

March 28, 1944.

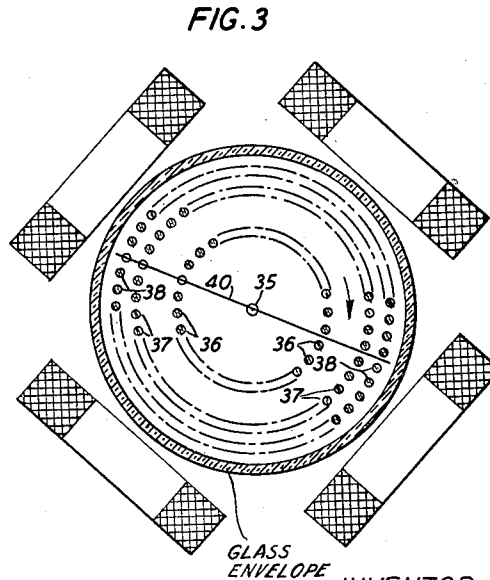
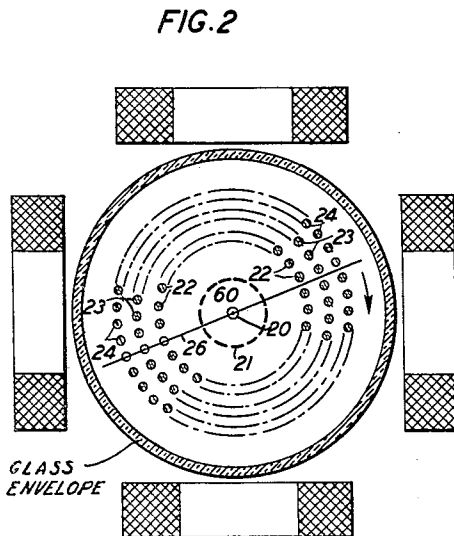
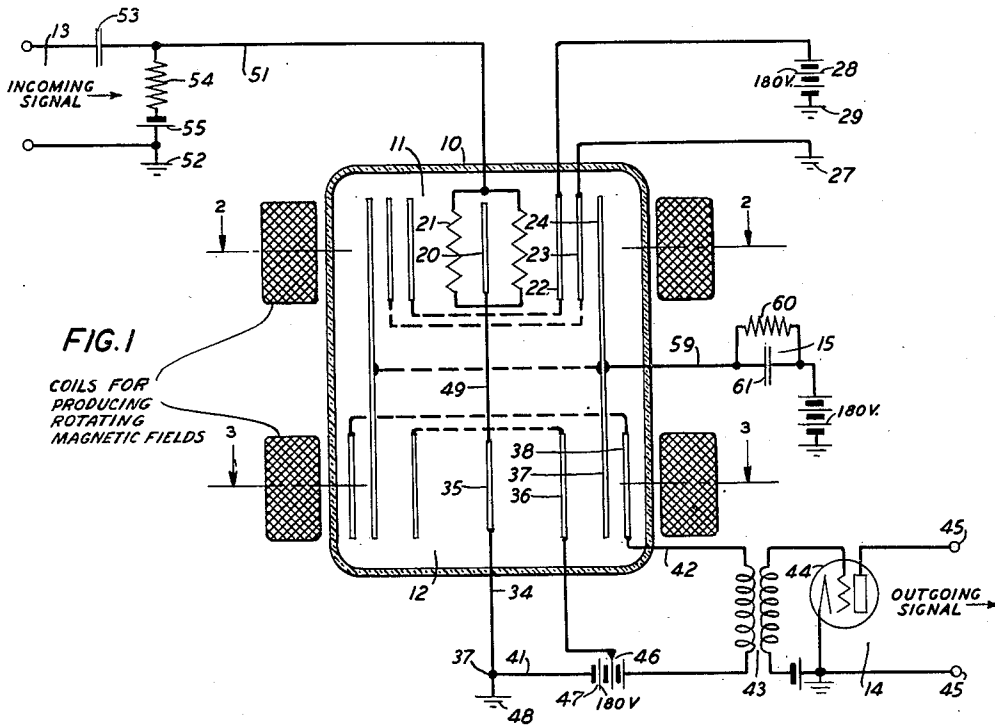
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2,345,115

WAVE TRANSMISSION SYSTEM

Filed May 22, 1941

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

FIG. 5

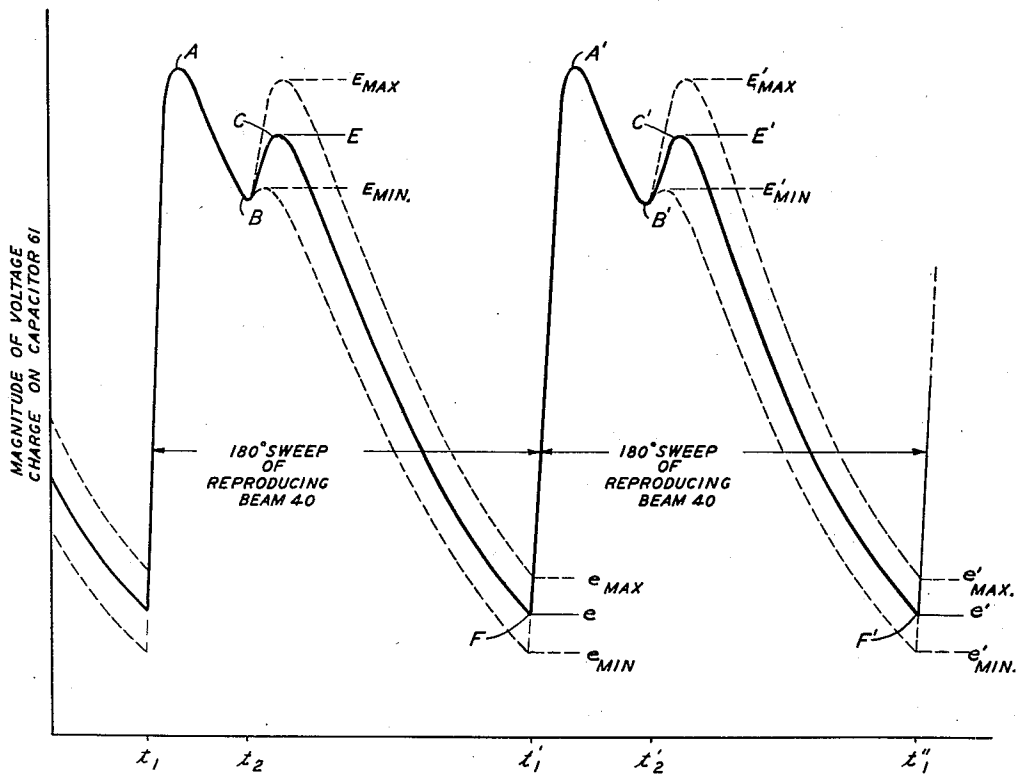
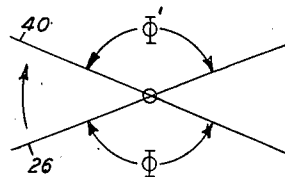


FIG. 4



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WAVE TRANSMISSION SYSTEM

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14 Claims. (Cl. 178—44)

This invention relates to a wave transmission system and more particularly to electron discharge apparatus for introducing time delay in such system.

Heretofore, electrical delay networks have been used together with voice operated devices to control echo and singing effects in signaling transmission systems. Such delay networks served to delay voice currents for a certain interval of time in order to prevent clipping of the initial syllables thereof. These delay networks are provided at a relatively high cost and therefore tend to increase the over-all costs of the signaling systems in which they are utilized.

This invention contemplates time delay apparatus which may be manufactured at a relatively low cost.

The main object of the invention is to provide a facile and inexpensive time delay apparatus.

Another object is to record signals of varying amplitude.

A further object is to reproduce signals of varying amplitude.

Still another object is to record signals of varying amplitude and at a predetermined time thereafter to reproduce such signals in an expeditious manner.

A still further object is to provide time delay apparatus embodying no mechanically moving parts.

In a specific embodiment, the invention comprises an electron discharge device embodying a plurality of targets arranged in a curvilinear path, and means to generate and move two discrete electron beams over the targets in two parallel horizontal planes such that one beam is in advance of the other. Associated with each target is a parallel R—C network in which the magnitude of the charge on the capacitor is controlled by the two electron beams passing over the targets associated therewith. Thus, the variations of the magnitude of the charge on the individual capacitors effectively transmitted to an output circuit are proportional to the variations of the amplitude of incoming signals applied to an input circuit. The time intervening between the charging of the individual capacitors in response to the incoming signals and the effective transmission of the charges on the individual capacitors to the output circuit is a measure of the time delay introduced between the input and output circuits.

The invention will be readily understood from

the following description taken together with the accompanying drawings in which:

Fig. 1 is a schematic circuit showing a specific embodiment of the invention;

Fig. 2 is a plan view taken along the lines 2—2 of Fig. 1;

Fig. 3 is a plan view taken along the lines 3—3 of Fig. 1;

Fig. 4 shows the angular relation between the electron beams of Figs. 2 and 3; and

Fig. 5 is a curve illustrating the action of Fig. 1.

Fig. 1 shows an electron beam discharge device 10 comprising, in general, a recording section 11 and a reproducing section 12. Connected to the recording section 11 is an input circuit 13 and to the reproducing section 12 is an output circuit 14. The necessary circuit means for effecting these connections will be subsequently described. Associated with the discharge device 10 is a plurality of discrete R—C networks 15 which cooperate with the respective recording and reproducing sections 11 and 12 to introduce a certain time delay between the incoming signals applied to the input circuit 13 and the effective transmission of these signals to the outgoing circuit 14 in a manner that will be presently explained.

The electron beam discharge device 10 follows in each of its upper and lower sections the general type of construction disclosed in the patent of A. M. Skellett, No. 2,217,774, granted October 15, 1940, in that in each section suitable electrodes are provided for producing an electron stream, and a plurality of coils are provided around the device 10 and suitably energized with alternating power in known manner for producing rotating magnetic fields, causing the electron streams to be formed into double-ended electron beams rotating at the frequency of the energizing power. The recording section 11 occupying the upper half of the discharge device 10, Figs. 1 and 2, comprises a cathode 20, a control grid 21, a plurality of screen electrodes 22, a plurality of suppressor electrodes 23 and a plurality of anodes 24. The respective screen and suppressor electrodes 22 and 23 and anodes 24 are arranged about the cathode 20 and control grid 21 in a concentric manner as illustrated in Fig. 2. The double-ended electron beam 26 rotates in a clockwise direction as indicated by the arrow in Fig. 2 at the frequency of the energizing power.

Each of the respective pluralities of screen

and suppressor electrodes 22 and 23 and anodes 24 comprises an odd number with uniform spacing between the individual electrodes or anodes of each plurality thereof so that as one end of the electron beam 26 is simultaneously moving over the associated screen and suppressor electrodes and anode, the opposite end of the electron beam 26 is moving between adjacent pairs of associated screen and suppressor electrodes and anodes as shown in Fig. 2. Each suppressor electrode 23 is connected to ground 27, Fig. 1, while each screen electrode 22 is applied to the positive terminal of a 180-volt source 28 of direct current voltage, whose negative terminal is connected to ground 29.

Referring to Figs. 1 and 3, the reproducing section 12 occupying the lower half of the discharge device 10 comprises a cathode 35, a plurality of screen electrodes 36, a plurality of control grids 37 and a plurality of anodes 38, the respective screen electrodes 36, control grids 37 and anodes 38 being arranged in a concentric manner about the cathode 35. The double-ended electron beam 40 rotates in a clockwise direction as indicated by the arrow in Fig. 3 at the frequency of the energizing power.

Each of the pluralities of screen electrodes 36, control grids 37 and anodes 38 comprises an odd number with uniform spacing between individual electrodes, control grids, or anodes of each plurality thereof so that as one end of the electron beam 40 is moving over the associated screen electrode, control grid and anode, the opposite end of the electron beam 40 is moving between adjacent pairs of the associated screen electrodes, control grids and anodes as indicated in Fig. 3.

The cathode 35 and anodes 38 of the reproducing section 12 are connected by leads 34, 41 and 42 to the primary winding of an output transformer 43 whose secondary winding is applied through a suitable amplifier 44 to output terminals 45, 45. The screen electrodes 36 are connected by a variable tap 46 to anode voltage source 47 of 180-volt direct current voltage embodied in the lead 41 and which is effectively applied through the primary winding of the output transformer 43 to the individual anodes 38. A terminal 37 common to the leads 34 and 41 terminates one end of the cathode 35 at ground 48 while the opposite end of the cathode 35 is connected by a lead 49 to one end of the cathode 20 associated with the recording section 11, Fig. 1.

The input circuit 13 is effectively applied by ground 52 and lead 51 across the respective cathode 20 and control grid 21 of the recording section 11, Fig. 1. The intensity of the electron beam 26, Fig. 2, is modulated by means of incoming signals applied through a coupling capacitor 53 to the cathode 20 and control grid 21. A high resistor 54 and source 55 of direct current biasing potential are embodied in the input circuit 13 in the customary manner.

Each anode 24 of the recording section 11 and each control grid 37 of the reproducing section 12 are shown in Fig. 1 as an individual unitary element, although such anodes and control grids may comprise discrete elements arranged such that associated anodes and control grids are joined by a suitable link, not shown. For the purposes of simplifying tube construction, the aforementioned unitary structure may be preferred. An previously pointed out, each associated anode 24 of recording section 11 and control grid 37 of reproducing section 12 have connected thereto by a lead 59 the individual R—C

network 15 comprising in parallel a resistor 60 and a capacitor 61.

The screen and suppressor electrodes 22 and 23 and the anodes 24 of the recording section 11 and the screen electrodes 36, control grids 37 and anodes 38 of the reproducing section 12 comprise the same odd number so that, as regards these electrodes, the same number thereof will appear in both the upper and lower halves of the electron device 10, Fig. 1.

The operation of Fig. 1 will now be explained. Assuming no signals applied to the input circuit 13, the left-hand portion of electron beam 40, Fig. 3, in moving over the individual anodes 38 commences to apply at a time t_1 , Fig. 5, to each capacitor 61 connected thereto via such portion of the electron beam 40 a charge whose magnitude is represented by point A. After this portion of the electron beam 40 leaves the individual anodes 38, the individual capacitors 61 charged to the point A commence to discharge through the associated resistors 60 until point B at a time t_2 , Fig. 5, is reached whereupon the left-hand portion of the electron beam 26 moves over the individual anodes 24 to commence to recharge at the time t_2 the individual capacitors 61 connected thereto to an amount represented by the point C, or voltage E. After this portion of the electron beam 26 leaves the individual anodes 24, the individual capacitors 61 connected therewith commence to discharge through the associated resistors 60 until the point F, or voltage e, is reached at a time t'_1 , Fig. 5. As the right-hand portions of both electron beams 40 and 26 wipe over the respective individual anodes 38 and 24 the individual capacitors 61 are successively recharged and discharged to similar amounts represented by the points A', B', C' and F'. Thus, the cycle of charging and discharging the individual capacitors 61 occurs twice for each 360-degree rotation of the electron beams 26 and 40, at a frequency which is twice the frequency of the voltage energizing the coils 25 and 39. The above presupposes a normal biasing voltage applied to the control grid 21 of the recording section 11.

When incoming signals are applied to the input circuit 13, Fig. 1, the magnitude of the voltage recharge on individual capacitors 61 at the point C due to the left-hand portion of the electron beam 26 moving thereover is determined by the effective instantaneous potential on the control grid 21. Therefore, as the potential of the control grid 21 becomes less negative, or more positive in one sense, relative to the normal biasing voltage, the individual capacitors 61 may be recharged to a magnitude represented by E_{max} because the recording section 11 presents a relatively low impedance to the current charging the individual capacitors 61. As the potential of the control grid 21 becomes more negative, relative to the normal biasing voltage, the individual capacitors 61 may be recharged to a magnitude represented by E_{min} because the recording section 11 presents a relatively high impedance to the current charging the individual capacitors 61. Accordingly, the individual capacitors 61 may then be discharged to magnitudes represented by E_{max} and E_{min} . Thus, the discharge curves of the individual capacitors 61 will fall between the two dash-line curves of Fig. 5, depending on the instantaneous magnitudes of the incoming signals applied across the input circuit 13.

At the point F, or time t'_1 , the right-hand portion of the electron beam 40 of the reproducing section 12 is commencing to recharge the

Individual capacitors 61 back to the magnitude represented by the point A'. During the interval of such recharge, the right-hand portion of the electron beam 40 serves via the control grids 37 to supply the recharging current for the individual capacitors 61 and at the same time via the anodes 38 to institute signals in the output circuit 14, Fig. 1. The magnitude of the signals in the output circuit 14 depends on the magnitude of the charge on the individual capacitors 61 at the point F, or time t'_1 . This, as previously pointed out, lies between $e_{\max}$ and $e_{\min}$.

At the point B', or time t'_2 , the right-hand portion of the electron beam 26 of the recording section 11 is commencing to recharge the individual capacitors 61 to values between the magnitudes represented by $E'_{\max}$ and $E'_{\min}$. As previously described the individual capacitors 61 will discharge, during intervals of no incoming signals at the input circuit, to magnitude e' , and during intervals of incoming signals to the input circuit 13 to magnitudes lying between $e'_{\max}$ and $e'_{\min}$ at a time t''_1 . Thereafter, the cycle of charging and discharging the individual capacitors 61 will be repeated in the manner illustrated in Fig. 5, at a frequency which is twice the frequency of the energizing current supplied to the coils 25 and 39 of Fig. 1.

At the point F', or time t''_1 , the left-hand portion of the electron beam 40 of the reproducing section 12 is commencing to recharge the individual capacitors 61 back to the magnitude represented by the point A, Fig. 5. During the interval of such recharge, the left-hand portion of the electron beam 40 serves via the control grids 37 to supply the recharging current for the individual capacitors 61 and at the same time via the anodes 38 to institute signals in the output circuit 14, Fig. 1. The magnitude of the signals in the output circuit 14 depends on the magnitude of the charge on the individual capacitors 61 at the point F', or time t''_1 . This as above seen lies between $e'_{\max}$ and $e'_{\min}$.

As the magnitude of the charge on the individual capacitors 61 at a time t'_1 , Fig. 5, varies between the values $e_{\max}$ and $e_{\min}$ in proportion to variations of the amplitude of the incoming signals at a time t_2 , the signals supplied to the output circuit 14 will be delayed with respect to the incoming signals at the input circuit 13 by a time equivalent to $t'_1 - t_2$. This time interval is also equivalent to the time interval required for the electron beams 26 and 40 to sweep through the angle ϕ in Fig. 4.

As the magnitude of the charge on the individual capacitors 61 at the time t''_1 , Fig. 5, varies between the values $e'_{\max}$ and $e'_{\min}$ in proportion to the variations of the amplitude of the incoming signals at the time t'_2 , the signals supplied to the output circuit 14 will be delayed with respect to the incoming signals at the input circuit 13 by a time interval equivalent to $t''_1 - t'_2$, which time interval is also equivalent to the time interval required for the electron beams 26 and 40 to sweep through the angle ϕ' in Fig. 4.

As the angles ϕ and ϕ' are equal, the time delay $t'_1 - t_2$ and $t''_1 - t'_2$ are also equal. In this connection it is to be understood that the amount of time delay is controlled by the magnitude of the angles ϕ or ϕ' between the rotating electron beams 26 and 40, and the speed of rotation of both of the latter; and also, while the two electron beams 26 and 40 are embodied in a single envelope, each electron beam may be contained in an individual envelope.

What is claimed is:

1. In a signal transmission system having input and output circuits and a plurality of individual electrical elements connected to both said circuits and provided with voltage charges, the method of introducing time delay between corresponding signals in said input and output circuits, comprising varying the voltage charges on successive elements in proportion to signals of changing amplitudes in said input circuit, dissipating the voltage charges on successive elements at a substantially uniform rate for a certain interval of time, and utilizing the remainder of the voltage charge on successive elements after the certain charge dissipative time interval to institute in said output circuit signals corresponding to the signals in said input circuit and having a time delay proportional to the charge dissipative time interval.
2. In a signal transmission system having input and output circuits and a plurality of individual electrical elements connected to both said circuits and provided with voltage charges representing signals in the input circuit, the method of introducing time delay between corresponding signals in said input and output circuits, comprising dissipating for a certain time interval at a substantially constant rate the voltage charges representing on successive elements signals in said input circuit, and utilizing the voltage charges remaining on successive elements after the charge dissipative time interval to institute in said output circuit signals corresponding to the signals in said input circuit and having a time delay proportional to the charge dissipative time interval.
3. In a signal transmission system embodying input and output circuits and a plurality of individual electrical elements connected to said circuits, the method of introducing time delay between corresponding signals in said circuits, comprising charging successive elements to a certain magnitude in the absence of signals in said input circuit, varying the voltage charges on successive elements relative to said certain magnitude in proportion to variations in the signals in said input circuit, dissipating the voltage charges on successive elements at a substantially constant rate for a predetermined time interval, and utilizing the voltage charges remaining on successive elements after the charge dissipative time interval to institute in said output circuit signals corresponding to the signals in said input circuit and having a time delay proportional to the charge dissipative time interval.
4. In a signal transmission system embodying input and output circuits and having a plurality of electrical elements connected to said circuits, the method of introducing time delay between corresponding signals in said circuits, comprising charging successive elements to a certain magnitude in the absence of signals in said input circuit, decreasing the voltage charges on successive elements at a substantially uniform rate for a predetermined time interval, increasing after the predetermined time interval the voltage charges on successive elements by varying amounts in response to changing amplitudes of signals in said input circuit, decreasing the increased voltage charges on successive elements at the substantially uniform rate for a further predetermined interval of time, and utilizing the voltage charges remaining on successive elements after the further predetermined time interval to institute in said output circuit signals

corresponding to the signals in said input circuit and having a time delay proportional to the further predetermined time interval.

5. In combination, in electron discharge apparatus, a plurality of discrete targets arranged in a curvilinear path, a network including a capacitor individual to each target, and means to generate and move two double-ended electron beams on a common transverse axis over said targets in the same direction such that one beam is in advance of the other and such that the longitudinal axes of individual beams and targets are normal to each other to charge successively said individual capacitors to different magnitudes for each 360-degree rotation of said two electron beams.

6. In the combination according to claim 5 in which said plurality of targets comprises an odd number arranged with uniform spacing between individual targets such that as one end of each beam moves over one target the opposite end of each said beam moves between two adjacent targets thereby effectively connecting the individual beams to only one target at a given instant.

7. In the combination according to claim 5 in which said plurality of targets comprises an odd number arranged with uniform spacing between individual targets such that as one end of each beam moves over one target the opposite end thereof moves between two adjacent targets thereby effectively connecting the individual beams to only one target at a given instant, and said two electron beams are arranged such that corresponding ends thereof move simultaneously over different individual targets and between different adjacent targets to control the time period intervening between the charging of successive individual capacitors.

8. A signaling transmission system comprising in combination, an input circuit, an output circuit, and means to introduce time delay between said input and output circuits, comprising a plurality of networks, each comprising a capacitor and a resistor in parallel, means to vary the voltage charges on successive capacitors in proportion to the amplitudes of signals in said input circuit which voltage charges are allowed to dissipate for a certain time interval at a substantially constant rate in the resistors connected to the individual capacitors, and means to utilize the remainder of the voltage charges on successive capacitors after the certain time interval to institute in said output circuit signals corresponding to the signals in said input circuit and simultaneously therewith to cancel on successive capacitors the charge variations due to the signals in said input circuit, the time delay between said input and output circuits being proportional to the certain time interval.

9. In combination, in a signal transmission system, an input circuit, an output circuit, and means to record and reproduce in said output circuit signals corresponding to the signals in said input circuit, comprising an electron discharge device embodying a plurality of targets arranged in a curvilinear path, a network comprising a capacitor and a resistor in parallel applied to each of said targets, and means to generate and move two electron beams over said targets in the same direction with a certain angular difference therebetween to control the voltage charges on successive capacitors such that one electron beam varies the voltage charges on successive capacitors in proportion to the amplitudes of the signals in said input circuit which

voltage charges are allowed to dissipate for a certain interval of time at a substantially constant rate in the resistors connected to individual capacitors and such that the other electron beam institutes, under control of the voltage charges remaining on successive capacitors after the certain time interval, in said output circuit signals corresponding to the signals in said input circuit and having a time delay proportional to the certain time interval.

10. In the combination according to claim 9 in which the amount of said angular difference between said two electron beams and the speed of movement of both electron beams over successive targets control the magnitude of the certain time interval and thereby the time delay intervening between corresponding signals in both said input and output circuits.

11. In combination, in a signaling transmission system, an input circuit, an output circuit, and means to introduce a time delay between corresponding signals in said input and output circuits, comprising a first electron beam discharge device embodying a cathode, a control grid, a plurality of discrete anodes disposed in a curvilinear path about both said cathode and control grid, and means to generate and move an electron beam over said first-mentioned anodes, a second electron beam discharge device embodying a further cathode, a plurality of discrete control grids arranged in a curvilinear path about said further cathode, a further plurality of discrete anodes arranged in a curvilinear path about both said second-mentioned cathode and control grids, and further means to generate and move a further electron beam over said second-mentioned control grids and anodes, each of said discrete anodes of said one device and each of said discrete control grids of said second device comprising a discrete unitary element, and a network including a capacitor individual to each said unitary element, said first and second electron beams arranged with a certain angular difference therebetween to control said time delay such that said first electron beam varies the charges on successive individual capacitors in proportion to signals of varying amplitude in said input circuit and said second electron beam utilizes the charges on successive individual capacitors to transmit effectively to said output circuit signals corresponding to signals in said input circuit.

12. A signaling transmission system embodying time delay, comprising an output circuit for delay signals, a first electron discharge device comprising a cathode, a plurality of control grids arranged about said cathode in a curvilinear path, a plurality of anodes arranged about said grids in a curvilinear path, and an electron beam moving over both said grids and anodes, circuit means to connect said cathode and said anodes of said first device to said output circuit, an input circuit for incoming signals, a second electron discharge device comprising a further cathode, a further control grid, and a further plurality of anodes disposed in a curvilinear path about said further cathode, and a further electron beam moving over said further anodes, each control grid of said first device and each anode of said second device forming a unitary element, a network including a capacitor applied to each said unitary element, and further circuit means to connect said further control grid and cathode of said second device to said input circuit, said electron beam of said first device effectively

transmitting to said output circuit signals corresponding to variations of the charges on successive individual capacitors while at the same time canceling the charge variations on said successive individual capacitors, and said further electron beam of said second device varying the charges on successive individual capacitors in proportion to the amplitudes of signals present in said input circuit and corresponding to said signals transmitted to said output circuit.

13. A signaling transmission system, comprising an input circuit for signaling waves of varying amplitudes, a plurality of networks, each comprising a resistor and a capacitor in parallel, for recording and reproducing said signaling waves, a first electron discharge apparatus interposed between said input circuit and said networks to vary the charges on the capacitors of successive networks in proportion to the signaling waves of varying amplitudes in said input circuit, an output circuit, and a second electron discharge device connected between said networks and said output circuit to utilize, after the charges on the capacitors of successive networks have dissipated at a substantially constant rate in the resistors associated therewith for a certain interval of time, the charges remaining on the capacitors of successive networks after the certain time interval to transmit effectively to said

output circuit signaling waves corresponding to the signaling waves in said input circuit and having a time delay proportional to the certain time interval.

14. A signaling transmission system comprising an input circuit, an output circuit, and means to introduce time delay between corresponding signals of said input and output circuits, including a plurality of networks, each comprising a capacitor, and an electron discharge device including a plurality of unitary targets arranged in a curvilinear path, each of said targets being connected to one of said networks, and a pair of double-ended electron beams arranged with a certain angular difference therebetween to sweep over said targets in the same direction such that the opposite ends of one electron beam alternately vary the charges on the capacitors of successive networks in proportion to the amplitudes of signals in said input circuit, and the opposite ends of the other electron beam alternately utilize the charges on the capacitors of successive networks to institute in said output circuit signals corresponding to the signals in said input circuit and substantially at the same time cancel the variations of the charges on the capacitors of successive networks due to the signals in said input circuit.

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