Oct. 11, 1932. W. A. KNOOP 1,881,684

SYNCHRONIZING SYSTEM

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FIG. 1.

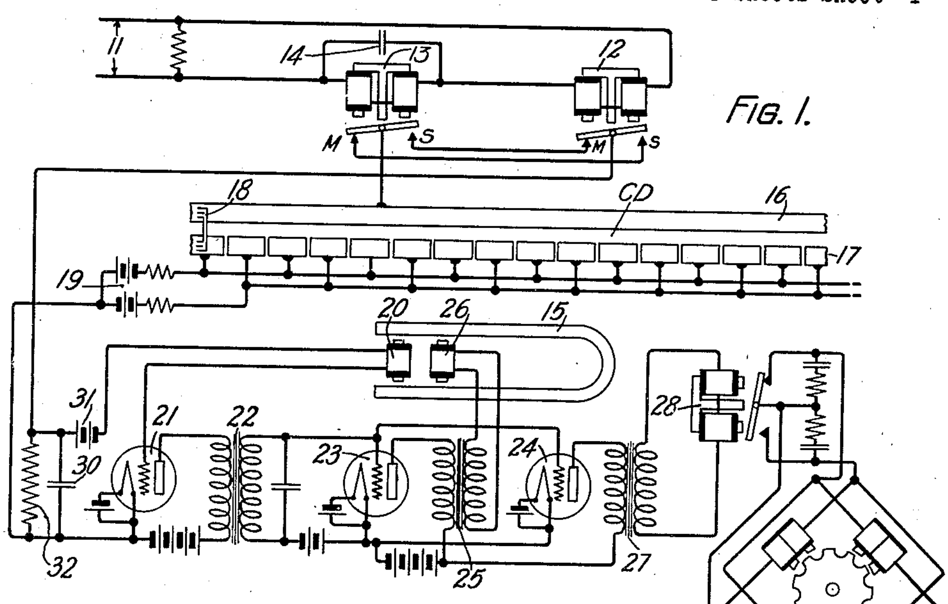

FIG. 2.

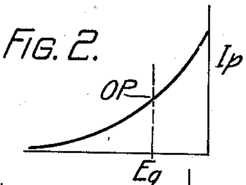

FIG. 3.

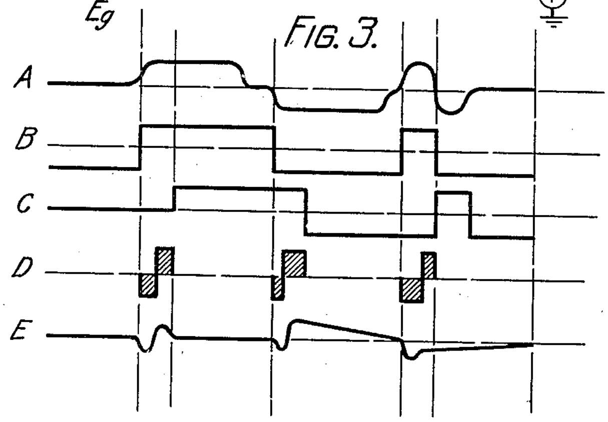

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FIG. 4.

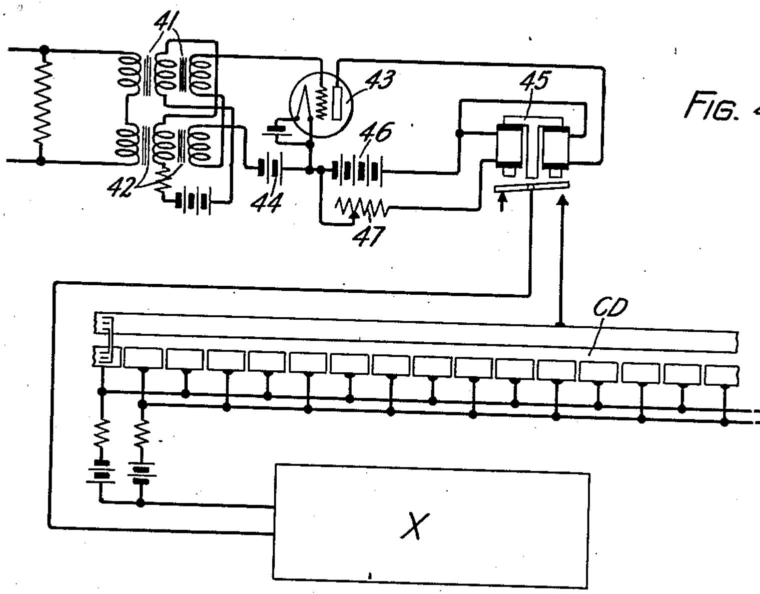

FIG. 5.

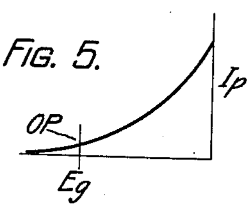

FIG. 6.

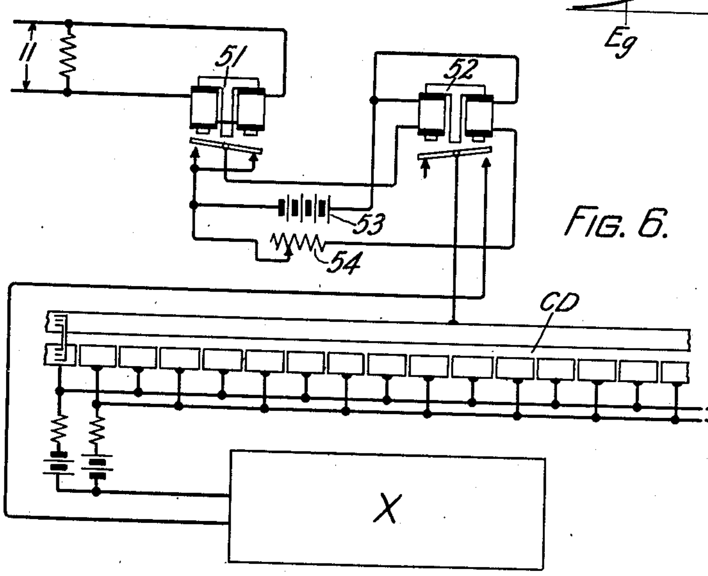

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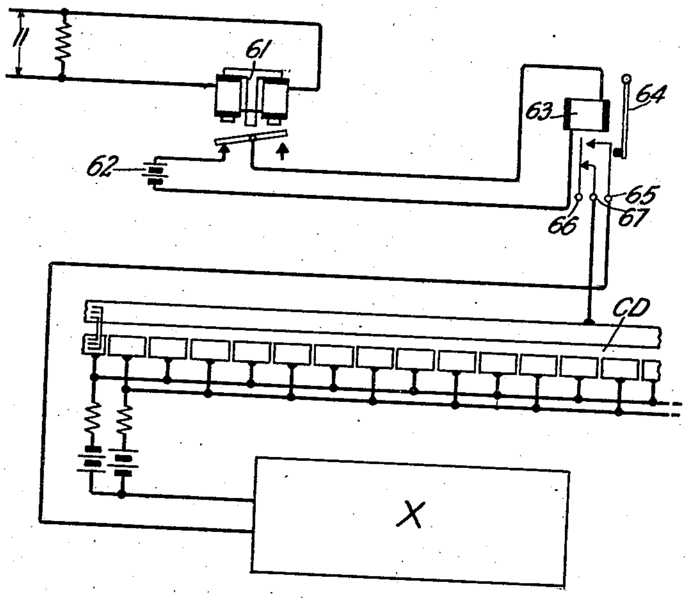
FIG. 7.



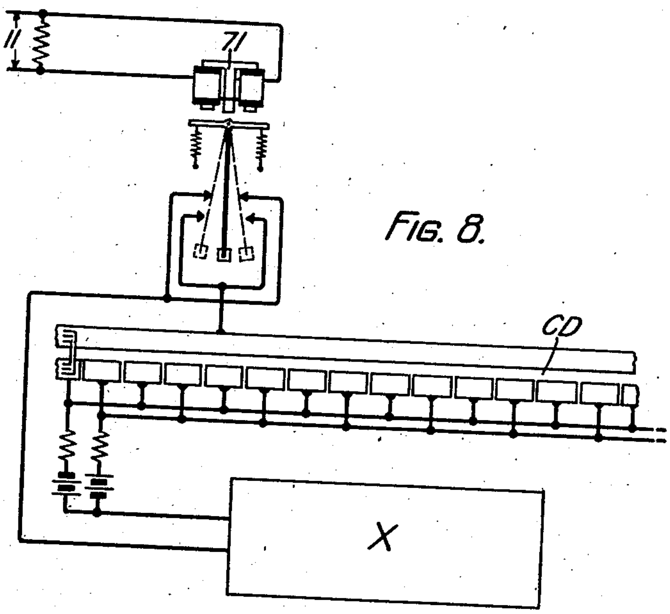


FIG. 8.

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UNITED STATES PATENT OFFICE

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SYNCHRONIZING SYSTEM

Application filed December 4, 1929. Serial No. 411,406.

This invention relates to synchronous communication systems, and particularly to high speed printing telegraph systems.

The general object of the invention is to maintain in a positive manner and with exactness, synchronism between transmitting and receiving apparatus at separated points.

A more specific object is to continuously maintain synchronism by causing the receiving apparatus to run as nearly as possible at the same speed as that of the associated transmitting apparatus. This is in contrast to systems in which the motor of the receiver runs at a speed inherently different from that of the transmitter and the receiving brushes are reset to obtain approximate synchronism with the transmitter, or in which the receiving distributor averages the same speed as the transmitter.

A feature of the invention is apparatus comprising a storing condenser connected across the input of the vacuum tube tuning fork circuit, which circuit is responsive to extremely small departures from synchronism in either direction for correcting the speed of the receiving apparatus. In U. S. Patent 1,747,248, granted to W. A. Knoop on February 18, 1930, there is disclosed an arrangement in which a series of short impulses of the one sign are produced and split by means of a distributor to produce effects upon two vacuum tubes, which are differently applied to effect the desired correction.

By circuit arrangements in accordance with the present invention a desirable simplification and other attendant changes are secured. This is done by a system in which impulses of both positive and negative sign are produced in response to each incoming signal impulse and impressed on the vacuum tube tuning fork circuit. A distributor which effects this production of the positive and negative pulses has alternate segments interconnected to form two groups and as the distributor brush rotates over adjacent segments the impulses so produced have either a preponderance of positive or negative voltage, or an equality of voltage therebetween in accordance with whether the local distributor is running fast, slow or in phase. The equal or unequal impulses are impressed together upon a storing condenser, wherein the former neutralize each other and the latter causes the excess voltage to be applied directly to the tuning fork circuit without the use of correcting vacuum tubes.

In the drawings, Fig. 1 shows a correction circuit wherein two polarized relays of the two-position type operate in response to the incoming signal impulses, one of the relays having a sufficient delay characteristic to remain non-responsive until the distributor brush has had time to engage portions of two adjacent segments and to thereby transmit two impulses of opposite polarities to the fork circuit;

Fig. 2 shows a plate current-grid potential characteristic of the pick-up vacuum tube of the tuning fork circuit of Fig. 1;

Fig. 3 shows the operation curves of the circuit of Fig. 1;

Fig. 4 shows a modification of Fig. 1 wherein a pair of transformer (preferably having high permeability magnetic cores at low magnetizing forces) are employed to convert the incoming signal current impulses to voltage impulses, which in turn are impressed over a negative "C" modulator tube and a differential impulse relay, the relay being adapted to transmit the correcting impulses to the fork circuit;

Fig. 5 is the plate current-grid potential characteristic of the negative "C" modulator tube of Fig. 4;

Fig. 6 is a modification of Fig. 4 wherein the transformers and the negative "C" modulator tube are replaced by an unbiased polarized relay;

Fig. 7 is a modification of Fig. 6, wherein the impulse relay for controlling the correcting impulses impressed on the tuning fork circuit is of the make-before-break type;

Fig. 8 is a modification of Fig. 1, wherein a single relay of the three-position type controls the correcting impulses impressed on the tuning fork circuit.

In Fig. 1 the correcting circuit 11 is connected to a suitable type of receiving circuit (not shown) wherein the incoming signals are regenerated in a manner to give a satisfactory reproduction of the transmitted signals. The circuit 11 includes relays 12 and 13, both of which are of the unbiased polarized type. A condenser 14 is connected across the windings of relay 13 to give the latter a delayed action whereby the relay is made slow to operate in contrast to relay 12. The aramature of relay 13 is connected to rotary distributor CD and the armature of relay 12 is connected to one side of the input circuit of the vacuum tube circuit which is arranged to control the vibration of tuning fork 15. In response to each change in polarity of the incoming signals, relay 12 operates to either of its contacts depending upon the polarity of the incoming signal impulse, and shortly thereafter relay 13 also operates to the corresponding contact but not until the distributor brush has passed from one to the other of two adjacent segments. The rotary distributor of which only the correcting rings are shown comprises a continuous ring 16, a segmented ring 17 and a rotatable brush 18. Ring 17 has its alternate segments interconnected to form two groups which are respectively connected to opposite poles of battery 19. The mid-tap of battery 19 is connected to the other side of the input circuit of the vacuum tube tuning fork circuit.

The vacuum tube circuit may be of the type disclosed in U. S. Patent 1,809,832, granted to A. M. Curtis on June 16, 1931 or its equivalent. In the circuit here illustrated a pick-up magnet 20 is arranged in the magnetic field of the vibrating fork 15 and is adapted to impress the frequency of the fork on a pick-up vacuum tube 21, transformer 22, a fork drive vacuum tube 23 and a relay drive vacuum tube 24, the grids of the two last mentioned tubes being connected in parallel. Fork frequency current in the output circuit of vacuum tube 23 flows through transformer 25 and the winding of magnet 26 in series to drive fork 15. Simultaneously, the fork frequency current in the output circuit of vacuum tube 24 flows through transformer 27 and the windings of relay 28, whereby the relay operates at the frequency of the fork. The operation of relay 28 causes battery to be alternately applied at the frequency of the fork to the two windings of the phonic wheel motor 29, which drives brush 18.

When the distributor CD is in synchronism with the incoming signals brush 18 is arranged to pass over equal portions of any two adjacent segments of ring 17 at the time a signal impulse is received, so that equal amounts of positive and negative charge are successively applied by brush 18 over the armature of relay 13, either of the relay contacts, the opposite contact and the armature of relay 12, to storing condenser 30. Condenser 30 which is of a relatively high capacity, say of about 1 microfarad, is connected across the input circuit of vacuum tube 21. Therefore, when equal voltages of opposite polarity are applied to condenser 30 in rapid succession, they will neturalize each other and no change will be effected in the normal fork frequency current in the input ciricuit of vacuum tube 21. But should the charge of either polarity predominate, a charge of the predominating polarity will be superimposed on the normal fork frequency current to cause an increase or decrease, depending on the polarity of the predominating voltage, in the average grid potential or operating point of the pick-up tube 21. This increases or decreases the output energy of tube 21 and tube 23 and this increases or decreases the amplitude of vibration of fork 15. The damping of fork 15 depends upon the amplitude of vibration and the frequency depends (to a second order degree) on the damping. When the amplitude of vibration increases the damping increases and the frequency decreases.

There is in the input circuit of vacuum tube 21 a negative "C" battery 31 and a relatively high resistance 32 of a value, say, of about 2 megohms. The "C" battery is of such voltage as to bring the operating point of vacuum tube 21 to approximately the middle of the curved portion of the plate current-grid potential characteristic of the tube, as indicated in Fig. 2.

The operation of the circuit arrangement of Fig. 1 may be readily understood by reference to Fig. 3, wherein the curves A to G inclusive, shows the effects of the incoming signals. Curve A represents signal impulses received by relays 12 and 13. Curve B represents the operation of the armature of relay 12 in response to the signal impulses shown in curve A, the armature moving to its right hand contact in response to impulses of positive polarity and to its left hand contact in response to impulses of negative polarity. Curve C represents the operation of the slow-acting relay 13, whereof the armature operates correspondingly with the armature of relay 12, but at a slight interval later. Curve D represents the impulses produced when brush 18 passes over portions of any two adjacent segments of ring 17, it being noted that positive and negative impulses are produced at every change of polarity of the incoming signals. The positive and negative impulses produced by the distributor occur during the interval between the operation of relays 12 and 13 and therefore are very short. When the distributor is in synchronism with the incoming signals these impulses will be equal, as indicated by the first pair of impulses shown in curve D. Should the distributor be running ahead of the incoming signals brush 18 will cover a greater portion of the segment connected to positive battery than that of the segment connected to negative battery and therefore the impulses produce will be like those shown in the second group of impulses in curve D, but should the brush 18 fall behind the incoming signals brush 18 will cover the greater portion of the segment connected to negative battery than that connected to positive and the resultant impulses will be like those shown in the third group shown in curve D. Curve E shows the corresponding effects of the impulses of curve D upon condenser 30.

The general principles of the invention may be applied to any driving mechanism which may have its speed corrected by inequality of normally equal positive charges or impulses.

Fig. 4 is a modification of Fig. 1, wherein the correcting circuit 11 terminates in the windings of two transformers 41 and 42 which preferably have high permeability cores of the type disclosed in copending application of E. T. Burton, Serial No. 280,709, filed May 26, 1928, corresponding to British Patent 312,338, the complete specification of which was accepted June 10, 1930. These transformers are equipped with cores of nickel-iron alloys of high initial permeability, which have high permeability at low magnetizing forces and have a magnetic circuit which becomes overloaded at low amplitudes of the signaling current. Therefore, a signal wave of slowly varying intensities when received in the transformers produces in the secondary windings thereof a wave of short discrete impulses, which occur while the magnetizing force is passing through values slightly above or below zero. By biasing the transformers magnetically in opposite directions, the intervals in which the sharp impulses occur, are shifted to the higher values of signal current, so that two impulses are produced during the rise and fall of a signal wave on either the positive or negative side of the zero value. The impulses so produced by each signal wave are of opposite polarity and are produced in one or the other of the secondary windings, depending upon the polarity or direction of the signal wave, that is, those caused by a positive wave are produced in one winding and those caused by a negative wave are produced in the other winding. For an illustration of how the secondary impulses occur, reference may be made to British Patent 312,338 supra. The secondary windings are connected in series, but reversed with respect to each other in order to invert the impulses in one winding, thereby obtaining a positive impulse at the beginning and a negative impulse at the end of each signal wave, or half cycle, regardless of the polarity of the wave. These voltage impulses are each impressed on vacuum tube 43 which serves in conjunction with battery 44, as an amplifier, whereby the impulses of positive polarity only are capable of producing an effective current in the plate circuit of the tube. As the grid is made sufficiently negative to normally block space current, negative impulses have no effect. The plate circuit of the tube includes the right hand winding of relay 45 and battery 46. Relay 45 is of the differential type, having its armature normally in the position shown, due to the current normally passing through the circuit which includes battery 46, the left hand winding of the relay and adjustable resistance 47. Each time a positive voltage impulse is received in the input circuit of tube 43 the plate current flowing through the right hand winding of relay 45 rises to a value whereat the normal current flowing through resistance 47 is overcome and the relay momentarily operates its armature to its right hand contact. Should the corrector distributor CD be in synchronism with the incoming signals the distributor brush will be passing over equal portions of any two adjacent segments, during the interval in which the relay armature is in engagement with its right hand contact, thereby permitting equal current impulses of positive and negative polarity to be applied to the vacuum tube tuning fork circuit (shown diagrammatically by block X) in the same manner as described above for Fig. 1. Should the corrector distributor be running ahead or behind the incoming signals the distributor brush will be engaging unequal portions of two adjacent segments, thereby causing unequal current impulses of negative and positive polarity to be applied to the fork circuit whereby the speed of vibration of the fork and motor relay are accelerated or retarded in the manner hereinbefore described.

Fig. 5 shows the plate current-grid potential characteristic of the amplifier tube 43, the battery 44 being of such value as to place the operating point of the tube near the lower end of the characteristic.

Fig. 6 shows a modification of Fig. 4, wherein the correcting circuit 11 terminates in relay 51, which is of the unbiased polarized type. Relay 51 is normally in engagement with either of its contacts, whereby a circuit is closed through the left hand winding of relay 52, also of the unbiased polarized type, to battery 53. Relay 51 in operating in response to every change of polarity of the incoming signals, changes the position of its armature and in the interval between breaking one contact and making the other, the shunt path across battery 53, which includes variable resistance 54 and the right hand winding of relay 52, becomes effective to operate relay 52 to its right hand contact. Relay 52 has its windings arranged in differential relation and the current flowing through the right hand winding is normally ineffective because of resistance 54.

Should the brush of correcting distributor CD be in synchronism with the incoming signals, equal current impulses of positive and negative polarity will be applied to the vacuum tube tuning fork circuit (shown diagrammatically by block X) when the armature of relay 52 momentarily engages its right hand contact, but should this synchronism be lacking, the current impulses produced through distributor CD will be unequal and thereby effect the desired correction of the speed of vibration of the tuning fork and the motor relay as described above for Fig. 1.

Fig. 7 is a modification of Fig. 6, wherein the correcting circuit 11 terminates in an unbiased polarized relay 61. The left hand contact is connected to the positive pole of battery 62 and the relay armature is connected to one side the winding of a non-polar relay 63, which has its other side connected to the negative pole of battery 62. Relay 63 has armatures of the make-before-break type whereof the armature 64 is in engageable relation with spring 65. Spring 65 is in engageable relation with spring 66 and spring 66 is in engageable relation with spring 67 which is connected to the corrector distributor CD. Normally spring 67 is in engagement with spring 66, but spring 66 is out of engagement with spring 65 and spring 65 is out of engagement with armature 64. When the polarity of the incoming signals changes from negative to positive the operating circuit for relay 63 closes and armature 64 is attracted and thereby pushes spring 65 into engagement with spring 66 to break contact between springs 66 and 67 and in the interval between the interengagement of springs 65 and 66 and the disengagement of springs 66 and 67 current impulses of negative and positive polarity are transmitted to the vacuum tube tuning fork circuit (shown diagrammatically by block X) in a manner hereinbefore described. The impulses transmitted to the fork circuit are equal if the distributor brush is in phase with the incoming signal, but should there be a difference in phase relation the impulses will be of unequal lengths to effect the desired correction in the speed of vibration of the tuning fork and the armature of the motor relay.

Fig. 8 shows a modification of Fig. 1, wherein correcting circuit 11 includes the winding of relay 71 which is of the biased polarized type. Relay 71 is arranged for three positions and is responsive to both positive and negative incoming signals. The relay has attached to its armature a weighted arm in engageable relation on each side with two contacts, one of which is arranged to be engaged by the arm before the other. Therefore, in response to each change of signal polarity the armature causes both contacts on either side to be interconnected to complete for a short interval an operating path to the fork circuit (shown diagrammatically by block X). The outer contact is connected to the correct distributor CD. Should the distributor brush be in phase with the incoming signals, it will be passing over equal portions of any two adjacent segments at the time both contacts on either side of the arm are interconnected, thereby sending equal current impulses of positive and negative polarity to the fork circuit as hereinbefore described, but should the brush be out of phase, then the current impulses will be of unequal lengths and will thereby effect the desired correction.

What is claimed is:

1. A method of causing a synchronous device to remain closely in phase with incoming current impulses which consists in generating a pair of impulses of opposite polarities in response to an incoming impulse, superimposing said pair of impulses of opposite polarities in rapid succession on an alternating current of substantially constant frequency for driving said device, and utilizing the preponderance of one polarity in each of said pairs of impulses to alter the frequency of said alternating current to thereby effect continuous correction for synchronism and phase relation.

2. The method of causing a synchronous device to remain closely in phase with incoming current impulses, which comprises producing a plurality of impulses of opposite polarities in response to an incoming impulse, impressing said impulses of opposite polarities in rapid succession on an energy storing element whereby any difference in the magnitudes of said impulses is retained on said storing element as a charge of positive or negative polarity depending on the predominating polarity of adjacent impulses of opposite polarities, and utilizing said charges to accelerate or decelerate, as desired, said device to the speed of the incoming impulses.

3. In a synchronous receiving system, a combination of elements for correcting for slight departures from synchronism comprising means for converting each received current impulse into a plurality of impulses of opposite polarities, a synchronous device, a source of constant frequency for driving said device, and storing means for receiving said impulses of opposite polarities in rapid succession and for impressing a charge resulting from any difference in the magnitudes of two succeeding impulses, in a direction tending to restore synchronism.

4. A system for correcting for phase departure in synchronous apparatus comprising means for receiving a series of impulses with which a local device is to be synchronized, means for driving said local device,

mechanically operated means for producing impulses of opposite polarities in response to one of said received impulses, means for impressing said impulses of opposite polarities on said driving means, and means for utilizing the preponderance of an impulse of one polarity over an impulse of the other polarity to correct the speed of said driving means when a slight departure in phase relation occurs.

5. A system for correction of phase departure, however small, in synchronous apparatus comprising means for receiving a series of incoming impulses with which a local rotary device is to be synchronized, means for driving said local rotary device, other rotatable means for producing impulses of opposite polarities in response to each incoming impulse, means for impressing said impulses of opposite polarities on said driving means, and capacity storing means for utilizing the preponderance of one polarity over the other polarity of adjacent produced impulses to correct the speed of said driving means when a slight departure in phase relation occurs.

6. In a synchronous communication system, means for producing synchronizing impulses of opposite polarities from a received signal impulse, electromagnetic means for operating said impulse producing means, a vibrating element for controlling the operation of said electromagnetic means, and a storing element responsive to said synchronizing impulses for varying the frequency of vibration of said vibrating element in accordance with the speed of the incoming signal impulses.

7. In a synchronous telegraph system, a rotary distributor for producing synchronizing impulses of opposite polarities from a received signal impulse, a motor for operating said distributor, a vacuum tube tuning fork circuit for controlling the operation of said motor, and a condenser connected across the input circuit of said vacuum tube circuit and responsive to said synchronizing impulses of opposite polarity for regulating the speed of said motor in accordance with the speed of the incoming signal impulses.

8. In a synchronous impulse receiving system, a combination of elements for correcting for slight departures from synchronism between a rotary receiving device and incoming signal impulses, comprising means including mechanically moving parts arranged to generate impulses of opposite polarities in response to each incoming signal impulse, and means for utilizing any difference in the magnitude or duration of two generated impulses of opposite polarities to correct for synchronism.

9. In a synchronous impulse receiving system, a combination of elements for correcting for slight departures from synchronism between a rotating receiving device and the incoming signal impulses, comprising a plurality of devices operating under the control of received impulses and having different operating time constants, means for causing a controlling current to flow in response to one incoming signal impulse in the interim between the instant of operation of said devices by the same impulse and means for utilizing said controlling current to correct said rotating device to synchronism with the incoming impulses.

10. A synchronous impulse receiving system, according to claim 9, wherein the operating devices are electromagnetic relays at least one of which is provided with means for adjusting its time of operation as compared to the other.

11. In a synchronous impulse receiving system arranged to receive polar signals, a rotating receiving device, means for converting each incoming signal impulse into a plurality of impulses of opposite polarities, means for eliminating the converted impulses of one polarity, means for changing each of the converted impulses of the other polarity into a pair of impulses of opposite polarities, and means for utilizing any difference in the magnitude or duration of two of the last mentioned impulses of opposite polarities to correct for any slight departures from synchronism between said device and the incoming signal impulses.

12. In a synchronous impulse receiving system according to claim 11, wherein the means for converting each of the incoming signal impulses into a plurality of impulses of opposite polarities is an oppositely biased pair of transformers having core material of a high permeability at the very low magnetizing forces.

13. In a synchronous impulse receiving system, a rotating receiving device, an instrumentality responsive to the incoming signal impulses to produce, in conjunction with said rotating device and during the interval of its movement, two current impulses of opposite polarities, and correcting mechanism controlled by any difference in the magnitude or duration of the two impulses of opposite polarities to correct for any departure from synchronism of said rotating device with the incoming signal impulses.

14. In a synchronous impulse receiving system, according to claim 13, wherein the said instrumentality comprises an electromagnetic relay of the make-before-break type.

In testimony whereof, I hereunto subscribe my name this 3rd day of December, 1929.

WILLIAM A. KNOOP.