Feb. 16, 1960 C. H. HOEPPNER ET AL 2,925,491

TIME BASE CONTROL CIRCUIT

Filed Feb. 27, 1946

3 Sheets-Sheet 1

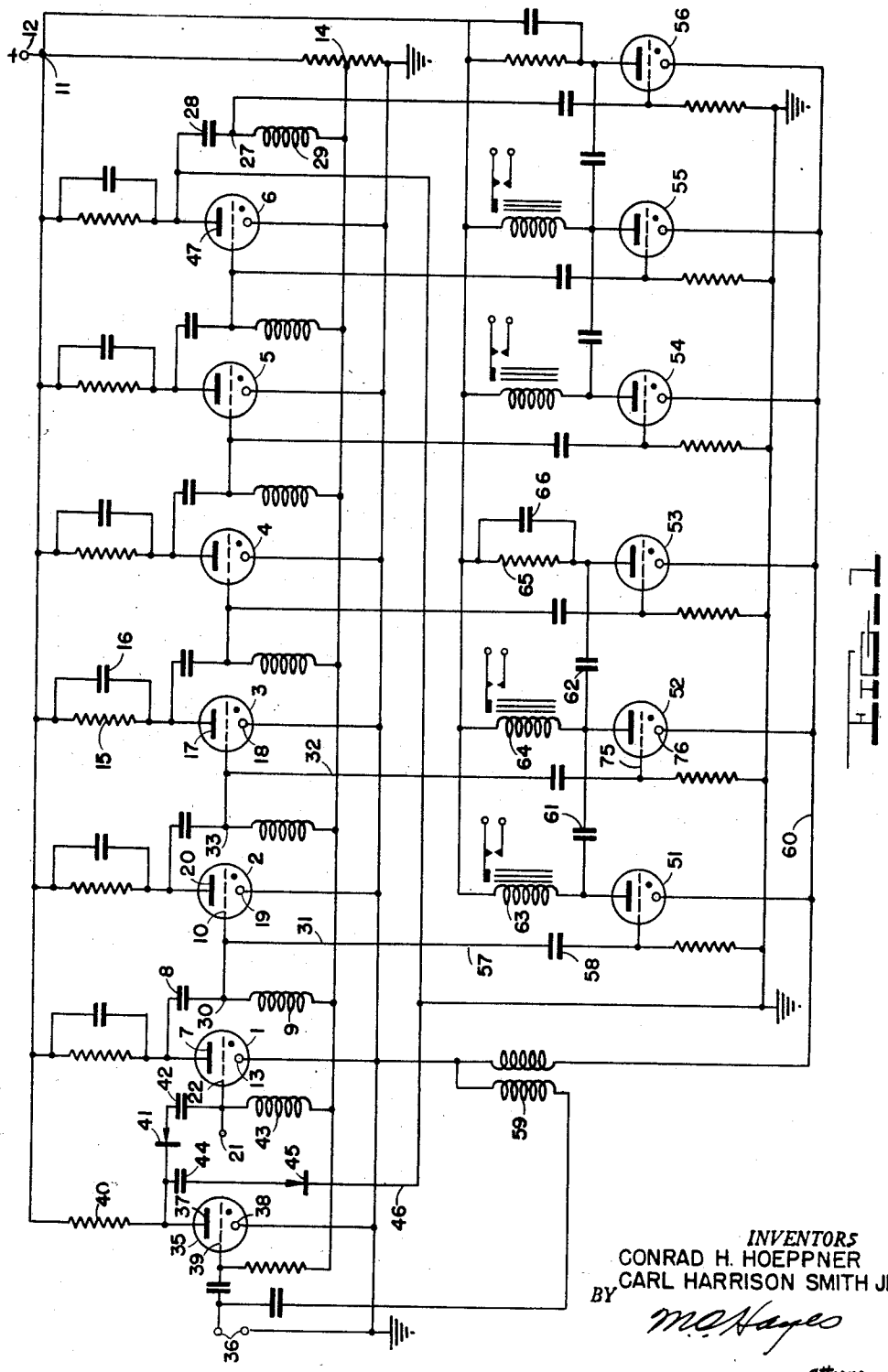


FIG. 1

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3 Sheets-Sheet 2

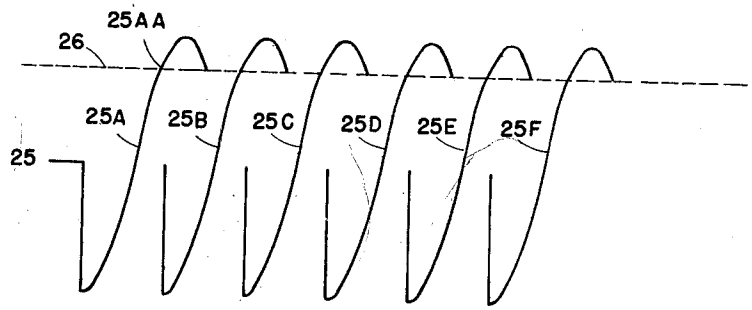


FIG. 2

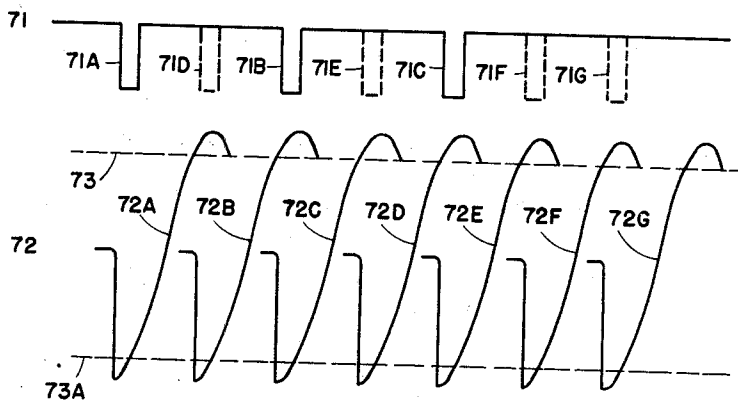


FIG. 3

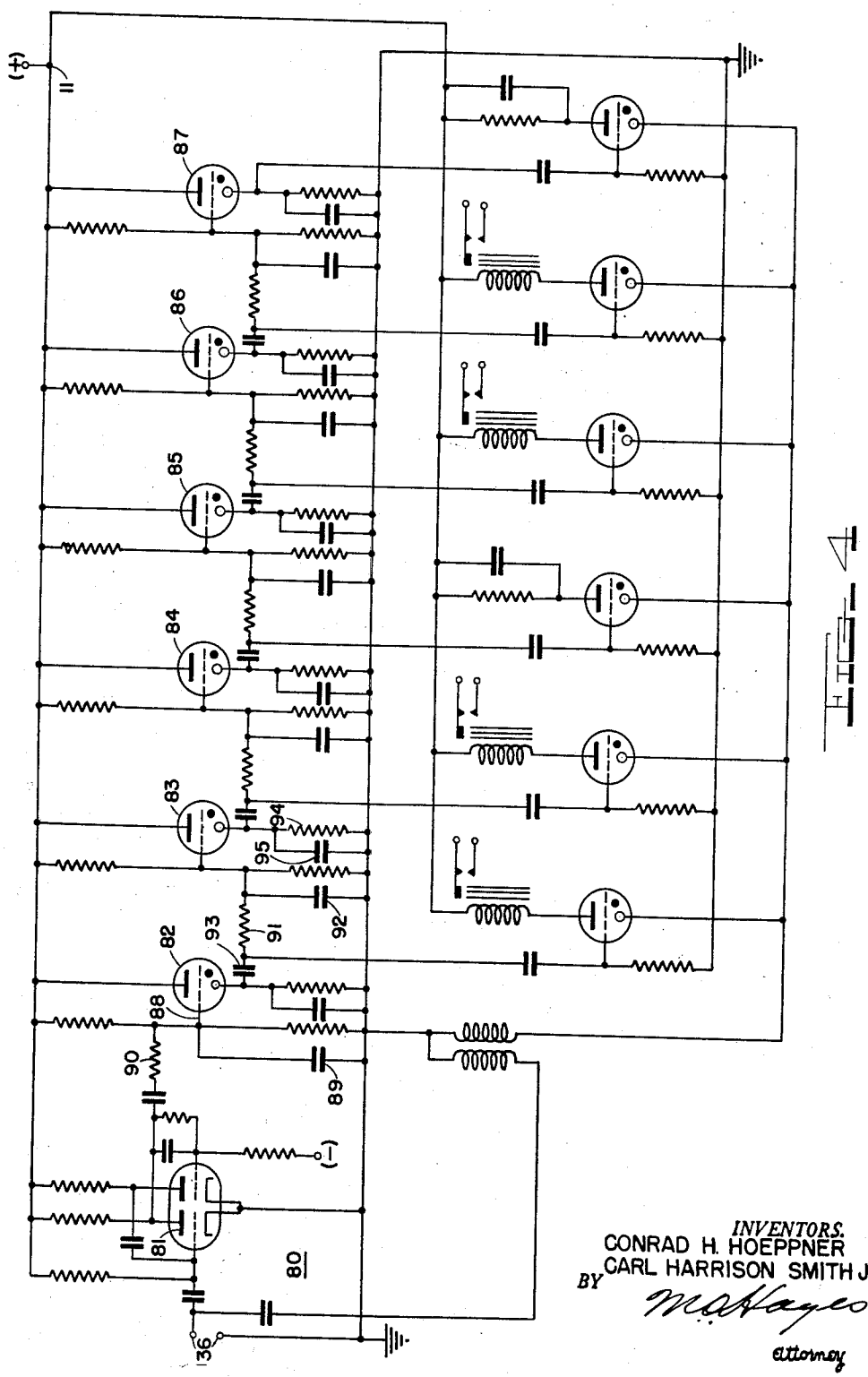
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3 Sheets-Sheet 3



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2,925,491

TIME BASE CONTROL CIRCUIT

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Application February 27, 1946, Serial No. 650,580

9 Claims. (Cl. 250—27)

(Granted under Title 35, U.S. Code (1952), sec. 266)

This invention relates to electronic control circuits and in particular to control circuits for pulse time base generation and utilization.

The prior art has provided a wide variety of gaseous discharge tubes, one class of which has in common the feature of a control element which does not actively participate in the principal discharge once that principal discharge has been initiated. Into this class fall such tubes known to the trade as thyratrons, ignitrons, and cold cathode tubes. These particular tubes are enough alike in their basic properties to permit the statement that any type of circuit set up with one of these tubes can also be set up with either one of the others. Each however, has its own particular operating characteristics which render it more suitable for certain applications than either of the others. For example, the thyratron and cold cathode gaseous discharge tubes may be employed for control circuits to better advantage than the high current capacity ignitron. Further, the cold cathode tube, where its limited current carrying capacity is not an obstacle, may be employed in such a manner as to require no quiescent anode power or cathode heating power. In certain embodiments of the teachings of this invention, such gaseous discharge tubes may be employed to better advantage from a standby power requirement point of view than conventional vacuum tubes, although either a vacuum tube or a gaseous discharge tube may be made to answer the fundamental requirement for a discharge device.

It is an object of this invention to provide a control circuit for producing a series of electrical impulses.

It is another object of this invention to provide a circuit for producing a predetermined number of electrical impulses predeterminedly time related.

It is another object of this invention to provide a control circuit for generating a time base comprising a series of electrical impulses predeterminedly time related.

It is another object of this invention to provide a control circuit for generating a time base comprising a series of predeterminedly time related electrical impulses each appearing on a separate circuit channel.

It is another object of this invention to provide a circuit requiring no standby power for producing a series of electrical impulses.

It is another object of this invention to provide a control circuit responsive only to the initial signal of a plurality of input signals in such a manner as to produce a series of electrical impulses.

It is another object of this invention to provide a combination of control circuits responsive to time modulated signals.

Other objects and features of this invention will become apparent upon a careful consideration of the following detailed description, when taken together with the accompanying drawings in which:

Fig. 1 is the circuit diagram of an exemplary embodiment of this invention;

Fig. 2 is representative of a waveform found useful in explaining the operation of the embodiment of Fig. 1;

Fig. 3 is representative of a series of waveforms found useful in explaining the operation of the embodiment of Fig. 1; and

Fig. 4 is the circuit diagram of a variant exemplary embodiment of this invention.

Among the principles upon which this invention is based are several of those governing gaseous discharges. One of these principles is that, once a gaseous discharge between two electrodes has been established, the potential between those electrodes required for the support of that discharge is less than that reqiured for its initiation, i.e., the discharge supporting potential is lower than the discharge initiating potential. Another of these principles is that the potential required to initiate a discharge is lowered when ionization is present in the gas. Still another is that a gaseous discharge between two electrodes may be extinguished if the potential between those electrodes is depressed below the discharge supporting potential for a long enough interval for de-ionization to occur and the discharge will remain extinguished even though the potential between the electrodes be subsequently increased above the discharge supporting value (but not attaining the discharge initiating value). Still another is that a certain minimum current must flow between the two electrodes if the discharge is to be maintained.

Other principles which contribute to the operation of this invention include certain of those governing the behavior of an L-C resonant circuit. One of these resonant circuit principles is that if a series or parallel combination of capacitance and inductance be shock excited, as by an abrupt electrical impulse, there will appear across the inductance an oscillatory voltage generally sinusoidal in character. The starting phase, i.e., the potential change direction of the initial excursion of this oscillatory voltage, may be determined by the polarity of the applied excitation and the frequency of oscillation may be determined by the choice of inductance and capacitance values.

For an illustration of one manner in which these principles have been applied in a practical embodiment of this invention, reference is now had to Fig. 1 in which tubes **1**, **2**, **3**, **4**, **5**, and **6** represent a sequence of discharge tubes. Each one of these tubes, except the last member of the sequence, is coupled to the immediately subsequent member of the sequence by a delay circuit means which, in this Fig. 1, takes the form of a series resonant circuit. This construction is typified by the coupling of principal discharge electrode **7** of precedent tube **1** through capacitor **8** and inductance **9** to control electrode **10** of subsequent tube **2**. From the circuit it will be seen that other similar resonant circuits each couple a respective precedent and a respective subsequent member of the sequence.

While tubes **1** through **6** might take the form of gaseous discharge tubes of the heated cathode type or even of vacuum tubes were cathode heating means supplied and appropriate circuits changes made, cold cathode type gaseous discharge tubes are included in the preferred embodiment shown since they eliminate the need for a cathode heating power supply. It is to be understood that, while one of the three electrodes, typified by control electrode **10** of tube **2**, is shown as having the grid structure as supplied in certain of such tubes (such as the RCA 1C21), this particular structure is exemplary and is not a limiting feature and other cold cathode tubes having a "starter-anode" control electrode (such as the RCA OA4G) rather than a "grid" control electrode may be employed. As mentioned previously, the glow discharge characteristic of these cold cathode tubes is such that they do not require auxiliary cathode heating power. Further, potential source **11** of power supply **12** is of such a value that it will support a dis-

charge between the principal discharge electrodes of the tubes, typified by electrodes 7 and 13 of tube 1, only if there is ionization present in the tubes. Still further, potential source 14 of power supply 12 is of such a value that it will not alone support a discharge between the control electrode (electrode 10 of tube 2, for example) and either of the associated principal electrodes. Thus, the fully quiescent condition of the sequence of discharge tubes 1 through 6 is such that no power is required from power supply 12 for the electrodes and as mentioned above, no cathode heating power is required.

Each member of the sequence has associated with it a separate impedance means which renders potential source 11 capable of supporting only temporarily a principal discharge in any of the tubes. It is characteristic of such gaseous discharge tubes that any current flow therein less than a critical minimum will not cause the ionization necessary to support discharge. Potential source 11 is of such a value that it is unable to supply a current greater than this critical minimum through the combined resistance of a series element, typified by resistor 15 in series with tube 3, and the tube itself. That potential source 11 is able to support a discharge in the tubes even temporarily is made possible by capacitance in parallel with the series resistance element. With particular reference to tube 3 as an example, capacitor 16, which represents this capacitance, may either be an actual circuit element or, in those instances in which the construction so provides, the distributed capacitance associated with the circuit. This capacitor 16 by-passes resistor 15 for abrupt changes in potential and thus permits the temporary support of a discharge between principal discharge electrodes 17 and 18 whenever ionization is present in the tube. As soon as capacitor 16 charges, potential 11 is unable to support a discharge in tube 3 and that discharge is automatically terminated.

Examination of the circuit will reveal that, as a member of the sequence is caused to discharge, an abrupt negative surge of potential is experienced at the principal discharge electrode directly connected to the parallel resistor-capacitor combination as the capacitor charges through the tube. For example, if a discharge is initiated in tube 1, a negative surge is experienced at principal electrode 7. This negative surge is applied to the series resonant circuit comprising capacitor 8 and inductance 9 and excites an oscillatory voltage therein. This oscillatory voltage, as it appears at the junction of capacitor 8 and inductance 9 (and hence at control electrode 10 of tube 2), proceeds in a negative direction on its initial excursion, i.e., its starting phase is negative. The period of the oscillation is determined substantially by the choice of values for capacitor 8 and inductance 9 so that this choice may be employed to determine the instant at which the voltage proceeds in the positive direction in producing the first cycle of oscillation.

A discharge between the principal electrodes of the sequence members may most conveniently be initiated by first initiating a discharge between the control electrode and one of the principal electrodes. The resulting ionization establishes the condition precedent to the desired principal discharge. Each of the control electrodes is maintained at a potential positive with respect to a principal discharge electrode by virtue of its connection through the associated inductance to potential source 14. Again choosing a particular tube member of the sequence for purposes of explanation, it will be seen that control electrode 10 of tube 2 is maintained at a potential which is positive with respect to principal electrode 19 by potential source 14. This arrangement so biases control electrode 10 with respect to principal electrode 19 that the negative excursion of the oscillatory voltage at control electrode 10 is unable to initiate a discharge in such a direction that control electrode 10 would act as the "cathode." On the other hand, this positive bias aids the positive excursion of the oscillatory voltage in such a manner that a discharge may be initiated thereby between electrode 10 and electrode 19 with electrode 19 acting as the "cathode." The oscillatory voltage at electrode 10 supports this discharge for the short interval necessary to establish a condition of ionization in tube 2. Responsive to this condition, potential source 11 is enabled to support the discharge between principal electrode 20 and principal electrode 19 which may be referred to as the principal discharge and which is temporary as hereinbefore described. The discharge between electrode 10 and electrode 19 is, of course, temporary because of the oscillatory nature of the initiating voltage. The damping inherent in such a resonant circuit, reinforced by the discharge between electrodes 10 and 19, is so pronounced that the oscillatory voltage dies out abruptly after fulfilling its function and the coupling circuit rapidly returns to a quiescent condition.

Let it be assumed that an input signal of positive polarity is applied at terminal 21 and hence to control electrode 22 of tube 1. This input signal initiates the principal discharge in tube 1. The oscillatory voltage excited in the coupling means comprising capacitor 8 and inductance 9 as may be observed at control electrode 10 of tube 2 is represented by element 25A of waveform 25 of Fig. 2 to which reference is now had. It will be seen from this waveform element that control electrode 10 is first carried negative by the oscillatory voltage and is then carried positive, a predetermined interval of time after the discharge of tube 1, to potential level 26. Potential level 26 represents the level to which the control electrodes of the members of the sequence must be raised in order to initiate a discharge in their respective members. When oscillatory voltage 25A proceeds to that predetermined point in its cycle represented by point 25AA (and thus reaches level 26), tube 2 is caused to discharge. This discharge in tube 2 in turn excites the oscillatory voltage represented by element 25B in the series resonant circuit for which tube 2 comprises the precedent member of the sequence. When oscillatory voltage 25B proceeds to that point in its cycle at which it reaches level 26, tube 3 discharges and thus the successive members of the sequence are caused to discharge with predetermined intervals of time separation. The process ends when tube 6 discharges to produce oscillatory voltage 25F of waveform 25 at junction 27 of capacitor 28 and inductance 29 connected to tube 6 in Fig. 1. All these discharges were temporary as described above and the end of the sequential cycle finds a quiescent circuit prepared for the next cycle of operation.

At this point, it would be well to note that the waveforms shown have been somewhat idealized in order to facilitate presentation. Despite slight waveform irregularities which exist in actual practice, it has been found that the series resonant delay circuits operate to produce accurate time spacing substantially as shown. Another item of interest in this connection is that a short but definite time allowance must be made for the ionization of each tube to occur after its control electrode has been raised above level 26. This is indicated in waveform 25 by a slight time interval before each element starts its downward excursion.

It will be seen that the sequence has produced a series of six electrical impulses comprising elements 25A, 25B, 25C, 25D, 25E, and 25F of waveform 25. A connection made at junction 30 of capacitor 8 and inductance 9, represented by lead 31, in combination with those circuit elements, represents a means for obtaining an output signal in response to the discharge of tube 1 consisting of oscillatory voltage 25A of waveform 25. Similarly an output signal consisting of voltage 25B may be obtained via lead 32 from junction 33 of the means coupling precedent tube 2 and subsequent tube 3. A total series of 6 electrical impulses may be thus obtained on separate cir-

cuit channels all predeterminedly time related in such a manner that they constitute a time base marked into the five intervals between pulses. These output signals may be employed for any desired purpose including that of acting as bias reducing signals in a following circuit.

It will be apparent that, if a plurality of input signals be applied at terminal 21 any two of which are so spaced that the second causes tube 1 to discharge before tube 6 has discharged in response to the first, the sequence will generate two series of electrical impulses overlapping in time. While this action might be desirable under special circumstances, it is, in general, and in this embodiment in particular, undesirable. For this reason, an input means has been coupled to the first member of the sequence for receiving a plurality of input signals in such a manner as to cause a discharge to be initiated in tube 1 only in response to the initial input signal. This input means in Fig. 1 comprises cold cathode gaseous discharge tube 35 which is operative to discharge continuously in response to the initial signal of a plurality of signals applied at input terminals 36. During such times as a principal discharge exists in tube 35 between electrodes 37 and 38, control electrode 39 is, of course, unable to affect the tube operation and signals applied at terminals 36 are impotent insofar as tube 35 (and the sequence 1 through 6) is concerned. This continuous discharge feature of tube 35, as compared to the temporary discharge feature of the sequence tubes, is secured by proper choice of resistor 40 in series with principal electrodes 37 and 38. Resistor 40 may be chosen to allow sufficient current to flow in tube 35 to cause the amount of ionization required for continuous discharge once that discharge has been established.

The delay circuit means coupling input tube 35 to tube 1 of the sequence comprises a unilateral element in the form of rectifier 41, capacitor 42, and inductance 43. The unilateral action of rectifier 41 is such that the initiation of a discharge in tube 35 excites an oscillatory voltage of proper amplitude in the resonant circuit to cause a discharge in tube 1 while the termination of a discharge in tube 35 fails to do so. The action of capacitor 42 and inductance 43 is such that a discharge is initiated in tube 1 in predetermined time relation to the signal at terminals 36 which causes tube 35 to discharge. This action is similar to that of the delay circuit means coupling the successive members of the sequence.

Tube 35, at principal electrode 37, is also coupled back through capacitor 44, rectifier 45, and lead 46 to principal electrode 47 of sequence tube 6. Rectifier 45 operates to prevent a discharge in tube 35 from exciting an oscillatory voltage in the input circuit of tube 6 and to permit a discharge in tube 6 to so depress the potential of principal electrode 37 of input tube 35 that the discharge supporting condition of ionization is lost and it is extinguished. By this means, tube 35 discharges continuously so as to ignore other than the initial of a plurality of signals applied at terminals 36 during the time the sequence is proceeding through its cycle and is then rendered responsive once more when tube 6 discharges. The possibility of so choosing resistor 40 that discharge in tube 35 is temporary but still of sufficient duration to allow for a complete sequence cycle will be obvious. The disadvantage of this arrangement is that a margin of time must be provided after tube 6 discharges during which the circuit is held unresponsive if erratic operation is to be avoided.

The plurality of gaseous discharge tubes 51, 52, 53, 54, 55 and 56 represents two groups each so coupled capacitively that the initiation of discharge in any one of the tubes in a particular group renders the remaining tubes of that particular group incapable of supporting a discharge. Each of the tubes in this plurality has a separate means, typified by lead 57 and capacitor 58 associated with tube 51 connected to a respective member of the sequence of tubes 1 through 6 so as to obtain therefrom a bias reducing signal in the form of the output signals previously described. Also the plurality of tubes 51 through 56 has been supplied with a means for receiving the signals applied at input terminals 36 which is common to all those tubes and which comprises transformer 59 and lead 60.

The operation of such a plurality of gaseous discharge tubes so arranged has been described in detail in our copending application S.N. 650,581, entitled "Gas Tube Control Circuit," filed February 27, 1946, now U.S. Patent 2,544,683. Briefly, however, one group comprises tubes 51, 52, and 53, all capacitively coupled by means of capacitors 61 and 62 in such a manner that the negative potential surge accompanying the initiation of a discharge in any one of the tubes acts to terminate discharge in any of the other two tubes which may be conducting. Tube 51 and tube 52 each has associated with it a relay represented by windings 63 and 64 respectively. Each of these relays may be used to institute a desired mechanical function such as, for example, the "right" and the "left" controls on a remotely controlled aircraft. Tube 53 has associated with it an impedance means comprising resistor 65 and capacitor 66 which renders it capable of supporting only a temporary discharge. Thus, the group corresponds to three functional states, tube 51 discharging corresponding to "right," tube 52 discharging corresponding to "left," and none of the tubes discharging corresponding to "neutral." It will be seen that the discharge of tube 53 may be initiated in order to terminate the discharge of either the "right" or "left" tube. Having accomplished this and instituted the "neutral" condition, tube 53 automatically extinguishes and the group requires no power, either electrode or cathode heating. The group comprising tubes 54, 55, and 56 is similarly arranged and may correspond to another three functions such as "up," "down" and "level" flight.

The combination of this plurality of tubes and the sequence 1 through 6 is so made that the bias reducing signals obtained from the sequence and applied to the control electrodes of the plurality are alone insufficient to initiate a discharge in any of the tubes 51 through 56. When, however, a bias reducing signal is received by any one of these tubes in time coincidence with a signal received on lead 60, the tube discharges to perform its assigned task.

Reference is now had to Fig. 3 for an explanation of how the combination of the sequence, the input tube and the plurality operate in accordance with the time relation of subsequent signals to the initial signal of a plurality of input signals. In Fig. 3, waveform 71 represents, by means of the solid lines, a plurality of input signals at terminals 36 of Fig. 1. This solid line waveform comprises initial signal 71A, signal 71B corresponding to a "left" function, and signal 71C corresponding to an "up" function. The dotted signals 71D, 71E, 71F and 71G correspond to "right," "neutral," "down," and "level" respectively which may be alternatively included in the plurality of input signals. Initial signal 71A does not correspond to such a particular function but marks the instant in time which forms the basis of function signal definition.

Initial signal 71A causes input tube 35 to discharge exciting an oscillatory voltage in the resonant circuit coupling tubes 35 and 1. This oscillatory voltage is represented by element 72A of waveform 72. When this oscillatory voltage reaches positive level 73, tube 1 discharges and the sequence of tubes 1 through 6 produces the series of electrical impulses (bias reducing signals) 72B, 72C, 72D, 72E, 72F and 72G.

Waveform 74 represents the plurality of signals shown in waveform 71 after inversion by transformer 59. The alternative dotted line signals of waveform 71 have been omitted from waveform 74 and the signals applied in common to the plurality of tubes 51 through 56 comprises 74A, the initial signal, 74B, the "left" signal, and

74C, the "up" signal. Reverting to waveform 72, it will be seen that element 72A does not act as a bias reducing signal but merely acts to delay the discharge of tube 1 so as to secure proper time coincidence between the bias reducing signals to follow and the function signals. Bias reducing signal 72B is obtained by tube 51 out of time coincidence with any of the plurality of input signals so that function "right" is dormant. Bias reducing signal 72C, however, is obtained by tube 52 in time coincidence with input signal 74B. When signal 72C reaches negative level 73A, the two aid to so increase the potential between control electrode 75 and principal electrode 76 of tube 52 that a discharge is initiated therein and the "left" function is instituted by the energization of relay 64. Similarly, bias reducing signal 72E aids function signal 74C so as to institute the "up" function corresponding to tube 54. It will be apparent that an alternative choice of time modulation for the input waveform would call into being alternative functions.

The mere fact that a positive voltage is applied to the principal discharge electrode of the function tube in such a manner as to decrease the potential between the principal electrodes does not prevent the principal discharge since the residual ionization after the disappearance of the function pulse will initiate the principal discharge.

Fig. 4, to which reference is now had, is illustrative of various circuit changes which may be made in the control circuits where such changes offer advantages. For example, a "one-shot" or "self-returning" multivibrator 80 has been employed rather than a gaseous discharge tube as a means of receiving a plurality of input signals at terminals 36 and producing a discharge initiating signal only in response to the initial signal of that plurality. When the initial signal causes the multivibrator to function, a positive gating voltage appears at plate 81. During the existence of this gating voltage, the multivibrator ignores input signals at terminals 36 and the sequence of tubes 82 through 87 responds only to the start of said gating voltage. The sequence has been provided with delay circuit coupling means comprising resistance-capacitance integrating circuits rather than resonant circuits and the couplings are made from the "cathode" side of each member of the sequence.

When the positive voltage appears at plate 81 of multivibrator 80 as aforesaid, it is communicated to control electrode 88 of tube 82. The voltage rise at electrode 88 is tempered, however, by the necessity of charging capacitor 89 through resistance 90. Only when electrode 88 is raised to a predetermined voltage level by the charging of capacitor 89 does tube 82 discharge. The delay involved in this action is employed to secure the desired time relation between the bias reducing signals produced by the sequence and the subsequent input signals. A similar delay (not necessarily of the same time duration) is introduced between the discharges of the sequence tubes by the resistance capacitance couplings typified by resistance 91 and capacitor 92 coupling tube 82 to tube 83. Capacitor 93 associated wtih this coupling is large enough in value that it loses negligible charge during the operation of the circuit. The control electrode of each tube of the sequence is maintained at a suitable bias potential by a voltage divider between potential source 11 and ground. Each of the sequence tubes has in its "cathode" circuit impedance means rendering the tube capable of supporting only a temporary discharge comprising, in the case of tube 83, resistor 94 and capacitor 95. The charge assumed by the capacitor in this parallel arrangement when the sequence tube discharges is lost through its parallel resistor at a rate which is gradual in comparison to the rise in potential at the control electrode to which the coupling is made. Except for the circuit and operating changes described, the cycle of this combination is the same as that described in connection with the embodiment of Fig. 1.

Since certain further changes may be made in the foregoing constructions and different embodiments of the invention may be made without departing from the scope thereof, it is intended that all matter shown in the accompanying drawings or set forth in the accompanying specification shall be interpreted as illustrative and not in a limiting sense.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed is:

1. A time base control circuit comprising, a sequence of cold cathode gaseous discharge tubes, a plurality of delay circuit means each coupling a respective precedent member and a respective subsequent member of said sequence operative responsively to discharge in said precedent member to initiate, a predetermined interval of time thereafter, a discharge in said subsequent member resistance-capacitance discharge quenching means connected in series with each member of said sequence rendering it capable of supporting only a temporary discharge, input means including a pulse forming network coupled to the first member of the sequence operative in response to the initial signal of a plurality of predeterminedly spaced input signals for applying a discharge initiating signal to the first member of said sequence, means holding said pulse forming network insensitive to input signals following the initial input signal within a predetermined time interval, and a plurality of means each connected to a respective member of said sequence for obtaining an output signal in response to the discharge thereof.

2. A time base control circuit comprising, a sequence of cold cathode gaseous discharge tubes, a plurality of resistance-capacitance integrating circuits each connected to a respective precedent member of said sequence and producing a voltage which increases with respect to time in response to discharge therein, each of said integrating circuits also being connected to a respective subsequent member of said sequence and applying said increasing voltage to said subsequent member to initiate, at a predetermined voltage level, a discharge in said subsequent member resistance-capacitance discharge quenching means connected in series with each member of said sequence rendering it capable of supporting only a temporary discharge, input means including a pulse forming network coupled to the first member of the sequence operative in response to the initial signal of a plurality of predeterminedly spaced input signals for applying a discharge initiating signal to the first member of said sequence, means holding said pulse forming network insensitive to input signals following the initial input signal within a predetermined time interval, and a plurality of means each connected to a respective member of said sequence for obtaining an output signal in response to the discharge thereof.

3. A time base control circuit comprising, a sequence of cold cathode gaseous discharge tubes, a plurality of resonant circuits each coupling a respective precedent member and a respective subsequent member of said sequence operative responsively to the discharge in said precedent member to initiate, a predetermined interval of time thereafter, a discharge in said subsequent member, resistance-capacitance discharge quenching means connected in series with each member of said sequence rendering it capable of supporting only a temporary discharge, input means including a pulse forming network coupled to the first member of the sequence operative in response to the initial signal of a plurality of predeterminedly spaced input signals for applying a discharge initiating signal to the first member of said sequence, means holding said pulse forming network insensitive to input signals following the initial input signal within a predetermined time interval, and a plurality of means

each connected to a respective member of said sequence for obtaining an output signal in response to the discharge thereof.

4. A time base control circuit comprising, a sequence of cold cathode gaseous discharge tubes of the cold cathode type each having at least two principal discharge electrodes and a control electrode, a source of potential of a value capable of supporting discharge between the two principal discharge electrodes of any of the members of said sequence only when ionization exists therein, said two principal discharge electrodes of each of said members being connected in series with said source of potential, a plurality of series resonant circuits each connected to a principal discharge electrode of a respective precedent member of said sequence and generating an oscillatory voltage in response to a principal discharge therein, each of said circuits also being connected to the control electrode of a respective subsequent member of said sequence and applying said oscillatory voltage to said control electrode to initiate, at a predetermined point in the cycle of said oscillatory voltage, a principal discharge in said subsequent member, resistance-capacitance discharge quenching means connected in series with said source of potential and the members of said sequence rendering said source of potential capable of supporting only a temporary principal discharge in any of said members, input means including a pulse forming network coupled to the first member of the sequence operative in response to the initial signal of a plurality of predeterminedly spaced input signals for applying a principal discharge initiating signal, means holding said pulse forming network insensitive to input signals following the initial input signal within a predetermined time interval, and a plurality of means each connected to a respective member of said sequence for obtaining an output signal in response to the principal discharge thereof.

5. A time base control circuit comprising, an input gaseous discharge tube of the cold cathode type operative to discharge continuously in response to the initial signal of a plurality of input signals, a sequence of cold cathode gaseous discharge tubes of the cold cathode type, a plurality of delay circuit means each coupling a respective precedent member and a respective subsequent member of said sequence operative responsively to discharge in said precedent member to initiate, a predetermined interval of time thereafter, a discharge in said subsequent member, resistance-capacitance discharge quenching means connected in series with the members of said sequence rendering them capable of supporting only a temporary discharge, unilateral impedance means connecting said input tube to the first member of said sequence operative responsively to the initiation of discharge in said input tube to initiate discharge in said first member, unilateral impedance means connecting the last member of said sequence to said input tube operative responsively to discharge in said last member to terminate discharge in said input tube, and a plurality of means each connected to a respective member of said sequence for obtaining an output signal in response to the discharge thereof.

6. A time base control circuit comprising, input multivibrator means operative to produce a gating voltage corresponding to a predetermined interval of time in response to the initial signal of a plurality of input signals, a sequence of cold cathode gaseous discharge tubes of the cold cathode type, a plurality of delay circuit means each coupling a respective precedent member and a respective subsequent member of said sequence operative responsively to discharge in said precedent member to initiate, a predetermined interval of time thereafter, a discharge in said subsequent member, resistance-capacitance discharge quenching means connected in series with the members of said sequence rendering them capable of supporting only a temporary discharge, input means including a pulse forming network coupled to the first member of the sequence operative in response to the initial signal of a plurality of predeterminedly spaced input signals to initiate discharge in said first member, means holding said pulse forming network insensitive to input signals following the intitial input signal within a predetermined time interval, and a plurality of means each connected to a respective member of said sequence for obtaining an output signal in response to the discharge thereof.

7. A time base control circuit comprising, an input gaseous discharge tube of the cold cathode type having at least two principal discharge electrodes and a control electrode operative to discharge continuously between said two principal discharge electrodes in response to the initial signal of a plurality of input signals applied to said control electrode, a sequence of cold cathode gaseous discharge tubes of the cold cathode type each having at least two principal discharge electrodes and a control electrode, a source of potential of a value capable of supporting discharge between the two principal discharge electrodes of any of said gaseous discharge tubes only when ionization exists therein, said two principal discharge electrodes of each of said tubes being connected in series with said source of potential, a plurality of series resonant circuits each connected to a principal discharge electrode of a respective precedent member of said sequence of tubes and generating an oscillatory voltage in response to a principal discharge therein, each of said circuits also being connected to the control electrode of a respective subsequent member of said sequence and applying said oscillatory voltage to said control electrode to initiate, at a predetermined point in the cycle of said oscillatory voltage, a principal discharge in said subsequent member, impedance means connected to said source of potential and the members of said sequence rendering said source of potential capable of supporting only a temporary principal discharge in any of said members, unilateral impedance means connecting one principal discharge electrode of said input tube to the control electrode of the first member of said sequence operative responsively to the initiation of discharge in said input tube to initiate discharge in said first member, unilateral impedance means connecting a principal discharge electrode of the last member of said sequence to said one principal discharge electrode of said input tube operative responsively to principal discharge in said last member to terminate principal discharge in said input tube, and a plurality of means each connected to a respective member of said sequence for obtaining an output signal in response to the discharge thereof.

8. In a control apparatus operative in accordance with the time relation of subsequent signals to the initial signal of a plurality of input signals, the combination of: a time base control circuit comprising, an input means including a pulse forming network for receiving said plurality of input signals and producing a discharge initiating signal only in response to the initial signal of said plurality, a sequence of cold cathode gaseous discharge tubes, a plurality of delay circuit means each coupling a respective precedent and a respective subsequent member of said sequence means holding said pulse forming network insensitive to input signals following the initial input signal within a predetermined time interval, operative responsively to discharge in said precedent member to initiate, a predetermined interval of time thereafter, a discharge in said subsequent member, delay circuit means connecting said input means and the first member of said sequence operative to apply said discharge initiating signal to said first member in a predetermined time relationship to said initial input signal, and a plurality of means each connected to a respective member of said sequence for obtaining a bias reducing signal in response to the discharge thereof; and a control circuit

comprising, a plurality of discharge tubes, a plurality of means each coupling last said discharge tubes in groups operative responsively to discharge in any tube of the group it couples to terminate discharge in any other conducting tube of last said group, a plurality of means each connecting a one of the tubes in said plurality of tubes to a one of said means for obtaining a bias reducing signal, a means also for receiving said plurality of input signals and applying them in common to the tubes in said plurality of tubes operative to cause a discharge therein only when a one of said input signals occurs in time coincidence with a one of said bias reducing signals.

9. In a control apparatus operative in accordance with the time relationship of subsequent signals to the initial signal of a plurality of input signals, the combination of: a time base control circuit comprising an input gaseous discharge tube of the cold cathode type operative to discharge continuously in response to the initial signal of said plurality of input signals, a sequence of gaseous discharge tubes of the cold cathode type, a plurality of delay circuit means each coupling a respective precedent member and a respective subsequent member of said sequence operative responsively to discharge in said precedent member to initiate, a predetermined interval of time thereafter, a discharge in said subsequent member, resistance capacitance discharge quenching means connected in series with the members of said sequence rendering them capable of supporting only a temporary discharge, unilateral impedance means connecting said input tube to the first member of said sequence operative responsively to the initiation of discharge in said input tube to initiate discharge in said first member in a predetermined time relationship to said initial input signal, unilateral impedance means connecting the last member of said sequence to said input tube operative responsively to discharge in said last member to terminate discharge in said input tube, and a plurality of means each connected to a respective member of said sequence for obtaining a bias reducing signal in response to the discharge thereof; and a control circuit comprising, a plurality of gaseous discharge tubes of the cold cathode type, a plurality of means each coupling last said tubes in groups operative responsively to discharge in any tube of the group it couples to terminate discharge in any other conducting tube of last said group, a plurality of means each connecting a one of the tubes in said plurality of tubes to a one of said means for obtaining a bias reducing signal, a means also for receiving said plurality of input signals and applying them in common to the tubes in said plurality of tubes operative to cause a discharge therein only when a one of said input signals occurs in time coincidence with a one of said biasing reducing signals.

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