DX SIGNALING SYSTEM

GENERAL DESCRIPTIVE INFORMATION

CONTENTS PAGE

1. GENERAL

A. Introduction

1.01 ➧This section describes the DX signaling system, designed to pass supervisory and dial pulsing signals over cable pairs used for voice transmission. The DX system is not intended for open-wire facilities and requires the two conductors of a cable pair and ground return to tie its terminals together. DX signaling provides equal and independent action in opposite directions for 2-way signaling, compensates for differences in ground potential, and does not require composite sets. Terminals of this system supplement trunk or signaling system circuits arranged for E and M lead signaling. DX signaling uses 48-volt signal battery and allows conductor loop resistances of 0 to 5000 ohms. It is equipped to pass 2-way supervision and nominal 10 or 20 pps dial pulses with little signal distortion and without pulse repeating adjustments or pulse correctors. These pulses are not impaired by the addition of E-type repeaters or by the signal bypass circuit of V-type repeaters.

1.02 This section is reissued to cover the mercury relay DX signaling circuits and to expand the description under Method of Operation.

1.03 There are two basic DX circuits, both of which provide A and B (or T and R) leads for connection to the wire facility and E&M leads to the connecting circuit. Of these two, the DX1 circuit is used when the connecting circuit is a signal circuit. DX2 is the same as DX1 except that it has an additional relay to convert the signals on the E&M leads for signal lead extension.

1.04 One conductor of a cable pair in the DX system carries the supervisory and pulsing signals; both conductors individually carry currents resulting from differences in terminal ground potentials and battery voltages so the current in the second conductor tends to cancel the effect of this unwanted current in the first conductor. With this arrangement, DX signaling introduces less noise in adjacent circuits than loop (battery and ground) signaling and is not significantly affected by the usual ac induction voltages. Each DX terminal circuit is generally joined to the line loop through the midpoints of a repeating coil that may serve also for impedance matching, signaling separation, and suppression of noise between office and line systems. Tied to the cable pair in this way and shunted by a 4 mf capacitor, DX signaling does not materially interfere with or suffer impairment from voice transmission.

1.05 A symmetrical and balanced circuit similar to that used in composite (CX) signaling is employed in the DX system. Identical circuits face the line conductors at both terminals, permitting full duplex signaling; ie, equal and independent signals in both directions. DX signaling has better operating margins than present forms of loop signaling because of the following design features.

(a) Signaling is accomplished by alternate applications of battery and ground potential to a line conductor, using contacts which maintain the same circuit and, therefore, the same current transition delay for the alternate conditions of signaling. This arrangement markedly reduces the amount of signaling distortion arising from variations in circuit resistance, inductance, and capacitance. While these circuit parameters do introduce signaling delay times, the resulting percent break is unaffected.

(b) Signals are received by the operation or release of a polar relay with opposing windings arranged to cancel the effect of variations in the circuit components and office battery voltages. The result is less signaling distortion than is possible from only a mechanical relay bias.

(c) A balancing network is provided with adjustments to compensate for whatever line conditions are present.

(d) The effective signaling current is confined to one wire of a pair so there is less resistance and more signal current for equivalent conditions than with loop signaling.

DX signaling circuits repeat 12 pps dial pulsing of 58 percent break input with pulse distortion within ± 4 percent break. This performance is better than that of most loop signaling circuits and is equal to that of intertoll CX signaling arrangements.

B. Applications

1.06 The DX signaling plan which includes the main circuit features and their relation to trunk and repeating coil circuits is shown in Fig. 1. This system replaces SX and CX signaling as the standard for telephone trunks with cable conductor, nonphantom, line facilities, except where two signaling circuits per wire pair are required. It is used exclusively on cable conductors to achieve the advantage of their high insulation resistance. The range of DX signaling is less than that of CX or SX, but its small distortion permits the use of two DX circuits in tandem for one trunk, when this is required. The arrangement shown in Fig. 1 is DX1 (see 1.03).

1.07 The DX signaling system is particularly suitable for automatic, multifrequency, or dial pulsing trunk operation of the following types:

(a) Short intertoll trunks

(b) 2-way exchange and tributary trunks

(c) Local and tandem trunks with high conductor loop resistance or equipped with E-type voice repeaters.

Standard circuits are available for these trunks with provision for E and M leads which allow use of DX signaling, and with options for idle circuit termination which is required with low-loss transmission plans. The DX system allows origination of independent signals at either end (necessary for 2-way trunks) and adds flexibility to separate signaling circuits for one-way trunks.

1.08 At trunk section junction points, where one section uses E and M lead signaling, the DX system provides a more economical means for extending E and M signaling leads than by relay auxiliary pulse links and assures proper termination of all carrier channels extended with cable pairs (Fig. 2). The arrangement shown in Fig. 2 is DX2 (see 1.03).

1.09 Several typical applications of DX signaling are shown in Fig. 3.

2. EQUIPMENT DESCRIPTION

A. General

2.01 There are three vintages of each of the two circuits. Basically, each DX signaling circuit consists of a polarized relay and a balancing resistance-capacitance network. The signal lead extension circuit consists of the basic DX signaling circuit with an added relay. The various equipment arrangements are covered in the following paragraphs.

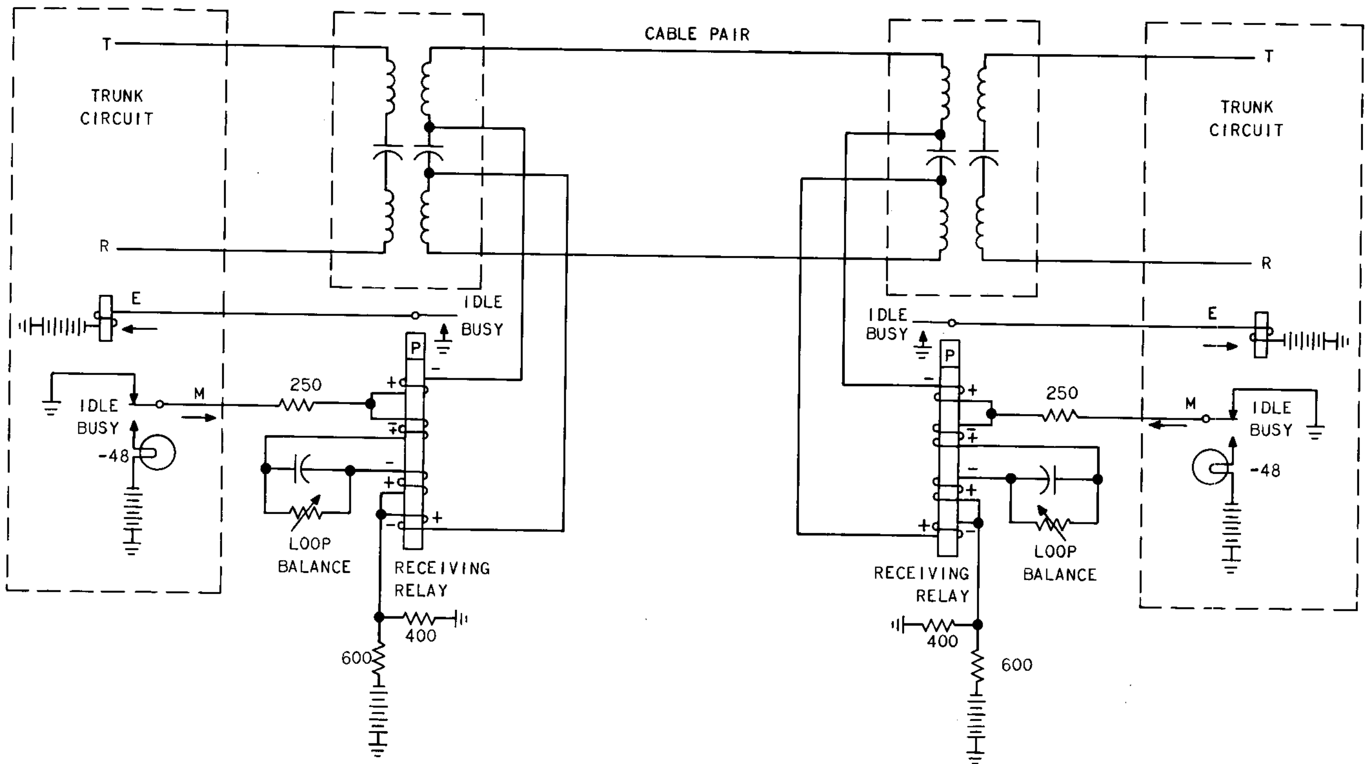

Fig. 1—DX1 Signaling Circuit

B. DX1 Signaling Circuit

2.02 The earliest vintage of DX1 circuits has an equipment arrangement of four DX1 circuits on two 2" x 23" mounting plates. Each circuit is provided with a test jack to facilitate testing of the 280-type relay. Network adjustment is accomplished by strapping capacitors and resistors on the back of the unit.

2.03 The early equipment used 18- and 19-type resistors and stud-mounted paper capacitors. By substituting ceramic resistors and mylar capacitors, both pigtail mounted on terminal strips, a more compact equipment arrangement is achieved. This arrangement provides four DX circuits on a single 2" × 23" mounting plate.

2.04 The present standard circuit uses a mercury contact relay packaged together with the necessary RC network and midpoint capacitor in a single plug-in package approximately 1-3/4" ×1-3/4" × 6-1/2" deep. This plug-in is coded 334A relay. This circuit is available in two apparatus configurations, one providing for ten circuits per shelf, the other (Fig. 4) providing for eight circuits, a test connector, and two indicator lamps. These configurations are available on 2" × 25" long shelves for use in No. 1 ESS offices and on 23" shelves for other offices. In addition to these equipment arrangements, an optional battery and ground isolation unit is provided for use in No. 1 ESS offices. This unit on a 2" × 25" mounting plate provides the optional apparatus needed to provide battery and ground isolation for 20 DX1 circuits. The arrangement with the test connector and indicator lamps is intended to be furnished on a one-per-office basis to permit ready testing of the DX relays.

2.05 DX signaling may also be incorporated and packaged as an integral part of another circuit. The type F signaling system has the current DX signaling circuit incorporated in auxiliary units, such as the FGA or FHA. Another arrangement where the DX signaling is an integral part of another circuit is in tie trunks, such as SD-65718-01.

C. DX2 Signal Lead Extension Circuit

2.06 The earliest signal lead extension circuit has an equipment arrangement providing three circuits on three 2" × 23" mounting plates. As in

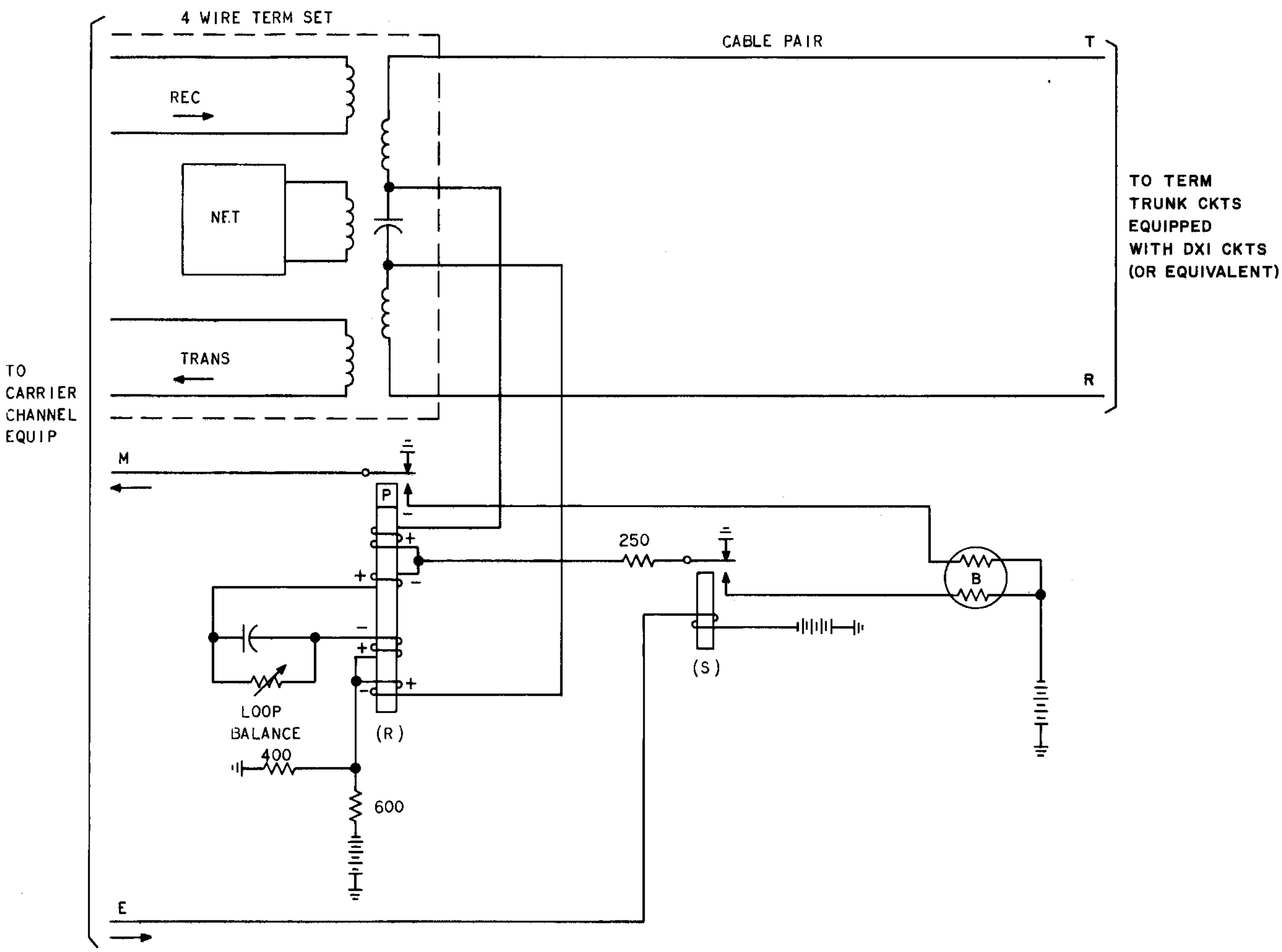

Fig. 2—DX2 Signaling at Intermediate Point

the DX1 circuit, each circuit is provided with a jack to facilitate testing the 280-type relay. Network adjustment is accomplished by strapping.

2.07 As with the DX1 circuit, use of pigtail-mounted components gave rise to a more compact equipment supplying four circuits on a 4″ × 23″ mounting plate.

2.08 Similar to the DX1 circuit, the present standard signal lead extension circuit uses mercury contact relays. The relays and network are packaged in the same 1-3/4" × 1-3/4" × 6" deep plug-in case (coded 334B relay) used for the DX1 circuit. This circuit is available in two equipment arrangements, both on 23″ shelves. One arrangement provides six circuits per shelf while the other (Fig. 4) provides five circuits, a test connector, and four indicator lamps. The arrangement with the test connector and indicator lamps is intended to be furnished on a one-per-office or one per frame (depending on the arrangement of the office bays) basis to permit ready testing of the relays.

3. METHOD OF OPERATION

A. General

3.01 The DX signaling system employs E and M leads for transmitting signals to and from the trunk or signaling system circuits. Signals are

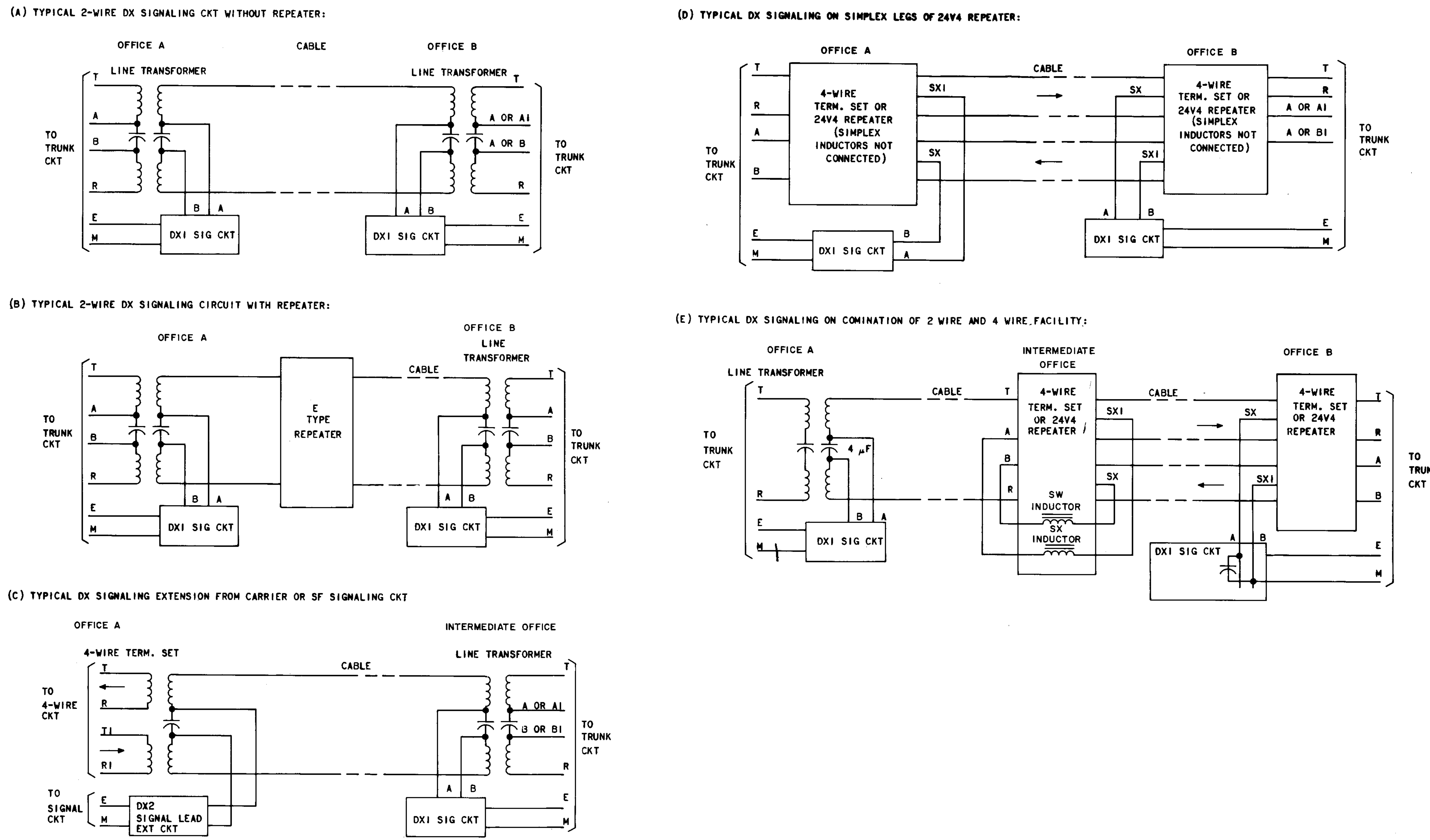

Fig. 3—Typical DX Signaling Applications

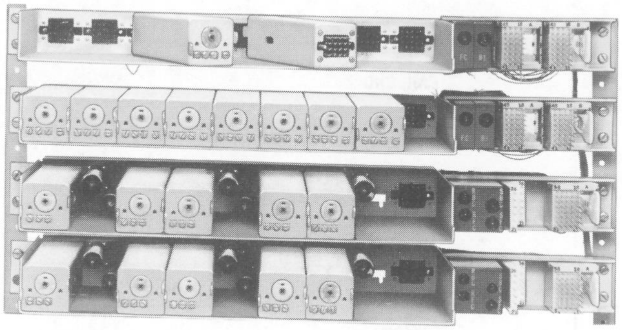

Fig. 4—Shelf Arrangement of Later DX1 and DX2 Circuits Using Mercury Relays

applied to the DX unit in the form of −48 volt battery or ground on the M lead. Signals are received at the trunk circuit in the form of ground or open on the E lead. The E and M leads are completely independent of each other; therefore, signals may be transmitted on the M lead and received on the E lead simultaneously, constituting a full duplex system. The various functions of DX signaling are described in the following paragraphs and illustrated in Fig. 5 and 6.

B. Supervisory Signaling and Pulsing

3.02 The DX circuit consists of a polar-type relay, a balancing network, and a voltage divider. Fig. 5 shows the original DX1 circuit using the 280-type relays, and Fig. 6 shows the later DX1 circuit using a mercury relay. The original unit has four equal windings, P1, P2, P3, and P4. Windings P2-P3 on the later unit appears as a single winding, but with twice as many turns as P1 or P4. The resistance of the balancing network is adjusted to equal the loop resistance of the facility plus 1240 ohms, the resistance of the terminating circuit at the other end (relay windings P1 and P4 plus the 240 ohm voltage divider and the 250 ohms to the M input).

3.03 When both ends are on-hook, ground is applied to both M leads. In this condition no current flows in the A lead (providing there is no differences in either ground or −48 volt battery supplies). A current does flow from ground through the network, P2-P3 windings, and voltage divider. This current reverse biases the relay holding the E lead open.

3.04 When the near end goes off-hook, battery is applied to the M lead, producing a current through the P1 winding and over the A lead to ground through the P1 winding of the far end R (DX) relay. This forward current through the P1 winding at the far end is sufficient to overcome the reverse bias and to operate the R (DX) relay, placing ground on the far end E lead. Battery on the near end M lead has forward biased the P2-P3 winding, but the current in the P1 winding is in the reverse direction, keeping the near end E lead open.

3.05 When the far end goes off-hook, applying battery to the M lead, the P2-P3 windings are forward biased. No current is now flowing through the P1 winding over the A lead to the near end. The forward bias on the P2-P3 lead keeps the far end DX relay operated in the direction to maintain ground on the E lead. With no current in the A lead and P1 winding, the forward bias on windings P2-P3 will operate the near end R (DX) relay in the direction to place ground on the E lead.

C. Extension of E and M Leads With DX2 Signaling Circuit

3.06 A signal lead extension circuit has been designed to interconnect a signaling circuit and a trunk circuit when the distance between them is too great to connect them directly through the E and M leads. In effect, this circuit is a pulse repeater for E and M lead signals. As shown in Fig. 2, it consists of the basic DX1 signaling circuit modified with an additional relay. With this circuit, signals received on the E lead from the signaling circuit will be retransmitted to the E lead of the trunk circuit. Also, signals transmitted over the M lead of the trunk circuit are retransmitted to the M lead of the signaling circuit.

3.07 Because of the low distortion characteristics of DX signaling, two DX signaling circuits can be used in tandem, if necessary. The signal lead extension circuit provides an economical intermediate link in such situations. All the other features of DX signaling, such as the neutralizing circuit and balancing network, are included in the extension circuit.

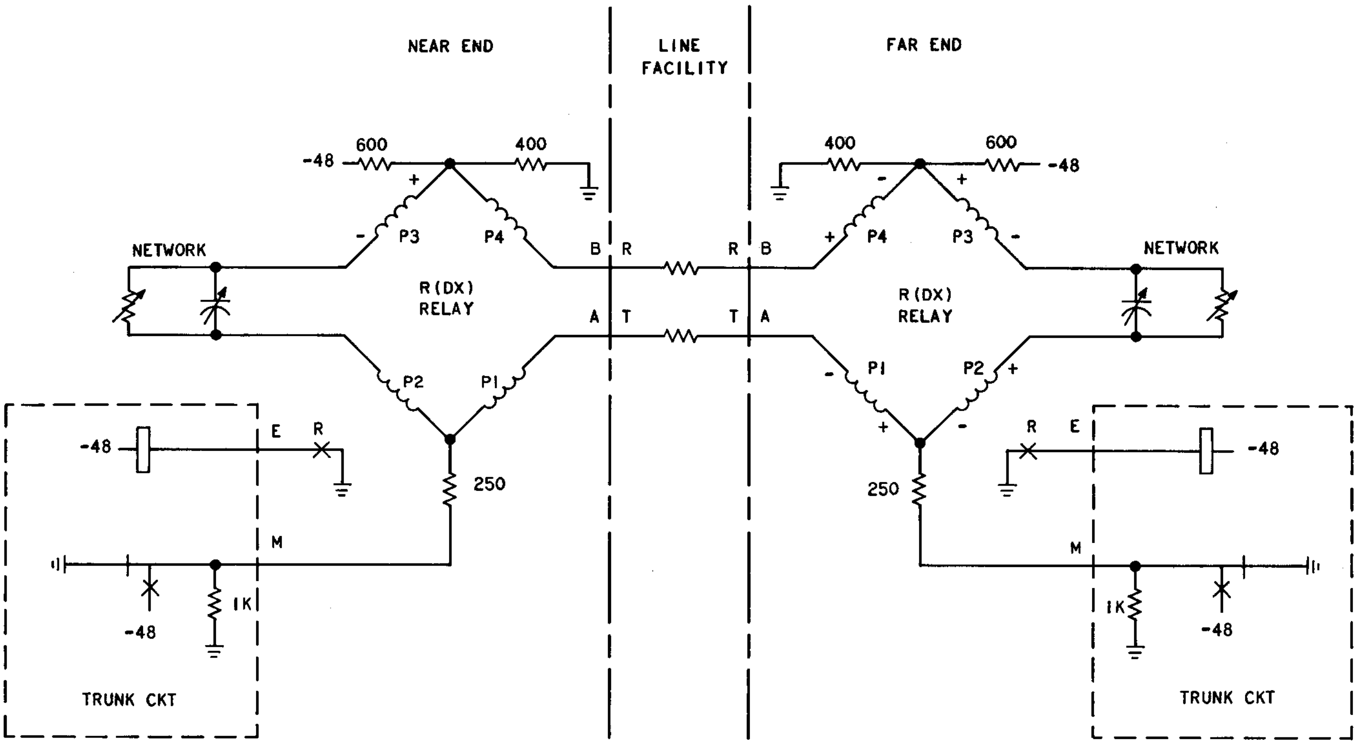

Fig. 5—Original DX1 Circuit Using 280-Type Relay

D. Neutralizing Circuit

3.08 Frequently, problems arise in signaling systems due to differences between ground potentials between signaling points. To overcome these problems in DX circuits, a balancing network is incorporated using the B lead and ring conductor of the line facility cable pair and winding P4 of each R (DX) relay. If no difference in ground potential exists, there will be no current flowing in the B lead. However, if a difference in ground potential does exist, a current will flow in the P4 windings of the R (DX) relays and the B lead. Also, this same potential causes a current to flow in the P1 windings and the A lead. Since the P1 and P4 windings are of opposite polarity, the effects of these two currents cancel, therefore, eliminating any tendancy for either R (DX) relay to operate due to this difference in ground potential. With this arrangement ac induction is cancelled and a ground potential of ± 45 volts can be tolerated.

E. Balancing Network

3.09 The R (DX) relay must be independent of its M lead condition. Independence under static conditions is achieved by adjusting the resistance of the balancing network in series with the P2-P3 windings to equal the loop resistance of the line plus 1240 ohms, the terminating resistance at the other end. Any current flowing in its own M lead is caused to effectively divide between the P1 winding path and the P2-P3 winding path. With this value of resistance, the net current in the windings of the R (DX) relay is at all times sufficient to hold the relay on its back contact (opening the E lead), independent of whether battery or ground is on the M lead.

3.10 When the state of the M lead is switched, there is an unwanted surge of current into or out of the T lead because of the capacitance of the line and the midpoint capacitor of the repeat coil. This transient tends to disturb the R (DX) relay. However, this surge is countered by the surge into the network capacitor so that no false contact operation of the relay results.

F. Network Adjustment

3.11 On the earlier vintage DX circuits, all network adjustment is made by strapping

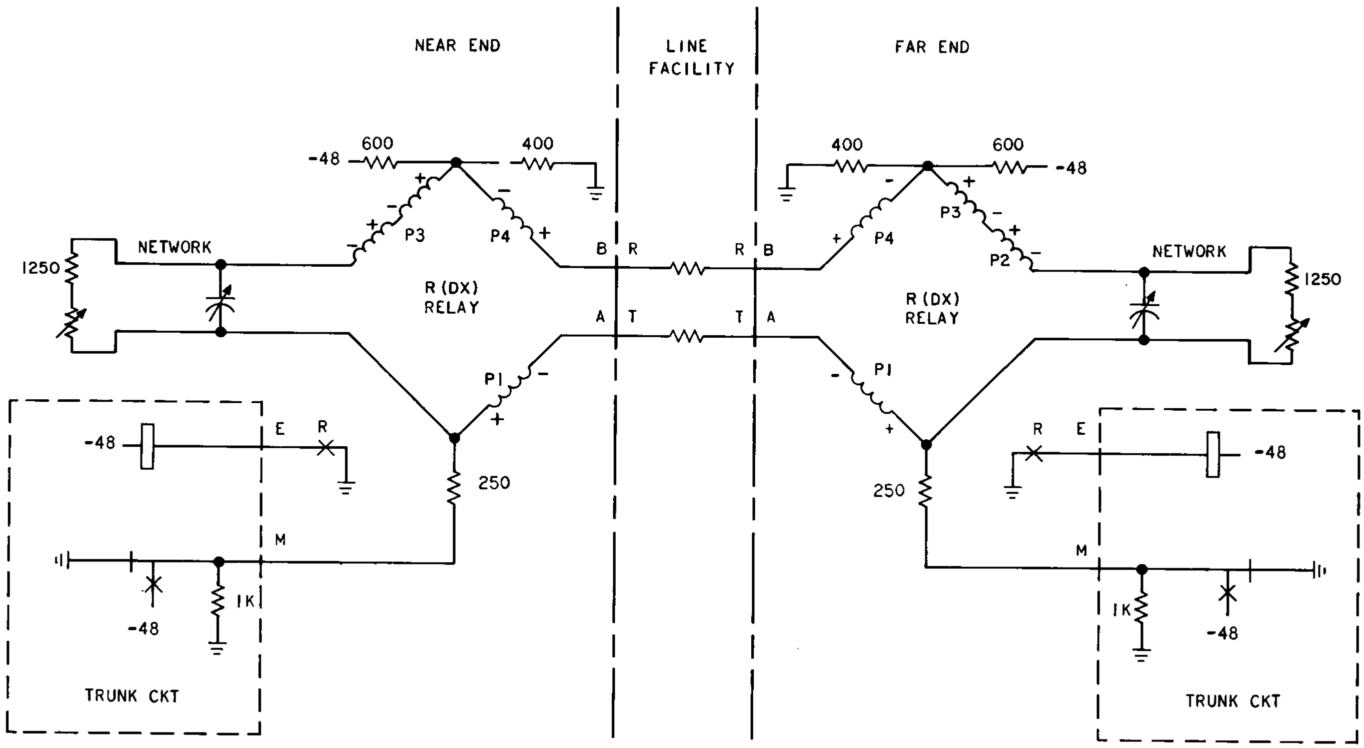

Fig. 6—Later DX1 Circuit Using Mercury Relay

changes. On the current DX circuits, network capacitance can be easily adjusted by means of screw switches on the front of the case. Network resistance is adjusted by means of a potentiometer also adjustable from the front of the case. The network capacitor is adjusted to proper value by prescription. Best results for 2-wire facilities are achieved with a 4 mf midpoint capacitor and 6 mf in the network capacitors. When V4 or E6 repeaters or other transmission devices are used, see Section 179-100-301.

4. MAINTENANCE

A. General

4.01 The balancing network is adjusted when the DX circuit is placed in service and does not require additional adjustment except when the line facility is altered.

B. Testing

4.02 Overall trunk tests for checking the signaling performance of DX circuits can be made as shown in the appropriate test sections of the Plant Series for toll trunks or in accordance with Section 333-124-500. A test jack is provided on the older vintages of DX circuits for testing and adjusting the 280-type relay. The present standard circuits using the mercury relays require no relay adjustment. However, a test connector is provided at each installation to permit checking the mercury contact relays. The test circuit used for testing the later DX1 units consists of a connector for plugging in the DX1 unit and two lamps designated BC (back contact) and FC (front contact). The lamps indicate continuity through the break contacts or make contacts of the R (DX) relay. The test circuit used for testing the later DX2 units consists of a connector for plugging in the DX2 unit and four lamps designated RBC (R relay back contact), RFC (R relay front contact), SBC (S relay back contact), and SFC (S relay front contact). The lamps indicate continuity through the break contacts or make contacts of the R or S relay.