

May 22, 1934.

A. D. DOWD

1,959,412

TELEGRAPH CIRCUIT

Filed Jan. 26, 1933

2 Sheets-Sheet 1

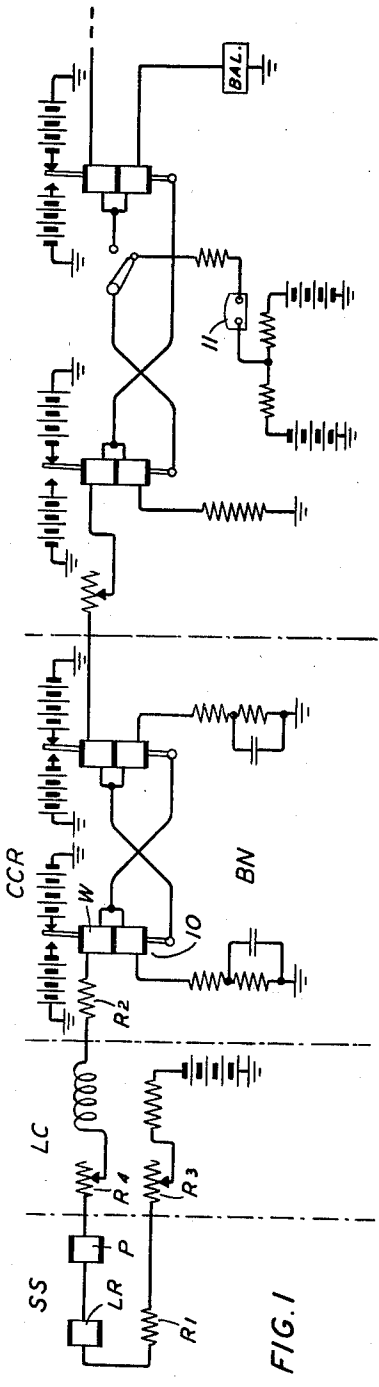


FIG. 3

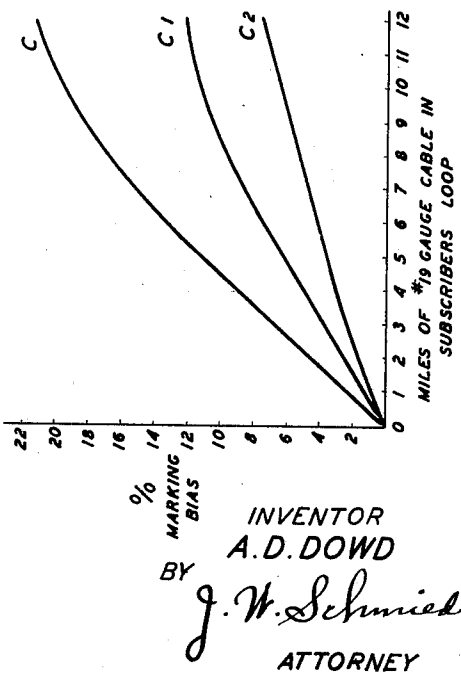
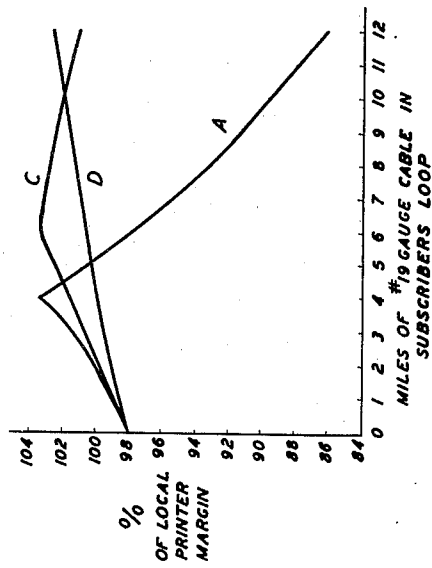


FIG. 4



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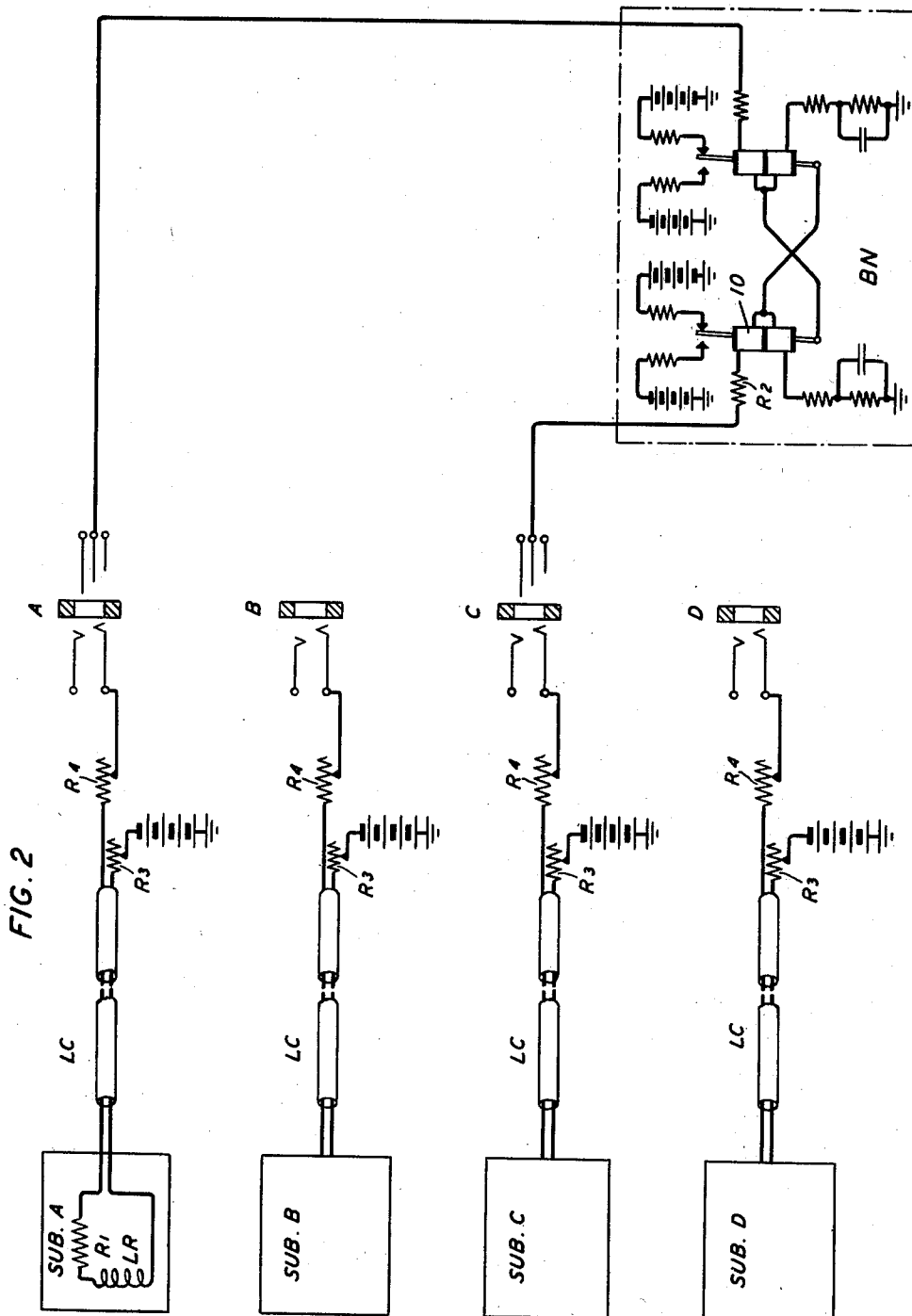
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TELEGRAPH CIRCUIT

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6 Claims. (Cl. 178—58)

The present invention relates to telegraph systems and more particularly to such systems in which telegraph apparatus is to be operated in a loop circuit extending from a central exchange station.

In telegraph exchange service, such as has been established for teletypewriter operation, each subscriber is connected to the nearest teletypewriter exchange by means of a cable or open-wire circuit commonly known as a subscriber's loop. Since subscribers are located at various distances from the exchange the loops are of different lengths and have different amounts of distributed capacity and resistance.

The total resistance of the loops is usually equalized by inserting so-called loop current limiting resistances at the telegraph exchange station or at the subscriber's station. Although this usually results in a uniform loop impedance for direct current, the impedance over the frequency range employed in direct current telegraphy will not be uniform but will vary from one loop circuit to another in a manner depending upon the values of the total distributed capacity and resistance as well as upon the values of the various resistance and inductance elements which have been connected into the circuit.

Whenever communication is established between two subscribers who are connected to a particular telegraph exchange, or between two or more subscribers connected to different telegraph exchanges, a cord circuit telegraph repeater is employed at each exchange. Such repeaters utilize the principle of duplex balance and employ fixed balancing networks which are required to give a satisfactory duplex balance when the repeater is connected to any subscriber's loop, or to the local circuits of a toll telegraph repeater.

It has been found practical heretofore to design a simple balancing network which is satisfactory for loop circuits having little or no capacity and for cable circuits having up to about 25 geographical miles of cable. For loop circuits containing longer lengths of cable, the duplex balance has been found unsatisfactory when using existing types of balancing networks and a limit has been found to apply to the length of the loop beyond which the printing telegraph apparatus inserted in the loop circuit ceases to operate efficiently. Beyond this limit, there was found to exist a certain amount of unbalance between the duplex balance circuit and the loop circuit. This unbalance frequently causes false operation of the polarized relay inserted at the exchange station, which transmits short spacing signals back to the sending loop circuit and thus interferes with the transmission of signals to the receiving loop circuit. A further disadvantage manifests itself in that the wave shape of

the signals received at the subscriber's station is unsatisfactory and excessively biased.

It is an object of this invention to so modify the impedance characteristics of long loop circuits, as seen from the telegraph exchange, that the duplex balance will be improved and made satisfactory even with cables whose lengths may be considerably greater than 25 miles, whereby the above mentioned disadvantages are minimized.

In pursuance of its objects, this invention proposes to rearrange the direct current loop limiting resistance referred to above, for example, by concentrating it at a point located near the subscriber's station, or by placing half of the resistance at the subscriber's end and dividing the other half into two equal parts, and placing one of these parts in the tip and the other part in the ring leads of the loop circuit, and finally by experimentally selecting such values for the resistances that first, false operation of the relay in the cord circuit repeater is prevented, and, second, the wave shape of the signal currents received will be improved.

The principles of the invention will now be described in detail in connection with the accompanying drawings in which:

Fig. 1 shows a diagrammatic circuit arrangement used for making telegraph impulse transmission tests for the purpose of studying the effect of the distribution of resistance upon the distortion or bias of telegraph signals;

Fig. 2 is a circuit diagram representing a practical embodiment of the invention;

Figs. 3 and 4 represent curves illustrative of comparative tests made on the circuits shown in Figs. 1 and 2.

Fig. 1 shows a diagram of a bias testing circuit including a subscriber's station SS, a loop circuit LC (12 miles of 19 gauge cable), and a cord circuit repeater CCR. In this circuit, all the loop current limiting resistance was placed as resistance element R2 in the repeater branch of the loop. Resistance R2 had a value of about 1600 ohms. In studying the effect which this resistance distribution of the circuit would have upon the form of the wave shape of the signals transmitted, alternate positive and negative impulses were transmitted from the subscriber's station SS, and the bias was measured by the bias measuring device 11. The values thus obtained are plotted in curve C of Fig. 3 which indicates that in the absence of a special resistance element at the subscriber's station the bias of the impulses transmitted reaches the high value of about 21% for a subscriber's loop having a length of 12 miles.

The loop current limiting resistance R2 was then divided into two equal parts and one part (800 ohms) moved from the central office to the subscriber's station, where it was connected in

series with the line relay LR of the printer P as shown at R1 in Fig. 1. It was found that this rearrangement of the resistance reduced the signal distortion for various lengths of subscriber's loops to the values plotted on curve C1 of Fig. 3.

Next, the remaining part of the resistance R2 was divided into two unequal parts; the larger part was moved to point R1 and the smaller part was placed at point R4 of Fig. 1; in this manner practically all the resistance was concentrated at the subscriber's station. Curve C2 of Fig. 3 shows the resulting improvement in the bias of the impulses transmitted.

These tests also tended to show that, all other factors remaining the same, to a certain extent, the lower the resistance R2 in the repeater branch, the higher the efficiency of the transmission from the subscriber. It was ascertained, however, that this resistance could not be reduced much below a certain value (about 140 ohms) for the reason that the current surges through the winding W of relay 10 in the repeater branch, when the direction of transmission was reversed, caused the relay to leave its armature in all cases in which the loop circuit contained a cable longer than about 12 miles. This irregularity in the operation of the relay was due to the use of the fixed balancing network BN of a fixed compromise value which was intended to balance all loops of ordinary length. The false operation of the relay 10 was substantially prevented by providing the special resistance element R4 in the repeater leg and by giving it a value of about 140 ohms. The resistance R4 may also be divided into two parts and one of each placed in each conductor of the loop, as shown at R3 and R4, of Fig. 1.

Although the use of a resistance element R1 of a value of 1600 ohms at the subscriber's station resulted in a satisfactory transmission over cables of a length of about twelve miles, the transmission was still further improved as the resistance R1 was increased to 2500 ohms.

The curves of Fig. 4 graphically depict the results of the practical application of the findings of the tests described above to printing telegraph circuits and apparatus such as those shown in Fig. 2.

Curve A of Fig. 4 depicts the percentage reduction of the printer margins for a teletypewriter transmitting signals from a subscriber's station over an ordinary loop circuit into a cord circuit repeater and then over 300 miles open wire line section in the absence of the provision of any special resistance at the subscriber's station. It is seen that the values of printer margins begin to become poor for loop lengths as low as 4 to 5 miles.

Curve C of the same figure corresponds to a printing telegraph apparatus transmitting signals from a subscriber's station over a loop circuit including a resistance element of 1600 ohms at the subscriber's station, into a cord circuit repeater and then over 300 miles of open wire line. The improvement is very noticeable.

Curve D of Fig. 4 also depicts the improved results obtained when transmitting signals from a subscriber's station over a loop circuit including a resistance element of 1600 ohms at the subscriber's station through a cord circuit repeater into a cord circuit repeater and then over 300 miles of open wire line.

The trend of curves C and D indicates that

the length of the cable comprised in the loop circuit may be safely increased considerably beyond the value of 12 miles to which the tests were limited.

The improvements contemplated by this invention are of importance in modern teletypewriter exchange service, not only since they increase the efficiency of existing circuits by enabling the correct transmission of telegraph messages over cable circuits of greatly increased length (up to about 35 miles), but also since they permit a reduction in the number of telegraph exchanges and repeater stations necessary to cover a given territory without the use of expensive long line equipment upon subscribers' loops.

What is claimed is:

1. In a telegraph circuit comprising a subscriber's loop circuit, a repeater station, a duplex balance circuit and current limiting resistance connected in said loop circuit, the method of increasing the length of the loop over which telegraph signals may be received free from such distortion as would interfere with their correct recording by printing telegraph apparatus, which comprises locating the greater portion of said current limiting resistance at a point near the subscriber's station.

2. In a telegraph system, a telegraph transmitter, a telegraph repeater, a plurality of telegraph circuits of different impedance characteristics, means for connecting said repeater to said telegraph circuits for repeating signals between said circuits, a balancing network for said repeater, said balancing network being capable of balancing the impedance characteristics of a substantial portion of said plurality of circuits, and an electric network including a resistance element in each of the remainder of said plurality of circuits, whereby unbalance effects caused by the impedance characteristics of the remainder of said circuits are reduced.

3. In a telegraph circuit comprising a transmitting station, a repeating station and a receiving station, a subscriber's loop circuit, a current limiting resistance element, a polarized relay and a duplex balance circuit at said repeating station, a method for preventing false operation of said relay due to unbalance effects in said duplex balance circuit, said method comprising dividing said current limiting resistance element into a plurality of units and providing one of said units at a point near said repeating station.

4. A telegraph exchange system having a plurality of subscribers' loops of varying electrical length and without intermediate repeaters, a central office including devices interchangeably connectable with said loops for telegraphic transmission thereover, equalizing resistances in at least certain of said loops for rendering their impedance more nearly similar to that of other loops, characterized in this that a substantial portion of the equalizing resistance in any loop is located near each end thereof.

5. A telegraph exchange system in accordance with claim 4 in which the total resistance at the exchange end of any loop is divided into two parts, one of which is placed in each conductor of the loop.

6. A system in accordance with claim 4 in which the said devices at the central office include two-way telegraph repeaters.

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