

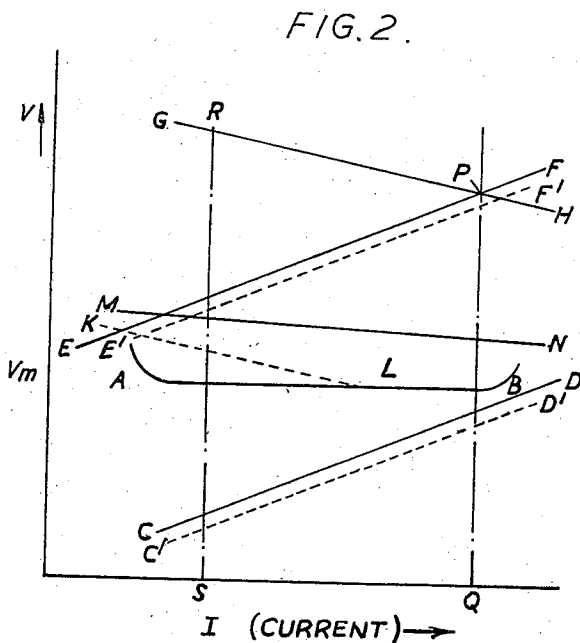
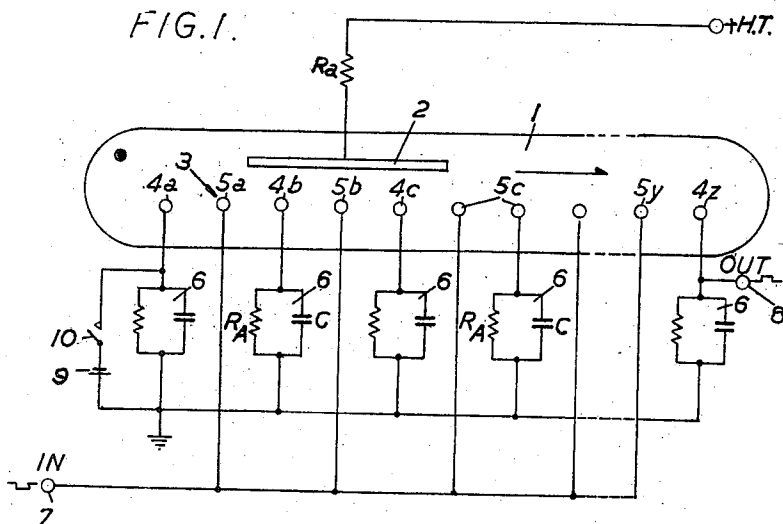
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G. H. HOUGH ET AL  
GASEOUS ELECTRIC DISCHARGE TUBE

2,686,273

Filed Dec. 29, 1951

3 Sheets-Sheet 1



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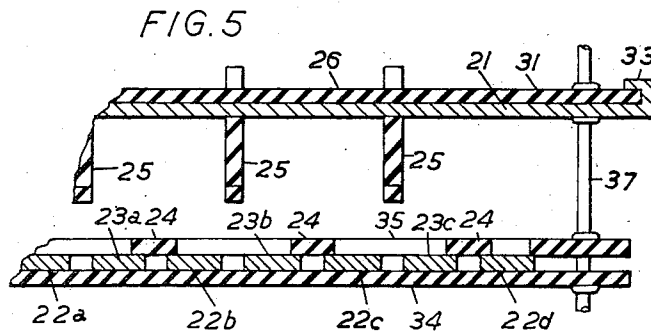
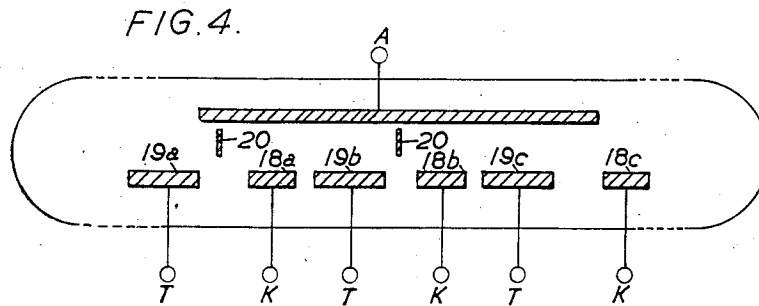
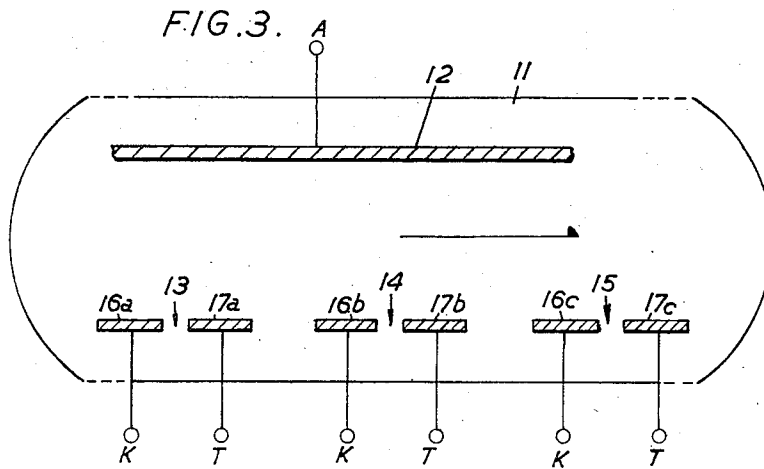
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GASEOUS ELECTRIC DISCHARGE TUBE

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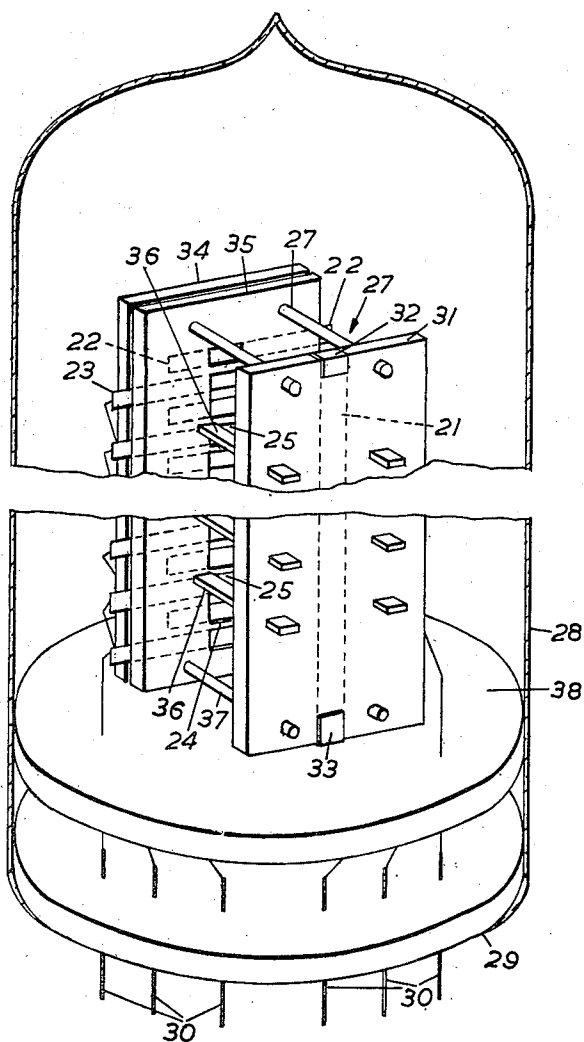
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GASEOUS ELECTRIC DISCHARGE TUBE

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3 Sheets-Sheet 3

FIG. 6.



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## UNITED STATES PATENT OFFICE

2,686,273

## GASEOUS ELECTRIC DISCHARGE TUBE

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Claims priority, application Great Britain  
January 3, 1951

5 Claims. (Cl. 313—190)

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The present invention relates to gaseous electric discharge tubes and is particularly concerned with such in which a glow discharge may be transferred from position to position along an array of discharge gaps by successive corresponding pulses.

In U. S. Patent No. 2,636,681 of A. H. Reeves issued April 28, 1953 there is disclosed and claimed a cold cathode gas filled electric discharge tube comprising separate cathode surfaces and a co-operate anode or anodes defining therewith an array of discharge gaps having substantially identical glow discharge voltage and current characteristics and being so positioned that a discharge caused at any one gap by a voltage impulse applied to all will set up a condition, due to ionisation coupling, such that the next application of a like voltage impulse will result in a discharge at an adjacent gap and the further subsequent application of another voltage impulse will result in a discharge at the gap next adjacent to the said adjacent gap in the same direction.

In the above mentioned specification the manner of operation proposed was such, that while at each successive actuating pulse a new discharge gap was fired, glow was maintained (or if temporarily extinguished, it was reestablished) at each of the preceding gaps of the array. Thus the total discharge current through the tube increased in steps with the number of gaps fired. In circuit application this mode of operation leads to difficulties, not only in view of the large variation of total discharge current which must be supplied, but also because the cumulative effect of ionisation from a number of simultaneous discharges tends to raise the general ionisation level in the discharge tube to such a value that the geometrical and circuit tolerances for more than a few gaps become very small. A preferable mode of operation is one in which a single discharge (ignoring any permanent priming discharge) is stepped from gap to gap along the tube, a new gap being fired and the previously discharging gap being extinguished by the application of successive applied pulses. Using a tube such as disclosed in the aforementioned specification, a single discharge stepping mode of operation is disclosed and claimed in U. S. application No. 100,462 of D. S. Ridler filed June 10, 1949, for "Gas Discharge Tubes and Circuit Arrangements Therefor" in which the discharge gaps of the array are sub-divided into three separate groups or sub-arrays, every second gap being connected as a gap of a storage array, the

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intervening gaps being connected as members of a pair of transfer gap arrays. The incoming pulses are applied alternately first to one and then to the other transfer gap array; a single glow discharge being maintained at one of the storage gaps may thus be stepped along to the next adjacent storage gap through the medium of a temporary discharge at the intermediate transfer gap. The transfer gaps have to be arranged in alternate groups and the pulses switched from one to the other alternately in order to avoid the discharge being sent forward one position by the application of one pulse and back again to its original position by the application of the next pulse. In order to overcome this difficulty, caused by the symmetrical ionisation coupling to either side of a discharging gap, use was next made of the invention disclosed and claimed in U. S. Patent No. 2,553,585 of G. H. Hough issued May 22, 1951, in which the cathodes of the storage array and, if desired, of an interleaved transfer array, are specifically shaped so as to provide the associated discharge gaps with unidirectional ionisation coupling features. In the tubes disclosed in the aforesaid U. S. Patent No. 2,553,585 incoming pulses are applied in common to all the gaps of the transfer array and discharge at one storage gap is transferred to the next storage gap in one direction along the array, the difference between the ionisation couplings in the forward and backward directions being sufficiently great, due to the special electrode shapings, to ensure uni-directional transfer.

Tubes such as those described above with reference to U. S. Patent No. 2,553,585 we refer to as cold cathode unidirectional sequence discharge tubes.

In order to distinguish clearly between a transient discharge, such as a spark, and a building up of a glow discharge which may be maintained, in the above discussion and throughout the present specification we say that a gap has been fired when a space charge has been built up within the gap by the discharge thereacross to such a value that glow discharge may be sustained by the continued application of an inter-electrode voltage equal to the maintaining potential for that gap. It will sometimes be convenient, for brevity, to speak of a cathode being fired, being primed or priming a further cathode; it is to be understood that in every such case it is the anode-cathode gap associated with the said cathode which is so fired or primed and that it is the discharge at that gap which primes the

anode-cathode gap associated with the further cathode.

According to the present invention there is provided a cold cathode unidirectional sequence discharge tube comprising electrodes defining an array of glow discharge gaps arranged in line in pairs in such manner that the ionisation coupling between the two gaps of each said pair has a large value while the ionisation coupling between each of two adjacent gaps not of the same pair has a smaller value than that appropriate to the shaping of the electrodes.

In such a tube, as stated above, the electrodes may be non-directional. Nevertheless the use of directional electrodes in a tube according to the present invention will provide still greater discrimination between forward and backward coupling; the consequent enlargement of circuit tolerances may, in some applications, outweigh the sacrifice of manufacturing simplicity involved.

In one mode of embodiment of the invention there is provided a cold cathode unidirectional sequence discharge tube comprising cathodes mounted in line in pairs, the separation between the cathodes of each said pair being small, the separation between adjacent cathodes not of the same pair being larger, each of the said cathodes so forming with an associated anode a discharge gap of an array each two successive adjacent gaps of which have alternately a large and a smaller value of ionisation coupling between them.

In other modes of embodiment use may be made of our discovery of the relative proportions in which photons, electrons and ions are contributory to ionisation coupling. It should be noted that in the term "ionisation coupling" we include the effects not only of the migration from gap to gap of charged particles or of photons, but also the distortion of the electric field in a gap due to the space charge in an adjoining discharge gap; should we wish to distinguish this latter type of coupling, we may refer to it as "field coupling." Ionisation coupling is measured by the reduction in the breakdown potential of a gap due to the presence of discharge at a priming gap and may conveniently be defined by the relationship

$$\phi = \frac{V_{BN} - V_{BP}}{V_{BN} - V_m} \times 100\%$$

when  $\phi$  is the ionisation coupling;  $V_{BN}$  is the normal breakdown of potential of the gap—i. e. substantially no ionization coupling;  $V_{BP}$  is the breakdown voltage of the gap when primed by the ionization coupling in question; and  $V_m$  is the maintaining voltage of the gap.

We have found that, neglecting field coupling, ionisation coupling between gaps is due to photons, electrons and positive ions in the proportions of 60%, 27.5% and 12.5% parts per cent respectively and have reason to believe, at the present time, that these relative proportions are largely unaffected by changes in electrode geometry or material or in the gaseous atmosphere employed. It will be evident therefore, that a large measure of unidirectional coupling between adjacent pairs of gaps may be obtained by shielding the light of the glow discharge between one pair of gaps but not between the others.

Accordingly the present invention provides a cold cathode unidirectional sequence discharge tube comprising cathodes mounted in line each forming with an associated anode an array of

discharge gaps and barriers mounted between alternate pairs of the said cathodes arranged to reduce the light from the cathode glow at either of the cathodes of each said pair irradiating the discharge gap associated with the other cathode of the pair.

The invention will be more fully described with reference to the accompanying drawings in which:

Fig. 1 shows a schematic circuit diagram illustrating typical working connections to a known unidirectional sequence discharge tube, which diagram is used in explaining the theory of the present invention,

Fig. 2 shows somewhat idealised graphs of various voltage current characteristics associated with the use of the tube,

Fig. 3 shows diagrammatically an electrode arrangement in a unidirectional sequence discharge tube according to the invention,

Fig. 4 shows a modification of the arrangement of Fig. 3,

Fig. 5 shows, in greater constructional detail other electrode arrangements according to the invention and is itself a fragmentary section through the electrode assembly of

Fig. 6, which shows, diagrammatically, a perspective view of a unidirectional sequence discharge tube according to the invention with dimensions, notably of thicknesses, exaggerated to show the construction.

In the schematic circuit diagram of Fig. 1 the sequence discharge tube 1 is represented as having an anode 2 and an array of cathodes 3 of which only the first few pairs and the last pair are shown. The cathodes, which according to the present invention are not necessarily unidirectional, are arranged in two groups or sub-arrays, namely an array of storage cathodes 4a, 4b, 4c, 4z. The intermediate cathodes 5a . . . 5y are arranged as a group of transfer cathodes. Each of the storage cathodes 4 are connected to ground through a resistance-capacity circuit 6 comprising a resistor  $R_k$  in parallel with a capacitance C. Anode 2 is connected through a series resistor  $R_a$  to the positive H. T. supply terminal. The transfer cathodes 5 are connected in parallel to a pulse input terminal 7. The last cathode 4z of the array is also connected to an output terminal 8. For starting or homing purposes the first storage cathode 4a may have applied to it a negative bias from the source 9 on closing key 10.

The H. T. supply voltage, the common anode resistance  $R_a$ , and the cathode resistances  $R_k$  are so chosen that a steady current  $I_k$ , say, may be maintained at any one storage gap.

The voltage-current characteristic for any of the discharge gaps in tube 1 is represented in Fig. 2 by the curve AB. By "voltage-current characteristic" is meant the relation between the voltage across a gap, i. e. between anode and cathode, and the current passing across the gap between these two electrodes over the glow discharge range of current. We have idealised the characteristic somewhat by assuming that over the greater part of the range the voltage is constant at the maintaining voltage of the gap for "normal" discharge. Towards the end B of the characteristic the voltage rises; this occurs when the whole of the available cathode surface is covered with glow, the discharge then being "abnormal." At the other end A of the characteristic, the voltage rises sharply; in this region, if the current be reduced without very consid-

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erable increase in applied voltage, insufficient ions are formed for the space charge conditions for glow discharge to be maintained.

Thus in the circuit of Fig. 1, if  $V_a$  is the anode voltage with respect to ground,  $V_m$  the maintaining voltage and  $I_k$  the cathode current,  $V_a$  is given by

$$V_a = I_k R_k + V_m \quad (1)$$

The cathode voltage  $V_k$  is represented in Fig. 2 by the straight line CD and the anode voltage by the line EF.

If the required H. T. supply voltage be  $V_b$ , we also have

$$V_a = V_b - I_k R_a \quad (2)$$

and the required value of  $V_b$  is given by

$$V_b = V_m + I_k (R_k + R_a) \quad (3)$$

Due to discharge at one storage cathode the breakdown potential of the other gaps is reduced. The effect of ionisation coupling between one storage gap and the next is represented in Fig. 2 by the curve GH, which relates the variation of striking potential of a storage gap with the discharge current at the preceding storage gap. At the point P the priming current in the discharging storage gap has caused the anode voltage to rise along the curve EF to its intersection with GH; if storage current be allowed to rise so far a second storage cathode will fire; thus the ordinate PQ may be regarded as defining the high current limit of operation of the tube. The ionisation coupling between a storage gap and the adjacent transfer gap will usually be arranged so that the breakdown potential of the transfer gap is reduced to its maintaining potential over at least a part of the range of priming currents in the storage gap. The variation of breakdown potential at a transfer gap with the discharge current at the preceding storage gap is represented by the dotted line KL for priming currents below a given value and for current in excess of this is represented by the straight portion of the curve AB i. e. it merges into the operating characteristic of the priming gap as 100% ionisation coupling is approached. The ionisation coupling between transfer gaps and storage gap when a transfer gap is discharging passing a current  $i_t$  is such that the breakdown potential  $V_{SKT}$  of the storage gap may be represented by a line such as MN whose equation is given by

$$V_{SKT} = V_m + \mu(I_t - i_t), \quad (i_t \leq I_t) \\ = V_m, \quad (i_t > I_t) \quad (4)$$

where  $\mu$  gives the slope of the line and  $I_t$  is the current corresponding to the intersection of MN and AB.

Let us assume that cathode 4b of Fig. 1 is discharging and that in consequence of a negative pulse applied to terminal 7 the transfer cathode 5b is fired and permits a constant discharge current  $i_t$  to flow through 5b. Because of the voltage drop across the anode load  $R_a$ , if  $i_t$  is less than  $I_k$ , the current conducted by cathode 4b falls suddenly to the value  $I_k - i_t$  and then tends to rise exponentially to a new equilibrium value, less than its original value, with a time constant  $1/R'C$  where  $R' = R_a R_k / (R_a + R_k)$ ; the anode voltage falls exponentially with the same time constant towards a value  $i_t R'$  less than before. Since the cathode current cannot become negative and, in fact, if it be reduced to a value less than, say,  $i_m$ , discharge thereat cannot

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not be maintained. The condition that discharge at cathode 4b will continue is

$$I_k - i_t \geq i_m \quad (5)$$

It will be noted that since  $R_k$  is greater than  $R'$ , if  $I_k > i_t$  the potential difference between the anode and cathode 4b does not fall below  $V_m$ . Thus, according to the value of the transfer pulse current, at least two modes of operation are possible, one in which the previously discharging storage cathode remains discharging at a lower current, while in the other mode the discharge at the storage cathode is extinguished. We will consider first the case where the storage cathode remains discharging.

Neglecting the contribution to the ionisation coupling of discharge at cathode 4b, the variation of striking potential of the storage gap associated with cathode 4c when primed by the discharge at 5b is represented by the curve MN of Fig. 2. Thus, the next storage gap will fire if the potential difference between anode 2 and cathode 4c (which is still at earth potential) is greater than or equal to the striking voltage for this gap. This condition reduces very simply to

$$V_{k4b} \geq \mu(I_t - i_t) \quad (6)$$

where  $V_{k4b}$  is the instantaneous voltage of cathode 4b. Allowing for a certain delay in the firing of 4c, so that the voltage of cathode 4b has fallen to some extent, we may represent the sum of this new value of cathode voltage and  $V_m$  by the dotted line E'F' shown in Fig. 2, while, if we add  $V_m$  to both sides of (6) we see that for cathode 4c to fire the operating point on the curve E'F' must be by above the operating point on the curve MN. It should be noted, however, that the curve E'F' relates to current through the storage gap while MN refers to current through the transfer gap. When cathode 4c is fired, since this cathode is initially at earth potential and its resistor  $R_k$  may be considered as momentarily short-circuited by capacitance C, the voltage of the anode 2 will momentarily be brought down to  $V_m$ . Cathode 4b, however, is still positive with respect to ground so that the potential difference between anode 2 and 4b is brought below the maintaining voltage for this gap, which, therefore, is extinguished. The voltage of cathode 4b then falls exponentially with the time constant  $1/R_k C$ . The value of the capacitance C is chosen so that during the transfer pulse the rate of increase in potential difference between anode 2 and cathode 4b is less than the rate of increase in striking potential for this gap.

At the end of the transfer pulse, discharge at the transfer gap is extinguished by removal of the pulse driving voltage and the discharge current at cathode 4c increases exponentially to the value  $I_k$ .

In the case when the transfer pulse current is sufficient to extinguish the discharge at cathode 4b, cathode 4c may still fire and continue discharging because initially it is at ground potential; the charging current of the cathode condenser will be sufficient, if the gap can be fired, to ensure that discharge continues during the transfer pulse. The condition that cathode 4c may fire during the pulse can readily be shown to be

$$I_k R_k \geq \mu(I_t - i_t) + R_a(i_t - I_k) \quad (7)$$

In Fig. 2 this condition may be interpreted as the requirement that the operating point for the storage discharge on the curve EF shall lie above

the corresponding operating point for the transfer discharge on the curve MN by a margin of not less than the voltage  $Ra(i_t - I_k)$ .

If the transfer current pulse be so large that discharge at cathode 4b is extinguished and the anode voltage is reduced below the striking potential for cathode 4c, at the end of the transfer pulse the anode will tend to rise towards the H. T. supply potential. The potential of cathode 4b is still above earth potential, but has fallen to a value  $V'_k$ , say, represented in Fig. 2 by a point on the dotted curve C'D'. Then the condition that the cathode 4c fires in preference to 4b, and therefore takes charge, is simply that the operating point on the curve MN shall lie above the corresponding point on the curve C'D'. In practice this condition is always fulfilled and it will always happen that at the conclusion of a transfer pulse, if the next storage cathode is not already conducting, it will fire in preference to the storage cathode originally discharging.

From the above discussion it will be seen that if we wish to work with small transfer pulse current, an ordinate RS may be fixed giving the lower limit of operation of the tube such that the curve EF lies above MN by a given margin. It follows therefore, that provided the tube be operated within the margins defined by the ordinates RS and PQ and provided the capacitance C be properly chosen, the transfer of discharge is unidirectional insofar as it be assumed that the correct transfer electrode is fired by the transfer pulse. So far, however, no reason has been given why transfer cathode 5b should have fired in preference to 5a when storage cathode 4b was discharging.

In order to determine which of transfer cathodes 5a and 5b shall fire on application of a transfer pulse when 4b is discharging, it is necessary to compare their respective primed breakdown voltage. Obviously it is necessary that the primed breakdown voltage of 5b be less than that of 5a. Now the breakdown voltage curve for 5b primed by 4b is the curve KLB. It is now to be recollected that, if the cathodes be non-directional, the ionisation couplings from either to the other of an adjacent pair is the same, i. e. the breakdown potential curve for 5b when primed by 4c must be the same as the breakdown potential curve for 4c when primed by 5b. The latter is represented by the curve MN. Hence, assuming similar characteristics between like pairs of adjacent gaps along the discharge array, the breakdown potential curve for 5a when primed by 4b is also MN. We thus obtain for the sufficient condition that 5b shall fire in preference to 5a, the requirement that the curve MN shall lie above the curve KLB for all storage currents in the operating range of the tube. It will be seen that the margin between MN and the working part of the characteristic AB is least at the maximum working current. Now by separating adjacent cathodes a distance less than the length of the cathode fall of potential, 100% ionisation coupling between them is automatically obtained. Hence we can arrange that the curve KLB is coincident with AB over the whole of the working range. It follows that the difference between curves MN and AB then gives us a measure of the directivity of transfer in the tube if, as is to be preferred, the difference between the forward and backward ionisation coupling between a storage gap and the adjacent transfer gap be made a maximum by providing 100% ionisation coupling in the forward direction.

In the above discussion we have shown that, using the circuit of Fig. 1, the necessary and sufficient condition for the construction of a unidirectional sequence discharge tube using non-directional electrodes, is that the ionisation coupling between a storage gap and the adjacent transfer gap in the forward direction shall be large and that the coupling between the storage gap and the rearward transfer gap shall be smaller. The most direct way of achieving the required difference in the ionisation couplings between a storage gap and the transfer gaps to either side of it is to make use of the basic principle which made the original construction of the sequence discharge tube possible, namely the decrease of ionisation coupling with increase of the distance between primed and priming gaps. This leads to a general electrode disposition such as is shown diagrammatically in Fig. 3, in which the discharge tube 11 is shown having an anode 12 and cathodes arranged in pairs of which three pairs, 13, 14 and 15 are shown. Cathodes 16a, 16b and 16c connected to terminals K are storage cathodes and 17a, 17b and 17c connected to terminals T are transfer cathodes. It is assumed that the discharge at a storage cathode is required to be transferred from left to right along the array as indicated by the arrow; thus the transfer cathode 17 of each pair is placed close to the storage cathode 16 of the same pair with a wider spacing between adjacent cathodes not of the same pair e. g. such as 17a and 16b. Using nickel electrodes in a gaseous atmosphere of 92% Ne, 1% A, 7% H<sub>2</sub> at 100 millimetres pressure of mercury, the spacing between cathodes of the same pair should be approximately 0.010 inch and between cathodes not of the same pair 0.025 inch to obtain a maximum working range of discharge currents.

In the discussion with reference to Fig. 2 it was pointed out that the upper limit of current operation of the valve is fixed by the intersection of the anode-voltage curve EF and the adjacent storage gap breakdown voltage curve GH. From the point of view of circuit tolerances it is evident that the point of intersection P should lie above the operating curve AB by as large a margin as possible; this margin may be improved at the expense of the maximum current in the tube by increasing the anode resistance  $R_a$  thus increasing the slope of EF. On the other hand an increased margin may be obtained if it is possible to increase the separation between the cathodes 16 of Fig. 3 without further increasing the separations between a cathode and the transfer cathodes to either side thereof. This may be achieved by making the transfer cathodes longer in the direction of the array than the storage cathodes, as is indicated in Fig. 4 in which storage cathodes K are indicated by the reference numerals 18a, 18b, 18c respectively and transfer cathodes are shown at 19a, 19b and 19c, the transfer cathodes being considerably longer than the storage cathodes. In this latter construction, in order to keep the transfer pulse current becoming excessive, it may be desirable to limit the transfer cathodes area by making the transfer electrodes of strip-like form and the storage cathodes in the form of plates. In this latter case the maintaining voltage of the transfer gaps, due to the more rapid ionisation diffusion favoured by a thin cathode, may be higher than for a storage gap, but this will not affect the principle of operation.

If differential spacing between adjacent cath-

ode pairs alone be relied upon, it will be found that geometrical tolerances are rather more severe than in other arrangements now to be described, for the slope of the ionisation coupling-distance curve is a maximum in the region with which we are concerned.

Further improvement in the operating tolerances of a tube employing an array such as shown in Fig. 3 can be achieved by placing curtains 20 between alternate pairs of gaps. These should be arranged so that the glow at a storage cathode cannot be "seen" by that part of the anode immediately above the adjacent storage cathode. Such a curtain hinders electrons from being drawn off from the electron cloud in the cathode dark space by the field of the anode of the other gap. The curtains may be either of insulating material or, preferably, metallic, so that they may be suitably biased to deflect electrons away from the gap it is not desired to prime.

In the fragmentary sectionalised illustration of part of an electrode assembly shown in Fig. 5, an anode 21 is shown cooperating with storage cathodes 22 and transfer cathodes 23, storage and transfer cathodes being evenly spaced from one another, the separation between adjacent cathodes being less than the length of the cathode dark space. Between adjacent pairs of cathodes, and partially overlapping them, are placed insulating barriers 24 which project towards the anode a distance of the order of the length of the cathode dark space. It follows that the cathode glow at a cathode such as 23b is masked from the adjacent cathode 22c but not from 22b. Since the cathode glow cannot be seen by the cathode surface of the adjoining gap the effect of photon coupling is negligible, while the shallow barrier has little effect upon the electronic coupling. By this means the ionisation coupling between the storage cathode 22c and the transfer cathode 23b is reduced to some 60% while that between 22c and 23c remains 100%. In the arrangement in Fig. 5 coupling between adjacent storage cathodes is reduced by means of curtains 25 of insulating material which are secured from a sheet of insulating material 26 on which the anode 21 is mounted. The curtains 25 project towards the cathode array and are spaced intermediate the barriers 24; their efficacy depends upon them being interposed between the direct path of the cathode glow of one storage cathode and that portion of the anode immediately above the adjoining storage cathode.

In Fig. 6 the constructional arrangement of a tube employing the arrangement of Fig. 5 comprises an electrode assembly 27 mounted in an envelope 28 having a glass base 29, the assembly being mounted upon leads welded to the valve pins 30. The anode 21 consists of a strip of metal bent over the ends of a sheet of insulating material 31 as indicated at 32 and 33. The cathodes 22 and 23 are formed of metallic strips clamped between an insulating sheet 34 and a mask of insulating material 35, the strips being mounted transverse to the anode strip. Rectangular slots are formed in the mask 35 in a line parallel with anode 21 so as to expose the discharge surfaces of the cathodes. Those portions of the mask 35 separating adjacent slots constitute the barriers 24, the cathode strips being arranged so that each slot exposes a pair of cathodes with a barrier 24 between adjacent pairs. Cathodes 22 project from one edge of the sandwich formed by sheet 34 and mask 35 and cathodes 23 from the other

edge. The curtains 25 are formed by bridge members 36 which are secured at right angles to the sheets 35, 36 and 31 and serve to space the anode from the cathode array. The assembly is locked together by rods 37 eyeletted to the corners of the insulating sheets. The assembly is supported upon a platform 38, locating it in the glass envelope, with the air of the wires joining the electrodes to the pins 39.

While the principles of the invention have been described above in connection with specific embodiments and particular modifications thereof, it is to be clearly understood that this description is made only by way of example and not as a limitation on the scope of the invention.

What is claimed is:

1. In a gaseous discharge device for sequentially transferring a glow discharge along a pre-selected path of similar discharge gaps preferentially in one direction; cathodes in the form of a plurality of metal strips mounted in a plane parallel to one another with substantially equal spacing between adjacent strips, an anode in the form of a metal strip mounted in a plane parallel to that of the said cathodes and at right angles to the said strip; a mask of insulating material of a thickness of the order of the length of the cathode dark space for normal glow discharge between the said anode and a said cathode mounted over the said cathode, the mask being apertured by aligned rectangular slots exposing the discharge surfaces of the cathodes, the boundaries between adjacent slots constituting the said light reducing barriers; and strips of insulating material projecting at right angles from the said anode for a distance less than the anode-cathode gap length constituting the said ionisation coupling reducing curtains.

2. A discharge tube according to claim 1 in which the said cathodes and the said anodes are mounted upon sheets of insulating material and positioned with respect to one another by a plurality of bridge shaped members of insulating material engaging both the anode and cathode supports and forming the said curtains.

3. In a gaseous discharge device for sequentially transferring a glow discharge along a pre-selected path of similar discharge gaps preferentially in one direction; a plurality of cathodes mounted so as to form with an associate anode an array of sequential discharge gaps, and shielding means mounted between pairs of said cathodes in a position to reduce the ionization coupling between the cathodes of each pair and those of the adjacent pair to a smaller value than between the cathodes of the same pair.

4. A gaseous discharge device according to claim 3 wherein said shielding means comprises curtains extending from the anode between a pair of gaps to a point above the cathodes and substantially between them.

5. A gaseous discharge device according to claim 3 wherein said shielding means are insulating barriers bridging the adjacent cathodes of successive pairs and extending towards the cathode a distance of the order of the length of the cathode dark space.

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