June 12, 1928. 1,673,726

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REGENERATIVE TELEGRAPH REPEATER

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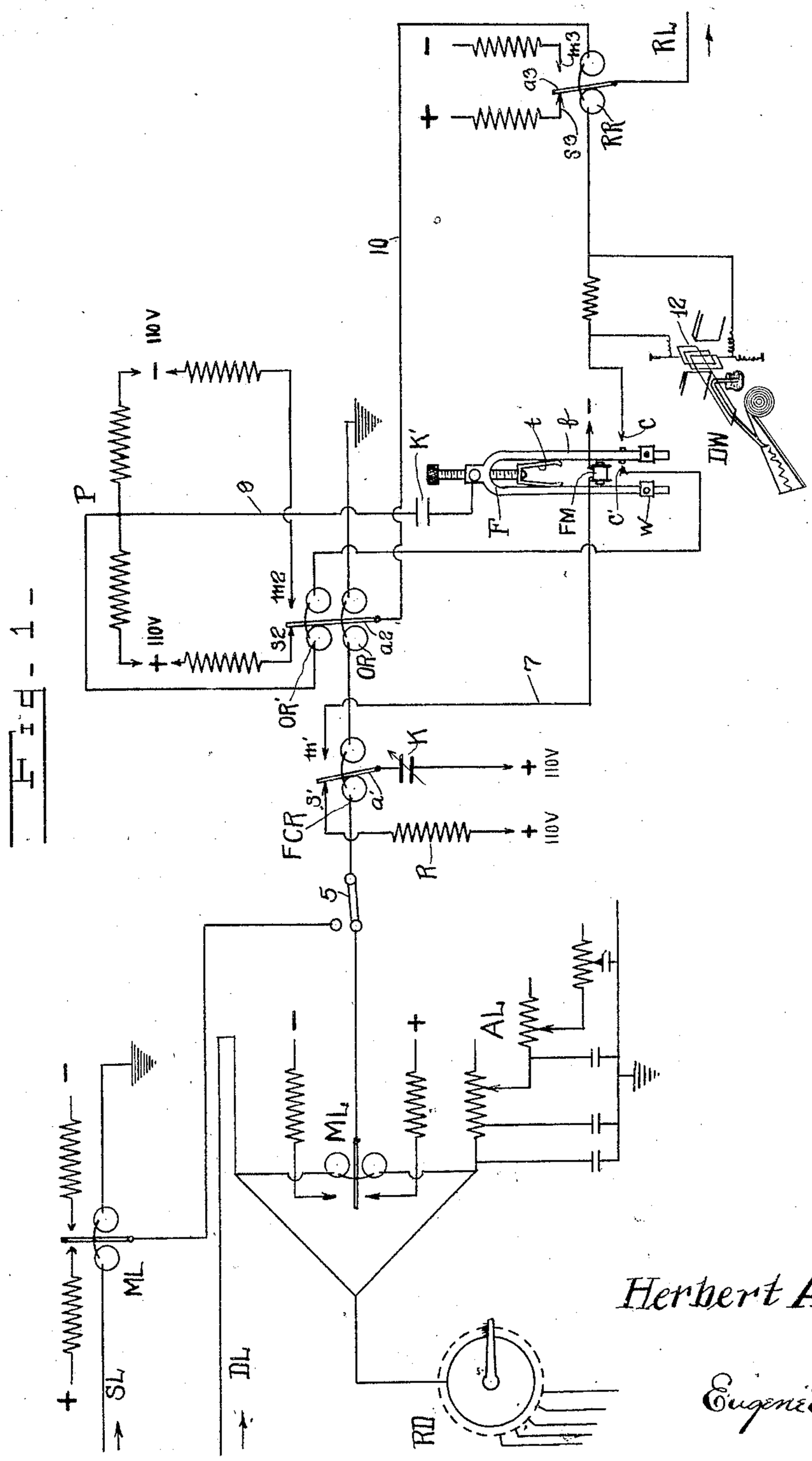

Fig. 1

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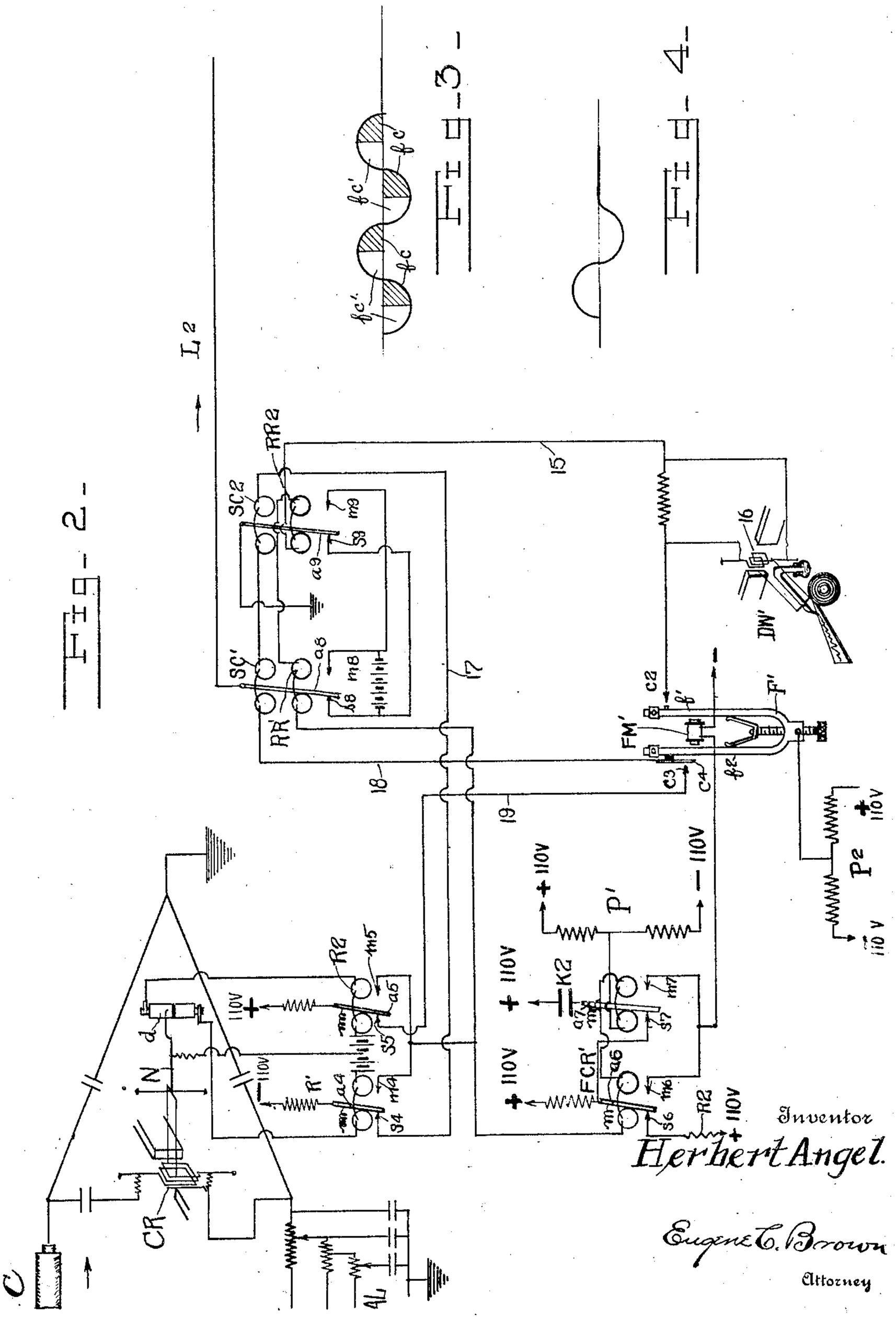

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UNITED STATES PATENT OFFICE.

HERBERT ANGEL, OF BROOKLYN, NEW YORK, ASSIGNOR TO THE WESTERN UNION TELEGRAPH COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

REGENERATIVE TELEGRAPH REPEATER.

Application filed April 14, 1924. Serial No, 706,598.

This invention relates to telegraph systems employing synchronized transmitters and receivers and pertains more especially to regenerating means for the receiving and retransmission of the signals. The main purpose of my invention is to provide a reliable means, free from any complicated mechanism, for regenerating and re-forming the received signals and transmitting to the succeeding line section or cable correctly shaped signals greatly augmented in strength.

As is known by telegraph engineers, signal impulses received over a cable or over a long land line are very much attenuated and are usually quite distorted from the original impulse. In order to regenerate and reconstruct the signal impulses to their original shape it is necessary that the repeater shall be capable of selecting only the best portion of the received signal. To accomplish this purpose I employ a tuning fork which is maintained in vibration by the direct action of the received signal impulses, the fork being tuned to vibrate in synchronism with said impulses but at twice the frequency of the transmitted signals, and the fork in turn picks off at regular intervals the desired portions of the signals and sets them up in a relay circuit which in turn repeats them into the succeeding line section.

In the following description I shall refer to the accompanying drawings in which—Figure 1 is a diagram showing an embodiment of my invention especially adapted for land lines; Fig. 2 is a diagram showing the same as arranged for cable operation: and Figs. 3 and 4, are diagrams explanatory of signal impulses.

In Fig. 1 I have shown the arrangement of apparatus at a repeater station connecting sections of a land line. The incoming section from which the signals are received may be a simplex line, as indicated at SL or a duplex line as indicated at DL, there repeater being connected to one or the other main line relay ML by a switch 5. The terminal of the duplex line at the repeater station is shown in the usual conventional manner, the artificial line being indicated at AL. It is to be understood that the transmitting station at the distant end of the lines SL and DL are provided with automatic transmitters which operate synchronously with corresponding automatic receiving apparatus at the distant end of the other line section RL. I have indicated conventionally at RD such a synchronously operated apparatus of the well known rotary distributer type usually driven by a La Cour motor. This apparatus is familiar to telegraph operators and engineers and is described in standard text books on telegraphy and in various patents, such as U. S. patents to Yorke & Benjamin No. 1,215,605 and Benjamin No. 1,447,747.

The repeater set includes three relays, i. e., the fork control relay FCR, the operating relay OR and the repeating and regenerating relay RR. The reed or fork F is set into vibration and maintained by periodic pulls exerted by the fork magnet FM as the fork control relay responds to the incoming signals. A recording instrument, which is indicated conventionally as the usual undulator or direct writer DW, is inserted in the local circuit of the repeating relay to check up the reconstructed signals regenerated under the control of the vibrating fork.

The positive and negative signal impulses received over the line SL or the line DL, energize the relays FCR and OR. If a positive impulse is received, the relay armatures a' and a^2 swing over against their marking contacts m and if a negative impulse is received the armatures are urged toward their left-hand or spacing contacts s. When the armature a' moves against its marking contact, a charging current flows into condenser K, flowing through the circuit from plus battery, through condenser K, armature a', contact m', conductor 7, fork magnet FM to minus battery, thereby imparting a momentary impulse to magnet FM, which exerts a sudden pull or jerk on the tines of the fork F and sets them in vibration. As previously noted, the fork has been adjusted by means of the weights w, or the tension spring t, to vibrate in synchronism with the impulses sent out by the transmitter at the sending station but at twice the rate of current reversals or signal impulses. The fork will continue to vibrate and will receive a pull or jerk as each marking impulse is received, these jolts or sudden pulls exerted by the magnet FM not only serving to maintain the vibration of the fork but also keeping it in exact phase with the received sig-

nals. When the tongue or armature a' is next moved against its spacing contact s', the charge on the condenser K is discharged by the resistance R.

The operating relay OR was energized sumultaneously with the fork control relay and its armature a^2 was moved against its marking contact m^2. During the first half of the signal impulse the tine f of the fork moved against the contact c', but as it vibrates at twice the rate of speed as the alternations of the signal impulses, the tine will contact with the contact c, during the second half of this signal impulse, thereby closing a circuit from positive side of potentiometer P, through conductor 9, condenser K', fork F, contact c, recorder DW, repeating relay RR, conductor 10, armature a^2 and contact m^2 of relay OR, to minus battery. The condenser current flowing through this circuit actuates the repeating relay and throws its armature a^3 to the marking side, thereby repeating the received signal impulse into the next section RL of the line. During the next succeeding swing or half vibration of the fork the condenser K' discharges through the auxiliary coils OR', of the relay OR. This discharge is timed by the fork so that the coils OR' assist the main coils of the relay OR to move its armature a^2 over against its spacing contact s^2 upon the next reversal of line current. In case of block signals being received by the relay OR, the discharge of condenser K' through the auxiliary coils OR' prepares the condenser to receive another charging current from the current source associated with potentiometer P upon the next outward swing of the fork tine closing the contact at c. In this manner the separate impulses of the character which make up the block signal will be interpolated and sent into the transmitting relay RR. I have indicated in Fig. 3, that the fork closes contact at fc during one half of each signal impulse and at fc' during the other half of each impulse. It is understood, of course, that the signals do not reverse in polarity at each impulse as shown in Fig. 3, but only in accordance with the plus and minus impulses of the code characters being transmitted.

The operation of the repeater apparatus will now be understood by telegraph engineers. Assume that reversals are being sent over the line SL or DL in accordance with the message signals. The signal impulses will be received by the relays FCR and OR and the fork F will vibrate in synchronism but at twice the speed of the signal impulses, being maintained in operation and in proper phase by the successive pulls of the magnet FM as the armature a' of the fork control relay engages its contact m' at each recurring marking signal.

The repeating relay RR is energized as the fork tine f swings outwardly and contacts at c, the circuit extending from minus battery through contact m^2, armature a^2 of the relay OR, repeating relay RR, coil 12 of the recorder DW, contact c, tine f of the fork, condenser K', conductor 9 to potentiometer P. At the next inward swing the tine f engages the contact c' and discharges the condenser K' through the auxiliary coils OR' of the relay OR, and as this occurs during the first half of the next succeeding signal impulse, it will assist a reverse current in moving the armature a^2 over to the spacing contact s^2. As indicated in Fig. 3, the tine f engages contact c' during the first half or unshaded portion of each signal impulse and the contact c during the latter half or shaded portion of each impulse. Consequently the repeating relay is not energized until the signal impulse has reached its mid-portion, which is the steadiest part of the current wave. The phase of the fork vibration may be varied with relation to the received signal impulses by adjusting the variable condenser K. Inasmuch as the vibrations of the fork are practically constant, it is obvious that the portions of the signal impulses selected by the vibrating fork and transmitted to the relay RR at the instant the tine f engages contact c, will recur at equal intervals and consequently the regenerated signal impulses repeated into the next line section RL will be properly re-formed and of the desired strength.

In Fig. 2 I have illustrated my repeater operating to repeat signals received from an ocean cable. In principle the repeater operates in the same manner as for land line operation but the circuit arrangements are modified somewhat to meet the requirements of ocean cable operation. It is to be understood that the transmitter at the distance end of the cable c and the receiver at the distant end of the line L^2, are operated in synchronism. It is also to be noted that the cable code employed is made up of positive, negative and zero impulses. As usual, the movements of the coil of the cable relay CR cause its pointer needle N to swing over one or the other portion of the drum d, thereby energizing either the dot relay R' or the dash relay R^2, and these in turn operate the fork control dot relay FCR' and fork control dash relay FCR^2.

The operation of this arrangement will now be understood. To illustrate, assume that the letter A followed by a space or zero impulse is received over the cable. These three impulses, i. e., positive, negative and zero are illustrated in Fig. 4. Assume that the fork is vibrating in proper phase relation with the received signals. The armature a^4 of the dot relay R' swings to its marking contact m^4, sending a current from minus battery through the coils of the fork

control relays to potentiometer P′ and thereby causes the armature a^6 of dot control relay FCR′ to move over to its right hand or marking contact m^6. This causes the fork magnet FM′ to exert a momentary pull on the tines f', f^2, by charging the condenser K^2 through the circuit from positive battery through condenser K^2, armature a^7, contact s^7, armature a^6, contact m^6 and magnet FM′ to minus battery. As the armature a^6, swings back to its spacing contact s^6, condenser K^2 is discharged by resistance R^2.

When tine f' of the fork engages contact c^2, the dot repeating relay RR′ is operated over a circuit from minus battery armature a^4 of relay R′, contact m^4, main coils of relays RR′ and RR^2, conductor 15, actuating coil 16 of recorder DW′ contact c^2, tine f' to potentiometer P^2. As the armature a^8 engages its marking contact m^8, a regenerated and re-formed dot impulse is sent into the line L^2. The dot repeating relay will remain on its marking contact until the dash signal is received.

The dash signal in the letter A follows immedaitely as an impulse of reversed sign or opposite polarity. The armature a^5 of dash relay R^2 swings to its marking contact m^5 and closes a circuit which causes the armature a^7 of fork control dash relay FCR^2 to swing to its marking contact m^7, thereby sending a charging current into condenser K^2 which momentarily energizes fork magnet FM′. As the fork tine f' engages contact c^2, a circuit is closed through the main coils of the repeating relays which causes the armature a^9 of relay RR^2 to move to its marking contact m^9 and the armature a^8 of relay RR′ to swing back to its spacing contact s^8. A regenerated and re-formed dash impulse is thereby sent into line L^2.

The zero signal, which it was assumed followed the letter A, causes the dot and dash relays R′ and R^2 to remain on their left-hand or spacing contacts. When the fork tine f^2 swings outwardly a circuit is closed from minus battery through armature a^4, contact s^4, conductor 17, auxiliary holding or spacing coils SC^2, SC′, of the repeating relays, conductor 18, contacts c^4, c^3, conductor 19, contact s^5, armature a^5, to negative battery. This current energizes the spacing coils of the repeating relays RR′ and RR^2 and swings the armature a^9 of the dash relay to its spacing contact. Inasmuch as the armatures of both repeating relays are against their spacing contacts, no current, or as it is termed a zero signal is transmitted to the line L^2.

It will be noted that in the arrangement shown in Fig. 2, just as in the case of Fig. 1, the fork vibrates at twice the speed of the fundamental frequency of signal impulses transmitted from the sending station at the distant end of the cable and selects the best portion of each signal current impulse and times the impulses sent out by the repeating relays so that the repeated signals are regenerated to the predetermined strength and are reconstructed to true form or shape. Moreover as the tine f^2 and contacts c^3, c^4, select the interval of no current, therefore the zero signals repeated into the line L^2 are re-formed or restored to predetermined length and position.

I claim:—

1. In a synchronous telegraph system, means for receiving the signals from one line or cable and repeating them into a second line in new and re-formed impulses, comprising a vibratory fork or reed actuated by the received signals, a current source, and a polar relay operating to transmit signals from said source into the second line, a second source of current and a condenser in circuit therewith, said condenser being alternately charged and discharged by the vibrations of said fork, the charging current of the condenser causing the actuation of said relay, and a polar relay under the joint control of the received signals and the discharge current of said condenser operating to determine the direction of said charging current.

2. In a synchronous telegraph system as set forth in claim 1 said vibratory element having a natural period of vibration which is double the transmitting frequency of the signals.

3. In a synchronous telegraph system as set forth in claim 1, means for adjusting the phase of the currents which cause the vibrations of said vibratory element with respect to the received signals.

4. In a synchronous telegraph system comprising a cable or line section having an automatic transmitter and a second line section having an automatic receiver operating synchronously with said transmitter, apparatus for repeating signals from said second section, comprising a source of current, a repeating polar relay operating to transmit signal impulses from said source, a vibratory element controlling the operation of said repeating relay, a second source of current and a condenser in circuit therewith, said condenser being alternately charged and discharged by the vibrations of said vibrating element, the charging current of the condenser causing the actuation of said relay, and a polar relay under the joint control of the received signals and the discharge current of said condenser operating to determine the direction of said charging current.

5. In a synchronous telegraph system, means for receiving the signals from one line or cable and repeating them into a second line in new and re-formed impulses, comprising a vibratory fork or reed actuated by the received signals, and a current source, said fork or reed also serving to transmit

signals from said source into the second line, and means for adjusting the phase of the currents actuating the vibratory element to thereby maintain the vibrations in phase with the current impulses of the received signals.

6. In a synchronous telegraph system, means for receiving the signals from one line or cable and repeating them into a second line in new and re-formed impulses, comprising a vibratory fork or reed actuated by the signals received from one line and operating synchronously with said received signals, and serving also to transmit signals into the second line, and means for adjusting the phase of the currents actuating the vibratory element to thereby maintain the vibrations in phase with the current impulses of the received signals.

In testimony whereof I affix my signature.

HERBERT ANGEL.