

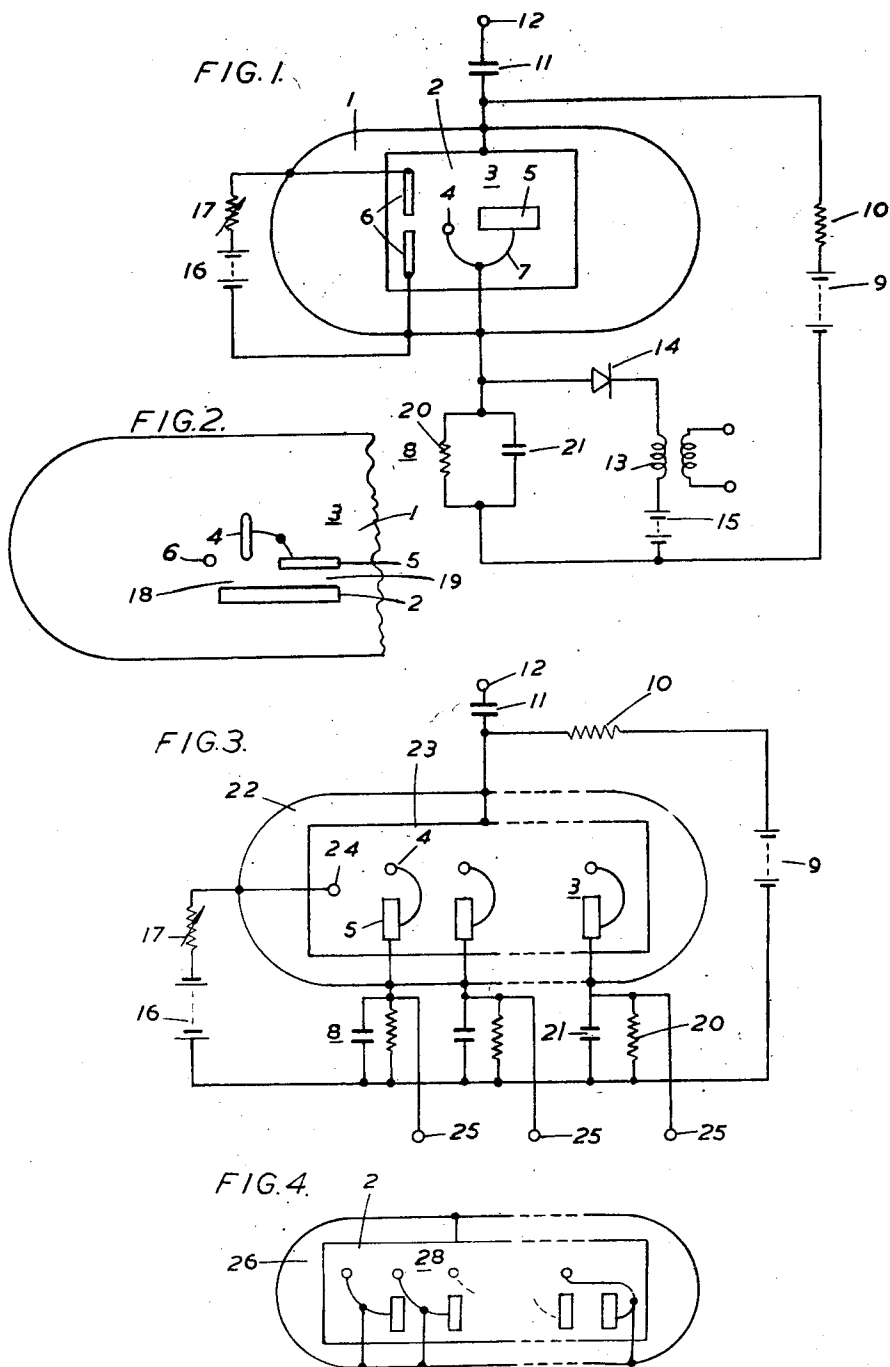
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A. H. REEVES
ELECTRIC DISCHARGE DEVICE

2,603,765

Filed May 11, 1948

2 SHEETS—SHEET 1



Inventor
ALEC HARLEY REEVES
By *AP Morris*
Attorney

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A. H. REEVES

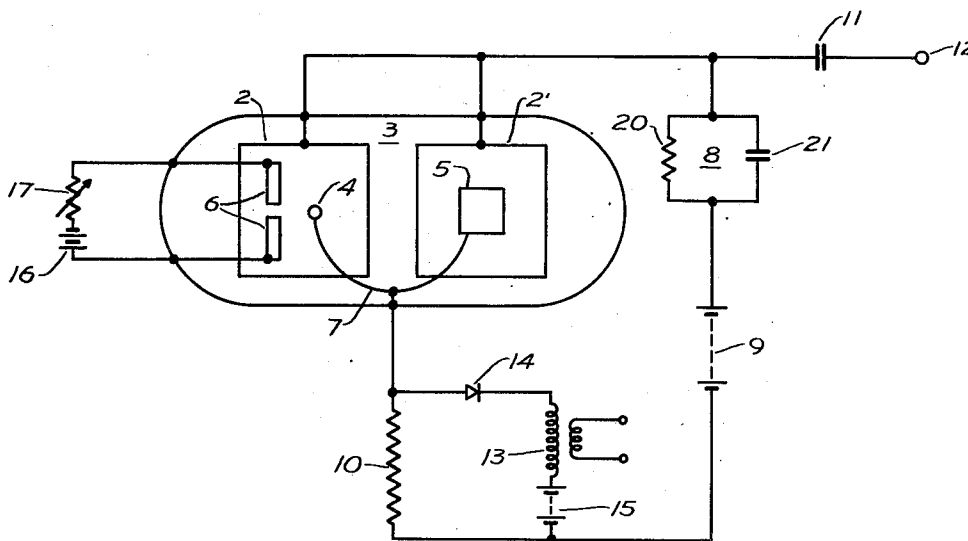
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2 SHEETS—SHEET 2

FIG. 2A.



INVENTOR.

ALEC H. REEVES

BY

Robert Harding Jr.

ATTORNEY

UNITED STATES PATENT OFFICE

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ELECTRIC DISCHARGE DEVICE

Alec Harley Reeves, London, England, assignor
to International Standard Electric Corporation,
New York, N. Y., a corporation of Delaware

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The present invention relates to cold cathode electric discharge tubes of the type in which spread of ionisation from a discharging gap is arranged to lower the striking potential for a discharge at a neighbouring gap.

Discharge tubes utilising this principle are described for example in application No. 763,655, filed July 25, 1947, and application No. 14,184, filed March 18, 1948. In general, in tubes of this type, a number of gaps are arranged so that a sequence of applied pulses fires first one, then a second gap and then the remainder of the gaps of an array. Alternatively, when a first pulse has been applied, the general ionisation level may be arranged to be such that the remaining gaps fire in sequence, automatically, due to the finite time taken by ionisation to travel from one gap to the other, so that the striking potentials for the array of gaps are lowered to the voltage of an applied battery one after the other. In such devices the total discharge current drawn from the battery increases during the discharge sequence and in the application of the tube certain difficulties may be encountered due to the need for a very carefully regulated voltage supply system.

Apart from the question of voltage regulation, there may well be other reasons why it is desirable that a discharge from a certain gap should be extinguished after a certain time, rather than that a whole array of discharging gaps should be extinguished together. It is not necessary however, that an array of discharge gaps be involved; rather in certain types of discharge tubes it may be desired to extinguish just one particular gap which may be the only gap in the tube.

The present invention therefore is particularly concerned with the problem of extinguishing a discharge from a discharge gap independently of the quenching of other discharges that may be present, and, although similar to, is distinguished from, the invention of application No. 19,083, filed April 5, 1948, now Patent 2,517,599, which is concerned with extinguishing means for an array of gaps.

According to the present invention a cold cathode electric discharge device comprises, in a gaseous atmosphere a pair of discharge gaps arranged so that ionisation from a discharge at the first gap of the pair which has the lower striking potential shall lower the firing potential of the other, said gaps being arranged with cathodes having different effective discharge areas, so that the discharge at the second of said

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gaps may pass a larger discharge current than the first for the same applied voltage thereby to extinguish discharges at both gaps due to the action of a resistance-capacity network common to both gap circuits.

As applied to sequence discharge tubes comprising an array of sequentially fired discharge gaps such as are proposed in applications Nos. 763,655 and 14,184, the present invention provides a cold cathode discharge device comprising, in a gaseous atmosphere, an ordered array of discharge gaps arranged so that ionisation from a discharge at one gap shall lower the firing potential of a neighbouring gap in said array, the cathodes of said array being arranged in pairs having discharge surfaces of different effective areas so that the cathode of larger effective area forms a gap of higher striking potential but may pass a larger discharge current than the other for the same gap voltage, whereby said larger discharge current may be caused to extinguish the discharge from said cathode and another of smaller area due to the action of a resistance-capacity network common to both gaps associated with the two last mentioned cathodes.

Before proceeding with the description of embodiments of the invention, it may be as well to recapitulate those principal discharge phenomena which are utilised in devices according to the present invention.

Consider, then, a pair of electrodes contained in a gaseous enclosure, the gaseous atmosphere normally, though not necessarily, being considerably below atmospheric pressure. If, now, a small voltage be applied to the electrodes a very small current will pass. On increasing the voltage the current will remain at first of very small magnitude (say of the order of microamps) until a critical potential is reached, which potential depends upon the gap separations and the nature and pressure of the gas. These, though not the only criteria, are the main ones which determine that critical voltage which we call the striking or firing voltage which is sufficient to initiate a discharge in the gap between the electrodes.

When once the discharge has been started, the external applied voltage may be reduced very considerably to a lower limiting value called the maintaining voltage. This potential is a function principally of the nature and pressure of the gas. According to the discharge current which is permitted to pass, and hence the number of ions formed in the gas, the cathode will

be more, or less, covered with a glow which tends to be most pronounced on any protuberances or other surface irregularities. In the case of a cathode surface without pronounced irregularities, so long as the complete surface is not covered by the cathode glow, the inter-electrode potential tends to remain constant. This phenomenon is used in familiar voltage stabilisers such as neon tubes and the like. After the whole cathode is covered with glow, the inter-electrode potential will rise with the applied voltage and, in general, in the devices with which we are concerned, discharge currents are maintained in this region. If the externally applied voltage be reduced below the maintaining voltage, discharge will cease and the gas will become de-ionised at a finite rate in general slower than that required to set up the initial ionisation.

The striking potential for a discharge gap is very considerably affected by ionisation. It is well known that such ionisation may be caused by radiation of the tube, with ultra-violet light, cosmic rays, and so on. Of far greater importance however for the present invention, is the ionisation due to previous discharges, or due to discharges already present at another gap in the tube. In a tube with more than one gap, if a discharge has been fired at the first gap, ionisation will spread from this gap to lower the striking potential of the other and at a definite rate which depends, inter alia, upon the magnitude of the discharge current passed at the first gap and upon the nature and pressure of the gas.

Embodiments of the present invention will now be described by way of example with reference to the accompanying drawings, in which:

Fig. 1 is a schematic diagram of a device according to the present invention connected in a simple circuit to illustrate its behaviour.

Fig. 2 is a diagrammatic illustration of part of the device of Fig. 1.

Fig. 2A is a schematic diagram of a modified form of the device shown in Figs. 1 and 2.

Fig. 3 is a schematic representation of a device and circuit employing discharge gaps according to the present invention, and

Fig. 4 shows a variant of the design of Fig. 3.

To facilitate an understanding of the drawing, some reference numerals are applied to identical elements in the several figures.

In Fig. 1, device 1 comprises an anode 2 in the form of a flat plate and a pair of cathodes 3. Cathode pair 3 comprises a rod 4 normal to the anode plate and a flat plate 5 substantially parallel with the anode plate. The arrangement of cathode 3 and the anode plate is shown from a different angle in Fig. 2. The striking potential for the gap associated with rod 4 is less than that associated with plate 5.

The tube also comprises a pair of electrodes 6 forming an auxiliary discharge gap in line with electrodes 4 and 5 and closer to 4. Electrodes 4 and 5 are connected together by means of a wire 7 which is bent away from the anode plate and is preferably coated with alumina or some similar insulating material to inhibit spread of cathode glow along the wire between the two electrodes. Wire 7 is connected through a resistance capacity circuit 8 to the negative pole of battery 9. Anode plate 2 is connected through resistance 10 to the positive pole of this battery, and also through blocking condenser 11 to terminal 12. The resistance capacity circuit 8 is shunted by the primary winding of a pulse transformer 13 in series with a rectifier 14 and biasing battery 15. A battery 16 is connected in series

with a variable resistance 17 across the auxiliary gap electrodes 6. The purpose of the auxiliary discharge electrodes 6 together with their battery circuit is to regulate the general level of ionisation in device 1 as described, for example, in my U. S. Patent No. 2,520,171, issued August 29, 1950. The voltage of the battery 9, and also the discharge current passed by the priming gap formed by electrodes 6, is adjusted so that the anode-cathode potential of the gaps 18 and 19 formed between the anode plate 2 and respective electrodes 4 and 5 is insufficient to initiate a discharge at either, but a discharge established at gap 18 is maintained by battery 9. Thus, if a pulse be applied to terminal 12 sufficient to cause gap 18 to strike, but not gap 19, then 18 continues discharging. After a certain time depending upon the general ionisation level in the tube, and the separation between gaps 18 and 19, ions from gap 18 will have reduced the striking potential for gap 19 to that of the applied anode cathode voltage. When this occurs gap 19 will fire. Due to the considerably larger effective area of plate 5 as compared with rod 4, the discharge current at gap 19 will tend to be very much larger than that at 18. In consequence, the potential drop across resistance 20 of the R. C. network 8 will charge up condenser 21 to a value greater than the difference between the potential of battery 9 and the maintaining voltage for the tube 10; the discharges at both gaps 18 and 19 will be extinguished. The sudden large increase of voltage across network 8 may be utilised by applying the same to the primary of transformer 13; due to the rectifier-battery combination, 14—15, transformer 13 responds only to the sudden large impulses which occurs when gap 19 fires. A short pulse is thus available at this moment at the secondary terminals of 13. If a train of pulses be applied to terminal 12, then, as pointed out in connection with a very similar circuit in my said U. S. Patent No. 2,520,171, the circuit provides, effectively, a pulse delay network whose time constant may be varied by changing the bias applied to the primary discharge at auxiliary electrode 6. In an alternative mode of operation for which the priming discharge electrode is not necessary, it may be arranged that gap 19 shall fire on application of a second pulse applied to terminal 12. This demands that either the general ionisation level should be lower than previously, or the pulse should be applied at closer time intervals.

It will be evident that various modifications may be made to the device of Fig. 1 without departing from the scope of the present invention. It is not necessary that an anode plate 2 should be common to both the cathode electrodes 4 and 5. If desired they may be fitted with separate anodes 2 and 2' as shown in Fig. 2A. Similarly, leads to these two electrodes could be taken out of the tube separately, and with such an arrangement it might be more convenient to place a resistance capacity circuit 8 in a common anode circuit rather than a common cathode circuit as shown in Fig. 2A.

An example of the use of pairs of cathodes to form a discharge gap array is shown in Fig. 3 in which device 22 comprises a flat anode plate 23 and a plurality of cathode pairs 3. Auxiliary cathode 24 forms with the anode plate 23 a priming discharge gap similar to that formed by the electrodes 6 of Fig. 1 and is connected via variable resistance 17 to the negative pole of battery 16. The cathode pairs 3 are connected individ-

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usually to resistance capacity circuits 8 outside the tube envelope and thence to the negative pole of battery 9. The positive pole of battery 16 is commoned to the negative pole of battery 9. In place of the transformer 13 and associated circuit of Fig. 1, terminals 25 are shown. For simplicity in the drawings only the first two pairs and the last pair of cathode pairs 3 are shown, the remainder being similarly connected. In other respects the circuit arrangements and also the principle of operation of the device 22, are similar to that described above in connection with Fig. 1 for one or other of the modes of operation of device 1. Thus in one mode of operation, the general ionisation level, battery voltage 9 and the amplitude of pulses applied to terminal 12 are so arranged that on a first pulse the only gap which is fired is the gap between the cathode rod of the left hand pairs of cathode 3. With the disposition of the priming cathode 24 as shown, the gap 18 for this cathode pair will be more ionised than the remaining gaps and consequently will be the first to fire. It may be arranged that the second pulse of a pulse train fires cathode plate 5 of the first cathode pair simultaneously with rod 4 of the second cathode pair 3. For brevity we may refer to the gap 18 as a small gap and the gap 19 as a large gap.

Thus, on the second pulse, the large gap of the first cathode pair fires simultaneously with the small gap of the second pair; both discharges of the first pair are thus extinguished while the second small gap remains discharging until the arrival of the third pulse, when discharge at the second pair is in turn extinguished by the second large gap being fired at the same time, simultaneously the small gap of the third cathode starts to discharge. In this manner, the cathode pairs will fire consecutively throughout the array and the pulses corresponding to the discharges at either of the electrodes of each pair may be utilised by being taken to further circuits by the appropriate terminal 25.

It should be pointed out that for the manner of operation just described the time constants of the resistance capacity circuits 8 should be considerably larger than the total time occupied by one pulse train in order to prevent the left hand cathode pair 3 from firing before the last pair has been fired.

As an alternative mode of operation, in the same way as described in connection with Fig. 1, it may be arranged that each large gap fires automatically at a definite time interval after a discharge has been established at the small gap of the corresponding pair. This time interval may be modified, if desired by application of appropriate voltages to terminals 25, and in this aspect a device according to the present invention may be used, for example, as a channel demodulator in a multi-channel pulse-modulation system.

A suitable tube for such operation has a gas filling containing 92% neon, 1% argon, 7% hydrogen at a total pressure of 100 millimeters of mercury. The electrodes may be of pure nickel while the spacings may be as follows:

	M. m.
Distance between cathode pairs.....	2
Distance between cathode rods and anodes..	2
Length of cathode rod.....	1½

The area of the cathode plate is not important so long as it is large and should be arranged to give, say, a peak squeg impulse of 5 to 10 times the current passed by the cathode rod.

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As in the case of the device of Fig. 1, alternative arrangements for the device 22 are possible; for example, the cathode 4 and 5 could be joined together externally of the tube, if desired, and separate anodes could be provided.

A further alternative which may find some application where it is desired to leave a cathode discharging rather longer than one pulse interval, is shown in Fig. 4, in which device 26 comprises an anode plate 2 as before, and a plurality of cathode pairs 28 arranged in an ordered array. Pairs 28 differ from pairs 3 of the previous examples in that the cathode rod of one pair, instead of being joined to its neighbouring plate, is joined to the cathode plate of the next cathode pair in the array. Consequently, an isolated rod has been shown on the left connected to the plate of the first pair while at the other end of the array an isolated plate has been shown connected to the rod of the last pair. In this device the left hand rod after firing is not extinguished until the plate of the first cathode pair has fired, the corresponding rod being fired intermittently. This delay may correspond to two pulse intervals. Similarly, throughout the array, the rod of each pair remains discharging for two pulse periods. As the isolated plate at the end of the array does not receive ionisation from a rod partner, it may be placed closer to the last pair of the array. In similar manner, the rod at the front of the array may be spaced closer to the first pair 28 than the inter-pair separations.

What is claimed is:

1. A discharge device comprising a gas-filled envelope enclosing an anode and a pair of directly interconnected cathodes spaced therefrom, one of said cathodes having a discharge surface facing said anode which is larger than the discharge surface of the other cathode facing said anode.

2. A discharge device according to claim 1 wherein said anode comprises a pair of conductive elements, one element being mounted adjacent said surface of said one cathode and the other element being mounted adjacent said surface of said other cathode and spaced from said one element.

3. A discharge device according to claim 1 further comprising an ionizing electrode mounted adjacent one of said cathodes.

4. A discharge device comprising a gas-filled envelope enclosing an anode having a flat surface and a pair of cathodes, one of said cathodes having the shape of a rod mounted with one of its end portions adjacent said surface and the other of said cathodes having the shape of a plate having a surface larger in area than said one end portion, and means mounting said plate with its said surface adjacent the flat surface of said anode.

5. A discharge device according to claim 4 further comprising an ionizing electrode mounted adjacent said rod-shaped cathode.

6. A discharge device comprising a gas-filled envelope enclosing an anode and a plurality of pairs of cathodes spaced therefrom and mounted adjacent thereto, each pair of cathodes comprising a first cathode having a discharge surface facing said anode and a second cathode having a discharge surface facing said anode greater than the surface of said first cathode.

7. A discharge device according to claim 6 wherein the cathodes of each pair are mounted adjacent each other and each pair is mounted in spaced relation with respect to the other pairs.

8. A discharge device according to claim 7 further comprising means connecting the first cath-

ode of each pair to the second cathode of the next adjacent pair.

9. A discharge device according to claim 8 further comprising a first further cathode having a discharge surface substantially equal to the discharge surface of said first cathode and mounted in spaced relation to but adjacent one of said pairs of cathodes and a second further cathode having a discharge surface substantially equal to the discharge surface of said second cathode mounted in spaced relation to but adjacent one of said pairs and mounted remote from said first further cathode.

10. A discharge device according to claim 6 further comprising means connecting the cathodes of each pair together.

11. A discharge device comprising a gas-filled envelope enclosing an anode and a pair of cathodes spaced therefrom, one of said cathodes having a discharge surface facing said anode which is larger than the discharge surface of the other cathode facing said anode, means connecting said cathodes together, a source of potential, and means connecting the positive end of said source to said anode and the negative end to said cathodes, said last-mentioned means including a load impedance.

12. A discharge device according to claim 11 wherein said load impedance comprises a resistor and a condenser connected in parallel with each other and in series with said source.

13. A discharge device according to claim 12 further comprising an output impedance, a rectifier and a further source of potential and means connecting said output impedance, said rectifier and said further source in series and in parallel with said load impedance.

14. A discharge device according to claim 11 further comprising means for producing ions mounted adjacent one of said cathodes.

15. A discharge device according to claim 11 further comprising a pulse source and means coupling said source to said anode.

16. A discharge device comprising a gas-filled envelope enclosing an anode and a plurality of pairs of cathodes spaced therefrom and mounted adjacent thereto, each pair of cathodes comprising a first cathode having a discharge surface facing said anode and a second cathode having a discharge surface facing said anode greater than the surface of said first cathode, means connecting pairs of said cathodes together, a source of potential, and means connecting the positive end of said source to said anode and the negative end to said connected pairs of cathodes, said last-mentioned means including a load impedance.

17. A discharge device comprising a gas-filled envelope enclosing an anode and a plurality of

pairs of cathodes spaced therefrom and mounted adjacent thereto, each pair of cathodes comprising a first cathode having a discharge surface facing said anode and a second cathode having a discharge surface facing said anode greater than the surface of said first cathode, means connecting the cathodes of each pair together, a source of potential, and means connecting the positive end of said source to said anode and the negative end to said connected cathodes, said last-mentioned means including a plurality of load impedances each comprising a resistor and a condenser connected in parallel and each connected between said source and one of said connected pairs of cathodes.

18. A discharge device according to claim 17 further comprising an ionizing electrode mounted adjacent said anode and one of said pairs of cathodes and a source of potential connected to said electrode.

19. A discharge device comprising a gas-filled envelope enclosing an anode and a plurality of pairs of cathodes spaced therefrom and mounted adjacent thereto, each pair of cathodes comprising a first cathode having a discharged surface facing said anode and a second anode having a discharge surface facing said anode greater than the surface of said first cathode, means connecting the first cathode of each pair to the second cathode of the next adjacent pair, a source of potential and means connecting the positive end of said source to said anode and the negative end to said connected cathodes, said last-mentioned means including load impedances connected between each connected pair of cathodes and said source.

20. A discharge device according to claim 19 wherein said load impedances each comprises a resistor and a condenser connected in parallel.

ALEC HARLEY REEVES.

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