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CARRIER CURRENT SYSTEM SUPERPOSED ON SIDE CIRCUIT OF PHANTOM SYSTEM

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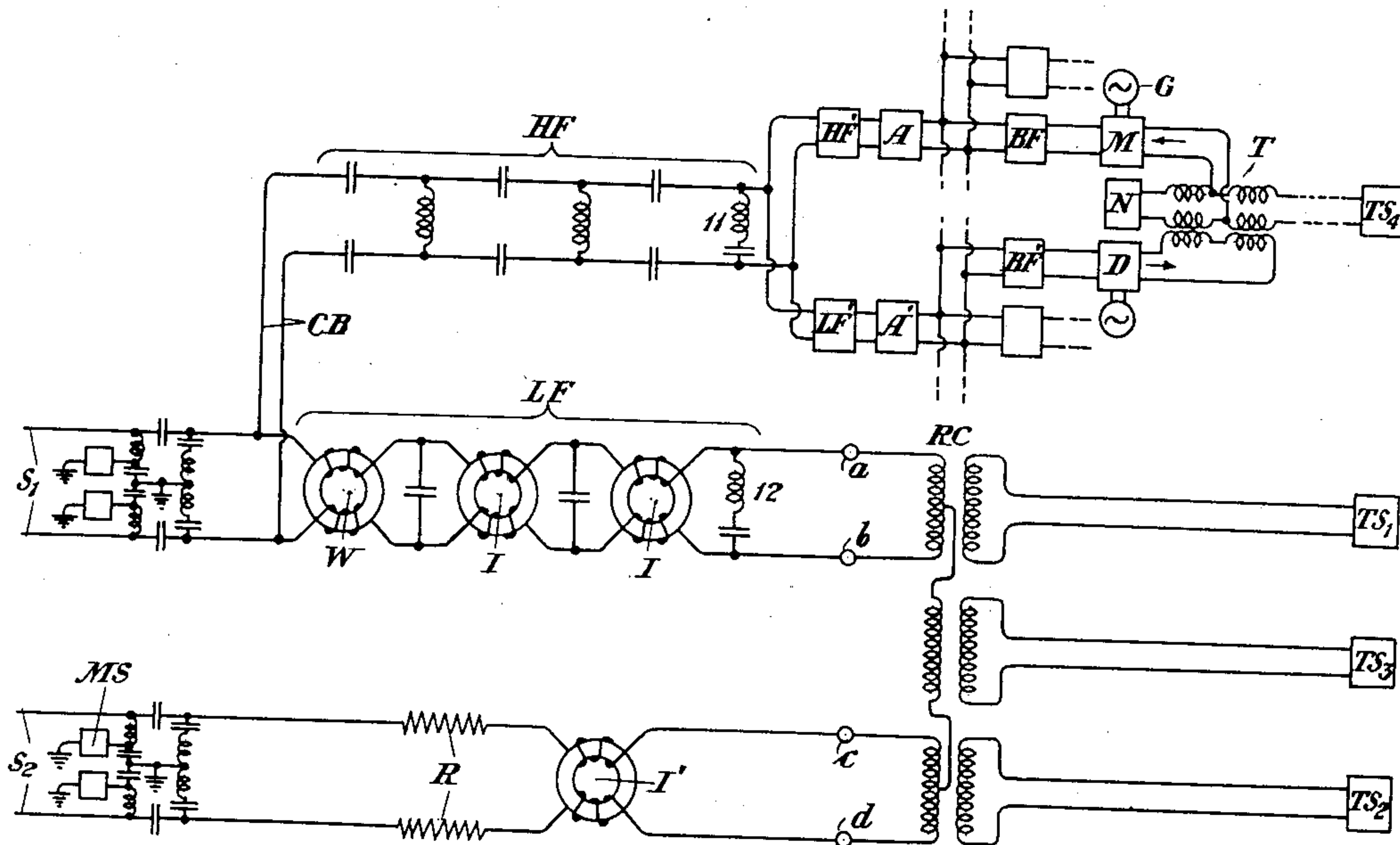


Fig. 1

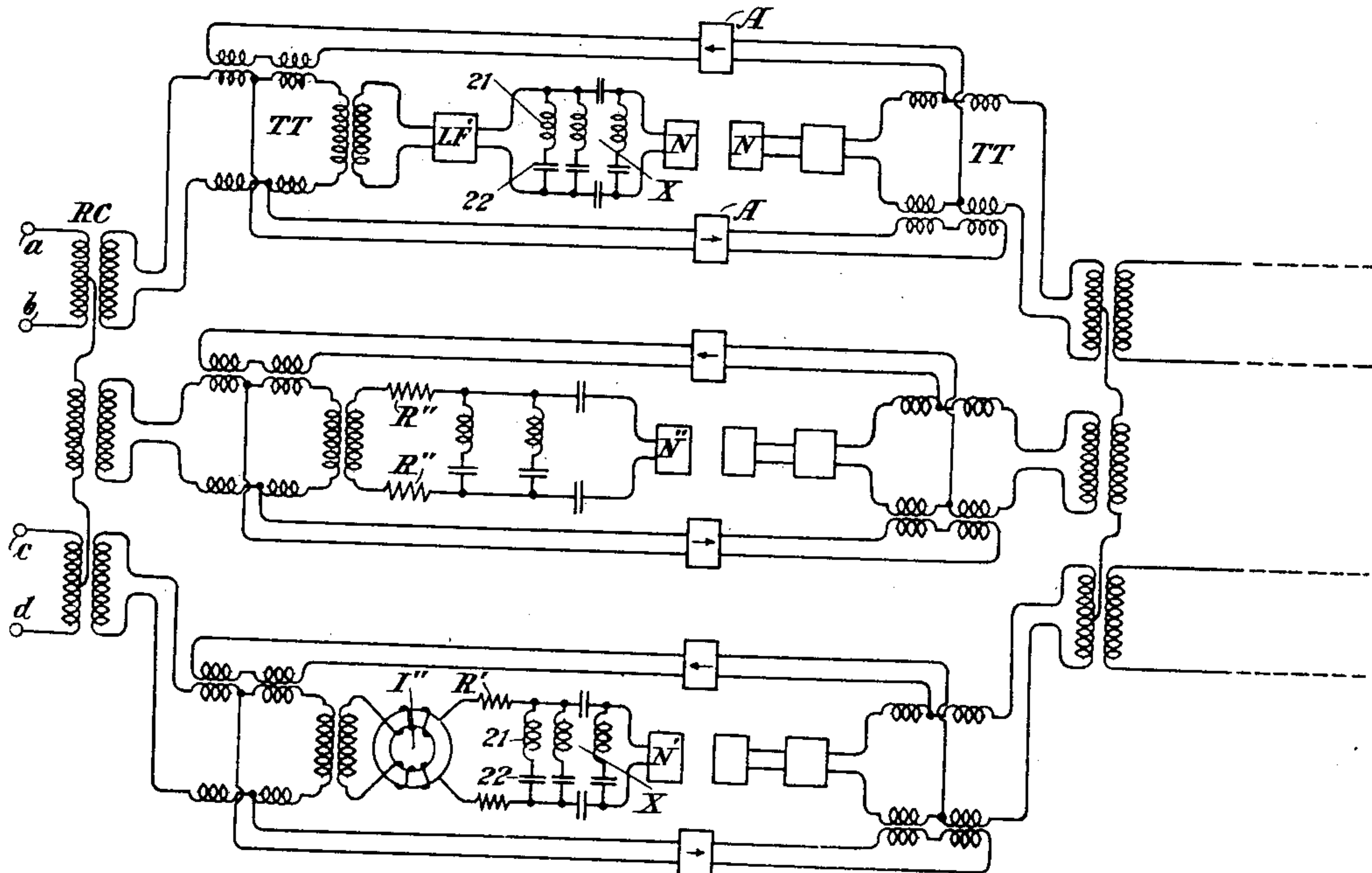


Fig. 2

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CARRIER-CURRENT SYSTEM SUPERPOSED ON SIDE CIRCUIT OF PHANTOM SYSTEM.

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It is an object of my invention to provide for superposing a relatively high frequency carrier current system on one of the side circuits of a phantom group system. Another object of my invention is to provide suitable modifications for one side circuit of a phantom system when connections and modifications are made for superposing a carrier current system on the other side circuit of the phantom group. These objects and various other objects of my invention will become apparent in connection with the following disclosure of one specific embodiment of the invention which I have chosen to present by way of example. It will be understood that this disclosure relates principally to this particular embodiment of the invention and that the scope of the invention will be indicated in the appended claims.

Referring to the drawings, Figure 1 is a symbolic diagram showing one end of a phantom group with the apparatus and connections at that end for a carrier current system superposed on one of the side circuits, and Fig. 2 is a diagram for a repeater embodying my invention.

In Fig. 1 the phantom group comprises the conductors  $S_1$  for one side circuit and  $S_2$  for the other side circuit. Connections are provided as shown for Morse telegraph sets such as MS. Terminal two-way telephone stations  $TS_1$  and  $TS_2$  are connected through repeating coils such as RC to the respective side circuits  $S_1$  and  $S_2$ . Another such station  $TS_3$  is connected on the phantom circuit as shown in the drawing.

Branch conductors CB are connected to the two conductors of the side circuit  $S_1$  for a carrier current system to be superposed on the side circuit  $S_1$ . A high-pass filter HF is interposed in these branch conductors and a low-pass filter LF is interposed in the side circuit  $S_1$  between the point of connection of the branch conductor CB and the repeating coil RC. Connected to the high-pass filter HF are branch conductors to a high-pass filter HF' and a low-pass filter LF'.  $TS_4$  is another two-way terminal telephone station connected over a line to the three-winding transformer T for two-way telephone transmission. The outgoing voice currents from the station  $TS_4$  go through the modulator M where they modulate carrier current of a certain frequency from the

generator G. These modulated currents go through a band filter of comparatively narrow pass range to bus-bars and thence through an amplifier A and the high-pass filter HF' to the input of the high-pass filter HF.

On the other hand, incoming modulated high frequency carrier currents go from the line  $S_1$  through the branch conductors CB and the high-pass filter HF, thence through the low-pass filter LF', amplifier A', bus-bars, band-pass filter BF', demodulator D, three-winding transformer T and over the line to the terminal station  $TS_4$ .

High-pass filter HF prevents diversion of the voice frequency currents from the side circuit  $S_1$  to the high frequency carrier current terminal apparatus shown at the upper right part of the drawing. On the other hand, the low-pass filter LF prevents the high frequency currents from getting back through the repeating coil RC.

These two filters HF and LF have appropriate terminal networks at the right, as shown at 11 and 12, designed to give proper impedance equality between the filter at that end and the connected circuits. The two filters HF and LF are designed so that each of them constitutes a proper terminal network for the other at that end.

The low-pass filter LF has the two series coils of each section wound on a common core, as shown in the drawing, and wound so that for the normal currents of the side circuit, the two coils on one core are series-aiding; that is, a current flowing one way on one of the two conductors of the side circuit  $S_1$  and back on the other conductor tends to build up magnetic fluxes the same way round in the common core, such as I. However, the end core W nearest to the line  $S_1$  is made of wood instead of iron as for the others. The coils are wound on this core so as to be mutually inductive but the core is of wood so as to prevent intermodulation between the high-frequency currents themselves and between the high-frequency currents and the low-frequency currents as might occur at this point if an iron core were used here.

It has just been explained how the windings on each core for the coils of the low-pass filter LF tend to aid in building up flux for side circuit currents. It will readily be seen that for the phantom circuit cur-



rents the two coils on one core oppose each other; the flux due to the one coil being in the opposite direction to the flux due to the other coil. Therefore, for phantom circuit  
 5 currents the low-pass filter would be of negligible effect were it not that for such currents there will inevitably be a certain amount of leakage flux in the coils and cores of the low-pass filter LF. Thus the cur-  
 10 rents in the phantom circuit will meet a certain amount of inductive reactance due to this leakage flux; and also the windings of the low-pass filter LF will necessarily have a certain amount of resistance which  
 15 will be opposed to the phantom circuit currents. These impedances would tend to unbalance the two sides of the phantom circuit; to maintain the proper balance I introduce in the other side circuit  $S_2$ , the two  
 20 coils on the common core  $I'$  and the series resistances  $R$ , which may by proper design be included in the coil windings.

The relation of the windings on the core  $I'$  is opposite to the relation of the windings  
 25 on core  $I$ . The windings on core  $I'$  are so that for side circuit currents through those windings the fluxes oppose one another and the coils give very little inductive effect. But for the phantom circuit currents in the  
 30 windings on the core  $I'$ , the fluxes in the two coils are in the same direction around the core. The design is such that the inductance reactance of the coils on the core  $I'$  for phantom circuit currents is equal to  
 35 the inductance reactance due to leakage in the coils of the filter LF for phantom circuit currents. Also, the resistance of the windings  $R$  is equal to the resistance of the low-pass filter LF.

40 By my invention, a high frequency carrier current system may be superposed on one of the side circuits of a phantom group, and simple, inexpensive apparatus interposed in the other side circuit to keep a good  
 45 balance between the two sides of the phantom circuit.

Where the voice frequency telephone circuit is equipped for repeater operation a similar advantage is gained in the balancing  
 50 circuit of the repeater by the use of a coil and resistances similar to  $I'$  and  $R$  in Fig. 1. This may be explained in connection with Fig. 2. Referring to the four junction points  $a, b, c, d$  in Fig. 1, the apparatus at  
 55 the right of these is terminal apparatus. This terminal apparatus may be cut off and repeaters connected at these four points as shown in Fig. 2. Each repeater comprises three winding transformers  $T, T$ , networks  
 60  $N, N$  to balance the lines, and amplifying elements  $A, A$ . To complete the balance of the line  $S_1$  of Fig. 1 the low-pass filter LF' is interposed in Fig. 2 like LF of Fig. 1; the coil 21 and condenser 22 simulate the  
 65 carrier branch CB and connected elements,

and the network  $X$  simulates the network for the Morse sets. Similarly the line  $S_2$  is balanced by the network  $N'$  supplemented with resistances  $R'$  and  $I''$  to match  $R$  and  $I'$ ; in this case, the elements 21, 22 and  $X$   
 70 are as explained above for the like elements associated with LF'. For the repeater on the phantom circuit the balancing network  $N''$  is supplemented by the resistances  $R''$  which simulate in the filter LF on one side  
 75 and the coil  $I'$  and resistances  $R$  on the other side in the phantom circuit.

I claim:

1. In combination, a phantom group with two side circuits and a phantom circuit, a  
 80 high frequency carrier branch circuit connected with one side circuit, a high-pass filter in said branch circuit, a low-pass filter in the associated side circuit between the connection of the carrier branch circuit and  
 85 the end of said side circuit, said low-pass filter having series coils wound in aiding relation for said circuit current and in opposing relation for phantom circuit cur-  
 90 rents, and coils in the remaining side circuit wound in aiding relation for phantom circuit currents and in opposing relation for side circuit currents.

2. In combination, a phantom group with two side circuits and a phantom circuit, a  
 95 high frequency carrier branch circuit connected with one side circuit, a high-pass filter in said branch circuit, a low-pass filter in the associated side circuit, and coils and resistances in the remaining side circuit,  
 100 these resistances being equal to the resistance of the said low-pass filter in the first mentioned side circuit and these coils having opposed windings for side circuit currents and aiding windings for phantom circuit currents with inductance value equal to  
 105 the leakage inductance in the said low-pass filter.

3. In combination, a phantom group with two side circuits and a phantom circuit, a  
 110 high frequency carrier branch circuit connected with one side circuit, a high-pass filter in said branch circuit, a low-pass filter in the associated side circuit between the connection of the carrier branch circuit and  
 115 the end of said side circuit, said low-pass filter having series coils in pairs, one on each side and alternately disposed shunt condensers, each pair of coils being wound on one core in aiding relation for side circuit  
 120 currents and opposing relation for phantom circuit currents, and the other side circuit having a coil and resistance in each of its two conductors the resistances being of the same value as the resistance of said low pass  
 125 filter, and the coils being wound on the same core and having opposing relation for side circuit currents and aiding relation for phantom circuit currents and the same inductance value as the leakage inductance  
 130



value for phantom circuit currents in said low-pass filter.

4. In combination, a phantom group with two side circuits and a phantom circuit, a  
5 high frequency carrier branch circuit connected with one side circuit, a high pass filter in said branch circuit, a low-pass filter in the associated side circuit, means in the  
10 of the phantom circuit and repeaters for the two side circuits and the phantom circuit

with balancing elements comprising a low-pass filter corresponding to said first mentioned low-pass filter and means corresponding to said first mentioned means and a re- 15  
sistance in the phantom repeater to balance both said filter and means in that circuit.

In testimony whereof, I have signed my name to this specification this 6th day of March, 1928.

JOSEPH T. O'LEARY.