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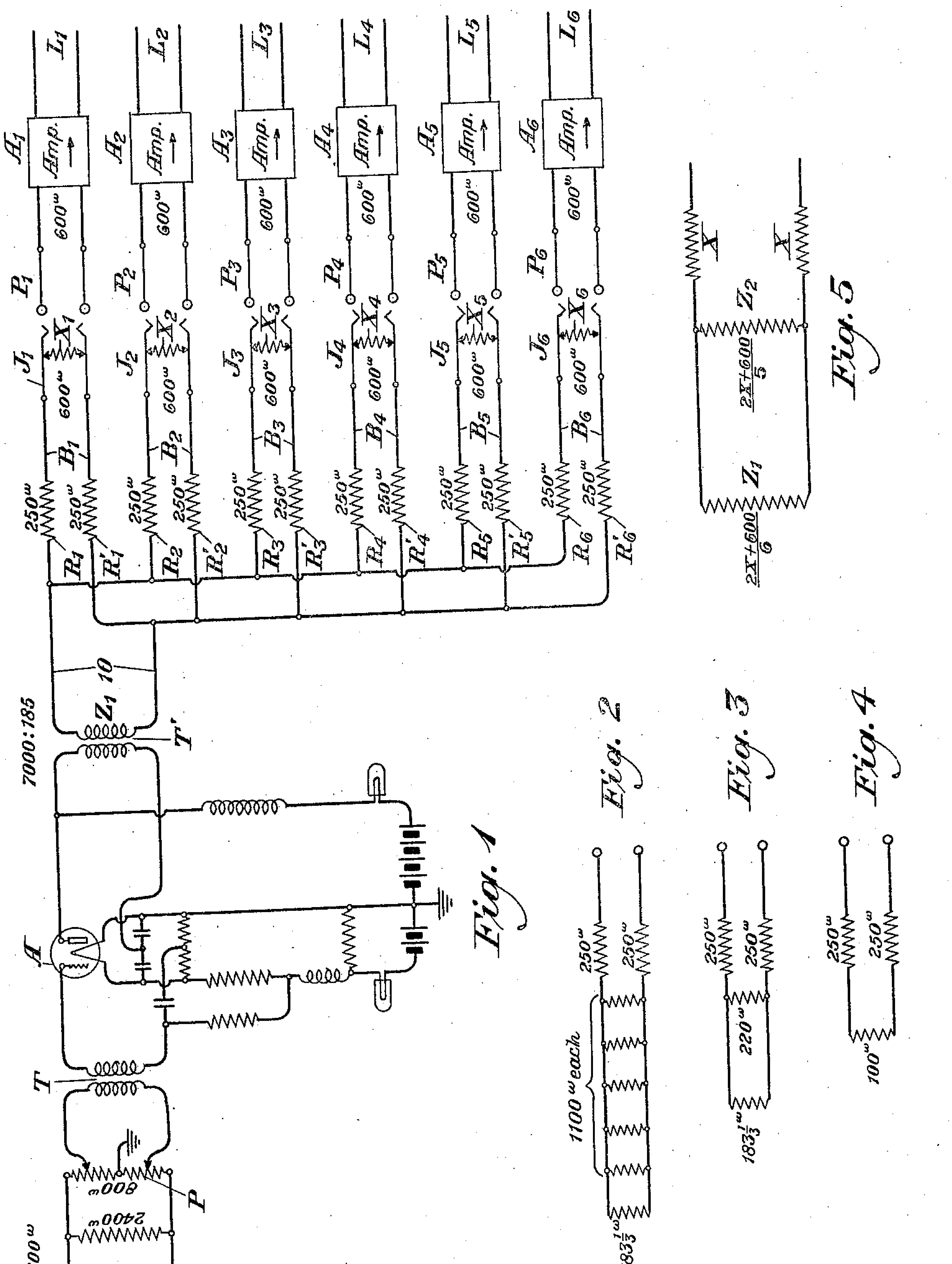

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BRIDGING CONNECTION FOR PROGRAM CIRCUITS

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This invention relates to transmission circuits, and more particularly to arrangements whereby a main transmission line may have a number of branch or auxiliary lines bridged thereto so as to receive transmission from the main line in multiple.

In program transmission it is frequently desirable to have a main program line connected so that the program transmitted thereover may be transmitted into each of a number of branch lines. In accordance with the present invention the branch lines are connected in bridged relation with respect to the main line so as to receive transmission therefrom in multiple with respect to each other. In order that any branch line may be disconnected from the network without affecting the existing impedance relations the circuit is arranged so that when any branch line is disconnected it will be replaced by its equivalent impedance.

The bridging arrangement is also designed so that the impedance looking into the bridging arrangement from the connection leading to any line will be equal to that of the line itself. This is accomplished by inserting series impedances in each branch of the bridging arrangement ahead of the branch line. These impedances also serve the purpose of preventing an accidental short across a branch line from disabling other branch lines.

The bridging network above described introduces a certain amount of transmission loss, and in accordance with the present invention this is made up by inserting in the main line an amplifier having its gain adjusted to compensate for the loss in the bridging network. This amplifier is preferably connected to the network by a transformer having such a ratio as to step up the impedance looking into the bridging network to the impedance of the output circuit of the amplifier.

The invention will now be more fully understood from the following description when read in connection with the accompanying drawing, in which Figure 1 shows a circuit arrangement embodying the present invention, and Figs. 2, 3, 4 and 5 are equivalent diagrams showing how the impedance looking into each branch of the bridging arrangement is made equal to that of the branch line itself.

Referring to Fig. 1, ML designates a main program line which it is proposed to connect to branch lines L_1 to L_6, inclusive, so that the same program may be transmitted to each of the branch lines. The main line ML is coupled through a transformer T to an amplifier A, a potentiometer P being included in the main line ahead of the transformer to adjust the gain of the amplifier A. The output of the amplifier A is coupled through a transformer T′ to a circuit 10 from which bridging connections B_1 to B_6, inclusive, are extended for the purpose of connecting the various branch lines L_1 to L_6, inclusive to the circuit. The bridging connections terminate in jacks J_1 to J_6, inclusive, in which plugs P_1 to P_6, inclusive, of the various branch lines may be inserted to complete the connections to the branch lines. In the idle condition of the jacks, resistances X_1, X_2, X_3, etc., are connected across the jack springs. These resistances are made equal to the impedance looking into each branch line, so that the connection or disconnection of any branch line does not affect the impedance looking into the bridging circuit 10 from the output of the amplifier A. Each of the branch lines L_1, L_2, etc., is provided with an amplifier indicated at A_1, A_2, etc.

It is, of course, necessary in order to avoid variations of the gain-frequency curves of amplifiers A, etc. when their gains are changed, that the impedance looking from a branch line into any bridging circuit such as B_1 and B_2 towards the amplifier A should be equal to the impedance looking into the branch line itself. Accordingly, resistances such as R_1 and R'_1 are inserted in the bridging circuit B_1 ahead of the jack J_1, and similar resistances are inserted in the other bridging circuits. These resistances also serve the useful purpose of preventing an accidental shorting of any of the branch lines from materially affecting the transmission in the other branch lines.

The bridging network above described, introduces a certain amount of loss in transmission from the main line ML to the input of the amplifiers such as A_1 or A_2 in the branch lines, and the gain of the repeater A is adjusted so that it will just compensate for the loss so introduced. In order that there may be no impedance irregularity between the output of the repeater A and the bridging circuit, the impedance looking into the bridging circuit 10 which is that looking into the several bridging circuits in parallel, is stepped up by means of the transformer T′ to the impedance of the output circuit of the amplifier A.

If we assume that each branch line has an impedance of 600 ohms looking into its amplifier such as A_1, each of the series resistances in each bridging circuit should have a value of 250 ohms in order that the impedance looking into each bridging circuit will be equal to that loking into the branch line amplifier. If no series resistances such as R_1, R'_1, etc., were provided, the impedance looking into the circuit 10 towards the bridging circuit would be that of six circuits in parallel, each having 600 ohms impedance, or 100 ohms. If then the impedance looking into the transformer T′ is made equal to the impedance in the other direction, the impedance looking into the output of the amplifier A would also be 100 ohms. The impedance looking towards the amplifier from any bridging circuit such as B_1, would then be equivalent to an impedance of 100 ohms looking into the amplifier in parallel with the impedance of five 600 ohm circuits connected in parallel with each other; that is, a 100 ohm impedance in parallel with an impedance of 120 ohms. Consequently, there would be a very serious impedance irregularity in passing from the amplifier A through the bridging circuit to the 600 ohm branch line.

If, however, an impedance of 250 ohms is inserted in each side of each bridging circuit, this impedance irregularity will be eliminated. The impedance looking into each branch, taken alone, will now be 1100 ohms, and the impedance as seen from the circuit 10 will be that of six 1100 ohm circuits in parallel, or 183⅓ ohms. Assuming that the transformer T′ has such ratio as to step the output impedance of the amplifier A down to 183⅓ ohms, the impedance looking from the circuit 10 into the transformer T′ will then also be 183⅓ ohms. The equivalent impedance as seen from any bridging circuit as, for example, the bridging circuit B_1, will then be as indicated in Fig. 2 which shows 5 parallel impedances of 1100 ohms each (these being the impedances of the five branch circuits B_2 to B_5, inclusive) in parallel with the impedance looking into the transformer T′ of 183⅓ ohms, and in series with this combination the 250 ohm impedances included in the branch circuit itself. Since the five 1100 ohm impedances in parallel are equivalent to a single impedance of 220 ohms, the circuit reduces to the simplified form shown in Fig. 3. But, 220 ohms in parallel with 183⅓ ohms is equivalent to an impedance of 100 ohms so that we have, looking into any bridging circuit, 250 ohms in series with 100 ohms in series with a second resistance of 250 ohms, or a total of 600 ohms as shown in Fig. 4.

As already stated, the impedance looking from the circuit 10 into the bridging network will be that of the six bridging circuits in multiple. As each bridging circuit has an impedance of 600 ohms which is seen through a series impedance of 500 ohms (250 ohms in each side) the actual impedance looking into each bridging circuit is 1100 ohms. Six 1100 ohm impedances in parallel are equivalent to an impedance of 183⅓ ohms so that this is the value of the impedance looking from the circuit 10 into the network. The impedance looking in the opposite direction from the transformer T′ should have substantially the same value. As the output circuit of the amplifier has an impedance of approximately 7000 ohms, by making the ratio of the transformer T′ 7000 to 185, the impedance looking into the transformer will substantially match that looking into the network.

The impedance looking into the main line ML would also normally be 600 ohms, and the connection looking into the amplifier A should therefore be 600 ohms. As the grid circuit of the amplifier is practically infinite the impedance looking through the transformer T will also be practically infinite, and the taps on the potentiometer P are, from an impedance standpoint, equivalent to having the primary circuit of the transformer T open circuited. Since the potentiometer P has an impedance of 800 ohms, and this impedance is shunted by a resistance of 2400 ohms, the impedance looking into the combination towards the repeater will be 600 ohms, as is required.

The values of the resistances R_1, R_1', etc., may be computed in the following manner. Referring to Fig. 5 which shows the equivalent of the impedance looking to the left from any branch circuit, we have two unknown series impedances X whose value is to be determined, and beyond these series impedances is a shunt impedance Z_2 which is the equivalent of the parallel impedances of the other five branch circuits, and a second shunt impedance Z_1 which is the impedance looking to the left through the transformer T'. Now, since each bridging circuit is to be terminated in 600 ohms and will have ahead of it two series impedances each having a value X, the impedance looking into each bridging circuit will be 2X+600, and hence, the impedance Z_2 which is equivalent to the five bridging circuits in parallel will be

$$\frac{2X+600}{5}$$

The impedance Z_1 of Fig. 1 is the impedance looking into the transformer T' and should be equal to the impedance looking to the right into the six bridging circuits. Consequently, the impedance Z_1 will be equal to the impedances of six bridging circuits in parallel or

$$\frac{2X+600}{6}$$

Now, since the impedance looking into the circuit of Fig. 5 is to be equal to 600 ohms (the impedance looking into the branch line amplifier) we have by setting down the equation of Fig. 5,

$$\frac{\left(\frac{2X+600}{6}\right)\left(\frac{2X+600}{5}\right)}{\left(\frac{2X+600}{6}\right)+\left(\frac{2X+600}{6}\right)}+2X=600$$

from which we get X=250.

If each of the resistances R_1 and R_1', etc., are given this value the impedance of the bridging network, as seen from any bridging circuit will be 600 ohms, and the impedance of the network as seen from the output side of the transformer T' will be equal to the impedance looking into the output circuit of the amplifier A through the transformer T', so that no impedance irregularities will occur. When any branch line such as L_3, for example, is disconnected from the bridging circuit by pulling the plug P_3 from the jack J_3, a corresponding 600 ohm resistance X_3 is substituted for the impedance looking into amplifier A_3 of the line which is disconnected, and hence, the impedance looking into the network from any of its other terminals is unchanged.

If, through accident, or circuit fault, an open circuit should occur to the right of the series resistances such as R_1, R_1', etc., the impedance relations of the other branches will not be seriously disturbed. The impedance beyond the series resistances of any other bridge terminal will then be that of four bridging circuits instead of five, in parallel with the impedance looking into the transformer T', which will be about 110 ohms instead of 100 ohms as given in Fig. 4. Consequently, the total impedance looking to the left from any bridging terminal will be about 610 ohms instead of 600 ohms.

If, instead of an open circuit, one of the branch circuits should be shorted to the right of the 250 ohm resistances, here again the impedances as seen from the other terminals of the network will not be greatly changed. For example, the impedance looking into the network from any other bridging terminal will be as shown in Fig. 2, except that one of the five 1100 ohm resistances shown will now be a 500 ohm resistance. The other four 1100 ohm resistances in parallel are equivalent to an impedance of 275 ohms which, in parallel with the impedance of 183⅓ ohms looking into the transformer, will be equivalent to about 110 ohms. This result in parallel with the now defective branch having an impedance of only 500 ohms, is equivalent to about 90 ohms which, taken in series with the two 250 ohm resistances, gives for the impedance as seen from any branch circuit a total impedance of about 590 ohms instead of the 600 ohms required by theory.

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 transmission system, a main line including an amplifier, a plurality of branch lines, a bridging circuit interposed between said amplifier and said branch lines, said bridging circuit having multiple bridge connections for said branch lines, impedances in each bridge connection between the bridging line and the junction point of the bridge connections, said impedances having such values that the impedance looking into the bridging circuit from any branch line will be equal to the impedance of the branch line itself and the impedance looking into the bridging circuit will be less than the impedance of a branch line, and a transformer associating said bridging circuit with the output of said amplifier and equalizing the impedance looking into the amplifier with respect to the bridging circuit.

2. In a transmission system, a main line including an amplifier, a plurality of branch lines, a bridging circuit interposed between said amplifier and said branch lines, said bridging circuit having multiple bridge connections for said branch lines, a transformer associating said bridging circuit with the output of said amplifier, and impedances in each bridge connection between the bridging line and the junction point of the bridge connections, said impedances having such values that the impedance looking into the bridging

circuit from any branch line will be equal to the impedance of the branch line itself and the impedance looking into the bridging circuit will be less than the impedance of a branch line, and the ratio of the transformer being such that the impedance looking into the amplifier from the bridging circuit will be stepped down to the impedance looking into the bridging circuit from the amplifier.

In testimony whereof, I have signed my name to this specification this 1st day of October, 1931.

GEORGE CRISSON.

In testimony whereof, I have signed my name to this specification this 22d day of October, 1931.

HAROLD S. HAMILTON.