

Aug. 20, 1940.

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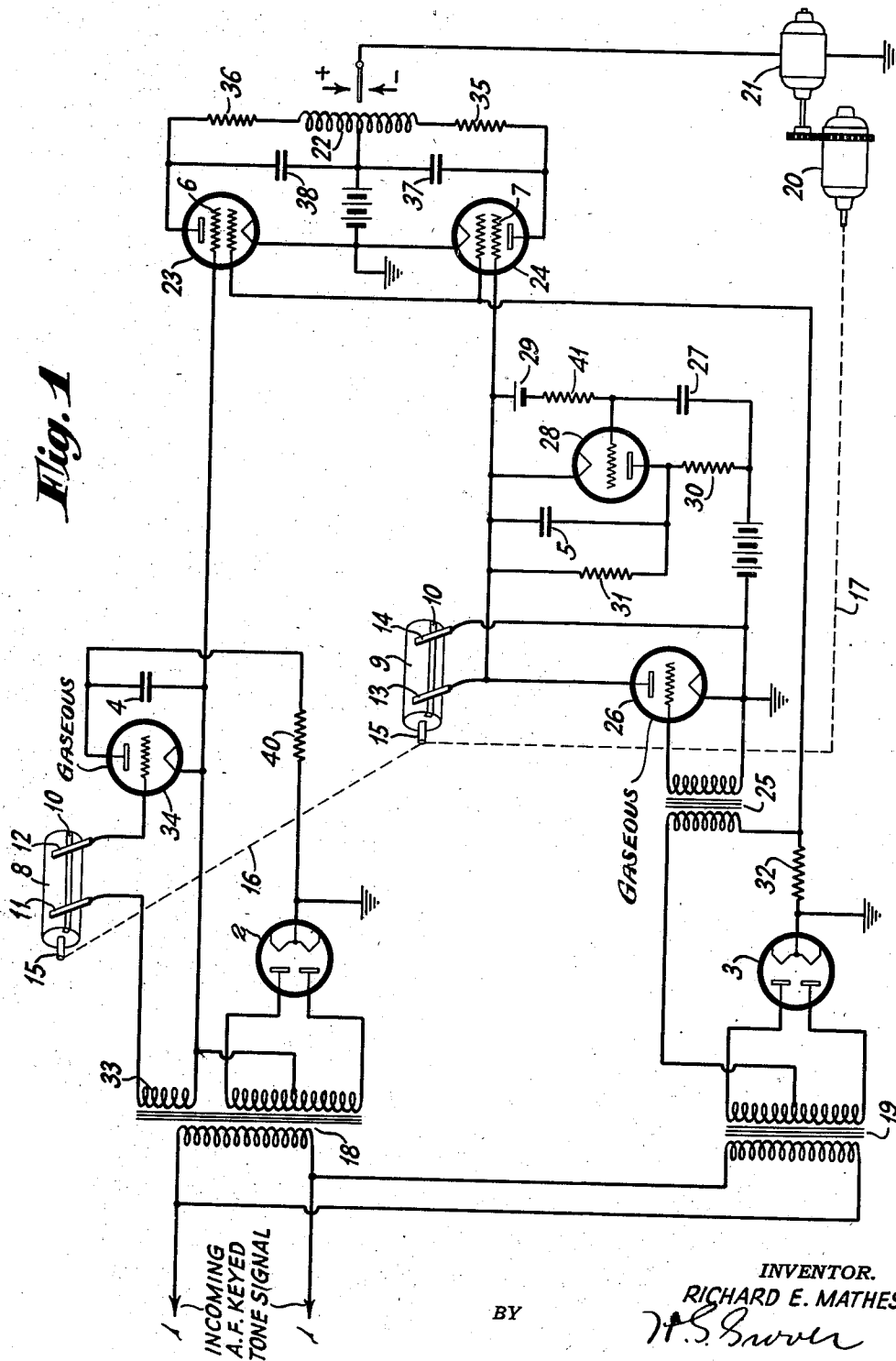
2,212,447

SYNCHRONISM CORRECTION FOR TELEGRAPH SYSTEMS

Filed Oct. 16, 1937

2 Sheets-Sheet 1

Fig. 1



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2,212,447

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2 Sheets-Sheet 2

Fig. 2

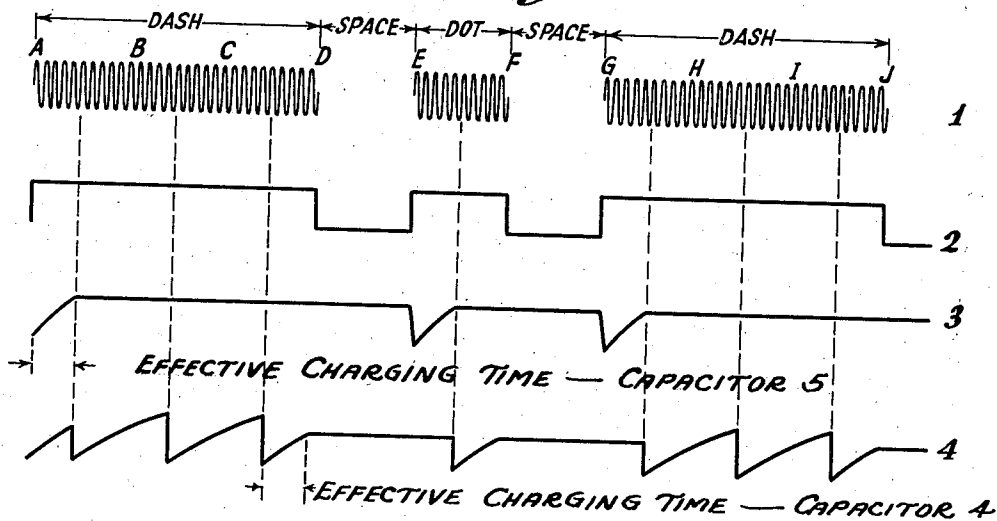
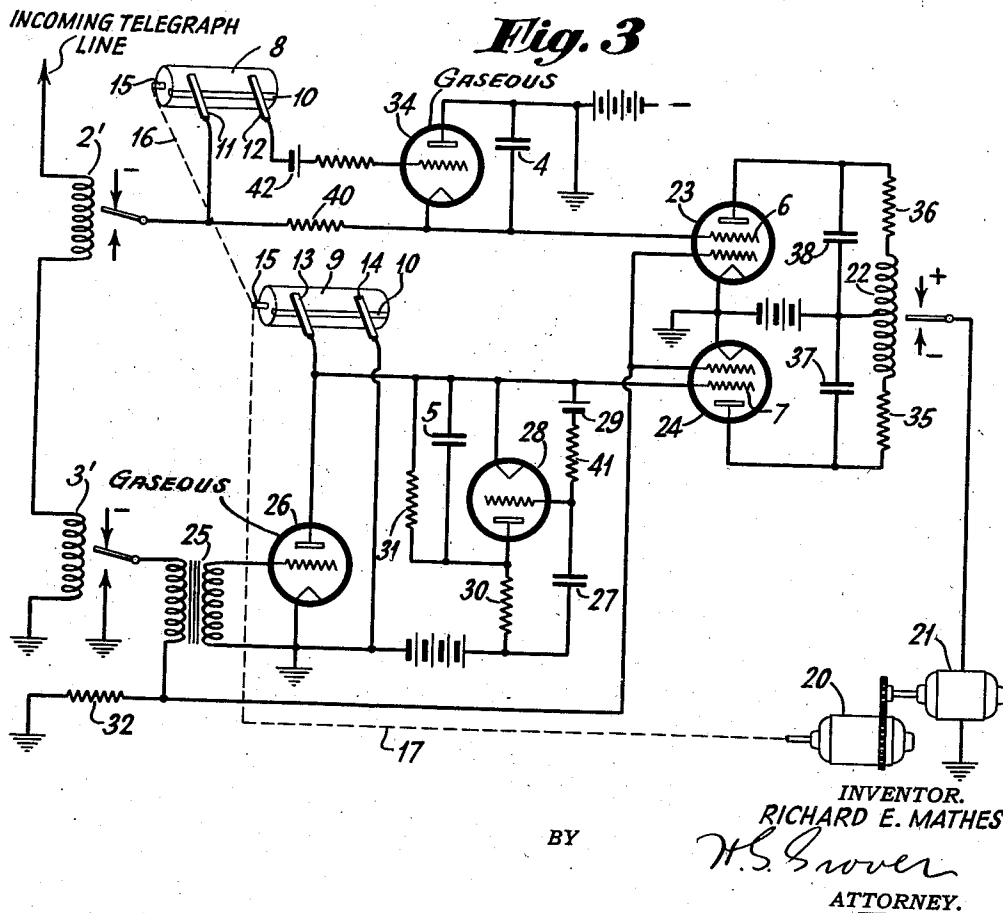


Fig. 3



UNITED STATES PATENT OFFICE

2,212,447

SYNCHRONISM CORRECTION FOR
TELEGRAPH SYSTEMSRichard E. Mathes, Westfield, N. J., assignor to
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Application October 16, 1937, Serial No. 169,365

10 Claims. (Cl. 178—69.5)

This invention is concerned with the correction of speed and phase synchronism of rotating machinery at the receiver of a telegraph communication system, and is particularly applicable to such of these systems which require no special pulse or signal to be sent from the transmitter for correction purposes.

It is known that synchronization correction can be achieved in telegraph systems by deriving pulses from the signal elements themselves; namely, from the steep rising and falling wave fronts corresponding respectively to the beginning and end of the signal elements, and determining the need for correction from the phase relationship existing between these steep wave fronts and the time of occurrence of a local circuit closure. Circuits of this known type are described in my United States Patents Nos. 2,038,375 and 2,062,009, granted April 21, 1936, and November 24, 1936, respectively. These known systems, however, are unsatisfactory when there exists large bias distortion on the telegraph circuit.

The present invention is designed to overcome the difficulties of bias distortion on the telegraph circuit by providing a synchronization or speed correction system between rotating mechanisms at the transmitter and receiver, wherein correction is determined from a differential comparison of the start of the signal element and the time of occurrence of a local circuit closure, and the end of the signal element and the time of occurrence of another local circuit closure. The times of occurrence of these two local circuit closures are so arranged that they occur either at the same time coinciding with the center of a signal of one unit length (i. e., the dot or baud), or at different times equally disposed on both sides of the center of a signal of one unit length.

A better understanding of the invention may be had by referring to the accompanying drawings, wherein Fig. 1 discloses a circuit arrangement at the receiver of a telegraph system for accomplishing correction in accordance with the present invention when audio frequency tone signals are received over the line; Fig. 2 illustrates graphically the received tone message signals, and the voltages on the condensers C₁, C₂ at various times during the signal, as they are available for correction purposes; and Fig. 3 is a modification of the system of Fig. 1 adapted for the reception of direct current telegraph signals on the line.

Referring to Fig. 1 in more detail, there is shown a motor 20 for driving the multiplex equip-

ment of the telegraph receiver, which motor it is desired to accurately synchronize with regard to a motor at a distant transmitting station. Motor 20 is under control of a small correction motor 21, in turn responsive to the operation of a differential electromagnetic relay 22 across whose winding are a pair of differentially operating vacuum tubes 23 and 24.

The incoming message waves which are in the form of audio frequency keyed tone signals arrive over line 1 and are rectified in full wave rectifiers 2 and 3 for providing across the condensers 4 and 5 suitable voltages which are applied to the grids 6 and 7 of the vacuum tubes 23 and 24.

A pair of kicker commutators 8 and 9, together with associated apparatus (to be described later), serve to control the discharge of the voltages stored on condensers 4 and 5. These commutators 8 and 9 each comprise a rotating insulated device across whose length is a suitable metal bar 10 for short-circuiting a pair of brushes 11, 12, or 13, 14. Each of the kicker commutators 8 and 9 are driven by suitable shafts 15, in turn linked to the drive motor 20, as shown by the dotted lines 16 and 17. A more amplified description of these commutators is given in my United States Patent No. 1,963,587, granted June 19, 1934. These kicker commutators may, of course, be of any suitable form to provide a circuit closure.

The audio frequency keyed tone signal received over transmission line 1 is fed to rectifiers 2 and 3 over audio frequency transformers 18 and 19, respectively. Upon receipt of the first signal element, whether it be a dot or a dash, the rectified tone signal produced by rectifier 3 will produce a potential drop through resistance 32, thus biasing the first grids of vacuum tubes 23 and 24 negatively, causing these tubes to cease passing current. It will thus be seen that during the actual reception of the message waves, tubes 23 and 24 will be inoperative to effect the operation of relay 22. Vacuum tubes 23 and 24 are effective, however, only during the space between signal elements when no current is being rectified. With the functioning of rectifier 3, the received waves will cause a sudden rush of current to be applied to the primary of audio frequency transformer 25, which will, in turn, generate in its secondary a sharp voltage pulse of a proper polarity to cause the grid of a gaseous conduction device 26 to become positive. Device 26 is of the well known Thyatron type which passes current in its anode circuit when a positive pulse of suitable value is applied to its grid. This sharp pulse

produced in transformer 25 causes the glow tube 26 to strike and pass current, in turn producing across condenser 27 and resistor 41 a pulse of such polarity as to cause vacuum tube 28 to pass current momentarily, thus short-circuiting or discharging any voltage which might at that moment be stored on condenser 5. The charge on condenser 27 is produced when glow tube 26 strikes, by the passage of current through the bias battery 29 and grid resistor 41, and this charge is of proper polarity to overcome the bias on the grid of tube 28 produced by the battery 29, thus enabling tube 28 to pass current momentarily. Since this pulse across condenser 27 is only momentary, the tube 28 will cease to pass current almost immediately after the discharge of condenser 5, subsequent to which condenser 5 will charge due to the passage of current in the anode circuit of Thyatron 26. The anode circuit of the Thyatron 26 includes relatively high resistances 30 and 31 arranged in series, the latter of which is connected across condenser 5. Condenser 5 will continue to charge due to the passage of current in the Thyatron 26, until such time as the glow in tube 26 is extinguished by the commutator 9 which shortcircuits the anode circuit of tube 26 through brushes 13 and 14. Condenser 5 will retain its charge, except for the comparatively slow leakage through high resistance 31, at the value dependent upon the interval between the cessation of current in vacuum tube 28 and the closure of brushes 13 and 14. Since for practical purposes the vacuum tube 28 passes current only momentarily at the start of the signal element, it can be said that condenser 5 is charged in the interval between the start of the signal and the closure of brushes 13 and 14. The charge on condenser 5 will be retained until such time as gaseous conduction device 26 functions to cause tube 28 to again operate. This charge on condenser 5 is utilized to affect vacuum tube 24 through its grid 7, which is directly connected to one plate of the condenser 5, as shown. At this time, it should be noted that commutators 8 and 9 are each arranged to close their respective brushes once during each signal element of dot length, it being understood, of course, that in the Continental Morse Code the dash is equal to three dots. For the purpose of this description, it will be assumed that kicker commutators 8 and 9 both close their respective brushes at the same time and that this time coincides with the center of the dot. Where a dash is being received, there will thus be three closures for each of the kicker commutators during a dash, since each dash has a length equal to three dots. Simultaneously with the functioning of rectifier 3, the received waves will appear across rectifier 2 and cause a sudden rush of charging current to be applied to condenser 4 through resistor 40. Due to this pulse produced at the start of the signal element, condenser 4 will slowly charge until such time as the kicker commutator 8 closes and shorts its brushes 11 and 12. When this occurs, a pulse through secondary winding 33 of the transformer 18 will cause the application of a position potential to the grid of a gaseous conduction device 34, also of the Thyatron type, in turn producing a discharge of the condenser 4. The glow in Thyatron 34 will be extinguished immediately upon the discharge of condenser 4, due to the action of the discharge, which reduces the voltage on condenser 4 to a value not greater than the extinction voltage of the Thyatron tube. Condenser 4 will again

start charging immediately after its discharge, and this charging will continue until the end of the signal element, at which time condenser 4 will maintain the charge it then has. For signals longer than one unit length (length of one dot) condenser 4 will be discharged once for each unit length due to the fact that commutator 8 will cause the Thyatron 4 to strike each time brushes 11 and 12 of the commutator are shorted while signals are received. It will thus be seen that the final charge on condenser 4 for each signal is a function of the time between the closure of brushes 11 and 12 on the commutator 8 and the end of the signal element. (1)

In reviewing what has been said above, it will be observed that the charge on condenser 4 which is available for affecting grid 6 of vacuum tube 23, is the function of the time between the last circuit closure of kicker commutator 8 and the end of the signal element, whereas the charge on condenser 5 which is available for affecting the grid 7 of the vacuum tube 24 is the function of the time between the start of the signal element and the first subsequent circuit closure of kicker commutator 9. If these two time intervals are equal, then synchronism between the transmitting-rotating mechanism and motor 20 of the receiving mechanism is correct. If, however, the time intervals are unequal, there is an inequality in the charges of condensers 4 and 5 which provides means for correcting for the departure from synchronism of the receiving motor 20. This correction is achieved as follows:

During the spacing or no-signal interval, there is no current flow or IR drop in resistance 32, for which reason the first grids of tubes 23 and 24 assume the bias of their respective cathodes. During this interval of no-signal current, tubes 23 and 24 will pass current, depending upon the voltages on grids 6 and 7 which are produced by the respective charges of condensers 4 and 5. Any differences in the charges on condensers 4 and 5 will thus manifest themselves on the grid circuits 6 and 7 of the vacuum tubes 23 and 24, causing the operation of polar relay 22 in one sense or the other depending upon which tube has the greater voltage applied to its control grid, to make the correction motor 21 run in one direction or the other, thereby to rotate the field of the motor 20. The correction motor will thus function, depending upon whether a positive or a negative current is passed thereto by the engagement of the armature of relay 22 with either its upper or its lower contact. Resistances 35 and 36 and condensers 37 and 38 function as filters to smooth the flow of current through the relay 22, and to integrate it over several units of signal length in order to reduce hunting and minimize the effect of any fortuitous distortion on the signal.

The operation of the system may perhaps be better comprehended by referring to Fig. 2 which illustrates, by way of example only, the charges on the condensers 5 and 4 during the receipt of a signal consisting of a dash, a space, a dot, a space, and another dash. For the purpose of this figure, it is assumed that the kicker commutators 8 and 9 both operate simultaneously. The first dash extends from A to D, while the second dash extends from G to J. The dot extends from E to F, and the spaces between the dashes and the dot are of dot length and indicate the absence of signal. It should be noted that each dash has a length equal to three times the length of each dot. The distance between any two

letters is the time interval of one dot or one unit of signal length. The vertical lines indicate the mid-point or center of each signal element of dot length, or multiple thereof; thus there are three vertical dotted lines in each dash, since each dash is equivalent to three dots in length.

The incoming keyed tone signal is indicated by curve number 1, which shows the alternating current in vertical zigzag form during the dash and dot intervals. Since there is no signal during the spacing interval between the dashes and the dot, there is a blank space between them. Curve 2 indicates the envelope of the rectified tone signal after it has passed through either rectifier 2 or 3. Curve 3 illustrates the building up and the discharge of the voltage across condenser 5. It should be noted that the current in condenser 5 starts to build up a very short time after the start of the signal pulse. This is because for an extremely short interval after the start of the signal, the charge on this condenser is brought to zero by the action of tube 28 which is only momentarily conductive. The voltage on condenser 5 builds up until the closure of the kicker commutator 9, which occurs at a time coinciding with the mid-point of each signal having a duration of at least one unit length. This mid-point is represented by the first vertical dotted line. The voltage on condenser 5, it will be noted, is retained until the next signal element is received which is at E, whereupon the condenser is discharged due to the reoperation of vacuum tube 28, subsequent to which the cycle of operations is again repeated. Curve 4 shows that the voltage across condenser 4 first builds up after the initiation of the signals until kicker 8 operates to cause Thyatron 34 to discharge condenser 4, whereupon condenser 4 will again build up until the next time kicker commutator 8 functions to operate Thyatron 34. Where the signal is a dash, it will be observed that the voltage stored on condenser 4 is greater in the interval between the operations of Thyatron 34 than the voltage stored in the interval between the initiation of the signal element and the first operation of the kicker commutator 8.

A comparison of curves 3 and 4 shows that the voltages across condensers 4 and 5, as available for the operation of relays 23 and 24 during the spacing interval, are steady in value. These voltages across the condensers 4 and 5 are applied to tubes 22 and 23 during the spacing or no-received-current interval and determine the sense of operation of relay 22, in turn controlling the correction motor 21. These voltages should be equal when synchronism is achieved, or where there is a slight difference in voltage on these condensers due to various circuit constants, the difference can be counterbalanced in the structure of the vacuum tubes 23 and 24.

An important characteristic of the operation of the present invention is that the two kicker commutators 8 and 9 must operate once for each signal element of unit length, (i. e., dot or baud), or where a multiple unit signal element is received, such as the dash, they must operate once for every length of signal element corresponding to a unit length; in other words, three times for the dash, since the dash has a length equivalent to three dots. Although it has been assumed above for the purpose of exposition that the kicker commutators 8 and 9 close simultaneously at a time coinciding with the center of the signal unit, it will be evident that commutators 8 and

9 may close at different times which are equally disposed in each signal element of unit length on opposite sides of the center of the signal duration of unit length. The greater the interval between the closures of commutators 8 and 9, the more sensitive the system will be to variations from true synchronism and the more readily will it correct for changes in the bias distortion. The present invention enables much wider changes in bias distortion than known types of synchronization systems and also enables adjusting the point of synchronization to the midpoint of the signal unit (dot), whether the bias on the telegraph circuit be heavy or light.

Fig. 3 shows a system which is substantially identical with that of Fig. 1, except that the system has been modified to function with direct current telegraph signals on the incoming line. In this figure, the rectifiers 2 and 3 of Fig. 1 have been replaced by suitable electromagnetic relays 2' and 3'. The audio frequency transformers 18 and 19 of Fig. 1 have also been omitted from Fig. 3. It will be noted that during actual signal reception there will be a negative charge applied to the inner grids on tubes 23 and 24 by relay 3' in order to cause them to cease passing current. The receipt of signals by relays 2' and 3' will cause the respective armatures of these relays to engage their upper contacts. During "no signal" or "space" the armature of these relays will engage their respective lower contacts. The operation of Thyatron tube 34 is here slightly different from that of Fig. 1 in that the receipt of signals will cause current to flow through resistor 40, here shown connected to the lower plate of condenser 4. The ground potential is here shown as being positive with respect to the potential applied to the upper contact of relay 2'. This ground potential is applied directly to the anode of tube 34 and to the upper plate of condenser 4. When the short circuiting bar 10 of commutator 8 shorts brushes 11 and 12 during the actual receipt of signals, the grid of Thyatron 34 will be at a positive potential relative to the cathode of this tube, thus causing the glow of tube 34 to strike. However, when no signals are being received, the armature of relay 2' will be connected to its lower contact (which is dead) and no current will be flowing through resistor 40. If at this time, the bar 10 shorts brushes 11, 12, as will happen during the spacing intervals, there will be no voltage applied to the grid of tube 34 of sufficient value to cause the glow in the tube to strike. Battery 42 is merely a bias source for the grid of the Thyatron. Except for the above mentioned differences, the operation of the system of Fig. 3 is the same as that outlined above in connection with Fig. 1, for which reason it is not deemed necessary to repeat same.

It will be apparent to anyone skilled in the art that the operation of applicant's invention may be improved, and its efficiency increased by a judicious selection of bias potentials in any or all of the various grid circuits of the tubes, and by using common anode supply connections, bias voltage sources, etc. Where desired, of course, various low pass filters may be employed to minimize tone ripples in the output circuits of the rectifiers of Fig. 1.

What is claimed is:

1. In a telegraph communication system, the method of maintaining synchronism between distributing mechanisms at two different stations which includes transmitting substantially rectan-

gular wave signal impulses from one of said stations, receiving said signal impulses at the other station, producing an electric charge whose value is substantially a function of the time between the steep wave front of the received signal impulse and the occurrence of a periodic local circuit closure, producing another electric charge whose value is substantially a function of the time between the steep wave terminus of the signal impulse and the time of occurrence of another periodic local circuit closure, maintaining a fixed time relation between the two said circuit closures, and utilizing the difference between the values of said two electric charges, to correct only during the interval between the receipt of signal impulses for departures from true synchronism.

2. In a telegraph communication system, the method of maintaining synchronism between distributing mechanisms at two different stations which includes transmitting substantially rectangular wave signal impulses from one of said stations, receiving said signal impulses at the other station, producing an electric charge whose value is substantially a function of the time between the steep wave front of the received signal impulse and the occurrence of a periodic local circuit closure, producing another electric charge whose value is substantially a function of the time between the steep wave terminus of the signal impulse and the time of occurrence of another periodic local circuit closure, causing the two said local circuit closures to occur simultaneously, once for every length of signal element corresponding to a unit length and at a time coinciding with the center of said unit length, and utilizing the difference between the values of said two electric charges to correct for departures from true synchronism.

3. In a telegraph communication system, the method of maintaining synchronism between distributing mechanisms at two different stations which includes transmitting substantially rectangular wave signal impulses from one of said stations, receiving said signal impulses at the other station, producing an electric charge whose value is substantially a function of the time between the steep wave front of the received signal impulse and the occurrence of a periodic local circuit closure, producing another electric charge whose value is substantially a function of the time between the steep wave terminus of the signal impulse and the time of occurrence of another periodic local circuit closure, causing said local circuit closures to occur at different times equally disposed on both sides of the center of every length of signal element corresponding to a unit length, and utilizing the difference between the values of said two electric charges to correct for departures from true synchronism.

4. In a telegraph communication system, the method of maintaining synchronism between distributing mechanisms at two different stations which includes transmitting keyed signals at one station, translating said keyed signals to audio frequency keyed tone signals, rectifying said tone signals at the other station thereby to produce substantially rectangular wave signals, producing from the steep wave front of said rectified keyed signals an electric charge whose value is substantially a function of the time between the arrival of said steep wave front and the occurrence of a periodic local circuit closure, producing from said rectified keyed signals another electric charge whose value is substan-

tially a function of the time between the time of occurrence of another periodic local circuit closure and the arrival of the steep wave terminus of said signal impulse and utilizing the difference between the values of said two electric charges to subsequently correct for departures from true synchronism, said correction being applied only during spacing intervals between said signals.

5. In a telegraph communication system, a receiving station having, in combination, rotating mechanism and a correction motor therefor, a vacuum tube relay for controlling said motor, a pair of condensers for controlling the operation of said vacuum tube relay in opposite senses, means for charging one of said condensers only during a time interval starting with the arrival of the steep slope of a substantially rectangular wave and ending at the normal center of a positive peak of said wave, means for charging the other of said condensers only during a time interval starting with said normal center of a positive peak and ending with the steep slope terminus thereof, means responsive to the dominating one of the condenser charges for actuating said relay in the proper sense and means operative only during negative peaks of said wave for enabling said relay to control said motor.

6. In a telegraph communication system, a receiving station having, in combination, rotating mechanism and a correction motor therefor, an electromagnetic three-position relay for controlling said motor, a pair of differentially connected vacuum tubes coupled to opposite terminals of the winding of said relay, said tubes each including a control electrode, a condenser directly connected to each of said control electrodes, means including a gaseous conduction device and a periodically operable local circuit closure for producing an electric charge on one of said condensers whose value is substantially a function of the time between the arrival of the steep wave front of a received signal impulse and the occurrence of said local circuit closure, other means including another gaseous conduction device and another periodic local circuit closure for producing an electric charge on the other one of said condensers whose value is substantially a function of the time between the occurrence of the last said local circuit closure and the occurrence of the steep wave terminus of said signal impulse, and a circuit responsive to the received signal impulse for preventing the passage of current through said vacuum tubes during the actual reception of said signal impulse.

7. In a system for correcting the phase of a receiving telegraph distributor, means under control of said distributor for producing momentary circuit closures having a periodicity commensurate with the rotational speed of said distributor, means for translating each incoming intelligence signal into a single substantially rectangular wave wherein the marking element is defined by steep front and back edges, electrostatic storage means operative to measure and compare two time intervals one of which is initiated at the moment of reception of the steep front edge of a marking element and is terminated by the next succeeding one of said circuit closures, the other time interval being initiated by one such circuit closure and being terminated by the next ensuing back edge of said marking element, and means operative in response to inequalities between said two time intervals for applying phase correction to said distributor.

8. A system in accordance with claim 7 in which said electrostatic storage means comprise two capacitors, each provided with means for retaining its charge during the period of reception of a spacing signal.

10 9. A system for correcting the phase of a receiving telegraph distributor, comprising means under control of said distributor for producing circuit closures having a periodicity which is determined by the cyclic operation of said distributor, means for translating an incoming signaling wave into rectified marking and spacing signals, a gaseous discharge tube having a capacitor in shunt therewith and being provided
15 with means including its control grid for igniting the same momentarily in response to one of said circuit closures which occurs during reception of a marking impulse, thereby to discharge said capacitor, means operative after extinction
20 of said tube and until the cessation of a marking signal for accumulating a charge on said capacitor, a second gaseous discharge tube having means connected thereto for igniting the same at the initiation of a marking signal, means for extinguishing this tube in response to the next ensuing one of said circuit closures, a second capacitor having means connected thereto and operative only during the ignition period of the second said gaseous discharge tube for accumulat-

ing a charge thereon, means for retaining the respective charges on both said capacitors during the period of reception of an ensuing spacing signal, a three-position relay operable in accordance with the predominance of one capacitor charge over that of the other and effective only
5 during the reception of a spacing signal, and a distributor phase corrector operable under control of said relay.

10 10. The method of maintaining a distributor in synchronous phase with the arrival moments of the mean centers of a train of marking impulses received over a circuit, which comprises accumulating an electric charge the initiation
15 of which occurs on arrival of the front edge of each marking impulse, causing said charge to accumulate until a predetermined phase of the distributor cycle is reached, accumulating another electric charge during a period which starts
20 when another predetermined phase of the distributor cycle is reached and which terminates upon arrival of the back edge of each marking impulse, storing said charges until the arrival of a spacing impulse, then comparing the voltages
25 of said charges, and accelerating or retarding said distributor in accordance with said comparison.

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