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GEIGER TUBE RADIATION METER

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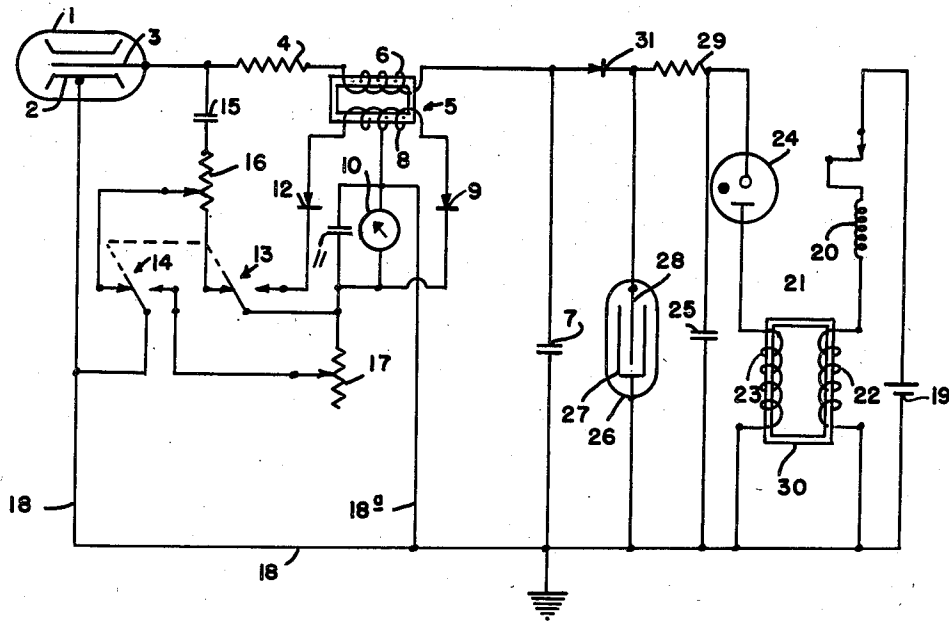


FIG. 1.

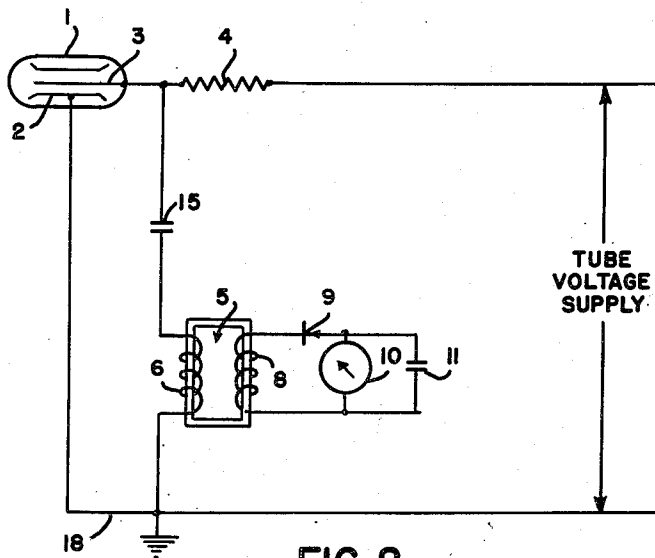


FIG. 2.

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## GEIGER TUBE RADIATION METER

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5 Claims. (Cl. 250—83.6)

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The present invention relates to a Geiger tube radiation meter and more particularly to a meter which is light in weight and has a long lived power supply.

As the science of nuclear physics advances and the discovery, mining, purification and application of radioactive materials becomes more widespread both in a civilian and military sense, it becomes increasingly important that simple, rugged, accurate, and lightweight detecting and measuring instruments for beta, gamma, and alpha rays and particles be made available. Heretofore, the most successful instruments were of the type employing Geiger-Mueller tubes and various types of vacuum tube amplifying means for increasing the output of the Geiger-Mueller tubes sufficiently to be readable on a microammeter integrating circuit. While these instruments are far superior to any previously available, they still have several serious disadvantages in that the vacuum tubes require both filament and plate supply batteries which are of considerable weight because of the added necessity of supplying relatively high voltages to the Geiger-Mueller tube therefrom, the vacuum tubes had to be miniaturized to reduce the drain on the batteries thereby to increase their lives which resulted in a delicate structure, and the vacuum tube amplifiers are both complex and, because of their complexity, inaccurate.

To obviate some of these disadvantages, special small high voltage batteries have been provided for use with these instruments. However, the weight of the batteries is still excessive, because they are non-standard they are not readily available so that prospectors for radioactive ores could not secure them in remote localities nor would they be on hand in areas of great emergency as when an atomic bomb has fallen, and the lives of such batteries by reason of their extremely small cell size is short and unreliable.

To eliminate the use of such batteries, special vibrators and transformers have been developed to convert the output of 3 volt batteries to the high voltage necessary to the operation of a Geiger-Mueller tube which ranges between 500 to 1500 volts. In this type of supply, the battery has one terminal connected to the mid-point of the primary of the transformer, the other terminal of the battery being connected to either end of the primary alternately by operation of the vibrator. The step-up ratio of the turns on the primary and secondary windings of the transformer is proportional to the ratio of the battery voltage to the desired voltage and, because the

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desired voltage is high, the turns on the secondary winding must also necessarily be high. It is obvious then that such a winding has both high resistance and inductive impedance which leads to large power losses in both the resistance of the winding and the iron in the transformer core.

Because the vibrator has to have its armature driven at its high resonant frequency and with considerable amplitude in order to swing between its two opposing contacts, a considerable mechanical loss is engendered thereby so that it has been found that by reason of the high resistance, magnetic and mechanical losses, this arrangement has a power conversion efficiency of only 5 to 10%. Other arrangements have been found to be equally inefficient by reason of the high electrical, magnetic, and mechanical losses inherent in their construction.

The present invention was designed after a thorough analysis of the foregoing disadvantages and with a view to producing an instrument that is simple, rugged, accurate, and requires such low battery consumption as to be both lightweight and long-lived. These results have been achieved by the total elimination of all filament type vacuum tubes with the consequent elimination of the necessity for filament supply batteries and a considerable enhancement in the ruggedness and simplicity of the arrangement without any sacrifice of its accuracy. The accuracy has been further increased by the provision of special integration and calibration circuits whereby both low count and high count radiations may be indicated with great precision by a simple switching between circuits of greater or lesser sensitivity. Further reduction in battery weight is accomplished, not only by the elimination of the filament supply battery, but also by providing a highly efficient power supply for the Geiger-Mueller tube which likewise serves as the source of power for such cold-cathode electronic tubes as are found necessary to the operation of the instrument. Because of the elimination of the filament battery and the high efficiency of the main power supply, battery life is also greatly extended beyond the maximum heretofore achieved. In a final attempt to secure simplicity, the power supply has been designed to operate from a single standard flashlight cell of the type readily available in any five-and-ten-cent store or cross-roads country store.

Specifically, the apparatus of the present invention comprises a Geiger-Mueller tube having its voltage supply connected thereacross. A step-down transformer is so connected to the tube

that pulses corresponding to the tube pulses pass through its primary winding and appear across its secondary winding at considerably decreased voltage but higher amperage. These low-voltage high-amperage pulses are rectified and supplied to a microammeter having an integrating condenser connected thereacross whereby the microammeter will indicate a value dependent upon the number of pulses produced by the tube per unit of time. The aforesaid rectification can be switched to be either half-wave or full-wave, the half-wave rectification having been found to be more sensitive for low tube counts and the full-wave rectification providing greater resolution for high tube counts.

For even greater sensitivity when the number of pulses from the tube is low, a storage condenser may be provided across the tube so as to enhance the intensity of the pulses and a variable calibration resistor is provided for simultaneously adjusting the effective value of the storage condenser and variably shunting the microammeter for calibration purposes. When full-wave rectification is employed, a second variable resistor is connected to shunt the microammeter to provide calibration thereof.

The novel power supply includes a closed core inductor having a low resistance primary winding in series with the winding and normally closed contacts of a vibrator relay, the series circuit being connected to a single dry cell of the flashlight type. The inductor is also provided with a fairly low resistance secondary winding connected in series with a gaseous tube rectifier to a storage condenser, the latter in turn being connected through a loading resistor to a voltage regulating tube. The voltage regulating tube is connected through either a surge limiting resistor or rectifier to a condenser which acts as the power supply for the Geiger-Mueller tube and its associated meter circuit.

An object of the present invention is the provision of a radiation meter in which all filament-tube amplifiers have been eliminated.

Another object is to provide a radiation meter having as its only source of power a single dry cell of the flashlight type.

A further object of the invention is the provision of a high efficiency low-drain power conversion system between a dry cell and a Geiger-Mueller tube.

Still another object is to provide an amplification means which converts the high-voltage low-current pulses of a Geiger-Mueller tube to low-voltage high-current pulses without the intervention of electronic tubes.

Yet another object of the present invention is the provision in a radiation meter of readily adjustable circuits which are capable of detecting low count pulses from a Geiger-Mueller tube with great sensitivity and high count pulses with great accuracy.

It is also an object of the invention to provide a radiation meter which is selectively responsive to both low and high count pulses from a Geiger-Mueller tube with simple calibration means.

A further object is to provide in the power supply system of a radiation meter, a voltage regulation means arranged to prevent surges produced by such regulation from having a deleterious effect on the operation of a Geiger-Mueller tube energized therefrom.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood

by reference to the following detailed description when considered in connection with the accompanying drawings in which like reference numerals designate like parts throughout the figures thereof and wherein:

Fig. 1 is a diagram of the preferred form of circuit employed in the radiation meter of this invention, and

Fig. 2 is a diagram of a modified circuit intended to replace a portion of the circuit of Fig. 1.

Referring now to the drawings, there is shown in Fig. 1 a gas-filled tube 1 of the type which discharges when the gas therein is excited by external radiations as from gamma, beta or alpha rays or particles, such tubes being generally known in the art as Geiger-Mueller tubes. The tube 1 is provided with the usual cathode 2 and anode 3, the anode being connected to one end of a resistor 4. The other end of resistor 4 is connected to one end of the primary winding 6 of a step-down transformer 5, the other end of the primary winding 6 being connected to one end of a condenser 7 which has its other end connected to the cathode 2 and is grounded. The condenser 7 is maintained charged at the operating voltage of the tube 1 by power supply equipment to be described hereinafter and serves therefore as the source of high voltage for making tube 1 operative when radiations excite the gases therein.

The transformer 5 is of the closed core type, as illustrated, and is provided with a center tapped secondary winding 8 having considerably fewer turns than the primary winding 6, a ratio of about 40 to 1 being preferred. One end of the secondary winding 8 is connected through a rectifier 9 to one end of a microammeter 10, the other end of which is connected to the center tap of the secondary winding. Connected across the microammeter 10 is an integrating condenser 11. The other end of the secondary winding 8 is connected to one end of a second rectifier 12, the other end of which is adapted to be disconnected from or connected to the same end of the microammeter 10 as is the rectifier 9 by the switch 13. The rectifiers 9 and 12 are poled to produce full-wave rectification of the output of the secondary winding 8 when both rectifiers are connected to the microammeter 10.

Connected between the anode 3 and the resistor 4 is one side of a condenser 15 of much smaller capacity than the power supply condenser 7, the other side of condenser 15 being connected to one end of a resistor 16 having an adjustable sliding contact thereon as illustrated. A second switch 14 mechanically interconnected with switch 13, as shown, to provide simultaneous operation thereof is arranged in its left-hand position to connect the sliding contact of resistor 16 to the grounded lead 18 of the power supply and in its right-hand position to connect a sliding contact on a resistor 17 to the grounded lead 18 for a purpose to be made apparent hereinafter. It will be noted that one end of the resistor 17 is connected to one end of the microammeter 10, the other end of the microammeter being connected by lead 18a to the grounded lead 13. In its left-hand position, the switch 13 connects the lower end of resistor 16 to the end of the microammeter 10 which is not connected to lead 18a.

In order to maintain the condenser 7 charged at a high voltage, a voltage conversion and regulating system energized from a single dry cell 19, which may be of the flashlight battery or equivalent,

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lent low voltage, lightweight type, is provided. The voltage conversion portion of the system comprises a relay 20 having a coil and normally closed contacts in series with the battery 19 and the primary winding 22 of an inductor 21, the inductor having a closed core 30 and a secondary winding 23 thereon.

The relay 20 is a current operated relay designed so that a minimum amount of power is required to effect opening of its contact, and the mechanical movement of the relay armature need be very slight and only great enough to break the contact as distinguished from the operation of the usual full-wave vibrator which must have sufficient mechanical movement in its armature to close a pair of back contacts. It is apparent that this type of construction reduces the battery drain considerably over other arrangements.

The primary winding 22 has very few turns and therefore low resistance loss to limit further the drain on the battery 19, the high inductance of the closed core 30 providing considerable magnetic energy storage therein to cause the primary winding 22 to have a large impedance thereby to slow down operation of the relay 20 with a further saving of mechanical energy and consequent reduction of the drain on battery 19. Opening of the contacts of relay 20 produces a large magnetic surge through the core 30 and this produces in the relatively few turns of the winding 23 a considerable voltage which is greater than the magnitude needed to operate the tube 1. The ratio of the turns of primary winding 22 to secondary winding 23 need not approach that of the ratio of the voltage of battery 19 to that needed to operate tube 1 as the voltage produced by winding 23 is not only a function of its turns but also of the rate of change of flux in core 30 which, as stated above, is very high. The use of a closed core provides high inductance and eliminates the losses inherent in an open core whereby the size and weight of the core can be made quite small. Thus the weight of inductor 21 is considerably reduced when compared with that of a step-up transformer or an open core inductor.

The secondary winding 23 has one side connected to grounded lead 18 and the other side is connected to the anode of a cold-cathode, high voltage rectifier 31, the cathode of which is connected to one side of a condenser 25 having its other side connected to grounded lead 18. Connected across the condenser 25 is a voltage regulator tube 26 of the ionization type having an anode 28 and a cathode 27 connected to grounded lead 18, a current limiting resistor 29 being arranged in the circuit between tube 26 and condenser 25. The resistor 29 and the tube 26 act to produce a load on condenser 25 which limits the peak voltage on the latter and therefore the voltage across the turns of secondary winding 23 and primary winding 22, the number of turns on winding 22 being selected to limit the voltage across the contacts of relay 20 to a safe value to prevent improper operation thereof.

If desired, the anode 28 may be connected directly to the primary 5 of transformer 5 thereby to eliminate the condenser 7 but it has been found more desirable to employ the condenser 7 to reduce the effect of surges likely to be produced by the voltage regulator tube 26 when the voltage of battery 19 is low. To achieve this result, the condenser 7 is connected through a rectifier 31 across the tube 26, the rectifier being

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poled so that surges from the tube 26 are isolated from condenser 7. When Geiger tube 1 is pulsing to cause thereby a drain on the power supply and a drop in its voltage during each pulse, the regulator tube will momentarily stop conducting during each pulse if the battery voltage is low and a surge will result when conduction resumes. This surge is blocked by rectifier 31 which acts as a low resistance in one direction and a high resistance in the other permitting thereby charging of condenser 7 but opposing the effect of surges. If desired, rectifier 31 may be replaced by a resistor which will permit condenser 7 to supply the peak currents while the condenser 25 need supply only an average current to the condenser 7.

Referring now to the arrangement of Fig. 2, there is disclosed therein a modification in all respects similar to that of Fig. 1 except that the primary winding 6 of transformer 5 is connected in series with condenser 15 across the tube 1, it being apparent that discharges of tube 1 will produce pulses in secondary winding 8 in a manner similar to the arrangement of Fig. 1.

The operation of the radiation meter described hereinabove will now be disclosed. Referring to Fig. 1, as soon as the battery 19 is connected in circuit as by a switch, the relay 20 commences to vibrate producing thereby intermittent high intensity flux surges in the closed core 30 of inductor 21 whenever the contacts of relay 20 open, it being apparent that the building up of the flux in core 30 is relatively slow when the contacts close. These high intensity flux surges link the turns of secondary winding 23 to produce high voltage pulses therein which are rectified by rectifier 24, the direction of winding 23 and poling of rectifier 24 being arranged to permit this. The intermittent high voltage pulses charge the condenser 25 to a voltage determined by the voltage regulator tube 26 and the loading resistor 29, such voltage being of a magnitude to produce discharge of the Geiger tube 1 in the presence of radiations. The condenser 25 gradually charges the condenser 7 through the resistance of the rectifier 31, or a resistor which may be substituted therefor as described above, the voltage of the condenser 7 remaining substantially constant by reason of the presence of the rectifier 31.

The meter is now ready for calibration, it being merely necessary to select the positions of switches 13 and 14 and set the calibration of resistors 16 or 17 depending on whether a low or a high radiation count is to be detected. Assuming that a low radiation count is to be detected, it is obvious that the instrument should have high sensitivity even at the sacrifice of good resolution. For high sensitivity, the switches 13 and 14 are thrown to the left or into the position shown in Fig. 1, in which position the condenser 15 is connected in series with a portion of resistor 16 and through its movable contact and the switch 14 to the grounded lead 18. It is thus apparent that the condenser and the upper portion of resistor 16 are connected across the anode and cathode of tube 1 and that the charge in the condenser will be discharged, when the tube 1 becomes conductive, at a rate determined by the portion of the resistor 16 in series with the condenser. It will be apparent, also, that the condenser 15 acquires its charge from the condenser 7 through the primary winding 6 and current limiting resistor 4.

With the switch 13 thrown to the left, the

rectifier 9 only is connected to the microammeter 10 and the lower portion of resistor 16 is connected across the microammeter by means of leads 18a and 18 and switches 14 and 13. It will be noted that when the adjustable tap on resistor 16 is moved downwardly to increase the amount of resistance in series with condenser 15 and thus decrease its rate of discharge and therefore the size of the pulse passing through primary winding 6, the amount of resistance introduced by resistor 16 across the microammeter 10 is reduced simultaneously to increase the shunt across the microammeter thus reducing its sensitivity. Thus, resistor 16 acts as a calibration means and it may be so adjusted when a standard source of radiations is placed adjacent Geiger tube 1 to provide any desired scale reading on microammeter 10.

The condenser 15 is a recognized means for increasing the pulse size of the Geiger tube when greater sensitivity is desired as it is obvious that it permits an enhanced discharge across the Geiger tube by reason of the charge stored in the condenser. An additional increase in sensitivity is achieved by the use of half-wave rectification in employing the rectifier 9 alone as this leads to pulse stretching in the winding 8 of transformer 5 by reason of the inductive lag in the core of the transformer when the entire pulse passing through the core is not utilized. Because of the latter means for securing greater sensitivity, the condenser 15 may be omitted.

From the foregoing, it will be understood that the meter is first calibrated against a standard source and that when the tube 1 is placed near a source of low count radiations, the pulses passing through primary winding 6 will induce pulses of a considerably higher amperage but lower voltage in the output of secondary winding 8 of transformer 5 which are rectified by rectifier 9 and integrated by condenser 11 to produce an average reading on the microammeter 10, the latter being properly calibrated to give a direct reading of the number of radiations received by the instrument.

For higher count radiations, the switches 13 and 14 are thrown to the right, thereby disconnecting condenser 15 and resistor 16 from the circuit but connecting rectifier 12 to the microammeter 10 to provide full-wave rectification of the output of transformer secondary winding 8, the calibration resistor 17 being also connected across the microammeter. The removal of the condenser 15 lowers the sensitivity of the meter but sensitivity is unnecessary when high radiation counts are to be detected. Likewise, as soon as the output of winding 8 is connected for full-wave rectification, the inductive lag in the core of transformer 5 is eliminated along with the pulse stretching produced thereby with a consequent reduction in sensitivity, now no longer necessary, but with a corresponding increase in resolution so that each pulse will produce a definite effect on the integrating condenser 11 thereby to increase the accuracy of the readings of microammeter 10. As before, the calibration of the meter is determined by a standard source, the resistor 17 being adjusted to produce a desired initial reading on the microammeter.

The operation of the modification of Fig. 2 is essentially the same as in Fig. 1. The condenser 15 is charged from the power supply through resistor 4. When Geiger tube 1 discharges by reason of radiations impinging thereon, the discharge of condenser 15 causes a high-voltage,

low-amperage pulse to pass through primary winding 6 and produces a low-voltage, high-amperage pulse in secondary winding 8 which is rectified by rectifier 9, integrated by condenser 11, and indicated by microammeter 10. As in Fig. 1, full-wave rectification may be employed for the output of secondary winding 8 and the various calibration means disclosed in Fig. 1 may be employed.

From the foregoing description, it will be apparent that a radiation meter has been provided which is simple, lightweight, and has very few parts while maintaining great efficiency and accuracy in its operation. Tests have shown that its power conversion efficiency is in the neighborhood of 40% whereas the highest previously known for this type of supply is 17%. The unit is so efficient that 70 hours of operation may be expected from one standard flashlight battery whereas heretofore twice the weight of batteries in other arrangements has given less than 8 hours of operation.

The power supply is inherently self-regulating in that when the battery voltage drops, the output high voltage does not drop in proportion as the relay 20 merely slows down but continues to produce practically the same induced voltage in the secondary winding 23 of the inductor 21, any drop in voltage being produced merely by the demands on the charge in condenser 25.

The tube 1 does not necessarily have to be a Geiger-Mueller tube as any counter tube which operates to produce small pulses may be employed in its stead. The indicating means need not be restricted to the microammeter 10 and the integrating condenser 11 as these may be replaced by other indicating or recording means satisfactory for the purpose.

Various modifications are contemplated and may obviously be resorted to by those skilled in the art without departing from the spirit and scope of the invention, as hereinafter defined by the appended claims as only preferred embodiments thereof have been disclosed.

What is claimed and desired to be secured by Letters Patent of the United States is:

1. A radiation meter comprising a gas-filled tube subject to discharge by radiations when energized, a source of electric power supply for energizing said tube, a step-down transformer having a primary winding and a secondary winding, said primary winding being connected to the source of power supply for said tube and responsive to the discharge of the latter, an indicating means connected to said secondary winding and energizable therefrom for indicating the rate of discharge of said tube, and a rectifier interposed between said secondary winding and said indicating means to supply the latter with unidirectional current.

2. A radiation meter comprising a gas-filled tube subject to discharge by radiations when energized, a source of electric power supply for energizing said tube, a step-down transformer having a primary winding and a secondary winding, said primary winding being connected to the source of power supply for said tube and responsive to the discharge of the latter, an indicating means connected to said secondary winding for indicating the rate of discharge of said tube, a rectifier interposed between said secondary winding and said indicating means to supply the latter with unidirectional current, and an integrating condenser connected across said indicating means and in series with said rectifier.

3. A radiation meter comprising a gas-filled

tube subject to discharge by radiations when energized, a source of electric power supply for energizing said tube, a step-down transformer having a primary winding and a secondary winding, said primary winding being connected in series with the source of power supply for said tube and responsive to the discharge of the latter, an indicating means connected to said secondary winding and energizable therefrom for indicating the rate of discharge of said tube, and a rectifier interposed between said secondary winding and said indicating means to supply the latter with unidirectional current.

4. A radiation meter comprising a gas-filled tube subject to discharge by radiation when energized, a source of electric power supply for energizing said tube, a step-down transformer having a primary winding and a secondary winding, said primary winding being connected to the source of power supply for said tube and responsive to the discharge of the latter, an indicating means connected to said secondary winding for indicating the rate of discharge of said tube, a rectifying arrangement interposed between said indicating means and said secondary winding for producing half-wave or full-wave rectification of the output of the secondary winding, and switching means operable for selectively connecting said indicating means to said rectifying arrangement to subject said indicating means to half-wave rectification for low rate tube pulses and to full-wave rectification for high rate tube pulses.

5. A radiation meter comprising a gas-filled tube subject to discharge by radiation when energized, a source of electric power supply for energizing said tube, a step-down transformer

having a primary winding and a secondary winding, said primary winding being connected to the source of power supply for said tube and responsive to the discharge of the latter, an indicating means connected to said secondary winding for indicating the rate of discharge of said tube, a rectifying arrangement interposed between said indicating means and said secondary winding for producing half-wave or full-wave rectification of the output of said secondary winding, switching means operable for selectively connecting said indicating means to said rectifying arrangement to subject said indicating means to half-wave rectification for low rate tube pulses and to full-wave rectification for high rate tube pulses, and an integrating condenser connected across said indicating means and in series with said rectifying arrangement.

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#### REFERENCES CITED

The following references are of record in the file of this patent:

#### UNITED STATES PATENTS

| Number    | Name         | Date          |
|-----------|--------------|---------------|
| 1,920,569 | Koros        | Aug. 1, 1933  |
| 2,026,421 | Fecker       | Dec. 31, 1935 |
| 2,225,700 | Laing        | Dec. 24, 1940 |
| 2,231,873 | Barrett      | Feb. 18, 1941 |
| 2,401,723 | Deming       | June 11, 1946 |
| 2,474,581 | Howell       | June 28, 1949 |
| 2,531,106 | Brown et al. | Nov. 21, 1950 |

#### OTHER REFERENCES

Nucleonics, Oct. 1948, pp. 52 and 55.