

Nov. 8, 1938.

W. A. KNOOP

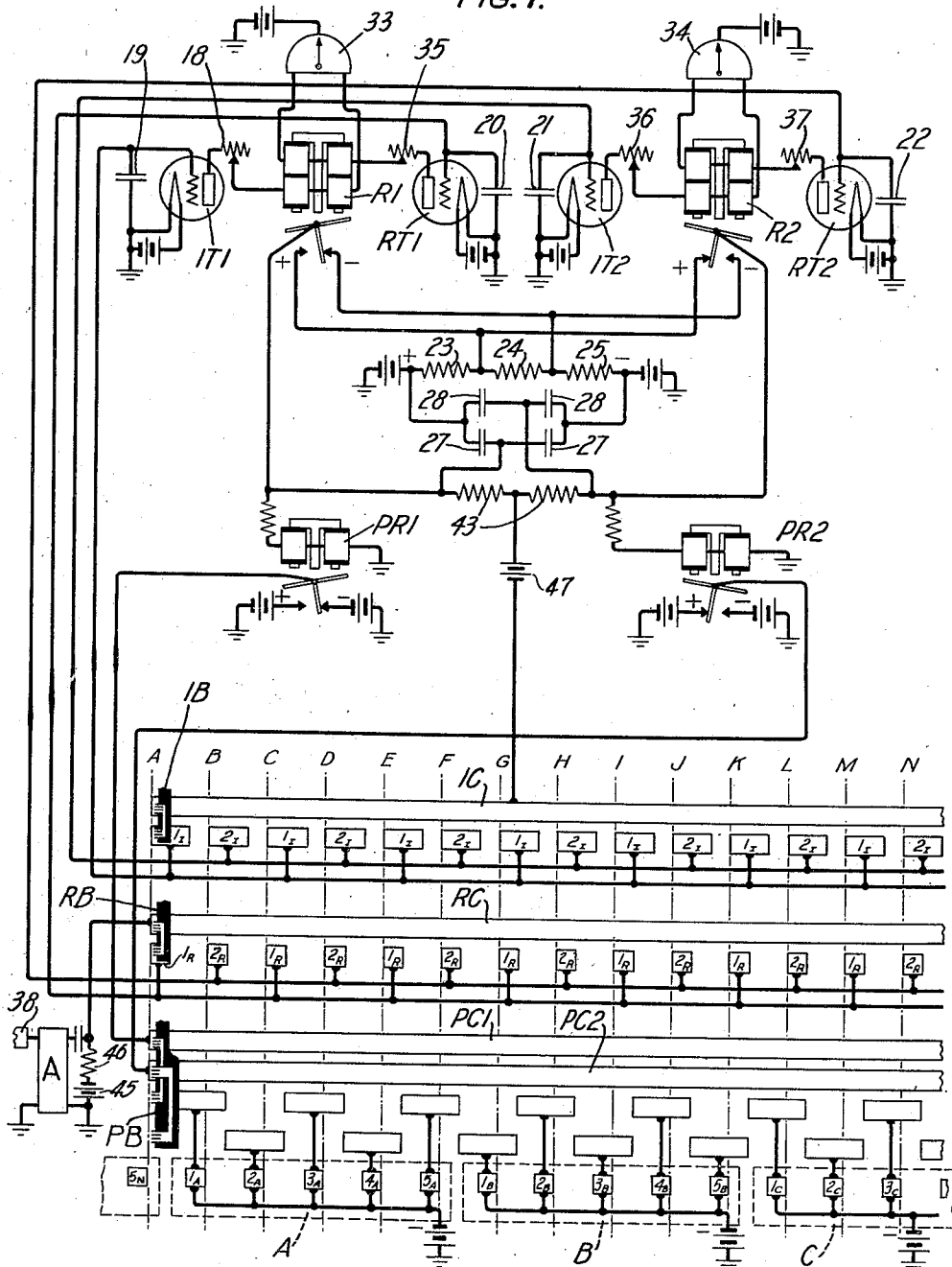
2,135,581

SYNCHRONOUS RECEIVING SYSTEM

Filed Feb. 10, 1928

2 Sheets-Sheet 1

FIG. 1.



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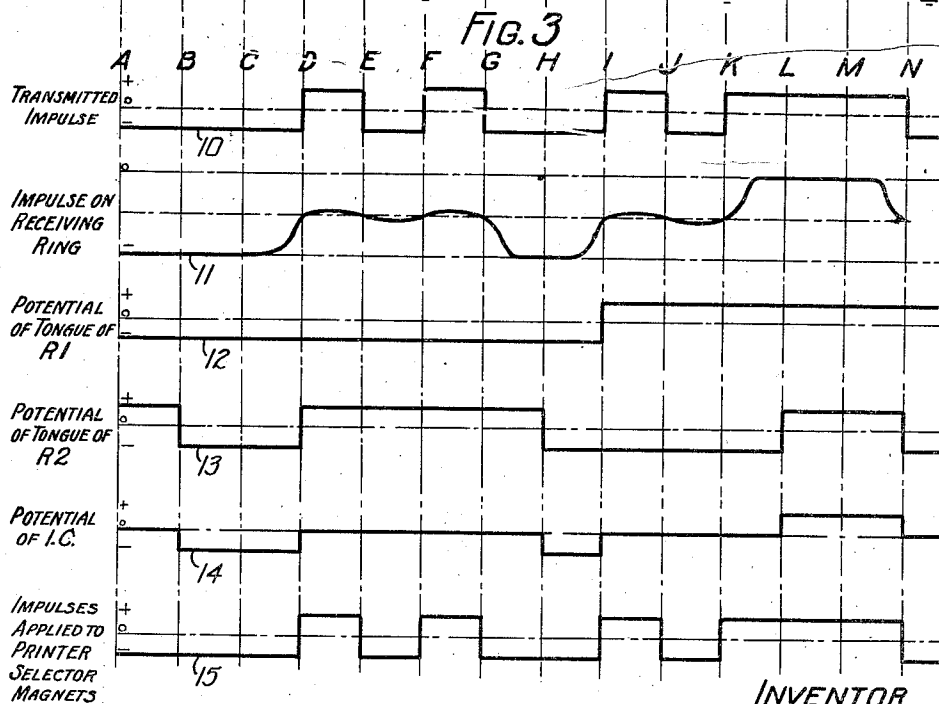
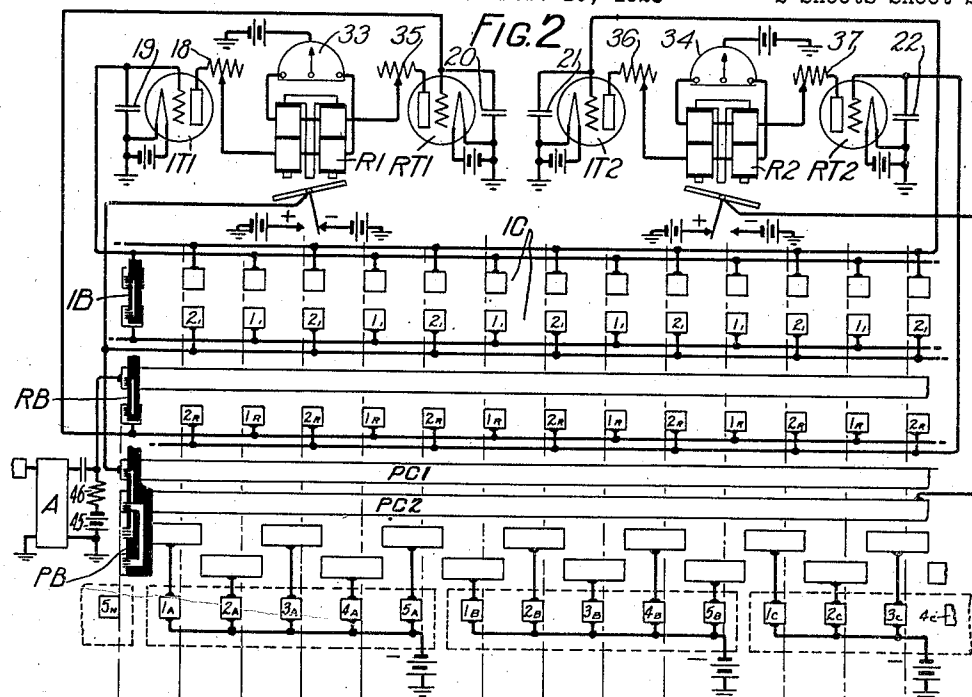
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SYNCHRONOUS RECEIVING SYSTEM

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2 Sheets-Sheet 2



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SYNCHRONOUS RECEIVING SYSTEM

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26 Claims. (Cl. 178—52)

This invention relates to high speed synchronous telegraph systems in which, due to the characteristics of the transmission line, short signal impulses are excessively attenuated and must be rebuilt at the receiving end or the relaying point. Heretofore receiving systems for this purpose have been commonly termed vibrating relay systems. This expression is somewhat misdescriptive of the system of this invention (because short impulses are rebuilt without vibration of any relay) and therefore, in this specification the expression "interpolating receiving system" will be used to define a system which restores, or interpolates short signal impulses which have been attenuated to such an extent that they are incapable of controlling a receiving relay or a relay for retransmitting the impulses into the next line section.

An object of the invention is to greatly increase the speed of interpolating receiving systems without sacrifice of accuracy and reliability.

Heretofore, as noted above, it has been a practice to rebuild or restore short impulses at the receiving station by means of relay systems in which a relay vibrates under the control of special distributor segments to automatically restore signal impulses of unit length. Such vibrating relay systems have rather definite speed limitations and long loaded telegraph cables are now in existence which have a possible speed of transmission exceeding that at which they are capable of operating satisfactorily.

This invention comprises a synchronous telegraph receiver in which successive unit signal impulses received over the line conductor are applied by a receiving distributor to a plurality of receiving relays in rotation. These relays repeat the impulses into a repeating distributor which rearranges them in the sequence of the original signal impulses for application to the printing magnets. One advantage of this arrangement is that each receiving relay need operate at only a fraction of the frequency of received impulses, and another more important advantage is that it permits the use of special means whereby when no signal impulses of appreciable strength are received the line relay tongues are locked on successively opposite contacts, thereby causing the printing distributor to apply impulses of alternately opposite polarity to the printing magnets without attendant motion of the relay tongues. Each relay tongue or armature, upon movement to a particular position tends to place the other in the opposite position and in the absence of line pulses of controlling amplitude is effective

to do so; consequently there is an interlock means between the relays and inasmuch as each relay is controlled by the other through a discharge tube there is an interlock between the tubes whereby each controls the other in endless chain fashion.

In applicant's copending application Serial No. 362,781, filed May 13, 1929 now Patent No. 1,992,220, granted Feb. 26, 1935 there are disclosed and claimed circuit arrangements whereby the more fundamental objects of the present invention are accomplished. Insofar as the subject matter of said application involves common principles said subject matter is claimed in said other application. The claims of the present application relate to features and modifications in accordance with which the speed and reliability of operation may be increased to a greater extent than by the use of the circuit arrangements of said other application.

A feature contributing to this increased speed and reliability consists in the use of thermionic discharge tubes in addition to the usual receiving amplifier, which tubes are energized by impulses received from the incoming line or line amplifier, as the case may be, to apply powerful and effective control currents to the receiving relays. These receiving relays when not required to move are energized by discharge tubes controlled locally over a synchronized distributor to maintain their armatures in position but when an arriving impulse is applied to one of them to move its armature the energy of the impulse is not only increased by the discharge tube but its time duration may be increased as well. Thus the discharge tube may be influenced by an impulse of short duration picked out of the center of the received impulse by a relatively short segment of the synchronized distributor but the relay is influenced for a correspondingly longer time owing to the pulse lengthening characteristic of the discharge tube and elements associated therewith.

In the drawings,

Fig. 1 is a schematic circuit showing a preferred arrangement of applicant's circuit,

Fig. 2 is an alternative arrangement, and

Fig. 3 is a series of curves showing the operation of the system.

Referring to Fig. 1, a developed portion of the receiving distributor is shown having receiving brushes RB, interpolating brushes IB and printing brushes PB with their associated common and segmented rings. Two main relays R1 and R2 each have two windings. One winding of relay R1 is under the control of receiving tube

RT1 and one winding of relay R2 is under the control of receiving tube RT2. The other winding of relay R1 is under the control of the interpolating tube IT1 and the other winding of relay R2 is under the control of interpolating tube IT2. The receiving tubes have their respective grids connected to successive segments associated with the receiving brush RB and the interpolating tubes have their respective grids connected to successive segments associated with the interpolating brush IB. The receiving common ring RC associated with the receiving brush RB is connected to a line conductor 38 through an amplifier A, and the common interpolating ring IC associated with the interpolating brush IB is connected to the mid-point of a special potentiometer circuit 43 whereby its potential depends on the positions of the tongues of both relays R1 and R2. PR1 and PR2 are printing relays controlled by relays R1 and RT respectively which serve to repeat signal impulses to two common printing rings PC1 and PC2 which are alternately associated with successive printing magnets by the printing brush PB.

In normal operation when no signals are being received the grids or control electrodes of all the tubes are at a steady negative potential supplied by a grid biasing battery 45, connected through leak resistance 46 to RC, or from battery 47 connected to the interpolating common ring IC, as a result of which the current in one winding of each of relays R1 and R2 is equal and opposite to that in the other winding, and the relay tongues remain stationary against opposite contacts. It will be noted that the interpolating tube IT1 and receiving tube RT1 derive their plate currents from a single source through a differential meter 33, and the interpolating tube IT2 and receiving tube RT2 also derive their plate currents from a single source through a differential meter 34. If the two tubes associated with either relay do not have characteristics exactly the same, one may normally draw more current than the other and to permit compensation for this, adjustable resistances 18, 35, 36 and 37 are inserted in the plate circuits of the tubes. Each set of distributor segments and its associated brush and ring or rings constitute a circuit interrupting or making and breaking device, operating to close their respective circuits at regular periodic intervals.

Summary of operation

When unit impulses of alternately opposite polarity are transmitted from the distant station, the signals are greatly attenuated, as shown in curve 11 of Fig. 3, and do not appreciably change the grid potentials of receiving tubes RT1 and RT2 from their average negative value. Therefore, the currents in the upper or line windings of relays R1 and R2 are normal. The currents in the lower or interpolating windings are also normal, and equal and opposite to those in the upper windings because the opposite ends of the potentiometer 43 are connected to the two relay tongues of opposite polarity and therefore the mid-point of the potentiometer is at zero potential and the interpolating common ring IC has a constant negative potential equal to that of battery 47. The relays remain in a state of equilibrium, with their tongues on opposite contacts as shown in curves 12 and 13 of Fig. 3 and the printing rings perform the function of restoring the unit impulses of successively opposite polarity by connecting the tongues of the two relays alternately to successive printing magnets.

When an impulse of greater than unit length is transmitted from the distant station, an impulse of appreciable strength is received, which upsets the balance of current in the two windings of the relay to which it is applied and causes the tongue of that relay to move to its opposite contact. Since the tongues of both relays are then lying against contacts of the same polarity, the potential of the mid-point of the potentiometer 43 rises from zero to that of the relay tongues. This potential is applied by the interpolating brush IB to the grid of the interpolating tube associated with the other relay and causes that relay to reverse the position of its tongue unless the received line voltage currently applied is sufficient to control the relay. If the received pulse is of controlling magnitude both relay tongues are retained on contacts of like polarity and the interpolating brush successively applies a potential to the grid of each interpolating tube and biases the relays associated therewith so that one of them operates in response to the bias as soon as but not until, the line potential again drops to zero. The operation of either relay leaves the tongues of the two relays on opposite contacts again and the mid-point of the potentiometer 43 is restored to zero potential. The relays therefore remain stationary, while the printing brush applies pulses of successively opposite polarity to the printing magnets until another impulse of controlling magnitude is received over the line conductor.

Operation in detail of the circuit of Fig. 1

Referring to Fig. 3 in connection with Fig. 1, assume that at time A a negative impulse is being transmitted from a distant station, not shown, and is being received as a negative impulse as shown in curve 11. This impulse is applied from the common receiving ring RC over the receiving brush RB to a segment 1R connected to the grid of receiving tube RT1. This charge is stored on the condenser 20 in the grid circuit of RT1 and causes the plate current of that tube to decrease. If it is assumed that an electron flow in either winding of R1 or R2 tends to move the relay tongue in the direction of the flow it will be seen that the decreased electron flow from the plate of RT1 through the upper winding of R1 permits the normal electron flow through interpolating tube IT1 and the lower winding to control the tongue and it is held on its right hand contact as shown in Fig. 1. Since the right hand fixed contact of each relay R1 and R2 is connected to a point adjacent the negative terminal of the potentiometer comprising resistances 23, 24 and 25, the potential of the tongue of relay R1 will be negative as shown in curve 12 of Fig. 3. Since printing relay PR1 is controlled by current over the tongue of relay R1 its tongue follows the movements of the tongue of R1 which in this case results in the application of negative current to common printing ring PC1 and over the printing brush PB and connected segment to the first printing magnet in 1A group.

The distributor brushes continue their travel and at time B the brush RB closes on a segment 2 and applies the line potential, which, as shown at B, curve 11 is still negative, to the grid of receiving tube RT2 associated with relay R2. This decreases the electron flow to the left through the upper winding of R2 and permits the normal electron flow to the right in the lower winding to control the relay and move the tongue to the right contact. This permits negative current to flow through resistance 25 over the right hand

contact and tongue of relay R2 to printing magnet PR2 and moves its tongue to the right hand or negative contact which supplies negative current to common ring PC2 and over brush PB and associated segment to printing magnet 2A when brush PB reaches that point. In addition to applying negative potential to printing relay PR2 the movement of the tongue of R2 to the right applies negative potential to the right end of the potentiometer 43 composed of resistances 30 and 31. Heretofore the extremities of this potentiometer were connected to sources of potential of opposite polarity and therefore the mid-point 32 was maintained at zero potential. However, with the tongues on both relays lying against their right or negative contacts, the mid-point of the potentiometer 43 becomes negative and this charge is applied over the interpolating common ring IC and brush IB to a segment 2r and the grid of interpolating tube IT2. This will tend to decrease the electron flow to the right, through the lower winding of R2 but is not effective to move the relay tongue because the plate current through the upper winding is also reduced as the result of the negative charge applied to the grid of RT2 by brush RB.

It particularly must be borne in mind in connection with this system that the charges applied to the grids of the tubes are stored there and control the current in the plate circuit until the grid charge is removed by brush IB or RB contacting with the next succeeding segment connected to that grid. The capacity of the several grids is increased by small condensers 19, 20, 21 and 22 connected between the grid and filament of each tube.

Thus at time B the tongue of relay R2 has been operated to its right position by a decrease in the current flow through its upper winding and cannot be restored to its left position until the negative charge on the grid of tube RT2 is removed by a subsequent contact of brush RB with a segment 2r.

At time C it will be seen, referring to curve 11 that the received signal impulse is still negative and this negative potential applied over a segment 1r by the brush RB to the grid of RT1 maintains the plate current of that tube at a low value so that there is very little tendency on the part of the upper winding of R1 to move the relay tongue to the left. At the same time since the tongues of both R1 and R2 lie against their negative contacts the mid-point of the potentiometer 43 is also still negative and a negative charge is therefore applied over the interpolating common ring IC, brush IB, and a segment 1r to the grid of IT1 which reduces the plate current in the lower winding of relay R1. Since the currents in both the upper and lower windings of this relay are reduced to substantially the same extent the tongue remains against its negative contact as shown in curve 12. Accordingly, printing relay PR1 applies negative current to printer magnet 3A over the printing common ring PC1 and brush PB.

At time D the tongues of relays R1 and R2 and consequently the mid-point of the potentiometer 43 are still negative. Therefore, an excessive negative charge is applied over the interpolating common ring IC, brush IB, and a segment 2r, to the grid of interpolating tube IT2 which reduces the current flow through the lower winding of R2 so that there is little tendency on the part of this winding to hold the tongue of the relay in the position against the right contact to which

it was formerly operated. At the same time the receiving brush RB connects the receiving common ring RC to a segment 2a and the grid of receiving tube RT2. By referring to curve 11 it will be seen that the potential of the receiving common ring has been raised from its previous negative value to its mean value. Hence when brush RB contacts with segment 2a it removes the excessively negative charge from the grid of RT2 and permits the plate current through that tube and the upper winding of R2 to increase to its normal value. This electron flow to the left through the upper winding of R2 moves the tongue of the relay to the left contact thus changing its potential from negative to positive value as shown in curve 13. This reverses the position of the tongue of the printing relay PR2 and applies positive current over printing common ring PC2 to operate the printer magnet 4A when brush PB reaches its segment. At the same time the mid-point of the potentiometer 43 has its potential raised from a negative value to zero since its extremities are connected to sources of potentials of opposite polarities. This changes the potential of the grid of tube IT2 from its previous excessively negative value to its mean value and increases the electron flow to the right through the lower winding of R2 but does not move the relay tongue because of the equal and opposite electron flow in the upper winding.

At time E the interpolating common ring IC is still at its average potential and the receiving common ring RC is also at its average potential as shown by curve 11. This is due to the fact that, as shown by curve 10, a series of short impulses of alternately opposite polarity have been transmitted and such short impulses are very highly attenuated during transmission. Therefore, when brushes IB and RB make contact with their respective segments 1 at time E the potentials of the grids of tubes IT1 and RT1 are simultaneously raised from their previous excessively negative value to the mean value but, as the currents in the upper and lower windings of R1, although increased by these changes in grid potential, are still substantially equal and opposite to each other, the tongue of the relay remains against its negative contact. Hence printing relay PR1 applies negative current to printing ring PC1 and to printing magnet 5A when brush PB reaches its associated segment.

At time F the interpolating common ring IC and receiving ring RC are still at their average potentials as shown by curves 11 and 14 and therefore the grids of tubes IT2 and RT2 remain at their average potentials and the plate currents from these tubes through the lower and upper windings respectively of relay R2 remain at their normal values. Therefore the tongue of the relay remains against its left or positive contact. The tongue of printing relay PR2 likewise remains against its positive contact and applies positive current to printer magnet 1B over PC2 and brush PB.

At time G the interpolating common ring IC and receiving ring RC are still at the mean potential and the current flowing through the windings of relay R1 is unchanged and the tongue of the relay remains against its right contact. Printing relay PR1 also remains in its former position and applies negative current to printing magnet 2B over printing common ring PC1 and brush PB.

At time H however, an impulse greater than unit length has been transmitted from the dis-

tant station and the potential of the receiving common RC has decreased to an excessively negative value. Hence an excessively negative impulse is applied by receiving brush RB over segment 2_R to the grid of tube RT₂, which reduces the electron flow to the left through the upper winding of R₂ to a low value so that the normal electron flow to the right through the lower winding moves the tongue of the relay to the right against its negative contact. This results in the tongues of the two relays being both connected to negative contacts and the potential of the mid-point of the potentiometer 43 is reduced from its former zero value to negative value as indicated in curve 14. Printing relay PR₂ applies negative current over printing common ring PC₂ and brush PB to printing magnet 3B.

The above detailed description of operation is sufficient to indicate how the system responds to signal impulses of different lengths and polarities.

Heretofore no function has been assigned the condensers 27 and 28 in the potentiometer 43 of Fig. 1. These condensers are to prevent sudden fluctuations in the voltage of the interpolating common ring at the time the tongue of relay R₁ or R₂ leaves one contact and before it has closed on the opposite contact. For instance at time H when a negative charge is applied to the grid of receiving tube RT₂ by the receiving brush RB, the current in the upper winding is reduced and this permits the normal current in the lower winding to move the tongue to the right. However, the instant the tongue leaves the left, positive contact, the potential of the potentiometer 43 at its mid-point would, if the condensers were not inserted, change from zero to a negative value (the potential of the tongue of the other relay R₁) and this would increase the negative potential of interpolating tube IT₂ and reduce the current in the lower winding sufficient to permit the relay tongue to fall back against its positive contact. The condensers 27 and 28 store appreciable charges which discharge through the resistances of potentiometer 43 following the departure of the tongue of relay R₁ or R₂ from one contact and serve to delay the change in the potential of the potentiometer mid-point 32 until the tongue has closed on the opposite contact.

In Fig. 3 the changes in the received voltage (curve 11) have been shown as occurring at the same time as those of the transmitted voltage (curve 10). Actually the changes in the received voltage would occur at a time later than the corresponding changes in the transmitted voltage due to line lag, but for convenience in explaining the operation of the system, this line lag has been disregarded, since it does not affect the operation of the receiving system.

System of Fig. 2

Fig. 2 shows a modification of the system of Fig. 1 in which the potentiometer 43, with its associated condensers, has been eliminated by substituting a second segmented ring for the solid common ring 1C in Fig. 1. The printing relays have also been eliminated in this circuit but it is also possible to eliminate them from the circuit of Fig. 1 by connecting the tongues of the relays R₁ and R₂ directly to the printing common rings PC₁ and PC₂.

The effect of using two segmented interpolating rings 1C with successive segments in the upper ring connected to the interpolating tubes associated with successive receiving tubes and the corresponding segments in the lower ring con-

nected to the tongue of the preceding relay is to apply only the potential of the tongue of the preceding relay to the grid of an interpolating tube at any time. As a result, each relay is always biased to a position opposite that of the preceding relay by its interpolating winding. This sets successive relay tongues on opposite contacts unless they are otherwise controlled by received line signals and therefore the relays cooperate to rebuild lost impulses in the same general manner as do those in the circuit of Fig. 1.

It will be noted that tubes IT₁ and RT₁ constitute one discharge tube system and IT₁ and IT₂ another discharge tube system; that these each control one-half the printer magnets 1A, 1B, etc. directly under the control of the line pulses and under the control of each other for interpolating unit pulses. The connections from ground through battery 47 over segments 1I, 2I, etc. in Fig. 1 and directly from contacts of relays R₁ and R₂ in Fig. 2 constitute an interlocking or interconnecting control means whereby the systems bias each other for control when the line pulses do not assume a preponderant control. It has already been shown that the discharge tube systems may vary in number and circuit arrangement and that each tube system may consist of one as well as of a plurality of tubes as shown in applicant's Patents 1,799,627, granted April 7, 1931 and 1,832,308, granted November 17, 1931; and the as yet unpatented application Serial No. 432,288, filed March 1, 1930 now Patent No. 2,060,222 granted Nov. 10, 1936; it is the intention therefore to include these and all other equivalent arrangements within the scope of the claims in so far as the terms of the claims are descriptive thereof.

An advantage of the system shown in Fig. 2 over that disclosed in Fig. 1 is that any desired number of relays may be used. Two relays are ordinarily sufficient but where an odd number of signal impulses are received during each revolution of the distributor, it is obvious that they cannot be equally divided between two relays. For instance in a five channel system utilizing a five impulse code the minimum of five receiving relays would be required to evenly divide the impulses.

Synchronizing apparatus has not been disclosed since such means is well known in the art and is not a part of this invention.

What is claimed is:

1. In a synchronous telegraph receiving system, a plurality of relays each having a movable armature operable between two contacts connected to opposite poles of a source of potential and having two operating windings, means connected to each winding for lengthening pulses applied thereto, synchronous distributing means for distributing received signal impulses to one winding of each repeating device through said pulse lengthening means in rotation and for concurrently applying to the other winding of said relay through the pulse lengthening means associated therewith an impulse from the tongue of the preceding relay of such polarity and in such direction as to tend to operate the tongue of said relay to a position or polarity opposite that of the tongue of the preceding relay, signal recording means, and synchronous switching means for connecting the tongues of the relays to said signal recording means in rotation.

2. In a synchronous telegraph receiving system, two relays, each having a tongue movable between two contacts connected to opposite poles of a source of potential and having two operating

windings, a potentiometer, each end of which is conductively associated with the tongue of one of said relays, synchronous distributing means for distributing received signal impulses to one winding of each relay in rotation and for concurrently connecting the other winding of said relay between the mid-point of said potentiometer and a mid-tap of said source of potential, signal recording means, and synchronous switching means for distributing impulses repeated by said repeating devices to said signal recording means.

3. Means as defined in claim 2 further characterized in that a resistance is inserted between each pole of said source of potential and the contacts of the relays associated therewith and a condenser is connected between the tongue of each relay and each pole of said source of potential.

4. Means as defined in claim 2 further characterized in that a resistance is inserted between each pole of said source of potential and the contacts of the relays associated therewith and a third resistance is inserted between opposite contacts of said relays, and a condenser is connected between the tongue of each relay and each pole of said source of potential.

5. In a synchronous telegraph receiving system, a plurality of relays each having a movable armature operable between two contacts connected to opposite poles of a source of potential and having two operating windings, two three-electrode vacuum tubes associated with each relay, a common source of plate potential associated with each relay and connected through the respective windings differentially to the plates of the tubes associated therewith, means comprising a capacity connected between the grid and filament of each tube for storing impulses upon the grid, synchronous distributing means for distributing received signal impulses to the grid of one tube associated with each relay in rotation and for concurrently applying to the grid of the other tube associated with the same relay an impulse from the tongue of the preceding relay of such polarity and in such a direction as to tend to operate the tongue of said relay to a position opposite that of the tongue of the preceding relay, signal recording means, and synchronous switching means for connecting the tongues of the relays to said signal recording means in rotation.

6. A system as defined in claim 5 further characterized in that current indicating means and current regulating means are included in the plate circuit of each tube.

7. A system for relaying discrete impulses as similar discrete impulses of increased effectiveness comprising (a) an incoming line terminal, (b) a plurality of space discharge tubes, (c) a distributor for distributing impulses arriving from said terminal to a plurality of said tubes in succession, (d) input circuits for said tubes containing energy storing means, said circuits being connected to said distributor whereby short impulses applied thereto continue to remain effective for a time longer than the duration of the impulses applied, (e) an outgoing path under the control of at least one of said devices to which impulses of enhanced effectiveness corresponding to those supplied by said line terminal are supplied, and (f) a utilization circuit under the control of said outgoing path having the further characteristic feature of (g) a distributor comprising a plurality of contacts closed in succession each for a definite time synchronized with said

first named distributor for controlling the duration of individual impulses in the utilization circuit.

8. In a telegraph system, two thermionic devices of the type including input and output circuits, a distributor equipment including a solid ring, a segmented ring and a rotating brush, alternate segments of said segmented ring being connected to the grid element of one of said devices, and the remaining segments of said segmented ring being connected to the grid element of said second device, a source of telegraph signals connected between the cathodes of said devices and the solid ring of said distributor, distributor elements for distributing impulses into various circuits under the control of impulses in said output circuits, signal responsive devices controlled by said distributor elements and means for rotating the brushes of said distributor and distributor elements in synchronism with telegraphic signaling impulses from said source.

9. In a signalling system, a transmission line, a plurality of printer magnets, electromagnetic means provided with armatures for relaying impulses received from said transmission line to said receiving printer magnets, circuit arrangements including repeater tubes for maintaining the armatures of said electromagnetic means in engagement with a predetermined contact while no impulses are being received over said line, and means including the armatures of said electromagnetic means for periodically reversing the polarity of impulses to said receiving printer magnets while no impulses are being received over said line.

10. In a telegraph system, a signalling line over which signalling impulses transmitted are so attenuated that the dot impulses are lost, receiving electromagnetic means including armatures, printer magnets, means including the armatures of said electromagnetic means for operating said printer magnets in accordance with the signals transmitted over said signalling line, and means including circuit arrangements whereby the armatures of said electromagnetic means are moved only in response to impulses received, said circuit arrangements including devices for selecting an impulse of length corresponding to a portion only of a dot impulse and devices controlled thereby for applying a lengthened impulse of increased energy to said electromagnetic means.

11. An impulse receiving system comprising an incoming circuit, a discharge tube, a synchronized device periodically connecting said circuit to an input circuit of said tube to apply selected portions of incoming pulses thereto, an indicator or relay instrument to be operated and a device synchronized with said other synchronized device for applying lengthened impulses under control of the output circuit of said tube to said indicator or relay instrument.

12. An impulse receiving or relaying system comprising an incoming circuit, impulse lengthening and strengthening means including a discharge tube, a distributor periodically connecting said circuit to the input of said means, an instrument to be operated and a distributor for applying pulses controlled by the output of said means to said instrument.

13. A system in accordance with claim 12 in which the first distributor applies short pulses to said means, and the second distributor applies longer impulses to said instrument.

14. A system comprising receiving elements, an incoming circuit, a plurality of electro-thermionic

instrumentalities each capable of receiving a short impulse to produce a longer impulse, a distributor for distributing incoming impulses in consecutive order between said devices, and a device for distributing impulses corresponding to said longer impulses to receiving elements, a plurality of which cooperate to produce a signal indication.

15. In a telegraph system, a source of signals, a resistance element, means for causing a current flow through said resistance in accordance with a received signal impulse, an electric discharge device having a cathode and a control electrode, and means responsive to the drop in potential across said resistance for controlling the operation of said device by changing the potential of said electrode with respect to said cathode, said means including a circuit making and breaking device for connecting the electrode to be under control of said source at periodic intervals.

16. In an impulse interpolating system, a path for supplying impulses of effective positive, effective negative and ineffective or zero values, a distributor for supplying the impulses in turn to two discharge tubes each having an anode-cathode circuit and a control element, resistance means through which current is caused to flow as a result of a positive charge from said path distributed to one of said tubes, receiving elements alternately connectable to be controlled by said discharge tubes, and an interlock connection whereby current flow in said resistance means upon reception of a positive impulse from said path assigns an indication corresponding to a negative impulse upon reception of a following zero pulse from said path.

17. In a system for receiving positive and negative impulses and interpolating unit impulses during received zero impulses comprising an incoming path, space discharge tubes, distributor means for distributing successive impulses to said tubes in succession, receiving or relaying elements, distributor means for placing said elements under control of said tubes to register marking or spacing conditions in succession in synchronism with said first named distributor means, and interlock means whereby distribution of a positive or negative impulse from said path to one of said tubes establishes a condition for assigning successive marking and spacing conditions to said elements in succession during a following zero impulse of any duration, said interlock means being connected to the output paths of said tubes in a symmetrical manner whereby the first marking or spacing condition assigned under the control of the interlock means is the opposite of the condition registered by the preceding element.

18. In a communication system, apparatus for repeating and regenerating received intelligence signals, comprising a receiving three-element tube relay characterized by the anode, cathode and control element, means for impressing the received signal impulses upon the control element, a source of current, pulse translating elements, and a distributor operating to complete the connection of said source to said elements synchronously with the received intelligence signals for predetermined intervals.

19. In a telegraph receiving system, a source of signal impulses, means for filling in attenuated impulses comprising a plurality of space discharge devices, arrangements whereby one of said devices assumes one definite grid potential in every unit impulse interval and the other as-

sumes another definite grid potential in every impulse interval under the influence of the last received signal impulse, a distributor whereby successive signal responsive elements are placed under the control of said devices in succession, and connections including a source of electric potential whereby each said element is controlled to a spacing or marking position dependent upon the grid potential of the device controlling it over said distributor at the instant of control.

20. In a system for receiving impulses and interpolating short impulses comprising a plurality of discharge tubes to which received impulses are distributed, distributor means for so distributing said impulses, receiving elements under the control of said tubes, and devices controlled by said tubes when no impulses are received to control said receiving elements alternately according to different conditions to interpolate the short impulses.

21. In a telegraph impulse relaying and interpolating system, two systems of amplifying discharge tubes, a distributing instrumentality for connecting said systems alternately to an incoming impulse supplying path, separate output paths controlled by said systems, signal responsive elements operatively controlled by said paths, and interconnecting means whereby the output path of one system reacts on the other system to maintain said paths in condition to oppositely control said elements during such times as only neutral or ineffective pulses from said path are applied to said systems.

22. A system according to the immediately preceding claim in which upon reception of a controlling pulse from said path to control either of said systems, said interconnecting means energizes the other system in a sense tending to place the opposite controlling condition upon the other system.

23. A system according to the second preceding claim in which upon reception of a controlling pulse from said path to control either of said systems, said interconnecting means is so connected as to energize the other system in a sense tending to place the opposite controlling condition upon the other system, and a polarizing source for said other system of such magnitude as to determine whether such controlling condition upon said other system will be effective dependent upon the cessation of said controlling pulse arriving from said path.

24. In a system for receiving long impulses and interpolating any one or more successive short impulses which are received only as neutral or ineffective values of current, a plurality of discharge tube systems, means for distributing all impulses in synchronism and in succession to said systems, elements to be controlled by interpolated, as well as received pulses, direct connections whereby said systems control said elements in succession in response to long received impulses and interconnecting control means whereby said systems control one another in definite succession and also control said elements in accordance with interpolated pulses.

25. In a telegraph system, a pair of thermionic discharge devices, input and output circuits for said devices, an electrically resistive element, means for alternately connecting said element to the input circuits of said devices whereby a drop of potential due to current flow in said element is applied to said input circuits during such connection, and means whereby the current flow

through said element is controlled by said output circuits.

26. In a telegraph system, a pair of thermionic discharge devices, input and output circuits for said devices, an electrically resistive element, means for alternately connecting said element to the input circuits of said devices whereby a drop of potential due to current flow in said element

is applied to said input circuits during such connection, means whereby the current flow through said resistance is controlled by said output circuits, conductive paths, and control devices periodically opening and closing said paths to effect said control. 5

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