Jan. 20, 1942. A. KAHN 2,270,449

ELECTRICAL PHASE SHIFTING DEVICE

Filed Nov. 1, 1938 2 Sheets-Sheet 1

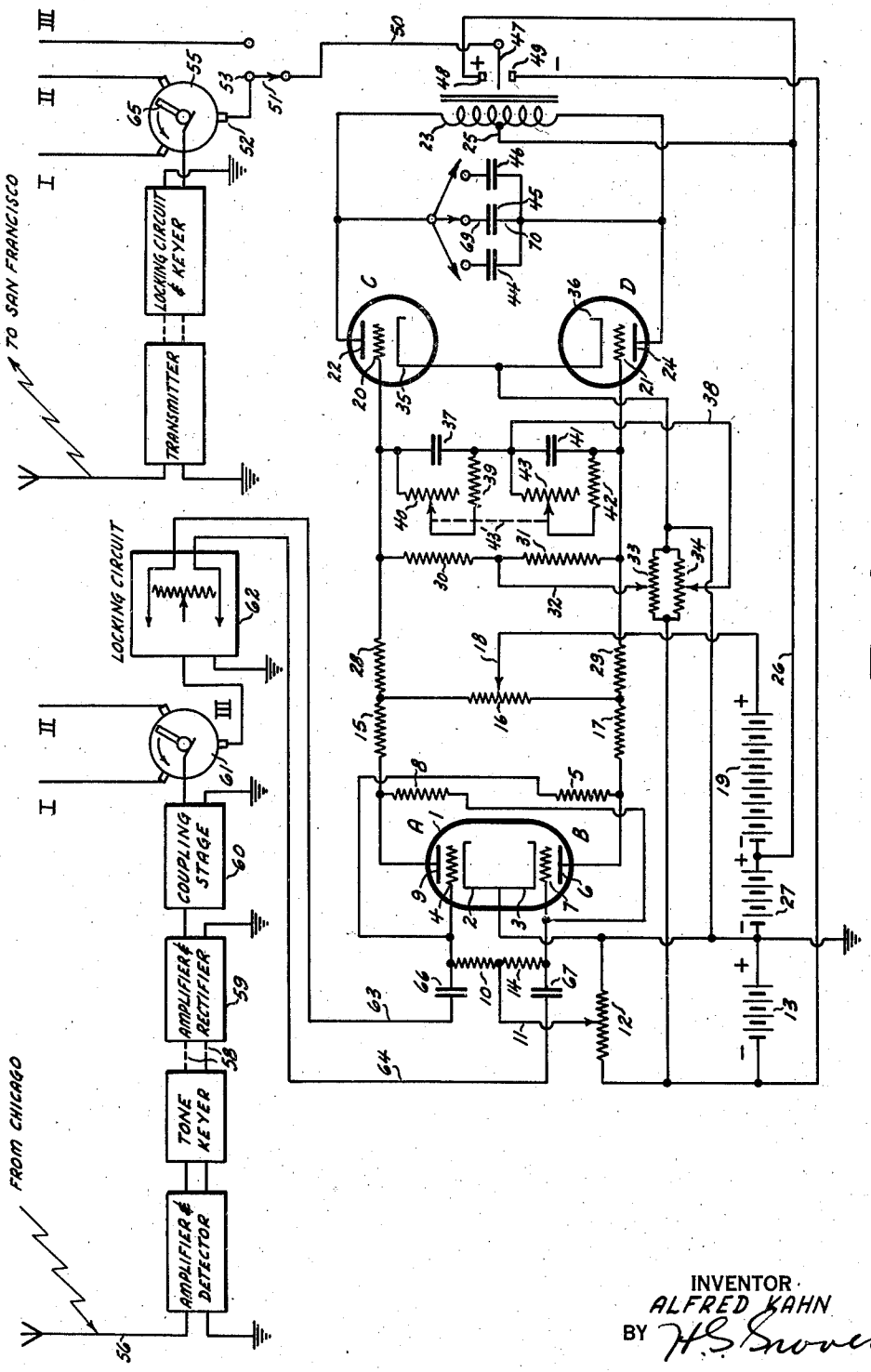


Fig. 1

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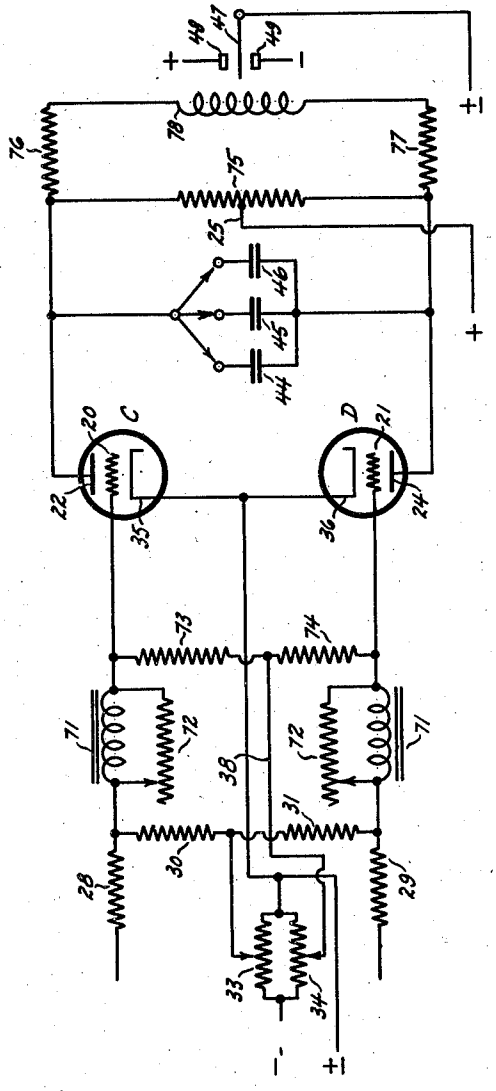


Fig. 2

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UNITED STATES PATENT OFFICE

2,270,449

ELECTRICAL PHASE SHIFTING DEVICE

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Application November 1, 1938, Serial No. 238,167

15 Claims. (Cl. 178—53)

This invention relates to phase delay devices and is useful in multiplex telegraph systems, both wire and radio, and particularly so in such systems where signals from one station are relayed through a second station to a third station. This relaying of messages is customarily referred to as channel extension. In time division multiplex telegraph systems the metallic conductor or radio link is assigned to the terminal equipment, consisting of senders or receivers, as the case may be, for equal portions of time by a distributing means and the commutator or distributor at the receiving end must run in synchronism and phase with a corresponding commutator or distributor at the transmitting end.

Each channel is assigned to the circuit for an equal period of time, this period being determined by the design of the distributing means and the speed of operation of the system. It has been found preferable, though not essential, to assign the circuit to a channel at approximately the middle of a signal unit in order to permit the signal unit to reach its steady state value, for consistently good operations.

The dot of the Morse code is adopted as the basic signal unit usually called a "baud." For more detailed explanation of a multiplex system reference is made to a patent of R. E. Mathes, No. 1,979,484, November 6, 1934.

In multiplex signaling, particularly with reference to transmitting, the clutch mechanism of the automatic tape transmitter head can be readily adjusted to retard the phase of the signal units so that the distributor assignment of each channel to the circuit occurs at the center of a baud. However, where signals from a distant station are received by means of a multiplex receiving apparatus and are combined with local signals and transmitted to another station, mechanical means cannot be advantageously utilized to phase the signals of the extended channel with the local distributor and it is, therefore, preferable to employ electrical phase shifters or delayers for the relayed signals.

One of the objects of my invention is to provide an electrical phase shifter for signal transmission.

Another object is to provide an electrical phase shifting device that can be inserted without complications directly into a multiplex system already in operation.

Another object of my invention is to provide an electrical phase shifting device that is stable in operation and that needs no attention after once being adjusted for producing a given phase delay.

Other objects of the invention will appear in the following description, reference being had to the drawings in which:

Figure 1 is an illustration of a multiplex radio system employing the phase shifting unit.

Figure 2 illustrates a modified form of phase shifter.

To illustrate completely every part of a multiplex system from the receiver to the transmitter would render this description unbearably long; therefore, well known parts and units in such a system have been shown in symbolic or in partial diagrammatic form.

Let it be assumed that a branch station at Chicago desires to transmit to say, San Francisco, by having the communication relayed through another station, say, one located in New York city. Such relaying of communication is not only preferable from an economical standpoint in most cases, but at certain times it is impossible to send direct communication between two stations because of atmospheric conditions or for other reasons, while the transmission over the indirect route is unaffected.

The drawings illustrate only the apparatus used at the main, or relaying, station as the invention can be fully understood without illustrating the apparatus at the other stations.

The two triodes A and B which may be incorporated in one evacuated enclosure 1, have indirectly heated cathodes 2 and 3, though the triodes may be entirely separate and may have directly heated cathodes. The grid 4 of triode A is connected through resistance 5 to the plate 6 of triode B, while the grid 7 of the latter triode is connected through resistance 8 to the plate 9 of the former. The grid 4 is also connected through resistance 10 and conductor 11 to potentiometer 12 which is connected across battery 13 or other suitable source of direct current. The grid 7 is similarly conducted through resistance 14 to potentiometer 12. This potentiometer permits one to adjust the bias on the grids. The plate 9 is connected through resistances 15, 16 and 17, to the other plate 6. An adjustable tap 18 connects the positive side of battery 19 to resistance 16 so that plate potential is applied to the triodes. The circuit thus far described is similar to the locking arrangement disclosed in my Patent No. 1,995,181, March 19, 1935.

The output resistances 15 and 17 are connected to grids 20 and 21, respectively, of gas tubes C and D, commonly referred to as "thyratrons" or "grid glow" tubes, which have the property of

being dependent upon the grid potential for starting the plate current but being independent of such grid while the plate current is flowing.

The plate 22 of the gas tube C is connected to one end of relay coil 23; the other end of this coil is connected to plate 24 of the other gas tube D. The center tap 25 of the relay coil 23 is connected by conductor 26 to the positive side of battery 27.

Batteries 13, 27 and 19 are connected in series and constitute one bank of batteries as indicated by the polarities given on the drawings.

The grid 20 is connected to one end of resistance 16 through resistance 28 and the grid 21 is connected to the other end of resistance 16 through resistance 29. Grid 20 is connected to the grid 21 by resistances 30 and 31 and the center point of these two resistances is adjustably connected to resistance 33 which, in parallel with resistance 34, is connected between ground and the negative side of the battery 13. Resistances 28, 30, 31 and 29 act as a voltage divider arrangement to permit one to adjust the voltages applied to the grids of the gas tubes.

A condenser 37 is connected between grid 20 and conductor 38, which is adjustably connected to resistance 34. Resistance 39 and adjustable resistance 40 are connected in shunt to condenser 37. Grid 21 is likewise connected by condenser 41 to the conductor 38 and this condenser is shunted by resistance 42 and adjustable resistance 43. The adjusting devices are connected together at 43' so that simultaneous adjustment is provided.

Condensers 44, 45 and 46 are adapted to be connected across the plates 22 and 24 of the gas tubes C and D. These commutating condensers, as they are usually called, alternately interrupt the plate current of the gas tubes when they are once fired by the potential appearing alternately on the grids 20, and 21, and the grids thereupon resume control.

When the upper portion of coil 23 is energized, relay tongue 47 is moved upwards into engagement with the contact 48 which is connected to the positive terminal of battery 27. When the lower portion of coil 23 is energized, tongue 47 is drawn into engagement with contact 49 which is connected to the negative terminal of the battery assembly, that is, the negative terminal of battery unit 13. The relay tongue 47 is connected by conductor 50 and switch 51 with the contact 52 of channel III of the transmitter distributor 55 of the New York station.

In order to properly adjust the commutation of the gas tubes C and D, a plurality of condensers have been provided with switching arrangements so that any one or more of these can be switched in the circuit. Of course this is merely for the adjustment of the gas tubes to the signal voltage conditions and when once the tubes are set no further change is required unless the signal voltages are changed.

With this description of the parts of the phase shift device, the operation will be explained in connection with the relaying of signals from some distant station, say, Chicago, whose apparatus is not shown, to another station, say, San Francisco, whose apparatus also is not shown.

Let it be assumed that at Chicago station, channels I and II are being used for direct communication with the station at New York city and that channel III at Chicago is being used for communicating with the station at New York city for relaying through the transmitter of the latter to the San Francisco station. It will also be assumed that channels I and II of the New York transmitting distributor 55 are being used for direct communication between the New York station and the San Francisco station, and that channel III of the distributor 55 is being used for extending the Chicago communication to San Francisco. Of course the various channels could be assigned in any order desired and the above description is given only for the understanding of the operation of my invention.

The signal coming in from the Chicago station will reach the receiving antenna 56 after which it will be amplified, detected and further amplified and then tone keyed, as particularly explained in patent to Beverage and Peterson, No. 1,874,866, August 30, 1932. The signals are then transmitted over lines 58, which may or may not be of considerable length, and at the local station the signals are rectified and further amplified as symbolically indicated at 59. The signals are next conveyed to a coupling tube stage also symbolically illustrated at 60, which feeds the composite signal into the receiving distributor 61 at the New York station. The distributor 61 transfers the signals to the channels I, II and III. The signals of I and II are transferred to locking circuits and utilization devices not shown.

The signals of the extended channel III are fed into locking unit 62 which produces alternating potentials across the conductors 63, 64, that mark the beginning and ending of the Morse code or other signals. The manner in which the rectifier coupling tube, distributor and locking unit operate are fully explained in my Patent No. 1,995,181, dated March 19, 1935, and it would unnecessarily lengthen this description to repeat theory of operation here.

When these signals arrive from Chicago over channel III, they will, except in rare instances, be out of phase with the signals arriving at the transmitter distributor 55 from local transmitting channels I and II; consequently, if the distributor arm 65 of the transmitter picks the signals from channels I and II at the center of the baud it will not pick the signals from extended channel III at such center. My invention provides an electrical adjustment between the locking unit 62 and the transmitting distributor 55 that will permit one to electrically delay the phase so that the signals from channel III can likewise be picked off at the center of the baud.

As has been previously said, positive and negative potentials appear alternately across conductors 63 and 64. By this is meant that the potentials are positive and negative in respect to each other without reference to ground potential. Let it be supposed that for the moment conductor 63 is positive and 64 negative. The positive charge on conductor 63 sends charging current through condenser 66, resistance 10, and conductor 11, to the negative side of the battery. This makes the grid 4 positive, or less negative, in respect to the cathode 2 connected to the positive end of potentiometer 12. The negative charge of conductor 64 charges condenser 67 in a reverse direction and sends current through resistance 14 to make the grid 7 negative in respect to its cathode. This causes current to flow from positive conductor 18 through resistance 15 and the plate 9 of the triode to the cathode 2 and blocks the current flow through plate

6 to cathode 3 if this state of affairs has not already previously been reached. This action is the well known locking action taking place in the locking unit as referred to in my above mentioned patent.

The current flowing through resistance 15 makes grid 20 of the gas tube less positive and the lack of current in plate resistance 17 causes the tube 21 of the other gas tube to grow more strongly positive. The grid 20, therefore, does not fire gas tube C but the positive potential on grid 21 does cause gas tube D to fire and plate current flows from conductor 26 to the lower part of coil 23 to plate 24, cathode 36, back to the negative terminal of battery 27. This draws polarized relay tongue 47 into engagement with contact 49 and a negative pulse appears on distributor contact 52.

The flow of plate current through gas tube D charges condenser 45 so that its terminal 69 is positive with respect to its terminal 70. This polarity is produced by the absence of current in the upper part of coil 23 and the presence of current in the lower part of the coil. It will thus be seen that full battery positive potential is applied to the terminal 69, whereas a lesser positive potential, namely, the potential from plate to cathode of tube D is applied to the terminal 70.

When the locking unit 62 reverses the potential of the signal, conductor 63 becomes negative and conductor 64 positive in respect to each other. The two condensers 66 and 67 then discharge in series through resistances 14 and 19, the circuit being completed through the locking unit 62. This makes the grid 4 negative and grid 7 positive. Plate current then stops flowing through resistance 15 to plate 9 and commences to flow through resistance 17 to plate 6. This places maximum positive potential on the grid 20 and a reduced positive potential on the grid 21 due to the absence of drop in the upper part of resistance 16 and the existence of a drop in the lower part of such resistance. This causes vacuum tube C to fire and plate current passes through the upper part of coil 23 and plate 22. This draws the relay tongue 47 into engagement with contact 48 and a positive potential is applied to contact 52.

When the tube C commences to draw current the voltage on condenser lead 69 immediately drops to the plate-cathode voltage of tube C. Condenser 45 cannot discharge immediately and for an appreciable length of time its negative terminal 70 makes plate 24 negative with respect to its cathode. The current flow through gas tube D immediately stops and the grid 21 resumes control, but since sufficiently a negative or insufficiently positive potential is applied to grid 21 at this time to prevent the firing of the tube, no current flows. The gas tubes are thus set for another reversal of current from locking unit 62 and the pulses are conveyed to the transmitting distributor 55.

In order to delay the phase of the signals in channel III so that the center of the baud of this channel's signals occur at the same time as the centers of the bauds of channels I and II, I adjust the contacts of resistances 40 and 43 shunting the condensers 37 and 41. This regulates the drop in resistances 28 or 29, and delays the time of building up of the voltages on grids 20 and 21 to the firing point so that the signals occurring in the relay coil 23 can be delayed due to the delay of the firing of the gas tubes. The firing of the tubes 21 and 22 can also be adjusted by varying the grid bias by means of potentiometer 33, as these adjustments delay the phase of the signals by delaying the firing of the tubes. The signals can also be delayed by adjusting the commutating time of the tubes by means of the plate condensers 44, 45 and 46.

In Fig. 2 I have shown in the grid connection an inductance 71 shunted by resistance 72 and two resistances 73 and 74 connected from grids 20 and 21, respectively, to the grid bias conductor 38. Also, in this figure I have shown a resistance 75 connected across the plates 22 and 24 with the positive voltage terminal connected to the center of the resistance. Resistances 76 and 77 are connected between the plates and a relay coil 78, for operating the relay tongue 47. Parts in this figure that are similar to those in Fig. 1 have the same reference characters.

In Fig. 2 the time of firing, and the delay of the signal phase, can be adjusted by adjustment of resistances in a way that will be readily understood without further explanation.

While my invention has been disclosed in connection with channel extension systems, it is useful also in the phasing of local signals to be assigned to the transmitter through the distributor arm. When so used it makes it unnecessary to make mechanical adjustment for this purpose.

By referring to my hereinbefore mentioned patent it will be seen that the tube stages A and B constitute a locking circuit and it will be apparent that the resistances 28 and 29 could have been connected directly to the locking circuit 62 without affecting the phase shifting operations. However, I prefer to install the locking circuit of tubes A and B with the phase shifting device as one unit. I have therefore illustrated it in this way in the drawings.

It will be apparent that one can determine when the correct phase adjustment is obtained by utilizing well known indicators such as the stroboscope shown in the application of R. E. Mathes, filed Nov. 1, 1938, Ser. No. 238,168.

Having described my invention, what I claim is:

1. In a multiplex telegraph system, a transmitter, a message channel, a gas triode adapted to be fired by a predetermined charge on its grid, means for connecting said channel to the grid and cathode of the triode, means connected between the plate and filament of the triode for applying potentials to the transmitter, a reactance connected between the grid and cathode of the triode, means to adjustably by-pass current around the reactance to delay the building up of signal potentials on the grid to the firing point of the triode, and means to extinguish the plate current after decrease of grid potential below the firing point.

2. In a multiplex telegraph sysem, a transmitter, a message channel, a gas triode adapted to be fired by a predetermined charge on its grid, means for connecting said channel to the grid and cathode of the triode, means connected between the plate and cathode of the triode for applying potentials to the transmitter, a condenser connected between the grid and the cathode of the triode, means to adjustably by-pass current around the condenser to delay the building up of signal potentials on the grid to the firing point of the triode and means to extinguish the plate current in the tube after it has been fired by its grid.

3. In a multiplex telegraph system, a trans-

mitter, a message channel, a pair of gas triodes, adapted to be fired by a predetermined charge on their grids, means for connecting said channels to the grids and cathodes of said triodes, means connected to the plates of the triodes for applying potentials to said transmitter, a condenser connected between said plates for commutating the plate currents and means to variably delay the building up of signal potentials on the grids to the firing point of said triodes.

4. In a multiplex telegraph system, a transmitter, a message channel, a pair of gas triodes, adapted to be fired by a predetermined charge on their grids, means for connecting said channel to the grids and cathodes of said triodes, means connected to the plates of the triodes for applying potentials to said transmitter, condensers bridged between the grids and cathodes of said triodes, an adjustable shunt around each of said condensers to delay the building up of signal potentials on said grids to the firing point of said triodes and a condenser bridged across the plates to commute the plate current alternately from one plate circuit to the other.

5. In a multiplex channel extension system, a transmitter, a plurality of transmitter message-channels, means to connect said channels in succession to said transmitter, a receiver, a plurality of receiver message-channels, means to connect said receiver message-channels in succession to said receiver, a gas triode, means to connect the grid and cathode of said triode to one of said receiver message-channels, means to connect its anode and cathode to one of said transmitter message-channels, means operated by a signal pulse in the last mentioned receiver message-channel for building up a charge on said grid to cause the triode to strike, means to quench said triode after termination of said signal pulse and means to vary the time of the building up of the charge on said grid for synchronizing the signal pulse with the connection of the last-mentioned transmitter message channel to said transmitter.

6. In a multiplex channel extension system, a transmitter, a plurality of transmitter message-channels, means to connect said channels in succession to said transmitter, a receiver, a plurality of receiver message-channels, means to connect said receiver message-channels in succession to said receiver, a gas triode, means to connect the grid and cathode of said triode to one of said receiver message-channels, and its anode and cathode to one of said transmitter message-channels, means operated by a signal pulse in the last mentioned receiver message-channel for building up a charge on said grid, means for varying the time of the building up of the charge on said condenser to cause the triode to strike when the last mentioned transmitter message-channel is connected to said transmitter, and means for rendering the anode of said triode negative in respect to its cathode after termination of said signal pulse.

7. In a multiplex channel extension system, a transmitter, a plurality of transmitter message-channels, means to connect said channels in succession to said transmitter, a receiver, a plurality of receiver message-channels, means to connect said receiver message-channels in succession to said receiver and in synchronism with the channel connection by the first mentioned means, a gas triode, means to connect the grid and cathode of said triode to one of said receiver message-channels, and its anode and cathode to one of said transmitter message-channels, means operated by a signal pulse in the last mentioned receiver message-channel for building up a charge on said grid, means for varying the time of the building up of the charge on said condenser to cause the triode to strike when the last mentioned transmitter message-channel is connected to said transmitter, and means for rendering the anode of said triode negative in respect to its cathode after termination of said signal pulse.

8. In a multiplex channel extension system, a transmitter, a plurality of transmitter message-channels, means to connect said channels in succession to said transmitter, a receiver, a plurality of receiver message-channels, means to connect said receiver message-channels in succession to said receiver, a gas triode, means to connect the grid and cathode of said triode to one of said receiver message-channels, and its anode and cathode to one of said transmitter message-channels, a condenser connected between the grid and cathode of the triode, means to delay the building up of a charge on said grid by a signal pulse in the last mentioned receiver message-channel, means to quench said triode after termination of said signal pulse in the last mentioned receiver message-channel, and means to vary the time of building up of the striking charge on said condenser to cause the tube to strike when the last mentioned transmitter message-channel is connected to said transmitter.

9. In a multiplex channel extension system, a transmitter, a plurality of transmitter message-channels, means to connect said channels in succession to said transmitter, a receiver, a plurality of receiver message-channels, means to connect said receiver message channels in succession to said receiver, a gas triode, means to connect the grid and cathode of said triode to one of said receiver message-channels, and its anode and cathode to one of said transmitter message-channels, means operated by signal marks in the last mentioned receiver message-channel for causing the triode to strike when the last mentioned transmitter channel is connected to the transmitter and means operated by signal spaces to quench said triode.

10. In a multiplex channel extension system, a transmitter, a plurality of transmitter message-channels, means to connect said channels in succession to said transmitter, a receiver, a plurality of receiver message-channels, means to connect said receiver message-channel in succession to said receiver, a resistance, a gas triode, means to connect the grid of said triode to one of said receiver message-channels through said resistance and its anode to one of said transmitter message-channels, a condenser connected between the grid and cathode of the triode, means to delay the building up of a charge on said grid by a signal pulse in the last mentioned receiver message channel, a variable resistance connected around said condenser for varying the delay to cause the triode to strike when the last mentioned transmitter message-channel is connected to said transmitter, and means to quench said triode after termination of said signal pulse in the last mentioned receiver message-channel.

11. In a multiplex channel extension system, a transmitter, a plurality of transmitter message-channels, means to connect said channels in succession to said transmitter, a receiver, a plurality of receiver message-channels, means to connect

said receiver message-channels in succession to said receiver, a gas triode, a resistance, a source of negative grid bias, means to connect the grid of said triode to one side of said receiver message-channels through said resistance and the cathode to the other side thereof through said source of negative bias, means to connect one of said transmitter message-channels across the anode and cathode of said triode, a condenser connected between the grid and cathode of the triode, a resistance around said condenser, and means to vary the second mentioned resistance to cause the triode to strike when the last mentioned transmitter message-channel is connected to said transmitter.

12. In a multiplex channel extension system, a transmitter, a plurality of transmitter message-channels, means to connect said channels in succession to said transmitter, a receiver, a plurality of receiver message-channels, means to connect said receiver message-channels in succession to said receiver, a gas triode, a resistance, a source of negative grid bias, means to connect the grid of said triode to one side of said receiver message-channels through said resistance and the cathode to the other side thereof through said source of negative bias, means to connect one of said transmitter message-channels across the anode and cathode of said triode, a condenser connected between the grid and cathode of the triode, a resistance around said condenser, and means to vary the second mentioned resistance to cause the triode to strike when the last mentioned transmitter message-channel is connected to said transmitter and means to quench said triode after termination of said signal pulse in the last mentioned receiver message-channel.

13. In a multiplex channel extension system, a transmitter, a plurality of transmitter message-channels, means to connect said channels in succession to said transmitter, a receiver, a plurality of receiver message-channels, means to connect said receiver message-channel in succession to said receiver, a pair of resistances, a first and second gas triode having their inputs connected in opposition to one of said receiver message channels through said resistances and their anodes in opposition to one of said transmitter message-channels, a condenser connected between the grid and cathode of each triode, means to delay the building up of a charge on said grid by a signal pulse in the last mentioned receiver message channel, a variable resistance connected around said condenser for varying the charging time of the condenser to cause the triode to strike when the last mentioned transmitter message channel is connected to said transmitter, and means to quench one triode when the other one strikes.

14. In a multiplex channel extension system, a transmitter, a plurality of transmitter message-channels, means to connect said channels in succession to said transmitter, a receiver, a plurality of receiver message-channels, means to connect said receiver message channel in succession to said receiver, a pair of resistances, a first and second gas triode having their inputs connected in opposition to one of said receiver message channels through said resistances and their anodes in opposition to one of said transmitter message channels, a condenser connected between the grid and cathode of each triode, means to delay the building up of a charge on said grid by a signal pulse in the last mentioned receiver message channel, and a variable resistance connected around said condenser for varying the charging time of the condenser to cause the triode to strike when the last mentioned transmitter message channel is connected to said transmitter.

15. In a telegraph system, a communication link, a message channel, a gas triode adapted to be fired by a predetermined charge on its grid, a resistance connecting the grid of said triode to said channel, means connected between the plate and filament of the triode for applying potentials to the communication link, a condenser connected between the grid and cathode of the triode, means to adjustably by-pass current around said condenser to vary the drop in said resistance for varying the time required to build up a firing potential on the condenser, and means to extinguish the plate current of the triode after it has been fired by its potential on said condenser.

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