June 26, 1928.

1,675,096

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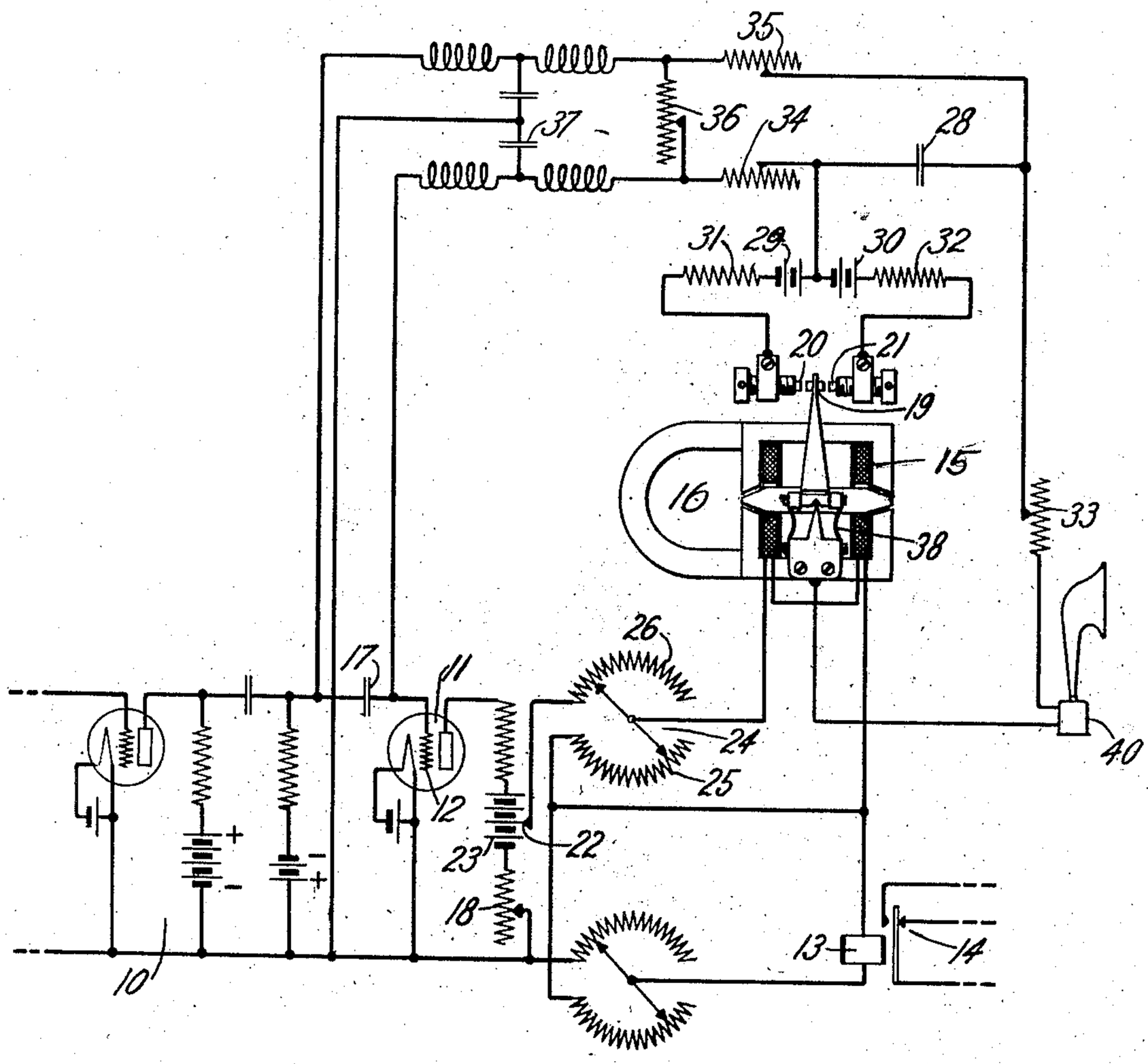
Filed May 3, 1926



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Patented June 26, 1928. 1,675,096

UNITED STATES PATENT OFFICE.

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SIGNALING SYSTEM.

Application filed May 3, 1926. Serial No. 106,355.

This invention relates to signaling systems and particularly to means responsive to received impulses for controlling the operation of a circuit.

In any system of electrical communication it is of great advantage to maintain uniform reception of signals corresponding to a certain normal reception. In practically all systems, however, various influencing factors tend to cause the signals to differ from time to time as regards some characteristic, so that similarly transmitted signals when received under differing transmission conditions deviate from any normal which may be established.

In transmitting signals over long submarine cables, it is always found that an appreciable difference of potential exists between the ends of the cable and that this potential is continually changing, resulting in so-called earth currents which may be large in proportion to the strength of the received signal, because of the great attenuation of the signals by transmission over the cable. For this reason it is necessary to prevent these direct currents from reaching the receiving apparatus by making the latter selective against direct or very low frequency alternating currents. The submarine cable transmission circuit as used in practice is therefore constructed so that it is incapable of transmitting a direct current from the transmitter through the receiver to ground. This fundamental limitation of the submarine cable transmission system makes it impossible to receive a signal which is a perfect reproduction of the signal impressed on the cable, since it is evident that a signal which consists at the transmitter of a sustained voltage of either polarity will at first, by the transmission of its higher frequency components, be received at the other end of the cable, but as the transients die out at the transmitter, the received current will also disappear.

When a cable system is handling commercial traffic, it will be found that peculiarities of language and of the telegraph code, or the stopping of certain channels in the operation of multiplex printing apparatus may cause the positive pulses to preponderate greatly over the negative pulses, or vice versa, during long periods. With the usual type of signal correction a preponderance of one sign of signal over the other will have little effect if it is maintained for a small fraction of a second or so, but after that the zero gradually shifts in the direction of the least frequent signal element.

When the receiving apparatus is the usual siphon recorder, the shifting of the zero, or as it is commonly called, the zero-wander, caused by the absence of the very low frequencies from the received signals is of relatively minor importance, but when relays are to be operated it becomes essential to limit the zero-wander to a rather small proportion of the total signal. If the shifting of the zero should be more than about 20% of the normal signal amplitude, the current in the relay windings of the receiving circuit may not be sufficient to move the armatures of the relays into engagement with both contacts and the relays will fail to operate, thus rendering the signals unintelligible.

In the case of printing telegraph systems where the apparatus at the opposite ends of the cable must be held in synchronism the uncertainty of operation of relays caused by zero-wander, in turn causes serious variations in synchronism and may make operation impossible.

The principal object of the present invention is to insure reliable and efficient operation of signaling apparatus. For example the invention may be employed to compensate for zero-wander in the operation of submarine signaling systems.

A further object of the invention is to control a circuit by preventing deviation of impulses from a predetermined normal.

The correction for deviation of signals from normal has been undertaken in various ways. According to one aspect of the present invention a correcting potential is applied to signal responsive means whenever the zero of the signals has shifted for any reason whatever beyond a certain predetermined value, and, when the signal zero has returned to its original position or to a position sufficiently close to its original position to insure proper operation of the receiving apparatus, the correcting factor is no longer applied.

One feature of the invention relates to a novel type of relay operation whereby certain impulses in one circuit are repro-

duced in a second circuit, whereas certain other impulses in the first circuit are not reproduced in the second circuit. This is effected by adjusting the first circuit and relay so that the second circuit is completed by the operation of the relay in response to only a portion of the received impulses.

Another feature of the invention relates to a control circuit comprising elements having progressively larger time constants whereby an impulse of very short duration may control a circuit which is responsive only to a sustained impulse.

Other objects and features of the invention will be clearly understood by reference to the accompanying drawing which illustrates a preferred embodiment of the invention as employed in the operation of submarine signaling apparatus.

In the embodiment of the invention illustrated a portion of a signal receiving amplifier 10 for submarine signaling is shown in which the last stage of amplification is preferably in the form of a space discharge device 11 having a control electrode 12. The output circuit of the receiving amplifier comprises the operating winding 13 of a receiving relay 14 or other suitable recording means, such as an ordinary siphon recorder. A preferred arrangement for associating amplifier 10 with a submarine cable is disclosed in my U. S. Patent No. 1,624,396, April 12, 1927, the last two stages of the amplifier therein disclosed being replaced by the two stages of amplifier 10. In circuit with the winding 13 of the receiving relay is the operating winding 15 of a correcting relay 16 which is preferably a three-position polar relay (similar in construction to that described and shown in my copending application, Serial No. 124,595, filed July 24, 1926). In this type of relay the armature is light and small, and operates between fixed poles of a very strong magnet. The armature is normally held in its mid or neutral position by means of springs 38. The adjustment of the springs is variable to obtain sensitive action of the relay. For the purpose of this invention it is preferable to use contacts made of platinum iridium, one being flat and the other sharply pointed. The current through the windings of relay 16 is preferably adjusted by means of the contact 24 engaging the series resistance 26 and shunt resistance 25 so that the current in the winding will be that best suited for the purposes of the invention. A similar adjustable series and shunt resistance arrangement is provided for the relay 14. The purpose of this combination of series and parallel resistance elements in the control circuit of the relay windings is to enable the current through one relay to be adjusted without changing the total current through the circuit and thereby through the other relays or receiving devices. For this reason the various points of the resistances are so chosen, in relation to the resistance of the relay winding, that a decrease in resistance caused by reducing the size of the shunt on the winding is counteracted by an increase in the series resistance. It may be desirable to have a repeating relay in series with the recording relay 14 and the correcting relay 16; also any other signal responsive means may be included in the output circuit. The combination of this type of relay with its associated circuits is such that a new type of relay operation is possible, that is, the relay may be adjusted so that the contact controlled by its armature normally vibrates between the side contacts without touching either; but, if the amplitude of the deflection of the armature from its said position should be more than a few per cent greater than normal, momentary contact will be made. It has been found that a relay of this type may be adjusted to operate on a bias of less than five per cent of the signal amplitude. The adjustments of the resistance 18 and of the tap 22 of battery 23 are such that the potential drop through one is just equal and opposite to that of the other and therefore when no signals are being received no current flows through the windings 13 and 15 of the relays.

Signals received from the cable are suitably amplified and impressed on the receiving circuit including the windings of signal receiving relay 14 and correcting relay 16 which controls a compensating circuit for the receiving apparatus. The compensating circuit comprises a storage element such as condenser 17, which as illustrated, may be located in the grid circuit of the last stage of the receiving amplifier and charged by any suitable source of potential through suitable resistances as will be described later. Shunted around condenser 17 is the adjustable resistance 36. The shunted grid condenser 17 serves a double purpose, to wit: it forms a by-pass to the high frequency signal voltages and the shunt passes the grid battery potential, thus preventing the correcting circuit from interfering with the normal amplifier operation. The adjustment of the correcting three-position polar relay 16 as outlined above is such that the armature vibrates with the signals between contacts 20 and 21 without touching either, so long as the zero of the received signal impulses remains substantially constant at its original setting, but if the zero should shift so that the relay armature moves more than a predetermined amount further toward one side than toward the other it will engage either contact 20 or 21, completing a circuit through one of the oppositely poled batteries 29 or 30, charging condenser 28. The armature of the relay may be damped by any suitable

means to render the armature free from inertia effects and prevent the effect of successive signal impulses from being cumulative or causing the armature to "overshoot" and make a false contact. This may be effectively accomplished by electrically damping the relay.

In order that the correction of the signals shall be more effective the correcting circuit for impressing a compensating potential on the condenser 17 has a large time constant and is therefore slow acting, retaining the correcting charge on the grid 12 with relatively few engagements of the armature 19 with contacts 20 and 21. For this purpose the condenser 28 is provided which receives its charge from either battery 29 or 30 through resistances 31 or 32 and adjustable resistance 33. The time constant of this latter circuit is preferably in the neighborhood of 1/100 of a second so that the condenser 28 is immediately charged upon contact of armature 19 with either contact 20 or 21. The condenser 17 is then charged slowly from condenser 28 through resistances 34 and 35. The charge on these condensers is allowed to leak off through resistance 36. The time constant of the circuit, including condensers 17 and 28 and resistances 34, 35 and 36 depends largely upon the characteristics of the signals being received, but may be of the order of a second, so that the charge on the condenser 17 will be retained an appreciable length of time for correcting purposes.

In the ordinary reception of signals the armature 19 will vibrate with the signals between the two contacts 20 and 21 without touching either. If, for any reason, the zero of the signals should vary more than a few percent from the original zero setting, toward the negative side for example, the current passing through the windings of the receiving relay 14 and control relay 16 will be of greater amplitude than normally for the negative impulses of the signal and of less amplitude than normally for the positive impulses. The armature 19 of relay 16 will move correspondingly further toward the negative contact than toward the positive, engaging contact 20. Upon the engagement of armature 19 with contact 20, a circuit will be completed so that a positive potential from battery 29 will be impressed directly on the left-hand side of condenser 28. A corresponding negative potential will be impressed on the right-hand side of the condenser through resistance 31, armature 19, and adjustable resistance 33. In this way the condenser 28 will be charged and its charge will at once commence to flow to condenser 17 through resistances 34 and 35. This charge can leak off through resistance 36. A positive charge on the right-hand side of condenser 17 will render the potential of control electrode 12 less negative and will thereby shift the zero of the signals back toward the positive side to compensate for the original shift of zero toward the negative side. In a similar way, if the zero should shift toward the positive side the armature 19 will engage contact 21 and potential of the opposite polarity will be impressed on condensers 28 and 17 from the battery 30. By impressing negative potential on the right-hand side of condenser 17, the potential of the grid 12 of the vacuum tube 11 is made more negative, shifting the zero of the signals toward the negative side to compensate for wander of the zero toward the positive side of the original adjustment.

The time constant of this circuit being large, the correcting potential will be maintained for a few tenths of a second to compensate for the shift of zero from the original position of adjustment when, if necessary, a further correcting charge will be applied by subsequent contacts of the armature of the correcting relay with either contact point 20 or 21. Since condenser 17 discharges through resistance 36, a prolonged shift of the zero will cause the armature 19 to make contact again as soon as the first charge is dissipated sufficiently to permit a reestablishment of a small zero bias. If the zero reverts to its original setting the discharging of condenser 17 will prevent any "over correction". In other words, the correcting action will take place only during periods when such correction is necessary. If for any reason there should be an over correction or a sudden change in the signal zero to the opposite side the relay contact would immediately make contact on the opposite side discharging the condenser 28 and charging it oppositely.

According to the embodiment of the invention described above, when the zero of the signals has shifted beyond a certain maximum amount, the armature 19 in vibrating will engage one of the contacts 20 or 21, impressing a correcting potential on the condenser 28 which in turn will impress a correcting charge on condenser 17 to change the grid potential of discharge device 11 and thereby cause the zero of the signals to shift back toward the original position. The amount of bias or wander of the zero before applying a correction can readily be adjusted by changing the position of contacts 20 and 21 of the relay 16, by adjusting the restoring tension applied to the armature in opposition to the field of the actuating magnets, or by proper adjustment of the strength of the signal flowing through the windings 15 of the correcting relay 16.

In making the original adjustment of the correcting relay and apparatus and in maintaining the proper operation of the correcting circuit, a novel means is employed for

determining the setting of the relay. For this purpose an audible signal receiving means such as an ordinary loud speaker 40 is inserted in the correcting circuit. The contacts of the correcting relay are then adjusted so that the contact member 19 engages the contacts 20 and 21 with every impulse of an unbiased alternating current used for purposes of testing. With each engagement of the contact making member 19 with either contact 20 or 21 a loud click will be heard in the loud speaker. This is due to the alternate charging and discharging of the condenser 28 on the batteries 29 and 30. The relay operating current is then adjusted by means of the contact 24 and resistances 25 and 26 until the clicks in the loud speaker cease or until they indicate that only one contact is being engaged by the armature. This will be evident from the fact that the clicks in the loud speaker will be much weaker since the condenser 28 is then not entirely discharging but is merely receiving a small amount of current from one of the batteries to recharge it to its full capacity. Whichever contact is then being engaged is adjusted until no clicks are heard in the loud speaker.

In the ordinary operation of the correcting circuit when traffic of ordinarily unbiased nature is being received, there will not be more than one or two of these clicks in the loud speaker every minute.

It is not necessary that the condenser 17 be located in the grid circuit of the last stage of the amplifier, as, if proper precautions in circuit design are observed, it may be applied to any other stage of the amplifier or may be associated with any other elements of the circuit whereby a compensating influence can be impressed on the signals.

As illustrated a filter 37 may be inserted between the condenser 17 and the remainder of the control circuit in order to prevent disturbances by impulses having frequencies higher than the essential signaling frequencies from reaching the condenser. This is particularly desirable when the apparatus is employed in the vicinity of other signaling apparatus which may set up induced currents in any exposed conductors.

It is, of course, understood that the invention may be employed in connection with other control elements of the circuit or with other signaling systems than that herein described without departing from the spirit and scope of the invention.

What is claimed is:

1. In an electrical circuit, a relay, an armature for said relay movable with each of a series of variable electrical impulses, means for completing a circuit through said armature when and only when said impulses differ from a predetermined normal character, and means for restoring the normal character of the impulses effective upon said relay as a result of the closure of said circuit through the armature.

2. In an electrical circuit, a relay comprising an armature, an operating winding for actuating said armature in response to each of a series of variable electrical impulses, adjustable contacts to be engaged by said armature to complete a circuit, the adjustment of said contacts being such that said armature makes contact when and only when the amplitude of said impulses exceeds a predetermined maximum, and means selectively actuated in a different sense in accordance with which contact the armature engages.

3. In a signaling system, a relay having a movable armature the movement of which is substantially critically damped, which is capable of responding to each of a series of incoming impulses and circuit control means controlled by said armature, the adjustment of the combination being such that the armature moves in response to each impulse but with an amplitude which will not actuate said circuit control means when the impulses are of a certain character, impulses of a certain different character causing the armature to actuate said circuit control means selectively in accordance with the polarity of the impulses.

4. In a zero wander correction circuit, a relay including two fixed contacts, an armature contact for said relay movable in response to each of a series of positive and negative impulses, said relay being adjusted so that the armature contact will touch a fixed contact when and only when the amplitude of signals of either polarity is increased beyond a predetermined limit, and means to correct zero wander in accordance with the fixed contact touched by said armature contact.

5. In a signaling system, a relay, an armature for said relay movable in response to each of a series of variable electrical impulses, means for damping the movement of said armature so as to eliminate substantially all inertia effects, a contact moved by said armature and stationary contacts to be engaged by said armature contact for completing a circuit, the adjustment of said combination being such that said armature contact engages one of said stationary contacts only in response to a portion of said signal impulses, and means controlled by engagement of said contact for regulating the impulses acting upon the relay.

6. Terminal apparatus for submarine signaling conductors comprising a receiving circuit and a relay the armature of which is free from inertia effect and moves in response to each impulse but makes contact only in response to impulses of abnormal character, a compensating circuit associated

with the receiving circuit and controlled by said relay for compensating for the abnormal character of said impulses.

7. In a signal receiving circuit, the combination of means responsive to each of a series of signal impulses, means in circuit with said signal responsive means adapted to respond to signals of an amplitude greater than a predetermined value, and a condenser supplied with polarizing charge by operation of said second signal responsive means actuating the first mentioned signal responsive means for maintaining the zero axis of potential of the received signal impulses corresponding to the zero axis of potential of the transmitted impulses substantially constant.

8. In a signal receiving system, a signal receiving device, a relay controlled by the signals, said relay including an armature in constant vibration, and a correcting circuit comprising circuits having progressively larger time constants, the first of said elements being controlled by said relay and the last of said elements maintaining the zero axis of potential of the received signal impulses operating said signal receiving device substantially the same as that of the impulses transmitted.

9. In a signaling system, an amplifier, a circuit controlled by said amplifier, a relay controlled by said amplifier and adapted to make contact only in response to signals of abnormal character, a condenser connected to the input circuit of said amplifier for controlling the operation thereof, said relay controlling the charge on said condenser and means associated with said condenser for causing the charge thereon to compensate for the abnormal character of the signals.

10. In a signal receiving system, a receiving circuit, a condenser associated with said receiving circuit, a control circuit for said condenser comprising a second condenser, and a relay controlled by the signals and adapted to impress a charge on said second condenser in response only to abnormal signals, said second condenser controlling the charge on said first condenser, and means associated with said first condenser for causing the charge thereon to compensate for the abnormal character of said signals.

11. Terminal apparatus for submarine signaling conductors comprising a receiving amplifier, a correcting circuit connected to the input circuit of said amplifier, and including a condenser, a relay controlled by the signals, and adapted to make contact only in response to abnormal signals, and a source of potential connected in circuit with said condenser by the operation of said relay to correct for the abnormal character of the signals, whereby the zero axis of potential of the signal impulses in the output of said amplifier is maintained substantially the same as that corresponding to the zero axis of potential of the transmitted signals.

12. Terminal apparatus for submarine signaling cable comprising a receiving circuit, a correcting circuit associated with said receiving circuit, and including a condenser, a relay controlled by the signals and adapted to make contact only in response to abnormal signals, a source of potential connected in circuit with said condenser by the operation of said relay to correct for the abnormal character of the signals, and means to shield said condenser from high frequency disturbances in the correcting circuit.

13. In a submarine cable signal receiving device, a relay controlled by the signals and a corrective circuit for maintaining the zero axis of potential of the received signal impulses operating said signal receiving device substantially the same as that corresponding to the zero axis of potential of the signals transmitted, said corrective circuit comprising a condenser, a resistance element, means comprising a contact moved by the armature of said relay for charging said condenser through said resistance element, a second condenser, a second resistance element and means for charging said second condenser through said second resistance element from said first condenser.

14. In a submarine cable signal receiving device, a relay controlled by the signals and a corrective circuit for maintaining the zero axis of potential of the received signal impulses operating said signal receiving device substantially the same as that corresponding to the zero axis of potential of the signals transmitted, said corrective circuit comprising a condenser, a resistance element, means comprising a contact moved by the armature of said relay for charging said condenser through said resistance element, a second condenser, a second resistance element, means for charging said second condenser through said second resistance element from said first condenser, and a high resistance leak path through which said second condenser may discharge.

15. In a submarine cable signal receiving system, a signal receiving device, a relay controlled by the signals and a corrective circuit controlled by said relay for maintaining the zero axis of potential of the received signal impulses substantially the same as that corresponding to the zero axis of potential of the signals transmitted, said corrective circuit comprising a condenser, a charging circuit therefor including a contact moved by the armature of said relay, a second condenser and a discharge circuit for said first condenser including said second condenser.

16. A submarine cable signal receiving system, a signal receiving device, a space discharge voltage controlled relay for repeating received signals, a condenser, a relay

controlled by said space discharge relay for charging said condenser when and only when signals are received which deviate a certain amount from those normally transmitted, and means for causing the charging and discharging of said condenser to vary the control potential of said space discharge relay.

17. A submarine cable signal receiving system, a signal receiving device, a space discharge, voltage controlled relay for repeating received signals, a condenser, a relay having contacts and two oppositely poled sources of potential controlled by said contacts for charging said condenser when and only when signals are received which deviate a certain amount from those normally transmitted, and means whereby the charging of said condenser varies the control potential of said space discharge relay.

18. A submarine cable signal receiving system, a signal receiving device, a space discharge voltage controlled relay for repeating received signals, a condenser, a relay controlled by space discharge relay for charging said condenser when and only when signals are received which deviate in a certain manner and amount from those normally transmitted, a second condenser associated with the input circuit of said space discharge relay and means whereby the potential of said first condenser controls the operating potential of said space discharge relay.

19. In combination, a signal responsive device, a signaling circuit for impressing signals thereon, a correcting circuit comprising terminals connected to said signaling circuit, contacts operated by said device in response to an abnormal signal for applying a correcting voltage to said terminals, and means between said terminals and the source of correcting voltage for smoothing out the abrupt changes in voltage which might otherwise be caused by operation of said contacts.

20. In an electrical system a series of circuits having progressively larger time constants, means responsive to each of a series of impulses, the first of said circuits being completely actuated under the influence of said means by an impulse of very short duration and the last of said circuits being actuated completely only in response to the accumulative effect of a plurality of impulses.

21. In a signaling circuit a plurality of relays in circuit, one of which relays is actuated by received signals and another of which is responsive to each signal impulse received, but operated only in response to signals of an abnormal character.

22. In a signal receiving circuit a receiving relay and a correcting relay in circuit with said receiving relay, said receiving relay being responsive to all received impulses and said correcting relay being responsive only to impulses of abnormal amplitude.

23. In a submarine signaling circuit a signal receiving amplifier, a plurality of signal responsive devices in the output of said amplifier, and an adjustable series and shunt resistance for each of said signal responsive devices for controlling the proportion of the total current received by each device without altering the current through the other devices.

24. A telegraph receiving system comprising the usual receiving apparatus and additional means for indicating audibly a departure of the zero axis of received impulses to a predetermined extent from normal conditions.

25. A telegraph receiving system comprising the usual receiving apparatus and additional means including a telephone receiver as an indicating element for indicating audibly a departure of the zero axis of received impulses to a predetermined extent from normal conditions.

In witness whereof, I hereunto subscribe my name this 1 day of May A. D., 1926.

AUSTEN M. CURTIS.