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COUNTING TUBE CIRCUIT

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Filed Aug. 10, 1955

2 Sheets-Sheet 1

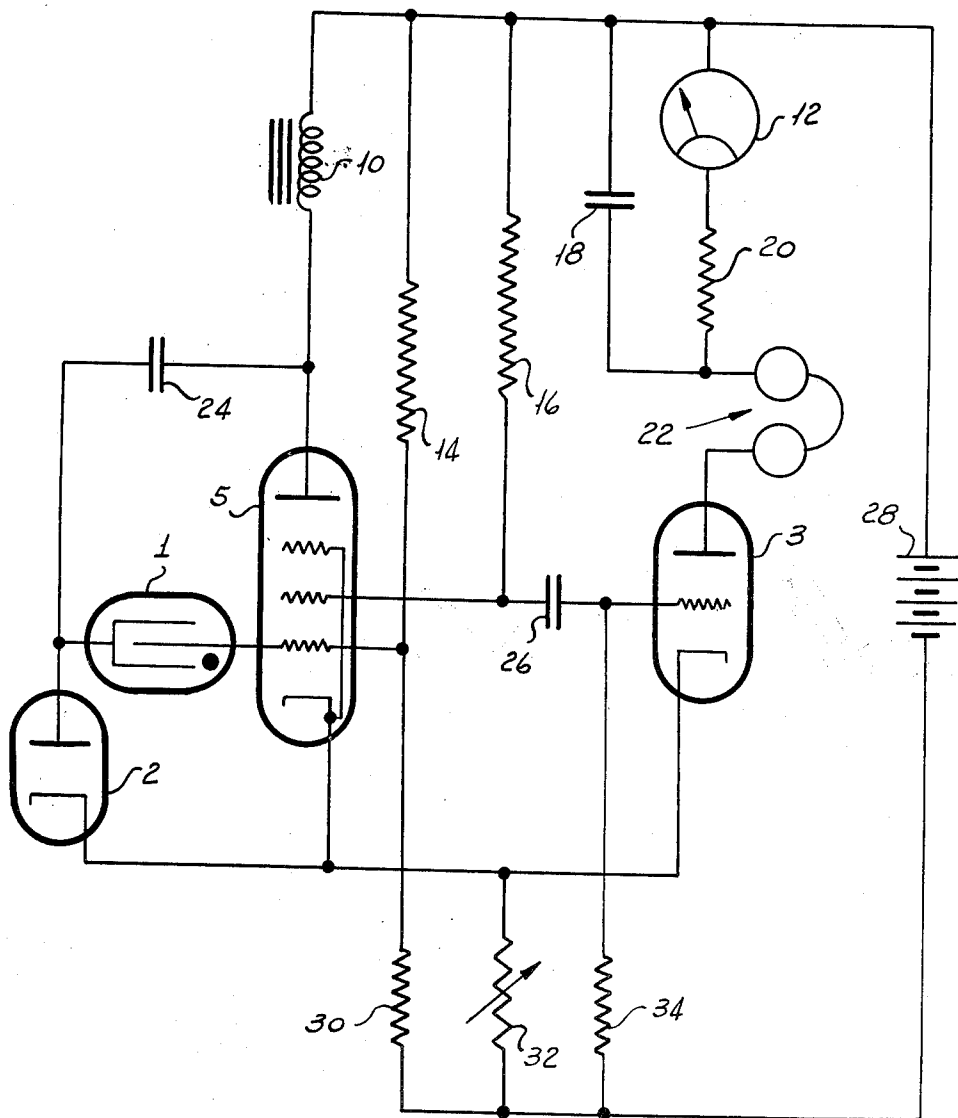


FIG 1

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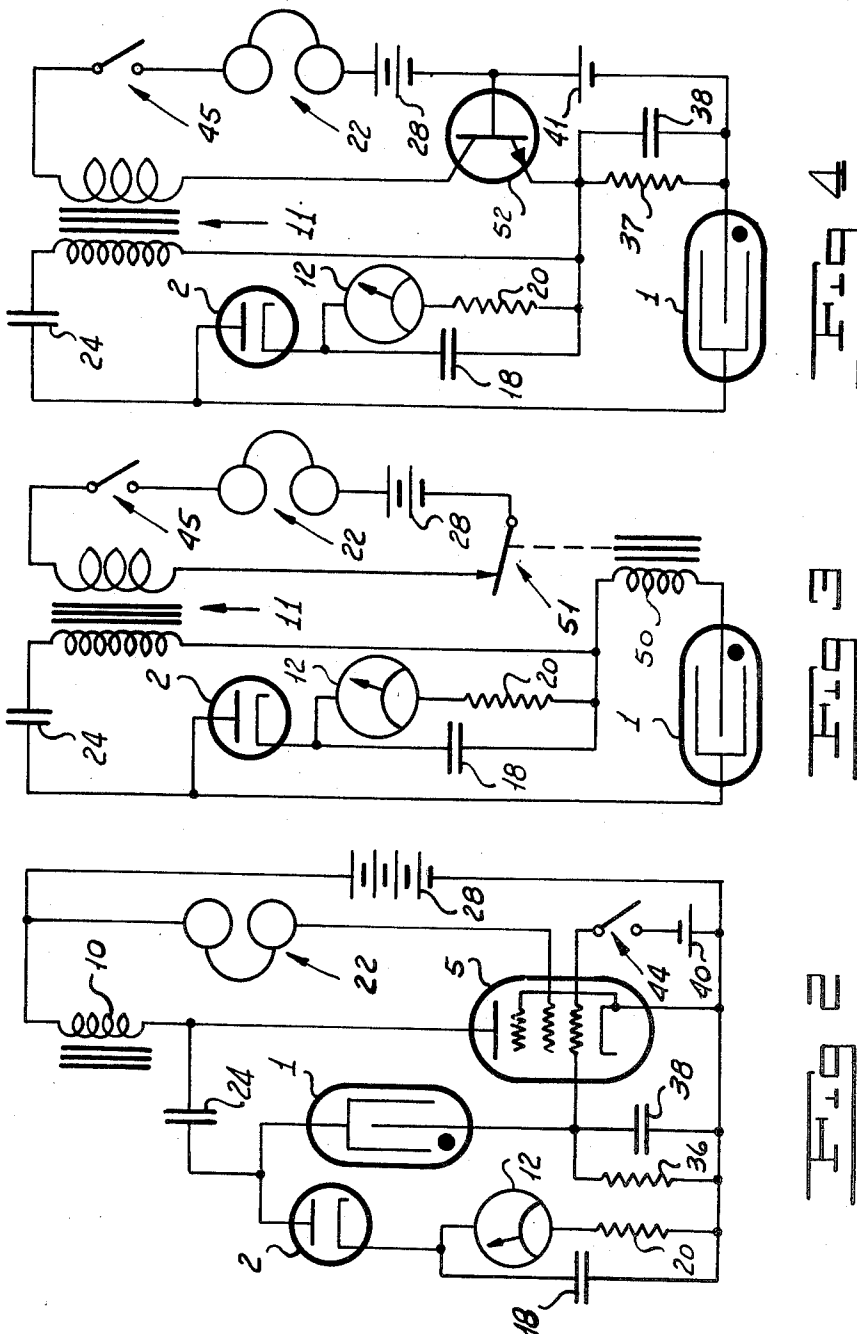
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COUNTING TUBE CIRCUIT

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8 Claims. (Cl. 250—83.6)

My invention relates to a radiation rate meter, and more particularly to a type of circuit employing a Geiger counter or Geiger-Muller tube.

The operation of a counting tube requires a high voltage energization which is not quite sufficient to cause breakdown of the contained gas. The production of this high voltage has most usually been accomplished by either high-voltage batteries or rectification of the alternating voltage produced by electro-mechanical vibrators and free-running inductance-loaded multivibrators. Unfortunately, the high-voltage battery or batteries are bulky, heavy, and expensive. The alternating-current rectification schemes require numerous components. Moreover, these schemes require extensive filtering to reduce the ripple which would otherwise cause gaseous breakdown and hence erroneous radiation rate indications. As a matter of fact, most earphone type instruments are noisy due to the hum or hiss caused by the ripple of the high-voltage supply.

One object of my invention is to provide a counting tube circuit which does not require high-voltage batteries for the tube.

Another object of my invention is to provide a counting tube circuit which does not require extensive filtering to remove alternating current ripple.

Still another object of my invention is to provide a counting tube circuit which gives an accurate radiation rate indication.

A further object of my invention is to provide a counting tube circuit which, when used with earphones, is free from high-voltage supply noise such as hum or hiss.

A still further object of my invention is to provide a counting tube circuit which both generates the high-voltage and supplies radiation rate information.

Still a further object of my invention is to provide a counting tube circuit which has few components and is inexpensively manufactured.

Other and further objects of my invention will appear from the following description.

In general my invention contemplates the interruption of current through an inductance upon the firing of a counting tube and the rectification of the resultant inductive "kick" to recharge a high-voltage storage capacitor which energizes the counting tube. Radiation rate information is supplied by either a meter or earphones or both connected integrally in the circuit.

In the accompanying drawings which form part of the instant specification and which are to be read in conjunction therewith and in which like reference numerals are used to indicate like parts in the various views:

Figure 1 is a schematic view of one form of my invention in which the interruption of current through the inductance is accomplished by a vacuum tube in a one-shot multivibrator circuit.

Figure 2 is a schematic view of another form of my invention in which the interruption of current through the inductance is accomplished by a vacuum tube.

Figure 3 is a schematic view of still another form of

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my invention in which the interruption of current is accomplished by a relay.

Figure 4 is a schematic view of a further form of my invention in which the interruption of current is accomplished by a transistor.

More particularly, referring now to Figure 1, a triode 3 and a pentode 5 are connected as a cathode coupled, one-shot multivibrator. The cathodes of triode 3 and pentode 5 are both connected to a common variable cathode resistor 32 which is returned to the negative terminal of a source of potential, such as a small plate supply battery 28. A load inductance 10 connects the plate of pentode 5 to the positive terminal of plate supply battery 28. The suppressor grid of pentode 5 is internally connected to the cathode. The screen grid is supplied by a screen resistor 16 from the positive terminal of battery 28. The potential of the control grid of pentode 5 is determined by its connection to the junction of two voltage dividing resistors 14 and 30, which serially shunt battery 28. The grid of triode 3 is connected by a grid resistor 34 to the negative terminal of battery 28, and by a coupling capacitor 26 to the screen grid of pentode 5. The plate of triode 3 is connected serially by a pair of earphones, indicated generally by the reference character 22, a filter resistor 20, and a galvanometer 12 to the positive terminal of battery 28. The meter 12 and filter resistor 20 are shunted by a smoothing capacitor 18. The plate of pentode 5 is connected by a storage capacitor 24 to the plate of a rectification diode 2. The cathode of diode 2 is returned to the cathode of pentode 5. The plate of diode 2 is connected to the control grid of pentode 5 by means of a counting tube such as a halogen Geiger tube 1.

In operation pentode 5 is normally conducting; and the current flowing therethrough establishes across cathode resistor 32 a sufficient bias to render triode 3 non-conducting and therefore inoperative. The circuit rests quiescently in this state. As a starting point assume that a high voltage exists across the Geiger tube 1 of such polarity that the plate of diode 2 is negative with respect to the control grid of pentode 5. Suppose now that the penetration of an ionizing particle or the impingement of ionizing radiation fires counting tube 1. The momentary glow discharge causes a negative pulse to appear at the control grid of pentode 5. An amplified positive pulse appears at the screen grid and is impressed by capacitor 26 upon the grid of triode 3. As soon as triode 3 reaches cut-off and begins conduction, it is operative. A closed loop is thereby completed through the cathode coupling afforded by cathode resistor 32. Since the feedback is positive and the loop gain greater than unity, the circuit is unstable and snaps into the other state in which pentode 5 is non-conducting and triode 3 is conducting. Although pentode 5 ceases conduction abruptly, the current through load inductance 10 continues to flow, but now through storage capacitor 24 and rectification diode 2. The stored energy of load inductance 10 charges storage capacitor 24 to a very high voltage. The circuit snaps back to its normal state after an interval dependent upon a time constant including screen resistor 16 and coupling capacitor 26. Diode 2 is now non-conducting and the voltage across storage capacitor 24 remains constant until another ionizing radiation triggers the circuit again. At each triggering a sound will be heard in earphone 22 when triode 3 conducts momentarily. Radiation rate information of a less subjective and more accurate nature is provided by meter 12. Filter resistor 20 and smoothing capacitor 18 average the momentary current pulses of conduction of triode 3, smoothing them to direct current, so that meter 12 does not fluctuate wildly upon each pulse. If the resistance of variable cathode resistor 32 is reduced so that the

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current through pentode 5 does not produce sufficient bias to cut-off triode 3, the circuit operates continuously as a free-running inductance-loaded multivibrator. This is one means well known to the art, and previously touched upon hereinabove, of establishing across counting tube 1 the high voltage which I assumed as a starting point for the description of the operation of my circuit.

Referring now to Figure 2, pentode 5 is supplied by battery 23 through plate load inductance 10, the screen grid is energized through earphones 22, and the control grid is returned to the cathode through a grid resistor 36 which is shunted by a filter capacitor 38. The plate of pentode 5 is connected to the plate of diode 2 through storage capacitor 24. The cathode of diode 2 is returned to the cathode of pentode 5 through galvanometer 12 and filter resistor 20 in series, which are shunted by smoothing capacitor 18. The plate of diode 2 is connected to the control grid of pentode 5 by counting tube 1. A bias battery 40 has its positive terminal connected to the cathode of pentode 5. The potential of the negative terminal of bias battery 40 may be impressed upon the control grid by a switch, indicated generally by the reference character 44.

In operation pentode 5 is normally conducting, with essentially zero bias because of grid resistor 36, through inductance 10. Assume for the moment as a starting point that a high-voltage exists across counting tube 1 of such polarity that the plate of diode 2 is negative with respect to the control grid. Suppose now that the penetration of an ionizing particle or the impingement of ionizing radiation fires counting tube 1. The momentary glow discharge causes a negative pulse to appear at the control grid. Capacitor 38 should preferably be small enough so that there is sufficient voltage to cut-off pentode 5, but this is not essential to the operation. Although the conduction of pentode 5 is reduced abruptly, the current through load inductance 10 continues to flow undiminished, but now at least partly through storage capacitor 24, rectification diode 2, and the galvanometer circuit including meter 12, filter resistor 20, and smoothing capacitor 18. Thus storage capacitor 24 is recharged. The essential feature is that the increment of charge produced by the inductive "kick" must be at least equal to the charge lost in the glow discharge of counting tube 1, so that the high-voltage will be restored to its initial value. The pulse at the control grid decays exponentially with an R-C time constant of grid resistor 36 and filter capacitor 38. In this case the pentode bias is returned gradually to zero and does not snap back to its original state as in the case of Figure 1. But it is not important that the bias of pentode 5 be increased abruptly to its original condition; it is only desirable that the R-C time constant of grid resistor 36 and filter capacitor 38 be smaller than the L-R time constant of inductance 10, since even if the bias of pentode 5 were returned abruptly to zero, the current in inductance 10 could not return immediately to its normal value but would return exponentially. Thus the circuit is conditioned for the arrival of another ionizing radiation. Upon each triggering a pulse appears at the screen grid and across the earphones 22 causing a "click" to be heard. The smoothed average value of the current pulses as read on meter 12 yields accurate radiation rate information. By closing switch 44 a negative pulse is applied to the control grid by bias battery 40. Opening and closing the switch 44 a few times will cause a large voltage to be built up on storage capacitor 24. This is one method of obtaining the high voltage assumed above as a starting point.

Referring now to Figure 3, battery 28 supplies current to the primary winding of a step-up transformer, indicated generally by the reference character 11, through earphones 22, a starting switch indicated generally by the reference character 45, and a pair of normally closed relay contacts, indicated generally by the reference character 51, of a sensitive, fast-acting relay. One terminal

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of the relay coil 50 is connected to one terminal of the high-voltage secondary winding of step-up transformer 11. The other terminal of the secondary winding of transformer 11 is connected through storage capacitor 24 to the plate of diode 2, which is returned to the other terminal of relay coil 50 through counting tube 1. The cathode of diode 2 is connected through the meter circuit, including the series combination of galvanometer 12 and resistor 20 shunted by capacitor 18, to the junction of the first terminals of relay coil 50 and the secondary winding of transformer 11.

In operation, when counting tube 1 breaks down due to an ionizing radiation the pulse of current through relay coil 50 causes relay contacts 51 to momentarily open, thereby momentarily interrupting the current in the primary winding. The inductive "kick" of the secondary winding is rectified by diode 2 to recharge storage capacitor 24. The interruption of current in the primary winding may also be accomplished by starting switch 45. By opening and closing switch 45 a few times, an initial high-voltage may be established across capacitor 24, thereby energizing counting tube 1. Upon each interruption of primary current a "click" will be heard in earphones 22.

Referring now to Figure 4, which includes an n-p-n transistor 52, transistor 52 may conveniently be a junction transistor because of its high collector resistance and sharp cut-off characteristic. The positive terminal of battery 28 is serially connected through earphones 22, starting switch 45, and the primary winding of transformer 11 to the collector of transistor 52. The base of transistor 52 is returned to the negative terminal of battery 28. The base is connected also to the positive terminal of a bias battery 41. The negative terminal of bias battery 41 is connected through a parallel combination of an emitter resistor 37 and filter capacitor 38 to the emitter of transistor 52. The secondary circuit of transformer 11 is the same as in Figure 3 except that relay coil 50 is omitted and the first terminal of the secondary winding is connected to the emitter and the counting tube is connected to the negative terminal of bias battery 41.

In operation, a large bias current flowing out of the emitter through resistor 37 causes a large current to flow in the collector circuit through the primary winding. When the counting tube breaks down due to an ionizing radiation, a pulse of current through capacitor 38 causes the emitter to become positive, thereby cutting off the collector current. The generation of the high-voltage is as described for Figure 3. The emitter voltage decreases exponentially according to the R-C time constant of emitter resistor 37 and filter capacitor 38. As in Figure 2, it is desirable that this time constant be smaller than the L-R time constant of the primary winding of transformer 11. The starting switch 45 functions as in Figure 3, and the meter and earphone connections are the same.

Figures 1 and 3 are closely analogous since a multivibrator has the on-off characteristic of relay contacts. In Figures 2 and 4, the current control elements are amplifiers which are pulsed essentially into non-conduction by the firing of the counting tube and resume full conduction gradually according to an R-C exponential return. All figures are subject to the natural limitation that the current in the inductance builds up gradually.

It will be seen that I have accomplished the objects of my invention. The largest battery required is in Figures 1 and 2, and this need be only the small B battery used in portable radios and hearing aids. In Figures 2 and 4, one or more small A batteries are all that are required. My invention has only one high-voltage filtering component; namely, the storage capacitor. Earphones used with my circuit have no extraneous hum or hiss noises, since the only sound will be a "click" when the counting

tube is fired by ionizing radiation. It will be appreciated that my circuit leads to a considerable economy in parts and produces quite a saving in components. My circuit produces high-voltage at a rate proportionate to the number of discharges per second of the counting tube, thus producing a large output signal for the earphones and the meter circuit.

It is to be understood that certain features and sub-combinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of my claims. It is further obvious that various changes may be made in details within the scope of my claims without departing from the spirit of my invention. It is, therefore, to be understood that my invention is not to be limited to the specific details shown and described.

Having thus described my invention, what I claim is:

1. A counting tube circuit including in combination inductive means, a source of current, a series circuit including said inductive means and said source and means normally completing said series circuit, a counting tube adapted to conduct in response to ionizing radiation, means including a storage capacitor for energizing the counting tube, means including a rectifier for charging the storage capacitor from the inductive means, means responsive to conduction through said counting tube for actuating said means normally completing said series circuit to interrupt said series circuit and means responsive to said actuating means for producing an output.

2. A counting tube circuit as in claim 1 in which the inductive means is an inductor.

3. A counting tube circuit as in claim 1 in which the inductive means is a transformer.

4. A counting tube circuit as in claim 1 in which said means normally completing said series circuit includes a vacuum tube.

5. A counting tube circuit as in claim 1 in which said means normally completing said series circuit includes a relay.

6. A counting tube circuit as in claim 1 in which said means normally completing said series circuit includes a transistor.

7. A counting tube circuit as in claim 1 in which said means normally completing said series circuit includes a one-shot multivibrator circuit.

8. A counting tube circuit as in claim 1 in which said inductive means is a transformer having a first winding and a second winding, said first winding comprising an element of said series circuit.

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