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STABILIZATION OF PHOTOMULTIPLIER TUBES

by

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Using a circuit suggested by G. A. Morton[1] two methods for stabilizing output pulses from electrostatically focused photomultiplier tubes against supply voltage fluctuations have been investigated. Both are useful with such multipliers as the RCA 5819 and the RCA C7151. The same stabilizing circuit is used in each method, the difference resulting from the point in the dynode system at which the circuit is introduced.

The first method[1], illustrated in Fig. 1, consists of fixing the potential of an interior dynode of an RCA 5819 multiplier (e.g., dynode No. 7 in Fig. 1) with respect to the potential of the preceding dynode by means of a battery. The battery voltage V necessary for stabilization depends somewhat on the properties of the individual multiplier. Battery voltages of 90-135 volts were found to be satisfactory. A variable resistor R connects the two dynodes on either side of the interior dynode. The value of R required for stabilization can be set as follows. When R is varied for a convenient, fixed supply voltage (800 to 1100 volts) the output pulse height from the multiplier varies as shown in Fig. 2 (supply voltage 1100 volts, V = 90 volts). By observing the output pulses on an oscilloscope R may easily be set at R_A corresponding to the half maximum point A. The output pulse is then unchanged for comparatively large changes in the supply voltage. A typical stabilization curve is shown in Fig. 3.

The width of the plateau and its starting voltage depend only slightly on the value of R_A. Curves such as that shown in Fig. 2 will depend on the initial voltage used; R_A varied from 5.2 to 4.5 Meg in going from a voltage of 800 volts to 1100 volts. However, there was no important change in the final stabilization characteristics (Fig. 3) and therefore the value of R used for stabilization is not critical. Stabilization occurs only for high supply voltages (above 1100 volts in the 5819 multiplier used here). The plateau is broad and flat, 200 to 300 volts wide in this study. The normal gain of the multiplier is reduced by a factor of about 1/5 by the stabilizing circuit when operating near the beginning of the plateau. The statistical distribution in output pulses from a scintillation crystal is unaffected.

A second method for stabilization, shown schematically in Fig. 4 for the RCA 5819, was investigated in which the potential of an exterior dynode (e.g., dynode No. 6 in Fig. 4) is fixed with respect to the potential of the preceding dynode. As in the first method, the battery voltage V most suitable for stabilization depends on the individual multiplier. Battery voltages of 50 to 100 volts were most satisfactory in this investigation. The variable resistance R is set as follows. First the supply voltage is set approximately at the desired operating level. The variation in output pulse height with R is shown in Fig. 5. R can easily be set at R_B corresponding to the point B by observing the output pulses on an oscilloscope. For this value of R, pulses are stable for changes in the supply voltage. Satisfactory stabilization at point A, as in the first method, is not obtained with this set of dynodes.

When the multiplier is stabilized at B the voltage between dynodes 6 and 7 is about 10 volts, independent of the battery voltage V and the supply voltage. Typical stabilization curves are shown in Fig. 6. For large battery voltages the stabilization curve has a characteristic maximum and minimum. As the battery voltage is decreased a flat plateau is formed which disappears as V is lowered still further. The width of the stable region varies from multiplier to multiplier and is affected by both the battery voltage and the supply voltage. Stabilization was obtained (using the above procedure for finding R_B) for supply voltages as low as 600 volts, where the stable region was about 30 volts wide, and for supply voltages up to 1500 volts where the stable region was about 200 volts wide. The normal gain of the multiplier is reduced by a factor of 1/5 to 1/10 by the stabilizing circuit. Like the first method, this stabilization does not affect the pulse height distribution.

Both of these methods have the advantages of excellent stabilization and simple non-critical circuit adjustments. The stabilized multipliers are no more affected by external magnetic fields than ordinary multipliers. Both methods, however, produce a considerable loss in multiplication as compared to unstabilized operation with the same overall voltages. The first method is especially advantageous where a broad plateau at fairly high supply voltage is desired. The second method is most useful where stabilization over a wide range of supply voltages is desired, or when it is desirable to vary the gain of the multiplier. In the latter case R is readjusted for the new operating point.

While the tubes described here refer to the RCA 5819 and the RCA C7151, it is likely that similar behaviour will be found for the 931A, 1P21 and 1P28 multipliers. The dynodes are numbered differently for the latter tubes (7 is an inside dynode in the 5819, while 6 and 8 are inside dynodes in the 931A). In employing either method the proper dynodes must be used. The difference in operation of the two methods described depends on the peculiar focusing properties of the dynode structure. We have used the second type of stabilization for about a year and found it to be dependable. Since no current is drawn from the batteries, it has not been necessary to replace them. We are indebted to Dr. G. A. Morton for stimulating discussions of these experiments.

This work was supported by the Atomic Energy Commission and the Higgins Scientific Trust Fund.

1. Morton, G. A., RCA Review 10, 525 (1949).

TITLES FOR FIGURES

Fig. 1 Stabilizing circuit for interior dynode.

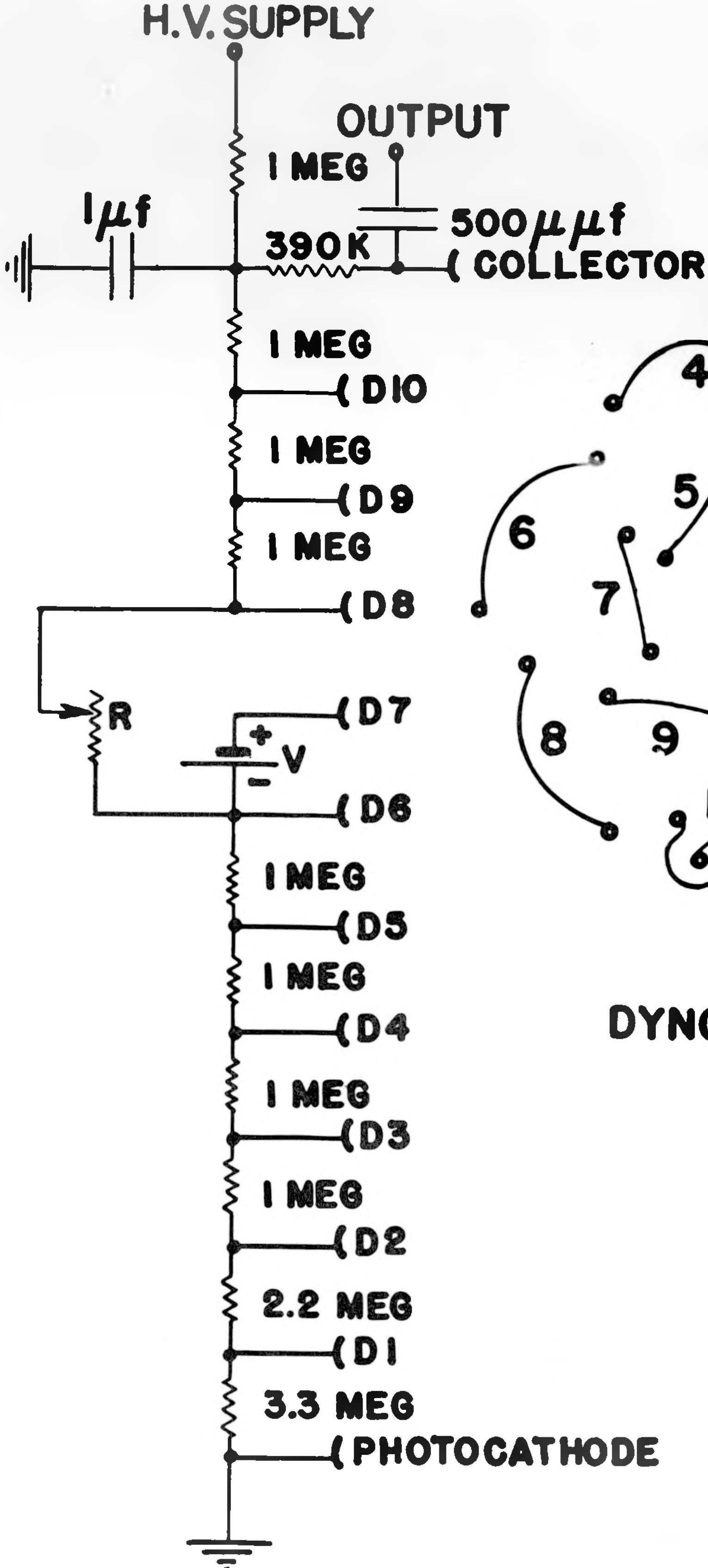
Fig. 2 Resistance characteristic of stabilizing circuit (first type).

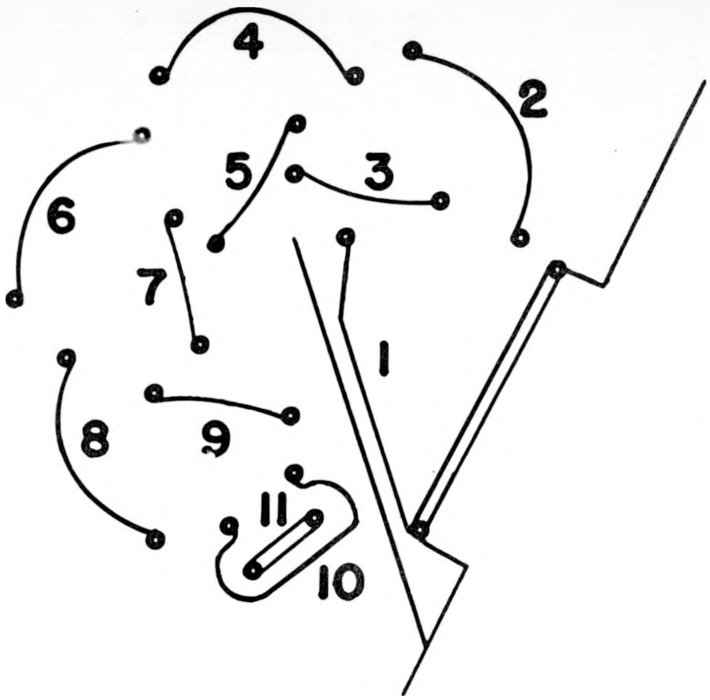
Fig. 3 Stabilization curve (first type).

Fig. 4 Stabilizing circuit for exterior dynode.

Fig. 5 Resistance characteristic for stabilizing circuit (second type).

Fig. 6 Stabilization curve (second type).





DYNODE STRUCTURE
RCA 5819

Fig. 1

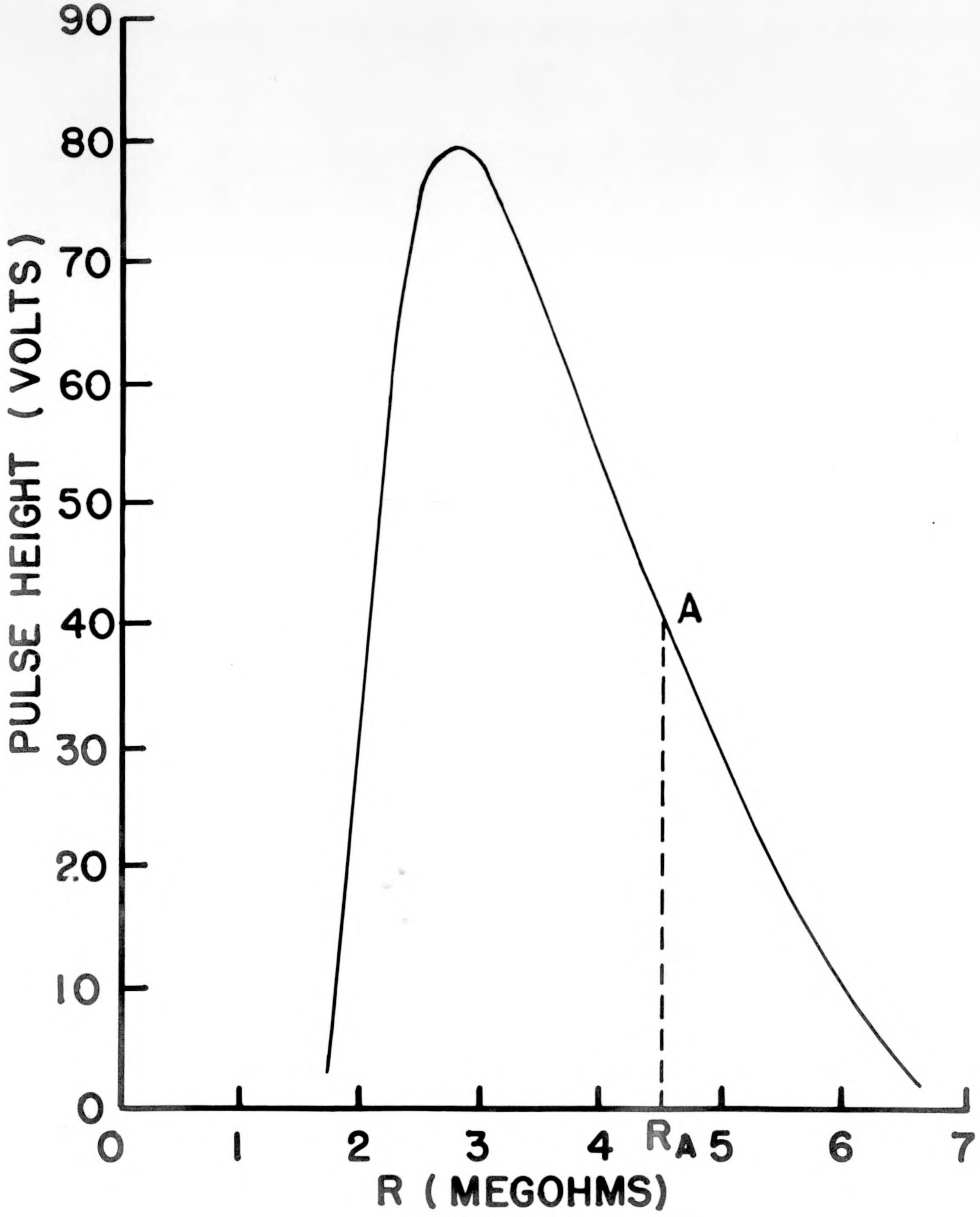

90
80
70
60
50
40
30
20
10
0
PULSE HEIGHT (VOLTS)
A
0
1
2
3
4
R_A
5
6
7
R (MEGOHMS)

Fig. 2

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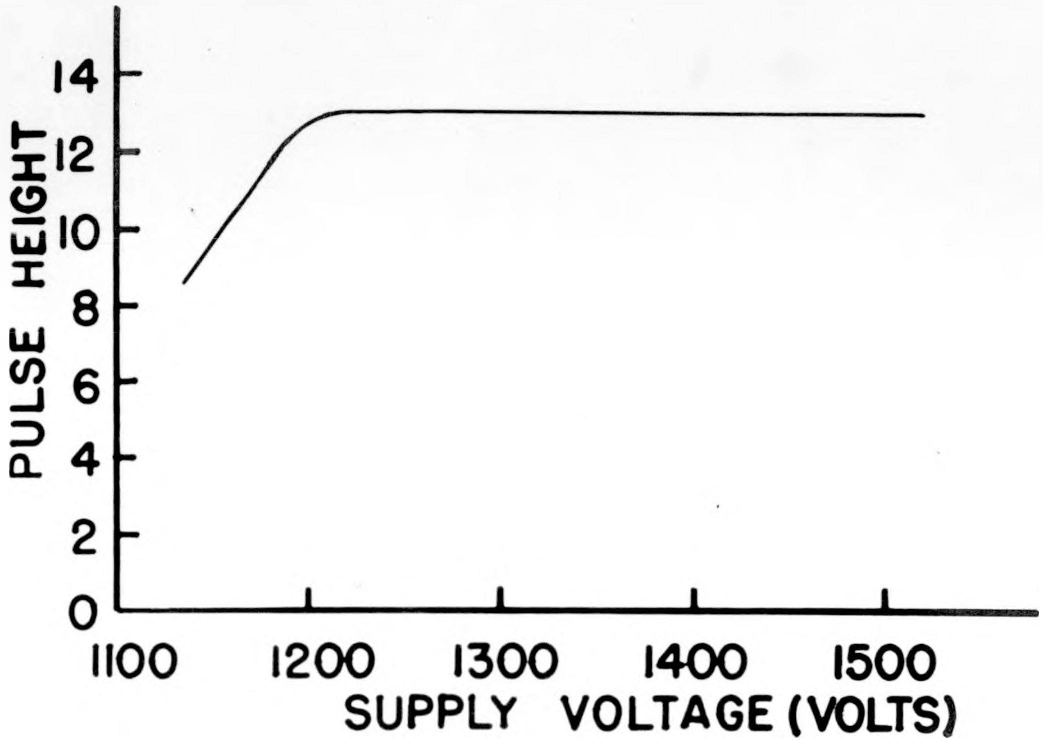
PULSE HEIGHT
14
12
10
8
6
4
2
0
1100
1200
1300
1400
1500
SUPPLY VOLTAGE (VOLTS)

Fig. 3

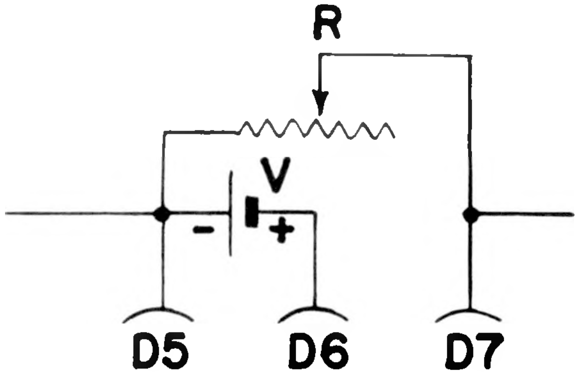
R
V
-
+
D5
D6
D7

Fig. 4

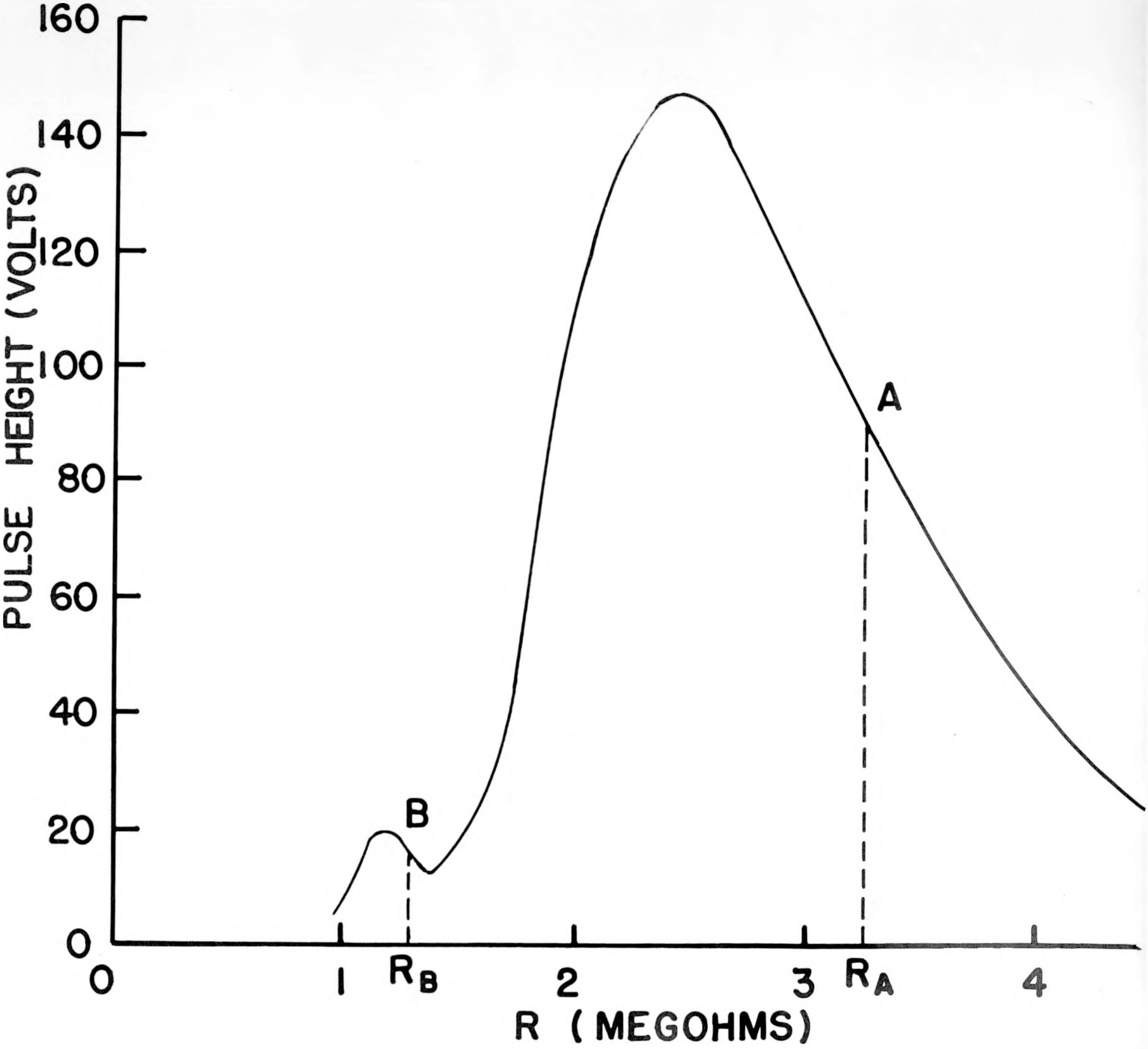
160
140
120
100
80
60
40
20
0
PULSE HEIGHT (VOLTS)
A
B
0
1
R_B
2
3
R_A
4
R (MEGOHMS)

Fig. 5

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10

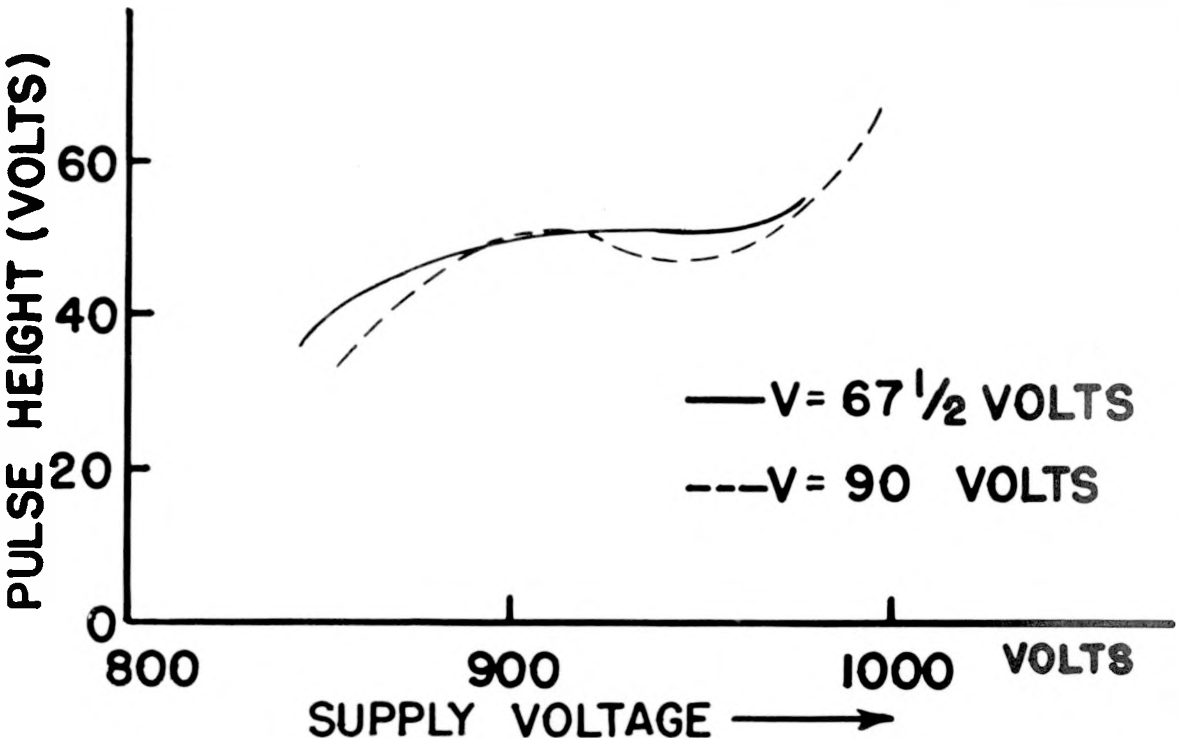

Fig. 6

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