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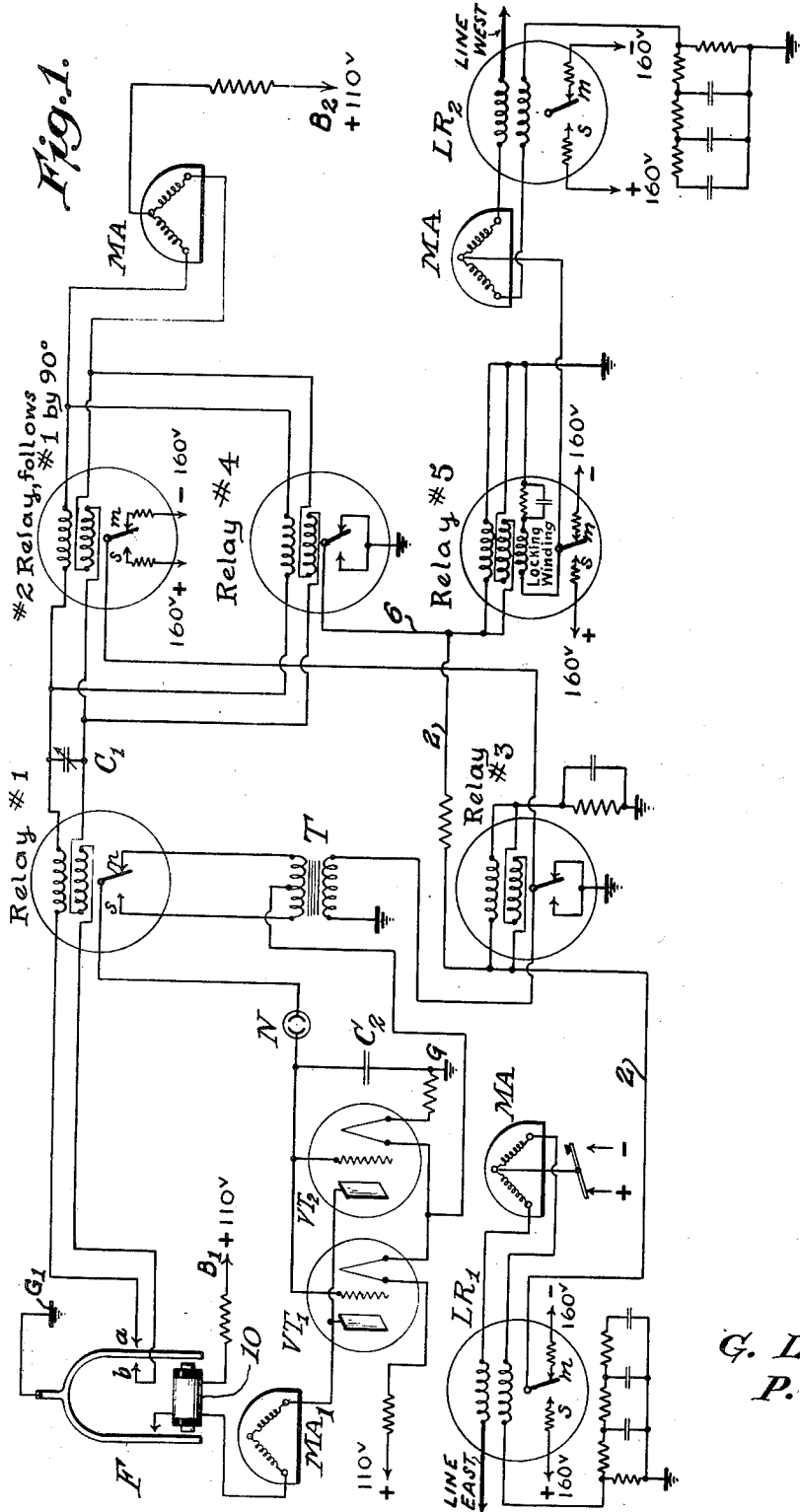
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REGENERATIVE REPEATER FOR TELEGRAPH SYSTEMS

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3 Sheets-Sheet 1



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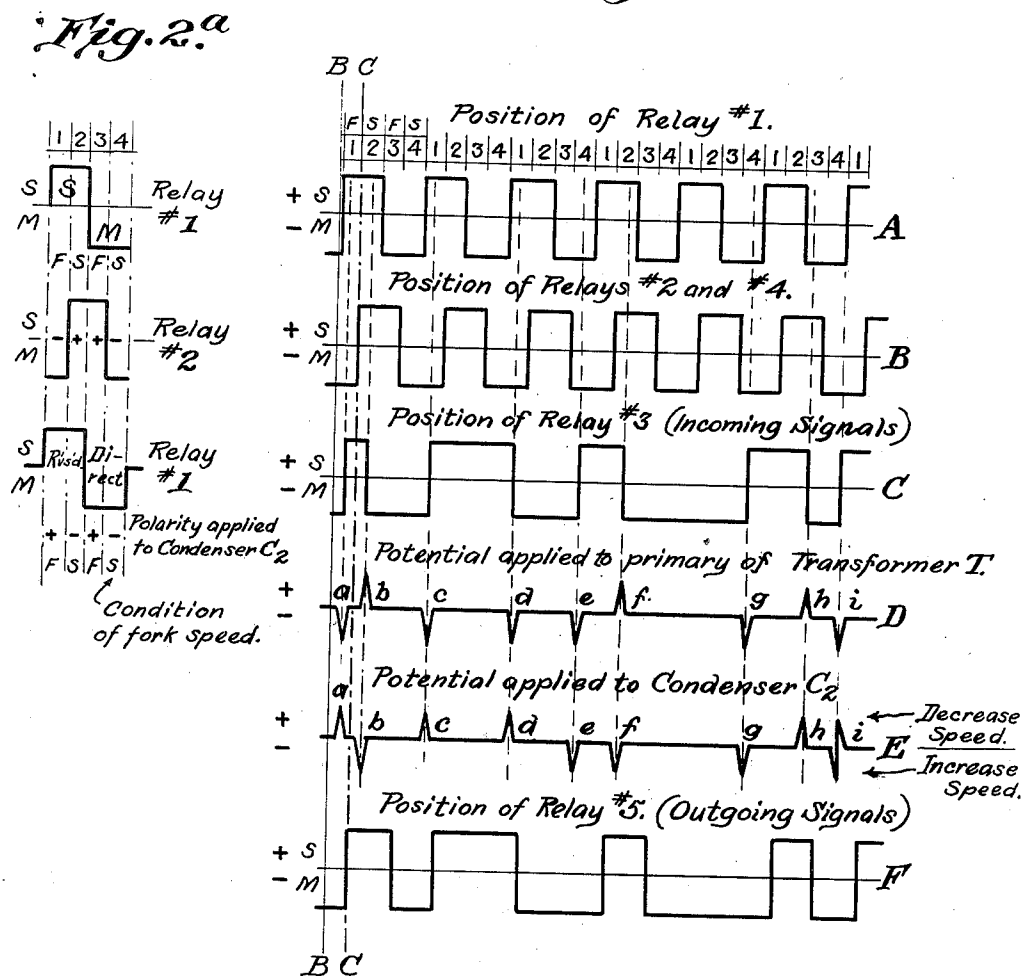
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Fig. 2.



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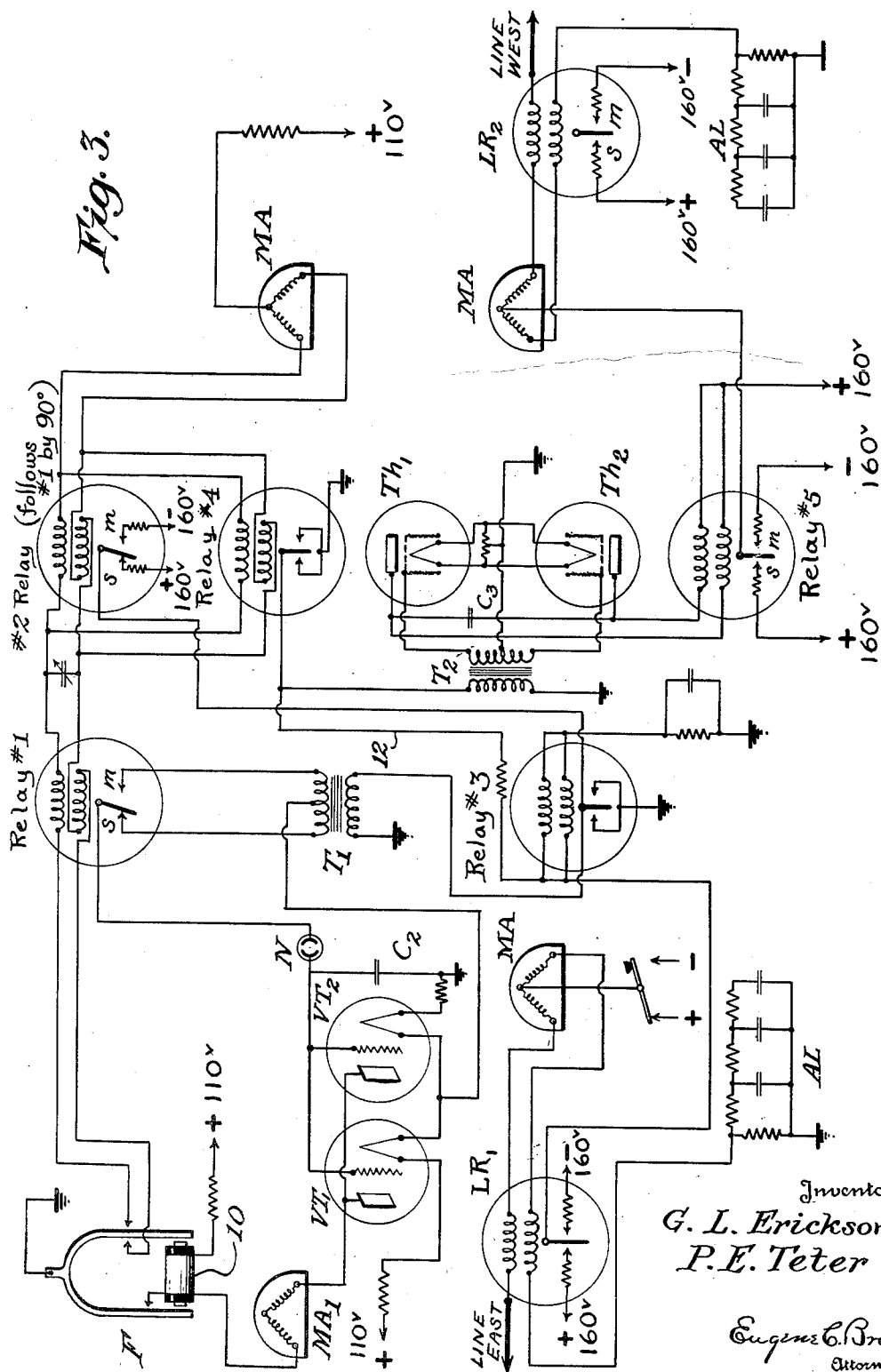
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UNITED STATES PATENT OFFICE

2,179,690

REGENERATIVE REPEATER FOR TELE-
GRAPH SYSTEMS

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10 Claims. (Cl. 178—71)

This invention relates to apparatus for regenerating and repeating telegraph signals received over a cable or telegraph line into another line or cable.

Regenerative telegraph repeaters comprise those repeaters in which a local device is run at a speed synchronous with the frequency of the incoming signals for the purpose of generating fresh signals for resending which will be in step with the originally transmitted signal, thus correcting for distortion.

Regenerative telegraph repeaters comprise two main elements. These are the primary signal repeating system and the synchronizing system. The primary repeating system usually includes the main elements of an ordinary telegraph repeater, with slight modifications. The synchronizing system includes a signal generator which may be a rotary distributor or commutator, a vibrating fork, a vacuum tube oscillator, or other device adapted to generate alternating currents having the frequency of the signaling speed and with a high degree of stability. To maintain the speed of this generator exactly in step with the distant transmitter usually requires a rather complex system of associated apparatus. In the present case a vibrating fork serves for this purpose although the repeater and the synchronizing system may be adapted to operate in conjunction with any other type of generator.

In the following detailed description we shall refer to the accompanying drawings, in which—

Figure 1 is a circuit diagram illustrating the regenerative repeater and the manner in which it functions in a telegraph system.

Figure 2 is a series of diagrams illustrating in detail the timing of the relays with relation to the signal impulses;

Figure 2^a is a series of diagrams to show the relative functioning of the contacts of relays 1 and 2 of the transformer T₁.

Figure 3 is a circuit diagram illustrating another embodiment of the invention.

In Fig. 1 the essential features of the regenerative repeater are shown in association with the primary elements of a conventional type of duplex telegraph arranged for east-west repeating. It can be seen that incoming signals received on the east main line relay LR₁ control the polechanger (relay 5) of the line west for signal repeating. These received signals at the same time control relay 3 for synchronizing purposes while the operation of relay 5 is in turn controlled by relay 4 over conductor 6.

The signal generator and associated synchro-

nizing apparatus comprises the fork F, driven in synchronism with the incoming signals. This fork is maintained in operation by a current which flows from a source B through the driving magnet 10 to the ground at G₁. Some of the magnet current flows continuously to ground through the vacuum tubes VT₁ and VT₂, and thus serves as a variable damping control for the fork. From the fork contacts *a* and *b*, current flows through the windings of relays 1 and 2 to the differential meter MA and thence to the battery or current source B₂. The meter MA is for the purpose of indicating the condition of adjustment of the fork contacts. Relay 1 follows the fork contacts directly and is in phase with the incoming signals, while by means of condenser C₁ relay 2 is caused to lag 90° behind relay 1. Relay 4, connected in parallel with relay 2, determines the instant of operation of relay 5 which is the west main line polechanger. It will be evident that relay 5 repeats signals westward in accordance with the polarity registered by the east line relay LR₁, the moment of reversal however being in step with relay 2. In other words the signals are regenerated and repeated with a 90° lag, in step with relay 2.

It is an essential of telegraph synchronizing systems that means be provided for discerning a departure from synchronism of the local apparatus and also the relative direction of the departure as fast or slow. A common method of doing this is to divide the signal dots (half cycles) as generated by the local generator, into two parts. Should a signal reversal occur during the first part, i. e., immediately following a local reversal, the local generator is fast and should be decelerated. If the signal reversal occurs in the second half, i. e., immediately preceding a local reversal, the local generator is slow and should be accelerated. This process of dividing the signals into slow and fast portions and the creation of appropriate correction pulses is performed by relays 1 and 2.

The function of relays 1 and 2 is to subdivide each signal cycle into four parts or quadrants which may be severally designated as fast or slow, and to generate appropriate correcting pulses depending upon the quadrant in which the incoming signal reversals occur. Such correction pulses are produced at each signal reversal as the tongue of relay 3 travels between its contacts. The correcting pulses are of sufficient voltage to break down the neon tube N, whence they charge the condenser C₂. The successive incremental charges remain isolated on this condenser where

they influence the grid of the tubes VT₁ and VT₂ to control the plate current and thus vary the speed of the fork through small limits.

In order to explain the functioning of relays 1, 2 and 3 to increase or decrease the speed of the fork, for the purpose of maintaining synchronism with the distant transmitter, reference should be made to Fig. 2. In this figure it can be seen that relay 2 lags 90° behind relay 1 and thus serves to divide the contact periods of relay 1 into four parts or quadrants per cycle, as numbered. The line C—C indicates the relative phase positions of the various relays of the system in the condition of repeating a sample signal. The line B—B indicates an initial or starting position in which the contacts of the relays of Fig. 1 are at present arranged. In order to explain the means for selecting the polarity of the fork control pulses so that the fork speed may be increased or decreased to maintain synchronism, reference should be made to Fig. 2a. In this figure the relative functioning of the contacts of relays 1 and 2 and the transformer T₁ are illustrated. It can be seen that during quadrants 1 and 4 the tongue of relay 2 is on its marking, or negative polarity contact, while during quadrants 2 or 3 it is on its spacing, or positive polarity contact. However, the contacts of relay 1 in conjunction with transformer T₁, are arranged to reverse these polarities during its spacing period (quadrants 1 and 2). Thus, finally the potentials applied to condenser C₂ will be positive for quadrants 1 and 3 and negative for quadrants 2 and 4.

Referring now to curve A of Fig. 2, it can be seen that a reversal occurring during quadrants 1 or 3, i. e., immediately following a fork reversal, indicates that the fork speed is fast, while a reversal occurring during quadrants 2 and 4 indicates a slow fork speed. Accordingly, the speed regulating circuit associated with the fork is arranged to supply an increased damping current under the influence of the positive pulses of quadrants 1 and 3, so that the fork speed will be decreased. Conversely, the negative pulses received during quadrants 2 and 4 will serve to increase the speed of the fork.

This orientation of polarities for application to the speed control mechanism of the fork may be further clarified by considering the passage of a series of distorted signals through the repeater. Such signals, illustrated in curve C, through the agency of relay 3, will produce pulses in the primary of transformer T₁, as indicated in curve D. It can be seen that reversals occurring during the marking position of relay 2 produce negative pulses *a*, *c*, *d*, *e*, *g*, *i*, while positive pulses *b*, *f*, *h* are produced when the reversals occur during the spacing position. These pulses are preponderantly negative, although the signals of curve C have not seriously departed from synchronism. In curve E, through the action of the contacts of relay 2 and the transformer T₁ as explained in Fig. 2a, the polarity of these pulses has been reoriented so as to provide an average potential of zero, thus leaving the fork speed unchanged. At *i*, where the reversal occurred in phase with the fork, the pulse was divided evenly into positive and negative portions. In general the incoming signals will not be exactly in step, and a correcting pulse will occur at each reversal. Thus a series of short positive and negative pulses are being continuously supplied to the fork control mechanism as signal reversals occur. So long as the fork and the signals are in synchronism,

these pulses will average to zero over short intervals of time, although momentary signal distortions may occur. Should the fork deviate from synchronism, the pulses will preponderate in one polarity or the other and thus build up an incremental charge on the condenser C₂, which through its control of the damping current will exercise a change in speed in the fork to restore synchronism.

The regenerated signals as repeated to the line west and corresponding to the received signals of curve C are shown in curve F. It will be noted that they are perfect in form and in phase with curve B (relay 2).

In the synchronizing system described herein it is only necessary to select the portion of the signal corresponding to the time consumed in transit by the tongue of relay 3. This period ordinarily constitutes about 15 percent of high speed signals. The magnitude of the correcting pulses should be such as to provide sufficient correcting effect to restore synchronism during the course of wide speed variations. At the same time these pulses should not be so large as to produce appreciable individual effects and thus induce hunting of the fork system. Theoretically the repeater will remain in synchronism and will reproduce perfect signals although the incoming reversals may vary through a range of plus or minus ¼ cycle and this range may be closely approached in practice.

In the foregoing description east-west repeating only has been considered. For west-east repeating the west-east repeating apparatus of the duplex repeater would be employed in the same fashion and, in addition, a second complete synchronizing system would be required, since it is not practicable to maintain the transmissions in the two directions at exactly the same speed. The operation of this second half of the system would be exactly as described with respect to the east-west half.

In the repeater of Fig. 1, the polechanger relay 5 is controlled as to polarity of the repeated signal from the east main line receiving relay LR₁, while the instant of operation is determined by relay 4. A locking winding serves to hold the tongue of this relay on the last operated contact. In Fig. 3, an improvement on this part of the repeater is indicated in which a pair of gaseous tubes TH₁ and TH₂ control the position of relay 5. These tubes are arranged in balanced relation, and provided with a condenser C₃ which, whenever either tube operates, serves to extinguish the opposing tube. Thus the tubes are alternately conductive, whereby relay 5 may be operated to either its marking or spacing contact under the influence of pulses controlled as to polarity from the east receiving relay LR₁ and as to time by relay 4, as in the system previously described in Fig. 1. This system has the advantage of being operable by smaller correcting pulses and thus will maintain synchronism over a wider range of speed variation.

In starting the operation, the regenerative repeater will generally be adjusted approximately in step with the incoming signals. If the local fork speed is too high or too slow, deviation from the normal plate current will appear on the milliammeter MA₁, associated with the correcting tube. The natural speed of the fork should then be adjusted mechanically or otherwise until this current remains approximately normal. Should the initial speed of the fork be essentially correct, it may be placed in phase with the incoming

signals by momentarily opening the circuit of the driving magnet 10 or by other means.

The regenerative repeater described herein overcomes many of the objections of previous repeaters of this type, and has been found to provide a very satisfactory grade of operation for high speed telegraph circuits. As noted, the essential elements of the telegraph repeater remain unchanged, thus permitting the conversion of an ordinary repeater to regenerative operation by the mere addition of this relatively simple synchronizing system along with its control of outgoing transmission.

We claim:

1. In a telegraph system, a regenerative repeater, comprising a relay responsive to received signals, an oscillatory means having a control coil, means under control of said oscillatory means for locally generating uniform impulses in phase with the received signals and in quadrature thereto, an instrumentality responsive to the incoming signals and operating in conjunction with said locally generated impulses in quadrature to produce incremental correcting polarities, depending upon the forward or rearward departure of the said oscillatory means from synchronism with the received signals, a condenser subjected to said incremental polarities, a thermionic tube having its grid connected to said condenser, and means for applying the varying currents in the output circuit of the tube to said control coil.

2. In a telegraph system, a regenerative repeater, comprising a relay responsive to received signal impulses, an oscillatory fork operating in substantial synchronism with said impulses, means for locally generating uniform impulses in quadrature with each other under the control of said fork, means controlled by the phase relation of the received signal impulses to the locally generated impulses to synchronize the fork with the received signal impulses, a retransmitting and regenerating relay, and means controlled by said fork to subject said last named relay to the mid-portion of said received signal impulses.

3. In a telegraph system, a regenerative repeater, comprising means for locally producing simultaneously impulses in quadrature with each other and in synchronism with the received signals, a pair of relays responsive respectively to said impulses in quadrature, an instrumentality responsive to the received signals and operating in conjunction with said relays to maintain said quadrature impulses in synchronism with the received signals, a repeating relay operating to transmit regenerated impulses, and means to subject said repeating relay to the received signals at the substantial mean center of the signals.

4. In a telegraph system, a regenerative repeater comprising means to locally produce simultaneously impulses in phase with the received signals and impulses in quadrature thereto, a pair of relays responsive respectively to said impulses in quadrature, an instrumentality responsive to the received signals and operating in conjunction with said relays to maintain said locally produced impulses in synchronism with the received signals, a repeating relay operating to transmit regenerated impulses, and a third relay actuated by said quadrature impulses and operating to sub-

ject said repeating relay to the received signals during the travel time of its armature between its contacts.

5. An organization as set forth in claim 3 and means to prolong each operation of the repeating relay.

6. In a telegraph system, apparatus for regenerating and repeating received signals, comprising a relay responsive to the received signals, an oscillatory fork provided with a control coil and having a period equal to the frequency of the line signals, means controlled by the fork for locally producing impulses in phase with the received signals and impulses in quadrature therewith, a thermionic tube having its output circuit connected to said fork coil, a condenser connected to the grid of the tube, a pair of relays responsive respectively to said locally produced impulses in phase and in quadrature with the received signals, a synchronizing circuit arrangement interconnecting said several relays and operating to deliver incremental charges to said condenser which are of increasingly positive polarity or increasingly negative polarity depending upon whether more line signal reversals occur when the armatures of said pair of relays are on like contacts or when said armatures are on unlike contacts.

7. In apparatus as set forth in claim 6 a repeating relay operating to transmit regenerated impulses and means to subject said repeating relay to the received signals at the substantial mean center of the signals.

8. In apparatus as set forth in claim 6, a repeating relay operating to transmit regenerated impulses and a timing relay actuated by said locally produced impulses in quadrature to the received signals operating to subject said repeating relay to the received signals during the travel time of its armature between its contacts.

9. In a telegraph system, apparatus for regenerating and repeating received signals, comprising a signal responsive device, means for locally producing impulses in synchronism with the received signals and which are in quadrature with each other, electro-responsive means actuated, respectively by said impulses, an instrumentality responsive to the received signals and operating in conjunction with said electro-responsive means to maintain said locally produced impulses in synchronism with the received signals, a repeating device operating to transmit regenerated impulses and means to subject said repeating device to the received signals at the substantial mean center of the signals.

10. In a telegraph system, an organization for regenerating and repeating received signals, comprising means for locally producing impulses in synchronism with the received signals and which are in quadrature with each other, an instrumentality operating in response to the conjoint action of said quadrature impulses and the received signals, to correct any deviation of said means from synchronism with the received signals, a repeating device operating to transmit regenerated impulses and means to subject said repeating device to the received signals at the substantial mean center of the signals.

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