Feb. 18, 1930. H. ANGEL 1,747,853

PREVENTING DISTORTED SIGNALS AND WANDERING ZERO IN CABLE TELEGRAPHY

Filed June 3, 1927 2 Sheets-Sheet 1

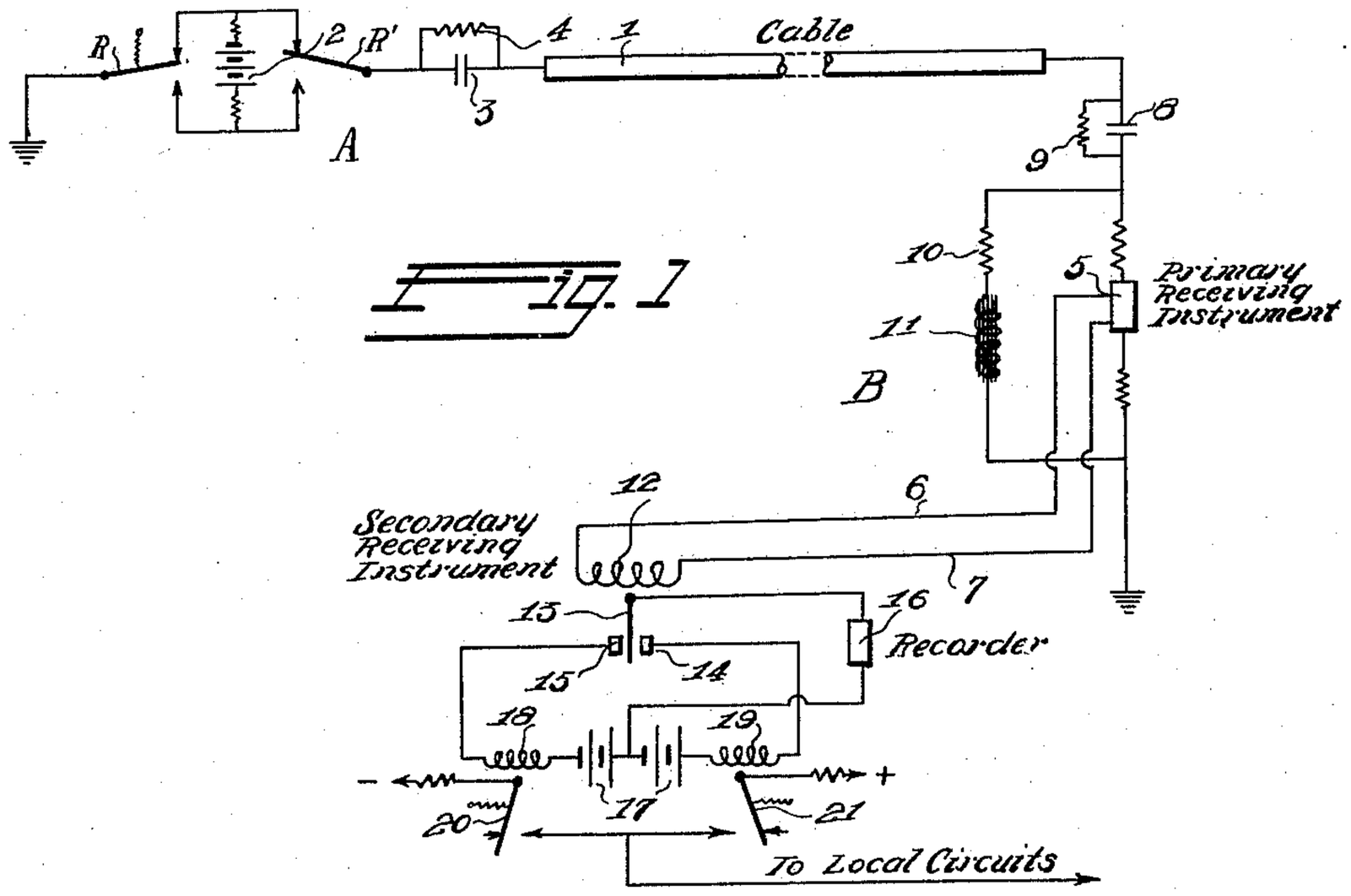

Fig. 1

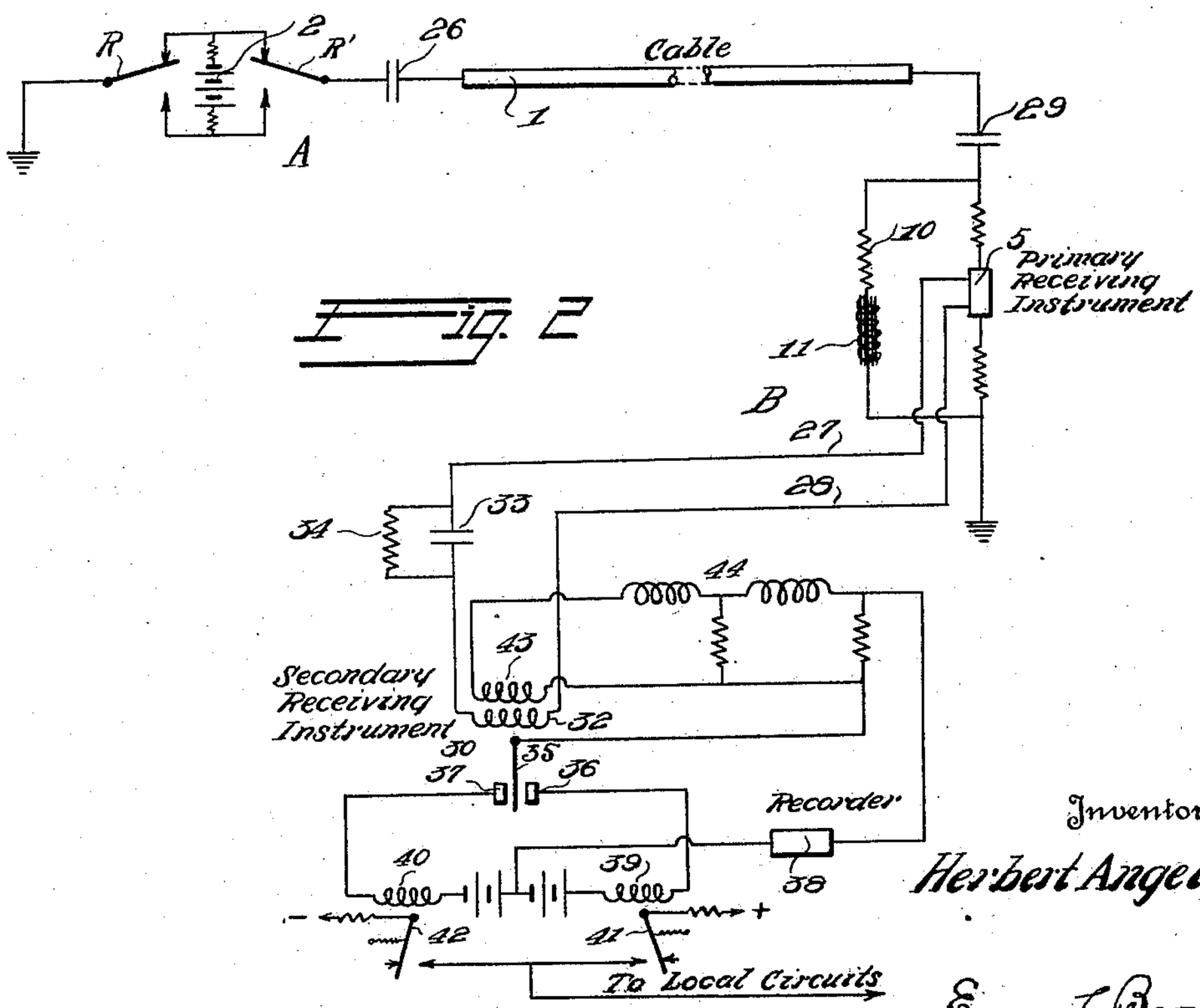

Fig. 2

Inventor

Herbert Angel

Eugene C. Brown

Attorney

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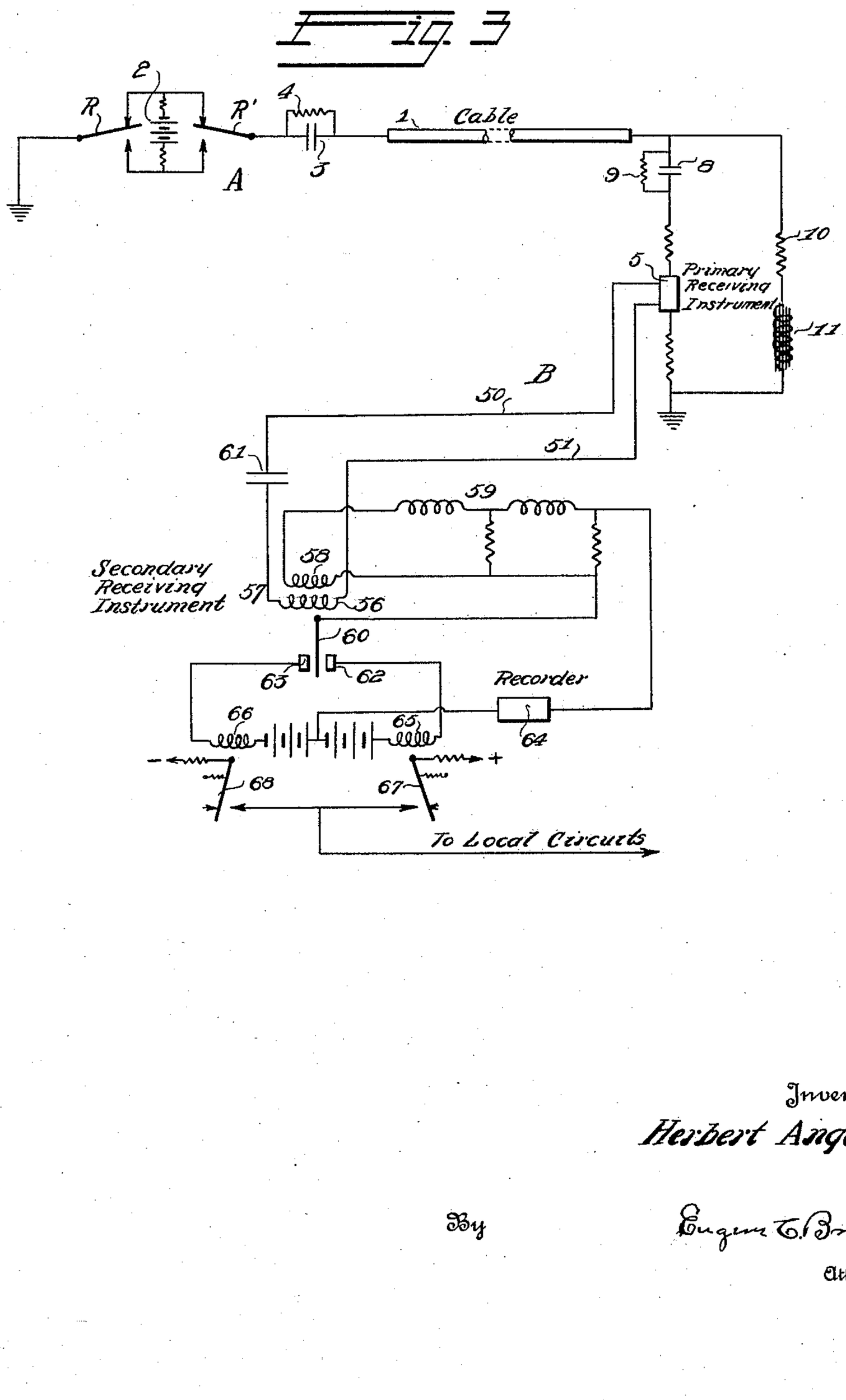
Fig. 3



Inventor
Herbert Angel

By Eugene T. Brown
Attorney

Patented Feb. 18, 1930 1,747,853

UNITED STATES PATENT OFFICE

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

PREVENTING DISTORTED SIGNALS AND WANDERING ZERO IN CABLE TELEGRAPHY

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The invention relates to signalling systems and more particularly to the transmission of telegraph impulses over long cables.

It is well known that at high speed of transmission over a long cable, the signalling cable is unable to discharge itself as rapidly as the signals are being transmitted. As a result, a charge gradually collects on the cable which results in a shifting of the zero position from the true zero to a value, either above or below, depending upon the character and speed of impulses. This phenomena is known as the "wandering zero." Considerable distortion of the signal wave shape is produced at the receiving apparatus due to this "wandering zero," and, if left to continue, the signal becomes so distorted at the receiving apparatus that inaccurate signal recording results.

The difficulties experienced with the wandering zero are partially overcome by employing as signalling codes, impulses of reverse polarity. This type of code considerably aids the cable in discharging impulses. Such a signal code would be ideal if each impulse were of the reverse polarity from the preceding one and of the same length. The result would be periodic, positive and negative impulses which would enable the cable to discharge and by the very character of the impulse, would prevent a wandering of the zero line.

However, the Morse code comprises dash impulses represented in this code by impulses of the same polarity following each other. In such cases a greater charge of one polarity is impressed upon the line than of the opposite polarity, with the result that the cable tends to gather a charge either of one polarity or the other depending upon the impulses.

An arrangement for minimizing the effect of the wandering zero is provided by employing condensers connected in the line at both ends of the cable. These condensers if properly designed with respect to the capacity of the cable itself, will so react with the cable as to prevent the accumulation of a charge in the cable and thereby prevent the "wandering zero" effect.

Not only is the speed of signalling considerably impeded, by reason of the wandering zero effect noted above, but, due to other inherent characteristics of the cable such as inductive surges from adjoining regions, the wave shape of the signal is considerably distorted, so much so that at times it is impossible to detect the true wave shape at the receiving end.

In order to overcome this difficulty, provision is made in the form of correcting networks comprising condensers and inductances in the cable circuit at the transmitting end which function to impress a wave shape of such a character on the cable that after being affected by the distorting effects noted above, it will be received at the receiving end in true wave shape. This is further aided by employing a similar correcting network at the receiving end of the cable. The resultant effect of the network for impressing a predetermined wave shape at the transmitting end and a network at the receiving end for correcting the wave shape, results in a wave shape approximating that impressed on the cable by the transmitter.

Here again however, considerable difficulty is experienced by reason of the fact that while the correction of the wave shape to overcome the distorting effects is made, the inherent wandering zero effect of the receiving instrument plus the wandering zero produced in the cable by earth currents, etc., still distorts the signal impulse. It is therefore highly desirable to provide some arrangement whereby the wave shape can be corrected for distortion while at the same time the wandering zero effect is eliminated.

An object of my invention is to provide means for producing a pure wave at the receiving end of the line similar to the wave shape of the transmitted impulse.

Another object of my invention is to provide in a system for transmitting impulses over a long cable at a high speed, means for approximating the wave shape of the transmitted impulse.

Still another object of my invention is to provide a method of telegraph signalling over a long cable which comprises the step of correcting for the distortion induced in the

cable, repeating the corrected wave and thereafter correcting for the wandering zero effect.

Other objects of my invention which together with the foregoing will appear in the specification which follows in which:—

Fig. 1 is a circuit diagram showing circuit arrangements and the apparatus for correcting for distorted wave shapes.

Fig. 2 shows circuit arrangements and apparatus for correcting for the wandering zero effect, and

Fig. 3 shows the circuit arrangement and apparatus for the preferred form of my invention in which the wandering zero effect is eliminated while at the same time the wave shape of the impulse is properly corrected.

Referring to Fig. 1, a transmitting station A, and a receiving station B are shown connected by a cable 1. At the transmitting station there is provided a battery 2, arranged to impress voltages of predetermined wave shape upon the cable 1 under control of the armatures R and R_1 of transmitting relays (not shown). These armatures R and R_1 may be operated in any of the well known Wheatstone transmitting arrangements, such for example, as shown in the patent to Benjamin 1,447,747. Connected between the sending relays and the cable 1, is a sending condenser 3 which is shunted by the sending condenser shunt resistance 4. By properly designing the sending condenser 3 and resistance 4, the signal impressed on the cable 1 can be made of such a shape that the distorting effects thereon will produce a corrected wave shape at the receiving end, approximating the shape of the wave impressed by the sending relays R and R_1.

At the receiving end B of the cable, there is provided a primary receiving instrument 5 which may be of any suitable type, such for instance as the Heurtley hot wire type, similar to that shown in the patent, No. 1,029,123. This is arranged in the well known manner to repeat the impulses received over the line 1 in accordance with the character of the impulses received. Arranged between the cable 1 and the primary receiving instrument 5, is a receiving condenser 8, shunted by a resistance 9. The receiving condenser 8 and the resistance 9 comprise a correcting network which functions to correct for distortion to the wave shape produced in the transmission of the signals over the cable. Shunted across the primary receiving instrument 5 is a resistance 10 and an inductance shunt 11, which corrects for the distortion of the wave shape in the primary receiver 5.

The conductors 6 and 7, connected to the secondary receiving instrument 12 conduct the signals repeated under the control of the primary receiving instrument 5 for operating the relay armature 13 to either of its contacts 14 or 15, in accordance with the impulses transmitted thereto from the primary receiving instrument. This secondary receiving instrument may be one of the usual types such as the well known rotating drum type, and as the armature 13, is moved either to the right or left across "no man's land" it engages with the right hand contact 14 or the left hand contact 15.

Connected to the armature 13 of the secondary receiving instrument 12 is a recording instrument 16 which is operated as the armature 13 moves into engagement with its left or right hand contact, for making a record of the received signals. The recording instrument is connected to the midpoint of the battery 17 and in series with either winding 18 or 19 depending upon the contact with which the armature 13 engages. The windings 18 and 19 control the movement of the armature contacts 20 and 21 respectively, which in turn, control a local circuit in a well known manner. Since this is not part of the present invention, the local circuit is not shown in detail.

It will be noted from the above arrangement that although a correcting network is provided at the transmitting and receiving end for correcting for the wave shape of the received signal, no provision is made for overcoming the effect of the wandering zero, with the result that the impulse repeated over the conductors 6 and 7 by means of the primary receiving instrument is distorted, not only due to the wandering zero of the cable itself, but also to the wandering zero effect of the primary receiving instrument 5. This distorted signal is repeated to the secondary receiving instrument for operating the recording device and local receiving apparatus.

Fig. 2 shows a circuit arrangement and apparatus for overcoming the wandering zero effect. In this figure, the stations A and B are connected by the cable 1, of such length that as the speed of transmission is increased, the capacity of the cable does not permit of sufficiently rapid discharge of the current impulses and produces, as a result, the wandering zero effect.

The sending apparatus at station A, as before, comprises two armatures R and R_1 controlled by relays which may be operated by a standard Wheatstone transmitter arrangement similar to that described in the patent referred to above, and are arranged to impress impulses of reverse polarity from the battery 2 as well understood. Connected between the transmitter at station A and the cable 1, is a sending condenser 26, which, as will be noted, is unshunted.

At the receiving end B there is provided a primary receiving instrument 5 of any standard type such as the Heurtley type, which is arranged to repeat the received impulses over the conductors 27 and 28 in ac-

cordance with the character of the impulses received over the cable. Connected between the primary receiving instrument 5 and the cable 1, is a receiving condenser 29. A resistance 10 and an inductance shunt 11 are connected in shunt to the primary receiving instrument 5 to correct for distortion of the received impulse wave shape.

The main winding 32 of the secondary receiving instrument is connected in the circuit of conductors 27 and 28 in series with a local condenser 33 shunted by a resistance 34.

The armature 35 of the secondary receiving instrument 30, as it engages one or the other of its contacts 36 and 37, controls a recording instrument 38 and local relays 39 and 40, which in turn control local circuits over the armatures 41 and 42 respectively. Since this portion of the circuit is well known and is not part of my invention, it is not shown in detail.

The secondary receiving instrument 30 comprises in addition to the main winding 32, a secondary winding 43, which is connected in a local correcting circuit 44. In this modification it will be noted that the sending condenser 26 and receiving condenser 29 are unshunted for the purpose of preventing wandering zero effects. In practice however, it has been found that owing to the fact that the condensers are unshunted the cable has no means for shaping the signals during the transmission of the signals through the cable, a condition which results in producing a surge and wandering zero effect at the receiving end with the result that the impulse received at the primary receiving instrument is distorted considerably in wave shape from that impressed upon the cable at the transmitting end by the transmitting apparatus.

In order to partially correct for such distortion of the signalling wave, a local correcting network 44 is provided which is arranged to reshape the distorted signal in the secondary circuit. Due to the local shunted resistance 34 of the condenser 33, the inherent wandering zero effect produced in the primary receiving instrument 26 itself plus the wandering effects of the cable are impressed across the main winding 32 of the secondary receiving instrument so that the armature 35 is moved in response to a partially distorted wave.

For the purpose of overcoming the difficulties encountered in the systems above described and illustrated respectively in Figs. 1 and 2, I have devised a system wherein the "wandering zero" effect is eliminated and the signal impulses are transmitted to the receiving instrument without distortion in wave shape.

My invention is illustrated diagrammatically in Fig. 3. The stations A and B are connected by the cable 1 over which impulses transmitted at high speed are distorted in wave shape and which is subject to the wandering zero effect. The sending relays at the transmitting station A are illustrated conventionally as in the previous figures. The armatures R and R_1 control the polarity of the impulse impressed upon the cable from the battery 2 in accordance with the position assumed by these armatures under control of the sending relays in the well known manner. Connected between the cable and the sending apparatus is a sending condenser 3 shunted by a resistance element 4. This network of condensers and resistances is of such value as to correct for the wave shape in the cable 1, producing a correct wave shape, but does not take care of the "wandering zero" effect.

At the receiving end, there is provided a suitable primary receiving instrument 5, which may be of the Heurtley hot wire type, similar to that shown in the patent to Heurtley referred to above, and which is arranged to control the circuits 50 and 51 in accordance with the impulses received over the cable for operating the secondary receiving instrument in a manner to be described in detail hereinafter.

Connected between the primary receiving instrument 5 and the cable is receiving condenser 8 shunted by a resistance 9. The receiving network 8, 9, and the primary receiving instrument 5 are shunted by a resistance element 10 and an inductance 11. This network is such as to correct for the distortion of wave shape of impulses transmitted over the cable.

Connected in the circuit 50 and 51 is the main winding 56 of the secondary receiving instrument 57. In addition to this main winding, the secondary receiving instrument is also provided with a secondary local winding 58 which is connected in the local correcting circuit 59 which is controlled by the armature 60 of the secondary receiving instrument. A local unshunted condenser 61 is also connected in the circuit of the conductors 50 and 51 in series with the main winding 56 of the secondary receiving instrument 57.

The armature 60 under control of the windings 56 and 58 engages either the contacts 62 or 63 in accordance with the received impulses, thereby operating the recorder 64 in series with either the winding of relay 65 or relay 66, and the armatures 67 and 68 in turn control the local circuits. Since these local circuits are not a part of my main invention, it is unnecessary to illustrate them in detail.

It will be seen by a comparison of the organization shown in Fig. 3 with those shown in Figs. 1 and 2, that the desirable features of those circuits are incorporated in Fig. 3 while overcoming the defects of each. The network 3, 4, at the transmitting end and the network 8, 9, 10, 11 at the receiving end, cor-

rect for the distortion of the wave shape of the impulse impressed upon the cable so that the impulses for operating the receiving instrument are of a wave shape closely resembling the impulses impressed upon the cable at the transmitting end. However, since a complete circuit is provided, the condensers being shunted by resistances, no correction is here made for the wandering zero effect of the cable as well as that of the receiving instrument. By inserting the unshunted condenser 61 in the local circuits 50 and 51 of the output of the primary receiving instrument 5, the wandering zero effects of the primary receiving instrument and of the cable are prevented from entering the main winding 50 of the secondary receiving instrument 57.

The secondary receiving instrument in this case is actuated through its main winding 56 by condenser impulses through the local unshunted condenser 61. To reconstruct these impulses into their original shape the local correction circuit 59 is employed simulating as nearly as possible the shape of the signal impressed at the transmitting end of the line, and the armature 60 is therefore operated accurately in accordance with the impulses sent into the cable at the transmitting station A.

It will be obvious to engineers that instead of eliminating the "wandering zero" effect by means of the unshunted condenser 61 I may connect the leads 50, 51 to the winding 56 through a suitable transformer, the condenser and the transformer being different forms of transient energy transfer devices.

Although the invention has been shown in connection with a telegraph system, it is obvious that it has more general application, as in any signalling system wherein a long cable is employed over which impulses are to be transmitted at a very high rate of speed, such that the impulses are distorted due to the capacity effect of the cable and other extraneous influences and in which it is desired to correct for the distorted wave shapes.

I claim:—

1. In a signalling system, a first station, a remote station, a signalling line having a wandering zero characteristic, a signal receiving apparatus at a second station responsive to impulses transmitted over said cable from said first station, an output circuit connected to said receiving apparatus into which said impulses are repeated, a secondary receiving instrument in said output circuit and means including an unshunted condenser connected in said output circuit of said receiving apparatus operating to time the impulses supplied to said secondary instrument and for nullifying the effect for said wandering zero.

2. In a signalling system, a cable over which signals are distorted due to wandering zero, a receiving apparatus arranged to be operated by said impulses, an output circuit for repeating the impulses received by said receiving apparatus, a secondary receiving instrument in said output circuit, and an unshunted condenser connected in said output circuit operating to produce a definite timing of the impulses supplied to said secondary instrument and for preventing the passage of said wandering zero.

3. In a signalling system, a cable over which signals are distorted due to wandering zero, a signal receiving apparatus arranged to be operated by said impulses, an output circuit for repeating the impulses received by said receiving apparatus, a secondary electromagnetic instrument in said output circuit and unshunted condenser means connected in said output circuit for nullifying the effect of said wandering zero.

4. In a signalling system comprising a signalling conductor over which impulses are distorted and which is subject to the wandering zero effect, a signal-actuated receiving apparatus, a correcting network connected between said receiving apparatus and said cable for correcting for said distorted wave shape, means controlled by said signal-receiving apparatus for repeating the impulse received from said receiving instrument and means including an unshunted condenser for correcting said repeated impulse for the wandering zero effect.

5. In a telegraph system, a transmitting station, a receiving station, a cable subject to distortion and wandering zero connecting said transmitting and said receiving stations, means at said transmitting station for impressing signalling impulses on said cable, a network at said transmitting station for modifying said transmitted impulse to produce a predetermined wave shape, a primary signal-actuated receiving instrument at said receiving station, a network at said receiving end for correcting for said distorted wave shape, a repeating circuit controlled by said primary receiving instrument for repeating said impulses, a secondary signal repeater in said repeating circuit and means including an unshunted condenser in said repeating circuit for correcting for said wandering zero effect on said received impulse.

6. In a telegraph system, a transmitting station, a receiving station, a cable subjected to distortion of the wave and wandering zero effect, a condenser at the transmitting station, a resistance shunting said condenser, a condenser at the receiving station, a resistance shunting said condenser, an inductance shunt associated therewith, said condensers and shunt at said transmitting and receiving stations and said inductance being arranged to produce a pure or natural shaped signal, a primary signal-actuated receiving instrument arranged to be operated by said

signals, a secondary receiving instrument controlled by said primary receiving instrument and a local condenser connected in the circuit of said secondary receiving instrument to supply impulses of equal duration and for preventing the wandering zero effect of the cable and primary receiving instrument from influencing the secondary receiving instrument and a local correction circuit controlled by the output of the secondary receiving instrument for controlling said secondary receiving instrument.

7. In a telegraph system, a transmitting station, a receiving station, a cable subjected to distortion of the wave and wandering zero effect, a condenser at the transmitting station, a resistance shunting said condenser, a condenser at the receiving station, a resistance shunting said condenser, an inductance shunt associated therewith, said condensers and shunt at said transmitting and receiving stations and said inductance being arranged to produce a pure or natural shaped signal, a primary signal actuated receiving instrument arranged to be operated by said signals, a secondary signal actuated receiving instrument controlled by said primary receiving instrument and a local unshunted condenser connected in the circuit of said secondary receiving instrument to supply impulses of equal duration and for preventing the wandering zero effect of the cable and primary receiving instrument from influencing the secondary receiving instrument.

8. In a signalling system, a cable over which the impulses transmitted are distorted by the "wandering zero" effect and by earth currents, transmitting apparatus including a condenser shunted by a resistance receiving apparatus including a condenser shunted by a resistance, a primary signal-actuated receiving instrument adapted to respond to received block signals, a shunt about said receiving apparatus including an inductance and a resistance connected in series, a secondary signal-actuated receiving apparatus connected to the output of said primary receiving apparatus including an unshunted transient energy transfer device, a secondary receiving apparatus having a winding receiving impulses from said transfer device, a correcting network, an auxiliary coil on said secondary receiving instrument connected in the output of the latter through said correcting network.

In testimony whereof I affix my signature.

HERBERT ANGEL.