

Nov. 24, 1936.

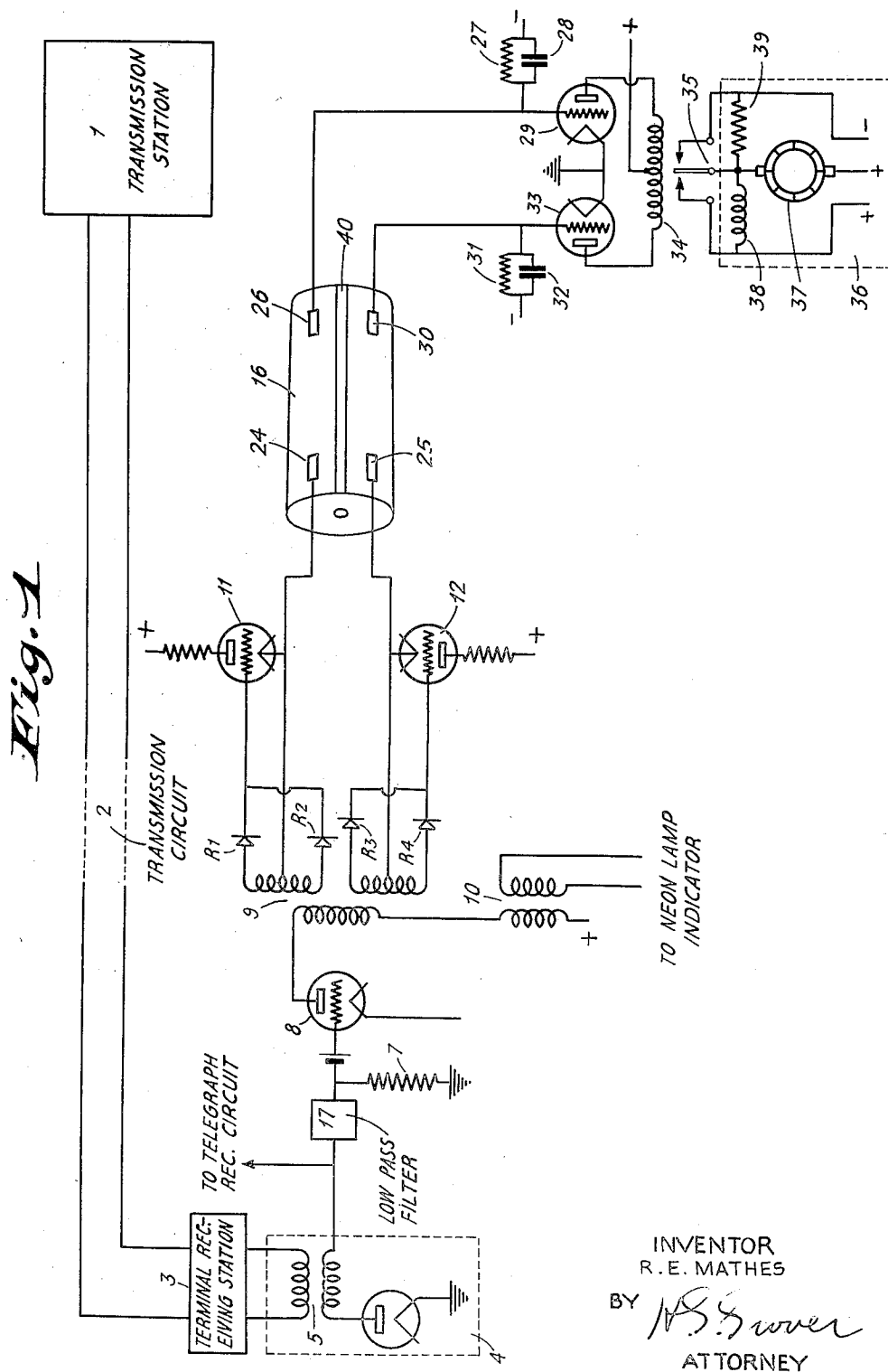
R. E. MATHES

2,062,009

SYNCHRONIZING SYSTEM

Filed Jan. 26, 1934

2 Sheets-Sheet 1



Nov. 24, 1936.

R. E. MATHES

2,062,009

SYNCHRONIZING SYSTEM

Filed Jan. 26, 1934

2 Sheets-Sheet 2

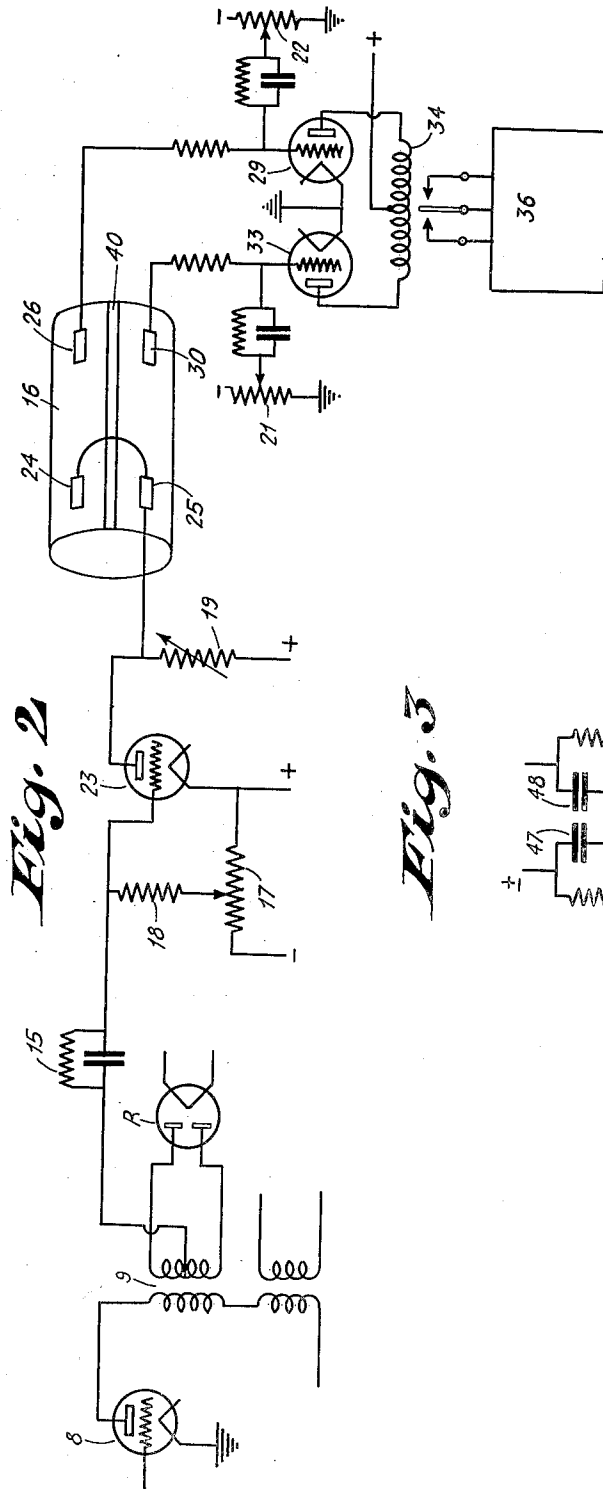
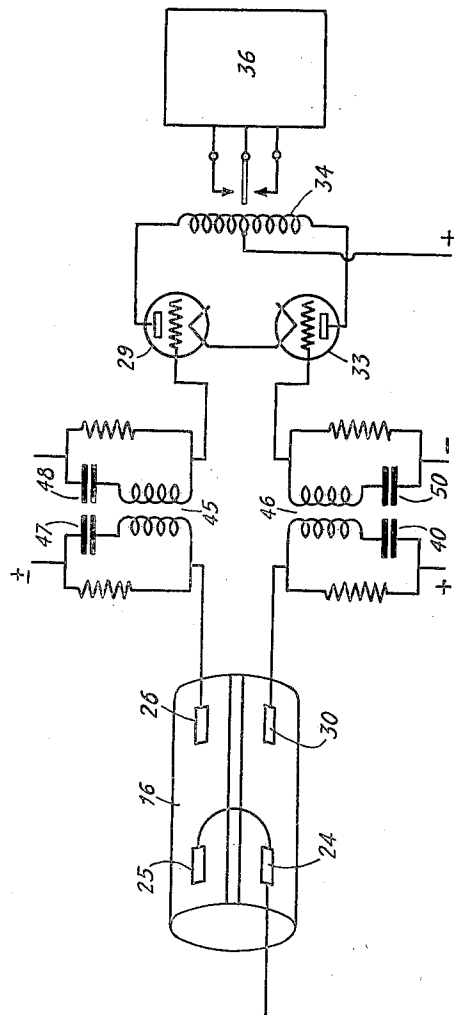


Fig. 2

Fig. 3



INVENTOR
R. E. MATHES

BY *W. S. Gower*
ATTORNEY

UNITED STATES PATENT OFFICE

2,062,009

SYNCHRONIZING SYSTEM

Richard E. Mathes, Westfield, N. J., assignor to
Radio Corporation of America, a corporation
of Delaware

Application January 26, 1934, Serial No. 708,378

19 Claims. (Cl. 178—69.5)

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

In the transmission of intelligence by facsimile and multiplex telegraph systems operating on the time division principle, it becomes necessary to maintain quite close synchronism between the transmitting and receiving stations. Hitherto, the usual practice has been to provide local, standard speed or frequency controls at each station, and to correct the phase and synchronism at the receiver in accordance with either the transmitted intelligence bearing signal elements or else by means of a special correction signal transmitted periodically at short intervals.

The use of a special signal for this purpose has been found to be undesirable since it results in a diminution of the time available for the intelligence bearing signals and so reduces the speed of the system to that extent. An economic use of such method of phase and synchronism control would require that not more than, say, 5% of the circuit time be assigned to the special correction signal, a requirement which necessitates the transmission of special signals at rare intervals, thus making it imperative to have a large amount of tolerance in the length and spacing of the intelligence bearing signal elements themselves to provide for possible phase displacement between the transmitter and receiver during the time between corrections. Consequently, there results a still further reduction in the effective intelligence speed.

When it is attempted to directly derive the correction or phasing from the transmitted signal elements themselves in accordance with prior methods, experience has shown that it is impossible to transmit telegraph signals without distortion, the amount and type of which depends upon the transmission circuit. For example, on a radio circuit fortuitous distortion may be especially bothersome. This type of distortion would cause either over or under correction, and thus would require comparatively large tolerance limits in the signal lengths to absorb the resultant floating.

The foregoing difficulties are overcome in accordance with the present invention by the provision of an auxiliary circuit in the receiver which, together with a distributor segment or cam arrangement, produces pulses whose times of occurrence are utilized to effect a speed controlling

device. More specifically, the auxiliary circuit is arranged to derive pulses from each end of the signal elements, namely, the start and stop steep wave fronts, and to transform them into unidirectional pulses by means of rectification, after which they are utilized through the medium of an integrating circuit to correct the synchronism of the receiving rotating mechanism in accordance with the average phase discrepancies taken over a period of several successive signal elements rather than correcting for each individual element.

One advantage of the present invention lies in the mode of connecting the phase and synchronizing apparatus to the telegraph receiving apparatus in such manner as not to disturb the signal envelope as it is subsequently available for receiving purposes. This is effected by means of a coupling tube.

In the accompanying drawings, Figure 1 shows, diagrammatically, one embodiment of a system for accomplishing correction in accordance with the present invention; and Figure 2 illustrates a preferred arrangement which, for the sake of simplicity, is shown as a modification of the receiving apparatus of the system of Figure 1. In the systems of these two figures, rectification of the steep wave fronts of the incoming signal is obtained prior to synchronizing the rotating mechanism; Figure 3 shows a modification of the receiving circuit between the kicker or impulse commutator arrangement and the relay tubes controlling the synchronization of the rotating mechanism for obtaining isolation of the grids of these relay tubes from the kicker commutator.

Referring to Figure 1, there is shown in conventional box form a transmitter station 1 which is arranged to transmit signals over any suitable type of communication circuit 2 such as a landline or radio channel to a receiving station comprising suitable terminal receiving apparatus 3, a rectifier 4 and additional equipment for phase and correction purposes. For obtaining unidirectional impulses from the steep wave fronts of the incoming signals there are provided rectifiers, such as R1, R2, R3 and R4, which are connected to the input circuits of two grid controlled glow discharge devices 11 and 12 known to the art by the trade name "Thyratron". These rectifiers are connected up as full wave rectifiers in well known manner and may comprise any suitable apparatus, such as a copper oxide rectifier. The outputs of the rectifiers function in cooperation with the thyratrons 11 and 12 to control the phase and correction of the receiving mechanism through the medi-

um of a kicker commutator herein designated as 16. The general operation of this receiving circuit and kicker commutator arrangement is more adequately described in my United States Patent No. 2,038,375, granted April 21, 1936, on an application filed December 1, 1932. In the operation of the circuit the incoming signal, which, for the purpose of the description, will be assumed to be a tone, is fed via a transformer 5 to the rectifier shown diagrammatically in box 4. Signal current passing through rectifier 4 causes an IR drop across a resistance 7 which effectively produces varying potentials on the grid of a coupling vacuum tube 8 in the plate circuit of which are the primaries of two transformers 9 and 10. If desired, a low pass filter 17 may be inserted between the rectifier 4 and resistance 7 for smoothing out whatever tone components remain in the rectifier signal. Since telegraph signals generally approximate the form of a square wave, a current pulse will be generated by the transformers 9 and 10 in the secondaries thereof during the transition period from space to mark and vice versa. No current, however, will be generated in the secondaries of these transformers during the intervals of steady space or steady mark. Due to the transformer action, two sharp pulses will be generated in the secondaries, one at the start of the signal impulse and the other at the end of the signal impulse. These two pulses will enable the rectifiers R1 and R3 to pass one of them as a positive potential to the grids of the glow tubes 11 and 12. When the signal impulse ceases, there will be induced in the secondaries of transformers 9 and 10 pulses in the opposite direction, which pulses will pass through rectifiers R2 and R4 to again impress positive potentials on the grids of the glow tubes. These pulses arriving at the grids of the glow tubes will cause the thyatrons to pass current only when at the same time therewith the cathode circuit is completed to negative potential through the medium of the short-circuiting bar 40 on the kicker distributor 16 as the brushes of the kicker commutator simultaneously contact with the segments, thus completing the circuit to the respective tubes 29 and 33. The cathode circuits of the grid glow tubes 11 and 12, it will be noted, are connected to brushes 24 and 25 of the kicker commutator. Associated with brush 24 is a brush 26 and associated with brush 25 is a brush 30. Brush 26 is connected to a resistance capacity circuit 27, 28 and also to the grid of a relay tube 29, and brush 30 is similarly connected to a duplicate resistance capacity circuit 31, 32 and to a tube 33. Negative potentials are applied through these resistance capacity circuits to the respective brushes. The outputs of tubes 29 and 33 are connected to a push-pull winding of a relay 34 which, in this case, is shown to be of the polar type having a neutral tongue 35. Polar relay 34 may be used to actuate any sort of correction mechanism, be it a small motor or other well known apparatus for applying correction to a controlled rotating mechanism. The preferred method of controlling the constant speed motor is to utilize a small D. C. motor 37 in the manner shown in the box 36, which permits rotation in either direction depending upon the contact to which the tongue 35 of polar relay 34 is connected. The D. C. motor 37 shows the motor field 38 in series with the current limiting resistor 39 connected between the positive and negative terminals of a 240 volt source of supply.

The armature is connected to neutral on one side and to the tongue 35 of the relay 34 on the other side, thus enabling a reversal of the current through the armature with a resultant reversal of the direction of rotation as the relay 5 tongue contacts with one or the other of the stationary relay contacts.

With this arrangement, the control motor may be run at as nearly true synchronous speed as possible and the residual synchronism in any direction may be corrected by rotating the field casting in the necessary direction. This is accomplished by means of the two sets of brushes 24, 26 and 25, 30. When the system is in absolute proper phase, short-circuiting bars 40 of the kicker commutator are located midway between these two sets of brushes upon the occurrence of a glow tube striking pulse in the rectifiers R1, R2, R3, and R4. If the control motor drifts a little slow, then brushes 24, 26 will be shorted by the bar 40 when the pulse is received and the grid glow tube 11 will pass a partial charge to capacity 28. If the motor remains slightly slow for a sufficient length of time, successive partial charges will accumulate on condenser 28 and permit the tube to attract the relay tongue 35 to the right, thus actuating the correction motor 37 and rotating the field casting in the same direction as the rotation of the motor. This will cause the armature to rotate slightly faster relative to the base, and, therefore, return the kicker commutator to proper phase. If the motor runs slightly fast, brushes 25 and 30 will be shortened when the pulse strikes the grid glow tube 12 and thus cause a partial charge to pass to the left hand capacity 32. Successive pulses will finally charge this capacity to such a critical value as to permit the actuation of its corresponding tube 33, in turn causing the relay 35 to be pulled into engagement with the left hand contact. This will actuate the correction motor in an opposite direction to the rotation of the armature and will, therefore, again bring the kicker commutator into proper phase with the incoming signals.

The above method of operation is somewhat similar to that described in my United States Patent No. 2,038,375, supra, to which attention is invited for a more complete description of the operation of the correction mechanism per se.

In order to indicate when the motor is in synchronism and, further, how much hunting is present, there is provided a neon lamp indicator, not shown, in circuit with the secondary winding of transformer 10, the light of which strikes in accordance with the incoming signals and which may be utilized in any well known manner to indicate proper phase relationship.

In actual operation, it is preferred that the resistance and capacity constants of the parallel arrangements in circuit with tubes 33 and 29 be such that there will occur only a partial charge on the respective condensers and, if the same cycle of operations repeats itself at the occurrence of the next signal impulse another partial charge will be placed on the condenser in addition to that already obtained. Such action will be repeated until the charge on the condenser is sufficiently high to cause the grids of the tubes to reach a polarity such as to cause the plate current of the tube to actuate the relay 34.

Figure 2 illustrates a preferred method of producing pulses at the receiver and of transferring the effect of these pulses to the output relay. In this particular arrangement a vacuum tube 23 is employed instead of the grid controlled glow dis-

charge tubes. The coupling tube 8 herein has its plate circuit connected through the primary of transformer 9, the secondary of which is center tapped and connected to a full wave rectifier R in a manner well known in the art. The center tap of the secondary winding of transformer 9 is carried through a condenser resistance combination 15 to the grid of vacuum tube 23 which is normally arranged to pass current and whose grid is connected to a biasing potentiometer 17 through a grid leak 18. The plate circuit of this tube includes a high variable resistance 19, the plate end of which is also connected to the input brushes of the correction kicker commutator 16. In this case, since only one tube 23 is used instead of the two glow tubes shown in Figure 1, brushes 24 and 25 are tied together. The output brushes are connected individually to the grids of the respective relay tubes and the circuits completed through condenser resistance combinations similar to those shown in Figure 1, to biasing potentiometers 21 and 22. The plate circuits of these tubes are connected to the windings of the polar relay 34, the output of which controls the operation of the correction mechanism shown in box 36.

In the operation of Figure 2, a signal impulse impressed on coupling tube 8 will cause a sharp pulse to be generated in the secondary of transformer 9 in, say, an upward direction. When the signal first starts, a portion will pass through one side of the rectifier and impress a pulse of negative potential upon the grid of the vacuum tube 23. Similarly, when the signal impulse ends, the downwardly produced pulse in the transformer secondary 9 will pass through the other side of the rectifier and again produce a negative pulse on the grid of the tube 23. The condenser resistance circuit 15 aids in passing the rapidly changing portion of the transformer pulse more readily than the more slowly changing portion of the pulse and thus sharpens up the pulse and shortens the tailing off effect. Although resistance condenser combination 15 is not essential to the fundamental operation of the device, it obtains, in practice a considerable improvement in the circuit. Since there is plate current flowing in tube 23 normally, the effect of a negative pulse on the grid of the triode 23 is to reduce plate current to zero for the duration of the pulse. This means, of course, that the voltage on the plate end of the plate resistance 19 will normally be low and will rise to full supply voltage for the duration of the pulse. This voltage is then applied through the correction brushes of the kicker 16 in normal manner to the relay tubes 29 and 33 which are arranged to operate as previously described above in connection with Figure 1.

The resistance shown in each lead from brushes 26 and 30 to the grids of the respective tubes 29 and 33 stabilize the action of the arrangement and provide the voltage divider circuit with such constants as permit the proper choice of grid potential bias on the relay tubes.

In Figure 3 is shown a modification of the circuit between the kicker commutator 16 and the relay tubes 29 and 33 whereby it is possible to isolate the grids of these tubes from the kicker arrangement. This is desirable in some cases since the channeling brushes for the multiplex proper are carried on the same commutator. In the course of operation small particles of carbon are deposited on the surface of the commutator from the brushes, and as these carbon particles pass under the channel brushes which are at a relatively high voltage they effectively acquire

a minute charge. This charge is retained until the particles reach the correction brushes where it is discharged into the grid circuits of the relay tubes, an effect which, in present practice, must be overcome by proper biasing of the tubes. In the embodiment of Figure 3 the pulses received through the kicker commutator are passed through transformers 45 and 46 which have condensers 47, 48, 49, and 50 in series with the respective windings and a leakage resistor across the combination of condenser and winding, as shown. Such an arrangement will cause the transference of the pulse from the kicker circuit proper to the grid circuit, but will effectively isolate this kicker circuit as regards the minute charge on the carbon particles.

Another possible way of overcoming this charge effect is to place an auxiliary brush on the commutator midway between the last channel brushes and the correction brushes and connect this auxiliary brush to ground. This should effectively discharge the carbon particles before they reach the correction brushes.

The invention, it is to be understood, is not limited to the precise arrangement shown since various modifications may be made without departing from the spirit and scope of the appended claims.

I claim:

1. In a communication system wherein communication is effected by the transmission of signal impulses from a transmitting station to a receiving station, each of said stations having rotating mechanism, the method of maintaining synchronism between the rotating mechanism at both said stations which includes receiving the transmitted impulses, obtaining from each and every received pulse two pulses of different polarity, rectifying said two pulses to obtain unidirectional pulses and utilizing both of said rectified pulses to control the speed of the rotating mechanism at the receiving station.

2. In a communication system wherein communication is effected by the transmission of signal impulses from a transmitting station to a receiving station, each of said stations having rotating mechanism, the method of maintaining synchronism between the rotating mechanism at both said stations which includes receiving the transmitted impulses, obtaining from each and every received impulse two pulses of different polarity, rectifying said two pulses to obtain unidirectional pulses and utilizing each of said rectified pulses to create a potential charge, and accumulating successive potential charges to control the speed of the rotating mechanism at the receiving station.

3. In a communication system wherein communication is effected by the transmission of signal impulses from a transmitting station to a receiving station, each of said stations having rotating mechanism, the method of maintaining synchronism between the rotating mechanisms at both stations which includes receiving the transmitted impulses, generating from each impulse four pulses, two of one polarity at the inception of the pulses and two of a different polarity at the cessation of said impulse, rectifying all four of said pulses to obtain unidirectional pulses, and utilizing all of said unidirectional pulses to control the speed of the rotating mechanism at the receiving station.

4. A communication system having, in combination, a transmitter for intelligence bearing signal impulses, a remote receiver for receiving

said impulses and having rotating mechanism thereat, means at said receiver for translating each of said signal impulses into a plurality of pulses, an electron discharge device normally in one condition of electrical stability, means for rectifying each of said pulses to produce unidirectional pulses and for applying said unidirectional pulses to the input electrodes of said device whereby its condition of electrical stability is altered, an output circuit for said electron discharge device comprising a condenser of relatively high capacity and a vacuum tube relay in circuit with said condenser and responsive to a predetermined accumulative charge on said condenser resulting from a plurality of successive changes in the condition of electrical stability of said device for controlling said rotating mechanism.

5. A communication system having, in combination, a transmitter for sending intelligence bearing signal impulses, a remote receiver for receiving said impulses and having rotating mechanism thereat, means at said receiver for translating each of said signal impulses into pulses of different polarity, an electron discharge device normally passing current, means for transforming said pulses to unidirectional pulses and for applying said unidirectional pulses to the input electrodes of said device whereby said device is caused to cease passing current for the duration of said pulse, and means responsive to the change in condition of said electron discharge device for controlling said rotating mechanism.

6. A communication system having, in combination, a transmitter for sending intelligence bearing signal impulses, a remote receiver for receiving said impulses and having rotating mechanism thereat, means at said receiver for translating each of said signal impulses into pulses of different polarity, an electron discharge device normally passing current, means for transforming each of said pulses to unidirectional pulses and for applying said unidirectional pulses to the input electrodes of said device whereby said device ceases to pass current for the duration of said pulse, an output circuit for said device comprising a high resistance, a condenser and a resistance in multiple with said condenser, circuit interrupting means between said condenser and said high resistance in said output circuit for controlling the charge to be deposited on said condenser, said output circuit being arranged to deposit a charge upon said condenser only upon the occurrence of a change in electrical stability of said device simultaneously with the closure of said circuit interrupting means, and a vacuum tube relay in circuit with said condenser and responsive to an accumulated charge thereon for controlling said rotating mechanism, said circuit interrupting means being under control of said rotating mechanism.

7. A telegraph communication system having, in combination, a transmitter for sending intelligence bearing signal impulses, a remote receiver for receiving said impulses and having rotating mechanism thereat, means including a transformer having a primary and a secondary winding for translating each of said signal impulses into a plurality of pulses of different polarity in said secondary winding, a full wave rectifier connected across said secondary winding for rectifying the pulses generated therein, an electron discharge device in circuit with said full wave rectifier and having its input circuit connected substantially to the center point of said second-

ary winding, said electron discharge device being responsive to the rectified pulses from said full wave rectifier for changing its condition of normal electrical stability, and means responsive to the change in electrical stability of said electron discharge device for controlling said rotating mechanism.

8. A system in accordance with claim 7, characterized in this, that said electron discharge device is a grid controlled glow tube and said means responsive to the change in electrical stability of said device comprises a relay under control of a condenser which is caused to be charged by said device.

9. A system in accordance with claim 7 characterized in this, that said electron discharge device is a multi-electrode vacuum tube normally arranged to pass current and which is biased to cut-off by the occurrence of pulses in said rectifier, and said means responsive to the change in electrical stability of said device is a vacuum tube relay under control of a condenser which is caused to be charged by the change in electrical stability of the device.

10. In a telegraph communication system, the method of maintaining synchronism between distributing mechanisms at two different stations which includes transmitting signal impulses from one of said stations, receiving said signal impulses at the other station, producing from each of said impulses a plurality of other pulses of different polarity, rectifying said last pulses of different polarity to produce unidirectional pulses and controlling the distributing mechanism from said unidirectional pulses.

11. In a radio communication system, the method of maintaining synchronism between rotating mechanisms at two remote stations which includes transmitting over the ether keyed signal impulses from one of said stations, receiving said keyed impulses at the other of said stations, rectifying said impulses, producing from each of said rectified impulses two other pulses of shorter duration than said rectified impulses, rectifying said pulses of shorter duration to produce unidirectional pulses, and utilizing said unidirectional pulses to control the rotating mechanism at the receiving station.

12. In combination, a transformer having a primary winding and a secondary winding, a signal input circuit connected to said primary winding, a full wave rectifier connected across both terminals of said secondary winding, a multi-electrode vacuum tube having a grid, anode, and cathode, the grid of which is connected to the center of said secondary winding, a source of potential connected to said anode through a high resistance, and means for biasing the grid of said tube so that normally there is a flow of current through the high resistance in said anode circuit, the occurrence of signals in said input circuit being arranged to cause said rectifier to pass current for changing the bias of said grid, whereby there is obtained a momentary cessation of current in the anode circuit of said tube, and means connected to said resistance for utilizing the change of electrical stability of said tube.

13. In a communication system, a receiving station having, in combination, rotating mechanism, a transformer having a primary winding and a secondary winding, a signal input circuit connected to said primary winding, a full wave rectifier connected across both terminals of said secondary winding, a vacuum tube having a grid, anode, and cathode, said grid being connected to

the center of said secondary winding, a source of potential connected to said anode through a high resistance, and means for biasing the grid of said tube so that normally there is a flow of current through the high resistance in said anode circuit, the occurrence of signals in said input circuit being arranged to cause said rectifier to pass current for changing the bias of said grid, whereby there is obtained a momentary cessation of current in the anode circuit of said tube, a synchronization circuit responsive to repeated changes of current in said tube for controlling said rotating mechanism, and a circuit interrupter controlled by said rotating mechanism located between said synchronization circuit and said tube, said interrupter having two contacts one of which is directly connected to the anode end of said high resistance and the other of which is connected to said synchronization circuit.

14. A system in accordance with claim 13, including a transformer for inductively coupling said last contact on said interrupter to said synchronization circuit.

15. A telegraph communication system having, in combination, a transmitter for sending intelligence bearing signal impulses, a remote receiver for receiving said impulses and having rotating mechanism thereat, means including a transformer having a primary and two secondary windings for translating each of said signal impulses into a plurality of pulses of different polarities, a full wave rectifier connected across each secondary winding for rectifying the pulses generated therein, an electric discharge device having two degrees of electrical stability in circuit with each of said full wave rectifiers and being responsive to the rectified pulses for changing its condition of normal electrical stability, and means responsive to the changes in electrical stability of said electric discharge devices for controlling said rotating mechanism.

16. In a communication system wherein communication is effected by the transmission of signal impulses from a transmitting station to a receiving station, each of said stations having rotating mechanism, the method of maintaining synchronism between the rotating mechanisms at both stations which includes receiving the transmitted impulses, generating from each impulse four pulses, two at the inception of the impulse and two at the cessation of said impulse, rectifying all four of said pulses to obtain unidirectional pulses, and utilizing all of said unidirectional pulses to control the speed of the rotating mechanism at the receiving station.

17. A system for correcting slight departures from synchronization between a rotating receiving device and incoming signal impulses, comprising an electron discharge device responsive to the incoming signals operating in combination with said rotating device to produce incremental impulses, the operating path of said electron discharge device being dependent upon the forward or rearward departure of said device from synchronization, capacity storing means for storing the incremental impulses received over a time interval, means for insulating said storing means from said electron discharge device while permitting the passage of said incremental impulses thereto, when a slight departure in phase relation occurs, and means for utilizing the resulting charge stored during any interval, to correct the speed of said rotating device.

18. A system for correcting slight departures from synchronization between a rotary receiving device and incoming signal impulses, comprising an instrumentality responsive to the incoming signals operating in conjunction with said rotating device to produce incremental impulses dependent upon the forward or rearward departure of said device from synchronization, capacity storing means for storing the incremental impulses received over a time interval, full wave rectifier means for insulating said storing means from said instrumentality while permitting the passage of said incremental impulses thereto when a slight departure in phase relation occurs, and means for utilizing the resulting charge stored during any interval to correct the speed of said rotary device.

19. A system for synchronizing a rotary receiving device for incoming signal impulses, which comprises an instrumentality responsive to incoming signals operating in cooperation with mechanically moving parts to produce incremental positive impulses when there is a departure in phase relation between said rotary receiving device and said signal impulses, capacity storing means arranged to receive said incremental impulses, an ionizable gaseous medium insulating said storing means but permitting the passage of said incremental impulses thereto when a departure in phase relation occurs, and means including a correcting circuit for utilizing the resulting varying potentials of said capacity means to vary the speed of said rotary device in accordance with the frequency of the incoming signal impulses.

RICHARD E. MATHES.