Aug. 12, 1941. G. R. CLARK 2,252,364

PHASE CORRECTOR FOR MULTIPLEX TELEGRAPH SYSTEMS

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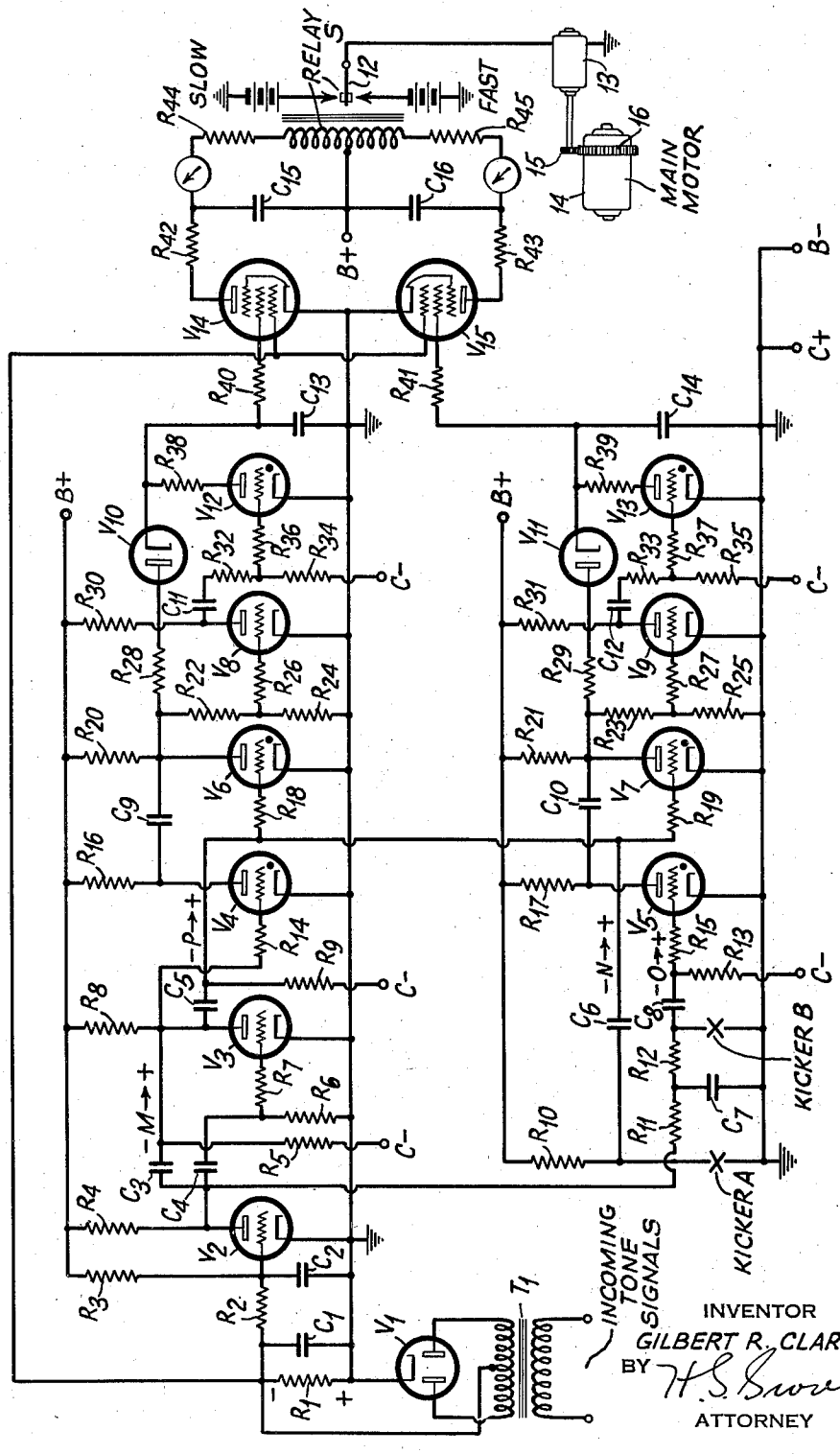


Fig. 1

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Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Fig. 7

Fig. 8

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PHASE CORRECTOR FOR MULTIPLEX TELEGRAPH SYSTEMS

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Application January 31, 1940, Serial No. 316,458

9 Claims. (Cl. 178—53)

This invention relates to a phase corrector for a multiplex telegraph system. In order to maintain a receiving commutator in phase synchronism with the speed of transmission of telegraph signals, it is necessary that the signals shall produce a corrective action whenever the speed of the receiving commutator departs from normal.

Heretofore phase correction of the distributor has been obtained by means of local pulses derived from the signal elements themselves in association with pulses derived from the commutator. The front edge of a marking signal impulse is thus correlated with a short impulse which, for example, represents the moment of passage of the commutator brush over the center of a commutator segment. A time interval is thus measured which, when it is longer than normal, may be used to speed up the distributor, and when it is shorter than normal, may be used to slow down the distributor.

An improvement over that method of correction has been disclosed in an application Serial No. 169,365, which was filed October 16, 1937, by Richard E. Mathes and assigned to the assignee of this application. In the Mathes disclosure the times of occurrence of two local circuit closures are compared one with the front edge of a marking impulse, and the other with the back edge of such a marking impulse. Two distinct time intervals are, therefore, derived which may be differentiated from one another in such manner as to produce the necessary phase correction of the distributor.

In the instant application certain of the teachings of Mathes, as above explained, are adopted. However, I have found certain advantages to be derived from using a specific circuit arrangement as will be hereinafter set forth in detail.

It is an object of my invention to provide a circuit arrangement for multiplex distributor phase correction such that the phase correcting factor may be made a function of the ratio between two measured time intervals, one of which elapses between the front edge of a marking signal and a local impulse near the normal center of a time allotment for dot unit impulse reception. The other time interval starts from a moment near said center of the unit signal time allotment and terminates with the back edge of the marking signal.

It is another object of my invention to provide circuit arrangements for the performance of phase correction in a multiplex receiving system such that accurate and dependable control of the speed and phase of the distributor may be insured.

My invention will now be described in detail, reference being made to the accompanying drawings in which,

Figure 1 shows diagrammatically a preferred circuit arrangement including elements in combination for carrying out the invention; and

Figs. 2 to 8 inclusive are plots of electrical impulses which occur in various parts of the circuit arrangement. These plots are all drawn to the same horizontal time scale in order to show the correlation of essential operations in response to signals.

By means of the circuit arrangements herein shown I am enabled to gain considerable advantage over the use of previously known phase correcting apparatus. The old method of making the correcting factor dependent upon the location of the front edge alone, or the back edge alone, of the signal in relation to the phase of the distributor, became undependable when the signal itself was distorted. With front edge correction the elongated mark elements may overlap into following space elements enough to adversely affect the multiplex signal distribution, inasmuch as the commutator brush is maintained at a fixed point with respect to the front edge of the mark signal.

My method is somewhat similar to that of the aforesaid Mathes application, in that I produce a correction factor which is derived from the correlation of both front and back edges of the marking signal with the center of the marking signal elements as defined by the commutator. My system provides further advantages, however, since the circuit constants are more stable, and a very heavy signal with relatively short space elements can be used for multiplex.

Briefly my method is one which applies phase correction to advance or retard the distributor brushes in accordance with a ratio derived from two time interval measurements. One of these time intervals is a function of that part of a marking signal of dot unit length which extends from its front edge to a predetermined position of brush passage over a commutator segment. The other of these time intervals is a function of that part of the marking signal of dot unit length which extends from a predetermined position of brush passage over a commutator segment to the back edge of the signal. The two predetermined positions of brush passage should be equally spaced from the center of the segment.

In the following description of a preferred embodiment of my invention all elements referenced V_1, V_2, V_3, etc., will be understood to be discharge tubes, whether of the vacuum tube, or of the gas-filled ionization discharge type. The gas-filled tubes, however, are conventionally designated in Fig. 1 by means of a black spot in the discharge zone.

Furthermore, the several resistors are referenced R_1, R_2, R_3, etc., while the several capacitors are referenced C_1, C_2, C_3, etc. Specific reference to each of the tubes, resistors, and capacitors will, for the sake of brevity, be frequently made by their identifying symbols alone.

The time interval which starts with the front edge of a marking impulse and terminates with a commutator brush passage over a predetermined portion of a segment near the center thereof is represented in the circuit arrangement by a charge stored on condenser C_{13}. Correspondingly the time interval which starts with the passage of the commutator over a predetermined portion of a segment near the center thereof, and which terminates with the back edge of a marking signal, is represented by a charge stored on the condenser C_{14}. These charges are held until a space occurs following a marking impulses. At that time both of the tubes V_{14} and V_{15} are rendered conductive through their control grids, and the impedances of each tube are determined by the amount of each charge respectively stored in C_{13} and C_{14}. Consequently more or less current will flow in V_{14} than in V_{15}.

A differential relay S is provided with windings such that current from the B+ terminal of the power supply source flows more or less through each of the anode circuits V_{14} and V_{15}, in consequence of which the armature **12** is moved either upwardly or downwardly in order to drive the correction motor **13** in the proper direction for correcting the phase of the main motor **14**.

The correction motor **13** as shown in Fig. 1 is provided with a pinion gear **15** meshing with a gear **16** mounted on the frame and field of the motor **14**. The correction motor **13** is required, therefore, to operate only momentarily while the relay S makes one contact or another, and the slight movement applied to the frame and field of the motor **14** is sufficient to restore the proper phase of the distributor brushes which are rotated by said motor **14**.

In accordance with the circuit arrangement shown in Fig. 1, if C_{13} has a higher potential than C_{14}, as when the receiving commutator is running slow, then the armature **12** is deflected upwards and the correction motor advances the phase of the distributor. If, on the other hand, C_{14} has the higher potential, the reverse action takes place by deflecting the armature **12** downwardly so as to operate the correction motor **13** in the opposite direction and thus to retard the phase of the distributor brushes.

I will now explain how the incoming signals and locally derived impulses from the commutator are made effective to store charges on the condensers C_{13} and C_{14} so that the proper control of the relays S may be obtained.

The received multiplex signal, consisting of a tone for mark and no tone for space, is passed through transformer T_1 and rectified by the full wave rectifier tube V_1. A diagram of the signal input before rectification is shown in Fig. 2.

The rectified signal voltage appears across resistor R_1 in the polarity indicated, with the positive end connected to ground.

The negative signal voltage is applied to the control grids of two electron discharge tubes V_{14} and V_{15}, thereby biasing these two tubes to cut-off whenever the signal is on mark.

Likewise, the negative signal voltage, after being filtered by the network consisting of capacitors C_1, C_2 and resistor R_2 is also applied to the grid of discharge tube V_2, biasing this tube to cut-off when the signal is on mark. In the curve of Fig. 3 the control of conductive times in tubes V_2, V_{14} and V_{15} is plotted on the same time scale as that of Fig. 2.

A voltage divider consisting of resistor sections R_3, R_2, R_1 is inserted between the plate supply source B+ and ground. Since R_3 and R_2 have a high value compared to R_1, this circuit has little effect on the rectified signal voltage developed across R_1. Furthermore, since R_3 is large compared to R_2, the rectified signal voltage across R_1 is applied practically undiminished to the grid of tube V_2.

The grid of V_2 is prevented from ever becoming appreciably positive, due to the high resistance of R_3.

The network keeps the grid of V_2 at zero bias or slightly positive until the signal voltage becomes strong enough to overcome this positive "threshold bias." Thus, weak line noises are prevented from causing false signal start pulses in the output of tube V_2.

The current in V_2 is cut off sharply when the mark starts, and starts flowing again when mark ends. A steep wave front voltage change appears between the anode of V_2 and ground. This change is in the positive direction when mark starts, and in the negative direction when mark ends.

Condenser C_3 has a low capacity, so that, when mark starts, it quickly charges through R_4 and R_5 to the higher plate potential of V_2. This temporary charging current causes a positive pulse to appear across R_5 when mark starts, and a negative pulse when mark ends. Fig. 4 shows a curve (in full line) of the momentary positive and negative pulses across R_5.

The positive front edge pulse is designated M and is carried by the conductor similarly referenced in Figs. 1 and 4.

In the same way network C_4, R_6 derives a positive front edge pulse and a negative back edge pulse, which are applied through grid R_7 to the grid of V_3. The negative back edge pulse is inverted by tube V_3 so as to appear as a positive back edge pulse between the plate of V_3 and ground.

This positive back edge pulse passes through the output coupling C_5, R_9 and is designated P in Figs. 1 and 4.

In addition to the distributor segments which are employed for channel distribution of the multiplex signals, certain segments and a brush, or two adjustable brushes and one segment, are employed purely for phase correcting functions. This brush and segment combination is known as a kicker, and its function is to deliver short, sharp impulses into one or more local circuits such as will be hereinafter described. In the drawings two points of circuit closures are indicated, one of which is under control of kicker contacts designated kicker A; the other circuit closure is provided by contacts designated kicker B. It will be understood that these circuit closures are accomplished at certain instants of the commutator cycle equally removed from the cen-

ter of a brush passage over the center of a given channel segment.

Closure of kicker A produces a surge impulse across resistor R_{10} from the power supply terminal B+ to ground. Prior to this closure, however, condenser C_6 has received a charge, since it is in circuit with resistors R_9 and R_{10} between the source terminals C— and B+. Closure of kicker A thus allows C_6 to discharge, and to impress a surge impulse across R_9.

At the end of the kicker A closure C_6 is again connected only through R_{10} to the supply source B+, and the recharging current produces a positive pulse N or N' across R_9. This positive pulse is applied through R_{18} and R_{19} to the control grids of two gaseous discharge tubes V_6 and V_7.

Kicker B has a short closure just following the center of every multiplex signal element and impresses a positive pulse O on the conductor so labeled.

In this case, however, it is necessary to suppress pulse O during signal space elements, since the back edge period applies only to the back end of the mark elements. The space between mark elements is used for the differentiating action between V_{14} and V_{15}, as explained previously.

Pulse O is suppressed during space by the expedient of obtaining the positive supply source for this pulse from the plate of tube V_2. When the signal is on space, tube V_2 is conductive and the anode potential is very low. Hence the pulses O are very weak.

During mark, however, tube V_2 is cut off, and its anode potential is the same as the plate supply source. The pulses O derived from the opening of kicker B are now strong.

Decoupling network R_{11}, C_7, R_{12} is added in order to prevent kicker B from interfering with the proper operation of V_2. If any such interference existed, it would produce false M-pulses, and also (through the full amplification of V_3), false P-pulses.

Condenser C_7 acts as a positive supply voltage reservoir for kicker B and is isolated from the plate of V_2 by R_{11} so as not to affect the wave front of the voltage changes between the plate of V_2 and ground.

Incidentally, this same decoupling network prevents the steep wave front voltage changes across V_2 from initiating false O-pulses prior to the closure of kicker B.

We now have four positive pulses M, N, O and P for each single marking element. The M- and N-pulses define the front edge integration period. The O-pulse when immediately followed by a P-pulse defines the back edge integration.

The operation of the front edge integration circuit (consisting of V_4, V_6, V_8, V_{10}, V_{12}, C_{13} and associated parts) will now be described.

The operation of the back edge circuit is identical except for the pulse sequence.

V_4 and V_6 are grid-controlled thyratrons. They are inter-related by means of a familiar circuit R_{16}, R_{20} and C_9. As is well known, if V_6 has been ionized and then V_4 is caused to be ionized, C_9 reduces the anode potential of V_6 to a negative value long enough for V_6 to de-ionize. Although the anode potential soon rises again above the point where it will sustain ionization, nevertheless V_6 will remain out if it has sufficient negative grid bias.

When the signal is on space, the state of this circuit is always as follows: V_6 is ionized and V_4 is out. This will be called the idle state.

When the signal goes on mark, a positive pulse M is generated by V_2 and is applied through R_{14} to the grid of V_4. This pulse ignites V_4, thereby extinguishing V_6.

The circuit remains in this new state, the active state, until the kicker A closure takes place. At the break of the kicker closure a positive pulse N is generated and applied through R_{18} to the grid of V_6. V_6 now ignites and V_4 goes out, thereby restoring the circuit to its original idle state.

The active period (during which V_4 is ionized) therefore coincides with the front edge period, and its duration is less than half the length of a dot unit signal, as shown by comparison of Figs. 2 and 6.

It will be observed that when V_4 is ignited by pulse M, the anode of V_6 is made negative by the existing charge on C_9. This charge normally persists long enough to permit V_6 to de-ionize. It is purposely made still longer to permit a certain necessary wipe-off action to be completed with respect to C_{13}.

The wipe-off is effected in the following way: During the idle state the grid of V_8 is at zero bias or slightly positive, due to the high resistance voltage divider network R_{22}, R_{24} between the anode of V_6 and ground. Therefore, V_8 is conductive, and its anode potential is low.

When the active period begins and the anode of V_6 receives a mometary negative surge impulse from condenser C_9, V_8 is sharply cut off because its grid becomes negative also. The anode potential of V_8 immediately rises toward the full voltage of the plate supply source.

C_{11} quickly charges to this new potential through R_{32} and R_{34}, and in so doing creates a strong, sharp positive pulse across R_{34} which is applied through R_{36} to the grid of V_{12}.

This positive pulse is created at the instant that V_4 is ignited, and cannot occur at any other time, since the anode of V_6 never becomes negative at any other time. The pulse is strong enough to ignite V_{12} even if the anode voltage of V_{12} (which is supplied by C_{13}) is very low.

Of course, once V_{12} is ignited, it immediately discharges C_{13} through R_{38} down to the point, say, 15 volts, at which point there is not enough potential to sustain ionization and V_{12} goes out.

All this must happen at the commencement of the active period and before C_9 charges enough to permit the anode of V_6 to become positive again. While the anode of V_6 is negative, diode V_{10} is non-conductive and isolates C_{13}, R_{38} and V_{12} from the rest of the integrating circuit.

When the anode of V_6 does become positive its potential continues to rise toward the full voltage of the B+ supply source, since the tube is non-conductive. The high potential at the anode of V_6 begins to charge C_{13} through R_{28} and V_{10}. The resistance and condenser values are such that C_{13} only partially charges within the duration of the active period (as in a saw tooth generator) so that the charge on C_{13} is substantially proportional to the duration of the period.

The end of the active period occurs when pulse N ignites V_6 and restores the circuit to the idle state. When this happens the anode of V_6 drops to, say, 15 volts. Since C_{13} is at some higher potential, diode V_{10} prevents C_{13} from discharging down to, say, 15 volts. C_{13}, therefore, holds its charge, except for leakage and the screen current drain of V_{14} during space, until the next front edge period begins.

The circuit arrangement shown in the lower part of Fig. 1 will be seen to have certain points

of similarity with that of the upper part. Thus, tubes V_5 and V_7 are inter-related in the same way as tubes V_4 and V_6. Likewise V_9 is the counterpart of V_8 and the control circuits for all of these tubes are similar in the lower portion of the diagram to those in the upper portion thereof. In view of this similarity of circuit arrangements it will be sufficient to briefly summarize the operation of tubes V_5, V_7, V_9 and V_{13} in the following paragraphs.

Kickers A and B, as stated above, make circuit closures periodically at predetermined points of brush passage over each commutator segment. Kicker B is effective, however, only during marking periods, that is, when V_2 is non-conductive. Fig. 5 shows the action of kicker B to deliver O-pulses during mark intervals only. These pulses are impressed upon the grid V_5 to ignite the same at the commencement of the back edge integration. This period is terminated with the back edge of the signal as denoted by the P-pulse which is impressed through R_{19} upon the grid of V_7. When V_7 is ignited a surge impulse from C_{10} reduces the anode voltage on V_5 to the point of extinction.

This action, as explained in the foregoing paragraph, takes place without intervening actions, provided the marking impulse of the signal is of one dot unit length.

If the signal continues on mark at the end of a dot unit length, it is necessary to ignite V_7 in response to an N'-pulse derived from the operation of kicker A. Thus, V_5 becomes extinguished either at the end of a true marking impulse or at predetermined points of circuit closure by kicker A when the marking impulse is prolonged. During these prolongations of the marking impulse the reversing operations of V_5 and V_7 take place but are ineffective, as shown by the shaded square waves of Fig. 7.

The back edge integration which is effective in all cases is initiated by an O-pulse igniting V_5 and extinguishing V_7. When the anode potential V_7 rises to that of the supply source B+ condenser C_{14} charges through the rectifier V_{11}. Momentarily, before this charge begins, the action of tubes V_9 and V_{13} is brought about in the same manner explained above in respect to V_8 and V_{12}, for the purpose of igniting V_{13} so as to discharge C_{14} to a fixed value, say, 15 volts. Thereafter the rectified current flowing across V_{11} increases the charge on C_{14} proportionately to the duration of the extinction time of V_7. In the back-edge integration circuit, resistors R_{17}, R_{21}, R_{31}, R_{23}, R_{25}, R_{27}, R_{29}, R_{33}, R_{35}, R_{37}, R_{39} and R_{41} are counterparts respectively of resistors R_{16}, R_{20}, R_{30}, R_{22}, R_{24}, R_{26}, R_{28}, R_{32}, R_{34}, R_{36}, R_{38} and R_{40} which are shown in the front edge integration circuit. Furthermore, the functions of C_{11} and C_{12} are identical.

Since there is no true back edge integration period to be measured until an O-pulse is immediately followed by a P-pulse within an interval of one dot unit length, all other occurrences of the O-pulse which take place during a prolonged marking signal must be rendered ineffective by an N'-pulse from kicker A. During these prolonged marking signals, therefore, C_{14} may become discharged repeatedly. But only on the last period, that is, at the back edge of the marking signal, does the stored charge remain on C_{14} to be rendered effective when V_{15} becomes conductive at the commencement of a spacing signal. A comparison of ignition intervals of V_5 (which correspond to extinction intervals of V_7) with the time intervals to be differentiated by relay S, as shown in Fig. 8, will show that, regardless of the length of the marking signal, the front edge integration period is always compared with a back edge integration period. The differentiation is shown by the symbol $\doteqdot$ to represent that the time intervals to be compared are more or less close approximations to equal time intervals, and that they are equal when no correction factor is to be applied. In other words, when the back edge period is finally ended by the P-pulse, then the charge on C_{14} is left to be impressed on V_{15} at the commencement of a spacing signal.

During the lapse of a spacing signal tubes V_2, V_{14} and V_{15} are rendered conductive. V_2 when conductive renders the action of kicker B ineffective and also maintains the idle state of the integration circuits, both for the front edge and for the back edge integration.

Fig. 5 shows two time graphs of pulses delivered by kickers A and B, respectively. As shown in the upper of the two graphs, an N-pulse occurs on the first opening of kicker A which occurs in a given mark period. If the mark is prolonged for more than a dot length, then kicker A delivers N'-pulses until a space occurs. During space periods kicker A delivers pulses marked X, but their effects are annulled by the fact that tubes V_6 and V_7 are already discharging. The operation of kicker B is shown in the lower of the two graphs in Fig. 5. O-pulses occur periodically upon each opening of kicker B, except during space periods. These pulses are suppressed, however, as shown at Y, due to the conductive state of V_2.

Throughout the duration of the space signal the control grids of V_{14} and V_{15} are unblocked and at zero bias, so that the charges on C_{13} and C_{14} respectively may control the screen grids of these tubes. The current flow through these tubes is substantially proportional to the screen grid voltage.

The anode currents from the supply source B+ pass through the windings of relay S in opposition to one another. When there is a sufficient difference in the two currents, the armature of relay S is pulled from its neutral position, thereby causing the correction motor to turn in the required direction.

A smoothing-out of anode currents of V_{14} and V_{15} is attained by means of condensers C_{15} and C_{16} respectively in combination with R_{44} and R_{45}. These elements cooperate in preventing a chattering of the relay armature at the signal element repetition rate. The operation of the relay S to control the direction of rotation of the correction motor **13** and thereby to correct the phase of the main motor **14** has already been explained.

I claim:

1. Apparatus for maintaining a distributor in synchronous phase with the arrival moments of the mean centers of a train of marking impulses received over a circuit, said apparatus comprising a pair of condensers, a unilateral charging circuit connected across the electrodes of each condenser, a discharging circuit in shunt with each charging circuit and including a grid-controlled gaseous discharge tube, means operated by said distributor for producing two surge impulses, the first preceding and the second following by equal time intervals the centering of a distributor brush on a distributor segment, means for accumulat-

ing a charge on the first of said condensers which is proportional to the time lapse between the arrival of the front edge of a marking signal and the first said surge impulse, means for accumulating a charge on the second of said condensers which is proportional to the time lapse between the second said surge impulse and the arrival of the back edge of said marking signal, means operative only during space-signal intervals for comparing the charges respectively stored on said condensers, means dependent on the operation of said comparing means for adjusting the phase of said distributor, and means for controlling each of said gaseous discharge tubes at the commencement of the charging period of its associated condenser, thereby to reduce each condenser charge to a predetermined value.

2. Apparatus according to claim 1 and including a pair of gaseous discharge tubes for controlling the time intervals of charging the first said condenser, one of said tubes being subject to ionization in response to the arrival of the front edge of a marking impulse, the other of said tubes being subject to ionization in response to the occurrence of the first said surge impulse, and each of said tubes being subject to de-ionization control by the other said tube.

3. Apparatus according to claim 1 and including a pair of gaseous discharge tubes for controlling the time intervals of charging the second said condenser, one of said tubes being subject to ionization in response to the occurrence of the second said urge impulse, the other of said tubes being subject to ionization in response to the arrival of the back edge of said marking impulse, or alternatively under control of a recurring first surge impulse, whichever event occurs first, and each of said tubes being subject to de-ionization control by the other said tube.

4. Apparatus for maintaining a distributor in synchronous phase with the arrival moments of the mean centers of a train of marking impulses received over a circuit, said apparatus comprising a pair of condensers, means operative upon arrival of the front edge of one of said marking impulses and including a grid-controlled gaseous discharge tube for dissipating a residual charge on one of said condensers down to a fixed voltage, means in circuit with a diode rectifier tube for thereafter building up a new charge on that condenser substantially proportional to and limited by the time interval from said front edge arrival until the occurrence of a periodic circuit closure, means for producing a second periodic circuit closure, means for maintaining the first and second circuit closures one in advance of, and the other equally retarded with respect to a brush passage over a given segment center of said distributor, means operative in response to one of said second circuit closures for dissipating a residual charge on the second of said condensers down to the same fixed voltage, means for thereafter building up a new charge on the second said condenser substantially proportional to and limited by the minimum time interval from one of said second circuit closures to the arrival of the back edge of said marking impulse, means operative during a subsequent space interval for differentiating between the voltages built up on the two said condensers, and means responsive to the differentiating means for accelerating or retarding said distributor.

5. Apparatus according to claim 4 and including a grid-controlled gaseous discharge tube in the means for dissipating a residual charge on the second of said condensers.

6. Apparatus according to claim 4 and including a diode rectifier tube in circuit with the means for building up a new charge on the second said condenser.

7. A synchronizing system for telegraph apparatus comprising a first condenser arranged to store a charge commencing with the arrival of the front edge of a marking signal and terminating with a local circuit closure, a second condenser arranged to store a charge commencing with a second local circuit closure and terminating with the arrival of the back edge of said marking signal, a rotary distributor member normally in phase with the mean centers of a train of marking signals, means operable by said rotary member for producing said circuit closures, the first immediately before and the second immediately after said rotary member passes across a mid-position for distribution of a signal element, means including a unilaterally conductive device in circuit with each of said condenser for impressing said charges thereon, means including a grid-controlled gaseous discharge tube in circuit with each condenser for dissipating its charge down to a fixed voltage value prior to the impress of a new charge thereon, and means for differentiating between the charges on the two said condensers thereby to accelerate or to retard said rotary distributor member.

8. A synchronizing system for telegraph apparatus comprising a first pair of grid-controlled gaseous discharge tubes each arranged to be rendered conductive by a positive impulse applied to its grid, means including a capacitor connected across the anodes of said tubes for extinguishing the discharge in each said tube when the other said tube is rendered conductive, means operable on arrival of the front edge of a marking signal for producing one of said positive impulses applicable to the first of said tubes, a rotary distributor member to be maintained in synchronism with the incoming signals, means operable by said rotary member for applying a second positive impulse to the second tube of the pair, a second pair of grid-controlled gaseous discharge tubes each arranged like those of the first pair and further arranged to be controlled, one tube by a positive impulse derived from the operation of said rotary member, and the other tube by a positive impulse derived at the instant of arrival of the back edge of said marking signal, capacitive storage means operable by the two said pairs of gaseous discharge tubes, a differential relay for determining the relation between two charges accumulated by said storage means, and phase corrector mechanism operable upon said rotary distributor member in response to the action of said relay.

9. Apparatus for maintaining a distributor in synchronous phase with the arrival moments of the mean centers of a train of marking impulses received over a circuit, said apparatus comprising a pair of condensers, a unilateral charging circuit connected across the electrodes of each condenser, a unilateral discharging circuit in shunt with each charging circuit, means operated by said distributor for producing two surge impulses normally equally disposed about the center of each one of said marking impulses, means for accumulating a charge on the first of said condensers which is proportional to the time lapse between the arrival of the front edge

of the marking signal and the first said surge impulse, means for accumulating a charge on the second of said condensers which is proportional to the time lapse between the second said surge impulse and the arrival of the back edge of the marking signal, means effective at the outset of each charging period for completing the appropriate one of said discharging circuits thereby to permit the charge on each condenser to be built up from a predetermined reference level, means for comparing the charges respectively stored on said condensers, and means to utilize the result of said comparison to adjust the phase of said distributor.

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