

DC SIGNALING SYSTEMS

DESCRIPTION

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1. INTRODUCTION

1.01 This section describes the direct current through supervision and dialing systems for use on such facilities as intertoll trunks, step-by-step tandem trunks, operator office trunks for community

dial offices and subscriber long lines circuits. The information covered deals with three classes of dc signaling systems: loop, composite, and simplex. Primary consideration has been given to composite and simplex arrangements, although loop signaling is mentioned briefly in order to point out its limitations.

1.02 Different signaling arrangements are available for operation under various conditions such as: at terminal and intermediate points on intertoll trunks with or without voice frequency repeaters, using line facilities consisting of open wire or cable. Other factors affecting the choice of signaling arrangements are the office voltage, range, ac and dc earth potential requirements, and the need for pulsing as well as supervision.

1.03 Provision is made for the transmission of dc signals around intermediate voice frequency repeaters and for single circuit or phantom group operation with or without Type D, G, or H carrier derived channels. Loop signaling and simplex or composite signaling circuits may be directly connected together by means of loop to simplex or composite, or simplex or composite to loop converter circuits where it is more economical to convert the type of signaling than to use selectors and trunks of a type suitable for the type of signaling involved. For example, for handling calls from a DSA switchboard over a loop signaling trunk to the toll office where access is obtained to intertoll dialing trunks, loop to composite signaling converters would be used at the toll office end of the DSA switchboard trunk. Arrangements are also available for connecting composite or simplex signaling systems to telegraph channels to obtain signaling and dialing channels for use in handling intertoll traffic.

1.04 The combinations of requirements to meet diversified conditions and the need for different equipment arrangements suitable for both new and existing installations, involving in some cases partial reuse of existing equipment, have necessitated development of numerous simplex and

composite signaling circuits and associated composite sets and repeating coil units. The principles of operation of equipment are discussed in this section. Specific arrangements for composite sets and repeating coils and for composite and simplex signaling circuits are covered in the appropriate sections.

2. GENERAL DISCUSSION OF DC SIGNALING

A. Loop Signaling

2.01 Loop signaling normally employs a pair of conductors over which pulsing and supervision is obtained by combinations of opening and closing the loop, reversing battery and marginal currents. The so-called ground to battery loop signaling arrangement falls under this classification. Such facilities are unsuitable for phantom operation, introduce signaling difficulties on through connections and on two-way dialing trunks, do not provide simultaneous two-way signaling and have limited range capabilities. Because of these limitations loop signaling is not used on the regular toll center to toll center trunks, although it may be employed on the shorter one-way dialing trunks use for completing toll calls to tributary offices and for handling intertoll calls originated at DSA switchboards, step-by-step tandem, or tributary offices which terminate at the associated toll offices or at its tributaries. It is also used on operator office trunks, recording-completing trunks, toll switching trunks, etc. For economic reasons loop signaling equipment is included as an integral part of the trunk equipment with which it is associated and, therefore, no description of it is included in this section.

B. Composite and Simplex Signaling

2.02 Composite and simplex signaling circuits are designed to meet the various conditions of different toll lines in new or existing installations with which they may be associated from time to time. They are duplex in operation, that is, they provide simultaneous two-way signaling and dialing features, and are also suitable for either single circuit or phantom group operation over cable or open wire.

2.03 Similar circuits are required at both ends of the line, with balancing arrangements for adjusting the signaling relays to the conditions of the particular line. The equipment at opposite terminations of the line function together to relay

dc signals over the line facilities to the associated terminal equipment such as switchboards, selectors, and intertoll trunks.

2.04 The attached Sketches A and B are typical overall intertoll trunk layouts showing the relation between the composite signaling elements and V1 and 22-type repeaters for 2-wire cable circuits. A similar schematic for 4-wire cable circuits is shown on Sketch C attached. Circuit drawings covering the arrangements within the blocks of these schematic drawings are listed in the associated practices which discuss specific arrangements.

2.05 Simplex and composite signaling circuits employ three winding relays which are usually of the polarized type. However, in certain cases B type relays have been employed for economy reasons where long range operation or dialing is not required. Balancing networks and, except for circuits used with community dial office trunks, test jacks are also provided for each signaling channel. Current for operating these circuits is generally obtained from the regular 48-volt central office single polarity battery. As an exception, certain one-way dial composite signaling arrangements are available for use with 38-volt offices. All the circuits are arranged for operation with or without terminal voice frequency repeaters except community dial office composite signaling circuits employing Type D composite sets, which are unsuited for use with voice frequency repeaters.

2.06 With simplex signaling arrangements a single signal channel is obtained from a pair of conductors or from a phantom circuit. Composite signaling, however, generally derives two signaling channels from a pair of conductors, or four channels per quad. Occasionally a phantom circuit is composited, in which case only two composite signaling channels are obtained from a quad.

C. Theory of Operation of Composite Signaling

2.07 The arrangement which permits dc signaling on a composited phantom group is shown in Fig. 1. The two physical circuits, known as the side circuits, have repeating coils at each end, and the third, or phantom circuit, is derived by connecting the third repeating coil at the midpoints of the repeating coils of the two side circuits. The composite set derives four dc signaling channels from the two side circuits by sets of retard coils

and condensers. These form a filter to keep the dc and low frequencies out of the voice circuits, and the voice out of the signaling channels, but the dc signals may be transmitted independently over each wire of the physical circuits. In this way four dc signaling channels are derived for each phantom group. This gives a signaling channel for each side circuit and the phantom, and a fourth that may be used to neutralize differences in earth potential at the two ends of the line.

2.08 For signaling and pulsing purposes, each circuit of the phantom group is provided with a CX relay at each end of the line, arranged as shown in Fig. 2. These relays have three windings, but one of them is employed for earth-potential compensation and need not be considered in the explanation of the signaling circuit itself. The two signaling windings S1 and S2 have the same number of turns and are connected differentially. One is connected to the composite signaling channel and the other to a biasing potentiometer through an artificial line, which has characteristics approximately the same as the line

itself, so that the current builds up and decays in the two windings at the same rate. The other ends of the two windings are connected together and to a lead, marked II, to the armature of the pole-changing relay, which is used for signaling and pulsing. The "thump killer" shown in the M lead in the diagram prevents the signal and dial pulses from affecting the telephone circuit.

2.09 Assume, for example, that a call is made from office A. Before the operator plugs into the intertoll trunk, current flows from the biasing potentiometer through the artificial line and the S1 winding to ground at the pole-changing relay. This biases the CX relays to their released positions. When the operator plugs into the intertoll trunk at office A, current flows through the pole-changing relay and operates it. This causes current to flow in the S1 winding of the CX relay in the opposite direction and tends to operate the relay. It also flows in the S2 winding, tending to release the relay; and because the voltage at the biasing potentiometer is higher than ground, the current through S2 is enough greater than that

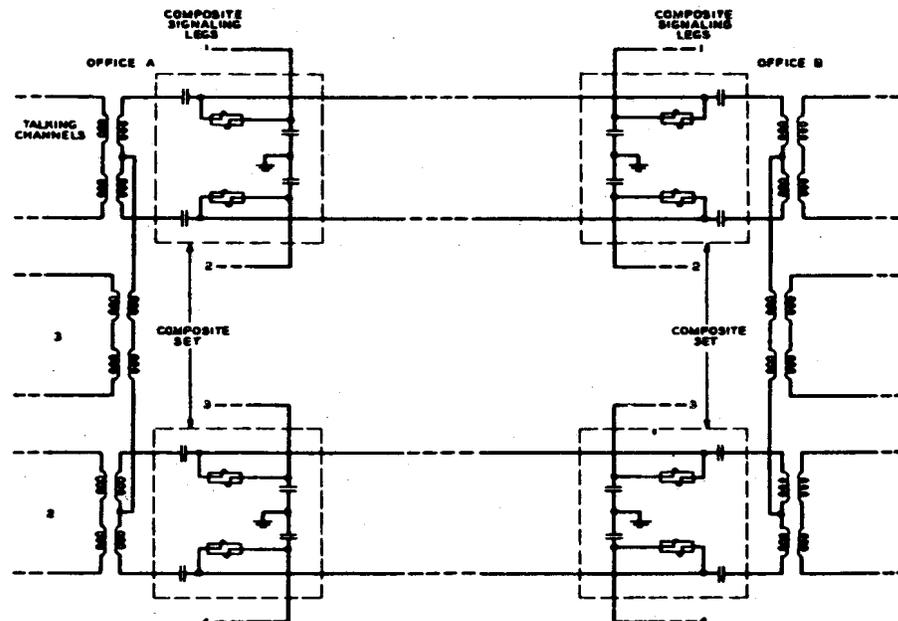


Fig. 1—Simplified Schematic of a Compositing Group, Showing the Derivation of Four Signaling Channels

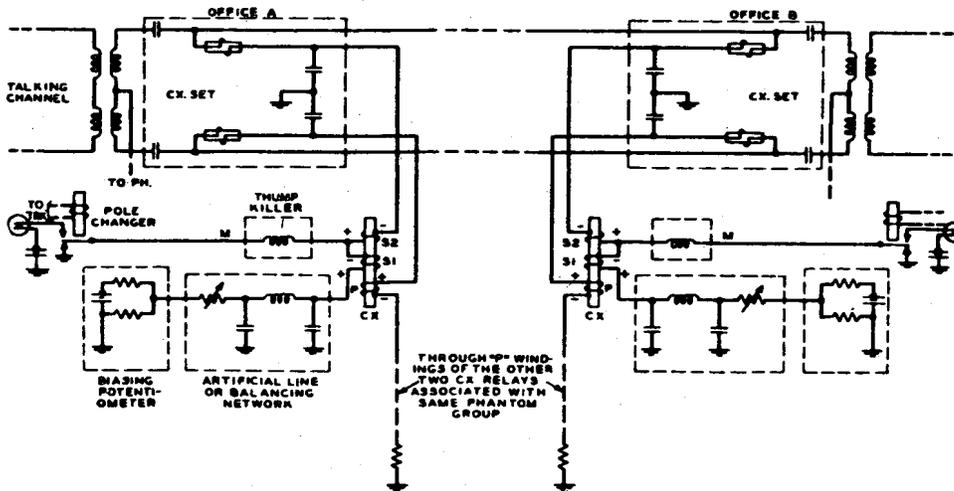


Fig. 2—Arrangement of Composed Signaling Circuit for One Voice Circuit

through S1 to hold the relay released. The current in the S2 relay flows out over the upper wire of the line, however, and through the S2 winding of the CX relay at office B. Here, because of its greater value, it overpowers the effect of the current in the S1 winding, and operates the relay. The operation of the relay, in turn, causes other relays not shown to prepare the selector for dialing.

2.10 When the operator starts to dial, the dial alternately makes and breaks the current to the pole-changing relay. Whether the pole-changing relay at office A is released or operated, the CX relay at this office will remain released, in one case because of the current in S1, and in the other because the current in S2 is greater than that in S1. The CX relay at office B, however, will operate and release with the pole-changing relay at office A as already described. This operates the sectors at office B and selects the desired line.

2.11 The full duplex action of this signaling system can now be illustrated by the subscriber-answer signal returning against the connect signal, which continues to be applied at office A as long as the plug is in the jack. When the subscriber answers, a signal is returned by office B, which requires

the operation of the CX relay at office A without releasing the CX relay at office B. The answer signal at office B will operate the pole-changing relay there, causing an operating current to flow in its S1 winding. Since the two S2 windings are now in series to battery at each end of the line, no current will flow in them. The CX relay at office A thus operates by the current through its S1 winding, and the CX relay at office B remains operated, the operating current in S1 taking the place of the previous operating current in S2. Another illustration of full duplex operation over the system would be on a disconnect against a flashing busy signal.

2.12 The connections for the complete phantom group are shown in Fig. 3. Trunk 1 uses the upper wire of the upper physical pair for signaling. The phantom trunk uses the lower wire of the lower physical circuit, and the third trunk uses the upper wire of the lower pair. This leaves the lower wire of the upper pair available for earth potential compensation. The connection from this wire is carried in series through the third, or P, winding of each of the CX relays to ground. The P winding has the same number of turns as the S2 winding, but is oppositely poled and has only

one-third its resistance. The three P windings together thus have the same resistance as an S2 winding.

2.13 The effect of a difference in earth potential at the two ends of the line is the same as inserting a battery between the ground terminals and ground at one end of the line. This is shown in Fig. 4, where a battery is shown in the ground lead to represent the difference in earth potential between the two offices. First consider what would happen with the added earth potential difference if there were no P winding on the CX relay. With an earth potential difference as shown in Fig. 4 the current through the S1 windings at both offices would be unaffected because the added potential is outside of these circuits. A current, however, which did not exist before would flow through the S2 winding via lead M and the line. This current would further bias the CX relay at office A in the release direction but since this relay is already released, no false signal would occur at office A. At office B this current would be an operating current. If great enough, it would overpower the S1 winding and operate the relay, causing a false signal. Had the voltage been in the opposite direction, no false signal would be created at office B, but one would occur at office A.

2.14 With the P windings in the circuit, however, the effect of the added current flowing through the S2 windings and the line would be offset by that flowing through the P windings, since these windings are equal in number of turns and oppositely poled to the S2 windings. The P circuit uses the lower wire of the upper pair of Fig. 3, and thus has the same line resistance as the S2 winding. Also, since each of the P windings has one-third the resistance of the S2 winding, the total winding resistance in each circuit is the same. The current through the P and S2 windings due to this earth potential difference thus would be the same, and since the windings are opposing, the relay is not affected. Under ideal conditions this arrangement is effective regardless of the value of the earth potential difference. In actual practice, however, there are limits beyond which the circuits will not function satisfactorily, as shown on the circuit drawings.

D. Pulsing Characteristics

2.15 The operator dial and the switches actuated by them over simplex or composite signaling channels, are given pulsing characteristics such that the rates of the "break" to the "make" periods of the pulses is that which results in the most margin for selector operation. This ratio is usually

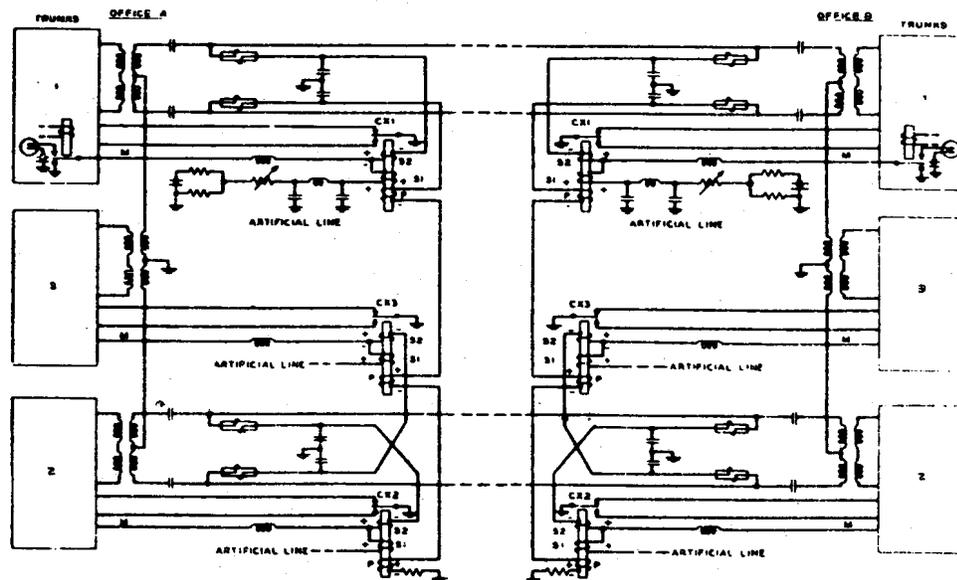


Fig. 3—Compositing Signaling and Pulsing Circuit for a Complete Phantom Group

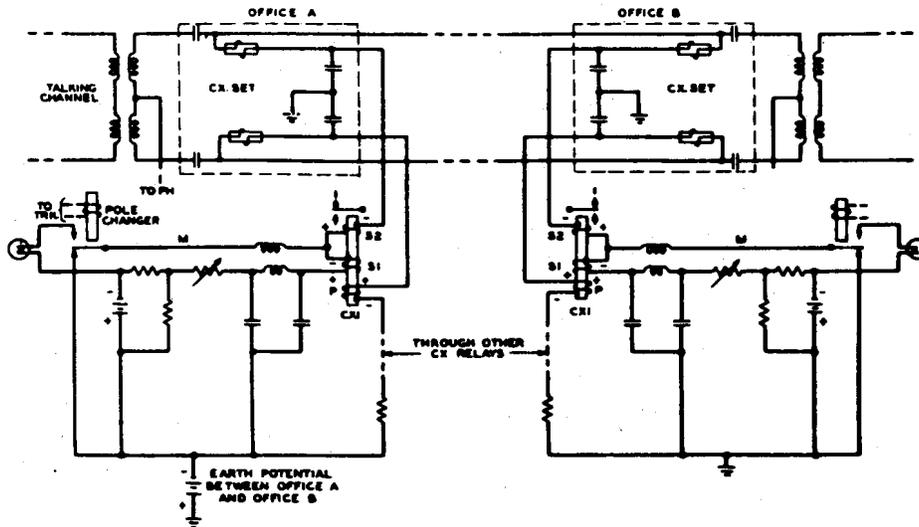


Fig. 4—Simplified Schematic Showing the Effect of an Earth Potential

expressed in "percent break" which may be defined as follows:

$$\text{Percent break} = 100 \times \frac{\text{break}}{\text{make} + \text{break}}$$

2.16 The percent break of the operator dials lies within the band 59.5 to 67.5 of which the average is about 64 percent. This value is the one most desirable for selector operation but it is not one which can be transmitted most readily over the signaling channels. A value near 50 percent break is better for this part of the overall system. In telegraph practice also, the optimum signal is one with 50 percent break, but, it is commonly described as a signal with zero percent bias, the percent bias being defined as:

$$100 \times \frac{\text{mark} - \text{space}}{\text{mark} + \text{space}}$$

2.17 The signaling circuits and trunks have been designed to obtain optimum overall pulsing results in transmitting the pulses from the dial to the selectors at the distant office. In this overall pulsing system it has been found that an input to the signaling system of 58 percent rather than 50 percent will best meet the various pulsing conditions encountered. Inasmuch as the dial delivers pulses with an average of about 64 percent break, it can be seen that the outgoing trunk which transmits these pulses to the signaling circuit, must shift the percent breakdown from about 64 percent to 58 percent.

2.18 The shifting of the percent break is usually accomplished by means of the setting of the electrical bias of a polarized repeating relay in the trunk circuit. The signal from the dial is almost a square wave. It is modified somewhat by the resistance and condenser in series, usually placed across the dial contacts as a spark killing measure. The operating winding of the repeating relay is shunted by a condenser and resistance network which tends to lengthen the time needed for the build-up and decay of the current as the condition shifts from make to break and vice versa. The relay will shift the percent break either up

or down, depending upon the ratio of the current in the biasing winding to the peak pulsing current. The average shift in percent break in the outgoing trunks from the switchboard is from about 64 percent to 58 percent, a shift of -6 percent.

2.19 The outgoing and incoming composite signaling circuits in combination with the trunk conductors and associated equipment will change the average percent break from 58 percent to 59 percent, or a shift of +1 percent in transmitting the pulses to the distant office.

2.20 It will be observed that different percent break limits for 375 and 350 type community dial offices are given on the drawings. This difference results from the fact that 375 and other types of offices having a locked-in pulse will function on pulses which have wider limits than those types of offices such as the 350, which do not employ this arrangement.

E. Balancing Network for Signaling Circuits

2.21 The signaling relays of simplex and composite signaling circuits are operated on a balanced basis in order to obtain duplex operation. This requires the use of balancing networks which are adjusted to the specific characteristics of the line. Thus the capacity of the condensers connected to ground in the signaling circuit balancing network depend upon the type and length of cable or open wire. The intermediate voice frequency repeater bypass equipment is likewise a factor in the determination of the balancing network. Also in some cases the network resistance will vary in value depending upon the minimum voltage limits of the office battery. For example, consider the network resistances (N2), (N3), and (N4) of the simplex signaling circuit as covered in Items (A) and (B), Table A of Drawing SD-95053-01:

- (a) Under the conditions of Item (A) on Table A on the SD drawing, in cases where the minimum voltage is 40 volts, with maximum conductor loops of 3080 ohms for 16-gauge or 6160 ohms for 19 and 22-gauge cable, the network resistance required is 25 percent of the conductor loop ± 30 ohms where no ac earth potential filter is employed. Where a 60-cycle earth potential filter is used, the resistance value should be 29 percent of the conductor loop ± 30 ohms.

- (b) Under the condition of Item (B) on Table A, in cases where the office battery minimum voltage is 44 with maximum conductor loops of 5000 ohms for 16-gauge, 7920 ohms for 19-gauge or 8800 ohms for 22-gauge, the network resistance should be 29 percent of the conductor loop ± 30 ohms where no ac earth potential filter is used. Where a 60-cycle earth potential filter is used in this case, the network resistance should equal 30 percent of the conductor loop ± 30 ohms.

F. Signaling Range

2.22 The signaling range of the trunk is affected by the characteristics of the line facilities and by such factors as battery voltage, minimum insulation resistance, and earth potentials. A study of the notes and range charts on the signaling circuit drawings is required in order to determine the suitability of a specific signaling circuit for a particular use. However, the charts in Section 179-702-101, which list the approximate maximum range capability of the various signaling circuits with information relative to their application and the type of composite set to be used with them, may be used as a general guide for determining the signaling circuit required. In this connection it should be mentioned that the term "short haul" refers to signaling arrangements having a range capability of approximately 5000 ohms or less. Circuits having a range in the order of 5000 to 12,000 ohms are referred to as "long haul". It should be noted also that the titles of the circuit drawings indicating restrictions to their use, apply only to the location at which the particular signaling circuit is furnished and not to the overall trunk. For example, a drawing title having the term "without repeater" should not be used at a point where a voice frequency repeater is provided. However, voice frequency repeaters may be provided at other locations on the same intertoll trunk.

G. Signaling Around Intermediate Voice Frequency Repeaters

2.23 Where intermediate voice frequency repeaters are involved, arrangements are required for passing the low-frequency pulsing and signaling currents around them, as illustrated schematically for 2-wire circuits on Sketch A for V1 repeaters and Sketch B for 22-type repeaters. Sketch C shows the arrangement for use on 4-wire circuits employing 44 or V1 type repeaters. This is accomplished by bypassing or by repeating the

signals. When the signals are bypassed, the dc paths in the two directions from the voice frequency repeater are joined through intermediate type composite sets or bypass circuits. When the signals are repeated at the intermediate point, terminal type composite sets are associated with the trunks in each direction and with the composite signaling circuits. These signaling circuits are connected together by means of auxiliary pulse links.

2.24 Since the signaling arrangements are limited to bypassing one intermediate voice frequency repeater, the location of the intermediate repeater in the overall circuit determines whether bypass or pulse repeating arrangements are required. Thus, in the case of an intertoll trunk employing three intermediate voice frequency repeaters, the two repeaters nearest the two terminals of the trunk may be bypassed, but auxiliary pulse link equipment will be required at the repeater located at the half-way point.

2.25 The auxiliary pulse link use for repeating pulses, may be of the nonrelay type if the signaling circuit on both sides of the intermediate voice frequency repeater is short haul. A relay type auxiliary pulse link is required for connecting together one long haul and one short haul signaling circuit or two long haul signaling circuits.

2.26 Sketch D illustrates the use of auxiliary pulse links for relaying signals around 22-type repeaters. Similar arrangements are used at V1 repeater points.

H. Signaling Around Repeating Coils at Junction of Open Wire and Cable

2.27 Bypass or signal relaying equipment may also be used where the junction of short haul open wire and cable portions of trunks occurs at other than intermediate voice frequency repeater points and where noise considerations require the use of repeating coils instead of autotransformers.

I. Connection of Simplex or Composite Signaling to Loop Signaling and to Telegraph Facilities

2.28 Other auxiliary pulse link equipment are (1) those for connecting simplex or composite signaling circuits to dc or vf telegraph channels for regular use in cases where speech channels employ carrier frequencies, and for use under emergency conditions, (2) arrangements for connecting

simplex or composite signaling circuits to loop signaling trunks and vice versa, (3) circuits for converting a simplex or composite dialing circuit to ringdown for regular or emergency use. Sketch E shows the use of the telegraph pulse link at a terminal of the intertoll trunk. At an intermediate point where the telegraph channel use for signaling is extended over a composite or simplex signaling circuit, and E and M leads of the telegraph pulse link are connected through a relay type auxiliary pulse link of the type shown or Sketch D.

J. Earth Potential Compensation

2.29 Direct-current earth potentials are compensated for by means of the third winding on the composite signaling relay as described in Paragraphs 2.12 to 2.14. However, circuits used for other than intertoll dialing may be operated without compensation if the dc earth potentials are negligible.

2.30 Where longitudinal alternating currents of any appreciable magnitude are encountered, ac earth potential filters are required to prevent these currents from reaching the signaling relay. Two different types of filters are available for this purpose, as described below.

Resonant or Bridge Type 60-Cycle Filter for CX Signaling

2.31 This type of ac earth potential filter provides a shunt to ground for 60-cycle ac currents of certain limited values. This arrangement may be used with or without dc earth potential compensation, on single circuits or on phantom groups. However, when used without dc earth potential compensation, two filters instead of one are required for each signaling circuit, one being connected from the CX leg to ground on the line side of the line winding and the other to the biasing winding in parallel with the network of the CX relay. The use of these arrangements for composite signaling circuits is illustrated on Sketches F and G. These sketches show Type D composite sets, although the same arrangements are used with Type C or E composite sets.

Longitudinal Retardation Coil Filter

2.32 Where 25-cycle earth potentials are encountered or where the 60-cycle potentials exceed the capability of a simple resonant type filter, a 4-winding retardation coil is used with one winding

in the connection from each of the four line wires as shown in Sketch H. These windings are all poled in the same direction for current coming in over the lines. As a result the coil offers high impedance to equal currents flowing on the four wires at the same time, and thus induced longitudinal currents are greatly attenuated. To a signal passing either in or out on only one wire of the group, however, the coil offers essentially zero reactance; its impedance is practically only that of the resistance of the winding.

2.33 Why this is so may be seen with the help of Fig. 5, which shows the 4-winding retardation coil connected to its associated lines and CX relays. A signal voltage E is shown applied to No. 1 operating leg. Under these conditions, the retardation coil may be looked upon as a transformer with a single primary winding and three secondary windings. Signal voltage E causes a current I_1 to flow over the No. 1 circuit and this current induces a flux in the retard coil proportional to NI_1 , where N is the number of turns on the winding. This flux induces an opposing E.M.F., e , in all four windings. In the winding for operating leg No. 1, e opposes E , and thus the net voltage applied to the No. 1 line is $E-e$, and the current that flows, I_1 is $E-e$ divided by Z where Z is the impedance of the line, which is the same under all conditions.

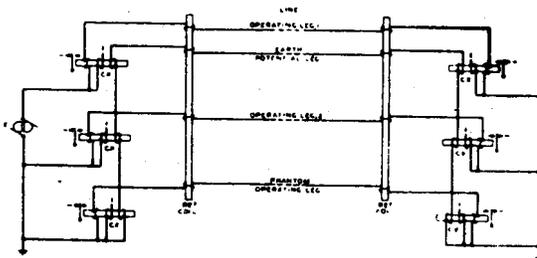


Fig. 5—Connections of 4-Winding Retardation Coil Used for Reducing Induced 25 and 60-Cycle Potentials

2.34 In each of the other three wires, the only voltage acting is e , and the current flowing in each of the other three wires, I_2 is thus e/Z . These currents are opposite in direction to I_1 because e is opposite in direction to $E-e$. The current effective in operating the No. 1 CX relay is I_1 through one winding and I_2 through another winding of the same number of turns. These windings are oppositely poled, but since the currents are opposite

in direction, they have assisting effects. The total effective current, I_0 in CX1 is thus $I_1, 1$, plus I_2 . Substituting the values of I_1 and I_2 given above,

$$I_0 = \frac{E - e}{Z} + \frac{e}{Z} = \frac{E}{Z}$$

Thus the effective current in CX1 is the same as though the retardation coils were not in the circuit. Actually, of course, their resistance is not balanced out, but this has only a very small effect on the amount of current flowing. Similarly, signals passing in or out on more than one of the operating legs, 1, 2, and 3 with the earth potential leg connected to the CX relay windings, as shown in Fig. 5, will encounter essentially zero reactance in the 4-winding retardation coil. Also, the CX relays through which signals are not passing, are not affected by the induced currents flowing in their operating and earth potential windings because these windings are opposing and their currents cancel each other.

Resonant Type 60-Cycle Filter for SX Signaling

2.35 The simplex signaling circuit is affected more by ac earth potential than the CX signaling circuits, due to the use of somewhat elementary type of balance network. Because of this, a more effective filter is required for blocking longitudinal currents from the SX relay. This is obtained in the case of SX circuits using earth potential compensation by means of a 2-winding retardation coil having its midpoint grounded through a condenser of suitable value to cause resonance at 60 cycles. By connecting the series opposing windings of the retardation coil in series with the simplex lead, the impedance of the shunt path at resonance for the 60-cycle current is the resistance due to the iron loss of the retardation coil. The resistance in the signaling conductor is that due to the copper loss only.

2.36 Two of these filters are required for each SX signaling circuit. One is connected in series with the signaling lead, which is designated T, R, or SX, and the other is connected in series with the network winding of the SX relay and the network itself, to balance the network and the line. An additional filter is required in series with

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the earth potential compensating lead, which is common to five simplex circuits.

2.37 For use where the compensating winding is not employed for dc earth potential compensation or where ac earth potentials exceed the limits of the particular SX circuit used with the resonant filter described above a more effective filter is required. Such a filter depends upon partial compensation of the ac earth potential by employing a 2-winding retardation coil which functions as a transformer. The primary of the transformer is in series with the operating winding of the simplex relay and the secondary is in series with the network winding, which permits a current flow in this winding in such direction as to produce a magnetizing flux opposing that caused by the longitudinal ac earth potential current flowing through the operating winding. In addition it is also necessary to employ a 60-cycle resonant circuit connected across the midpoints of the two operating and network windings of the SX relay to permit part of the longitudinal current to flow directly into the network winding. Thus approximately equal alternating currents flow through these windings in such direction as to produce opposing lines of force.

K. Composite Sets

2.38 Composite signaling circuits are associated with the toll line by means of a filter known as a composite set, which functions to pass the low frequency dc supervisory signals or pulses to and from the composite signaling circuit, and at the same time to discriminate against voice frequency currents. One composite set will provide two composite signaling legs from one physical circuit, and two composite sets will provide four composite signaling legs from a phantom group. Composite sets are discussed in the section covering composite sets and associated line or hybrid transformers.

2.39 Simplex signaling circuits do not require a composite set since the simplex is derived by connection to the midpoint of a repeating coil of a physical circuit. The simplex signaling

arrangement is, accordingly less expensive than composite signaling, but, of course, provides only one signaling channel per physical circuit or per phantom circuit.

3. DRAWINGS

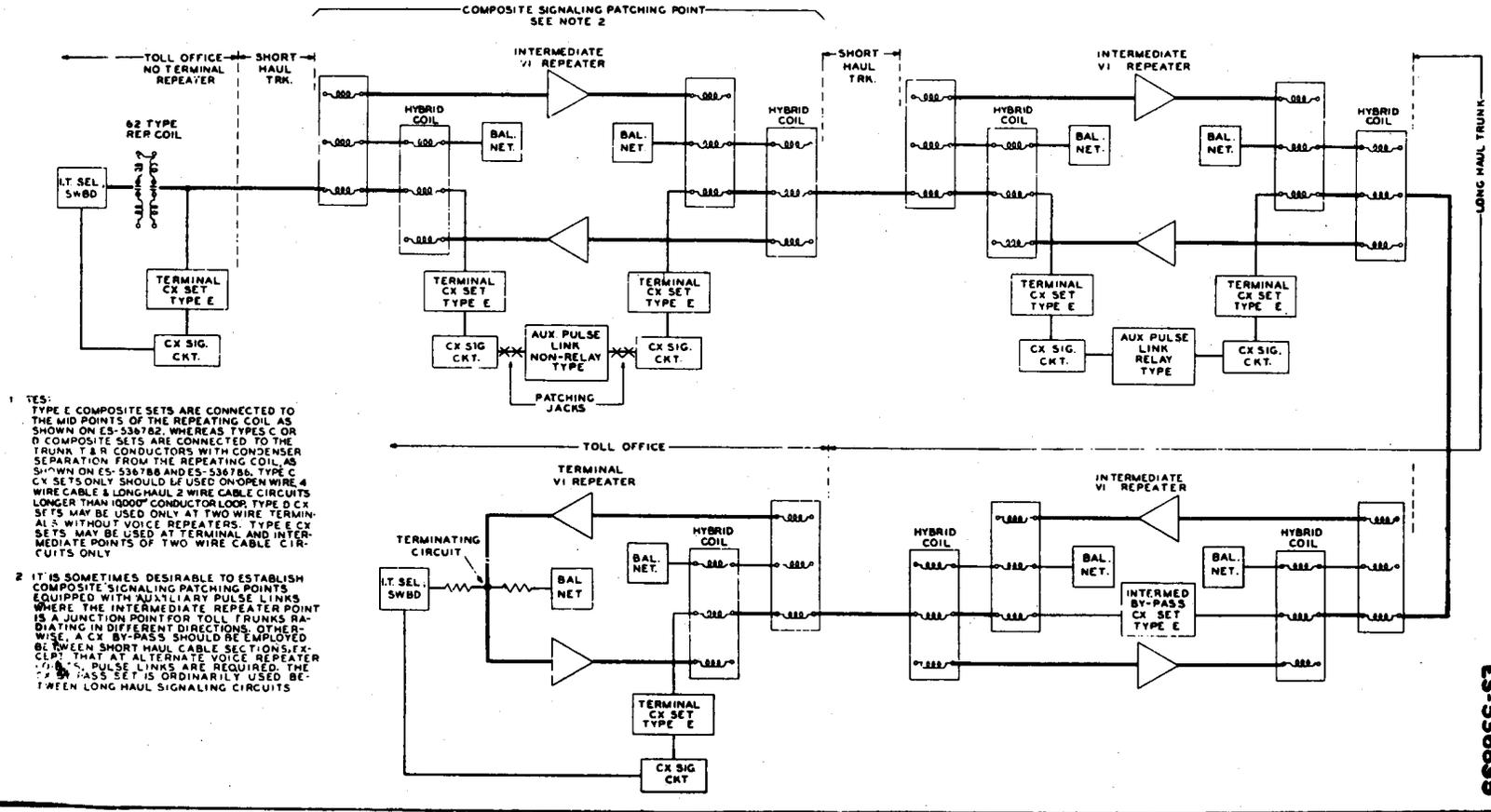
A. Drawings Included in Text

<u>FIG. NO.</u>	<u>DRAWING NO.</u>	<u>ABBREVIATED TITLE</u>
1	ES-536887	Derivation of Four CX Sig. Channels
2	ES-536888	CX Sig. Ckt. for One Voice Ckt.
3	ES-536889	CX Sig. Ckt. for Phantom Group
4	ES-536890	Effect of DC Earth Potentials
5	ES-536891	Reduction of AC Earth Potentials

B. Drawings Attached

<u>SKETCH DESIG-NATED</u>	<u>DRAWING NUMBER</u>	<u>ABBREVIATED TITLE</u>
A	ES-536835	Signaling with V1 Repeaters
B	ES-536836	Signaling with 22-Type Repeaters
C	ES-536840	Signaling with 4-Wire Repeaters
D	ES-536785	Relay and Nonrelay Pulse Links
E	ES-536841	Telegraph Pulse Link
F	ES-536786	60-Cycle Filters with Earth Potential Compensation
G	ES-536787	60-Cycle Filters without Earth Potential Compensation
H	ES-536788	60 and 25-Cycle Longitudinal Filter

COMMON SYSTEMS
 COMPOSITE SIGNALING
 SCHEMATIC DIAGRAM
 SHOWING RELATION BETWEEN SIGNALING ELEMENTS
 AND VI VOICE FREQUENCY REPEATERS
 ON TWO WIRE CABLE CIRCUITS
 SHOWN WITH TYPE E CX SETS



1. TYPE E COMPOSITE SETS ARE CONNECTED TO THE MID POINTS OF THE REPEATING COIL AS SHOWN ON ES-536782. WHEREAS TYPES C OR D COMPOSITE SETS ARE CONNECTED TO THE TRUNK T & R CONDUCTORS WITH CONDENSER SEPARATION FROM THE REPEATING COIL AS SHOWN ON ES-536788 AND ES-536786. TYPE C CX SETS ONLY SHOULD BE USED ON OPEN WIRE 4 WIRE CABLE & LONG HAUL 2 WIRE CABLE CIRCUITS LONGER THAN 10000' CONDUCTOR LOOP. TYPE D CX SETS MAY BE USED ONLY AT TWO WIRE TERMINALS WITHOUT VOICE REPEATERS. TYPE E CX SETS MAY BE USED AT TERMINAL AND INTERMEDIATE POINTS OF TWO WIRE CABLE CIRCUITS ONLY.
2. IT IS SOMETIMES DESIRABLE TO ESTABLISH COMPOSITE SIGNALING PATCHING POINTS EQUIPPED WITH AUXILIARY PULSE LINKS WHERE THE INTERMEDIATE REPEATER POINT IS A JUNCTION POINT FOR TOLL FRUNKS RADIATING IN DIFFERENT DIRECTIONS. OTHERWISE, A CX BY-PASS SHOULD BE EMPLOYED BETWEEN SHORT HAUL CABLE SECTIONS. EXCEPT THAT AT ALTERNATE VOICE REPEATER POINTS, PULSE LINKS ARE REQUIRED. THE BY-PASS SET IS ORDINARILY USED BETWEEN LONG HAUL SIGNALING CIRCUITS.

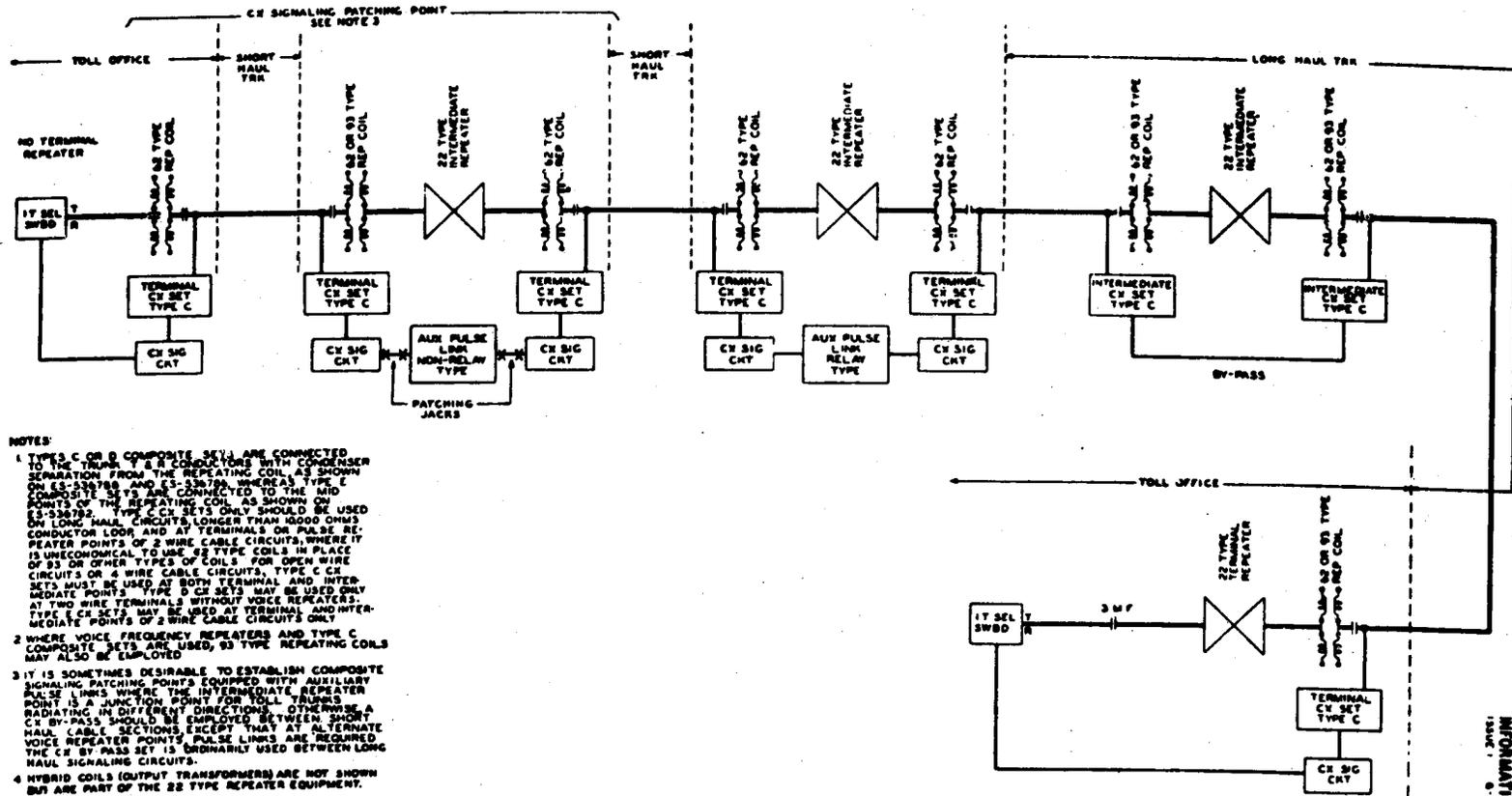
SKETCH A

ES-536835

BELL TELEPHONE LABORATORIES, INC.

ES-536836

COMMON SYSTEMS
COMPOSITE SIGNALING
SCHEMATIC DIAGRAM
SHOWING RELATION BETWEEN SIGNALING ELEMENTS
AND 22 TYPE VOICE FREQUENCY REPEATERS
ON TWO WIRE CABLE CIRCUITS
SHOWN WITH TYPE C CX SETS

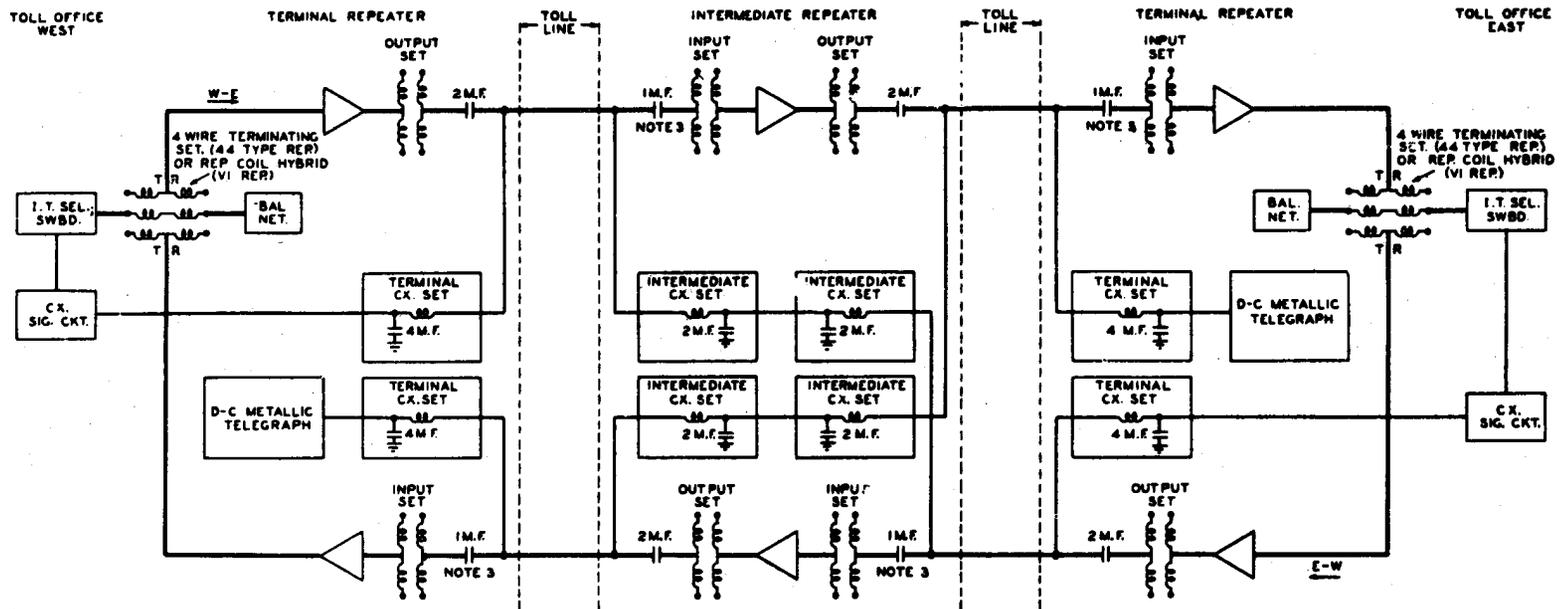


- NOTES:
- 1 TYPES C OR D COMPOSITE SETS ARE CONNECTED TO THE TRUNK T & R CONDUCTORS WITH CONDENSER SEPARATION FROM THE REPEATING COIL AS SHOWN ON ES-536788 AND ES-536789. WHEREAS TYPE E COMPOSITE SETS ARE CONNECTED TO THE MID POINTS OF THE REPEATING COIL AS SHOWN ON ES-536792. TYPE C CX SETS ONLY SHOULD BE USED ON LONG HAUL CIRCUITS LONGER THAN 10000 OHMS CONDUCTOR LOSS AND AT TERMINALS OR PULSE REPEATER POINTS OF 2 WIRE CABLE CIRCUITS, WHERE IT IS UNECONOMICAL TO USE 22 TYPE COILS IN PLACE OF 22 OR OTHER TYPES OF COILS FOR OPEN WIRE CIRCUITS OR 4 WIRE CABLE CIRCUITS. TYPE C CX SETS MUST BE USED AT BOTH TERMINAL AND INTERMEDIATE POINTS. TYPE D CX SETS MAY BE USED ONLY AT TWO WIRE TERMINALS WITHOUT VOICE REPEATERS. TYPE E CX SETS MAY BE USED AT TERMINAL AND INTERMEDIATE POINTS OF 2 WIRE CABLE CIRCUITS ONLY.
 - 2 WHERE VOICE FREQUENCY REPEATERS AND TYPE C COMPOSITE SETS ARE USED, 93 TYPE REPEATING COILS MAY ALSO BE EMPLOYED.
 - 3 IT IS SOMETIMES DESIRABLE TO ESTABLISH COMPOSITE SIGNALING PATCHING POINTS EQUIPPED WITH AUXILIARY PULSE LINKS WHERE THE INTERMEDIATE REPEATER POINT IS A JUNCTION POINT FOR TOLL TRUNKS RADIATING IN DIFFERENT DIRECTIONS. OTHERWISE A CX BY-PASS SHOULD BE EMPLOYED BETWEEN SHORT HAUL CABLE SECTIONS EXCEPT THAT AT ALTERNATE VOICE REPEATER POINTS PULSE LINKS ARE REQUIRED. THE CX BY-PASS SET IS PRIMARILY USED BETWEEN LONG HAUL SIGNALING CIRCUITS.
 - 4 HYBRID COILS (OUTPUT TRANSFORMERS) ARE NOT SHOWN BUT ARE PART OF THE 22 TYPE REPEATER EQUIPMENT.

ES-536836
INFORMATION
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SKETCH B

COMMON SYSTEMS
 COMPOSITE SIGNALING
 SCHEMATIC DIAGRAM
 SHOWING APPLICATION
 TO FOUR WIRE CABLE REPEATERS
 44 AND VI TYPE REPEATERS



NOTES:

1. ON FOUR WIRE TRUNKS, THE SIGNALING CKTS. ON THE WEST-EAST SPEECH CHANNEL MUST BE CONNECTED TO THE EAST-WEST SIGNALING CKTS. AT INTERMEDIATE VOICE REP POINTS BY CONNECTING "INPUT" TO "INPUT" AND "OUTPUT" TO "OUTPUT." INTERMEDIATE Cx. SETS ARE OF COURSE EMPLOYED BETWEEN THE TWO INPUT OR THE TWO OUTPUT SETS AS SHOWN.
2. TERMINAL Cx. SIGNALING EQPT. SHOULD BE CONNECTED TO OUTPUT PHANTOM Cx. EQPT. HOWEVER, IF IT IS NECESSARY TO CONNECT IT TO THE INPUT, THE LATEST INFORMATION SHOULD BE OBTAINED.

3. THE CAPACITY OF THE INPUT BLOCKING CONDENSER IS 1 M.F. FOR 44 TYPE REPEATERS, AND 2 M.F. FOR VI TYPE REPEATERS.

SKETCH C

BELL TELEPHONE LABORATORIES, INC.

- NOTES:**
1. AUXILIARY PULSE LINKS ARE REQUIRED FOR REPEATING PULSES AT ALTERNATE VOICE FREQUENCY REPEATER POINTS. THEY ARE ALSO EMPLOYED AT COMPOSITE SIGNALING PATCHING POINTS WHERE THE REPEATER LOCATION IS AT A JUNCTION WHERE TOLL TRUNKS RADIATE IN DIFFERENT DIRECTIONS. IN ADDITION THEY ARE EMPLOYED AT REPEATING COIL JUNCTIONS OF OPEN WIRE AND CABLE CIRCUITS.
 2. NON-RELAY AUXILIARY PULSE LINKS ARE USED AT JUNCTION POINTS OF OPEN WIRE AND CABLE FOR CONNECTING TOGETHER TWO SHORT HAUL COMPOSITE DIALING CIRCUITS AND ONE LONG OR ONE SHORT HAUL COMPOSITE SIGNALING CIRCUITS WHICH ARE NOT ARRANGED FOR DIALING.
 3. RELAY TYPE AUXILIARY PULSE LINKS ARE USED FOR CONNECTING TWO LONG HAUL OR ONE LONG HAUL AND ONE SHORT HAUL COMPOSITE DIALING CIRCUITS.
 4. ON THIS DRAWING, THE SIGNALING CIRCUITS ARE BASED ON SD-55415-01 OR SD-95048-01, AND THE COMPOSITE SETS ON SD-60136-03.
 5. THE OPTIONAL GROUND IS PROVIDED ON THE SIGNALING RELAY ARMATURE UNLESS THE "F" LEAD IS REQUIRED BY THE CONNECTING CIRCUIT.

COMMON SYSTEMS
COMPOSITE SIGNALING
AUXILIARY PULSE LINK
FOR REPEATING SIGNAL AROUND AN INTERMEDIATE
22 TYPE VOICE FREQUENCY REPEATER
SHOWN WITH TYPE "C" CX SET
FOR OPEN WIRE OR TWO WIRE CABLE CIRCUITS

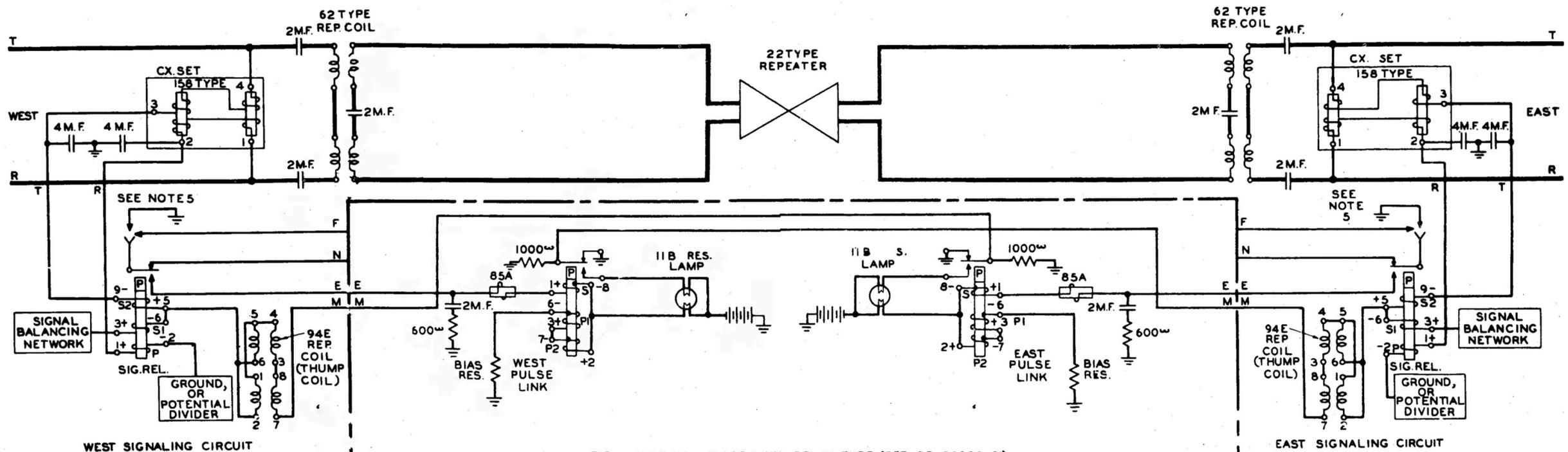


FIG.1 AUXILIARY PULSE LINK RELAY TYPE (SEE SD-95095-01)

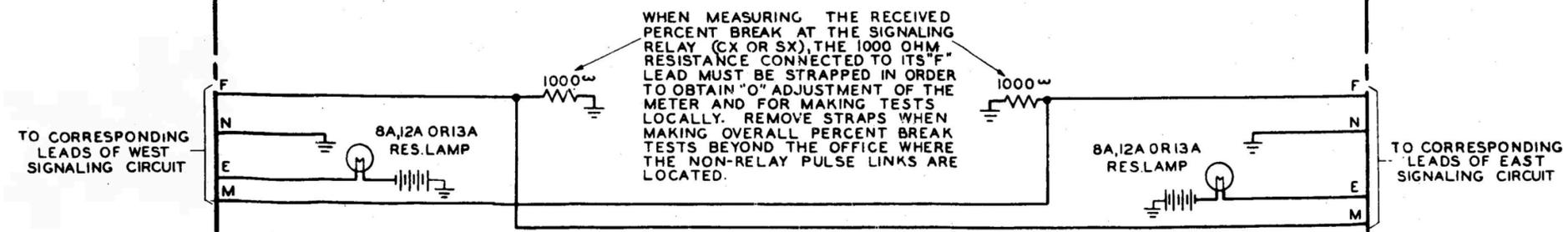
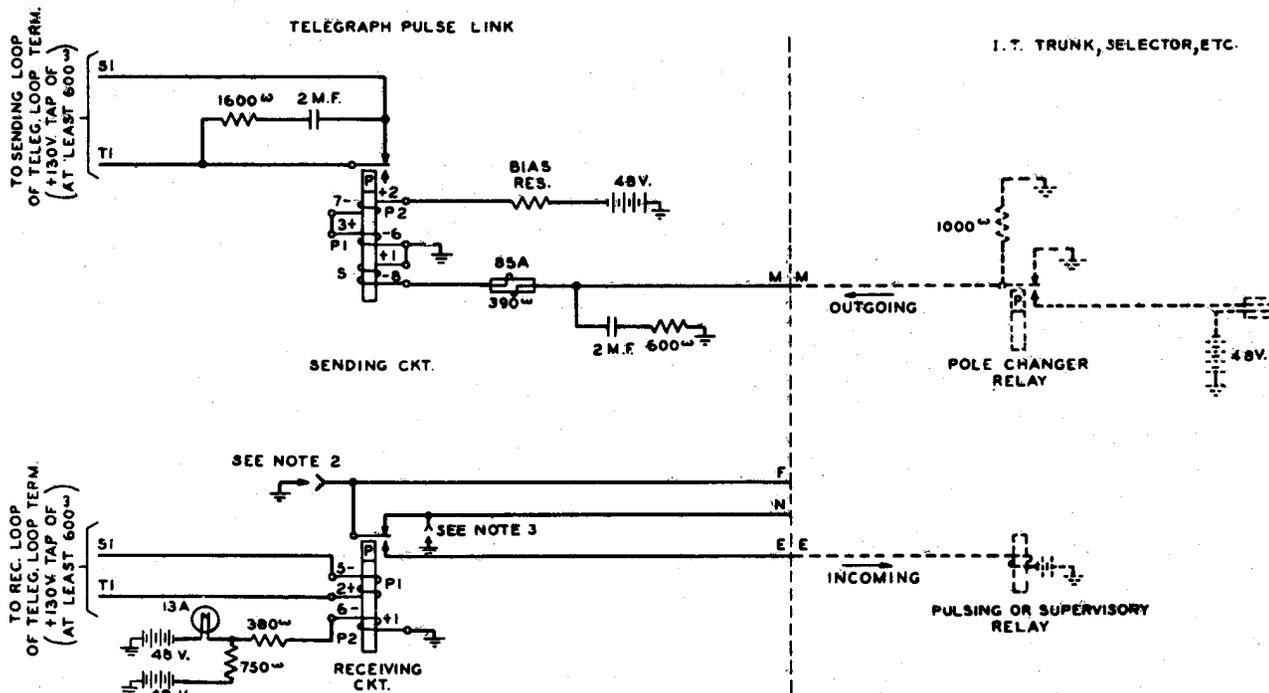


FIG.2 AUXILIARY PULSE LINK NON-RELAY TYPE (SEE SD-95043-01)

SKETCH D

**COMMON SYSTEMS
 COMPOSITE SIGNALING
 TELEGRAPH PULSE LINK
 SHOWN CONNECTED TO I.T. TRUNK
 FOR USE AT TERMINALS**



- NOTES:**
1. THE TELEGRAPH PULSE LINK IS USED AS A CONNECTING LINK BETWEEN CX. SIGNALING EQPT. AND A TELEGRAPH LOOP TERMINAL
 2. THE "F" AND "N" LEADS ARE OMITTED WHEN NOT SHOWN ON THE CONNECTING CKT. THE OPTIONAL GROUND IS FURNISHED WHEN THE "F" LEAD IS NOT REQUIRED.
 3. THE "N" LEAD IS CONNECTED TO GROUND WHEN THIS CIRCUIT IS CONNECTED TO A PATCHING JACK CIRCUIT.
 4. THIS LAYOUT IS BASED ON SD-95311-01, SD-64472-01 AND SD-64469-01 OR SD-64470, ETC.

ES-536841

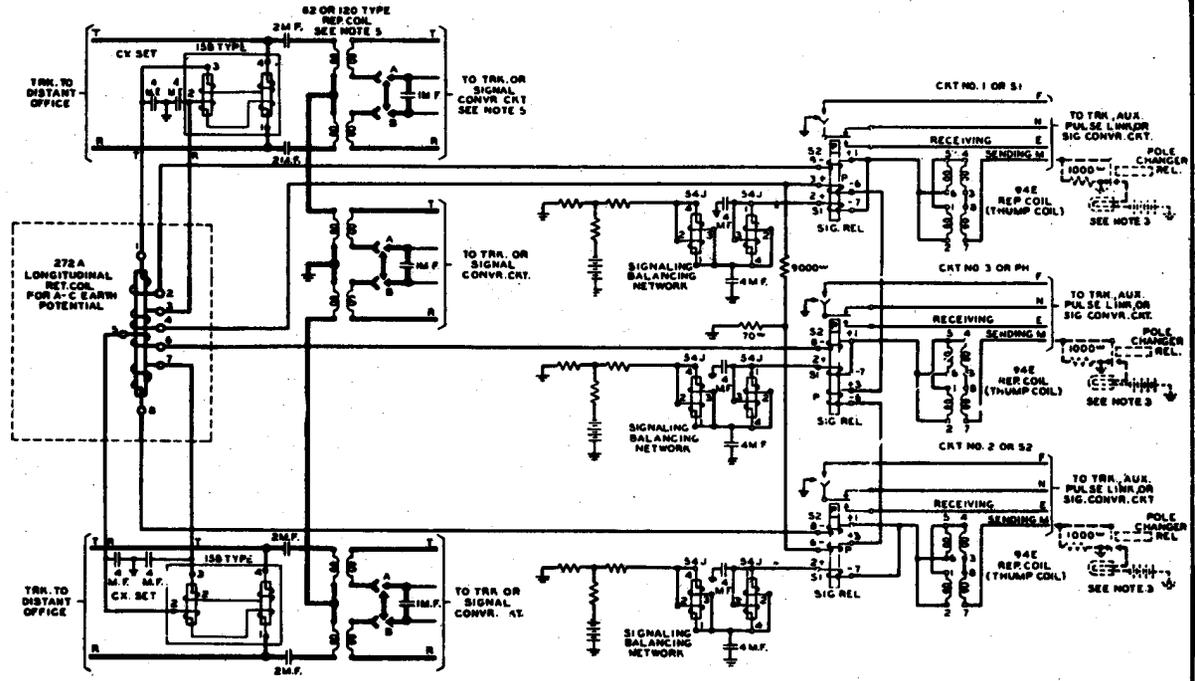
SKETCH E

BELL TELEPHONE LABORATORIES, INC.

- NOTES**
- LEADS "M" AND "P" (AND OTHER LEADS WHEN SHOWN ON THE CIRCUIT DRAWING) ARE OMITTED WHEN NOT REQUIRED BY THE CONNECTING CIRCUIT.
 - THE 94E REP COILS IN THE "M" LEADS FUNCTION TO DECREASE SIGNALING DISTURBANCES.
 - WIRING AND APPARATUS CONNECTING TO "M" LEAD AND SHOWN DOTTED IS LOCATED ON A ASSOCIATED TRUNK CIRCUIT.
 - THE LONGITUDINAL RETARDATION COIL MAY ALSO BE USED WITH TYPES D OR E CX SETS.
 - IF A NO 22 TYPE TEL REPEATER IS USED, THE 120 TYPE COIL IS NOT USED BUT EITHER 52 OR 53 TYPE OR SIMILAR OLDER TYPES REPEATING COILS MAY BE USED.
 - THIS DRAWING IS BASED ON SD-90136-00, SD-90973-01 AND SD-90048-01.

COMMON SYSTEMS
COMPOSITE SIGNALING
AC LONGITUDINAL RETARDATION COIL FILTER
FOR USE WITH EARTH POTENTIAL COMPENSATION
SHOWN WITH TYPE C CX SET
FOR OPEN WIRE OR CABLE CIRCUITS

CS-346700
INFORMATION
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SKETCH H