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A. B. CLARK ET AL

DISTORTION MEASURING SYSTEM

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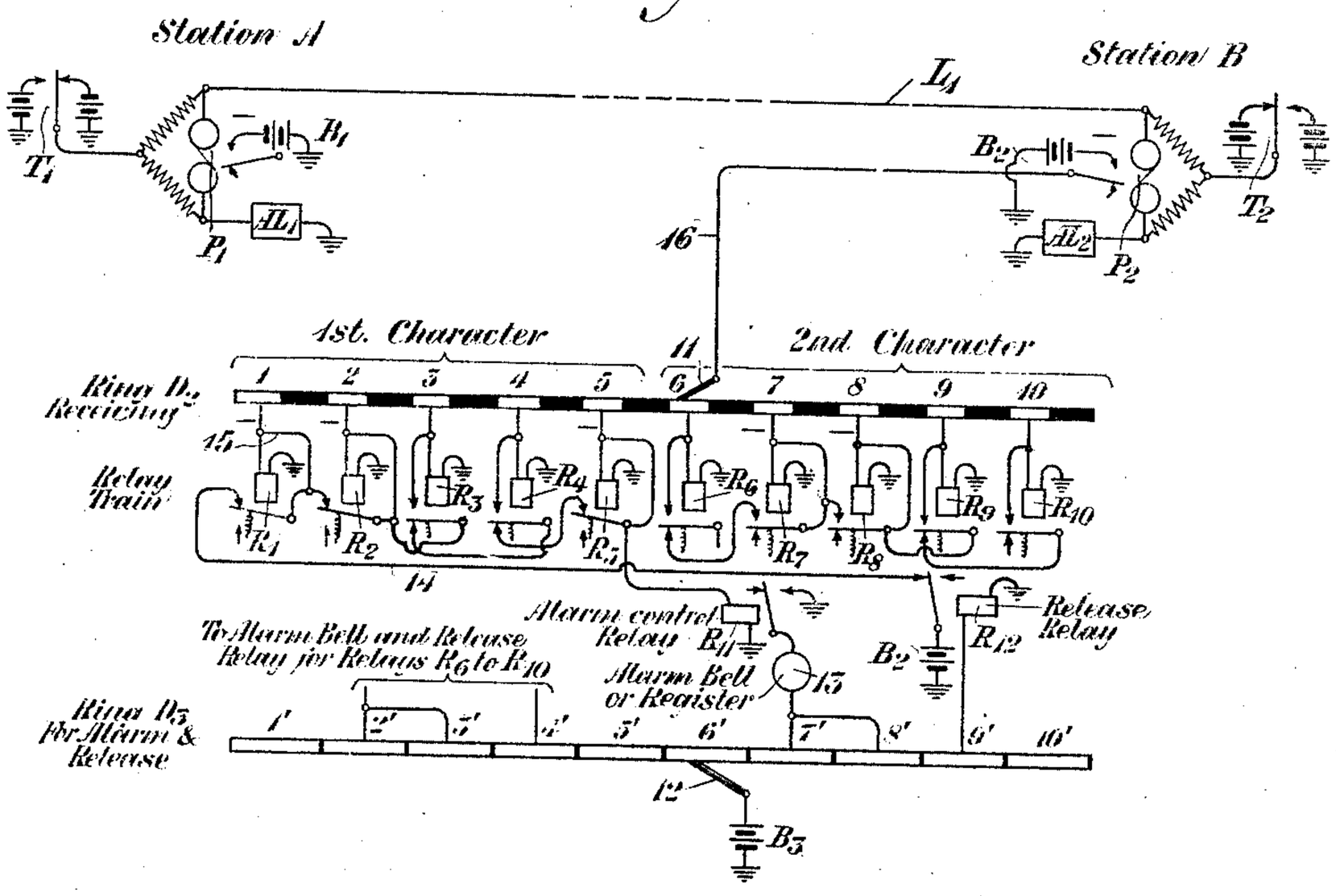
Fig. 1



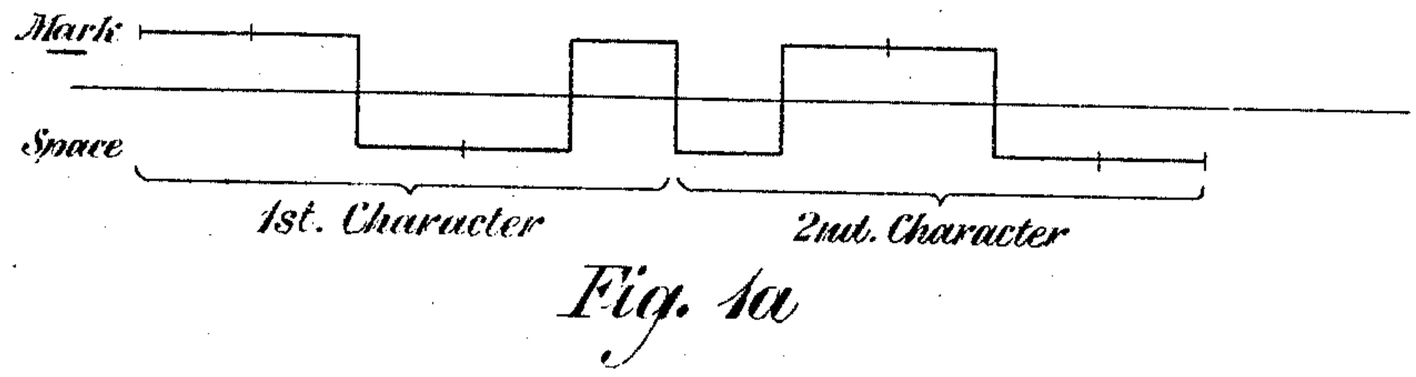


Fig. 1a

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DISTORTION-MEASURING SYSTEM.

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This invention relates to electrical measuring systems and particularly to means for determining the existence and the magnitude of distortion of telegraph signaling impulses produced in the course of transmitting the said impulses between two stations upon the same line.

In the transmission of telegraph signals, each made up of a plurality of impulses, and each impulse having a definite length, distortion of the impulses (and therefore of the signals) may be produced by various causes inherent in the line or in the apparatus connected therewith or both. The distortion with which this invention is concerned manifests itself in lengthening or shortening the duration of the impulses which constitute the signal transmitted over the line. This lengthening or shortening of the duration of the impulse interferes with the proper recording of the signals at any station connected with the said line and consequently impairs the efficiency of transmission.

Various systems for determining the existence and the magnitude of this form of distortion have been devised and used, but, due either to the complexity of the apparatus required or to other causes, they have not been widely used. One such method consists in the use of a Wheatstone tape recorder connected with the receiving end of a line, to which perfect signals are applied at the sending end for the purpose of recording the said signals at the receiving end. The tape records of these signals are then measured whereby any distortion and the magnitude thereof may be determined. This method, however, is quite laborious and expensive. Other ways employed heretofore indicate only average distortion.

It is the object of this invention to provide simple means for indicating the existence of distortion of the signaling impulses and for measuring the magnitude of the same.

This invention will be clearly understood from the following description when read in connection with the attached drawing, of which Figure 1 shows schematically an arrangement embodying the invention and Fig. 1[a] shows graphically two signal characters each comprising five impulses, which figure will assist in understanding the nature of the invention.

In Fig. 1, A represents a station from which signalling impulses may be applied to the line L_1 extending between station A and station B. The transmitting device T_1 is intended to represent symbolically any form of transmitting device such as a tape transmitter, a printing telegraph distributor or other device by means of which a plurality of impulses representing signal characters may be applied to the line L_1. P_1 represents a differential polarized relay connected with the line L_1 and with the artificial line AL_1 adapted to balance the real line. For the sake of brevity the details of the apparatus at station A need not be further described since they form no part of this invention.

The terminal apparatus at station B, which preferably is similar to that at station A, includes a transmitter T_2 and a differential polar relay P_2 connected between the line L_1 and the artificial line AL_2. The armature of relay P_2 may be connected through its upper contact with the negative pole of the battery B_2, and the lower contact may remain disconnected. This armature is connected by conductor 16 with the brush 11 which is adapted to make contact with the segments of the receiving distributor ring D_2. The ring, which is shown developed in a straight line in the drawing, comprises ten conductive segments of equal size and equally spaced by insulating segments, but as will be apparent from the subsequent description of this invention, it may comprise any number of segments. Each segment is connected with its individual relay of the train of relays designated R_1 to R_{10} inclusive. These relays, which as shown, are of the neutral type, will be operated when a current impulse is impressed upon their respective segments by the brush 11, and thus in effect store up, for the purpose of further investigation, the signal character received at station B. It is customary in printing telegraph systems to represent a signal character by a combination of five impulses, so the segments 1 to 5 and their associated relays are arranged to receive one signal character and the segments 6 to 10 with their associated relays to receive another and preferably a different signal character. Since the nature of the invention will be clearly understood by the description of the mode

of operation of the circuit connected with the first five segments representing the first signal character, it will be unnecessary to describe or to fully show the mode of connection of the circuit connected with the segments 6 to 10 inclusive, because it will be the same as that of segments 1 to 5 inclusive.

The armature of each relay is connected in a predetermined manner either with a contact or with the armature of the next higher numbered relay with the exception of relay R_5, the armature of which is connected through the winding of relay R_{11} to ground. As will be apparent from the subsequent description of this circuit, the mode of connection of the armatures with the contacts of the adjacent relays depends upon the signal character that the said relays are intended to store up. Furthermore, one of the contacts of relay R_1 is connected over the back contact of the release relay R_{12} with the battery B_2. Each relay is so arranged that if a marking impulse, namely, a negative current impulse, is applied thereto, the said relay will be locked up by current from the source B_2. Another ring D_3, shown as developed in a straight line, comprises a plurality of conductive segments, designated 1′ to 10′ inclusive, of equal size, equally spaced and insulated from each other, the length of which, however, is almost equal to the combined length of a conductive and an insulating segment of D_2. Associated with ring D_3 is a brush 12 connected with the battery B_3. Segments 7′ and 8′ of this ring are connected with an alarm bell or other indicating or recording device 13 which in turn is connected with the armature of the relay R_{11} in such manner that when the said armature is upon its back contact, namely, the right-hand contact, the bell 13 will be grounded. It is to be understood, however, that this bell may be connected with segment 6′ or, in fact, with any segement having a number higher than 5′, the reason for which will be clear from the following description. Connected with segment 9′ is the winding of the release relay R_{12}, by means of which any relay in the groups R_1 to R_5 which has been operated and locked-up may be restored to its normal inoperated condition. The brushes 11 and 12 are, preferably, connected with the same driving shaft so that they may be rotated around their respective rings simultaneously and at the same rate by means of a synchronous motor or other synchronous driving means. The ring D_2 is adapted to be oriented upon its axis so that the margin that the system possesses for the reception of signaling impulses may be measured.

Having in mind the foregoing description of the circuit in which the invention is embodied in Fig. 1, the nature of the invention will be clearly understood from the following description of the method of determining the existence and magnitude of distortion of signaling impulses. This method comprises four steps as follows:

1. Calibration of the receiving apparatus to determine the margin when the received signals are undistorted.

2. Adjusting the receiving apparatus in order to compensate for the time lag between the transmittal and reception of signals.

3. Determination of the margin for signaling impulses transmitted over the line from the distant end, which impulses may be distorted or undistorted, depending upon the characteristics of the circuits.

4. Interpretation of the difference in margin in terms of distortion.

In order to calibrate the receiving apparatus, that is, to determine the distance through which the ring D_2 may be oriented in a right-hand or left-hand direction before failure occurs to properly receive signals, it is necessary to apply to the said ring undistorted signals. Such signals may be derived from any suitable source, such as another transmitter similar to T_1, which would be located at station B and adapted to operate the receiving relay P_2 located at that station. An alternative arrangement for applying undistorted signals to the ring D_2 would be a ring similar to D_3 having its segments connected with sources of potential, the polarity of which should be such as to impress upon a brush moving over the said segments the signaling characters shown in Fig. 1ª, which are the same characters as those transmitted from station A by the operation of the transmitter T_1. The brush of such distributing ring should be connected with the conductor 16 and the brush of the said ring should be operated by the same shaft that operates the brushes of rings D_2 and D_3. While the impulses which make up the signaling characters shown in Fig. 1ª are being applied to the ring D_2 by means of the local source just referred to, the ring D_2 should be oriented upon its axis in one direction until failure occurs, which will be indicated by the operation of the device 13. Then the said ring should be oriented in the opposite direction until an indication of failure is similarly given. The manner in which the system operates to indicate failure to properly receive signals is as follows:

We have assumed that the source of distortionless signals is arranged to apply to the ring D_2 the signal characters shown in Fig. 1ª. Accordingly, there will be applied to the segments 1 to 5 inclusive a character comprising two marking impulses followed by two spacing impulses, which in turn are followed by a single marking impulse. The

second signal character, which will be applied to the segments 6 to 10 inclusive, comprises a spacing impulse followed by two marking impulses, which are in turn followed by two spacing impulses. For the sake of brevity we will describe the operation of the system for the first signal character. The application of the first marking impulse, viz, a negative impulse, will continue as long as the brush 11 remains in contact with the segment 1 and until the brush is about to enter upon segment 2. Similarly, the application of the second marking impulse will continue throughout the time that the brush 11 remains in contact with segment 2 and until it is about to move onto segment 3. And, in like manner, the succeeding impulses will continue as long as the brush 11 remains in contact with the respective segments, assuming, of course, that the said source of distortionless signaling impulses is not only in synchronism but also in phase with the ring D_2. As the brush 11 moves over segment 1, current will flow through the winding of the relay R_1 to ground, thereby effecting the operation of the said relay, which will be locked-up by current that flows through a circuit embracing battery B_2, the back contact of relay R_{12}, conductor 14, upper contact of relay R_1 and the winding of the said latter relay. In similar manner, relay R_2 will be operated when the brush 11 moves over segment 2 and the said relay will be locked-up by current from battery B_2. As the brush 11 moves over segment 3, relay R_3 will not be energized since the armature of relay P_2 will be on its lower contact with which no source of potential is connected. It is desirable to point out that if sources of opposite polarity were connected with the upper and lower contacts respectively of relay P_2, it would necessitate the use of polar relays in the relay train represented by R_1 to R_{10} inclusive. For the sake of simplicity, neutral relays have been used for this purpose and therefore a space is represented by the absence of current rather than by a current impulse of polarity opposite to a marking impulse. Accordingly, relay R_3 remains unoperated and consequently its armature is held against its lower contact by the action of the retractile spring. In like manner, relay R_4 remains unoperated during the passage of the brush 11 over the segment 4 and its armature is similarly held against its lower contact. Relay R_5 will respond to the flow of current representing a marking impulse during the passage of the brush 11 over segment 5 and its armature will be drawn against its upper contact, and the relay will be locked-up by current from the source B_2.

Upon the operation of relay R_5, current will flow from the battery B_2 over a circuit embracing conductor 14, upper contacts of relays R_1 and R_2, lower contacts of relays R_3 and R_4, upper contact of relay R_5 and winding of relay R_{11} to ground, thereby energizing the last relay and causing its armature to be held away from its grounded contact. It will, therefore, be seen that relay R_{11} will not operate unless the circuit through the said contacts is closed, which in turn depends upon the operation of relays R_1 to R_5.

Whether relay R_{11} has operated is determined as follows: While the brush 11 is traveling over contacts 6 to 10 inclusive and is thereby storing up the second signal character of Fig. 1ª, the brush 12, associated with the ring D_3, is likewise traveling over segments 6′ to 10′ of ring D_3. When the brush 12 makes contact with segment 7′, the grounded source of potential B_3 will be applied to the indicating device 13. This, however, will not operate if the armature of relay R_{11}, with which the device 13 is connected, is held away from its grounded contact due to the energization of the said relay R_{11}. The failure of this device to operate indicates, of course, that the ring D_2 is so oriented while the distortionless signals are being applied to it during the process of calibration that the relays of the relay train have been properly operated to close the circuit of the alarm control relay R_{11}. When the brush 12 makes contact with segment 9′ the release relay R_{12} will be energized and its armature will be drawn to its right-hand contact, thereby disconnecting the grounded battery B_2 from the train of relays R_1 to R_5 inclusive and also from the alarm relay R_{11}, thus restoring the system to normal.

In calibrating the system, it is desired to determine how far in either direction of rotation, the ring D_2 may be oriented before it fails to properly transmit to the relays R_1 to R_5 inclusive the signaling impulses impressed by the source of distortionless signaling impulses upon the brush 11. If the ring D_2 is oriented, for example, in the left-hand direction a point will be reached where, for example, a negative impulse will be applied to the relay R_3. This is evidenced by the fact that relay R_3, which would normally not be energized if the signaling impulses were properly centered, will now be energized by the flow of current therethrough. Accordingly, its armature will be attracted to its upper contact and locked in that position, and consequently the circuit embracing battery B_2 conductor 14 and the contacts of relays R_1 to R_3 will be cut off from relay R_4. Accordingly the alarm control relay R_{11} will not be energized and its armature will remain upon its grounded contact. When the brush 12 moves onto segment 7′ the alarm device 13 will be operated by current flowing therethrough from battery B_3 to ground. The operation of this

device serves to apprise the person who is making the test that the ring D_2 has been oriented so far in a left-hand direction that the receiving apparatus fails to receive the distortionless signals being applied to the brush 11. The angular distance through which the ring D_2 may be oriented before failure occurs is noted upon the ring and then the said ring is oriented in a right-hand direction until the apparatus fails to properly receive signals, which would be indicated in the manner just described. This latter point is also noted upon the said ring and the distance between the two points is known as the range of orientation without failure. One-half of this distance is commonly known as the margin for distortionless signals.

Having determined the margin through which the receiving ring D_2 may be oriented before failure when receiving distortionless signals, the receiving apparatus should then be connected effectively to the line L_1. After the receiving apparatus has thus been connected it should be adjusted to compensate for the time lag resulting from the transmission of signals over the said line. This adjustment consists in orienting the ring D_2 in such direction and to such extent that the brush 11 will begin to make contact with the segment 1 when the first impulse of the signal transmitted over the line L_1 from the distant station A is arriving at station B. Since the rings at station B are operated in synchronism with the transmitting apparatus at station A and since there is a time lag in the transmission of a signal from A to B, the brush 11 will normally have travelled some distance along the segment 1 before the signal transmitted from station A begins to arrive at station B if the brush 11 began to make contact with segment 1 of ring D_2 at the same time that the armature of the transmitter T_1 at station A touched the contact point connected with one of the poles of the transmitting battery. The adjustment for time lag consists simply in orienting the ring D_2 so that the brush 11 moves over the segment 1 while the signal transmitted from station A arrives at station B.

Having calibrated the distortion measuring apparatus, that is, having determined its margin for distortionless signals, and furthermore, having adjusted the receiving apparatus for time lag, the next step consists in determining the change in the margin due to distortion of signals received at station B.

Let it be assumed that the transmitting apparatus at station A is sending the first signal character shown in Fig. 1^a, consisting of two marking impulses followed by two spacing impulses, which in turn are followed by a single marking impulse. As these impulses are transmitted over the line they may be distorted, the distortion consisting in the lengthening or the shortening of the period of duration of an impulse. If, therefore, any impulse is lengthened or shortened when it arrives at station B and is applied by the brush 11 to the segments of the ring D_2, such lengthening or shortening will be manifested by the operation of the indicating device 13 when the ring D_2 is oriented. If the third impulse, which is an open circuit spacing impulse, is appreciably lengthened, the preceding marking impulse, which is a closed circuit impulse, will be correspondingly shortened. To determine the magnitude of this distortion the ring D_2 should be oriented in both directions. Since the duration of the marking impulse, which would normally be applied to the segment 2 while the brush 6 is in contact therewith, is shortened by the corresponding lengthening of the succeeding spacing impulse, it will be apparent that the ring D_2 cannot be oriented as far in one direction as when distortionless signals are being received before failure occurs, which would be indicated by the alarm bell 13. The difference between the margin with no distortion and the margin with distortion is the measure of the distortion of the signal.

The manner of testing the existence of excessive distortation in the signal character set up by the relays R_6 to R_{10} inclusive by the passage of the brush 11 over the segments 6 to 10 is identical with that for testing the first signal character and need not be described in detail. Furthermore, for the sake of simplicity, the indicating device and the release relay and other equipment associated with the relay train R_6 to R_{10} have not been shown since such apparatus and its mode of connection would be similar to that shown and described in connection with relays R_1 to R_5 inclusive.

It is desired to point out that the mode of connection of the armatures of relays R_1 to R_5 with the contact points or the armatures of their adjacent relays depends upon the arrangement of the marking and spacing impulses constituting the particular signal character intended to be received by the train of relays R_1 to R_5. Thus, for example, if, instead of the signal character represented by Fig. 1^a, it is desired to receive a character in which the first, third and fifth impulses are of the marking type and the second and fourth of the spacing type, the armature of relay R_1 should be connected with the armature of relay R_2 and the lower contact of relay R_2 with the upper contact of relay R_3, the armature of relay R_3 with the armature of relay R_4, the lower contact of which should be connected with the upper contact of relay R_5. In practice, it is de-

sirable to provide a plurality of simple switches whereby the armatures of each relay of a train may readily be connected with the adjacent higher numbered relay in any desired manner.

In the drawing the length of the conductive segment of ring D_2 is shown as approximately one-half the total length of a conductive and an insulating combined. In practice better results will be obtained if the length of the conductive segment is small, that is, one-fourth or even less of the said total length of the conductive and insulating segments.

The form of embodiment of the invention shown in Fig. 1 is purely schematic and is not intended to constitute a limitation of the scope of the invention. It is desired to point out that while we have shown the receiving apparatus, viz, the distortion measuring apparatus located at a different station from that from which the signals are transmitted, it is to be understood that such distortion measuring apparatus may be located at the transmitting station, such being the custom in making so-called loop measurements wherein both terminals of the line are available at the same station. In such case, a printing telegraph distributor might be used as a transmitter of the signal characters, which distributor would be operated by the same shaft that drives the brushes of rings D_2 and D_3 so that exact synchronism of the transmitting and receiving apparatus could readily be maintained.

While this invention has been disclosed as embodied in a particular form and arrangement of parts it is to be understood that it is not so limited but is capable of embodiment in other and different forms without departing from the spirit and scope of the appended claims.

What is claimed is:

1. In a distortion measuring system in which a signal comprising a plurality of electrical impulses is transmitted over a line, the combination with a source of current impulses of a line and a receiving device comprising means to automatically indicate the magnitude by which the distortion of any of said impulses exceeds a predetermined magnitude.

2. In a distortion measuring system in which a signal comprising a plurality of electrical impulses is transmitted over a line, the combination with a source of current impulses of a line and a receiving device comprising means to indicate automatically the distortion of any impulses exceeding a predetermined magnitude and to measure the degree of the said distortion.

3. In a distortion measuring system the combination with a line of a transmitting device adapted to impress upon said line signaling characters, each comprising a plurality of impulses, and a distortion measuring device comprising a train of relays connected with a segmental distributing ring whereby each relay of said train may be effectively connected with said line, and an indicating system connected with said relays to show whether distortion of said signal characters exceeds a predetermined limit.

4. In a distortion measuring system, the combination with a line of a source of current impulses, a receiving relay responsive to said impulses, a segmental distributor having its brush connected with the armature of said relay whereby open or closed impulses may be applied to said distributor depending upon the position of said armature of the receiving relay, a relay train comprising a plurality of relays, each individual to and connected with a segment of said distributor, the armatures of which relays are connected with certain contacts of the succeeding relays, the mode of connection depending upon the signal character to be received, a second distributor having a source of potential connected with the brush thereof and an alarm device connected with a predetermined segment thereof, and a relay connected with the armatures of said relay train to prevent the operation of said alarm device when the distortion of the received signal does not exceed a predetermined limit.

5. The method for determining the degree of the lengthening or shortening of signal impulses transmitted by a printing telegraph transmitter over a line to a printing telegraph receiver, which consists in applying undistorted impulses to the said receiver and measuring the range through which the receiving segments may be oriented without failure, applying undistorted impulses to the sending end of the said line for transmission thereover, adjusting the receiving segments to compensate for the time lag between the transmission and reception of signal impulses transmitted over the said line, measuring the range through which the said receiving segments may be oriented without failure and determining the magnitude of distortion by the difference between the said second measurement and the said first measurement.

6. The method for determining the degree of the lengthening or shortening of signal impulses transmitted by a printing telegraph transmitter over a line to a printing telegraph receiver, which consists in measuring the range of the receiving segments for undistorted signals, measuring the range of said segments for signals distorted by transmission over the said line and determining the magnitude of distortion by the difference between the second range and the first range.

7. The method for determining the degree of the lengthening or shortening of signal

impulses transmitted by a printing telegraph transmitter over a line to a printing telegraph receiver, which consists in adjusting the receiving segments for the reception of undistorted signals, adjusting for the time lag between transmission and reception of the said signals. orienting the receiving segments in each direction until failure occurs in the reception of the said segments, and producing an alarm whenever the receiver fails to receive the signals as transmitted.

In testimony whereof, we have signed our names to this specification this 8th day of May, 1923.

ALVA B. CLARK.
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