April 22, 1952 A. H. REEVES 2,593,486

ELECTRIC DISCHARGE TUBE

Filed June 5, 1948 3 Sheets-Sheet 1

FIG. 1.

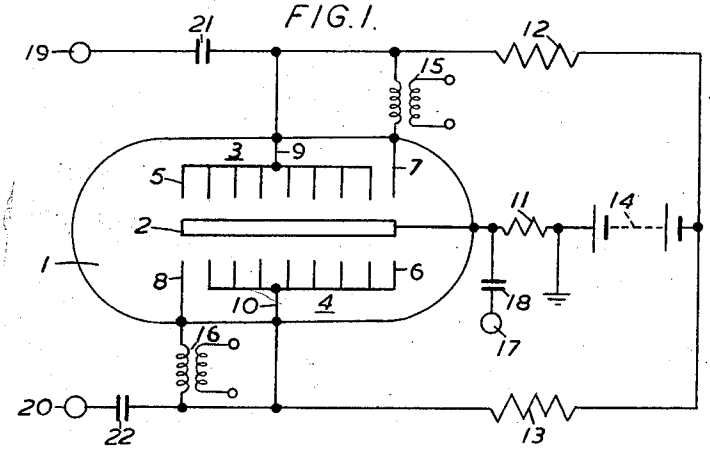


FIG. 2.

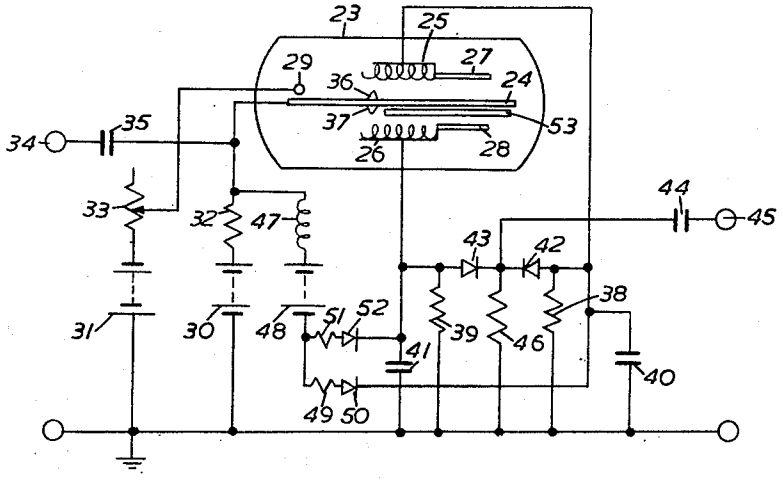
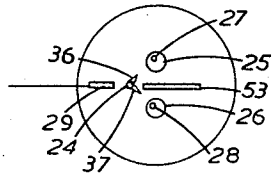


FIG. 3.



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ELECTRIC DISCHARGE TUBE

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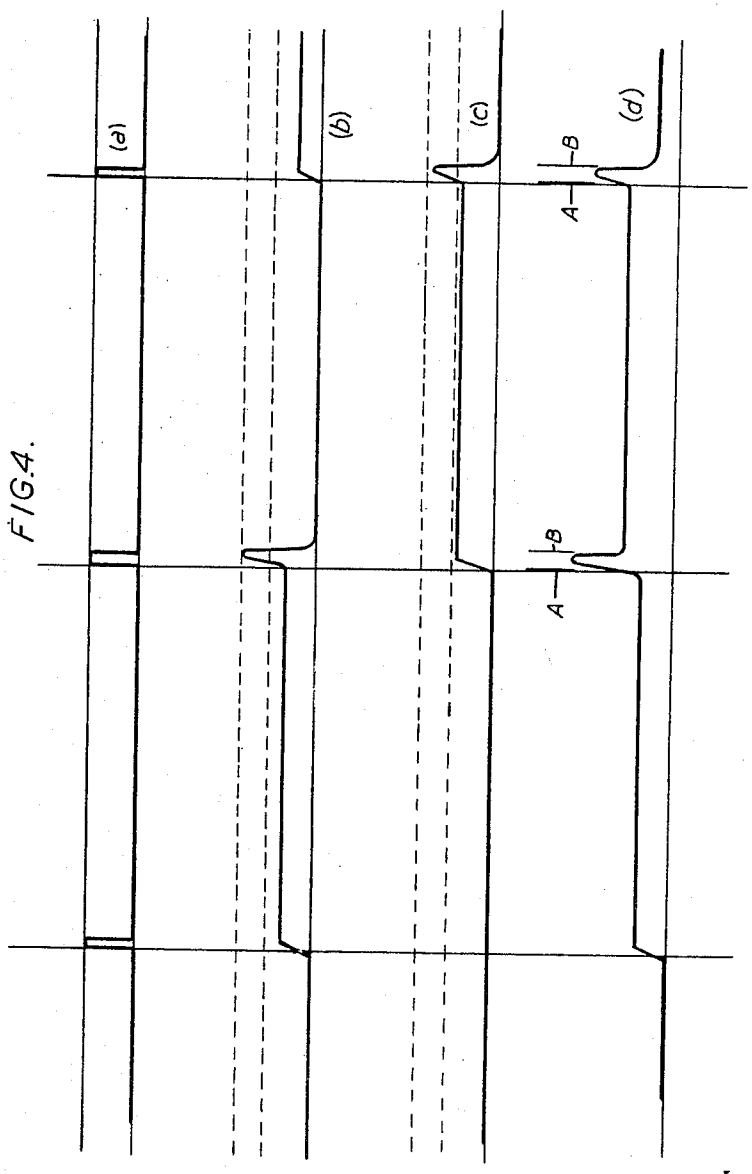


FIG.4.

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ELECTRIC DISCHARGE TUBE

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FIG.5.

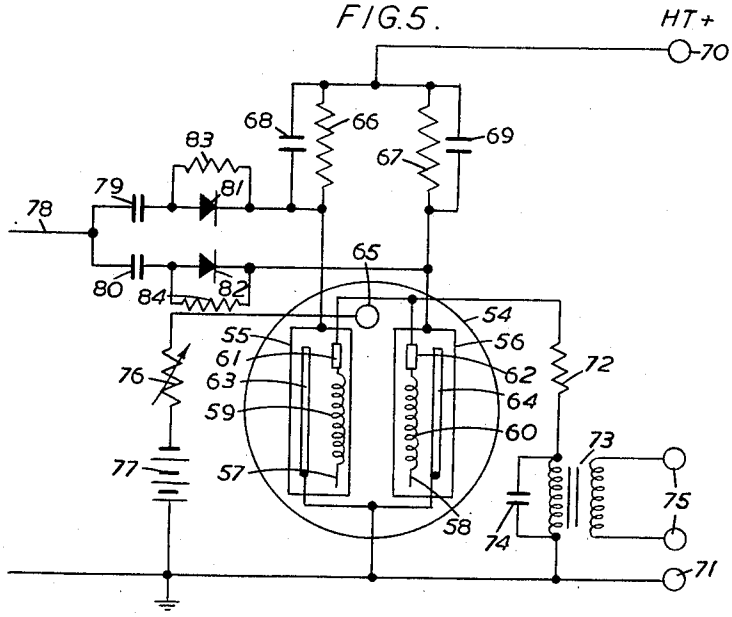
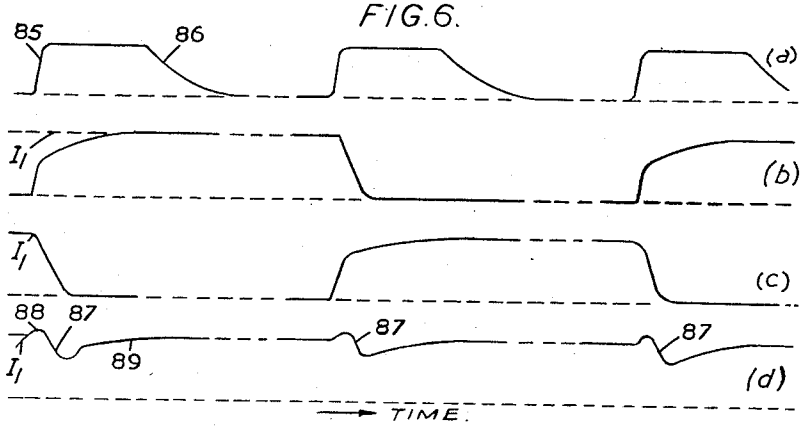


FIG.6.



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Patented Apr. 22, 1952

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UNITED STATES PATENT OFFICE

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ELECTRIC DISCHARGE TUBE

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In Great Britain June 5, 1947

19 Claims. (Cl. 250—27)

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The present invention relates to cold cathode gas filled electric discharge tubes of the sequence discharge type, and to integrating or storage circuit arrangements employing such tubes. By "sequence discharge tube" we mean a gas filled tube having a plurality of gaps arranged in an ordered array and adapted to be made to discharge consecutively in order due to ionisation coupling between adjacent gaps in said array. Such devices are described in the specifications of my co-pending applications bearing Serial Numbers 763,655 and 14,184, and filed July 25, 1947, and March 11, 1943, respectively. Individual gaps may be caused to discharge—or "fire"—in response to corresponding pulses in a pulse-train, or, by reason of the finite time of spread of ionisation—they may be fired automatically after a first gap has been fired as the spreading ionisation reduces the striking potential for—or "primes"—successive gaps to the potential of an applied battery or other quasi-steady voltage.

In devices of the aforementioned type, the discharge from the gaps of a given array may be maintained indefinitely by means of a steady applied voltage which will prevent the inter electrode voltages of the gaps from falling below the maintenance potential for the tube. In such cases, before a new sequence of discharges can be initiated, those already present must be extinguished. Various means for extinguishing the discharges are described, for example, in the specification of my co-pending application bearing Serial Number 777,815 and filed October 3, 1947, now U. S. Patent No. 2,516,915 dated August 1, 1950, and in U. S. Patent No. 2,517,599 issued to me on August 8, 1950. For the greater part these rely upon a "squeg" action, analogous with the phenomenon employed in relaxation oscillators. For this reason, coupled with the comparatively long de-ionisation times often required in gas tubes, a considerable delay may occur between the quenching of discharges in a tube and re-establishment of the initial ionisation conditions to permit a second discharge sequence to take place. Thus in many circuits it would be necessary to use two tubes alternately. Applicant has found, however, that it is often possible to use instead of two or more distinct tubes, a single tube containing a plurality of separate discharge arrays, and that, due to the ionisation coupling between arrays, much simpler circuits are possible than with separate tubes.

According to the present invention, there is provided a cold cathode sequence discharge tube comprising within a gas-filled envelope, a plural-

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ity of discharge arrays, arranged so that discharges may occur in sequence along each array, said discharge sequence commencing at different times in a given order for the respective arrays.

According to another aspect, the invention provides an electric pulse storage circuit comprising a cold cathode gas-filled electric discharge tube having a discharge gap formed by two extended electrodes arranged substantially parallel to one another, means for applying to the gap a maintaining potential which is insufficient to initiate a discharge across the gap, means for applying a pulse to strike a discharge at one end of the gap, the arrangements being such that the said discharge spreads along the electrodes for a distance depending on the energy content of the pulse, and then remains fixed after the disappearance of the pulse, and means for deriving an output current from the said gap, the magnitude of which current depends on the energy content of the pulse.

Embodiments of the invention will be described having reference to the accompanying drawings in which:

Fig. 1 illustrates diagrammatically a discharge tube according to the present invention in a simple circuit to explain its manner of operation, and;

Fig. 2 is a schematic circuit diagram of a pulse de-modulating arrangement according to the invention for use in a pulse communication system and employing another type of tube according to the present invention;

Fig. 3 shows an end view of the tube used in Fig. 2;

Fig. 4 shows curves used to explain the operation of Fig. 2;

Fig. 5 shows a schematic circuit diagram of a pulse demodulating circuit for demodulating time-duration modulated pulses in a multi-channel electric pulse communication system, utilising another type of tube according to the present invention; and

Fig. 6 shows a diagram used to explain the operation of Fig. 5.

In Fig. 1 the gas filled tube 1 comprises an anode 2, in the form of a rod or wire, and two cathode arrays 3 and 4. Each of these arrays comprises a plurality of individual cathode rods of which an end rod 5 of array 3 and an end rod 6 of array 4 is slightly longer than the others to form a shorter starting gap for the sequence discharges. The gap opposite 5 is shorter than that opposite 6. All the cathodes, except the end rods 7 and 8 of the respective arrays 3 and 4 are

joined to common wires or bars 9 and 10. The gap lengths for all gaps except 5 and 6 are the same, say 2. m. m., while the spacings between gaps are also substantially the same.

The anode 2 is shown connected to ground through resistance 11, while the common cathode bars 9 and 10 are connected through resistances 12 and 13 respectively to the negative pole of battery 14, whose positive pole is grounded. Cathodes 7 and 8 are connected through pulse transformers 15 and 16 respectively to the respective cathode wires 9 and 10. Positive input pulses may be applied at terminal 17 through condenser 18 to anode 2 and extinguishing pulses may be applied through terminals 19 and 20 and condensers 21 and 22 to cathode arrays 3 and 4 respectively.

Assume now that a train of positive pulses is applied to terminal 17. The amplitude of these pulses should not be sufficient to fire any gap except that opposite starting cathode 5 in the absence of ionisation, while the battery 14 must also provide insufficient voltage to fire any gaps in the absence of pulses at 17, but must maintain discharge when once established. By the time the second pulse arrives, ionisation from the starting gap will have reduced the striking potential for the second gap to a value equal to or less than the combined pulse and battery voltage. This gap therefore fires, and in similar manner the other gaps of the array 3 fire in succession on consecutive pulses. When cathode 7 fires, the discharge current therefrom passes through the primary winding of transformer 15; an output pulse is thereby fed to a further circuit to operate, say, a further dividing circuit and also to trigger a device, not shown, to apply to terminal 19 a positive pulse sufficient to extinguish all discharges at array 3. Meanwhile, the next pulse at terminal 17 causes the gap opposite starting cathode 6, to fire; this now having been ionised from the discharges at array 3 and in particular from the gap opposite cathode 7. The sequence of discharges then continues from right to left along array 4, at the end of which cathode 8 fires, a pulse is delivered from transformer 16 and a positive extinguishing pulse is applied to terminal 20. For the mode of operation described above, the extinguishing pulse at terminal 19 must be of sufficient duration to prevent the starting gap opposite cathode 5 from firing before the second discharge sequence has been concluded.

Alternative manners of use of the tube of Fig. 1 will occur to those skilled in the art. Not all modes of operation will be possible with identical tubes, but factors such as the spacings between the cathode arrays and the nature and pressure of the gas may be varied. In particular, it may be desirable to have the starting cathode 6 and the cathode 8 of array 4 interchanged in position. Another alternative mode of operation which may find application would be so to arrange the gap spacings of array 4 that after a certain number of gaps of array had fired, a discharge sequence proceeded automatically along array 4, in the manner described in the specification of the aforementioned co-pending application bearing Serial Number 14,184 and filed March 11, 1948. Again, it could readily be arranged so that the extinguishing pulse at terminal 19 was not applied until the discharge sequence had proceeded some distance along array 4.

Some examples will now be given of circuits employing cold cathode gas-filled electric discharge tubes according to the invention.

The storage circuit shown in Fig. 2 is designed for demodulating a train of pulses whose durations are modulated in accordance with a signal to be conveyed by the train. It is to be noted that the pulses may be repeated at irregular intervals without affecting appreciably the operation of the circuit.

In Fig. 2 there is shown a gas-filled discharge tube 23 having an anode rod 24 and two similar cathodes 25 and 26 of helical shape. These two cathodes are equally spaced from the anode, which should preferably be displaced behind the plane containing the axes of the helices, as shown in Fig. 3. Each turn of the helix provides a separate discharge gap to the anode, and the glow discharge may be prevented from spreading round each turn by coating the helix (except at points on a straight line opposite the anode) with a material which has insulating properties or which raises the work function of the surface. Alumina is a suitable material and has both these properties.

The right-hand ends of the helices terminate in plain rods or strips 27 and 28 which are spaced from the anode 24 by the same distance as the uncoated points of the corresponding helices.

A permanently discharging ionisation control cathode 29 is provided, and is connected to the anode through batteries 30 and 31 in series with a common anode load 32 and variable resistor 33, for control and stability purposes, as described in the specification of another of my co-pending applications bearing Serial Number 19,084, filed April 5, 1948, now U. S. Patent No. 2,520,171 dated August 29, 1950. To make the construction clear, the tube in Fig. 2 has been slightly rotated; the cathode 29 is actually directly behind the anode 24, as shown in Fig. 3. Duration-modulated pulses are intended to be applied to terminal 34 which is connected to the anode 24 through a blocking condenser 35. The anode 24 is provided at the left-hand end with two projecting discharge points 36 and 37 directed towards the cathodes 25 and 26, as shown more clearly in Fig. 3. The gap between the point 36 and the cathode 25 should be slightly smaller than the other gap between the point 37 and the cathode 26.

The cathodes 25 and 26 are connected to the negative ground terminal of the battery 30 through resistances 38 and 39, shunted respectively by condensers 40 and 41, and also through respective rectifiers 42 and 43 and a common blocking condenser 44 to an output terminal 45. The common point of the rectifiers is connected to ground through a resistance 46.

The potential of the battery 30, and the nature and pressure of the gas, the nature of the electrodes surfaces, and the gap between the point 36 and the cathode 25 should be such that in the absence of any applied pulses, no glow discharge is produced (besides the control discharge to the cathode 29). A suitable positive signal pulse applied to terminal 34 with respect to ground, should be capable of starting a discharge between the left-hand end of cathode 25 and the projecting point 36 on the anode 24. Current from cathode 25 will then flow to ground through resistor 38.

During the period of this first pulse, the ionisation glow will rapidly spread from left to right along the helix 25; but the conditions should be so chosen that before the glow reaches the right-hand end of the helix the pulse has disappeared.

Battery **30** should be capable of maintaining this glow at whatever point on the helix has been reached, and the cathode current at a corresponding value depending on the pulse duration and amplitude.

When the second signal pulse arrives at terminal **34**, two things occur at once:

(1) The glow will start to spread further from left to right along cathode **25**, starting where it left off, and

(2) Owing to the ionisation coupling between cathodes **25** and **26** a glow will be struck between the left-hand end of cathode **26** and anode point **37**.

When the glow on cathode **25** reaches the smooth rod **27**, it will spread very rapidly along it, the corresponding rapid increase of current can be made to cause a squeg between cathode **25** and the anode **24**, on account of resistor **38** and the small condenser **40** which shunts it. Cathode current from **25** is thus very quickly shut off. This extinguishing squeg operation is described in the specification of my said U. S. Patent No. 2,517,599.

The nature of a squeg or extinguishing action although its use is well known, may perhaps, warrant a brief approximate explanation.

Consider a cold cathode discharge tube within a gas-filled envelope having its electrodes across a source of potential. Assume that the potential source may be raised continuously from some level well below the discharge-maintaining potential of the tube. Initially, for low voltages, negligible current will flow between the tube electrodes. What minute current does flow is merely due to free electrons which are normally present. Negligible ionization takes place. As the potential is raised and depending upon the spacing of the electrodes from each other, the pressure and nature of the gas filling and the material of the electrodes, the current will remain minute until the striking potential for the gap between the electrodes is reached. Ionization of the gas then sets in and a discharge between the electrodes takes place. If a resistance is serially connected between the potential source and the discharge gap defined by the tube electrodes, and if the value of such resistance is large enough in relation to the potential of the source, as soon as the discharge takes place, the resistance will limit the discharge current to a value below that which is sufficient to produce enough ionization to maintain the discharge and the tube is extinguished or squegged.

The operation of the circuit will be explained with reference to Fig. 4.

The signal pulses are shown as duration modulated in curve (*a*) of Fig. 4, and the resulting current of cathode **25** is shown in curve (*b*).

The current of cathode **26** will rise to, and remain at, a value depending on the duration and amplitude of the second signal pulse—as shown in curve (*c*) of Fig. 4.

The third signal pulses causes the cathode **26** to squeg and shut itself off, while the current of cathode **25** rises again to a new value depending on the duration and amplitude of this third signal pulse. An alternate action thus takes place between the two cathodes **25** and **26**, one or other of the cathode currents remaining at a constant level, until the next pulse arrives, depending on the duration and amplitude of the immediately previous pulse. Voltage from the two cathode circuits added together is fed to the common output resistor **46**, Fig. 2, through rectifiers **42** and **43**, the latter being connected as shown so that the cathode voltages (always positive to ground) cannot react on each other. The total output voltage is shown in Fig. 4 (*d*); it can be obtained from terminal **45** through blocking condenser **44**. If the period between successive pulses is large so that the cathodes have to store the information about the pulse for a long time, the condenser **22** may be omitted and replaced by a direct connection.

If the overlap area A to B of Fig. 4 (*d*) be neglected, it is clear that the signal frequency components of the output voltage at **45** will be independent of the pulse recurrence frequency, and will depend only on the modulation characteristic.

With the conventional demodulation systems, where the current from each pulse is simply integrated, if the recurrence frequency is doubled the output current is doubled. In multichannel pulse communication systems where the total pulse displacement depends on the momentary sum of the signal amplitudes, as in the pulse period modulation system described in the specification of the co-pending application of P. K. Chatterjea-A. H. Reeves bearing Serial Number 756,262 and filed June 21, 1947, this would result in very serious cross talk between channels—which is eliminated by the circuit arrangement of Fig. 2.

In practice, the overlap area A—B of Fig. 4 (*d*) can in fact often be neglected when the pulse duration and collapse time are small compared with one (average) period between pulses. When this is not the case, other means have to be adopted to eliminate the bad effect of this area, as explained in the last mentioned specification.

Pulse choke **47**, battery **48** and the resistor-rectifier pairs **49**, **50** and **51**, **52** may be used to stabilise partially the voltage between the anode and cathodes **25** and **26** respectively, without eliminating the input pulses as described in the specification of another of my co-pending applications bearing Serial Number 19,086, and filed April 5, 1948, now abandoned.

It should be added that when the squeg occurs for extinguishing one half of the tube, there may be a tendency for the large amount of ionisation produced by the squeg to cause the whole of the other cathode also to discharge. To prevent this a sheet of mica **53** (which is really in front of the anode **24** in the view shown in Fig. 2) may be included in the tube between the two rods or strips **27** and **28** and extending nearly but not quite to the points **36** and **37**, for the purpose of cutting off the ionisation coupling except just in the region where it is required to produce the alternate operation of the two halves of the tube.

Fig. 5 shows a modified form of the tube shown in Figs. 2 and 3, employed in another storage circuit designed for demodulating time-duration modulated pulses, and suitable for use in a multichannel pulse communication system.

It will be assumed that the time-duration modulated pulses corresponding to the various channels have been separated out by conventional arrangements, and that a single train of channel pulses will be applied to the demodulating circuit of Fig. 5.

It will be clear that the time-duration modulated pulses might have been originally derived from time-phase modulated pulses by known methods.

The principal element in the circuit of Fig. 5 is a cold cathode gas filled discharge tube 54, which has in the same envelope two similar sets of electrodes. Each of the anodes 55, 56 comprises a rectangular metal plate, and spaced therefrom is a principal cathode 57, 58 which consists mainly of a helix 59, 60 of wire having at one end a small plate 61, 62. This helix will generally be arranged parallel to the corresponding anode 55 or 56, but may be inclined thereto at a small angle. An additional extinguishing cathode 63, 64 is formed from a straight strip or rod arranged parallel to the anode, though it need not be parallel to the helix.

The shortest gap between the two corresponding cathodes 57, 63 or 58, 64 should be about equal to the shortest gap between the two principal cathodes 57 and 58, and the shortest gap between the extinguishing cathode 63 or 64 and the corresponding anode 55 or 56 should be about equal to the shortest gap between either of the principal cathodes and the anode 56. As will be explained later, the plates 61 and 62 are provided to ensure a stable initial discharge and should be spaced from the corresponding anodes by a distance equal to the distances therefrom of the corresponding active points of the helices.

The tube 54 may likewise be provided with a permanently discharging ionisation control cathode 65 which should preferably be placed at the upper end of the principle cathodes, slightly nearer to the plate 61 than to the plate 62, and forms the cathode of an auxiliary primary discharge gap. This ensures that the discharge strikes at the upper ends of these cathodes, and first on the cathode 57. Alternatively, instead of providing the cathode 65, the cathodes 57 and 58 may be placed slightly nearer to the anodes 55 and 56 respectively, at the upper ends. The anodes 55 and 56 are connected through resistances 66 and 67 shunted by condensers 68 and 69 to the positive terminal 70 for the high tension operating source for the tube, and the cathodes 63 and 64 are connected directly to the earthed negative high tension terminal 71. The cathodes 57 and 58 are both connected to ground through a resistance 72 and the primary winding of the output transformer 73, which winding is shunted by a high frequency by-pass condenser 74. The secondary winding of the transformer is connected to the output terminals 75.

The ionisation control cathode 65 is connected through an adjustable resistance 76 to a grounded negative direct current source 77.

The duration modulated pulses shown in curve (*a*) Fig. 6 are applied to the demodulator circuit Fig. 5, over conductor 78 which is connected to each of the anodes 55 and 56 over individual circuits comprising blocking condensers 79 and 80 connected in series with rectifiers 81 and 82 shunted respectively with resistance 83 and 84. These rectifiers are used to prevent the anodes from reacting upon each other through the input circuits and should be directed as shown so that they do not impede positive applied pulses.

The arrangements should be such that with a permanent discharge to the cathode 65, the voltage of the high tension source is insufficient to start any other discharge, but should be capable of maintaining a discharge when once started. The leading edge 85 of the first of the pulses shown in Fig. 6 curve (*a*) is applied to the two anodes over conductor 78 and because the ionisation control electrode 65 is nearer the plate 61, a discharge is started from this plate, which thus

functions as a starting cathode. By suitably adjusting the resistance 72, a discharge to the other plate 62 may be prevented, by producing a condition which would be unstable if both cathodes were discharging. As the potential applied to the anode 55 by the leading edge 85 increases, the discharge progressively spreads along the helix 59 by jumping from turn to turn, and this spreading continues for the duration of the applied pulse and until at some point such as 86 in the trailing edge, the applied potential has fallen to a point at which no further spreading is possible. The corresponding current flowing through the transformer 73 from the cathode 57 therefore increases to a maximum value I_1 and then remains constant as shown in Fig. 6, curve (*b*).

When the next pulse arrives over conductor 78 the leading edge is now able to start a discharge from the extinguishing cathode 63 because the striking voltage has been lowered by the discharge from the neighbouring cathode 57. When this new discharge starts, it extends rapidly over the surface opposite the anode 55. The resulting increase in the current flowing through the resistance 66 charges the condenser 68, and as a result of the negative slope of the resistance of the gap caused by the spreading of the discharge, the condenser potential is sufficient to extinguish the whole of the discharge from the anode 55. A brief pulse of cathode current flows directly to ground from the cathode 63. This pulse is not required in this circuit, but could be utilised, if desired, by connecting a pulse transformer (not shown) in series with the common ground connection of the cathodes 63 and 64.

Owing to the recent discharge from the cathode 57 the striking voltage of the cathode 58 is lowered sufficiently to permit the leading edge of the second pulse (which has just extinguished this discharge) to start a discharge from the plate 62 which then spreads along the helix 60 in the same way as in the case of the helix 59. The cathode current flowing through the transformer 73, is then shown in Fig. 6, curve (*c*), which is the same as curve (*b*) but shifted one signalling period to the right. The third pulse of curve (*a*) then starts a discharge from the cathode 64 which extinguishes both discharges by the squegger effect as before. This third pulse also starts the discharge again from the plate 61 and the cycle is repeated. Thus, the two sections of the tube 54 operate on alternate pulses applied over conductor 78.

The total current through the transformer 73 is then the sum of the currents represented by curves (*b*) and (*c*) of Fig. 6, and will be shown in curve (*d*). This current remains at the value I_1 except for the small local irregularities 87 which are due to the imperfect compensation of the ionisation and extinguishing curves of the cathodes 57 and 58.

It will be evident that since the value of I_1, which is ultimately reached by the total cathode current, depends on the duration of the pulses of Fig. 6, curve (*a*), it will also depend on the instantaneous amplitude of the corresponding modulating signal. In other words, if this amplitude increases (or decreases) as a result of the modulation, the current I_1 will likewise increase (or decrease). It follows that the modulating signals can be obtained from the output terminals 75.

The local irregularities 87 each comprises a slight initial hump 88 due to the fact that the initial rise of the cathode current is steeper than

the initial fall at the commencement of extinction. There is also a period at **89** which corresponds to the period over which the cathode current is still slowly increasing before the point **86** on curve (*a*) of Fig. 6.

The local irregularities **87** are small, and their effect on the demodulated signal will usually be inappreciable, particularly in a multi-channel system with a large number of channels in which the interval between successive pulses of any given channel is large compared with the period occupied by each local irregularity.

It should be noted that the plates **61** and **62** of the cathodes **57** and **58** could be omitted, the helices **59** and **60** being extended to the end provided that the modulation depth does not exceed about 40%. In this case it is usually possible to arrange the potential of the operating source and the other conditions so that the discharge is stably maintained over any section of the helices for the duration of the signalling period. The use of the plates **61** and **62** however, renders it easier to produce a stable condition, and if the area of the plate is for example 60% of the total active area of the whole cathode including the helix, then 60% of the maximum cathode current will be reached in a very short time by the rapid spread over the smooth surface for the plate. Thus the cathode current is always initially at least 60% of the maximum and then it is possible to arrange so that the combined potential drops in the resistances **66** and **67** do not interfere with the stable operation of the tube.

It should be noted also that if the storage time required is small, say, less than 50 microseconds, the cathodes **57** and **58** could be plain plates, over which the discharge will spread rather rapidly. The use of the wire helices (or other forms of rough or corrugated surfaces) make it possible for lower spreading rates to be obtained.

The following table gives details of a suitable tube **54**:

Gas filling and electrode material	90% Ne, 7% A, 3% H, at a total pressure of 100 mm. Hg.
Spacing between anode 55 or 56 and cathode 57 or 58 or cathode 63 or 64	5 millimetres.
Spacing between cathodes 57 and 63 or 58 and 64	5 to 10 millimetres.
Length of helix 59 or 60	About 30 millimetres.
Number of turns of helix 59 or 60	At least 100.

It will be evident that the combined output current from the cathodes **57** and **58** is substantially proportional to the duration of the pulses applied to conductor **78**, and this output current is also not appreciably dependent on the repetition frequency of the pulses.

The pulses could arrive at irregular intervals. A single pulse is sufficient to provide a permanent indication of its duration. It will be evident therefore that the arrangement has both integrating and storage features.

What is claimed is:

1. An electric pulse integrating circuit comprising a cold cathode gas filled electric discharge tube having an anode and two similar cathodes arranged substantially parallel to the anode and forming therewith two extended discharge gaps in ionisation coupling relation, each of said cathodes having a portion presenting a large discharge surface to said anode, means for applying to each of the gaps a maintaining potential which is insufficient to initiate a discharge across either gap, means for applying a train of pulses in positive sense to the anode in

such manner that the first pulse strikes a discharge at one end of one of the gaps which spreads along the corresponding cathode for a distance depending on the energy content of the pulse, and then remains fixed after the disappearance of the pulse, and in such manner that the second pulse extends the said discharge further along the cathode to said portion presenting a large discharge surface, thereby producing an extinguishing squeg, and also strikes a discharge at one end of the other gap which spreads along the corresponding cathode for a distance depending on the energy content of the second pulse and then remains fixed after the disappearance of the second pulse, and in such manner that succeeding pulses produce alternate operations of the two cathodes in like manner, and means for deriving from the said discharge gaps an output current which varies in accordance with the variations in the energy content of the pulses of the train.

2. A circuit according to claim 1 in which each cathode is connected to the source of the maintaining potential through a resistance, and also the anode of a rectifier, the cathode of which is connected to an output circuit common to the two cathodes.

3. A sequence discharge tube comprising a plurality of electrode arrays, each array comprising two spaced electrode systems, said systems forming therebetween a plurality of voltage responsive discharge paths and at least one of said systems comprising an electrode having a spacing with respect to another electrode system, which is less than the spacing of the other electrodes of said one system with respect to said other system for reducing the voltage required to produce a discharge in one of said paths, means for mounting one array adjacent another and with one discharge path of said one array within the discharge field of said other array and a gas-filled envelope enclosing said arrays.

4. A sequence discharge tube according to claim 3 wherein the electrode terminating said one discharge path of said one array within the discharge field of said other array has a closer spacing with respect to the other electrode system than the other electrodes of said one array but a larger spacing than said closer spaced electrode in said one electrode system.

5. A sequence discharge tube according to claim 3 wherein the electrode terminating one end of said one discharge path of said one array within the discharge field of said other array has a spacing with respect to the other electrode system of said one array which is less than the spacings of the other electrodes of said one array.

6. A sequence discharge tube comprising a plurality of electrode arrays, each array comprising two spaced electrode systems, said systems forming therebetween a plurality of voltage responsive discharge paths and at least one of said systems comprising means for reducing the voltage required to produce a discharge in one of said paths, means for mounting one array adjacent another and with one discharge path of said one array within the discharge field of said other array, a shield mounted between the other discharge paths of said one array and the discharge field of said other array and a gas filled envelope enclosing said arrays.

7. A sequence discharge tube comprising a plurality of electrode arrays, each array com-

prising two spaced electrode systems and at least one of said systems comprising a plurality of spaced electrodes, at least one of said electrodes having a spacing with respect to the other system which is less than the spacing of the other electrodes of said one system with respect to said other system, means for mounting one array adjacent another and with the path between one of the electrodes and the other electrode system within the discharge field of said other array and a gas filled envelope enclosing said arrays.

8. A sequence discharge tube according to claim 7 wherein said one electrode terminating one end of said path has a spacing with respect to the other electrode system which is less than the spacing of the other electrodes of the system of which said one electrode is a part.

9. A sequence discharge tube according to claim 8 wherein the path between the closer spaced electrode and the other electrode system is located within the discharge field between the closer spaced electrode of the other array and its other electrode system.

10. A sequence discharge tube according to claim 7 wherein said one electrode terminating one end of said path has a spacing with respect to the other electrode system which is less than the spacing of the other electrodes of the system of which said one electrode is a part and wherein the path is located with the discharge field of the other array but remote from the closer spaced electrode of the other array.

11. A sequence discharge tube comprising an anode, a pair of helical cathodes mounted symmetrically with respect to the anode and with the axes of the helices substantially parallel to said anode, the spacing of one portion of each cathode with respect to the anode being less than the other portions of the cathodes but one spacing being greater than the other, a conductive extension connected to the end of each cathode, an auxiliary priming electrode adjacent said anode and a gas filled envelope enclosing said anode, cathodes and electrode.

12. A sequence discharge tube according to claim 11 further comprising a screen mounted between said cathodes.

13. A sequence discharge tube according to claim 11 comprising projections of unequal length on said anode.

14. A sequence discharge tube comprising a pair of anode plates, a pair of helical cathodes mounted adjacent each plate, a pair of extinguishing cathodes mounted adjacent said helical cathodes, electrode means adjacent a portion of one of said helical cathodes for initiating a discharge between said helical cathode and its associated plate in preference to a discharge between the other helical cathode and its associated plate, and a gas filled envelope enclosing said plates, cathodes and electrode means.

15. A sequence discharge tube according to claim 14 wherein said electrode means comprises an electrode connected to the helical cathode and an auxiliary priming electrode mounted closer to said last mentioned electrode than to the other electrical cathode.

16. A sequence discharge tube comprising a gas filled envelope, a pair of discharge electrodes each comprising a plurality of discharge projections, one of said projections being longer than the others of said projections, and an electrode mounted adjacent the ends of said projections.

17. An electric pulse measuring circuit comprising a gas filled electric discharge tube having a discharge gap formed by two extended electrodes arranged substantially parallel to one another, means for applying to the gap a potential which is sufficient to maintain a discharge across the gap after such discharge has been initiated but which is insufficient to initiate a discharge across the gap, means for initiating a discharge at one portion of the gap, means for applying a pulse to said gap to strike a discharge at said portion of the gap, the arrangements being such that said discharge spreads along the electrodes for a distance depending on the energy content of the pulse and then remains fixed after the disappearance of the pulse, means for deriving an output current from said gap, and means for extinguishing the discharge across said gap after the pulse has terminated.

18. A pulse measuring circuit comprising a gas discharge tube having a discharge gap formed by a pair of electrodes each comprising a plurality of discharge projections, an electrode mounted adjacent the ends of said projections, means for initiating a discharge between one portion of one of said discharge electrodes and said second mentioned electrode in preference to a discharge between another portion of said discharge electrode, a discharge between one projection of said electrode conditioning an adjacent projection for discharge at a potential lower than that required for more remote projections, means for applying pulses having an amplitude sufficient to operate said initiating means and to cause a discharge at a projection adjacent another projection at which a discharge is already in existence but otherwise of insufficient amplitude to cause a discharge between said electrodes to said electrodes, means for applying between the discharge electrodes and said second mentioned electrode a potential which is insufficient to initiate a discharge between the electrodes but which is sufficient to maintain a discharge between the electrodes once the discharge has been initiated, and an output circuit connected between said electrodes.

19. A pulse measuring circuit comprising a gas filled tube including a pair of electrodes each comprising a plurality of discharge projections, one of said projections being longer than the others of said projections and an electrode mounted adjacent the ends of said projections, means for applying pulses to said discharge electrodes and the other of said electrodes for producing a discharge therebetween, an output circuit connected between said discharge electrodes and the other of said electrodes and means for terminating said discharge.

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