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BARNABY

A Transportable Counting-Rate Meter for Gamma Measurements

Up to 200 Feet Distant by Means of a Small Probe

by

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OPERATING INSTRUCTIONS

After the equipment has been properly placed, the penlite cell (BA 58) can be slipped in the probe circuit (Figure 1). In doing this, the positive terminal goes toward the bottom of the probe. After insertion the battery might be rotated with the thumb to insure a good connection. Check the counter tube connection, insulators and thread for dirt and the probe is ready to seal. Originally, the probes had a mercury switch so that they could be stored on their side without removal of the battery; but as this made them too inconvenient to handle, it was eliminated.

At the panel, the two cords to the reel and the connections to the Esterline-Angus recording milliammeter should be checked at each end. Provided all panel knobs are turned to the left and switches off, the power cords from the storage cells can be connected to the reel (Figure 2).

The circuit is then ready to be turned on for a warm-up period of several minutes. During this or any given period of operation it is important to keep the input voltage set at 35 volts as the circuit depends upon this control for maintaining all voltages. Any change here will cause an error in the output reading.

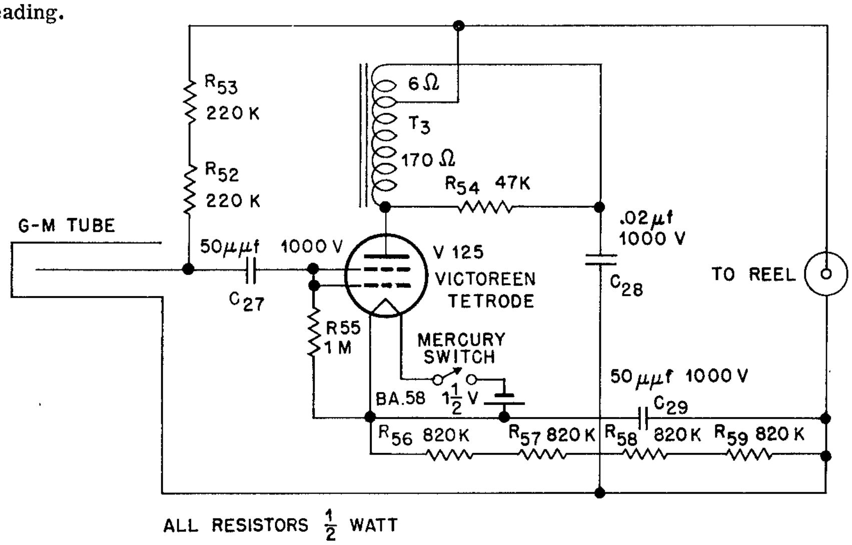

Figure 1. Circuit of the Barnaby probe.

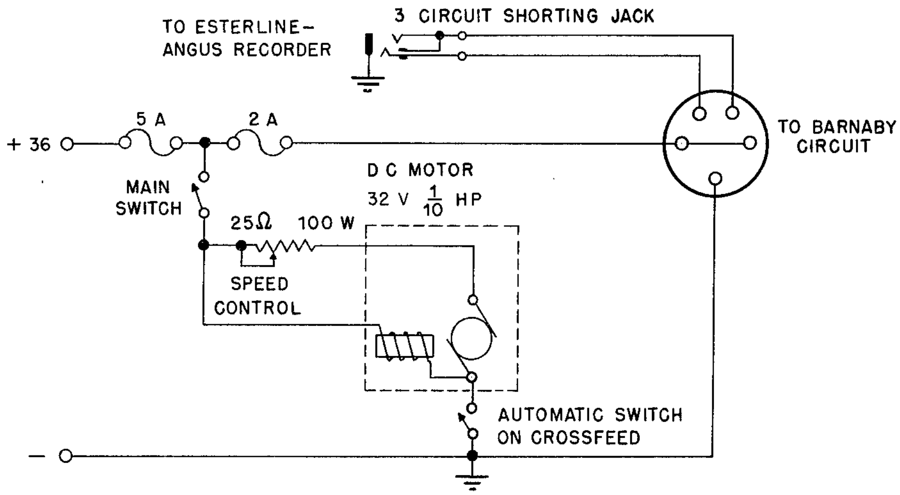

Figure 2. Circuit of the Barnaby panel.

Selection of the full scale reading of the rate meter will depend upon the intensities expected. It is best for the equipment if, as the meter goes off scale, it is switched to the next higher scale. This switch, besides changing range, doubles the time constant of the response of the two lower ranges where the statistics are the most severe.

As soon as the high voltage is turned on, it should be set promptly to the correct voltage. If that voltage has not been established, one will have to determine the threshold of the counter by slowly increasing the high voltage until the lowest voltage at which pulses are heard is determined. For the large (6 and $9\frac{1}{2}$ inch) tubes, a regular operating voltage should be chosen of about 40 volts above this apparent threshold. As the small tubes have a very short plateau an additional 20 volts is sufficient. Due to the nature of the circuit, this apparent threshold approximates the bottom of the plateau. Damage to the tube as well as spurious data will result from an over-voltage on the tubes.

The switch on the side of the panel controls additional capacity across the output. Selection of capacity depends upon the combination of the speed of response required against the statistics in the output that can be tolerated. Although increased capacity lengthens the time constant and thereby diminishes the effects of statistics, it may be so long as to miss small but important changes of intensity unless the probe travels very slow. Because of this slow response, the full capacity is generally inadvisable.

The procedure for turning off the equipment is unimportant as long as the probe isn't opened with the high voltage on.

SERVICE NOTES

The most probable sources of failure are the pilot bulbs. As they are an integral part of the circuit, their absence will cause a change of B and high voltages. The lamp used is the 2.5 volt, 0.5 ampere, No. 41 bulb. Replacement is facilitated by a small piece of rubber tubing.

Shorting of the high voltage will probably occur only in the external circuit; in which event it can be traced out with an ohmmeter. Should the circuit be in apparent order but no pulses received, there may be an open circuit to the probe. The most conclusive test for the line and the probes is a current measurement. Disconnect the line at the panel, use a ground jumper, put a 1 ma meter in series with the center-wire, and proceed to operate as normal. As the meter is at a high potential, it should be properly insulated. The normal current should be near 300 microamperes.

In case of failure in the panel circuit, the lower half (power supply) should be checked first. If the high voltage reads correctly on the meter, there is no trouble in the high voltage section. Should it be somewhat low the 2X2 or the 6SF5 may need replacement. Should it be quite low and the action of the voltage control reduced, the General Electric No. 991 neon bulb may be bad. A quick check of the filaments should be made. If the 2X2 and 6SF5 are not lighted, the vibrator may be out of order. However, if the VR-150 is glowing, the B supply is correct and any further trouble is most likely in the upper portion of the panel.

When examining the counting-rate meter circuit, the cover should be placed on the lower half to eliminate interference from the power supply. With an oscilloscope (use shielded leads) the pulse from the probe can be checked from the input to the output to determine the point of failure. The first point to check is the green wire from the small transformer in the iron shield. If there, it can be traced to the plate (lug No. 5) of V.T.1, V.T.2, and the screen (lug No. 6) of V.T.3. The pulse is very sharp and will be rather hard to see, but this is still the easiest means of determining if any of the tubes are not operating correctly.

If a good pulse is present at the screen of V.T.3 but the output meter does not read, then V.T.5 should be checked for a short between cathode and ground, and continuity between the plate of V.T.4 and B + should be checked. Normal resistance is less than 6000 ohms. Should the connections to the Esterline-Angus be found open, any one or two of C_{11}, C_{12}, C_{13}, C_{14}, or C_{15} may be ruined and all should be tested with an ammeter. The connection to the Esterline-Angus should be left open for this test. Their internal resistance for correct polarity should be over 30,000 ohms.

Should the unit still fail to operate, a more complete check of voltages and resistors will be necessary as per the circuit diagram (Figure 3). Should the output meter not read zero on the "Warm Up" position when V.T.4 is replaced, the bias on that tube will have to be adjusted to cut-off by changing R_{32}, a small "Dividohm" near that tube. This will also change calibration slightly and this should be corrected by the calibration adjustment control and whatever means of field calibration is used.

For laboratory calibration of the four ranges in multiples of ten, an accurate pulse source for these rates is necessary. Originally, a Hewlett-Packard oscillator and a scale of sixty pulse forming circuit was used. The pulse can be applied to the probe input or the grid V.T.1. Any adjustments are made with the four potentiometers near 6AK5.

Table 1. Error introduced by counting-rate meter dead time.

Average Readings		Per cent
Barnaby	Scaler	Error
42	47	11
62	72	14
530	595	11
767	876	12
850	977	13
8280	9180	10
9500	10,637	11
14,000	14,387	3
22,100	23,600	6
51,000	5,400	6

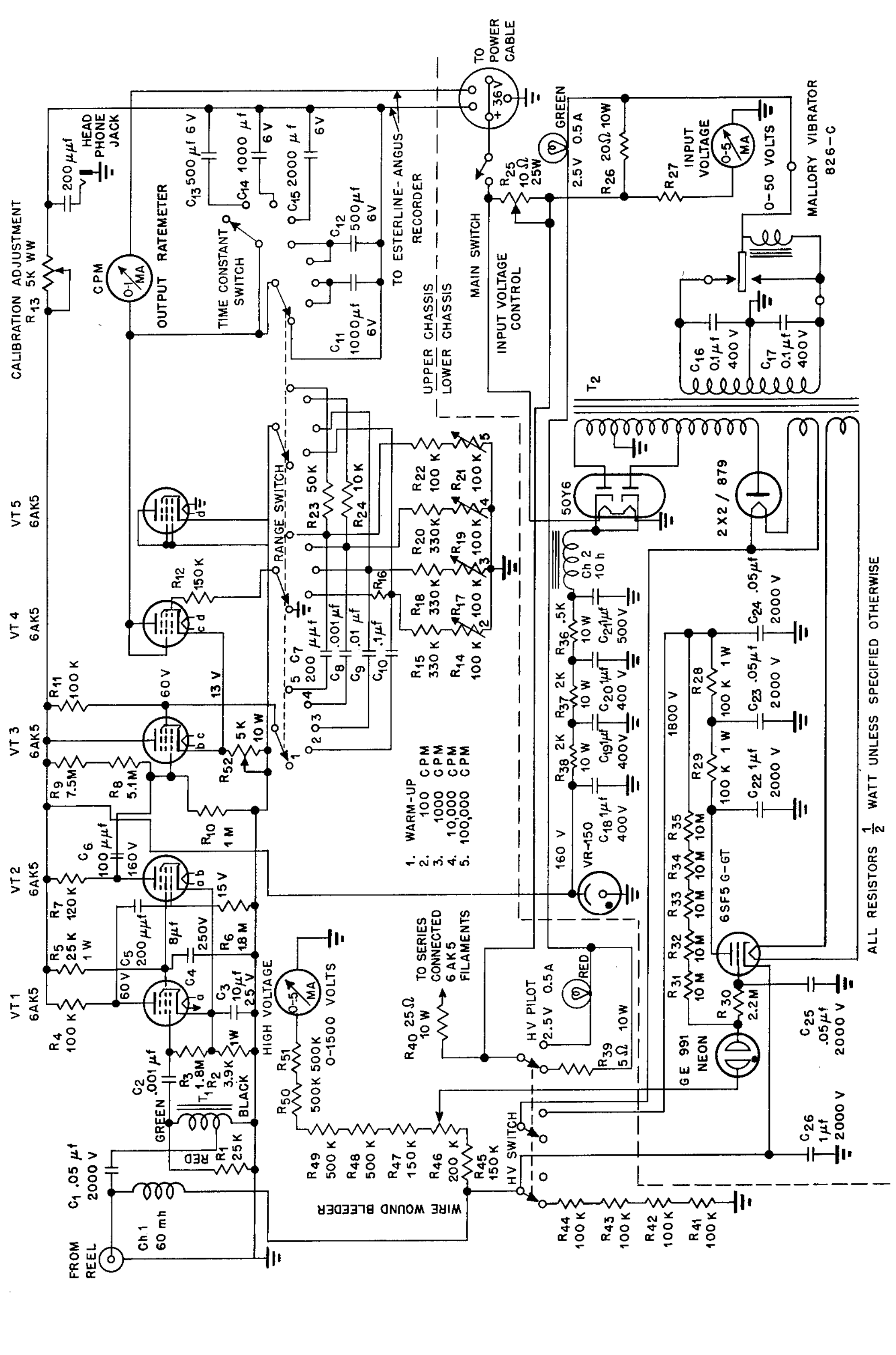

Figure 3. Complete circuit of the Barnaby.

The dead time of the trigger pair in Barnaby is the duration of the formed pulse plus a recharge time of the coupling circuit. This recharge time is minimized by V.T.5, but the pulse time is rather long except scale 4 (0 to 100,000) where it is less than the width of the counter pulse. However, with the recharge time it is still slightly longer as indicated by the decreased percentage error remaining.

SPECIAL PARTS

T_1, T_3 — Auto transformers wound on Hypersil cores (P9760, Utah Transformer Company, Chicago). The winding is insulated from the core and consists of 6 ohms of No. 38 enameled wire and a tap followed by 160 to 180 ohms of No. 40 enameled wire. T_3 has flexible leads and T_1 is set in plastic in an iron shield.

T_2 — A Stancor P9791 that has been disassembled and had the filament windings removed and replaced by 8 turns No. 18 wire for the 2X2 and 19 turns No. 20 wire for the 6SF5. These new windings and leads were insulated for high voltage. In addition, the approximate center of the primary was tapped and each side of the winding pulled out until it was 0.75 ohm. Care must be taken to see that the inner wire of the high voltage winding is connected to the outer wire of the "B" winding.

C_{27}, C_{29} — Centralab ceramic capacitors.

C_3, C_4, C_{11}, C_{12}, C_{14}, C_{15} — Cornell-Dubilier Electrolytics. All other capacitors have paper or mica dielectric.

R_{27} — Wire wound resistor near 9700 ohms. Adjust so that input voltage is at red line when potential measured is 32 volts.