voltage	Counts per Minute	Remarks
1440	24	1
1460	41	1
1480	68	1
1500	112	2
1520	140	3
1540	156	
1560	158	
1580	160	
1600	162	
1620	159	
1640	164	
1660	170	

March 25, 1950
Counter No. 4 - At a pressure of 11 cm. Hg of argon and 1.1 cm. Hg of alcohol vapor.

Voltage	Counts per Minute	Remarks
1380	10	1
1400	38	1
1420	71	2
1440	110	2
1460	141	3
1480	158	
1500	161	
1520	163	
1540	165	
1560	169	
1580	170	
1600	188	

March 28, 1950
Counter No. 4 - At a pressure of 10 cm. Hg of argon and 1 cm. Hg of alcohol vapor.

Voltage	Counts per Minute	Remarks
1400	16	1
1420	36	1
1440	59	2
1460	98	2
1480	133	3
1500	158	
1520	161	
1540	159	
1560	160	
1580	162	
1600	166	
1620	182	

March 28, 1950
Counter No. 4 - At a pressure of 9 cm. Hg of argon and .9 cm. Hg of alcohol vapor.

Voltage	Counts per Minute	Remarks
1340	12	1
1360	38	1
1380	62	2
1400	89	2
1420	138	3
1440	150	
1460	154	
1480	156	
1500	160	
1520	162	
1540	174	

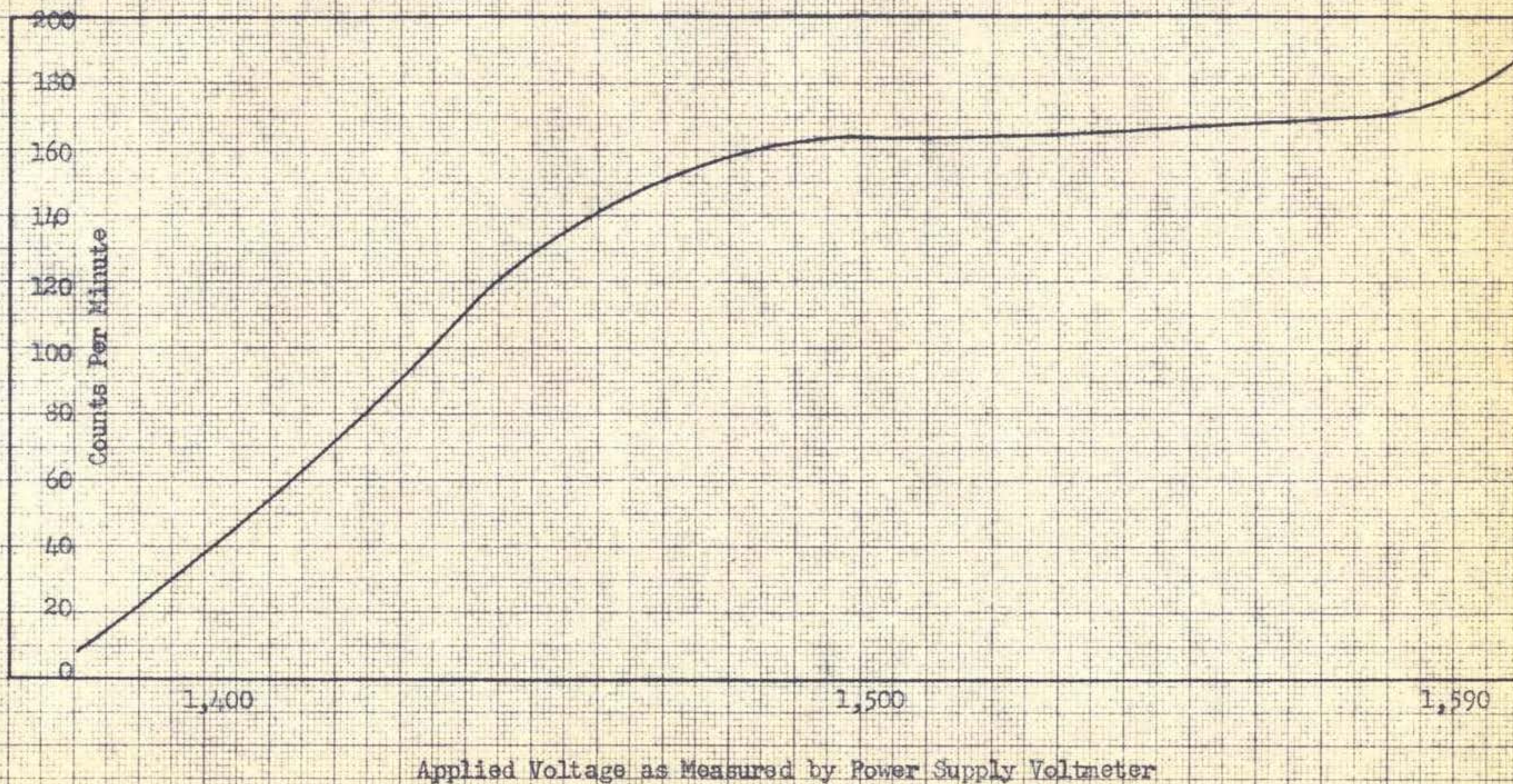
April 1, 1950
Counter No. 4 - At a pressure of 8 cm. Hg of argon and .8 cm. Hg of alcohol vapor.

Voltage	Counts per Minute	Remarks
1260	13	1
1280	36	1
1300	70	2
1320	104	3
1340	149	3
1360	158	
1380	160	
1400	161	
1420	162	
1440	164	
1460	165	
1480	171	
1500	196	

April 1, 1950
Counter No. 4 - At a pressure of 7 cm. Hg of argon and .7 cm. Hg of alcohol vapor.

Voltage	Counts per Minute	Remarks
1220	11	1
1240	29	1
1260	59	2
1280	114	3
1300	148	3
1320	152	
1340	157	
1360	159	
1380	158	
1400	164	
1420	170	
1440	188	

Operation Curve for Counter Nol 4 at 11 cm. Hg Argon and 1.1 cm. Hg Alcohol Vapor



Curve No. 4

CHAPTER IV

CHLORINE ARGON COUNTERS

The last two counters were made out of 3/4" stainless steel tubing of .020" wall thickness. Polishing and cleaning was identical with that for the brass counters. The wire was 5 mil. tungsten wire as in the first four counters. Flashing to remove sharp points was the only treatment used on this wire. In each of these counters the insulator used at one end was large enough so that it could serve as the end plug. The other ends were fitted with stainless steel plugs which in turn were fitted with small insulators. The counters were pumped through the large insulators using the same method as before. The argon gas was the same as in the other counters but the quenching gas was chlorine. The theory of these counters is the same as that of the first four except that the chlorine molecules dissociate into chlorine atoms[1]. The chlorine atoms recombine to form chlorine molecules in a short time. The detecting device and the procedure of calibration were the same as that used on the larger counters.

The chlorine argon counters theoretically have a longer life than the alcohol argon counters, whose life is limited by the dissociation of the alcohol. The only life limita-

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1 S. H. Liebson and H. Friedman, "Self Quenching Halogen Filled Counters", The Review of Scientific Instruments, (May, 1948)

tions of the chlorine argon counters would be pitting of the central wire and chemical reactions between chlorine and any reactable material within the counter.

April 23, 1950

Counter No. 5 - At a pressure of 65 cm. Hg of argon and 6.5 cm. Hg of chlorine.

Voltage	Counts per Minute
1440	9
1460	12
1480	16
1500	18
1520	24

Counter No. 5 - At a pressure of 60 cm. Hg of argon and 6. cm. Hg of chlorine.

Voltage	Counts per Minute
1320	10
1340	14
1360	21
1380	39

Counter No. 5 - At a pressure of 55 cm. Hg of argon and 5.5 cm. Hg of chlorine.

Voltage	Counts per Minute
1080	11
1100	19
1120	22
1140	43

Counter No. 5 - At a pressure of 50 cm. Hg of argon and 5. cm. Hg of chlorine.

Voltage	Counts per Minute
1000	13
1020	14
1040	19
1060	20
1080	40

Counter No. 6 - At a pressure of 35 cm. Hg of argon and 3.5 cm. Hg of chlorine.

Voltage	Counts per Minute
1480	13
1500	16
1520	19

April 23, 1950 (Continued)

Counter No. 6 - At a pressure of 30 cm. Hg of argon and 3. cm. Hg of chlorine.

Voltage	Counts per Minute
1420	14
1440	15
1460	18
1480	32

Counter No. 6 - At a pressure of 25 cm. Hg of argon and 2.5 cm. Hg of chlorine.

Voltage	Counts per Minute
1360	16
1380	19
1400	21
1420	41

Counter No. 6 - At a pressure of 20 cm. Hg of argon and 2. cm. Hg of chlorine.

Voltage	Counts per Minute
1260	15
1280	17
1300	19
1320	23
1340	39

The data gathered on the chlorine argon counters does not warrant a graph. Five points hardly determine a curve. The lack of range may be due to the soft solder connection. To produce acceptable results soldered joints might have to be replaced by welded joints. These counters seemed to have no proportional region; all pulses were about the same height. Before they began to count a slight grassiness was observed on the scope. This may indicate that the range was limited by the detecting device rather than the counters themselves.

CHAPTER V

CONCLUSION

The performance of these counters is not satisfactory for precise work. The curves do not follow the accepted pattern for Geiger counter curves. The plateaus are not long enough or as flat as they should be. In Counters No. 1 and 2 there seems to be two plateaus. Those at the lower voltage may be due to accidental characteristics of the wall surface. They can not be attributed to the gas because they do not show up in the other two counters. Before careful cosmic ray work can be done the counters will have to be improved. It is my opinion that glass counters would be more satisfactory if they could be made to stand the rough treatment they are likely to receive. Considering the many rugged devices used that depend on glass vacuum tubes this should not be a prohibitive drawback. The metal counters have limited durability due to the insulators and the rather fragile central wire. Glass construction would eliminate the need for soldered joints. Such counters could be more thoroughly cleaned and out gassing could be more complete. They could be used also as beta ray counters. The interior of the counter would be visible to the operator and this may be of advantage in locating imperfections, if any exist.

Should more work be done on metal counters there are some points which should be given special attention. The surfaces of both the walls and the central wire should be very smooth.

Any irregularity is an invitation to trouble. If the irregularity is on the central wire, unpredictable fields result which will make one part of the counter function differently from another. Irregularities in the wall, as a rule, are not as likely to cause trouble but they can result in a varied work function for the surface formed by the cleaning processes. The solder area exposed to the interior of the counter should be as small as possible. Careful machining will help here. Any water vapor in the counter impairs the functioning and precautions should be taken to dry the gas used to fill the counter.

The recording device used in this study is not adequate for further work. All the connecting wires should be shielded. This would require a type of shielded wire that will withstand a higher voltage than that of the power supply. The pulses charge the condenser which acts in series with the power supply thereby increasing the potential to a point that would rupture a dielectric only strong enough to withstand the voltage of the power supply. For large counters the counts per second is great enough to make visual recording uncertain. A scaling circuit[2] or a mechanical counter would be needed if counters with active cross sections of 100 sq. cm. or larger are to be used.

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2 Serge A. Korff, op. cit., p. 171.

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