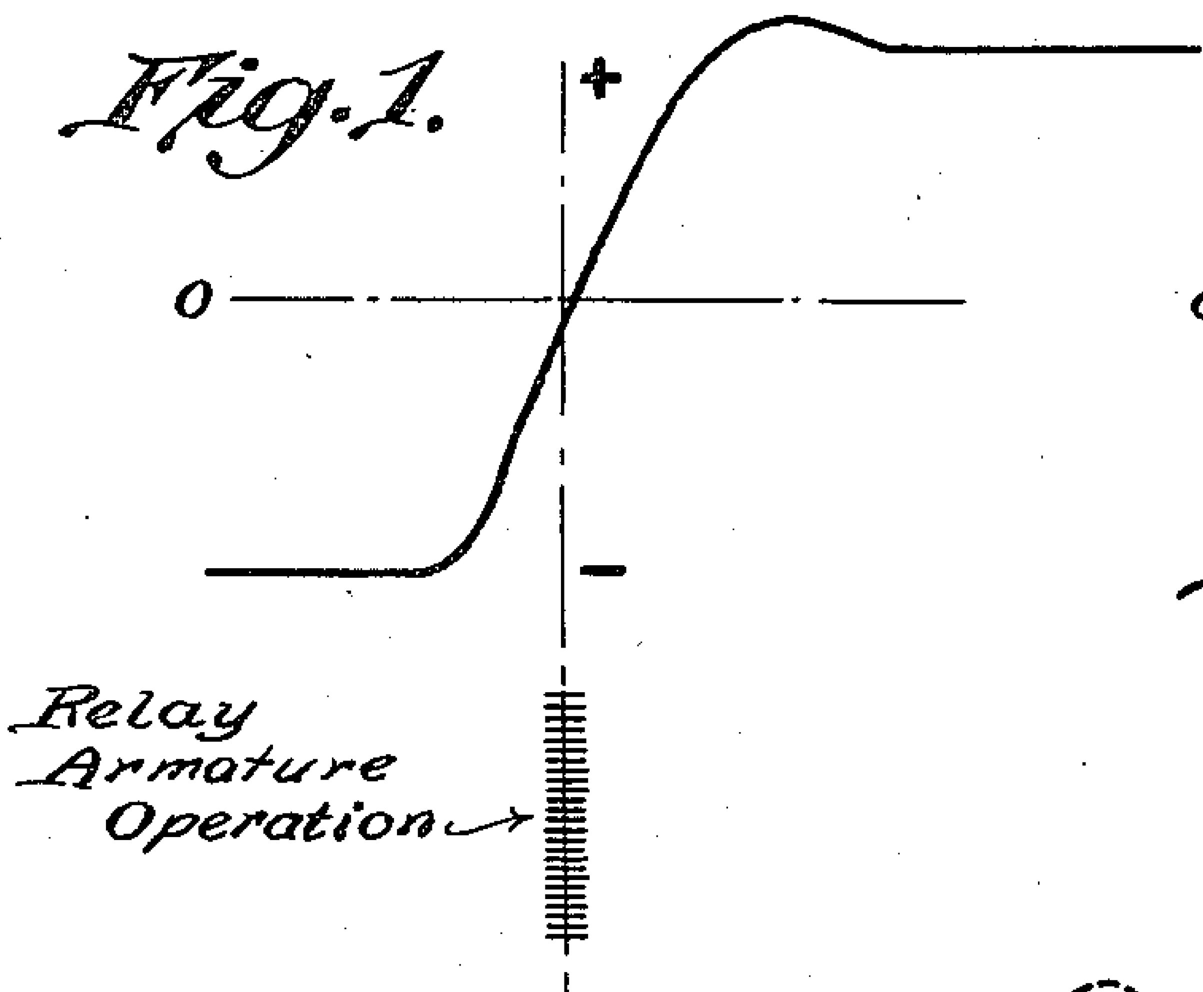
Sept. 1, 1936. G. L. ERICKSON ET AL 2,053,025

SYNCHRONIZING SYSTEM

Filed May 21, 1934 2 Sheets-Sheet 1

Fig. 1.



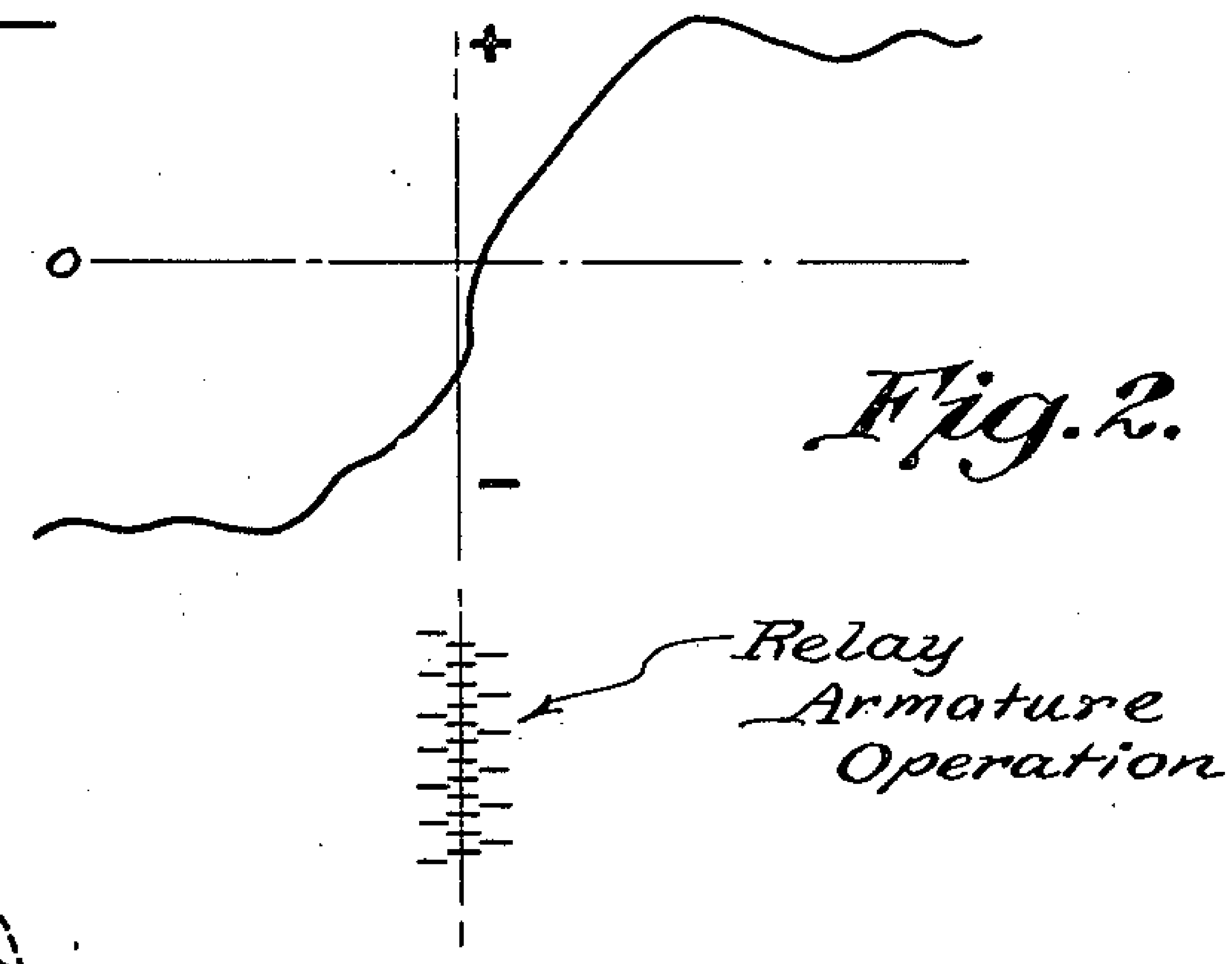


Fig. 2.

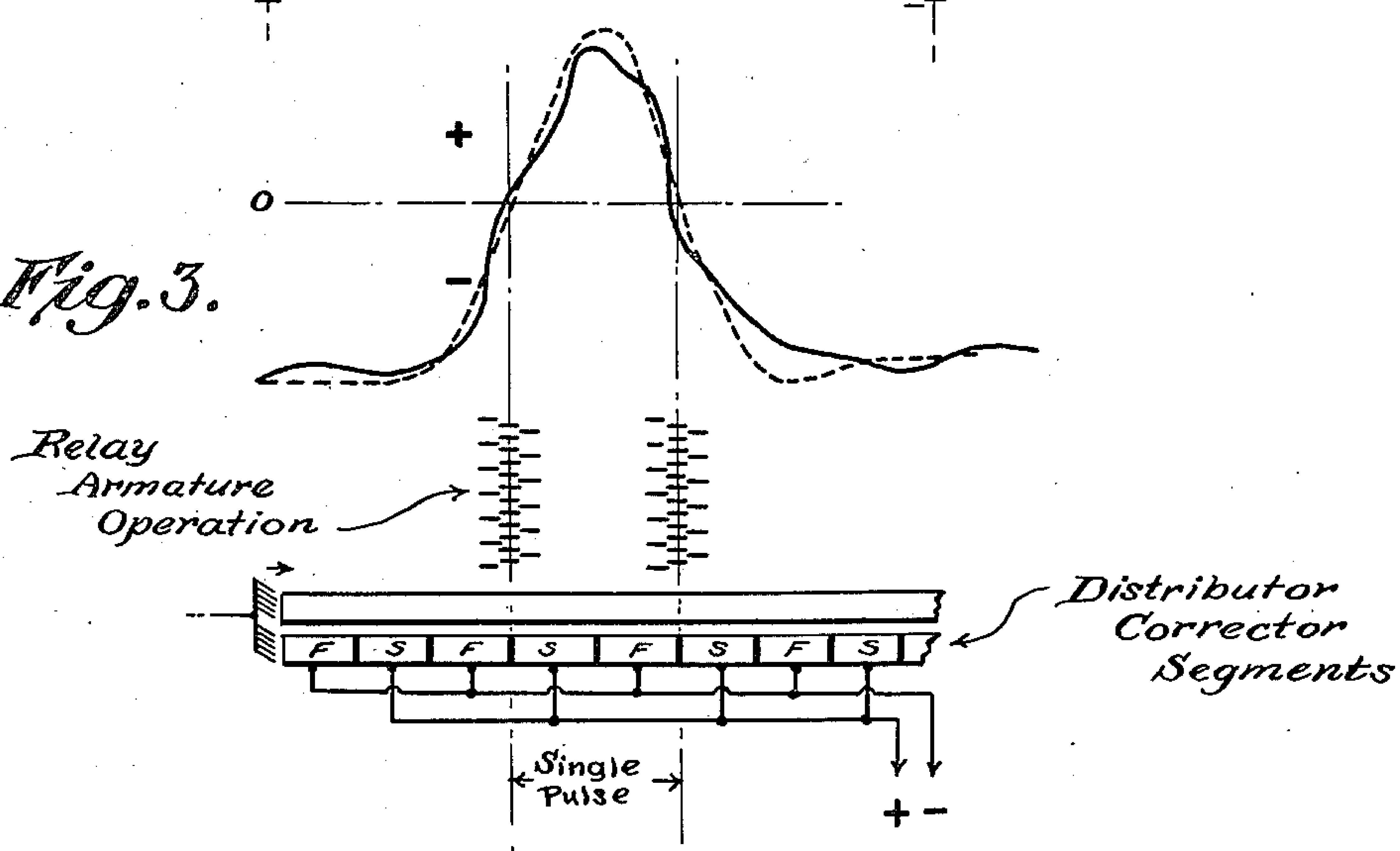


Fig. 3.

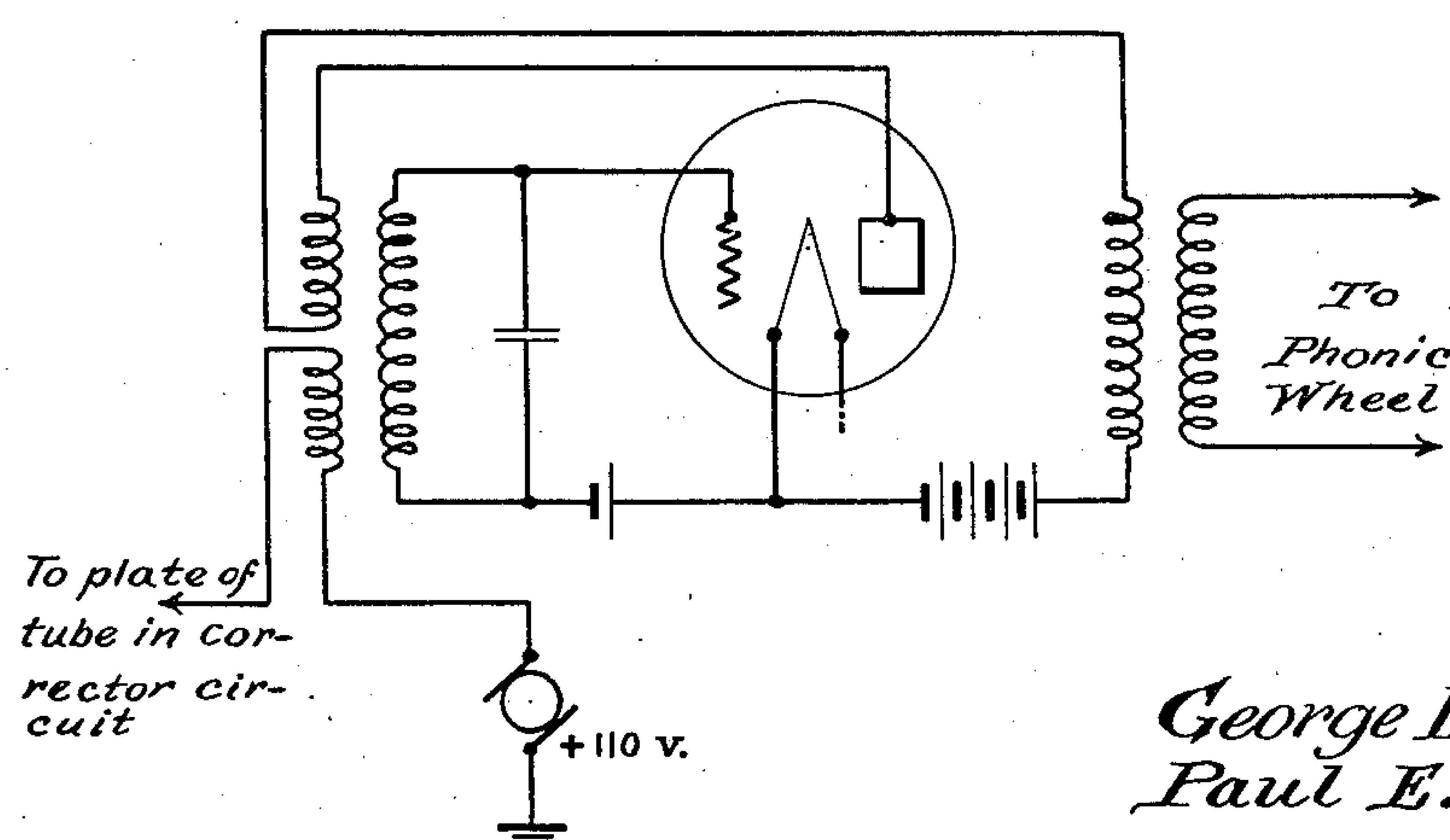


Fig. 6.

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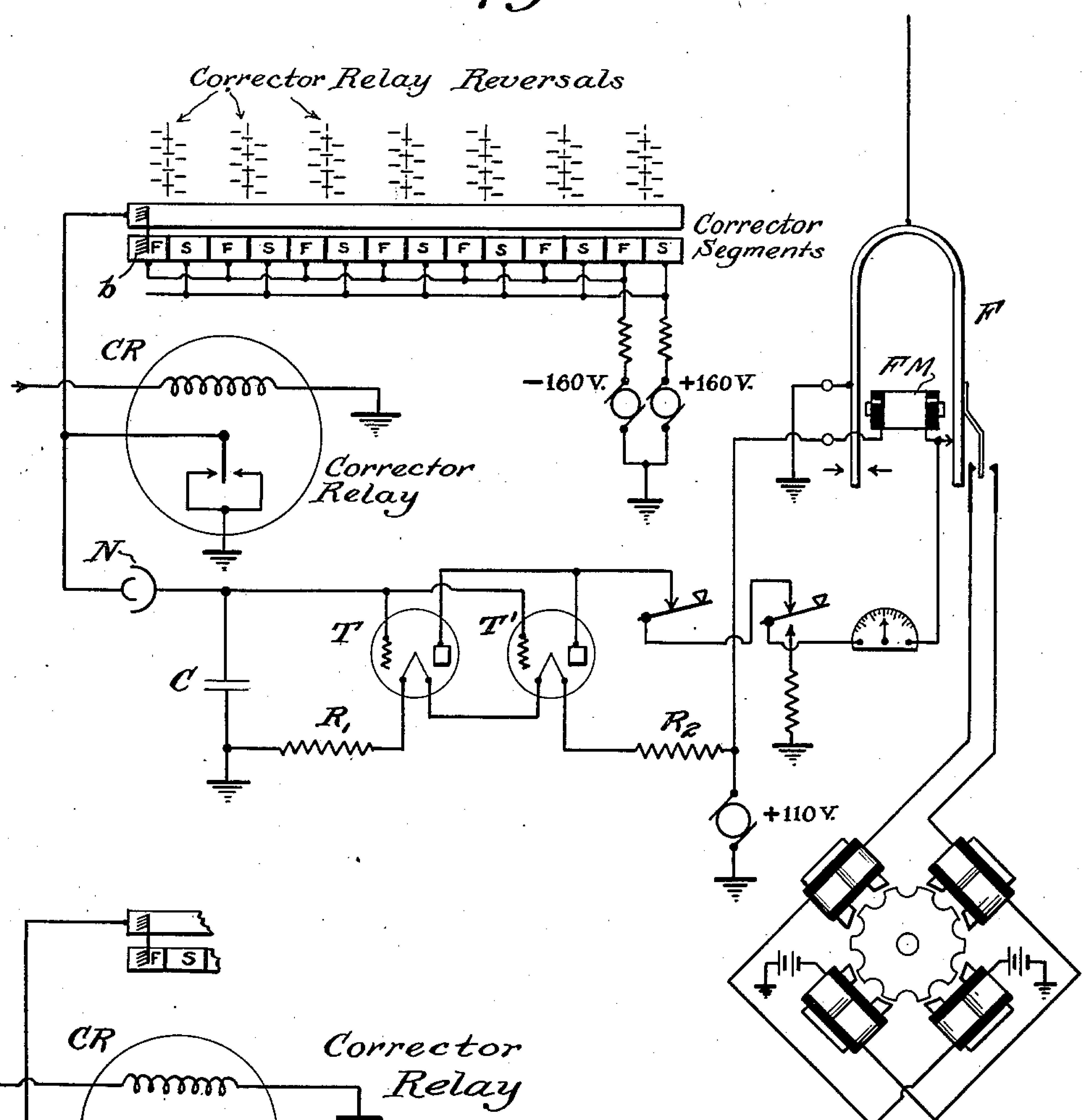
Fig. 4.



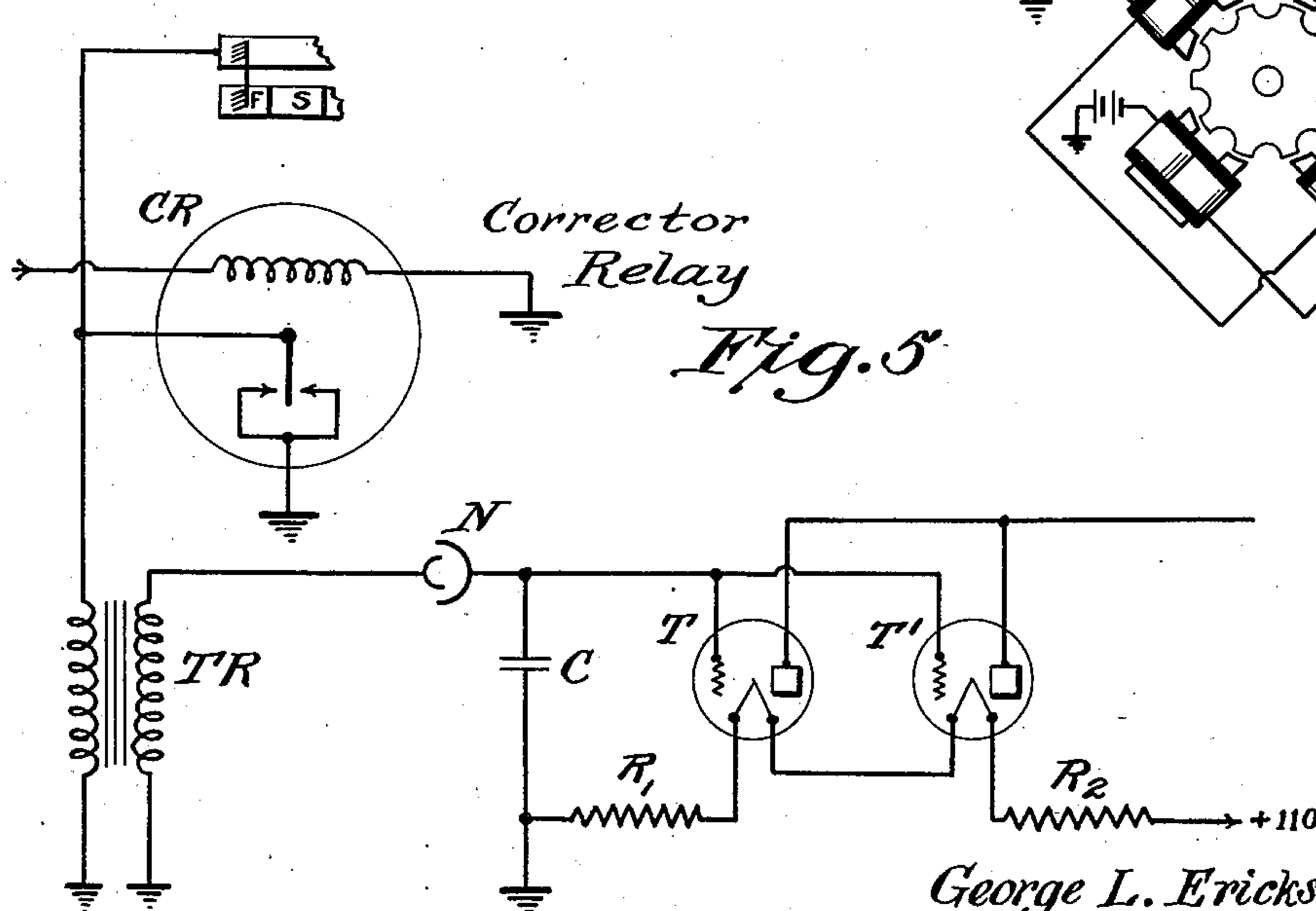


Fig. 5

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SYNCHRONIZING SYSTEM

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Application May 21, 1934, Serial No. 726,730

4 Claims. (Cl. 178—53)

This invention relates to synchronous communication systems and is particularly adapted for high speed printing telegraph systems.

The main object of the invention is to accurately maintain synchronism between the transmitting and receiving apparatus by employing thermionic tubes in the control circuit of the driving fork or constant frequency source employed to drive the distributor and continuously deriving from the received signal impulses correction components in either direction which are applied to the tubes, to thereby supply a correction component to the natural period of the driving fork.

In order to apply the correcting components to the control circuit, a relay, when operated by signaling impulses transmitted over the line, serves in conjunction with the correcting segments of the distributor to furnish a correcting impulse upon a storing condenser with every small departure from synchronism in either direction, and these reversals are continuously averaged in a manner to apply a component of speed to the driving motor which is some function of the phase displacement of the brushes of the distributor.

This and other features of the invention will be clearly understood from the following description in connection with the accompanying drawings in which—

Figures 1, 2 and 3 are diagrammatic illustrations employed to explain certain underlying principles of our invention;

Figure 4 is a circuit diagram illustrating one embodiment of the invention;

Figures 5 and 6 are diagrams illustrating modifications of our invention.

Figure 1 illustrates a typical transient current reversal received at the end of a telegraph line. A polar relay connected to receive the signal impulses will operate its armature very nearly at the instant at which the current wave crosses the zero axis. If successive current reversals of this type are received over a circuit free from distortion or extraneous interference, the relay armature will operate at precisely the same point on each current reversal as indicated in Fig. 1.

When the relay is connected to an actual circuit however, the received current impulse has superposed upon it, various disturbances due to interference currents which distort the wave shape somewhat as indicated in Fig. 2. Due to this distortion, the current reversals in the signal impulses do not recur at the same uniform periods and hence the operations of the relay armature occur at somewhat irregular intervals as indicated in Fig. 2.

We have shown in Fig. 3 a single current impulse such as received over a circuit distorted by interference, and have indicated below the irregular manner in which the relay armature operates when receiving distorted current waves of this type. The dotted curve passing through the distorted current wave indicates the transient that would be received if no interference were present.

The corrector rings of the receiving distributor are shown in the lower part of the figure and as indicated, if the speed of the receiving distributor is in exact synchronism with the received current impulse, the relay armature will operate at the instant the distributor brush is crossing the insulation between two segments and hence no correction would occur.

Our correcting arrangement disclosed herein maintains synchronism between the receiving distributor and the sending distributor at distant points on a telegraph circuit by applying a correction component to the natural period of oscillation of a driving fork or constant frequency source used to drive the distributor, thereby causing the receiving distributor to operate exactly in phase with the sending distributor. The corrector brush indicated in Fig. 3 is connected in a correction circuit in the manner indicated in Fig. 4, which illustrates one embodiment of our invention.

The corrector rings and rotating brush *b* of the distributor operate in conjunction with the polar correcting relay CR which responds to the received signals to deliver a small incremental pulse to a condenser C for every operation of the relay armature. The polarity of this incremental pulse will depend upon the particular corrector segment over which the brush happens to be passing at the instant the relay armature is operated. The alternate segments are marked F and S respectively to indicate the fast or slow correction component which is transmitted to the correction circuit. The operation of the relay armature due to current reversals which occur when the brush is passing over the "fast" segments F, result in negative polarity incremental pulses while those which occur when the brush is passing over "slow" segments S, result in positive incremental pulses. These short correcting pulses occur at the instant the relay armature is passing across the gap from one contact to the other.

The incremental correcting impulses are employed to charge the condenser C. In order that the condenser may function as an accumulator to continually average the received incremental charges and exercise a constant governing action upon the amplifier tube or tubes of the correcting circuit, we interpose a neon tube N between the condenser and the corrector segments. This completely isolates the condenser and thus conserves its charge during the interval between successive incremental pulses.

It is evident that when the condenser receives an equal number of positive and negative incremental pulses per unit of time, its potential will not change. When, however, a preponderance of positive or negative impulses is received, the potential across the condenser is either added to or subtracted from the normal grid biasing potential determined by the drop across the resistances R_1 and R_2. It will be evident that when the relation between the speed of the brush *b* and the corrector relay reversals is as indicated in Fig. 1, the condenser will receive an equal number of positive and negative incremental pulses per unit of time. If, however, the speed of the brush *b* should begin to increase with respect to the signal reversals, a greater number of relay operations would occur when the brush is passing over the segments marked S and fewer when the brush is passing over the segments marked F. Consequently the grid side of the condenser C will become more positive, thus reducing the effective grid bias potential on the tubes T, T' and causing the plate current to increase. The plate current of the amplifier tubes flowing through the fork magnet M produces a damping effect upon the driving fork F. This tends to reduce the frequency of the fork and hence slows the speed of the phonic motor PM which rotates the distributor brushes until synchronism is again established. Likewise if the speed of the brush *b* should tend to decrease with respect to the current reversals, a greater number of relay operations would occur when the brush is passing over the segments marked F, thus impressing a preponderance of negative incremental pulses upon the grid side of the condenser and correspondingly reducing the plate current of the amplifier tubes. The effect of this, of course, is to reduce the damping effect of the magnet FM, resulting in an increase in the fork frequency with a corresponding increase in speed of the phonic motor. Synchronism will be established at a point where the condenser receives just enough excess incremental charges of the proper polarity per unit of time to maintain the plate current of the tubes at the proper value for exact synchronism of the sending and receiving distributors.

In the modification shown in Fig. 5 we have interposed a transformer TR between the corrector brush and the condenser. This arrangement possesses certain advantages under conditions which require control of the size of the incremental pulses. In the arrangement illustrated in Fig. 4, the time duration of the pulse is equal to that of the travel time of the relay armature; whereas in the arrangement shown in Fig. 2 the time duration of this incremental pulse can be controlled by varying the resistance and inductance in the transformer primary circuit.

One of the advantages derived from our method of correction is the remarkably small amount of "shift" in the relative position of the receiving distributor brush with relation to the incoming signals when operating near the limits of correction. In all correcting devices a definite variation in speed must occur in order to bring about a correction. In most correcting devices the correction effect is more or less momentary. This action introduces some phase shifting effect between the receiving distributor brush and the received signals and consequently reduces the operating margin. In our correcting arrangement, however, we are able to maintain synchronism within fairly wide limits with a small phase shifting effect.

The arrangement of our correcting circuit is such that the correcting effect is protected against sudden changes such as power induction surges. By employing the high insulation resistance of a neon lamp and the accumulator function of the condenser the grid bias is sustained at its proper value for a considerable length of time. The correcting brush will, therefore, assume and maintain an average midway position between the (F) fast and (S) slow correcting segments. The condenser works through a range approximately of about 25 volts positive to 10 volts negative and its potential is from 5 to 40 volts negative with respect to the cathode.

Unless the relation between the incremental pulses per unit of time and the capacity of the condenser is correct, there will be a tendency to "hunting" of the receiving distributor brush with respect to the received signal reversals. We have found that in order to prevent this hunting action, the effect on the potential across the condenser (E_C) for succeeding incremental pulses of the same polarity should become less and less. This may be accomplished by employing a charging potential (V) which is comparable with the potential across the condenser C. Then as the potential across the condenser becomes large, the magnitude of the incremental charges is reduced, since the potential available to charge the condenser ($V-E_C$) becomes less.

The general principles of our invention may be applied to any driving mechanism which may have its speed corrected by inequality of the incremental pulses applied to a correcting circuit. Thus our corrector arrangement is also applicable to the control of the frequency of an electrical oscillating circuit or any periodic arrangement which is controllable by a direct current component from the plate circuit of our corrector through one of the oscillator coils, thus changing its inductance sufficiently to affect the period of oscillation of the oscillator.

We claim:—

1. A system for correcting slight departures from synchronism 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 of polarities depending upon the forward or rearward departure of said device from synchronism, a capacity storing means for averaging the incremental impulses received over a time interval, means for insulating said storing means while permitting at all times the passage of said incremental impulses thereto, and means for utilizing the resulting charge stored during any interval to correct the speed of said rotary device when a slight departure in phase relation occurs.

2. A system for synchronizing an oscillatory fork with a series of received impulses, which comprises instrumentalities for producing incremental correcting impulses of one polarity or the other depending upon the phase relation of

the fork oscillations and the received impulses, a storing condenser for receiving said incremental impulses, means for insulating said condenser from said instrumentalities while permitting at all times the passage of said incremental impulses, whereby said incremental impulses produce over a time interval an average potential charge stored in said condenser, and means including correcting circuits for utilizing the resulting potential charge to correct any departure in phase relation between the oscillations of the fork and said received impulses.

3. A system for synchronizing an oscillation generator with incoming signal impulses, which comprises an instrumentality responsive to incoming signals operating in cooperation with mechanically moving parts to produce incremental impulses of one or the other polarity depending upon the departure in phase relation between oscillations of said generator and said signal impulses, a capacity storing element arranged to receive said incremental impulses, an ionizable gaseous medium insulating said storing element but permitting at all times the passage of said incremental impulses thereto and means including a correcting circuit for utilizing the resulting varying potentials of said element to vary the frequency of the oscillations of said generator in accordance with the frequency of the incoming signal impulses.

4. A system for correction of phase departure in synchronous apparatus, comprising a rotating receiving device, a relay responsive to incoming signal impulses to produce in conjunction with said rotating device during the travel interval of the relay armature, incremental impulses of one or the other polarity dependent upon the phase relation between the rotating device and the incoming signal impulses for any departure from synchronism, a capacity element for storing said incremental impulses, an ionizable medium permitting at all times the passage of said incremental impulses, the resulting polarity charge upon said storing element operating to correct the speed of said rotating device when a slight departure in phase relation occurs.

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