

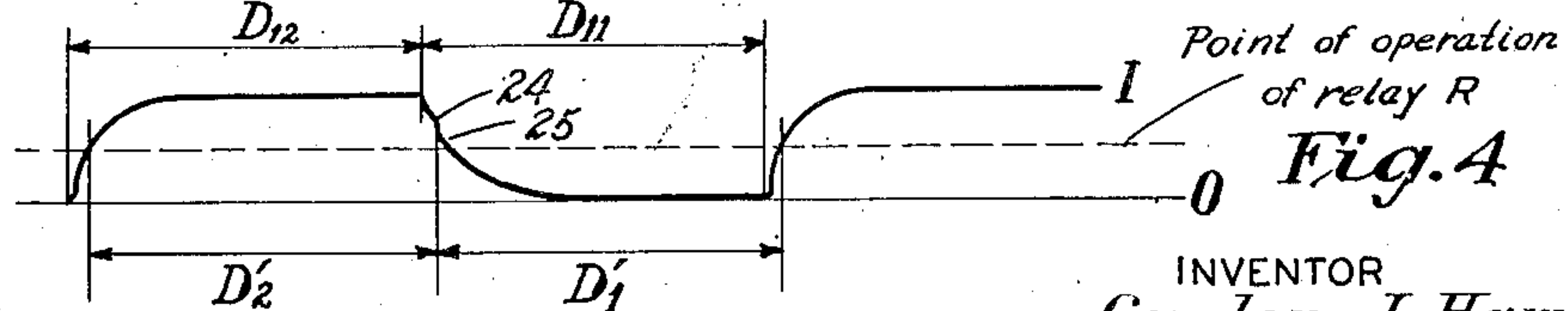
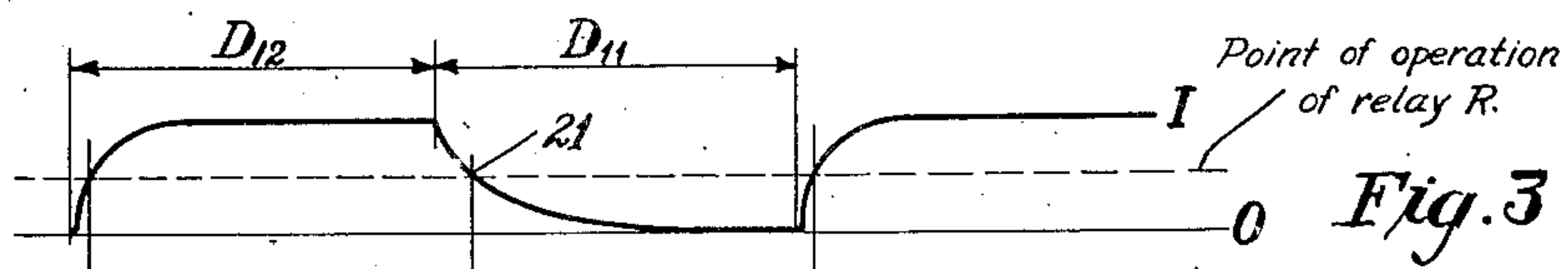
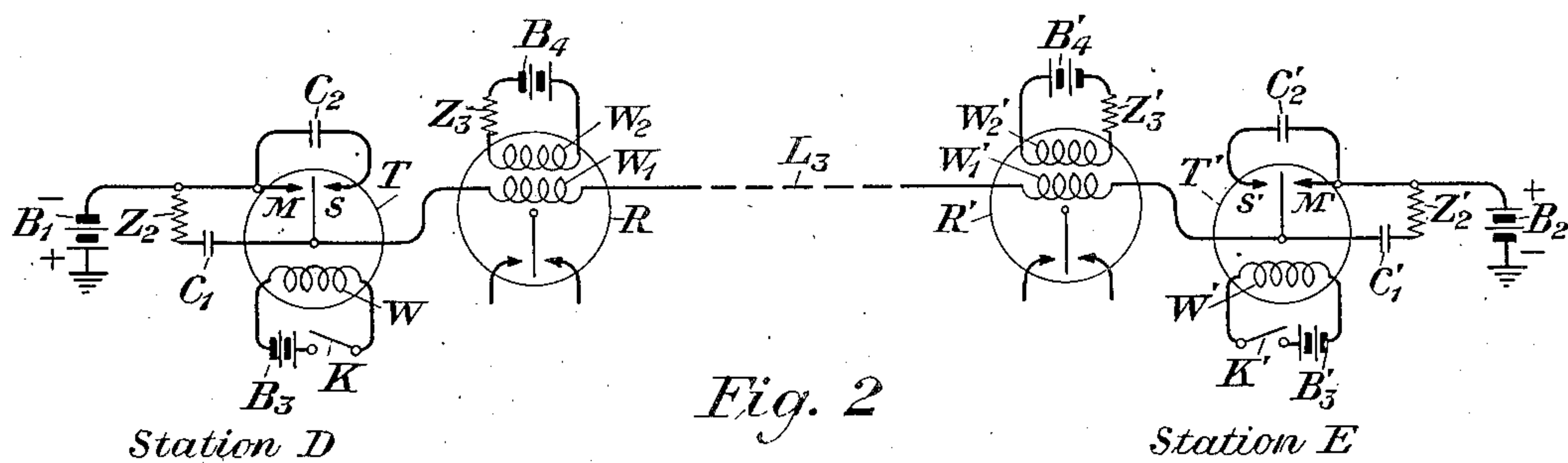
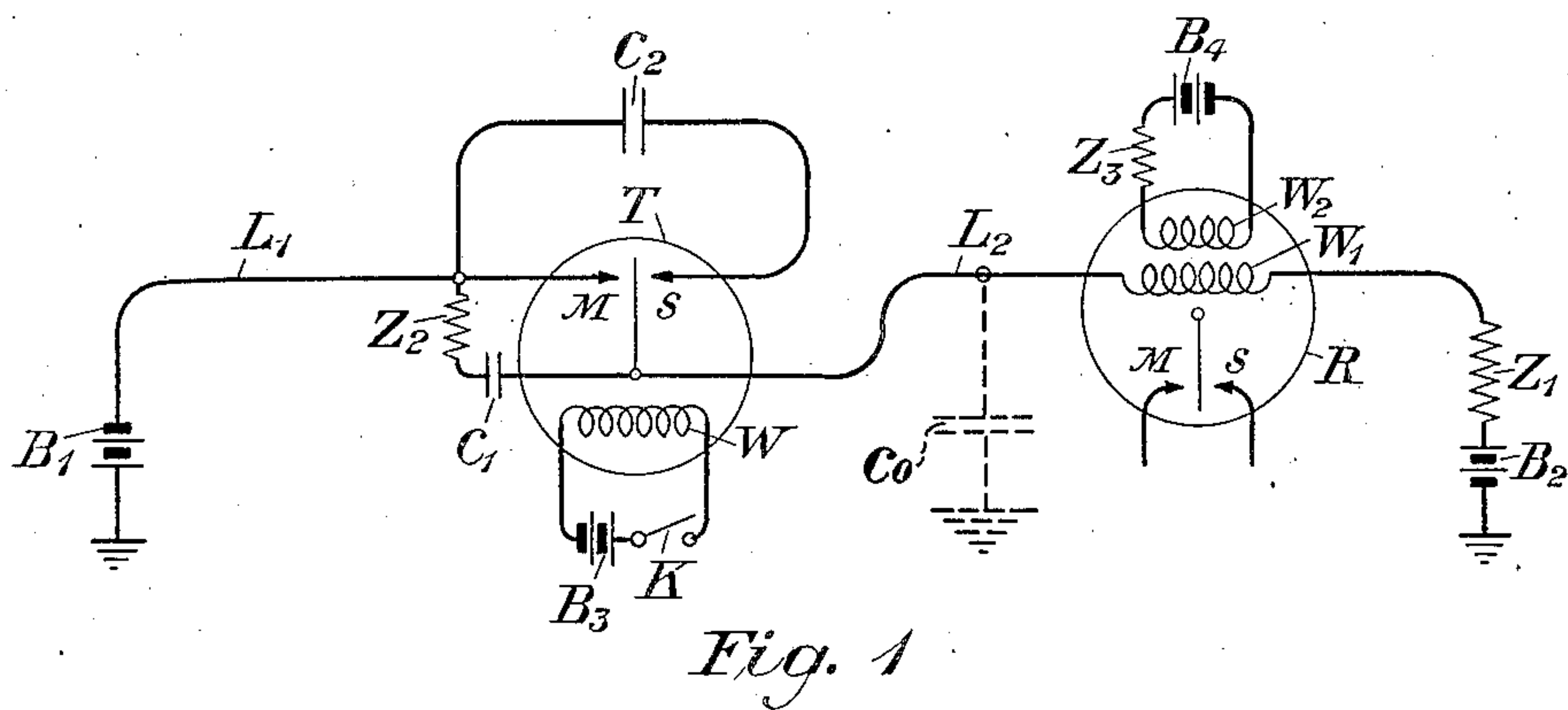
Nov. 12, 1940.

G. J. HARMS

2,221,136

TELEGRAPH SYSTEM

Filed Feb. 1, 1939



INVENTOR
Gordon J. Harms
BY William H. Ballard
ATTORNEY

UNITED STATES PATENT OFFICE

2,221,136

TELEGRAPH SYSTEM

Gordon John Harms, Kansas City, Mo., assignor
to American Telephone and Telegraph Com-
pany, a corporation of New York

Application February 1, 1939, Serial No. 254,105

19 Claims. (Cl. 178—68)

This invention relates to telegraph circuits and systems. More particularly, this invention is intended to provide arrangements for reducing or eliminating signal distortion in telegraph systems.

In neutral telegraph systems signals may be transmitted under the control of a relay the armature and marking contact of which are arranged to close the line or loop so as to cause current to flow and thus produce a marking pulse, and to interrupt the current flow or open the circuit to produce a spacing pulse. To reduce sparking at the contacts of the relay as its armature travels back and forth interrupting the line circuit, a so-called "spark-killer" is usually employed, the "spark-killer" comprising a resistor and condenser connected in series with each other between the armature and the marking contact of the relay. As the armature leaves the latter contact, the condenser becomes charged and remains charged until the armature later returns to that contact at which time the condenser becomes discharged through the resistor.

In such neutral telegraph systems, the circuit has a finite impedance when the circuit is closed for producing the marking pulse, but the impedance of the circuit is increased considerably, to an infinite value for direct current, when the line circuit is opened for producing the spacing pulse. Thus the impedance of the circuit is variable between two widely different values during signaling. These circuit impedance changes cause the growth of current at closure to differ from the decay at opening and this results in lengthening of one of the pulses relative to the other, as is well known.

The average lengthening of one of the pulses relative to the other is a type of distortion called "signal bias." This may be so large due to the circuit characteristics as to seriously affect transmission quality.

It is an object of this invention to reduce or eliminate signal bias in telegraph transmission over circuits of the type referred to.

It is another object of this invention to produce well-defined signals in neutral telegraph systems by reducing or eliminating distortion.

These and other objects of the invention will be better understood from the detailed description hereinafter following when read in connection with the accompanying drawing in which Figure 1 shows schematically a telegraph circuit broadly illustrating the features of this invention and Fig. 2 shows a telegraph circuit suitable for two-way transmission.

Fig. 1 of the drawing shows a schematic of a form of neutral telegraph circuit to which the invention has been applied merely for purposes of illustration. The circuit comprises battery B₁, conductor L₁, the contact M and armature of a

sending relay T, the line conductor L₂ with its grounded capacity C₀ (shown in dotted lines), the winding W₁ of a receiving relay R, the resistor Z₁, the battery B₂ and ground. The contact M and armature of the sending relay T are connected by a series circuit comprising resistor Z₂ and condenser C₁. These form the so-called spark-killer circuit. The winding W of relay T may be connected to a battery B₃ and a key K the key K being employed for initiating the marking and spacing impulses. The winding W₂ of the receiving relay R may be connected in series with a resistor Z₃ and a battery B₄. The latter circuit is known as a "biasing" circuit. The telegraph circuit so far described is of well known type and in this circuit the relay T may be omitted if desired, the conductors L₁ and L₂ being then interconnected by the key K with the spark-killer circuit bridging the lever of the key K and its marking contact. To this telegraph circuit of well-known type a condenser C₂ is added, this condenser being bridged across the contacts M and S of the relay T in accordance with this invention.

The operation of the circuit of Fig. 1 will now be described, assuming for the present that the condenser C₂ is omitted as in the prior art, and that the line conductor L₂ does not have grounded capacitance as represented by C₀. If the key K is closed, the armature of the relay T will close its marking contact M. Current will then flow from batteries B₁ and B₂, which are arranged to be series aiding, this current traversing the winding W₁ of the receiving relay R and the resistor Z₁. The armature of the relay R will then close its marking contact M to register a marking pulse. When the key K is subsequently opened, the armature of relay T will leave its marking contact M and will then close its spacing contact S, thereby interrupting the flow of current from batteries B₁ and B₂. The current in winding W₁ of relay R will then decay to a zero value. The armature of the relay R will then travel to its spacing contact S to register a spacing pulse.

The decay of current for the spacing pulse will generally occur at a substantially different rate from the rise of current for the marking pulse. The difference between the two rates of current variation is due to the impedance changes of the line circuit between the marking and spacing conditions, and is also due to the presence of the spark-killer in the circuit. The condenser C₁ of the spark-killer circuit will be charged by batteries B₁ and B₂ whenever the armature of relay T is separated from its contact M. Condenser C₁ will be discharged through resistor Z₂ when the armature of relay T rests upon its contact M.

Thus on initiating a spacing interval, current will flow through the line conductor L₂ to charge

condenser C_1 for a time, and this current will gradually decay to zero, as is indicated at 21 of Fig. 3 for the spacing interval D_{11} . The length or duration of the spacing impulse recorded by relay R will hence be modified, i.e. shortened by the flow of this charging current. The duration of the spacing pulse as recorded by relay R, is illustrated in Fig. 3 by the reference character D_1 . But the marking impulse will begin almost immediately after contact M of relay T is closed, if the reactance of the circuit is small. The length of the marking pulse as recorded by relay R, is designated D_2 in Fig. 3. The times during which the armature of relay T closes its spacing contact S and its marking contact M are also shown in Fig. 3, where they are designated D_{11} and D_{12} , respectively.

It will be observed from Fig. 3 that although the marking and spacing intervals are intended to be substantially equal, the unsymmetrical operating current traversing the winding W_1 of relay R results in a lengthening of the marking interval D_2 and a shortening of the spacing interval D_1 in the signals repeated by the relay R. This undesirable effect is known as marking bias. The neutral telegraph circuit with its spark-killer circuit operates, as pointed out above, to establish a flow of current for each marking signal and to interrupt the current by opening the line circuit for each spacing signal. Such a circuit commonly involves what is known as signal bias. On the other hand, in a polar type of telegraph circuit the marking and spacing intervals are produced by oppositely poled batteries, and there is, therefore, no significant change in impedance between the marking and spacing conditions, and no such signal bias takes place. In polar circuits the wave shape is substantially symmetrical, i. e. the rate of growth of current is exactly or nearly the same as the rate of decay of current.

In accordance with this invention the advantages of the polar type of telegraph circuit above referred to may be obtained in a neutral telegraph circuit without actually having two separate and distinct transmitting batteries. This advantage may be obtained merely by connecting a suitable condenser, such as that designated C_2 in Fig. 1, across the marking and spacing contacts M and S of the sending relay T.

When the condenser C_2 is employed it will be seen that when the armature of relay T is on its contact S, the condenser C_2 will be charged to a voltage equal to the sum of the voltages of the batteries B_1 and B_2 . Likewise the condenser C_1 of the spark-killer will be charged to this same voltage. When the armature of relay T moves to its marking contact M in response to a marking signal, current will flow through the winding W_1 of relay R to register a marking pulse, but condenser C_2 will remain fully charged, except for the unavoidable leakage which for practical purposes is negligible. While contact M of relay T remains closed, the spark-killer condenser C_1 becomes discharged through its own resistor Z_2 .

Just as soon as the armature of the sending relay T opens its marking contact M, the batteries B_1 and B_2 will begin charging condenser C_1 over a circuit which includes the battery B_1 , the conductor L_1 , the resistor Z_2 , condenser C_1 , the line conductor L_2 , the winding W_1 of relay R, the resistor Z_1 , the battery B_2 and ground. Much before the charge of condenser C_1 is completed, the armature of relay T will touch its spacing contact S and condenser C_2 , being fully charged, will

act to rapidly complete the charge on condenser C_1 . If condenser C_2 is large compared to condenser C_1 , the charge on condenser C_2 will not be much reduced by this process. The current flowing in the line conductor L_2 will immediately fall to a negligible value. Condensers C_1 and C_2 will thus be charged fully to the voltage of batteries B_1 and B_2 by this current flow. The presence of this small current flowing after the operation of relay R to its spacing contact will, of course, have no effect upon the spacing signal reproduced by relay R. The important feature, however, is that the comparatively gradual decay of current experienced before condenser C_2 was added to the circuit has now been changed to a comparatively rapid decay and the signals reproduced by relay R will be improved thereby.

Fig. 4 shows a graph of the operating current in the case in which the condenser C_2 has been added to the circuit. It will be seen that the comparatively slow decay of current illustrated at 21 of Fig. 3 during the spacing interval is changed to a rapid decay, as shown at 24 and 25 of Fig. 4. The spacing and marking intervals during which the relay R registers the spacing and marking signals respectively are designated D_1' and D_2' in Fig. 4, and it will be observed that the disparity between these intervals in the signals registered by relay R is considerably reduced. Upon the addition of the condenser C_2 across the marking and spacing contacts of the relay T, the neutral telegraph circuit is thus converted in practical effect, so far as the operation of the circuit is concerned, to the polar type of circuit with the accompanying improvement in transmission.

Condenser C_2 is chosen large enough in capacity so that it will be able to complete the charge of condenser C_1 of the spark-killer circuit when the contact S of relay T is closed without itself dropping appreciably in voltage. In one arrangement tried out the condenser C_2 was of 4 m. f. capacity—16 times as large as condenser C_1 , which was $\frac{1}{4}$ m. f. capacity. The resistor Z_2 was of 1,600 ohms. It was also found that the capacity of condenser C_2 could be varied over a wide range without appreciably affecting transmission.

If desired, a resistor may be inserted in series with the condenser C_2 to reduce the tendency of the circuit to oscillate and also to reduce any sparking which might exist when the armature of relay T closes its spacing contact S.

To recapitulate: The condenser C_2 of large capacity is first charged to a voltage equal to that of batteries B_1 and B_2 which, for the sake of convenience, will be called the line or battery voltage. This occurs whenever the armatures of the sending relay T closes its contact S. The line or battery voltage is also applied to the smaller condenser C_1 of the spark-killer circuit but the charging rate is somewhat held down by the resistor Z_2 which is interposed in the path of the condenser C_1 . When the armature of relay T later closes contact M, current will flow through the winding W_1 to register a marking pulse, but condenser C_2 will remain fully charged except for unavoidable leakage which, for practical purposes, is negligible. While contact M remains closed, the spark-killer condenser C_1 becomes discharged through its own resistor Z_2 .

Just as soon as the armature of the sending relay T opens its contact M, the line battery will again charge the condenser C_1 to a voltage approaching that of the battery voltage. When the

armature of relay T then closes its contact S, the condenser C₂ will rapidly complete the charge of condenser C₁, through resistor Z₂ and because of its large relative size, the voltage of condenser C₂ will not be much reduced. And while contact S remains closed, the voltage of condenser C₂, which is approximately equal and opposite to that of the line battery, will fully oppose the line battery voltage and therefore no current will flow through the winding W₁ of the receiving relay R. Hence the relay R will register a spacing signal. These conditions will be repeated again and again as the sending relay armature travels back and forth between its contacts.

In the circuit of this invention, the spark-killer circuit of resistor Z₂ and condenser C₁ may be omitted if so desired. The spark-killer circuit may be omitted, for example, when arcing at the relay contacts is small or of no consequence. In that event when contact S of relay T is closed, the condenser C₂ which has previously been charged to the line or battery voltage, will oppose the line or battery voltage and the receiving relay R will register a spacing signal. But when contact M of relay T becomes closed, the line battery current will energize the winding of relay R which will then register a marking signal.

The schematic circuit of Fig. 1 has been described as a one-way telegraph system for transmitting marking and spacing signals from the point where relay T may be located over line conductor L₂ to a possibly different point where relay R may be located. However, two-way transmission may be accomplished by a circuit such as that illustrated in Fig. 2.

In Fig. 2, the batteries B₁ and B₂ are poled so as to be series aiding as in Fig. 1. The apparatus at the two ends of the line L₃ are otherwise duplicates, the apparatus at station E being indicated by reference characters which are primed with respect to the same apparatus at station D. It will be understood, of course, that the armature of relay T' will be maintained at contact M' when signals are to be transmitted from station D to station E, and that the armature of relay T at station D will be held at its contact M when signals are to be transmitted from station E to station D.

When signaling from station D to station E, the voltage applied to condenser C₂ will oppose the voltages of batteries B₁ and B₂ taken together whenever the armature of relay T closes its spacing contact S. A spacing signal will then be registered by both receiving relays R and R'. Similarly, the condenser C₂' will have a voltage at charge which will oppose the total line voltage whenever the armature of relay T' closes its spacing contact S₁ as when signaling from station E to station D. And in the circuit of Fig. 2, the spark-killer circuits C₁ and Z₂ and C₁' and Z₂' may be omitted if so desired. Furthermore, a single battery may be used in place of the two batteries shown.

It will be understood that any number of transmitting (and receiving) relays may be added in series with each other for signaling between any number of stations. This series arrangement cannot be employed with the typical differential telegraph system which, as is well known, employs a circuit which connects oppositely poled batteries to the line for producing the marking and spacing signals. The advantages of the present invention are that the condensers C₂, C₂', etc. do not involve any battery poling considerations whatever, the circuit impedances are main-

tained substantially constant, and signal bias is substantially reduced or eliminated. In using the circuit of the invention, however, the charges of condensers C₂, C₂', etc. will be somewhat dissipated after a long marking interval and the condenser charges must be restored before signal distortion will be eliminated.

The biasing circuit of the receiving relay, i. e. the circuit of winding W₂, resistor Z₃ and battery B₄ of Fig. 1, for example, should preferably have a high resistance. It has been found that the circuit of the invention will operate very satisfactorily if the resistance of the bias circuit is made at least as high as the resistance in the line or loop. A low resistance for the bias circuit will introduce considerable signal distortion which is clearly undesirable.

While this invention has been shown and described in certain particular arrangements merely for the purpose of illustration, it will be understood that the general principles of this invention may be applied to other and widely varied organizations without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. In a neutral telegraph system, the method of signaling to a loop or line with a source of voltage and a condenser charged to the voltage of said source, which consists in sending current through said loop or line from said source to produce one type of pulse therein, and then applying the voltage of the condenser to the loop or line to oppose the voltage of said source and thereby suppress the flow of current through said loop or line to produce a different type of pulse therein.

2. In a neutral telegraph system, the method of signaling between two points with a source of voltage and a condenser charged to the voltage of said source, which consists in applying the voltage of said source between said points to send current therebetween, maintaining the condenser voltage substantially unchanged, and neutralizing the voltage between said points by opposing the voltage of said source by the condenser voltage to stop the flow of current between said points.

3. The method of sending signals in a telegraph system which consists in charging a condenser to a predetermined voltage, applying an equal voltage to produce one type of signal, and opposing the applied voltage with the voltage impressed on the condenser to nullify the effective voltage to produce another type of signal.

4. The method of signaling in a neutral telegraph system with a source of voltage and a condenser which consists in charging the condenser to the voltage of said source, applying the source of voltage to the system to transmit current in accordance with a marking signal, and then applying the condenser to the system so that its voltage will oppose the voltage of the source and thereby suppress the flow of current in accordance with a spacing signal.

5. In an open-and-close telegraph system, a source of potential, a condenser, a line, a relay having two contacts between which said condenser is permanently connected, said line being connected in series with said source and the armature and one of the contacts of said relay, said condenser being effectively connected both to said line and said source only during the time when but one of the contacts of said relay is closed.

6. In a telegraph system, a sending device hav-

ing a vibrating member and only two terminals between which said vibratory member may move, a source of voltage connected between said vibratory member and one of its terminals, and a condenser permanently connected between both terminals of said device.

7. In a telegraph system, the combination of a sending armature which is movable between first and second contacts, a condenser permanently connected between said first and second contacts, a source of voltage, a load, said source being connected in series with said load and the armature and its first contact, and a spark-killer circuit connected between said armature and its first contact.

8. In a telegraph system, the combination of a sending relay, a receiving relay, a source of voltage, and a condenser permanently connected between the contacts of the sending relay, the source of voltage being connected in series with the receiving relay winding and the armature of the sending relay and one of its contacts.

9. In a telegraph system, the combination of a sending relay, a receiving relay, a source of voltage, a first condenser of large capacity connected across the fixed contacts of the sending relay, a spark-killer circuit including a second condenser of small capacity, the source of voltage being connected with the receiving relay winding and the armature and one of the contacts of the sending relay, the spark-killer circuit being connected to the armature and the same contact of the sending relay.

10. In a telegraph system, the combination of a source of voltage, a member which is movable between two contacts, and two circuits containing capacitances of different magnitudes, the circuit of larger capacitance being connected between said two contacts, the circuit of small capacitance being connected between said movable member and one of its contacts, and a load connected between said source of voltage and said movable member and the latter contact.

11. In a telegraph system, a source of voltage, a loop, a condenser which is normally charged to the voltage of said source, means for producing a marking impulse in said loop by connecting said source thereto, and means for producing a spacing impulse in said loop by connecting said source and said condenser to said loop so that the voltage of said condenser will oppose that of said source.

12. In a telegraph system, a source of voltage, a condenser, a loop, means for sending current from said source through said loop for producing one type of telegraph signal therein, and means for substantially reducing the current flowing from said source to said loop to produce another type of telegraph signal therein, said latter means including means to connect the condenser to said source through the loop so that the charge on the condenser will oppose the flow of current from said source.

13. In a telegraph system, a relay, a spark-killer circuit connected between the armature and one of the fixed contacts of the relay, and a con-

denser connected between both fixed contacts of the relay, the spark-killer circuit comprising a resistor and a second condenser connected in series.

14. A telegraph system comprising a line, a source of voltage, a receiving relay, a sending relay, the line being connected in series with said source and the receiving relay winding and the armature and one of the fixed contacts of the sending relay, a spark killing circuit comprising a series connected resistor and condenser connected between the armature and the same contact of the sending relay, and a second condenser connected across both fixed contacts of the sending relay.

15. In a telegraph circuit, a source of voltage, a transmitting relay having an armature and two contacts, a condenser, means for charging said condenser to the voltage of the source when the armature closes one of its contacts, the condenser charge remaining substantially unchanged after the armature leaves the latter contact, and means for transmitting a substantial current from said source when said armature closes its other contact.

16. In a neutral telegraph circuit, a source of voltage, a condenser charged to the voltage of said source, a load device, means for producing a marking signal at said load device by allowing current to flow from said source through said load device, and means for producing a spacing signal at said load device by opposing the voltage of the condenser against the voltage of said source.

17. In a neutral telegraph system, the combination of a line over which marking and spacing signals are to be transmitted by the flow of current or the absence of current, respectively, the combination of a source of voltage, means for intermittently connecting said source to said line to transmit marking current thereover, a condenser, means for charging said condenser to the voltage of said source, and means connecting said source and said condenser to said line so that both will oppose each other for conveying a spacing signal over said line.

18. In a telegraph circuit having an element movable between two contacts for opening the circuit to establish a spacing signal and for closing the circuit to establish a marking signal, means for maintaining the impedance of the circuit substantially constant for the frequencies employed during signaling, said means comprising a condenser connected between the two contacts of said element.

19. In a telegraph circuit including a keying device having two fixed terminals, one terminal being contacted for opening the circuit for a spacing pulse, the other terminal being contacted for closing the circuit for a marking pulse, means for avoiding undesirable changes in impedance between the marking and spacing conditions, said means comprising a condenser permanently connected to the terminals of said keying device.

GORDON JOHN HARMS.