April 22, 1930. G. CRISSON 1,755,243

SIGNALING MEANS FOR TELEPHONE SYSTEMS

Filed Aug. 21, 1928

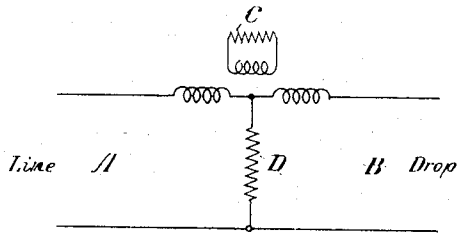


Fig. 1

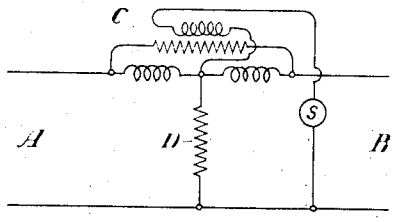


Fig. 2

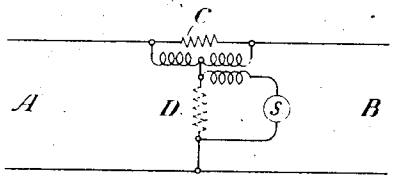


Fig. 3

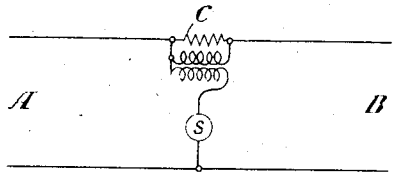


Fig. 4

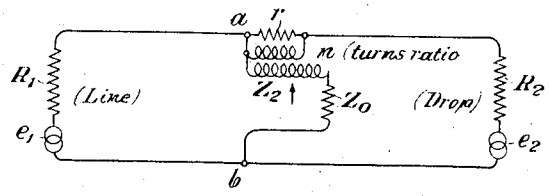


Fig. 5

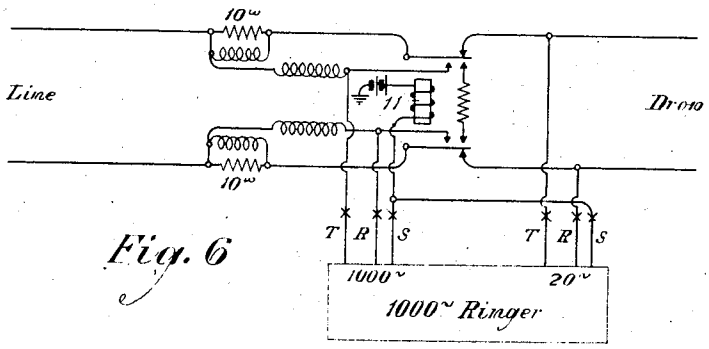


Fig. 6

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SIGNALING MEANS FOR TELEPHONE SYSTEMS

Application filed August 21, 1928. Serial No. 301,030.

This invention relates to signaling means for telephone systems, and more particularly relates to means by which auxiliary apparatus may be associated with a transmission line.

An object of the invention is to provide means by which such auxiliary apparatus may be associated to the line without substantially affecting the transmission properties of the line for other purposes. Such auxiliary apparatus may comprise ringing circuits or transmission level measuring sets or a variety of other types of auxiliary apparatus.

Another object of the invention is to provide a circuit arrangement by which when such apparatus is associated there will be no echo or reflection effects showing themselves therein.

Another object is to provide a unidirectional bridge to the line which will be responsive to impulses coming from the one direction and will send signals thereto but which will not be responsive to impulses from the other end or send impulses thereto.

Still a further object is to provide a circuit of the kind described above but which shall be symmetrical so as not to unbalance the line to which it is connected.

On telephone lines, it has become very common to carry on the signaling over the telephone lines with voice frequencies such, for example, as 1,000 cycles. The voice frequency ringers responsive to such signals, however, are subject to echo effects which may be exceedingly disturbing and may even render the ringer inoperative. This invention is for an arrangement for connecting voice frequency ringers responsive to such signals or for connecting other devices to toll lines so that they will receive signals coming from one direction and will not be affected by signals or echoes coming from the other direction.

Also, it has become necessary from time to time to make measurements on the transmission level at various points in a line or to measure the loss or gain in transmission level due to the introduction of apparatus such as repeaters. In general, the association of the necessary measuring sets to the line may react on the line in such a way as to vitiate the readings or to unfavorably affect the normal signaling transmission. This invention obviates such possibiltes.

The invention will be better understood by reference to the following specification and the accompanying drawing in which Figures 1, 2, 3 and 4 show circuits leading up to the final desired form of this invention; Fig. 5 is a simplified circuit for purposes of calculation; and Fig. 6 is a circuit incorporating my invention in one complete form.

In the case of many telephone lines, and especially two-wire circuits which are not equipped with terminal repeaters, there is normally no place to which the ringer or other apparatus may be connected where it does not receive signals equally well from both directions. As a result, the echoes or reflections coming from the one side may be sufficiently disturbing to render the ringer useless or vitiate readings on other apparatus. To overcome this situation, I make use of a modified form of hybrid coil or three-winding transformer arrangement which consists preferably of a small series resistance in each side of the line with a winding of a coil bridged across each. Another winding of the transformer is connected in series with the ringer or other apparatus. This winding is so poled that it adds to the voltage impressed on the apparatus an equal and aiding voltage in the case of signals coming from the one direction and an equal and opposite voltage in the case of signals coming from the other direction.

The principle and theory will be better understood by referring to Fig. 1. In this figure there is shown a hybrid coil connected between the line A and the drop B. Connected across the series winding of this hybrid coil is an impedance C and bridged across the line is another impedance D. Such a hybrid coil as shown is commonly used in repeater circuits, and the usual practice would be to have the system balanced; that is, the coils would be symmetrical and the impedances A and B would be equal to each other. The impedances C and D would be proportioned to each other according to the turn ratio of the transformer. Under this balanced condition the branches C and D would be conjugate to

each other and A and B would be conjugate. As a result, signals coming in on the line A would not produce any current in the impedance B. It would, however, be possible to unbalance the system by making C smaller and D larger, and in that event current would be transmitted from A to B, the extent of this transmission being determined by the extent to which C and D are changed, one in the one direction and the other in the other.

Fig. 2 shows a modification of this circuit but one which is the electrical equivalent of Fig. 1. In this Fig. 2 the impedance C has been placed in its equivalent electrical position; that is, bridged across the line windings, while the series coil, which formerly contained the impedance C, now is connected in series with a load S, such as a ringer equipment, and the two are bridged across the line, being quite evidently in parallel to the impedance D.

Fig. 3 represents a redrawing of the circuit of Fig. 2. If the impedance C is reduced to a small value and the impedance D is increased to a large value, then D, which is in parallel with the series winding and the load S, might be omitted entirely without important effect on the resulting network. This is indicated by showing D in broken lines.

Fig. 4 shows a further development in the modification. Here, the impedance D has been omitted entirely and the contact for the series winding has been transferred from the bridge point of the main winding to one end of that winding.

Referring now to any of these figures but more particularly to Fig. 4, it is seen that the ringer in this arrangement receives the sum of two voltages one of which is the voltage between the two sides of the line and the other of which is proportional to the current through the small impedance C which, in my invention, preferably takes on the form of a resistance element. The first of these voltages is in the same direction whether the transmission is from A or from B, but the latter voltage reverses in direction as the direction of transmission changes, so that for currents coming from A it adds to the first named voltage and for currents coming from B it subtracts. This arrangement incidentally has the advantage that no substantial coil losses are involved in the main transmission between A and B.

While this qualitative explanation just given above will make it evident that echoes or signals from drop B will be discriminated against as compared with signals from line A, it will, of course, be desirable to have this discrimination as marked as possible even to the extent that echoes from B shall have no effect whatsoever on the ringer. The conditions for attaining this can be shown from the following considerations, reference being had to Fig. 5 in which the impedances as seen looking into the line A and into the drop B are represented, respectively, by R_1 and R_2. The small series resistance r is shunted by a coil which was originally the main winding of the hybrid coil, and associated with this is a coil which, with the first, has a turn ratio of n and whose impedance is Z_2, this impedance being connected in series with the impedance Z_0 of the ringer. Sources of voltage e_1 and e_2 are represented, either one or the other or both of which may be present at one time, as indicated below.

With the condition attained that no current is produced in Z_0 by e_2, it is apparent that Z_0 may be opened without disturbing the currents in the rest of the circuit (e_2 being the only voltage acting). In series with Z_0 there are impressed two voltages which must be equal and opposite. These are:

$$e_{ab}=\frac{e_2 R_1}{R_1+R_2+r} \text{ and } ne_r=\frac{e_2 n r}{R_1+R_2+r}$$

Setting these equal and solving for n,

$$n=\frac{R_1}{r}$$

It will be noticed that, since n is a ratio and has no angle, r must have the same angle as R_1 for perfect balance.

Now reconnect Z_0 and add e_1 just equal and opposite to e_2 so that i_2 is reduced to zero. The current i_0 is now wholly due to e_1. Since there is now no current in it, R_2 may be opened without changing the currents or voltages in the rest of the network. The current in Z_0 is:

$$i_0=\frac{e_1}{R_1+Z_0+Z_2} \text{ where } Z_2=rn^2$$

It is interesting that the current i_0 (the ringer current) has this value regardless of the impedance of the drop. In the usual ringer practice (Z_0 connected directly between a and b with $r=o$) the value of i_0 is practically

$$\frac{e_1}{2Z_0}$$

The change in sensitivity of the ringer is, therefore, expressed by the current ratio:

$$\frac{2Z_0}{R_1+Z_0+Z_2}$$

It will be evident also, from a consideration of the coil relations, that if these coils constitute an ideal transformer, the following relation exists:

$$Z_2=rn^2=\frac{R_1^2}{r} \text{ or } r=\frac{R_1^2}{Z_2}$$

In general, there will be certain practical considerations which will limit the maximum value of Z_2. Having determined this value, it is then seen that one of the relations above gives the value for r, and that having determined r the value of n is set.

Further theoretical considerations make it possible to show that under these conditions the loss to voice transmission in either direction is held to a very low value and that the reflections are also kept very low.

Referring in particular to the use of the invention for ringer purposes, it may be mentioned that the impedance Z_2 will be too large to permit signaling through it out to the line. Also, for ringing current coming in from line A the impedance is high, all of this being necessary in order that the transmission for normal telephone currents shall be kept low. It is, therefore, desirable if not necessary, that this impedance should be removed from the circuit as soon as it has served its purpose. This can be done in a number of ways, one arrangement being shown in Fig. 6. In that figure a cut-off relay 11 is shown which has contacts that short-circuit impedance Z_2. When incoming signals arrive the ringer circuit would be subject immediately to echo effects unless some apparatus similar to that described is attached to the line. When the ringing signals have persisted for a sufficient time to operate certain relays in the ringer apparatus they will operate the relay 11 which will short-circuit the impedance Z_2, thus affording an even easier path for the ringing current coming in on the line. Also, the signal going out on the drop side, which may be a low frequency signal, such as 20 cycles, will now be transmitted the more effectively. On the other hand, when this low frequency signaling current comes from the drop side it will also operate the relay 11 so that 1,000-cycle ringing current may now readily pass out to the line A without the necessity of endeavoring to traverse the high impedance Z_2. When the ringer is unoperated, however, which is the condition under which it is exposed to echoes, the circuit is equivalent to that shown in Fig. 5.

It will be noted in this Fig. 6 that the small series resistance is divided, half being placed on each side of the line, and the same is true of the windings, thus affording a symmetrical arrangement.

While this invention has been described specifically in connection with the association of a ringer circuit to the transmission line, it should be emphasized that the invention is broader than this in that it provides a method and means by which any supplemental or auxiliary circuit may be associated with a transmission line, all in a manner which will make this auxiliary circuit markedly more receptive to signal currents coming from one direction than from the other, at the same time doing this in a manner or with apparatus which will not substantially affect the transmission of the line for the normal telephone currents; that is, in a manner which will not introduce large loss to voice transmission in either direction. For example, it may be desired to measure the transmission level by introducing suitable measuring sets at Z_0. From what has been said, it is evident that this can be done without error due to the impedance or change in impedance of the line beyond the measuring point and without causing errors at other points due to mishandling of the measuring apparatus at the point first mentioned.

This invention also has another important aspect which will be clear from a consideration of Fig. 5. If we consider an E. M. F. generated in the impedance Z_0, the circuit arrangement is such that signals transmitted through the transformer, as a result of such E. M. F., may be caused to be transmitted to the terminal impedance such as, for example, R_1 with much greater amplitude than to the other terminal impedance such as R_2. In fact, if the system is properly adjusted in accordance with the relations given above, no signal impulses would be transmitted to or received from R_2, thus providing a unidirectional bridge to the line.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. In a telephone transmission system a line circuit and a drop circuit, an auxiliary circuit, and means for associating the auxiliary circuit to said system comprising a series connection in the line consisting of a resistance and a coil in parallel, and a bridge connection to the line consisting of the auxiliary circuit and a coil in series, the two coils being so related that currents from the line enter the auxiliary circuit more effectively than currents from the drop.

2. In a telephone transmission system a line circuit and a drop circuit, a supplemental circuit, and means for associating the supplemental circuit to said system comprising a series connection in the line consisting of a resistance and a coil in parallel, and a bridge connection to the line consisting of the supplemental circuit and a coil in series, the coils being so related that current from the line enters the supplemental circuit and current from the drop does not enter the supplemental circuit.

3. In a telephone transmission system comprising a line circuit, a drop circuit, and an additional circuit associated therewith, the method of preventing echo effects in the additional circuit which consists in having the series current in the line when in one direction assist the shunt current going to the additional circuit, and when in the opposite direction having the series current in the line oppose the shunt current going to the additional circuit.

4. In a telephone transmission system a line circuit and a drop circuit, a supplemental circuit, means for associating the supplemental circuit to said system comprising a coil in series with the line and an impedance shunting the coil, a second coil inductively connected to the first coil and in series with the supplemental circuit, the two being bridged across the line.

5. In a telephone transmission system a line circuit and a drop circuit, a ringer circuit, means for associating the ringer circuit to said system comprising a coil in series with the line and a resistance shunting the coil, a second coil inductively connected to the first coil and in series with the ringer circuit, the two being bridged across the line, one end of the second coil being connected to one end of the first coil.

6. In a telephone transmission system a line circuit and a drop circuit, a ringer circuit, means for associating the ringer circuit to said system comprising a coil in series with the line and a resistance shunting the coil, a second coil inductively connected to the first coil and in series with the ringer circuit, the two being bridged across the line, the windings being so related that the induced E. M. F. from the first to the second coil is in the same direction or the opposite direction as the line voltage in the bridge circuit according as the line current is in one direction or the other.

7. In a telephone transmission system a line circuit and a drop circuit, an auxiliary circuit, means for associating the auxiliary circuit to said system comprising a coil in series with the line and a resistance shunting the coil, a second coil inductively connected to the first coil and in series with the auxiliary circuit, the two being bridged across the line, the windings being so related that the induced E. M. F. from the first to the second coil is in the same direction or the opposite direction as the line voltage in the bridge circuit according as the signal is from the line side or the drop side.

8. In a telephone transmission system a line circuit and a drop circuit, a ringer circuit, means for associating the ringer circuit to said system comprising a coil in series with the line and a resistance shunting the coil, a second coil inductively connected to the first coil and in series with the ringer circuit, the two being bridged across the line, the turn ratio of the second to the first coil being equal to the ratio of the line impedance to the resistance shunting the first coil.

9. In a telephone transmission system, a transmission circuit extending between two terminal stations, an auxiliary circuit, and means for associating said auxiliary circuit with said transmission circuit between said stations, said means comprising a series impedance and inductively related coils so connected to the line that signals from the auxiliary circuit will be transmitted unequally to the terminal stations of said transmission circuit.

10. In a transmission system, a line, an auxiliary circuit, means for so associating the auxiliary circuit to an intermediate point of the line that signals from one side enter the auxiliary circuit more effectively than from the other, said means comprising a series impedance and a coil, a portion of which is in shunt to the line and in series with the auxiliary circuit.

11. In a transmission system, a line, an auxiliary circuit, means for so associating the auxiliary circuit to an intermediate point of the line that signals originating in the auxiliary circuit will be transmitted more effectively in one direction than the other, said means comprising a series impedance and a coil, a portion of which is in shunt to the line.

12. In a transmission system, a line, an auxiliary circuit, means for so associating the auxiliary circuit to an intermediate point of the line that signals originating in the auxiliary circuit will be transmitted in one direction only, said means comprising a series impedance and a coil, a portion of which is in shunt to the line.

13. In a transmission system, a line, an auxiliary circuit, means for associating the auxiliary circuit to an intermediate point of the line comprising an impedance in series with the line, a coil shunting the said impedance, a second coil inductively connected to the first coil and in series with the supplemental circuit, the two being bridged across the line and the turn ratio of the second coil to the first coil being equal to the ratio of the line impedance as seen in one direction to the said impedance.

14. In a transmission line, means for measuring the transmission level comprising a network with two conjugate branches, the outgoing line constituting one of these and the measuring apparatus constituting the other.

15. In a transmission system, a network comprising an input and an output line and a measuring circuit, the measuring circuit and the output line being in conjugate relationship.

In testimony whereof, I have signed my name to this specification this 17th day of August, 1928.

GEORGE CRISSON.