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OPERATION AND ADJUSTMENT OF THE PORTABLE GEIGER-MULLER COUNTER, TYPE RL202

by

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C O N T E N T S

I L L U S T R A T I O N

1. INTRODUCTION

This instrument has been designed in the Radiometric Laboratory of the Bureau of Mineral Resources, to meet the needs of those uranium prospectors who wish to build Geiger counters.

The circuit has been designed so that it can be adjusted with a minimum of test equipment.

Indication of the count rate is provided by a ratemeter with three ranges; 0 - 200, 0 - 1,000 and 0 - 10,000 counts per minute. Earphones also provide an audible indication of the count rate.

The following note describes the operation of the circuit and the procedure to be adopted to adjust the voltage at various points in the circuit for correct operation. A schematic circuit diagram is also provided and several points concerned with the mechanical design of the instrument are mentioned.

2. OPERATION OF THE CIRCUIT

The operation of the circuit can be described by reference to the schematic circuit diagram (Plate 1.)

(a) The Geiger Tube

The G10H Geiger tube shown in the circuit is a low voltage halogen-quenched tube which is sensitive to gamma radiation only. This tube operates at approximately 400 volts but any type of low voltage Geiger tube could be used in the circuit. For survey work there is no point in using a beta sensitive tube, since all the beta radiation from the surface of the ground would be absorbed before reaching the Geiger tube. Moreover, the beta-sensitive tubes are far more fragile than the thick-walled tubes, which are sensitive to gamma radiation only.

When a photon (or particle) of gamma ray energy is absorbed by the cathode (outer electrode) of the geiger tube, electrons are ejected from the cathode, the gas in the tube becomes ionised and a small current passes from the anode (centre electrode) to the cathode. The passage of this current through the 10 megohm load resistance (R6) produces a negative pulse of a few volts at the point "D", each time a gamma photon enters the geiger tube.

(b) The E.H.T. Power Supply

The high voltage supply (400 volts) for the geiger tube is called the E.H.T. supply to distinguish it from the 90-volt supply (H.T.) required to operate the ratemeter circuit.

The E.H.T. supply is obtained, in part, from the "B" battery and in part from a radio frequency supply.

The valve V_1 is operating as an R.F. oscillator, the output voltage of which is stepped up by the transformer action of the R.F. coil (L_1, L_2, L_3). The R.F. voltage appearing across L_2 is then rectified by the diode section of V_2, so as to produce a negative D.C. potential of about -300 volts at the point "C". This voltage can be varied by changing the screen resistor (R_2) in the oscillator. This negative voltage is applied to the cathode of the geiger tube, the anode being returned to the positive side of the "B" battery which is at about 105 volts above "earth" potential. The total voltage applied to the geiger tube is therefore about 405 volts.

(c) Ratemeter

The valves V_2 and V_3 make up a conventional univibrator circuit. The grid of V_3 is returned to the H.T. line through 1.5 megohms so that this valve is normally fully conducting.

The grid of V_2 is returned through a 1 megohm resistor to a bias voltage of approximately -20 volts. The grid of V_2 is also returned to +90 volts through a resistance of about 6 megohms, resulting in a voltage at the grid of about -15 volts. This valve is therefore normally cut off.

When the geiger tube is exposed to gamma radiation, a succession of negative voltage pulses occurs at the point "D".

The effect of a single pulse at the grid of V_3 is to reduce the conduction in this tube; this, in turn, raises the voltage at the grid of V_2, causing it to conduct. As V_2 begins to pass current the potential at the plate of V_2 falls, further lowering the voltage at the grid of V_3. The final result is that V_3 is rapidly cut off and V_2 becomes fully conducting. The valves remain in this state until the coupling condenser, C_2, discharges (through R_7) sufficiently to allow V_3 to start drawing current again, whereupon both valves rapidly return to their initial state. The circuit is then ready to be triggered by the next pulse from the geiger tube.

The metering circuit consists of a 0 - 50 microamp. meter (M_1), a series resistor (R_8) and a large condenser (C_3) in parallel with M_1 and R_8. This combination is placed in the plate circuit of V_2 so that current flows into the condenser C_3 each time the valve V_2 is "turned on" by a pulse from the geiger tube. The potential difference which is developed across C8 produces a current, through M_1, which is proportional to the rate at which pulses are being produced by the geiger tube. This is in turn proportional to the intensity of the radiation to which the geiger tube is exposed.

The counting range of the meter is determined by the time constant $R_7 \times C_2$. In this circuit three ranges can be selected by means of the switch S_2 which adds additional condensers in parallel with C_2. The ranges provided are 10,000, 1,000 and 200 counts per minute for full scale deflection of the meter.

The time constant of the ratemeter circuit (R8 x C3) is changed automatically with the range switch so that the accuracy is approximately 10% (in full scale deflection) on each range. This is necessary because the random nature of radioactivity causes larger fluctuations in the meter readings on the low range (low count rates) than on the higher ranges. The meter time constant is therefore largest on the lowest range - the time required for a reading to be taken being about 2 minutes.

3. CIRCUIT ADJUSTMENT

When the circuit has been wired up and carefully checked against the circuit diagram, the E.H.T., H.T. and Bias voltages must be adjusted to their correct values.

These adjustments can be made without the aid of any test equipment by following the procedure outlined below.

(i) Place all valves in their sockets (except the geiger tube) and turn S_2 to "FIL." position. The meter is now operating as a volt-meter (5 volts full scale) connected across the filament supply and should register 1.5 volts when S_1 is turned to the "ON" position.

(ii) Set R_3 to obtain maximum bias (as indicated in the circuit diagram).

(iii) Turn the switch (S_2) to "H.T." position and adjust R_1 until the meter indicates 90 volts (full scale deflection corresponds to 100 volts).

(iv) Turn S_2 to "X200" position. The meter should show no deflection or at the most 2 or 3 micro-amps. If the meter is showing a large deflection, there is some fault in the wiring or else the bias control (R_3) has not been set to obtain maximum bias.

(v) Turn S_1 to the "OFF" position, remove the shorting bar between terminals A and B and disconnect the meter M_1 from the ratemeter circuit. Connect M_1 across the terminals A and B, the + meter terminal to A and the - meter terminal to B. The meter is now operating as a voltmeter (1,000 volts full scale) and is measuring the voltage between the point "C" and earth.

(vi) Turn S_1 on again and adjust the variable condenser C_1 to obtain a maximum reading on the meter. M_1.

(vii) Adjust R_2 until the meter indicates a voltage which is 100 volts less than the operating voltage of the particular geiger tube to be used. For example if the operating voltage of the G.M. tube is 400 volts, set R_2 to obtain -300 volts at the point "C". Since the anode of the G.M. tube is returned to the point "D", which is at +100 volts approximately, there will be a total of 400 volts applied to the geiger tube when it is connected to the circuit.

(viii) Turn S_1 off and return the meter M_1 to the ratemeter circuit. Replace the shorting bar between A and B and connect the geiger tube.

(ix) Turn S_1 on and switch S_2 to "H.T." position. If necessary re-adjust the H.T. to 90 volts by means of R_1.

(x) Turn S_2 to the "X4" position and reduce the bias (by means of R3) until the ratemeter begins to count. If there is no source of radioactivity close to the tube a background count rate of about 90 counts per minute should be obtained with a G10H tube.

If the bias is reduced too much the univibrator will oscillate and a large meter deflection will be obtained on all ranges even with the geiger tube removed from the circuit.

4. MECHANICAL DESIGN

The following points should be noted in connection with the mechanical layout of the circuit.

(i) The following components should be mounted on the front panel -

(a) The meter M_1
(b) The on-off switch S_1
(c) The meter selector switch S_2
(d) The "H.T. Adjust" potentiometer, R_1
(e) The 'phone jack'.

(ii) The terminals A and B and the adjustable components C_1, R_2 and R_3 should be mounted inside the case.

(iii) The geiger tube should be mounted close to the bottom of the ratemeter.

(iv) In order to reduce eddy-current losses the R.F. coil (L_1, L_2, L_3) should be mounted as far away as possible from the sides, top and bottom of the case.

(v) This circuit has been built into a case measuring approximately 10" x 6½" x 4½". However, careful planning was required to reduce the instrument to this size, and in general a somewhat larger case is recommended.

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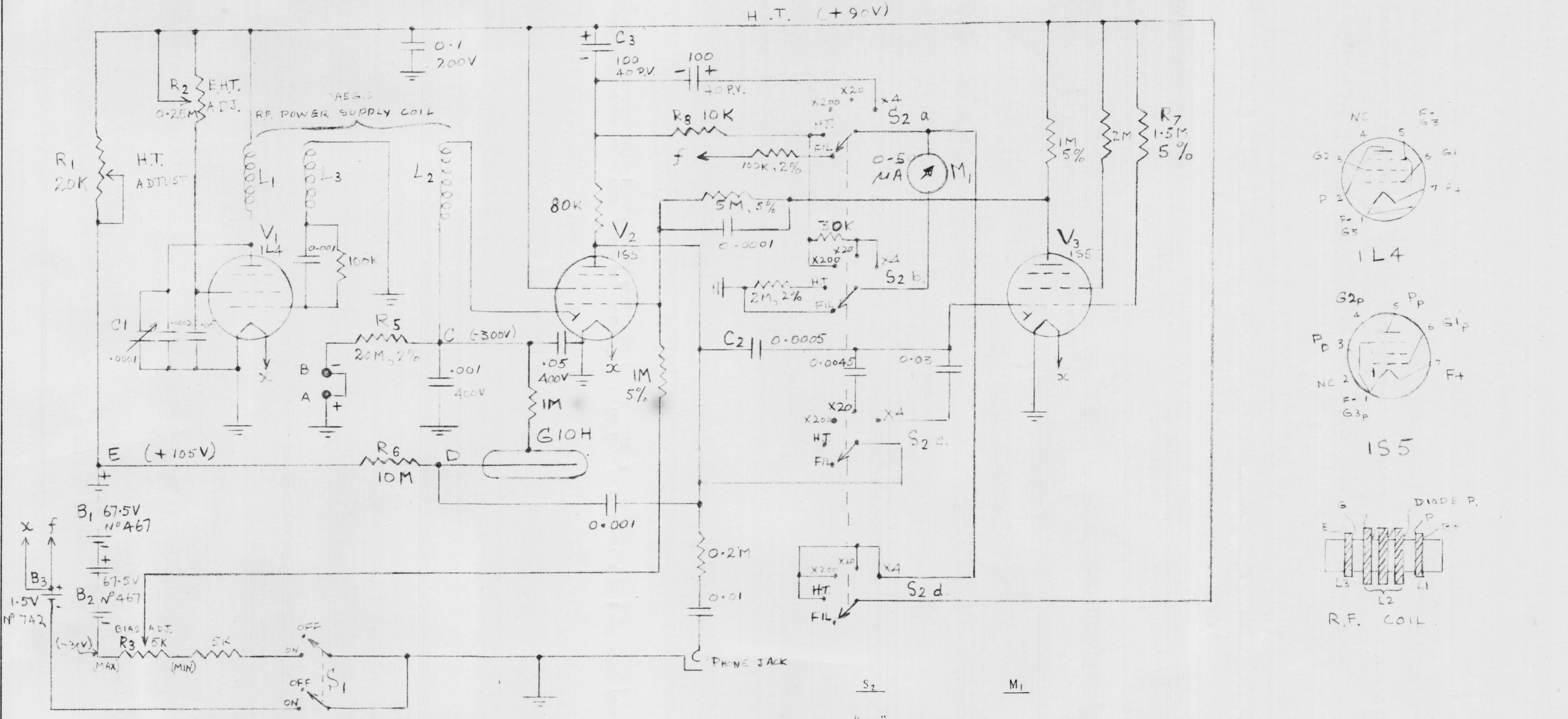

Values of all condensers given in microfarads.

All resistors are ½ watt 20% except where otherwise stated.

S2 is a 4 pole, 5 position "break before make" wafer switch

S_2	M_1
"FIL"	0 to 5 volts
"H.T"	0 " 100 "
"X200"	0 " 10,000 counts/min
"X20"	0 " 1000 " "
"X4"	0 " 200 " "

PORTABLE GEIGER-MÜLLER COUNTER TYPE RL 202

CIRCUIT DIAGRAM