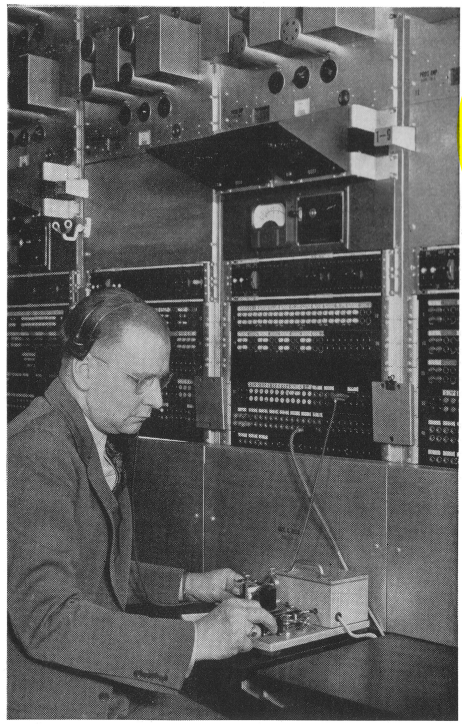

Remote Control for Reversible Program Circuits

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WIRE networks over which radio programs are transmitted form extensive systems, with broadcast stations or studios in most of the larger cities interconnected by high-quality circuits employing amplifiers. The transmission over these circuits differs from ordinary telephone transmission in that it is unidirectional and one-way amplifiers are employed. Because a studio may either transmit or receive programs, however, it is necessary to provide means for changing the direction of transmission over the network. This has been done in the past either by using separate facilities which transmit in opposite directions, or by interchanging the input and the output of the amplifiers by the use of patch cords or by switches* which are manually operated.

To provide quicker reversals, a remotely controlled reversing circuit has been developed which permits the reversing of the circuits to be controlled from the studio originating the program. Reversals are effected by relays controlled by direct current transmitted over the two conductors of the program circuit and returned through ground. Any studio may assume control and set up the network so as to transmit the program from it to the other points on the network. As long as this studio retains control, no other studio can alter the conditions; but upon release of control by one, any other studio may assume control, reversing such parts of the network as are necessary to permit transmitting the program to the rest of the network.

The reversing equipment is required at every amplifier point, which may be a simple amplifier station along the line, or a main junction or terminal connecting to a broadcast studio. The basic equipment, which is that required at a cable amplifier station, is shown in Figure 1. It consists of two relays L and M, which

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receive the control current from the line, and operate relays A and B that change the connections of the amplifiers and other equipment such as equalizers to conform to the desired direction of transmission. A green lamp and a white lamp are also provided to indicate the direction of transmission. With the relays in the positions shown in the diagram, transmission is from east to west, and the white directional light is lighted to indicate this fact. This condition had been brought about by connecting battery to the mid-point of a high resistance bridged across the line at some control point to the east of the amplifier station shown. The direct current resulting was taken from the line at the mid-point of the high-resistance bridge, and operated relay M through a back contact of L. The operation of M opened the circuit of the B relay and allowed A to operate through back contacts of L and B. The operation of A following the release of B closed a contact that changed the connections of the equipment for an east-to-west condition, and lighted the white light.

The battery connection at the control station should be maintained until a change of direction is desired. The control may be released some time before the change is made, if desired. This allows relay M to release, but relay A will remain operated, and thus the circuit will remain in the east-to-west condition. Relays L and M, now being released, are ready to receive operating current from either direction. If some station to the west of the amplifier station is to take control and transmit, for example, a similar direct current will be sent over the line from the west control point, and this current will operate L. When L operates, the holding circuit of A is opened and the B relay is operated through back contacts of M and A. This extinguishes the white lamp, changes the equipment connections for west-to-east transmission and simultaneously lights the green lamp.

These four relays, or equivalent ones, perform the reversing function at all amplifier points, but certain additional relays and keys are added to accomplish a number of other purposes. The A and B relays actually control the reversing changes and light the directional lamps to indicate which direction is in use. Each of these relays is interlocked through a back contact of the other so that only one is operated at a time. The L and M relays—also interlocked through a back contact on the other—receive the

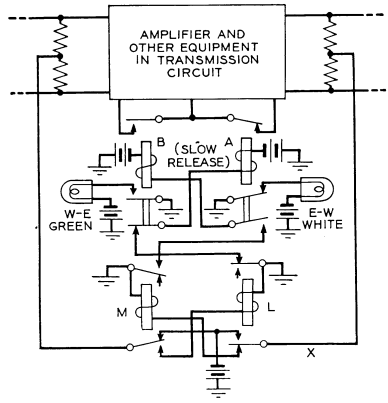


Fig. 1—Schematic of reversing circuit used at amplifier points between two cable sections

control current, and in turn operate the A or B relay. Whichever directional relay, A or B, is operated will remain operated when both L and M are released. This enables a station to relinquish control a few minutes in advance of the next reversal. Both A

and B are given slow-release characteristics so that momentary disturbances on the line will not cause false operation.

Besides controlling its own directional relays, the L and M relays also send a control current over the next section of line. When a control pulse comes in from the east, for example, and operates M of Figure 1, battery will be connected through a front contact of M to the bridging resistance across the west-bound cable, so as to

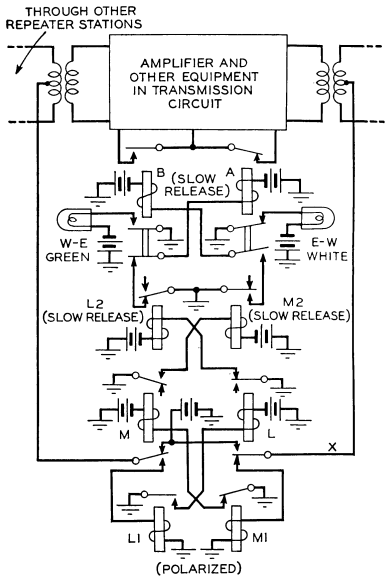


Fig. 2—Transmission-reversing circuit for use between open-wire lines

operate the M relay at the amplifier station next to the west. In a similar manner, this station will repeat to the next, so that control current sent from New York, for example, will reverse all the amplifiers along the line to the distant terminal. As is evident from the diagram, this repeating action works for both directions of transmission. A control current coming from the west will operate L of Figure 1, which will repeat it over the

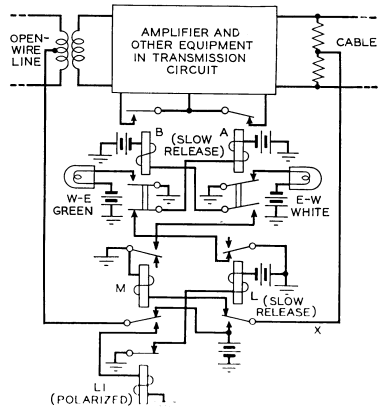


Fig. 3—Transmission-reversing circuit for use at junction of cable and open wire line

next section of cable to the east, and so on. This repeating of the control current to the next section is not affected by the slow-release characteristics of the A and B relays, and thus the control current is transmitted rapidly over the entire circuit. One thousand miles of cable circuit, with amplifiers located at approximately fifty-mile intervals, may be reversed in a few seconds.

When the amplifier station is between two open-wire sections instead of between two cable sections, additional relays are required to insure satisfactory operation. These are needed because open-wire lines are not only much more subject to outside disturbances than are cables, but have much higher leakage to ground. The circuit arrangement for an amplifier station between two open-wire

sections is shown in Figure 2. It will be noticed that the d-c control path is connected to the line at the mid-point of a repeating coil rather than of a high-resistance bridge. Because of the high leakage of the open-wire lines, much more current must be put on the line to insure that a sufficient amount reaches the distant station to operate the relays, so that the high-resistance feed is not satisfactory.

The current actually reaching the distant end varies widely not only because of varying leakage but because of variations in the ground potential. To make sure the relays do not operate falsely, their minimum operating current must be held to close limits, and for this reason polarized relays are used ahead of the regular L and M relays. These relays are marked L1 and M1—L1 operating L, and M1 operating M. Because of the greater likelihood of disturbances, it is necessary also to provide a greater time delay between the action of L and M and of A and B. This is provided by two slow-release relays, L2 and M2, between L and M and A and B. These enable A and B to "hold in" over longer surges of current than the slow-release of A and B alone would permit.

For amplifier stations between an open-wire line section and a cable section, these additional precautions need be taken only on the side toward the open-wire line. Only one polarized relay is employed therefore, as shown in Figure 3, and the additional delay between the L and M and the A and B relays is obtained by giving either the L or M relay slow-release characteristics. This puts a delay in the d-c transmission path, while the arrangement of Figure 2 does not. It is not satisfactory, therefore, for general use, but since the junctions of open wire and cable are of comparatively rare occurrence, it is permissible to take advantage of the simpler circuit that this arrangement permits.

Where the open-wire section is particularly subject to very wide variations in leakage and ground potential, a "metallic" path over the line is provided for the control current as shown

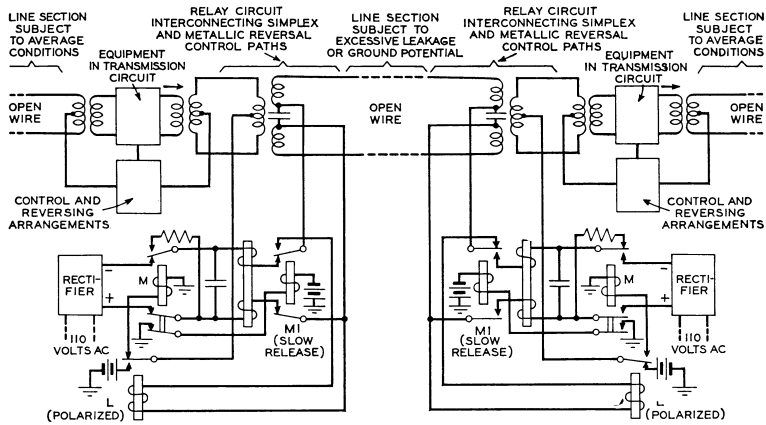


Fig. 4—Metallic control circuit used with open-wire lines subject to excessive leakage or ground potential difference

in Figure 4. The transmission-reversing circuit is the same as Figure 2, but between it and the open-wire line is another repeating coil with a large-capacitance condenser inserted in the line side of the coil. This provides the two feed points for a metallic control circuit, which is arranged in a similar manner at the other end. This circuit also uses a polarized relay, L, for receiving control current from the open-wire line, and an M relay to receive the grounded control current from the local amplifier station. With all relays released, grounded control current from the amplifier station operates M through a back contact of L. M operates M1, and connects d-c from a rectifier to the metallic line circuit. At the other end, this current operates L, which sends a grounded current to the amplifier station. A filter consisting of a retard coil and a condenser is connected between the rectifier and the line. When M releases, a resistance is connected across the line to discharge both the filter condenser and the condenser in the repeat coil to avoid false pulses or clicks in the program circuit due to the discharge current. The slow-release characteristic of M1 maintains the connection to the repeating-coil condenser for a long enough time to discharge it.

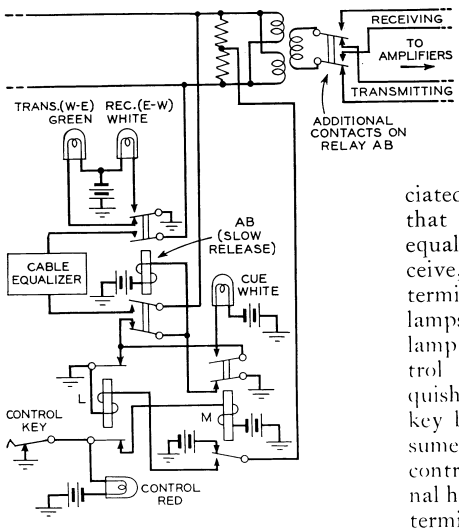


Fig. 5—Schematic diagram of typical control circuit for a terminal

At a terminal the amplifiers are under control of the broadcasting company, and the only switching of equipment associated with the line required at that point is the insertion of an equalizer when that terminal is to receive, and its disconnection when that terminal is to transmit. Directional lamps are also provided, and a "cue" lamp is added to indicate when control of the circuit has been relinquished. In addition there is a control key by which that terminal may assume control of the circuit. A red control lamp lights when that terminal has control. A schematic of such a terminal circuit is shown in Figure 5. The cue lamp is lighted only when no station has control of the circuit, since it is extinguished by the operation of M, or by the operation of L, if M is released. A single relay, AB, takes the place of the A and B relays at amplifier points, and operates on outgoing control current, and releases on incoming. Its only function is to light the directional lamps, and to insert an equalizer across the line when the direction of transmission is inward, and to remove it when the direction of transmission is outward.

Certain amplifier points act as junctions for a number of lines, and the direction of transmission might be from any one of them to all the others

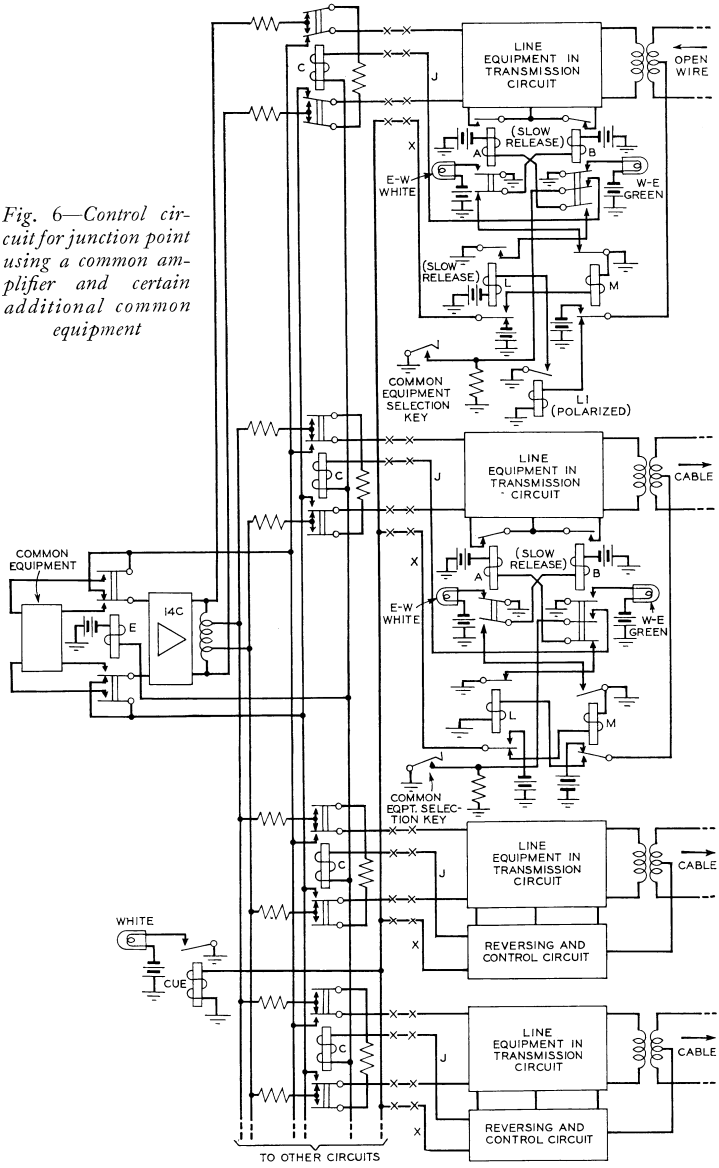


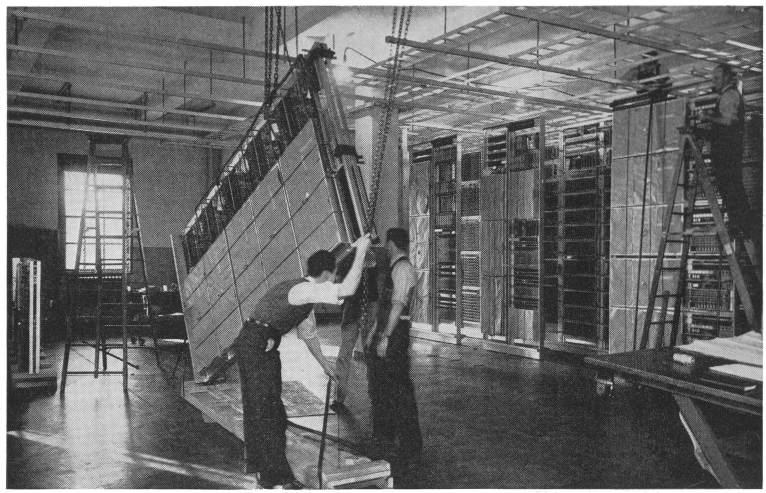
Fig. 6—Control circuit for junction point using a common amplifier and certain additional common equipment

through a bridging multiple.* Under these conditions there would be a reversing control circuit like one of those illustrated above for all the lines. Then by connecting all the leads "x" from the L relays together, the proper reversals will take place as the various lines assume control.

Under these conditions, however, it is frequently more economical to use only a single amplifier to supply all the outgoing circuits, rather than one for each circuit, and possibly a certain amount of other common equipment as well. This is made possible by adding one relay, C, for each line and one common relay, E, as shown in Figure 6. Here, it will be noticed, the X leads are all tied together as already mentioned. In addition another contact has been added to the B relays and the lead from it, J, runs to the added relay C whose winding is in series with that of the common relay E. This latter is a marginal relay, and requires more current to operate than do the C relays. It operates, therefore, only when a "common equipment selection key" is operated for one of the lines. When E is not operated, only the amplifier is used in common, but when one of the "common equipment" keys is operated, E also operates and inserts the additional common equipment.

Throughout the development of this reversing system, stress has been laid upon simplicity of operation and on dependability of service. The remote control feature constitutes an important improvement in nation-wide program-network operation.

*RECORD, *Aug.*, 1940, *p.* 362.



Swinging a unit of crossbar switching equipment into place in a Washington, D. C., central office, as part of a program to increase telephone facilities required by defense activities in the nation's capital. Normal installation periods are being shortened by as much as fifty per cent and it is expected that 22,500 additional telephone lines will be in service by the end of 1941