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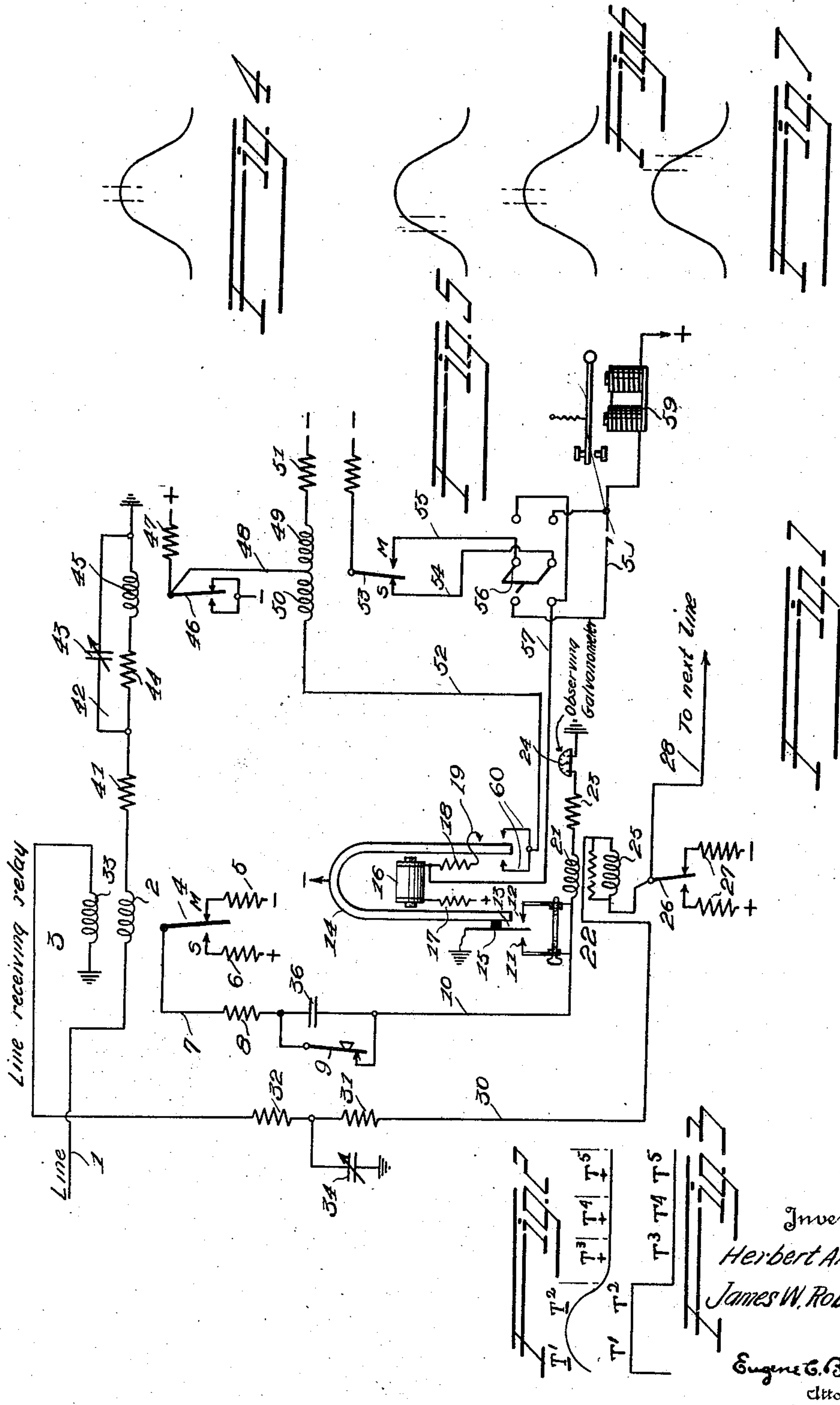
H. ANGEL ET AL

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HIGH SPEED FORK REGENERATING REPEATER FOR TELEGRAPH SYSTEMS

Filed Aug. 30, 1929

2 Sheets-Sheet 1



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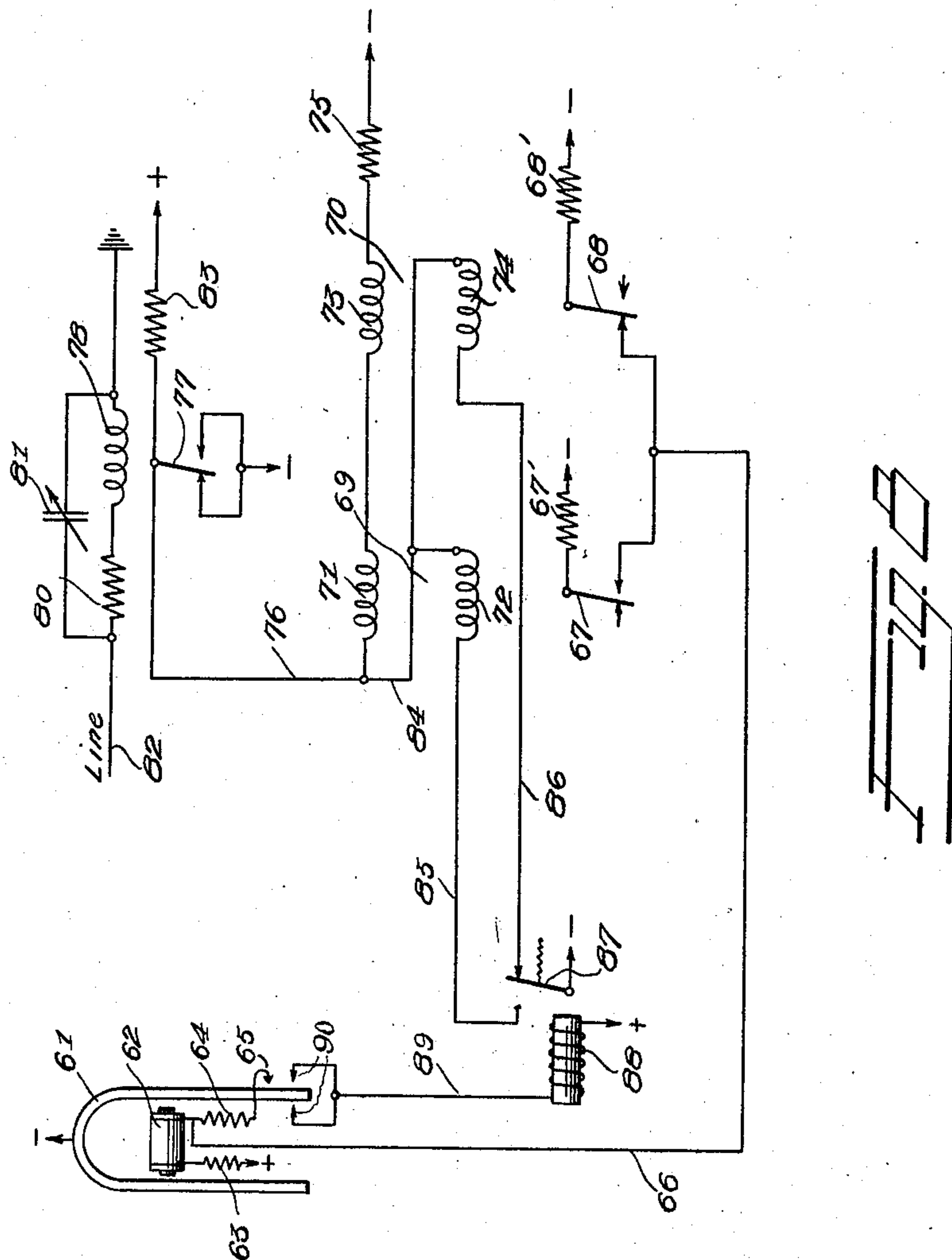
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HIGH SPEED FORK REGENERATING REPEATER FOR TELEGRAPH SYSTEMS

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This invention relates to telegraph systems wherein the telegraph signals received over a land line or cable are so attenuated and distorted that the usual telegraph receiver ordinarily cannot respond thereto, so that regeneration of these signals to reproduce the transmitted signals is necessary before they flow into the telegraph receiving apparatus.

The main object of our invention is to provide an organization of apparatus and a method of operation which will facilitate the transmission of messages and increase the load carrying capacity of long signaling lines.

As is known, signals transmitted over a long land signaling line or over an ocean cable are very much attenuated and distorted in shape at the receiving end. As a result, the amplitude of a received signal impulse is very small and the wave shape is very irregular due to this attenuation and distortion. A considerable portion of the impulse interval is therefore over before the amplitude of impulse is sufficiently large to be effective in operating a receiving apparatus. This latter portion of the interval during which the current is sufficiently large for operation, amounts to often less than 25% of the entire impulse interval and furthermore may occur in different portions of the signal depending on the system and its operating conditions.

Inasmuch as the wave shape of other portions of the received signal impulse is irregular and undesirable for regeneration, it is desirable that only that portion of the impulse interval which is of a predetermined minimum amplitude be regenerated.

To this end, the repeating apparatus must be arranged not only to be operative only during an interval equal to the effective interval noted above, but must also be adjustable so that it may be effective during the interval while the signal is at the desired maximum value. Furthermore the repeater must be maintained in synchronism so as to invariably select the proper interval of the impulse for regeneration.

The rate of signaling must accordingly be reduced, from that normally possible over a

short line, to an amount such that each impulse interval is sufficiently long to enable the amplitude of the signal at the receiving end to reach a large enough value to operate the receiving apparatus. Decreasing the rate of signaling, however, increases the cost of operation and is therefore an unsatisfactory solution of this problem.

In order to increase the rate at which signaling may effectively be carried on over long lines, regeneration systems have been developed in which vibrating members, usually of the tuning fork type, are arranged to vibrate in synchronism with the received signaling impulses, the tines of the fork, as they engage a contact during a cycle of oscillation, generating signal impulses under control of the received signal impulses.

The period during which the signal impulse is regenerated in such an arrangement, is limited to the interval that the tine engages its outer contact. Inasmuch, however, as the tine engages the contact only during a comparatively short portion of its complete cycle period, a very limited amount of time is available for regeneration. Not only is this interval for generation only a portion of the tuning fork period, but very little variation of the time can be made during the cycle when such contact closing is to occur.

Due, however, to the transient or irregular character of the attenuated and distorted received signal, it is desirable that the most ideal portion of the received impulse, which in most instances is a very small portion of the entire signal impulse, be employed for controlling the circuit closed by the tine in its outer position. This, however, is not possible under the conditions described above inasmuch as the adjustment of the tine to vary the period of engagement is considerably limited. Furthermore, as the amplitude of vibration of the fork is cut down considerably in order to cause engagement at a point most desirable in the signaling period, the fork will remain in engagement with its contact over a longer period, whereas actually the shortest possible period for engagement is desirable.

Accordingly, one of the objects of our invention is to provide means for selecting the best portion of the impulse period and utilizing only that portion for controlling the regenerator.

A further object of our invention is to provide means for varying the portion of the signal which is to be regenerated over any length from zero length to a length which is above that which it is desirable to regenerate.

Still a further object of our invention is to provide means for regenerating any desired portion of the received signals.

Another object of our invention is to provide means for increasing the rate at which signaling may be carried on over long lines.

In order to select the proper impulse period for regeneration, it is necessary not only to provide proper apparatus therefor as will be described hereinafter, but also to maintain this apparatus in proper synchronism and phase with the received signal impulses. Heretofore, tuning forks have been maintained in synchronism by providing a correcting medium for the tuning fork, arranged to operate at the same rate as the fork is vibrating, the correcting medium functioning to vary the amplitude of vibration in accordance with variations of synchronism of the fork. Such correcting mediums fail to hold the fork in synchronism for the obvious reason that as the fork vibration is varied, it tends to wander from the correct vibrating frequency.

We have discovered that the correcting medium or circuit must be one in which the fork is suddenly arrested and held in check by a steady unbroken application of the correcting current, and, under these conditions, even when received at a relatively high rate of speed, the signals are regenerated and reshaped although they may be distorted almost beyond recognition.

Accordingly, a further object of our invention is to provide means for suddenly arresting or holding in check vibrating members by a steady unbroken application of a correcting current.

Vibrating members heretofore used, vibrate at double the line signaling frequency. At such fork frequencies, there is double the movement during any one period of time and greater difficulty is experienced in maintaining synchronous operation than would be the case if the fork were vibrated at the signaling frequency. According to our invention, the tines may be vibrated at the same rate of frequency as the line fundamental frequency and the problem of maintaining the fork in synchronism is proportionately reduced.

Accordingly, a still further object of our invention is to provide means for regeneration of signals by means of a tuning fork

vibrating at the fundamental signaling frequency.

In the following description, we shall refer to the accompanying drawings, in which only so much of the telegraph equipment has been shown as would be necessary to a clear understanding of the invention.

Figure 1 illustrates an organization of receiving apparatus used in a preferred embodiment of our invention.

Figure 2 illustrates the form of the received attenuated signal.

Figure 3 illustrates the form of the signal shown in Fig. 2 after it is regenerated.

Figures 4 to 7 show signal waves with the various portions thereof selected for regeneration under varying conditions as will be described hereinafter; and

Figure 8 illustrates a modified organization of apparatus for carrying out our invention.

In Figure 1, a signaling line 1 extending from a remote transmitting station is connected to a primary winding 2 of a line receiving relay 3. The line relay 3 is provided with an armature 4, which operates between marking and spacing contacts connected to the negative and positive terminals of a battery respectively through resistances 5 and 6. Armature 4 is connected over a conductor 7 and through a resistance 8 and key 9 and conductor 10 to contacts 11 and 12. Contacts 11 and 12 are arranged on either side of a tongue 13 carried on the tines of a tuning fork 14. The tongue 13 which is grounded and insulated from the tuning fork by insulation 15, alternately engages the contacts 11 and 12 as the fork 14 vibrates.

The fork 14, of any well known construction, is maintained in vibration in approximate synchronism with received signals over line 1 by any well known means. In the present case, the fork is arranged to be vibrated at a rate slightly greater than the signaling frequency and a brake action is periodically applied by magnet 16, one terminal of which is connected to the positive side of battery through resistance 17, and the other terminal of which is connected through resistance 18 to a contactor 19 which is adapted to be engaged by one of the tines of the fork. As shown, the fork is connected to the negative side of battery so that when the tine of the fork engages contact 19, an energizing circuit is completed for the brake magnet 16 from the positive side of battery through resistance 17 to the negative side of battery at the fork 14.

Connected to conductor 10 in multiple with the contacts 11 and 12, is a winding 21 of the regenerating relay 22 connected in series with a resistance 23 and an observing galvanometer 24, the purpose of which will be described hereinafter.

Regenerating relay 22 comprises in addition to winding 21, locking winding 25, connected to the armature 26 of the regenerating relay 22 operating between contacts extending through resistances 27 to the positive and negative sides of a source of energy. Armature 26 repeats the regenerated impulses over a signaling line 28 extending to a receiving apparatus or another line or cable section.

The locking winding 25 is connected to conductor 30 and through resistances 31 and 32 to the winding 33 of the line relay 3. Connected in shunt relation with respect to winding 33 is a variable condenser 34, one terminal of which is grounded and the other terminal of which is connected to the mid-point between resistances 31 and 32, the function of this condenser being to delay energization of the winding 33 after the circuit therefor is completed.

The operation of the apparatus thus far described is as follows: It will be assumed that a negative or marking impulse is received over the signaling line 1 from the remote station. This current flows through and energizes the winding 2 of the line relay 3. At the beginning of the impulse interval, the wave shape of the signal is irregular and the amplitude too small to positively operate armature 4. The amplitude of the current rises, however, until it is sufficient to operate armature 4 to engage its right hand or marking contact which is connected through resistance 5 to the negative side of battery.

During the time while the current amplitude is growing to a value sufficient to operate armature 4, the armature may, as is well known, chatter and uncertainly move to the right hand contact. During this period, however, which is the undesirable portion of the impulse interval, no regeneration will take place as will be clear from the description to follow.

During the period while armature 4 uncertainly engages its marking contact in response to a received impulse which, however, is still weak, the tines of the fork 14, if the fork is in synchronism with the received signals, will be in its outermost position at which tongue 13 will engage the contact 11. Current will then flow from the negative side of battery through resistance 5, marking contact in engagement with armature 4, conductor 7, resistance 8, switch 9, conductor 10, contact 11 and tongue 13 to ground.

An instant later armature 4 positively engages its marking contact and the tine of the fork starts to move inwardly and tongue 13 will disengage the contact 11. At the instant contact 11 is disengaged by contactor 13, the circuit traced above over tongue 13, which it will be noted, short circuited the winding 21, is opened and the current from the negative side of battery at armature 4 will now flow through the winding 21 of the regener-

ating relay 22, resistance 23 and galvanometer 24 to ground.

Relay winding 21, upon energization, will operate its armature 26 to engage its right hand or marking contact and a marking impulse will thereupon be repeated from the negative side of battery, resistance 27, back contact and armature 26 and over the conductor 28 to the receiving apparatus, or next line section. A multiple circuit will be completed from the same source of energy through the locking winding 25 over conductor 30, resistance 32 to the winding 33 of the receiving relay 3. The current through winding 33 flows in the opposite direction from that flowing in winding 2 and accordingly it tends to throw the armature 4 to its opposite position. The ampere turns in the windings 33 are so calculated, however, as to be less than in winding 2 and the armature therefore remains in position as long as current flows through winding 2.

In order to delay the energization of winding 33, the condenser 34 is interposed in a multiple circuit therewith. As is well understood in the art, the condenser connected in parallel with the inductance increases the lag of the current in the relay winding and therefore delays the energization of the winding 33, depending upon the adjustment of the condenser 34.

The tongue 13 of the fork 14 has now moved through the gap or space between the contacts 11 and 12 and engages its right hand contact 12. As a result the bypass circuit, traced above, is again completed. However, the regenerating relay 22 is now locked in position and the shunt circuit therefore has no effect thereon.

It is assumed for the purpose of this illustration, that a second marking impulse, as indicated in Figure 2, is received during the second impulse period so that armature 4 remains in engagement with its marking contact when the tongue 13 of fork 14 engages its right hand contact to complete the bypass circuit described above. When now the tongue 13 disengages contact 12 and moves into the gap between contacts 12 and 11, the original energizing circuit for the winding 21 is again completed. The current flows in the same direction and accordingly this has no further effect other than to maintain armature 26 in engagement with its marking contact which is already held by locking winding 25. When now the tongue engages its left hand contact 11, two complete impulses have been regenerated as illustrated in Figure 3, for transmission over conductor 28.

It will be assumed that the next impulse as illustrated in Figure 2, is a spacing signal in which case positive current will flow through the winding 2. At the moment of reversal when the line current falls to zero the energizing current in the winding 33 be-

comes effective to accelerate the operation of the armature 4 to engage its spacing or left hand contact. At the instant when this signal is received, the tongue 13 as described above, engages its left hand contact 11 and a bypass circuit is completed from the positive side of battery at resistance 6 through the tongue 13 and contact 11 bypassing the winding 21. An instant later and during the best portion of the signal interval, the tongue 13 again moves into the gap intermediate the contactors 11 and 12. Current from the positive side of battery at resistance 6 therefore flows through the winding 21, which, upon energization, operates its armature 26 to engage its left hand contact connected to positive side of battery and an impulse from the positive side of battery is repeated over the conductor 28. Simultaneously current from positive battery flows through locking winding 25 over conductor 30 to charge the condenser 34 and to energize the relay 33, which thereupon tends to operate armature 4 to its marking contact.

As will be clear from this description, the period during which the tongue of the fork is in the gap position is utilized for regenerating the received signal. In the description to follow, it will be shown that by this arrangement, the best portion of the signal may be selected.

In the drawings, the air gap between contacts 11 and 12 are shown rather wide apart for purposes of clearness. These contacts may be adjustable to vary the air gap between any desired limit. By properly narrowing the air gap, the energizing time for the regenerating relay may be reduced to zero; that is, substantially none of the received impulses will be regenerated if the contacts 11 and 12 are brought together, thus completing a permanent bypass circuit, by passing the winding 21. As the air gap, however, is widened, the regenerating period is proportionally increased to a time representing the full time of a single impulse interval impressed upon the line.

In regenerating systems, however, the least amount of time that can possibly be used for regenerating the impulses is desirable inasmuch as the less time used for regeneration, the more efficient the system, due to the fact that the signal is so distorted that only a very small portion thereof is suitable for regenerating purposes.

In Figures 4 to 7, the portions of the signals desirable for regeneration are shown between the vertical lines. For signals, such as in these illustration, the air gap would be adjusted to maintain the tongue in the gap approximately 25% of the signal period, but as already stated, the gap may be varied to regenerate any portion of the signal from 0% to 50% or more thereof.

As will be clear from this description, by

employing the air gap for selecting the regenerating portion of the impulse, a greater margin for adjustment can be made than if the contact itself is used as was heretofore the practice, adjustment of which can be obtained only by varying the amplitude of vibration of the fork and accordingly reducing the efficiency of operation.

Not only is it desirable to be able to select varying proportions of the signals for regeneration, but it is also desirable to determine which portion is to be selected. As shown in Figures 4 to 7 varying portions of the signals may be regenerated but only the crest of the signal is desirable for regeneration. In order to regenerate the proper portion of the received signal, it is necessary that the fork tongue 13 be in the gap position at exactly the interval when the crest portion of the signal is received and to remain in the gap portion while the crest continues.

To this end, a condenser 36 is shunted across the switch 9 and cooperates with the remaining portions of the circuit already described to operate the observing galvanometer 24 for indicating when the best portion of the signal is being regenerated as will appear from the description of the operation to follow.

In order to determine when the crest of the signal is being regenerated, the key lever 9 is removed from its contact thus removing the shunt from around the condenser 36 so as to extend the circuit from the armature 4 through the condenser 36, winding 21 to the observing galvanometer 24 when not shunted by tongue 13 on either contact 11 or 12. As the armature 4 now operates between its marking and spacing contacts, impulses are repeated therefrom though the resistor 8, condenser 36 and either over the shunt path described or through the winding 21 and observing galvanometer 24. If now during the rising portion of the impulse interval, the tongue 13 leaves either contact 11 or 12, the changing value of current in the conductor 7 will flow though the condenser 36 and through the observing galvanometer 24, and the galvanometer will operate in accordance therewith. Deflection of the galvanometer pointer will indicate that an undesirable portion of the impulse is being received. If on the other hand, the armature 4 has moved to engage one or the other of its contacts and the crest of received impulse has been received when the tongue 13 is in the air gap, the condenser will have been fully charged while the tongue 13 was in engagement with either contact 11 or 12. When therefore the tongue 13 is in the gap, no further current will flow in the conductor through the charged condenser 36 and accordingly there will be no deflection of the pointer of galvanometer 24.

In other words, when the pointer of the

galvanometer 24 fails to deflect, this is an indication that the proper portion of the impulse is being regenerated, as deflection of the pointer takes place only if an improper portion of the impulse is regenerated. Adjustment of vibration of the fork may now be made in the manner to be described until the galvanometer fails to deflect, which indicates that the proper portion of the impulse is being regenerated, whereupon the key lever 9 is moved to engage its contact, bypassing the condenser 36 and the apparatus is in condition to receive signals.

This phase adjustment is accomplished by mechanism now to be described.

The line relay winding 2, it will be noted, is connected in series with a resistance 41, connected in series with a tuned circuit 42, comprising an adjustable condenser 43, resistance 44 and phase-correcting relay winding 45, comprising an inductance and controlling an armature 46.

The armature 46 is connected through a resistance 47 to the positive side of battery and operates between two contacts connected to the negative side of battery. The armature is also connected over conductor 48 to the mid-point of windings 49 and 50. The winding 49 is connected through a resistance 51 to the negative side of battery and the winding 50 is connected over a conductor 52 to the inner and outer contacts 60, alternately engaged by one of the tines of fork 14.

Windings 49 and 50 control an armature 53 which operates between contacts of conductors 54 and 55 respectively in turn connected to a switch 56. The switch 56 when in its left hand closed position, extends a circuit from conductor 54 over to conductor 57 to the brake magnet 16 and when the switch 56 is in its right hand closed position extends a circuit from conductor 55 over the same conductor 57 for controlling brake magnet 16. In either of these positions, the switch 56 also completes circuits over the alternate conductors 55 and 54 and over conductor 58 to the sounding magnet 59 connected to the positive side of battery.

Normally the armature 46 moves to its right and left hand contacts in synchronism with the armature 4 of the line relay 2. During the period while armature 46 is moving from one to the other of its contacts in response to a received signal impulse, current from positive side of battery at resistance 47 flows over the conductor 48 and through winding 49 and resistance 51 to negative battery. If the tine of fork 14 is at this time in engagement with one of its contacts 60, as it should be if it is in proper phase with the signal impulses, current will also flow through the relay winding 50, conductor 52 and over the contact 60 with which the tine of the fork 14 is in engagement to the negative side of battery, the current flowing in

winding 50 overcomes the effect of the current in winding 49 and is in a direction to throw the armature 53 to engage its right hand contact. As a result, a circuit is completed from the negative side of battery through the armature 53, conductor 55, switch 56, conductor 58 to the sounder 59, but no circuit is completed over conductor 57 inasmuch as this conductor is connected over conductor 54 to the left hand contact of armature 53. If on the other hand, the tine of fork 14 is at this time not in engagement with one of its contacts, but is in the air gap therebetween, as would be the case if the fork is ahead of the signal due to its normal higher speed of operation, the circuit traced above through the winding 50 is not completed and only the circuit from the positive side of battery through resistance 47, conductor 48, through the winding 49, resistance 51 to negative battery is completed. In that case, armature 53 is thrown to engage its left hand contact and an energizing circuit is completed to the brake magnet 16, which is thereupon energized by a continuous brake current and acts as a brake to slow up the vibration of the tuning fork by continuous brake current. This current will continue to flow until the tine has been sufficiently slowed up to be in synchronism again with the received signals, whereupon a circuit through winding 50 will be completed during the period while armature 46 is in mid gap position in response to a changed signal as described above and the armature 53 will again be thrown to its right hand position, opening the circuit of the brake magnet 16.

From the above, it will be clear now that the tuning fork is driven at a slightly faster rate of speed than the line speed and is quickly arrested or slowed down by applying a steady unbroken direct current to the brake magnet until the fork has slowed to proper speed, at which time the slowing down circuit is disconnected and the fork is again allowed to run free until some time when it runs faster than it should whereupon it is again slowed down.

In order to adjust the phase of the tuning fork with respect to received impulses so that a proper portion of the impulse shown in Figures 4 to 7 may be received, the relay 45 is so arranged in circuits that its response to a received impulse may be variably delayed.

This is accomplished by means of the tuned circuit including the resistance 44 and adjustable condenser 43. As is well known an inductance produces a lag in the circuit throwing the current a variable amount behind the voltage depending on the value of the inductance. A condenser connected in parallel with such an inductance as distinguished from a series connection, will throw the current still further behind the voltage depending on the value of the capacity. Ac-

cordingly, by varying the capacity of condenser 43, the period of energization of relay 45 can be variably delayed and the armature 46 can be made to move between its contacts at a different time in the period of a received impulse from that of armature 4. Since, however, the vibration of fork 14 is controlled by armature 46, the fork 14 may be made to maintain its tongue 13 in engagement with contacts 11 or 12 at different times in the impulse interval to select the proper crest portion of the received signals for regeneration.

Reviewing the means for correcting the fork, it will be noted that the synchronizing relay 45 repeats an impulse over conductor 48, which is always of less time duration than the usual signal, inasmuch as the repeated signal flows only during the period when the armature 46 is in the air gap position between its contacts. This makes the correcting impulses of shorter time duration than the air gap time of the fork time, so that the impulse can only be effective during a part of the time that the fork time is on its contact 11 or 12.

As will now be clear from the above description, not only may the percentage of impulse interval be selected by adjustment of the contacts 11 and 12 to vary the air gap therebetween, but the portion of the crest selected may be varied as shown in Figures 4 to 7 by adjustment of the condenser 43 which adjustment will control the time interval of a received signal impulse so that the armature 46 will operate between its contacts to in turn control the phase of the tuning fork 14 with respect to the received signals.

The switch 56 is shown as a double throw switch. When in its left hand position, a fixed relation between the operation of armature 46 and the vibration of the tuning fork is maintained. By throwing the switch 56 to its right hand position, the connections thereto are reversed with respect to the marking and spacing contacts of the relay 50 so as to shift the checking circuits from spacing to marking contact, which in turn shifts the moment of impulse regeneration through an angle of 180°.

In the above description, the fork is described as normally vibrating slightly faster than the fundamental line frequency and maintained at true speed by repeatedly slowing it down when it gets beyond a predetermined phase position with respect to the received impulse.

The fork may, if preferred, be arranged to run at exactly the line frequency and be varied to decrease or increase its rate of vibration in accordance with variations thereof from the fixed rate. In Figure 8 an arrangement for this kind of correction is shown. The receiving apparatus, being similar to that described in connection with Fig-

ure 1, is not here disclosed, only that portion of the synchronizing means being shown which is different from that shown in Figure 1 being illustrated. Tuning fork 61 in this system is normally maintained in vibration by any well known means and a brake magnet 62, one terminal of which is connected through a resistance 63 to positive side of battery, controls its rate of vibration. The other terminal of magnet 62 is connected through resistance 64 to the contact 65 co-operating with one of the tines of the tuning fork and is also connected in multiple over a conductor 66 extending to the right and left hand contacts respectively of armatures 67 and 68 of the relays 69 and 70 respectively. Relay 69 comprises two windings 71 and 72 and relay 70 comprises two windings 73 and 74. Windings 71 and 73 are connected in series with resistance 75 to the negative side of battery and over conductor 76 to the armature 77 of the synchronizing relay 78. Relay 78 is connected in a circuit with a resistance 80 and a variable condenser 81 for adjusting the time when the relay winding 78 is affected by the line impulse received over the line 82 as described in connection with Figure 1. The armature 77 is connected through the resistance 83 to the positive side of battery.

Windings 72 and 74 are connected in multiple to the conductor 84 and each winding in turn extends over the conductors 85 and 86, respectively, to the left and right hand contacts of armature 87 of relay 88. Relay 88 in turn is connected over conductor 89 to two contacts 90 engaged by the tuning fork in either its inner or outer position.

The fork in this case is adjusted to run at exactly the speed of line frequency. When the correcting relay 78 operates armature 77 from its left to its right hand contact in response to a received impulse and while the armature 77 is in mid gap position, current flows from positive side of battery through the resistance 83, conductor 76 and through the windings 71 and 73 and resistance 75 to negative battery. Current may also flow in multiple through either the winding 74 to armature 87 or to the winding 72 and armature 87 depending upon whether the armature 87 is in engagement with its front or back contact. The relay 88, it will be noted, is energized twice per movement of the tuning fork; that is, once in its inner position and again when in its outer position and is de-energized while the fork is in mid way position.

If the armature 87 of relay 88 is in mid gap position as it should be, the fork having just left a contact when the correcting impulse flows in the conductor 76, as described above, neither winding 72 nor 74 will become energized. The current in conductor 76 flows through the windings 71 and 73 and operates

their armatures 67 and 68 respectively to spacing or left hand contacts. In this case, the fork is vibrating at the correct speed and in proper phase relation. A circuit is completed from negative battery over the resistance 68', tongue 68 in engagement with its left hand contact and over the conductor 66 to the magnet 62. This is a normal condition when the fork is running at true speed.

If on the other hand, the relay 88 is energized when the correcting current flows over conductor 76 due to the fact that the tine of fork 61 engages either its inner or outer contact 90, the current in conductor 76 will flow through the winding 72, the front contact and tongue 87 to negative battery. Current flowing through the winding 72 is sufficiently greater than the current flowing through the winding 71 to overcome the effect of the current in the winding 71 and the armature 67 is operated to its marking or right hand contact. This is the condition obtained when the fork is running faster than it should and the checking circuit completed over the conductor 66 being now multiplied to negative battery over armatures 67 and 68 and resistance 67' and 68', a greater current will flow over this circuit and the increased current in the winding 62 increases the brake action of the magnet slowing up the fork vibration.

If on the other hand, when the correcting current flows over conductor 76, the relay 88 has completely deenergized due to the fact that the tuning fork has moved sufficiently far from the contacts 90 of the fork to have provided sufficient time for the relay 88 to deenergize, this indicates that the fork is behind the received signal. Deenergization of the relay 88 causes its armature 87 to move to the position shown in the drawing, breaking the circuit through winding 72 and completing the circuit through winding 74. The current flowing through winding 71 again becomes effective to move armature 67 into engagement with its left hand contact. The flow of current from conductor 76 through the winding 74 will produce sufficient ampere turns to overcome the ampere turns in the winding 73 and the armature 68 will move to its right hand or marking contact, in which case no current will flow in the conductor 66. As a result, the brake action of the brake magnet 62 will be reduced and the fork will then increase its speed of vibration.

Although we have described our invention in connection with a specific adaptation thereof, it will be clear that it has other applications where remote signaling is carried on over synchronizing systems and may have other embodiments thereof. Thus, although we have described this system in connection with telegraph systems it will be apparent that it may be used in any signaling systems based on synchronous principle of operation.

Our system possesses many advantages over prior systems. By the arrangement shown, signaling may be carried on at considerably increased speed inasmuch as regeneration can be considerably improved over prior systems and the portion of the crest of signal waves to be regenerated can be readily selected by adjustment of the vibration of the tuning fork contact and the proportion of the crest to be utilized for regeneration can be selected by adjustment of the contacts.

A greater degree of accuracy may be obtained inasmuch as the tuning fork vibrates at the signal frequency and a sudden unbroken direct current controls the operation of the tuning fork.

We claim:

1. In a signaling system, a first signaling line, a second signaling line, a tuning fork operating between contacts and means controlled by said tuning fork for repeating that portion of said signaling impulses received while said tuning fork is in non-contacting position between said contacts.

2. In a signaling system, a first signaling line, a second signaling line, a tuning fork regenerator operating in accordance with impulses received over said first line for controlling the repeating of said impulses over said second line and means for indicating which portion of a received impulse is regenerated, means responsive to received impulses for controlling the rate of vibration of said fork and means for varying the action of said last mentioned impulse means for variably selecting any portion of said received impulse for regeneration as determined by said indicating means.

3. In a signaling system, a first line, a second line, a tuning fork operating between two contacts, a first relay in said first line having an armature connected to said contacts, a second relay connected to said armature in multiple with said contacts whereby said second relay is energized in accordance with the operation of said first relay when said contacts are disengaged from said fork.

4. In a signaling system, a first line, a second line, a tuning fork operating between two contacts, a first relay in said first line having an armature connected to said contacts, a second relay connected to said armature in multiple with said contacts whereby said second relay is energized in accordance with the operation of said first relay when said contacts are disengaged from said fork, other contacts between which said fork operates, a third relay connected in said first line and a brake magnet controlled by said third relay in accordance with the position of said fork and said other contacts when a signal is received for maintaining a predetermined frequency of vibration of said fork.

5. In a signalling system, a first line, a second line, a first relay in said first line comprising a line winding and an accelerating winding operating in response to reversals of impulses received over said first line, a second relay in said second line having an armature connected to said accelerating winding, means whereby said second relay is operated in accordance with the operations of said first relay for repeating the received first line impulses over said second line and a condenser connected to the circuit extending from said accelerating winding to the armature of said second winding for assisting said first relay to be reversed when the first line current falls to zero at the moment of reversal and for further causing said first relay to be repeatedly reversed at the fundamental rate of frequency as long as the line current remains at zero.

6. In a repeater system, means vibrating at a predetermined frequency, a signaling line, a relay means in said line, means controlled by said vibrating means for generating impulses in accordance with the impulses received over said signaling line to which said receiving relay means responds and means responsive to variations of said vibrating means from the frequency of said signaling impulses for applying a correction thereto, said last means continuing as long as said vibrating means remains out of synchronism.

7. In a repeater system, a tuning fork maintained in vibration at a predetermined frequency, magnetic means for controlling said tuning fork and means controlled by variations of said tuning fork from the predetermined frequency for applying an energizing current continuously to said magnetic means to change its frequency, said controlled means continuing in operation during the time that said correction is applied.

8. In a repeater system, a tuning fork, a controller therefor, a signaling line, a relay means in said line, a repeater line, means controlled by said tuning fork for repeating impulses over said repeater line in accordance with the impulses received over said signaling line to which said receiving relay means responds, means responsive to variations of said fork from a predetermined rate of vibration for applying a continuous energizing current to said controller.

9. In a repeater system, a vibrating member maintained in vibration at a predetermined frequency and a brake magnet for decreasing the rate of vibration of said vibrating member, means for applying a continuous energizing current in accordance with the variations of said member from a predetermined frequency to said brake magnet to increase the brake action thereof during the time that a correction is applied.

10. In a signaling system, a vibrating member vibrating at a predetermined frequency,

means controlled by received signaling impulses, second means jointly controlled by the rate of vibration of said vibrating member and by said first means for varying the frequency of vibration of said vibrating member, said last mentioned means being continually operative after being started into operation by said first means for varying the vibration until said vibrating member has been adjusted to vibrate at the predetermined frequency.

11. In a signaling system, a vibrating member vibrating at a predetermined frequency, means controlled by received signaling impulses, second means jointly controlled by the rate of vibration of said vibrating member and by said first means for varying the frequency of vibration of said vibrating member, said last mentioned means being thereafter operative independently of said first mentioned means for varying the vibration of said vibrating means solely under control of said vibrating member.

12. In a signalling system, a first line, a second line, a first relay in said first line comprising a line winding and an accelerating winding operating in response to reversals of impulses received over said first line, a second relay in said second line having an armature connected to said accelerating winding, means whereby said second relay is operated in accordance with the operations of said first relay for repeating the received first line impulses over said second line and a condenser connected to the circuit extending from said accelerating winding to the armature of said second winding for assisting said first relay to be reversed when the first line current falls to zero at the moment of reversal.

13. In a signalling system, a first line, a second line, a first relay in said first line comprising a line winding and an accelerating winding operating in response to reversals of impulses received over said first line, a second relay in said second line having an armature connected to said accelerating winding, a vibrating member operated in synchronism with received impulses for operating said second relay in accordance with the operations of said first relay for repeating the received first line impulses over said second line and a condenser connected to the circuit extending from said accelerating winding to the armature of said second winding for assisting said first relay to be reversed when the first line current falls to zero at the moment of reversal and for further causing said first relay to be repeatedly reversed at the fundamental rate of frequency as long as the line current remains at zero.

14. A signaling system comprising an incoming line, a receiving relay connected to the incoming line, a repeating regenerating relay operating in response to the movements of the armature of the receiving relay, means

for indicating the portions of the signal impulses being repeated, and means for variably selecting any desired signal portion determined by said indicating means.

5 15. A signaling system, comprising an incoming line, a receiving relay, and a signal recording or retransmitting means embodying a repeating relay and a vibratory device, said repeating relay being under the joint
10 control of said vibratory device and said receiving relay, said vibratory device having a member operating between a pair of contacts adjustable toward and from each other to determine the portion of the signal im-
15 pulses being repeated.

16. A signaling system, comprising an incoming line, a receiving relay connected thereto, signal recording or retransmitting mechanism embodying a repeating relay re-
20 sponsive to said receiving relay and a vibratory device operating between adjustable contacts to determine the portion of each signal impulse to be repeated, and means responsive to a variation in the phase relation of the
25 vibratory device with respect to the incoming signals for applying a continuously operating adjustment during said variation.

17. A signaling system as set forth in claim 16, said signal impulses being repeated while
30 said member is in non-contacting position between said contacts.

In testimony whereof we affix our signatures.

HERBERT ANGEL.
JAMES W. ROBINSON.

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