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GERMAN COLD CATHODE TUBES

SIEMENS REINIGER WERKE, RUDOLSTADT

COMBINED INTELLIGENCE OBJECTIVES

SUB-COMMITTEE

LONDON - H.M. STATIONERY OFFICE

GERMAN COLD CATHODE TUBES

SIEMENS REINIGER WERKE, RUDOLSTADT

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PHYSICAL and OPTICAL INSTRUMENTS and DEVICES

COMBINED INTELLIGENCE OBJECTIVES SUB-COMMITTEE
G-2 Division, SHAEF (Rear), APO 413

CONTENTS

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Investigation of Cold-Cathode Tubes made by Siemens Reiniger Werke, Rudolstadt

1. Persons Interrogated

(a) Employees of Siemens Reiniger Werke, Rudolstadt

JACOBI - Director of development of electronic tubes (except x-ray tubes).

THALER - Production engineer for cold-cathode tubes.

HARMSEN - Head of research on cold-cathode tubes (from Siemens-Halske, Berlin).

(b) Employees of Flugfunkforschungs Institut, (Nr. Munich)

WICHMAN - Research engineer.

LUDER - Research engineer.

(c) RUHLEMANN - Director of Rheinmetall-Borsig.

As far as could be ascertained, Siemens Reiniger were the only manufacturers of potassium activated cold-cathode tubes in Germany. Rheinmetall used these tubes in the manufacture of flare fuzes, experimental time fuzes for shells and experimental influence (proximity) fuzes for shells and bombs. F.F.O. (Graefelfing) assisted in the development of suitable circuits for the Rheinmetall fuzes.

2. General Note

JACOBI appeared to have very little knowledge of the details of design or production of cold-cathode tubes, and the information obtained from him was of little value and in some respects unreliable when checked against the information obtained from those more concerned with the details.

THALER supplied useful information on the production details.

HARMSEN as the designer of the later types of cold-cathode tubes supplied useful information on the theory of operation, particularly for the new tetrode. His theory and claims for the tetrode are plausible but require experimental checking before they can be accepted.

LUDER was largely concerned with the measurement of the characteristics of the tetrode, and he appeared to be of the opinion that the tetrode is undoubtedly a better tube than the triode, but does not work exactly in accordance with HARMSEN'S theories, and is capable of further development.

WICHMAN claimed to have developed a circuit incorporating two diodes which is more reliable than the tetrode, and just as sensitive. He also claimed that Rheinmetal proposed to use the two-diode circuit for the Influence Fuze. This claim was denied by RUHLEMANN who stated that the triode had been used in large numbers in the development of the Influence Fuze and that it was about to be superseded by the Tetrode when Germany collapsed. The two-diode circuit had only been tried as a laboratory hook-up and had never been used in a fuze. LUDER did not believe the two-diode circuit to be practicable. The most likely explanation of these conflicting statements is that WICHMAN had suggested the two-diode circuit and probably tested it in the laboratory with a small number of different diodes, but that he had no knowledge of what Rheinmetall were using or proposed to use. It is also quite likely that he did not test enough diodes to be sure that his circuit was a practical proposition.

RUHLEMANN appeared to have a good working knowledge of the use and behaviour of the cold-cathode tubes in the Rheinmetall fuzes and supplied useful information on the users reaction to these tubes.

A report on the information obtained is given in detail below. The theories of operation of the tetrode and the two-diode circuit are given as supplied by HARMSEN, LUDER and WICHMAN, but cannot be accepted until they have been tested experimentally. For this reason the characteristics claimed must also be proved by tests before they can be accepted.

Manufacturing details will be given in a second report which will be issued in the near future.

Technical Details

The basis of all the cold-cathode tubes dealt with in this report is a metal (usually nickel-plated iron) cathode coated with a comparatively thick layer of pure potassium and other metal electrodes (not potassium coated) designed in accordance with the function of the tube, sealed into a glass envelope which is filled with pure Argon at a pressure determined by the electrical characteristics required. Such tubes with potassium activated cathodes are found to have very constant and reproducible electrical characteristics provided suitable precautions are taken during manufacture to ensure absolute freedom from organic impurities on the electrodes and the interior of the envelope, a high standard of purity of the potassium layer and freedom from gas impurities in the Argon filling (Note:- Diodes and triodes with potassium activated cathodes have been developed and made on a fairly large scale in England since 1942 by Ferranti Ltd., to meet M.O.S. requirements, and similar properties of constancy and reproducibility have been obtained.)

(a) Diode. The Siemens diode is shown in Fig.1., and consists of two similar metal electrodes each supported by three wires fuzed into a glass bead and mounted one at each end of the tubular glass envelope. One electrode is coated with a bright mirror of potassium and serves as the cathode, the other electrode (anode) is not purposely coated with potassium, but is nevertheless unavoidably contaminated by small traces of potassium. The outside of the envelope is painted with a conducting film of colloidal graphite leaving two windows for examination of the cathode and a space round the anode wire for insulation purposes. This film is connected to the cathode and acts as an electrostatic screen. The whole tube is coated with a nitrocellulose lacquer to prevent electrical leakage under moist conditions. This lacquer is coloured with dye, a different colour being used for each type of tube. Each tube has a serial number stamped on a metal label attached to one of the leads and the relevant details of each tube are recorded.

The two controllable factors which determine the striking voltage of the diode are the electrode spacing and the gas pressure. The accuracy of electrode spacing depends on the skill of the glassblower during assembly and spacing inaccuracies are corrected as far as possible by adjusting the gas-filling pressure during processing. This means that the striking voltage of each individual tube must be measured before sealing off from the processing pump. When these precautions are taken the practical range of striking voltage within which the tubes can be manufactured with reasonable efficiency is 160 $\pm$ 4 volts. A stability of $\pm$ 1 volt from the original striking voltage value is claimed for each tube on standing idle for periods up to 3 years. It is also claimed that only 20% of the tubes tested wandered more than $\pm$ 1 volt in 5 years. The tubes were tested every 6 months with a rate of rise of anode voltage of 6 volts per second for each test. Some tubes had wandered more than $\pm$ 1 volt on some intermediate tests but had returned within the $\pm$ 1 volt limits at the end of the

5 year period, these were attributed to delayed strikes (see below) and were counted as good tubes. (N.B. Total rejects including those which had wandered more than ± 1 volt at any test during the 5 year period is estimated at 35%). A rough idea of the distribution of striking voltages at the end of the 5 year period is given in Fig.2.

If diodes are stored in darkness and tested in darkness with a rate of rise of anode voltage of 6 volts per second it is found that their measured striking voltages are higher than the true values due to appreciable delays in firing (see Fig.3).

The delay is attributed to lack of ions or electrons to start the discharge and is not observed if the tubes are illuminated during test. As the tubes are used in darkness a more practicable cure is to introduce Radium, and it was found that a coating of 10^{-8} gm. of Radium on the anode reduced the delay almost to zero (see Fig.3). Owing to the difficulties involved in introducing Radium into tubes under production conditions a compromise measure was introduced which consisted in painting Radium-activated luminous paint on the outside of the envelope in a narrow strip stretching from anode to cathode. This resulted in a partial reduction in delay, and although it was not as effective as Ra inside the tube, it was adopted as a standard method. (See Fig.3). (Note:- Radium applied internally has been successfully used in England for curing delays in striking, but the theory that the delay is due to lack of ions or electrons for initiating the discharge does not explain why the delay does not appear until tubes have been stored for several hours in darkness after their previous strike, or why some tubes do not show the delay at all). HARMSEN explained these effects by suggesting that in the first case insulating particles on the cathode surface will stay charged for long periods and produce a few electrons by auto-electronic emission, and that in the second case there is a high-resistance film of potassium on the internal glass wall which is connected to the cathode and passes near the anode, allowing a very small current discharge to pass between anode and film at a lower voltage than the true striking voltage of the tube, thus providing the ions when they are needed. As supporting evidence, HARMSEN claimed that a single wire anode was found not to be very satisfactory for diodes because it did not approach close enough to the wall to allow this small discharge to take place.

General Notes on the Diode

Although nickel-plated iron was used on production for the cathode base metal and the anode, HARMSEN considered chrome-iron alloy to be a better material to use, but had not been able to persuade the production people to adopt it.

The standard diode in an 11mm diameter envelope suffers some inaccuracies in striking voltage due to wall charges and a better tube can be made by using a 16mm diameter envelope and introducing 10^{-8} gm. of Radium internally (1000 a- particles per sec).

300 such tubes were made in the laboratory and gave a constancy of $\pm$ 0.15 volt over a period of 1 year after allowing an initial period of 2-3 weeks for the tubes to settle down. This tube was not put into production owing to the objections raised by the factory to putting Radium inside each tube.

A tube with diode characteristics and not requiring Radium can be made by introducing a third electrode T near the cathode and connecting it to the anode through a high resistance (see Fig.4).

The breakdown from T to C occurs at a lower voltage than the main gap and the small current flow supplies enough ions to eliminate delays in the main gap breakdown.

Gas Filling

Pure argon is used at a pressure of about 12 mm of mercury. Argon was chosen because its highest metastable energy is only 11 e.v. which is not high enough to ionise any likely impurities except mercury (which is easily eliminated by the use of a liquid air trap). On the other hand, the metastable energies are 21 e.v. for Helium and 16 e.v. for Neon, which are high enough to ionise hydrogen and other likely impurities. For this reason Argon is less affected by small traces of impurities than are Helium or Neon. On this argument, Krypton and Xenon should be better than Argon, but in fact this is not the case, possibly due to the difficulties of purifying these gases ready for use.

Mixtures, such as Neon and Argon were not used because they give lower striking voltages and smaller differences between striking and running voltages, thus introducing difficulties in obtaining the necessary arc discharge in operation.

Early work on the diode was started in 1932 by Dr. Vatter. Vatter

The temperature coefficient of the diode is -0.01V per .°c., due mainly to reduction in gas pressure by expansion of the envelope, and to some extent by elongation of the electrodes and supports.

Diodes are used mainly for time fuzes, and two simple circuits for this purpose are shown in Fig.5, (a) and (b). For a shell fuze travelling at 800 metres per sec., an accuracy of 20 metres is required, calling for a timing accuracy of .025 sec. For a rate of rise ✓

of voltage of 6 volts per sec. on the diode, this requires an accuracy of ± 0.15 volt in striking voltage. For this purpose the diodes must also withstand accelerations up to 25,000 g.

25.000 g !

(b) Triode

The three electrode tube is similar to the diode, but with the addition of a third electrode in the form of a straight wire projecting through a hole in the anode cup (see Fig.6). The functions of wire and cup as anode and grid can be reversed, depending on the applications.

The cathode activation and gas filling are similar to the diode.

The control curve for the triode is shown in Fig.7.

The initiation of main discharge is different in each of the four regions (a), (b), (c) and (d), and is as follows:-

(a) Anode - grid.

(b) Anode-cathode (independent of grid voltage).

(c) Grid-cathode (independent of anode voltage).

(d) Grid-anode.

In each case the initiation results in main gap breakdown (anode-cathode). At point X the initiation causes main gap breakdown at 10^{-7} amp and at point Y at 10^{-11} amp. In practice these sensitive points cannot be used because of instability. Region (c) is the most satisfactory to use because it is stable and reproducible. The initiating current rises on moving along (c) from Y to Z.

Two alternative circuits for the triode are shown in (a) and (b) Fig.8.

In both cases C_1 is the main reservoir condenser supplying the anode voltage, and the triggering impulse is applied across C_2. In (a) the anode voltage is slightly below the trigger breakdown voltage and the applied impulse causes breakdown, in (b) R_1 R_2 is a high resistance potentiometer which holds the trigger just below its triggering voltage and the applied impulse trips it. In both cases for reliable working a 5 volt triggering impulse is required.

The application of the triode to an Influence Fuze for a projectile is shown in Fig.9, using the circuit (b) of Fig.8.

The grid potentiometer is of the order of 1000 megohm. The triggering impulse is obtained from the higher rate of rise of the nose capacity to ground (or other target), compared with the body capacity, the whole projectile being at a different potential to the target.

A 5V signal can be obtained in this way.

The triode requires Radium to prevent delays in firing in a similar way to the diode.

Triodes have been made with the triggering electrode consisting of a single straight wire (0.55 mm diameter) projecting through the side of the envelope near the cathode. This type of tube was found to be more satisfactory in operation than the standard triode described above, but it was not considered to be a manufacturing proposition by Siemens, owing to their hand-made methods of assembly.

(c) Tetrode

Owing to the shortage of Radium in Germany, attempts were made to design a tube with the triggering properties of a triode and which did not require Radium to prevent firing delays. This led to the Tetrode which was developed by HARMSEN of Siemens, and the claims for this tube are that it does not suffer from firing delays and that it has a triggering sensitivity of 0.1 volt if properly used. The claims for the tetrode need careful checking as different observers in Germany do not agree on their properties.

The tetrode consists of a potassium-activated cathode (similar to diode cathode) mounted at one end of a cylindrical glass envelope and three wire electrodes mounted close together at the other end. (See Fig.10). The centre wire is the anode with a trigger electrode on one side and an auxiliary discharge electrode on the other. The gas filling is pure Argon at about 25 mm pressure.

The circuit diagram is shown in Fig.11.

The electrode H serves as cathode for a very small current which flows continuously from the anode A up to the instant of triggering. The electrode T is the trigger and it passes a very small continuous current to the cathode K. The triggering signal is applied across C2.

HARMSEN'S Theory of the Tetrode

Consider a diode circuit composed of the trigger electrode T and its associated circuit R and V (Fig.12).

If the voltage V is slowly raised from zero the tube characteristic will be as shown in Fig.13, curve (1).

If R_L represents the resistance load in series with the diode, the working point is P_1. This condition is stable if R_L is a pure resistance, but if we include the self capacities C_T of the tube and C_R of the resistance, or if C_R is an added capacitor across the resistance, this condition is not stable because of the negative slope of curve (1) at P_1. These capacities then form a relaxation oscillator with the diode. Curve (1) represents the Townsend current before a self-maintained flow has been formed. If a small current of the order of 10^{-9} amp is now passed between electrodes A and H, the shape of the Townsend current curve for the trigger diode will be modified (Curve (2)). A flattened portion with a positive slope will appear because of the ions provided by the auxiliary discharge between A and H which enter the trigger diode portion and are multiplied to some extent by collisions (gas amplification). The working point is now P_2 which represents a stable condition because the slope at P_2 is positive. Instability will only arise if the applied voltage increases above V causing the operating point to fall on the negative slope of the curve, or if a voltage greater than v is suddenly applied across C_R or C_T.

The extent of the positive slope region is claimed to be a function of the auxiliary discharge current between A and H, an increase in the latter causing an increase in the former (e.g. curve (3)). The nearer the operating point is to the peak of the curve the greater the sensitivity to a signal applied to C_R and the greater the risk of instability.

If the applied voltage is raised above V or if a signal greater than v is applied to C_R, the working point moves on to the negative slope of the curve. This results in the capacity C_R breaking into relaxation oscillations with the tube and if C_R is not too small the amplitude of these oscillations will be big enough to cause breakdown in the main anode-cathode circuit. It will be seen, therefore, that for stable operation the applied voltage must not exceed V , and to trigger the tube a signal greater than v must be applied to C_R. It is also evident that the value of C_R is important.

The auxiliary discharge A-H, since it is a source of ions, will eliminate the need for Radium to prevent delays in firing.

If the above theory is correct it will be seen that the reliability of the tetrode depends on the constancy of the Townsend Current curve for the trigger discharge using the specified resistances in the trigger and auxiliary discharge circuits and the specified anode voltage. The greater the triggering sensitivity required, the more important this constancy becomes. It is also evident that the constancy of the resistors is important and such constancy is not easily obtained with resistors of the order of thousands of megohms. Siemens, however, claim to be able to make constant resistors of this magnitude.

The tetrodes are normally designed to operate with a 0.5 volt triggering signal, and the triggering wave-front must be at least 150 volts per second for a time constant of 1 second in the grid circuit.

The provisional acceptance test for tetrodes is as follows:-

(a) Anode self-breakdown must be greater than 200 volts. (Normal anode voltage 170V).

(b) Trigger self-breakdown 155 ± 5 volts, without auxiliary discharge and without series resistance in trigger circuit.

(c) Include series resistance in trigger circuit and pass subsidiary discharge using the recommended resistance values. The breakdown voltage must now be at least 15 volts higher than (b).

(d) Using the recommended circuit values, the tube must fire with a 0.5 volt signal applied to the trigger condenser C_R.

These conditions are illustrated in Fig.14.

To cover tube to tube variations it is found that two alternative values of R_1 (see Fig.11) must be allowed, either 10^9 ohms or 5×10^9 ohms, the better value being found by trial and noted on a label on each tube, together with the recommended applied voltage. (Note:- Most of the samples obtained do not carry this label).

C_2 (Fig.11) may be 20 pf, but for safety should be 100 pf, and preferably is evenly divided with one half across the trigger input resistance and the other half across trigger to cathode (Note with the high value of C_1, this means that both halves are effectively across the tube). In this way spurious firing due to switching surges is avoided. Otherwise the anode charging circuit must have a time constant not less than 1 second.

Input frequencies greater than 10 Kc. per sec. require a bigger signal to trigger.

For a low resistance input circuit, the circuit shown in Fig.15 may be used.

References:-

(1) Dällenbach - (believed) - Ziet.f.Tech.Phys.

(2) Stienbech - Space Charge Theory.

(3) Schade - Ziet.f.Phys. 10, 487, 1937.
Collisions of Second Kind.

(4) Rogovski - Positive ion sheath theory.

References (2) (3) and (4) are in connection with the theory to account for the shape of the Townsend Current curves.

Reference (1) is in connection with the stability of the circuit.

HARMSEN has written a mathematical analysis of the fundamental theory of the Tetrode and this has been included with the official records taken from Siemens.

HARMSEN started work on the tetrode in 1936 following preliminary work carried out by others (not named).

Temperature coefficient of the Tetrode is claimed to be negligible from -40°C to +50°C.

Information obtained from LUDER on the Tetrode

The tetrode does not necessarily work on the position slope of the tube characteristic (Fig.13), but will also work satisfactorily on the negative slope. The reason for this is not understood, but is suggested to be due to the capacity across the resistor causing small relaxation oscillations (indicated by the closed loop) which are not necessarily big enough in amplitude to cause instability. (See Fig.16).

Instability or triggering will only occur when the oscillations are big enough in amplitude to pass point Q. This will occur when a signal of suitable magnitude is applied to the trigger condenser.

Tests have shown that a continuously applied sine-wave signal will trigger the tubes with greater sensitivity than a single steep-fronted pulse, and also with more uniformity. This is presumably because a tube will fire with greater sensitivity if the signal is applied from point X rather than P or any intermediate position and a continuously applied signal will in a short time operate from X, whereas a single pulse will operate from any part of the cycle depending on the instant of application. It was also found that one particular frequency is most sensitive which is believed to correspond to the natural frequency of relaxation oscillations. This has been checked qualitatively by noting that an increase in capacity across the resistor results in a lower frequency for maximum sensitivity. Resonant frequencies are found in the range 100 to 300 c.p.s. (For a saw tooth pulse this corresponds to a rate of rise of about 200 volts per sec.).

The characteristic curves for the tetrode have not been measured by LUDER and he has accepted HARMSEN'S curves. Sensitivity measurements were made with the test circuit shown in Fig.17.

HULZER (HARMSEN'S Assistant) measured 50 tetrodes and found the characteristics shown in Fig.18.

50 tubes were checked, using either 10^9 or 5×10^9 ohms for the Auxiliary Discharge resistance. 10 of them would not trigger at 0.1 volt with either value of resistance, but most of these rejects would give 0.5 volt sensitivity.

In some cases with a continuously applied A.C. signal satisfactory operation could be obtained with 0.01 volt. (Must be working on the negative slope region of the characteristic curve).

All tubes and resistors must be set in wax or oil to avoid leakage under moist conditions.

The tubes are not intended for continuous running, and during test the anode current must not exceed 0.1 milliamp, and a short rest period (few seconds) must be allowed for recovery of the original characteristics. Sputtering of the potassium from the cathode is one of the biggest causes of trouble, as the sputtered metal settles on the tube envelope and the other electrodes causing changes in characteristics. Sputtered potassium settling on the auxiliary discharge electrode will cause the discharge to wander up and down the wire resulting in variations of the tube characteristics. This effect can be overcome if the auxiliary electrode is bent as in Fig.19. This improvement was not introduced on production because of lack of time, but is important. A glass sheath was not used because it is too complicated for production.

(d) <u>The Two-Diode Trigger Circuit - WICHMAN</u>

WICHMAN had not found the tetrodes to be very reliable or uniform in behaviour. He claimed that the trigger condenser value is critical and should not exceed

20 p.f. if instability on switching the anode circuit is to be avoided. He has developed a two-diode circuit which he claims is a satisfactory alternative to the tetrode.

The two-diode circuit is shown in Fig.20.

Tube 1 is passing Townsend current and judging from the circuit values given, the working point is on the negative slope. The principle of operation is similar to the tetrode working on the negative slope (Fig.16), but in this case the drop in voltage across diode 1 is reduced suddenly on receipt of a signal and causes a sudden rise in the voltage across diode 2 which is enough to cause it to strike and hence both diodes strike together. The applied voltage is rather less than the sum of the striking voltages of the two diodes.

The stability of this circuit is difficult to explain and in any case is rather critical. The triggering condenser must not exceed 100 p.f. (absolute maximum) including self capacity of the tubes and resistor, also precautions must be taken to avoid surges on switching the main circuit (see Fig.21).

For C_1 equal to 8 pf (self capacity of circuit), the lowest permissible value of R_2 is 150,000 ohms.

The frequency range of operation is 300 to 800 c.p.s. and 0.5 volt sensitivity is easily obtained. The use of Radium is not necessary and the circuit will operate equally well in light or darkness.

The effect of the value of C_1 (Fig.21), excluding self capacity, is shown in Fig.22.

Triggering sensitivities as low as 0.1 volt have been obtained with diodes filled at optimum gas pressure (8-10 mm). Diode 1 must be a small diameter tube, diode 2 is not critical. This is possibly connected with the flow of an auxiliary small current discharge to the high resistance film on the tube wall in diode 1, which may be necessary for satisfactory operation.

The circuit has not been tested on single pulses, but behaves very well with continuously applied A.C. signals and has been tested for long periods for stability by applying an A.C. signal just below the triggering value, with satisfactory results. The effect of frequency on triggering sensitivity is shown in Fig.23.

The possibility of maximum sensitivity at a frequency corresponding to the relaxation oscillation frequency is indicated here.

The trigger voltage values shown in the curves are likely to be inaccurate at low frequencies because the signal generator had a high impedance at the lower values.

The two-diode circuit had been tested for stability for periods up to one month with satisfactory results, but the tubes and resistors must be set in paraffin wax to avoid leakage effects due to moisture.

The two diodes can be substituted by a single three electrode tube provided there is no appreciable diffusion of ions between the two halves. For example the standard German triode can be used if the wire electrode does not project through the cup (see Fig.24).

WICHMAN'S objection to the tetrode is on the grounds of instability and lack of uniformity. The original laboratory models behaved much better than a subsequent batch of 100 production tubes. The sensitivity is good, being 0.5 volt at 50 cycles per sec., and 0.1 volt at 300 cycles per sec. He considers that the only useful function of the auxiliary discharge is to reduce firing delays from 10^{-4} to 10^{-6} second.

4. Information obtained from RUHLEMANN

(a) Diode

Work on time fuzes using diodes was started in 1931-33. Before 1942 diodes had given trouble with glass breakages caused by potassium attacking the sealing wires and starting cracks, but the material of the wire was changed in 1942 and since then very little trouble had been experienced.

The tubes are set in pitch (melting point 100-120°C) inside a bakelite moulding. Siemens had imposed a limit of about 60°C for maximum safe temperatures, but in fact setting in pitch did not appear to disturb the tubes.

Diodes were accepted between the limits 155-165 volts, being measured after having been installed in the fuzes (in darkness) for two or three days. (Values usually about 0.3 volt lower than the Siemens figures). Stocks did not generally accumulate for more than 3 to 5 months. Measurement difficulties were overcome by keeping 20 or 30 control tubes which were passed backwards and forwards between Siemens and Rheinmetall and were used to check the measuring instruments.

The diodes were labelled with a number by Siemens and a record of striking voltages were kept. In fact Rheinmetall did not refer to these records so that tube changes of several volts would not be detected provided the final value was between limits. However, laboratory tests had shown that very few tubes would be expected to wander more than 0.3 volt from their recorded values.

After 2-3 years shelf life tests on completed fuzes, there were 20% rejects, but only 1% were due to diodes, the remainder being due to condensers. The best condensers would be the hermetically sealed type using glass bushings from Jena.

(b) Triode and Tetrode

Several thousand experimental Influence Fuzes had been made, nearly all with triodes. About 30 had been made with tetrodes and none at all with the two-diode circuit of WICHMAN.

The two-diode circuit had been tested in the laboratory and found to be insensitive.

The standard circuit for the triode was the simple relay circuit with the trigger biased to 5 volts below the strike value by means of a high resistance potentiometer (see Fig.9).

The test circuit for triodes is shown in Fig.25.

C is a variable capacity which is rapidly raised by automatic means from 0 to approximately 40 cm. The value of V required to fire the tube under these conditions was determined and insensitive tubes were rejected.

On firing trials it was found that the firing delays in the triode were too high. The use of luminous paint applied externally did not cure the trouble and although it was suggested that Radium applied internally would be a successful cure it was never put into practice and no tubes with internal Radium had been fired in fuzes. The high cost and shortage of Radium was given as the reason for this.

The Tetrode was proposed as a means of eliminating the delay, but no firing trials have been made to check the delay in this type of tube. The increased sensitivity of the Tetrode was also of interest because it offered possibilities of introducing filter circuits to discriminate between clouds and the more solid targets. This was only an idea and had not been tried. The standard fuze using the triode (5 volt sensitivity) suffered from a pronounced tendency to air bursts due to cloud.

Work on influence fuzes was started 10 years ago, but was stopped at the beginning of the war because the influence range was considered to be too small. Early in 1944 the requirement was changed and work was started again. The fuze had not been accepted as ready for operational use.

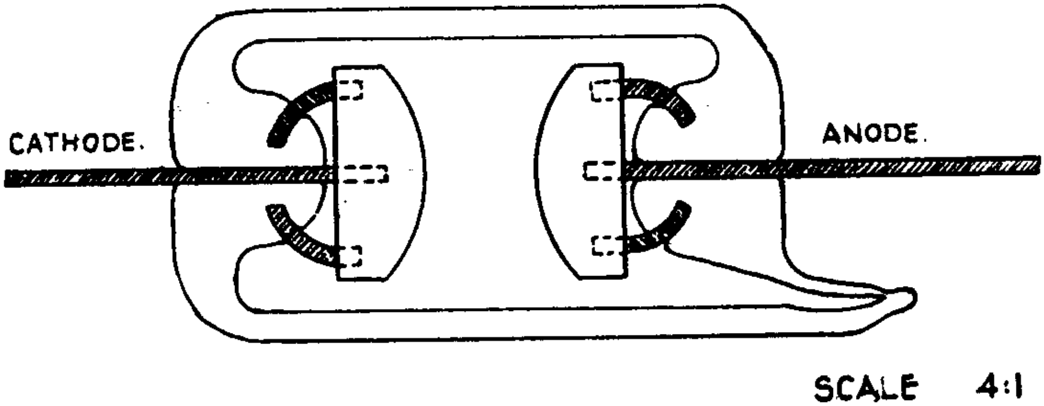

FIG. 1

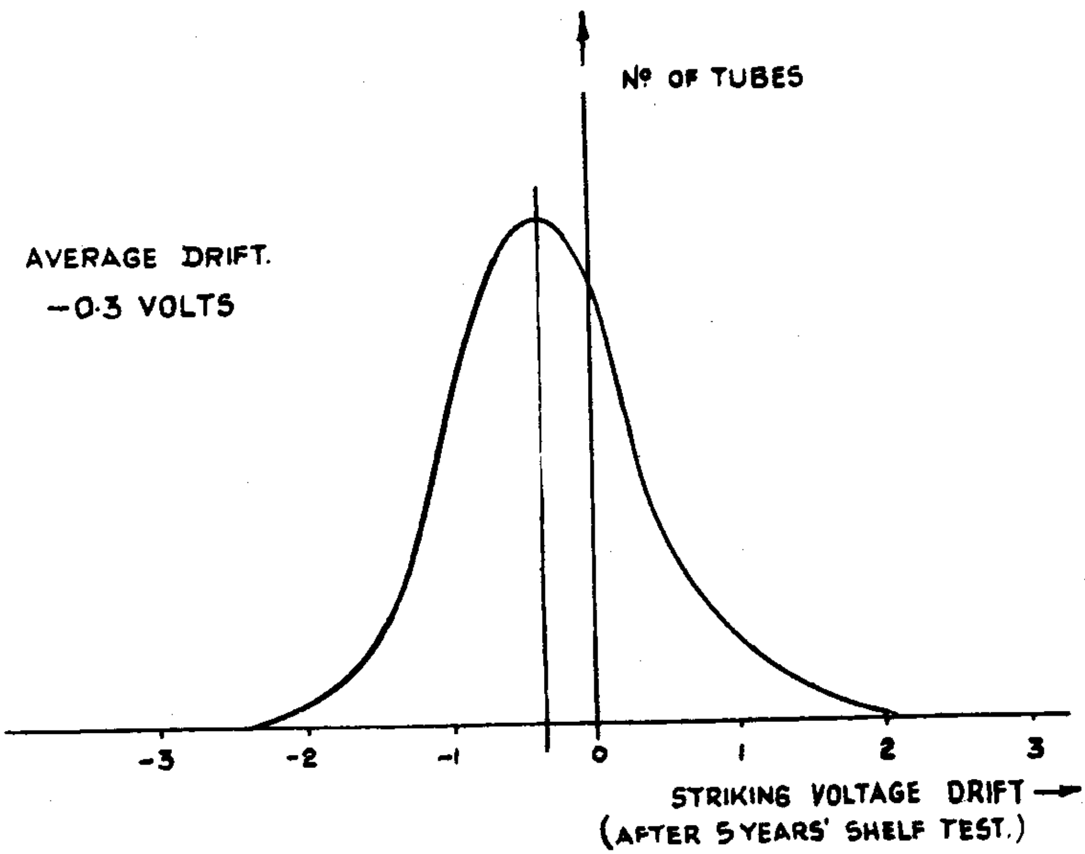

FIG. 2.

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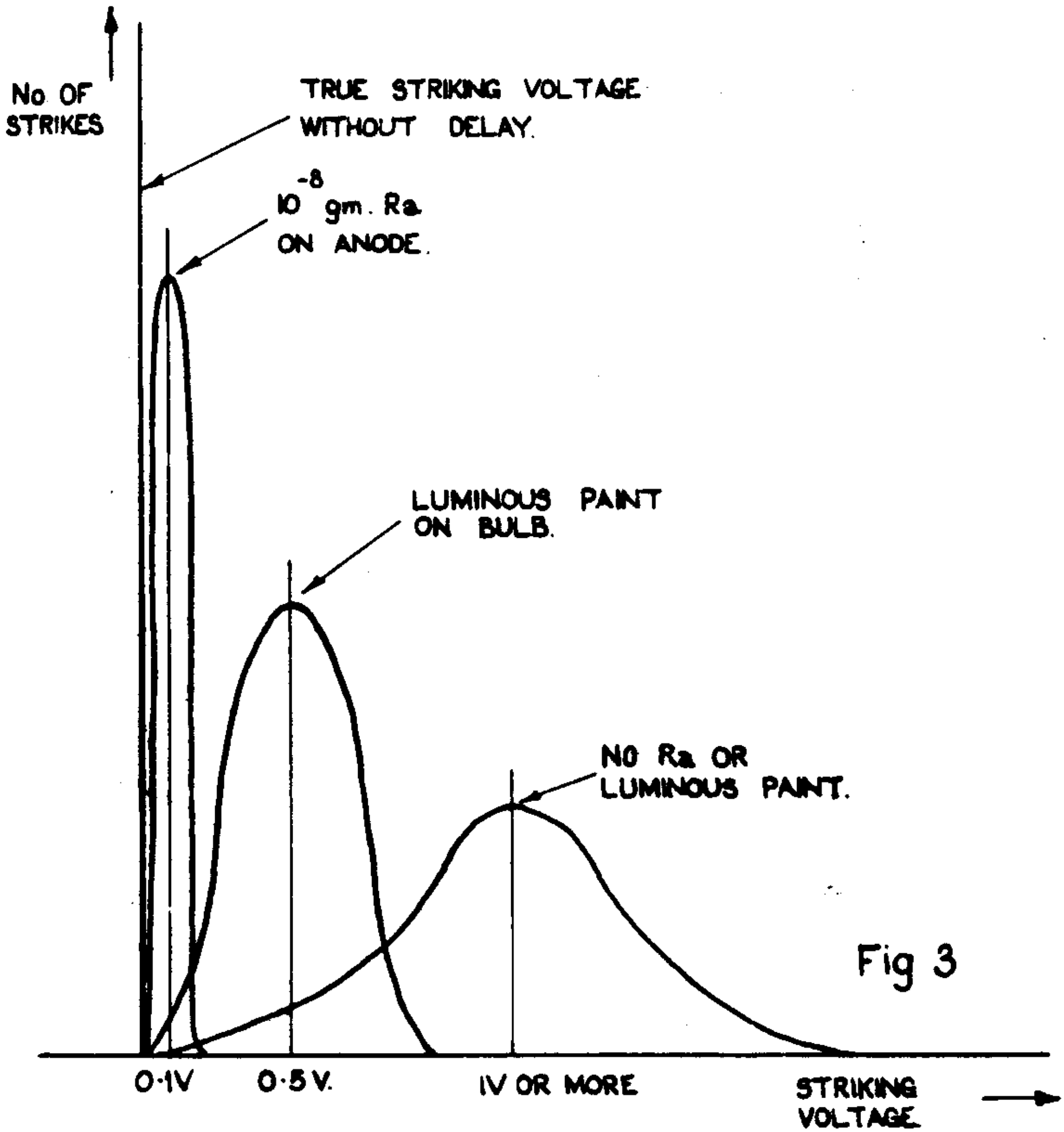

Fig 3

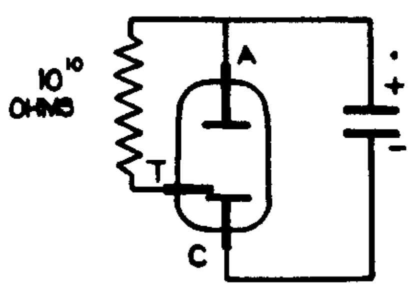

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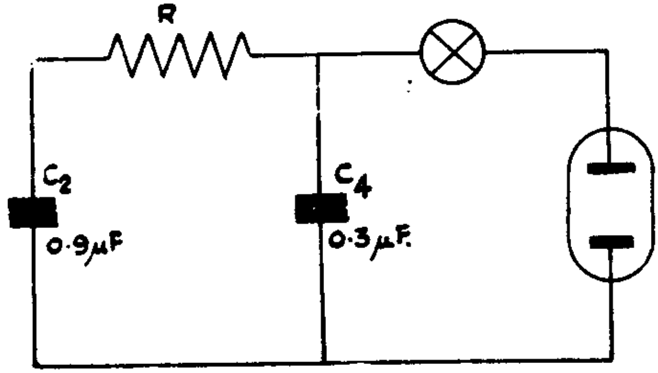
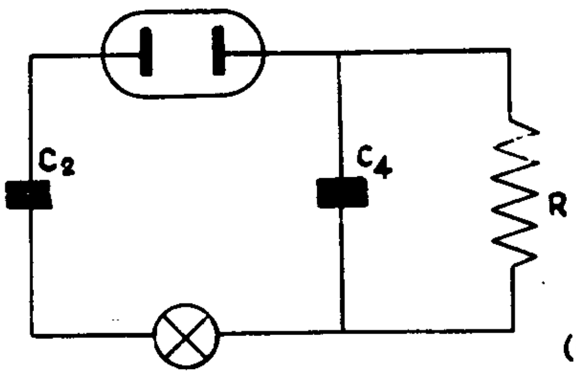
Fig. 4.



(a)



(b)

FIG. 5

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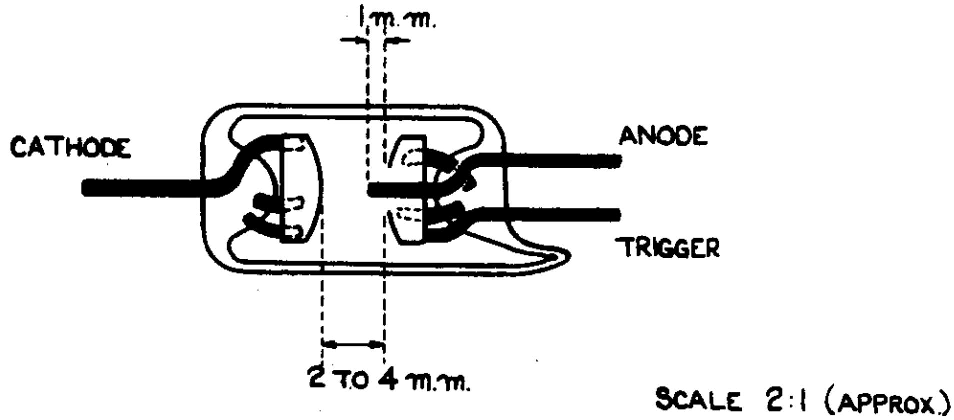


Fig. 6.

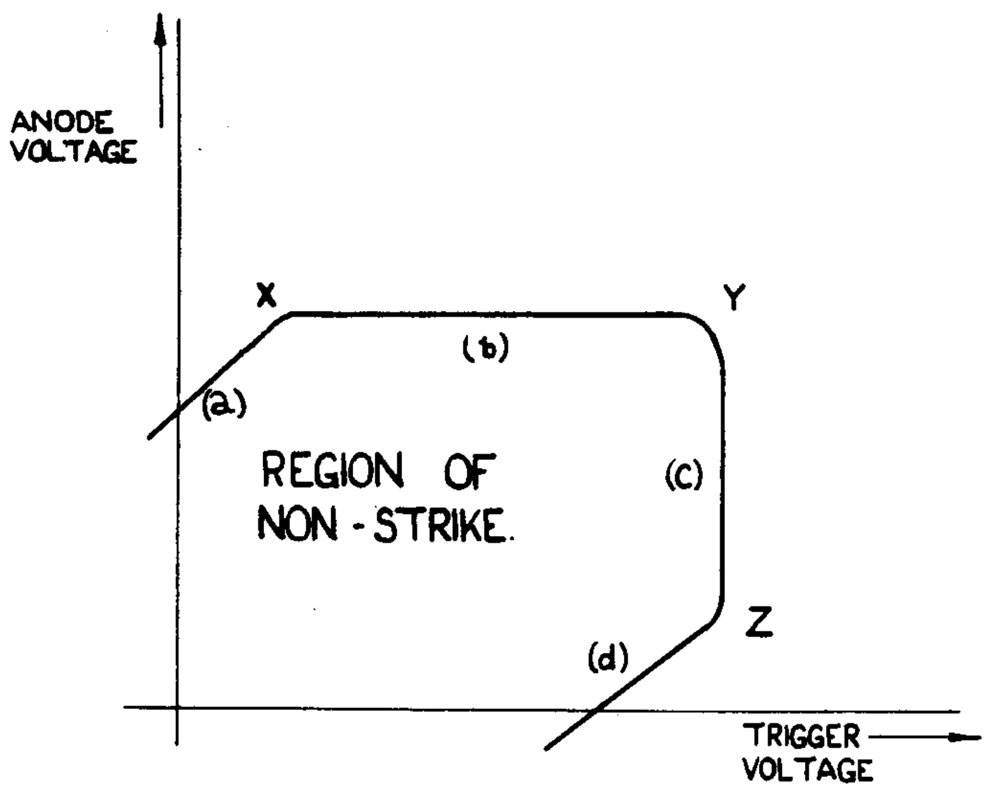
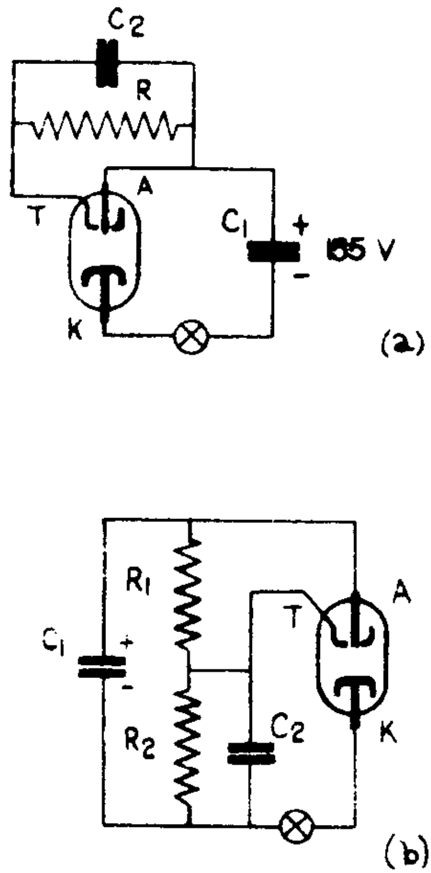


Fig. 7.

63660-2



BREAKDOWN

T - K	160 VOLTS
A - K	190 VOLTS

Fig 8

63660-2

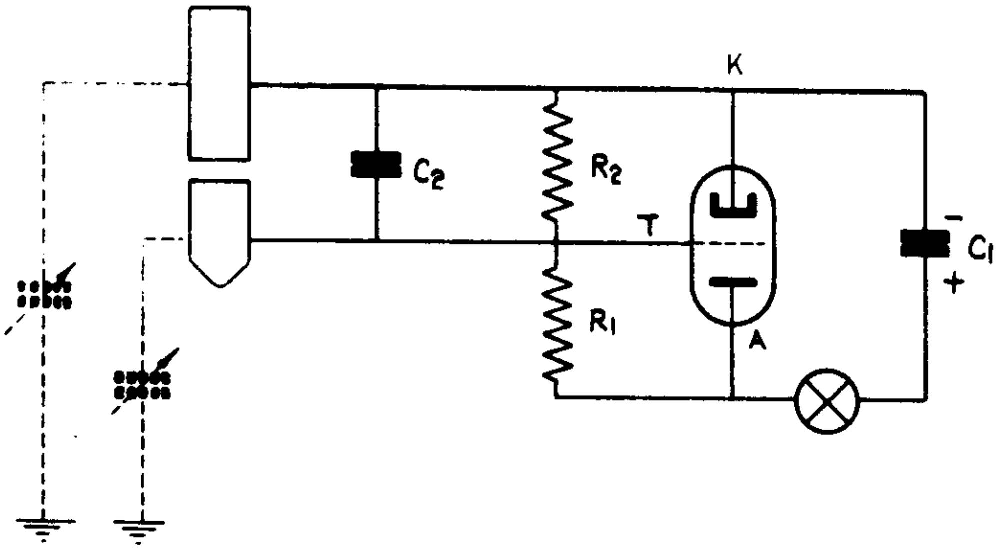
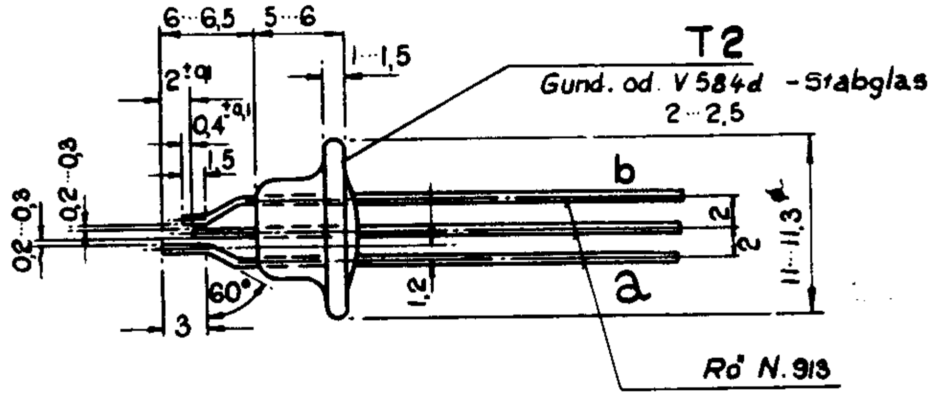


Fig. 9.

63620-2

G2



G3

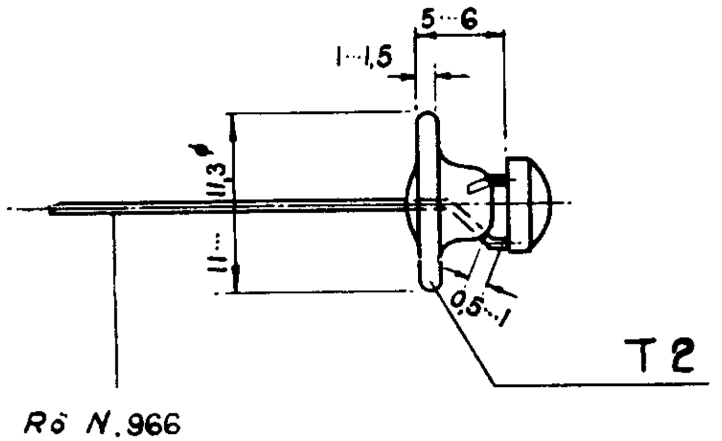
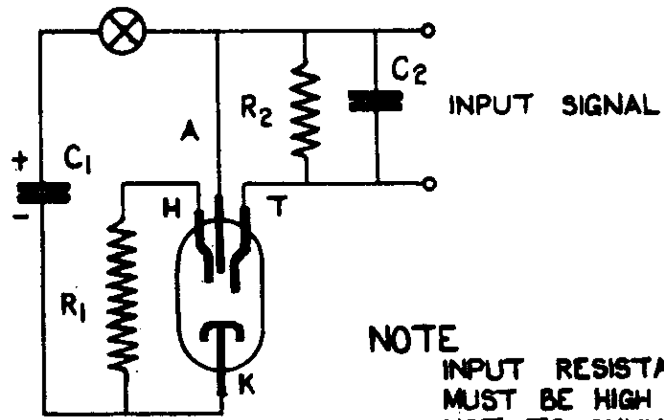


Fig 10

63640-2



NOTE
INPUT RESISTANCE
MUST BE HIGH ENOUGH
NOT TO SHUNT R_2

R_1 = 10^9 OR 5×10^8 OHMS.
R_2 = 5×10^9 OHMS.
C_2 = 100 pf. (MAX.)

Fig. 11.

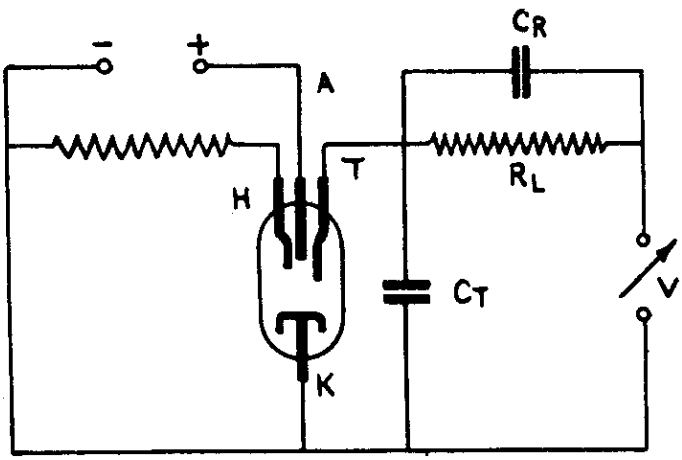
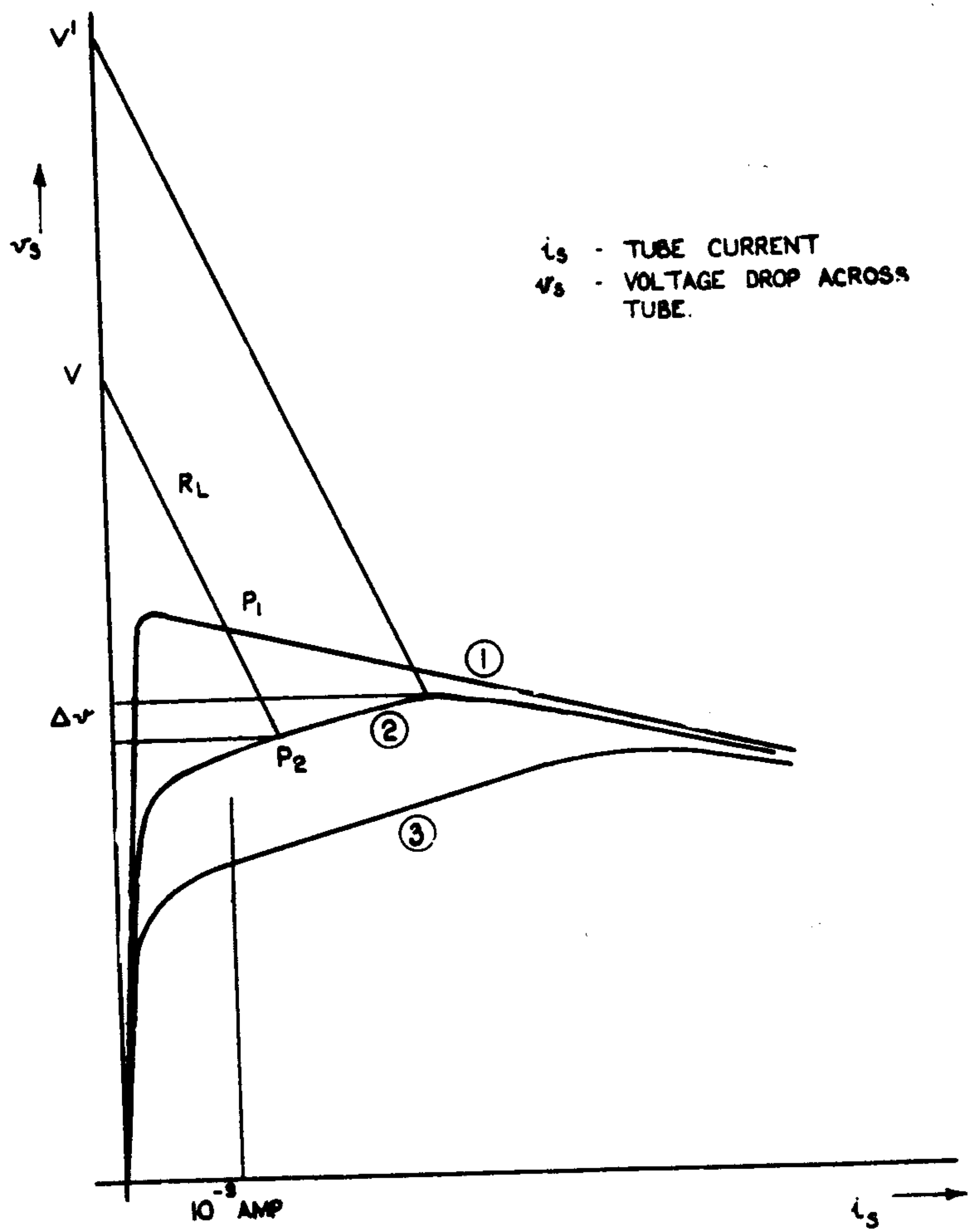


Fig 12

63640-2



63620-2

Fig. 13.

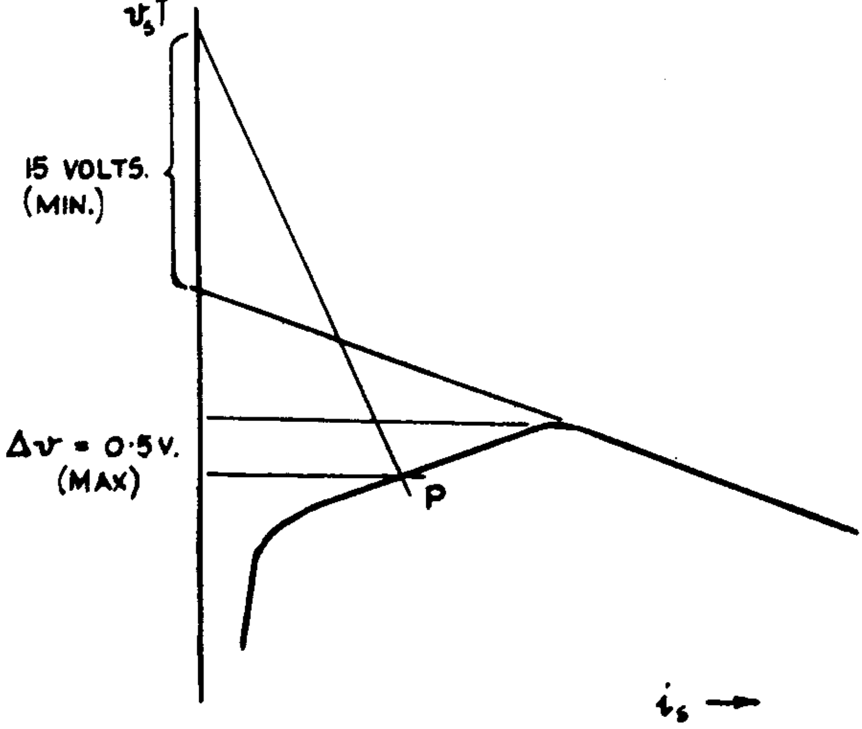


FIG. 14

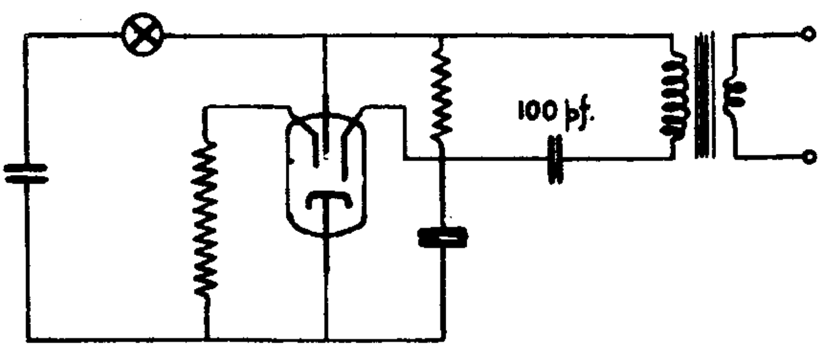


FIG. 15.

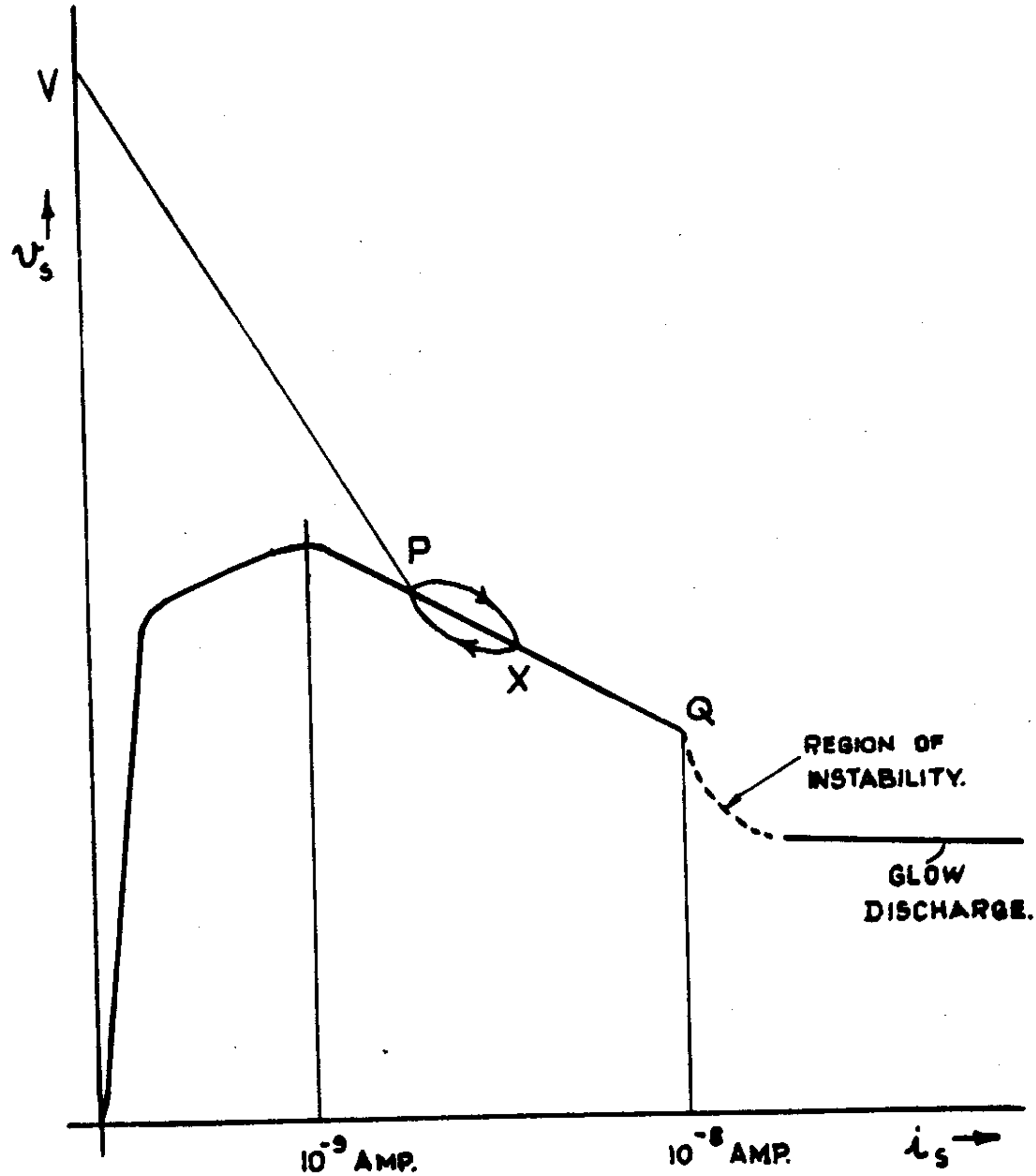


FIG. 16.

63640-2

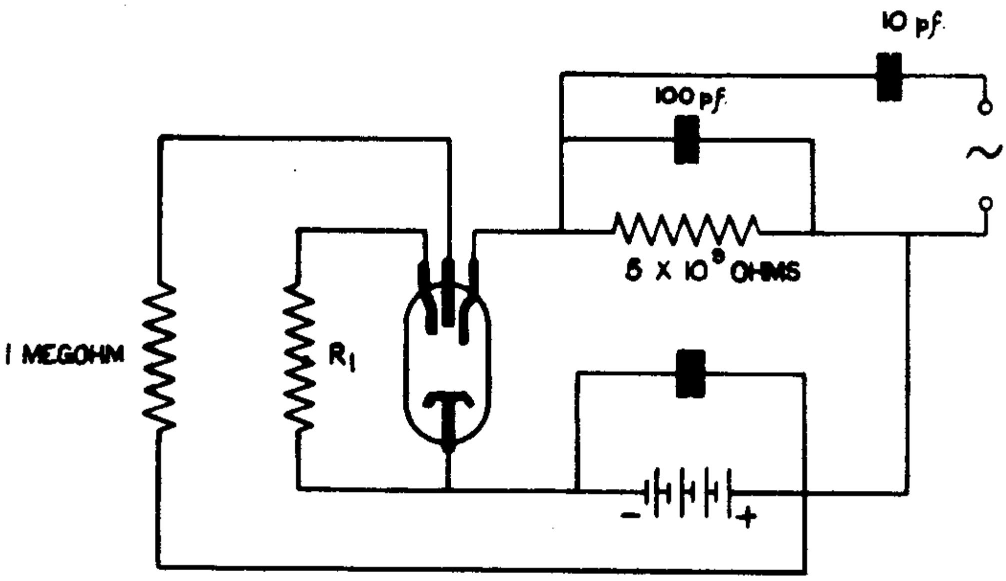
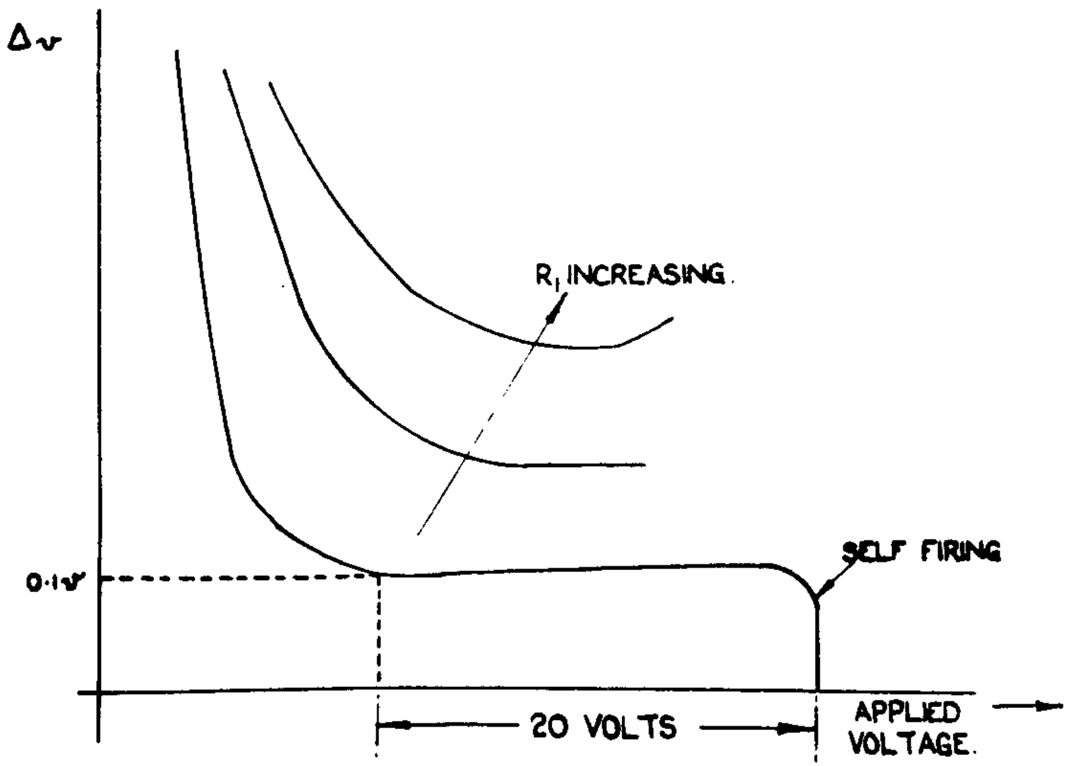


Fig. 17



63640-2

Fig. 18.

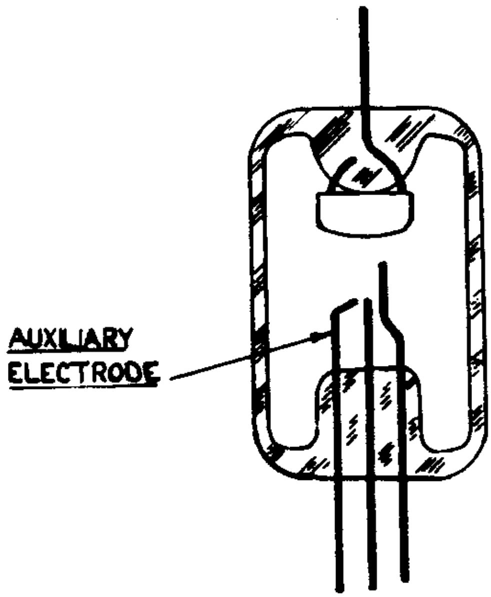
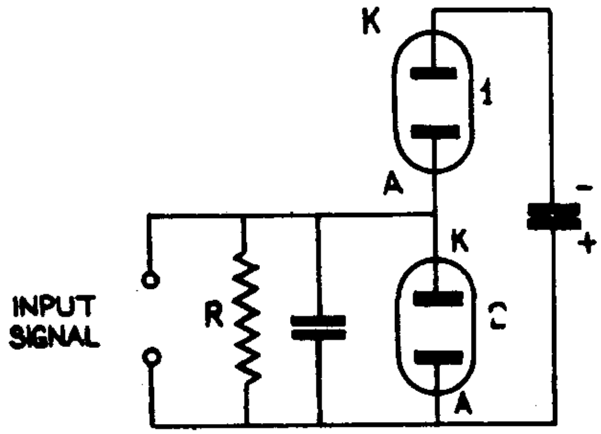


Fig_19

63640·2



R = 5 X 10^{8} TO 1 X 10^{9} OHMS.

Fig 20

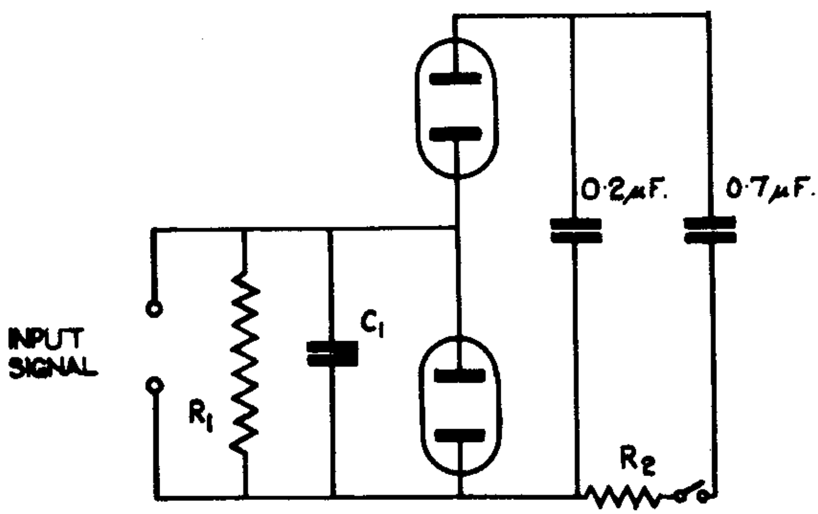


Fig 21

63620·2

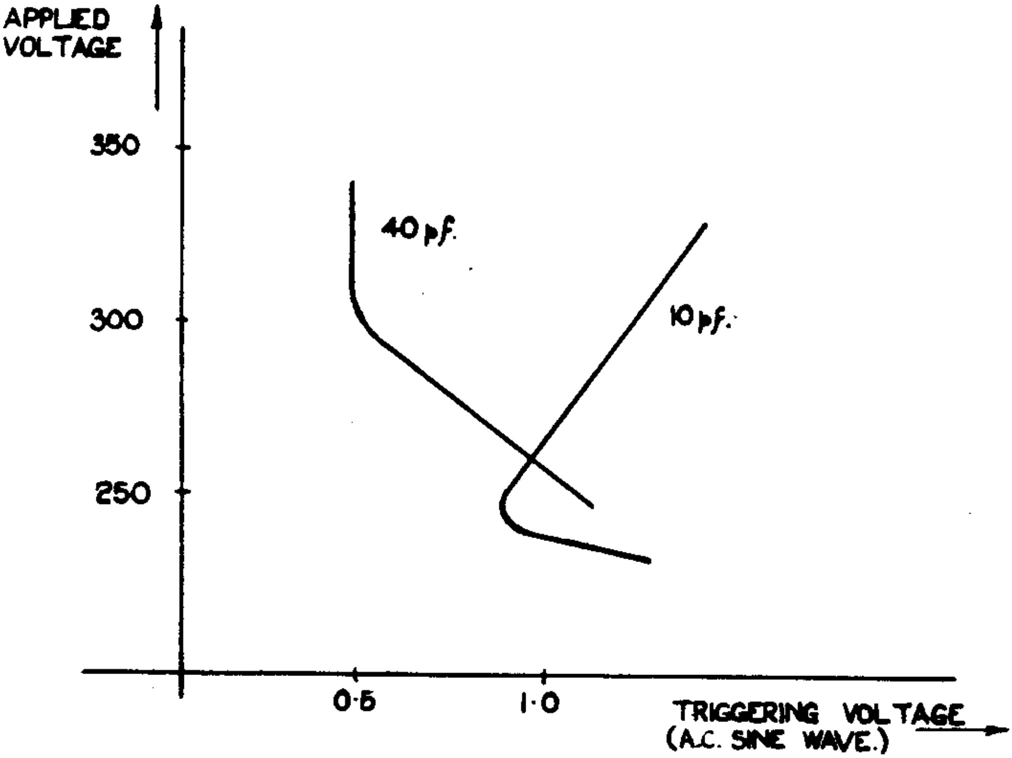

APPLIED
VOLTAGE
350
300
250
40 pf.
10 pf.
0·5
1·0
TRIGGERING VOLTAGE
(A.C. SINE WAVE.)

Fig. 22

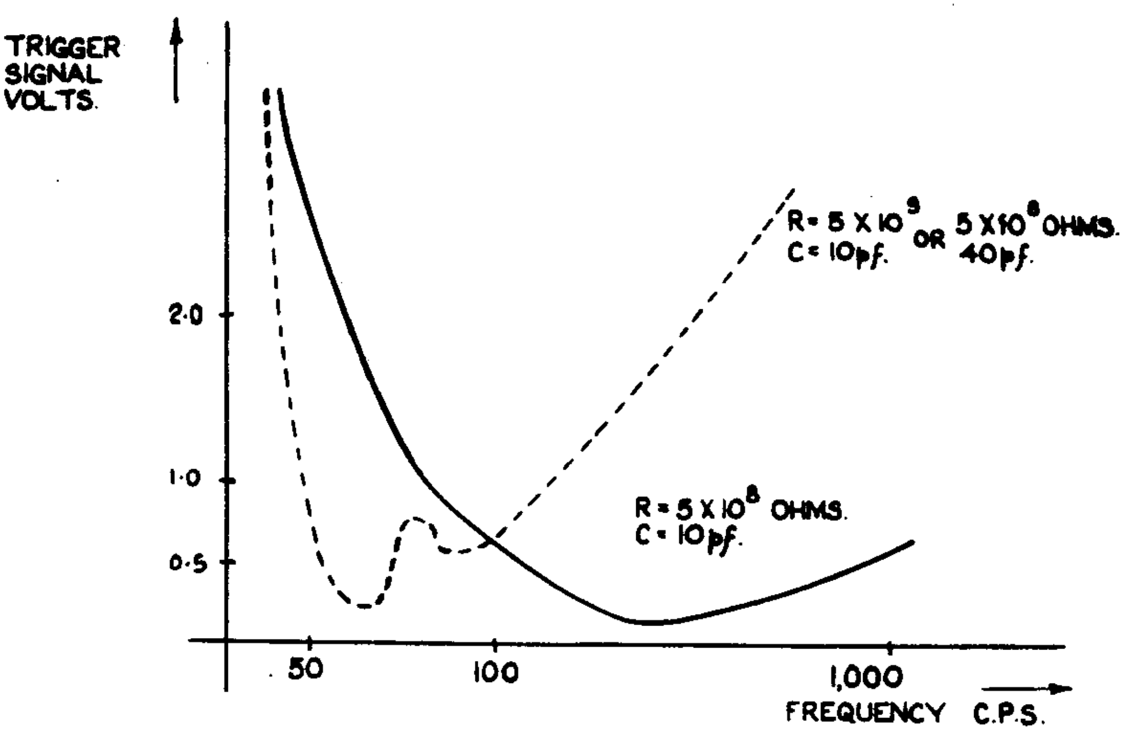
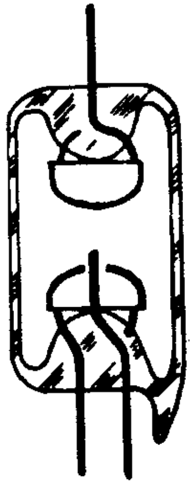
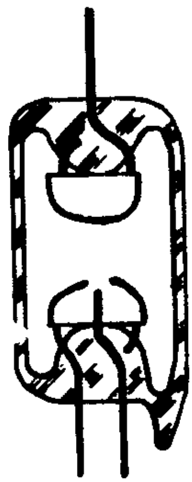

TRIGGER
SIGNAL
VOLTS.
2·0
1·0
0·5
R = 5 X 10^9 OR 5 X 10^8 OHMS.
C = 10 pf. 40 pf.
R = 5 X 10^8 OHMS.
C = 10 pf.
50
100
1,000
FREQUENCY C.P.S.

Fig. 23.



UNSUITABLE



SUITABLE.

FIG. 24.

63640-2

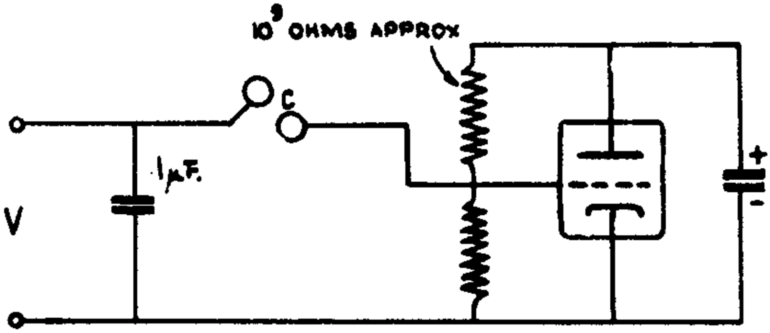


FIG. 25.

D 63640-2 750 D/d R.122 5/46 P.R.P.