

REPEATING COILS AND THEIR USES

BULLETIN 331

Simplex, Phantom, and Composite Circuits

AUTOMATIC  ELECTRIC

**MAKERS OF TELEPHONE, SIGNALING AND COMMUNICATION APPARATUS
ELECTRICAL ENGINEERS, DESIGNERS AND CONSULTANTS**

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Illustrative Material Drawn from the following A.E.Co. Circuits: Simplex & Phantom, H-70001; Phantom & Composite, H-35455; Composite, H-33474; Composite Ringers, H-41069 & H-41477.

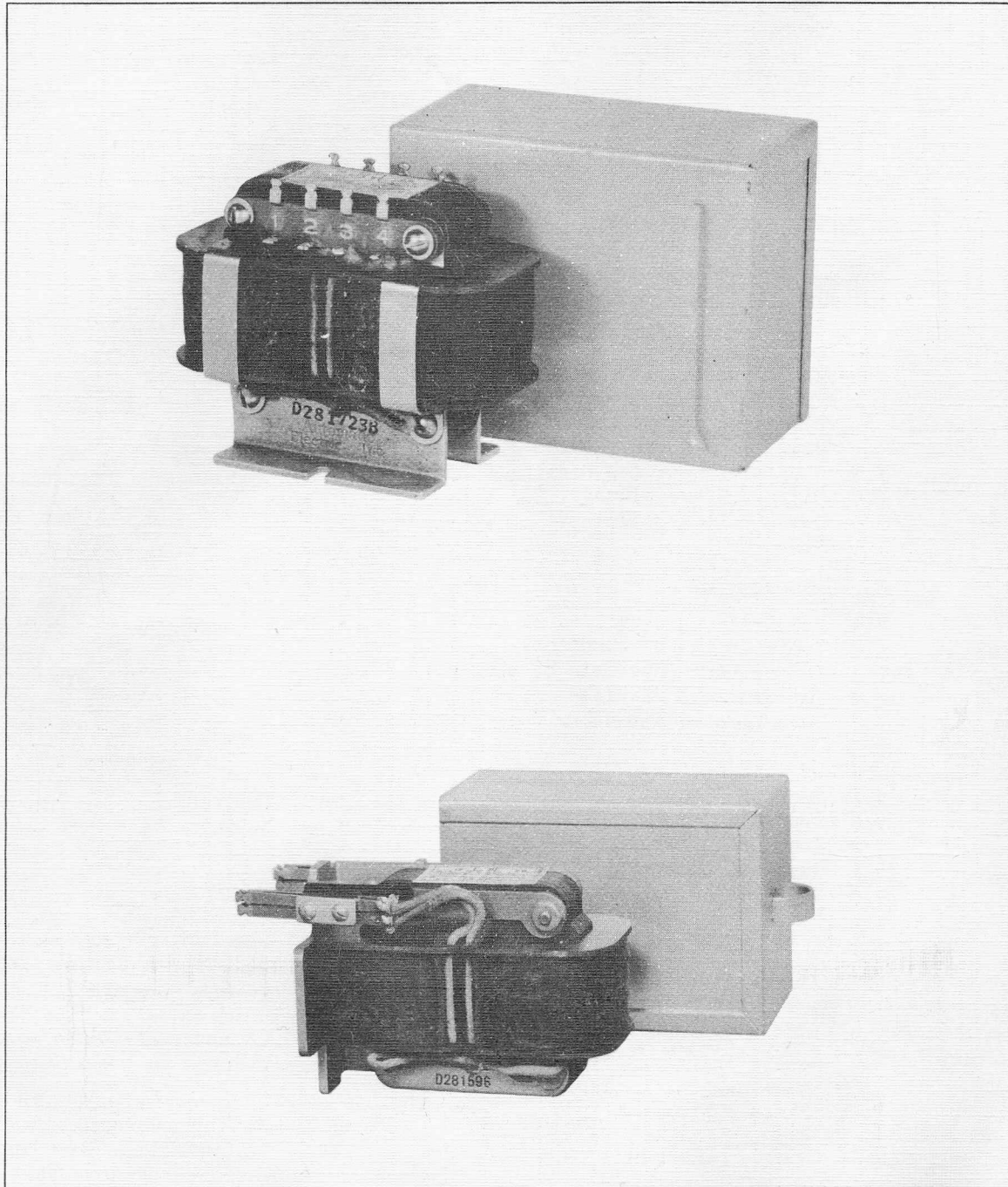


FIG. 1 TOP: TYPE 3 REPEATING COIL. BOTTOM: TYPE 4 REPEATING COIL FOR RELAY RACK MOUNTING.

REPEATING COILS AND THEIR USES

1. INTRODUCTION

Industrial concerns, including telephone, telegraph, pipe line, railroad, and public utility companies, which operate communication systems will find that many of their problems related to increased communication facilities and improved telephonic transmission will be solved by the use of Automatic Electric repeating coils described in Section 3. Suggested circuits for obtaining additional signaling and communication channels from present facilities are given elsewhere in the bulletin.

Repeating coils are essentially transformers. They consist of two series of windings: input (primary) and output (secondary) wound on a single laminated iron core. Repeating coils are available with either continuous (closed) or slotted (open) cores depending on the use to which the coil will be put. When the continuity of the core is broken by a slot, an air gap is introduced. Such coils are used for non-ring-through service (See Paragraph 3.2).

Repeating coils are not primarily intended to transform voltages. In telephone practice a repeating coil, as its name implies, is employed to repeat the energy received over one circuit into another circuit. This may be desirable for one of three reasons.

(1) It may be desired to separate metallically two circuits yet permitting the transfer of energy. For example, in cord circuits it is desirable to separate the direct currents flowing in the two ends of the cords so that separate supervision may be given. In addition to this use, repeating coils may be used to separate ends of a cord circuit so that magneto subscribers cannot ring through, thus permitting double supervision. The repeating coil also offers a convenient method for feeding battery to the lines. See the cord circuits shown in Section 3.2.

(2) Another reason for using repeating coils is to match the impedances of two dissimilar circuits; for example, it may be desired to couple a line of low characteristic impedance to a second line of high characteristic impedance. If this were done directly, losses would occur. In order to meet the optimum condition in which the impedance of the first line equals the impedance of the second line, a repeating coil of the inequality ratio type is inserted between the two lines. These unequal-ratio repeating coils have impedance ratios, primary to secondary windings, of such values as to meet the usual conditions.

The proper ratio is governed by the relation

$$\frac{N_1^2}{N_2^2} = \frac{Z_1}{Z_2}$$

where N_1 is number of turns of first winding and N_2 of the second winding. Z_1 is impedance of first winding, and Z_2 is impedance of second winding.

(3) A third reason for employing repeating coils is often among the most important. This is to create phantom circuits, obtaining additional telephone or telegraph circuits from a fixed number of metallic circuits already in use.

2. FULLY BALANCED COILS

Automatic Electric has developed special methods in the manufacture of repeating coils to insure accurate balance between the windings of a single coil, uniformity between coils, and desirable transmission characteristics. Accurately balanced windings are necessary to prevent cross-talk. The magnetic balance of the coils is accurate to within 0.01 of one percent. This balance is maintained on the switchboard windings as well as on the line windings which feature permits an Automatic Electric coil to be employed reversibly. Thus, a 1:2.69 can be used as a 2.69:1 coil. In order to secure this precise balance, two spools are each wound with two parallel windings of duplex wire. This gives in effect four parallel windings on each spool. These are now connected as shown in Figure 2. Thus, one of the twin outside windings on Spool 1 is connected in series to one of the twin inside windings of Spool 2. This forms one half of a side--or quarter winding, say one half of the primary. To get the other half, the other twin outside winding of Spool 1 is connected to the other twin inside winding of Spool 2. The secondary winding 6, 5-8, 7 is similarly obtained.

Thus, each half of both the primary and secondary consists of one inside and one outside winding on different spools, both inside windings and both outside windings being duplex wire wound. The proper combination of these gives two accurately balanced windings.

The windings of all repeating coils are impregnated with an insulating compound to make them moisture proof. All windings are tested to withstand an insulation breakdown test of 500 volts direct current and to have an insulation resistance between windings and between the windings and the core of 400 megohms. The complete coil is enclosed by a removable cross-talk-proof cover.

REPEATING COILS AND THEIR USES

TABLE OF REPEATING COILS

TYPE 1 RING AND TALK THROUGH COILS (Balanced, No Slot in Core: See Figure 5)

No.	Piece No.	Imp. Ratio	Res. of Windings per Quarter	Design Features	Remarks
1A	D-281638-A	1:1	9.28 ohms	Voice Transmission	With Cover
	D-281638-B			Efficiency, Figs. 4, 8, 6 and 7	Less Cover
1B	D-281851-A	1:1.69	9.28 and 18.6 ohms	Odd Ratio, Fig. 10	With Cover
	D-281851-B				Less Cover
1C	D-281852-A	1:2.69	9.28 and 29.7	Odd Ratio, Fig. 10	With Cover
	D-281852-B				Less Cover
1D	D-281932-A	1:1	21	Ringin Efficiency, Figs. 4, 9, & 6	With Cover
	D-281932-B				Less Cover
1E	D-282029-A	1:4 Std.	23 and 28.5	Monitoring	With Cover
	D-282029-B				Less Cover

Cover Dimensions: 2-1/4" x 4-3/8" x 3-5/8"

TYPE 2 NON-RING-THROUGH CALLS (Slotted Core; See Figure 11)

2A	D-281686-A	1:1	8.1 and 8.2	Non-Ring-Through, Figs. 4, 12, 6	With Cover
	D-281686-B				Less Cover
2B	D-281933-A	1:1.5	20 and 30	Non-Ring-Through, Fig. 10	With Cover
	D-281933-B				Less Cover
2C	D-281934-A	1:1	20	Non-Ring-Through, Figs. 4, 13	With Cover
	D-281934-B				Less Cover
--	D-282395-A-F	(Special Vertical Mounting for Above Coils. See Top Fig. 5)			

Cover Dimensions: 1-7/8" x 3-5/8" x 2-7/8"

TYPE 3 TALK THROUGH COILS (Non-Slotted Core; See Figure 14)

3A	D-281723-A	1:1	8.1 and 8.2	Non-Phantom, Figs. 4, 16, 6	With Cover
	D-281723-B				Less Cover
	D-282395-G-H	(Special Vertical Mounting for Above Coils. See Top Fig. 5)			

Cover Dimensions: 1-7/8" x 3-5/8" x 2-7/8"

TYPE 4 (SAME AS TYPE 2 EXCEPT MOUNTING) (Non-Ring-Through, Slotted Core; See Figure 17)

4A	D-281596-A	1:1	8.1 and 8.2	Relay Rack Mounting (See 2A, Figs. 4, 12, 6)	With Cover
Cover Dimensions: 2" x 3-7/8" x 2-5/8"					

TYPE 5 (SAME AS TYPE 3 EXCEPT MOUNTING) (Talk Through, Non-Slotted Core; See Figure 17)

5A	D-281724-A	1:1	8.1 and 8.2	Relay Rack Mounting (See 3A, Figs. 4, 16, 6)	With Cover
	D-281724-B				Less Cover

Cover Dimensions: 2" x 3-7/8" x 2-5/8"

To convert Types 2 & 3 coils to vertical mounting, use 1 D-310427 Strap and 1 D-730764 Vertical Mounting Bracket.

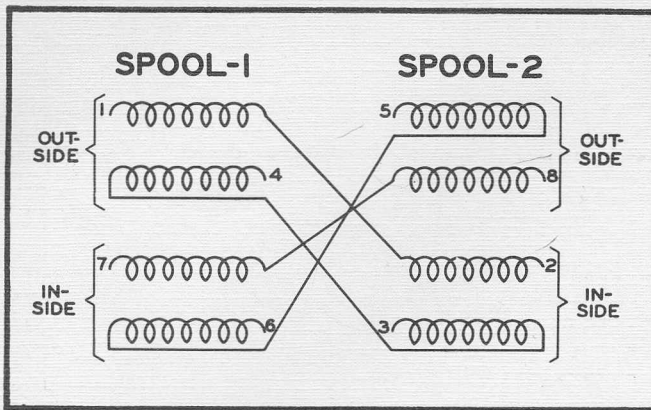


FIG. 2. A SCHEMATIC DRAWING SHOWING CONNECTIONS BETWEEN SPOOLS OF A REPEATING COIL.

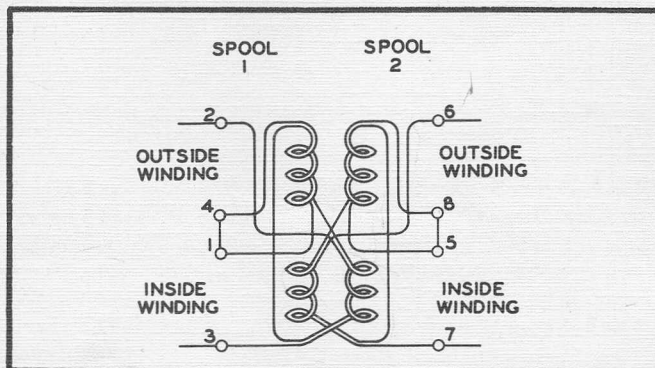


FIG. 3. DIAGRAMMATIC SKETCH OF WINDINGS OF REPEATING COIL.

3. TYPES OF REPEATING COILS

Repeating coils themselves may be classified into the following groups: (a) ring-and-talk through, (b) non-ring-through, and (c) talk-through.

3.1 Type 1 Repeating Coils - Ring Through

Type 1 coils are of the ring and talk through class. These are used principally in simplex and phantom circuits wherein it is desired to transmit both voice-current and ringing-current frequencies. To avoid distortion, such coils have a uniform loss at all frequencies within the commercial range of speech, i.e., between 200 to 3500 cycles. In addition such a coil must permit ringing current of 16 to 66 cycles to pass without too much loss. This latter condition requires a continuous and fairly heavy laminated core.

It is also essential that the coils be accurately balanced for distributed capacitance, inductance, and effective resistance in order to prevent cross-talk and extraneous noise.

Transmission losses for both types 1-A and 1-D are shown on the graph in Figure 4. The Type 1-A is a high-efficiency talking coil while the Type 1-D has maximum ringing efficiency. Voice-frequency loss on the 1-A is approximately 0.26

db., on the 1-D, 0.56 db. At 20 cycles, the loss on the 1-A is 3.4 db., on the 1-D, 1.7 db. The Type 1-D should accordingly be employed on phantom circuits where ring-through must be accomplished with a standard generator. Figures 8 and 9 show characteristics at ringing frequencies.

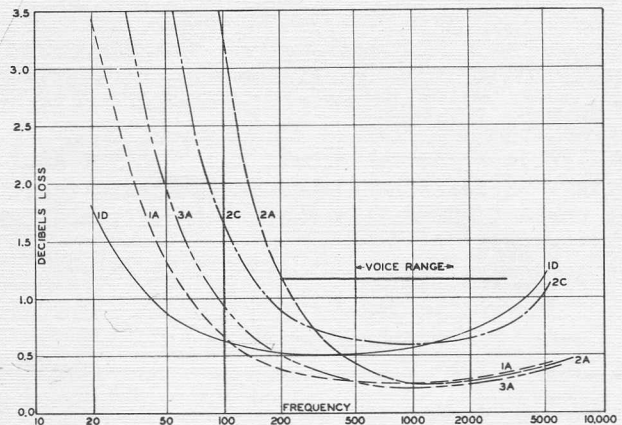


FIG. 4. TRANSMISSION LOSSES IN EQUAL RATIO REPEATING COILS AT DIFFERENT FREQUENCIES.

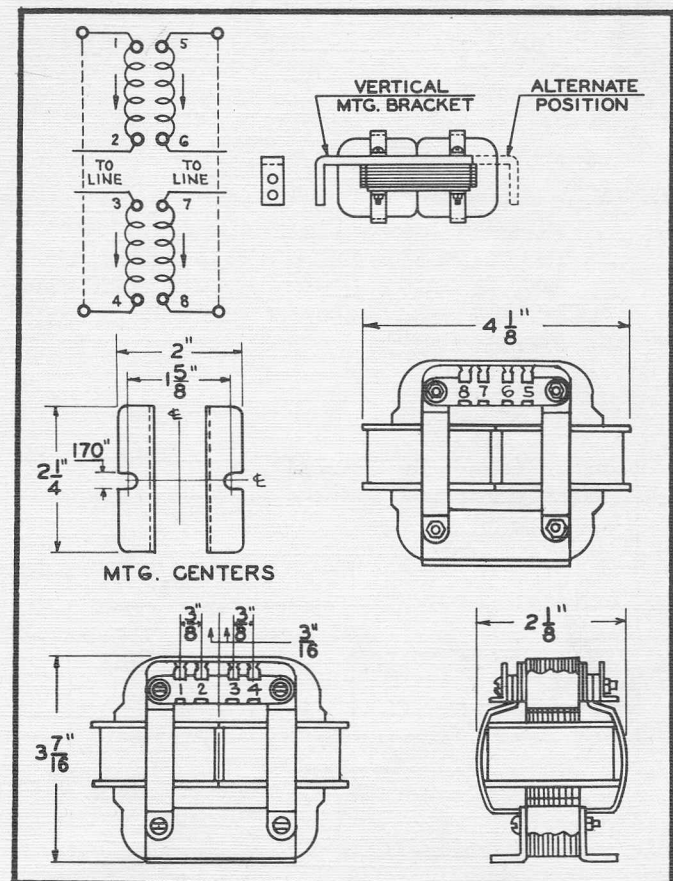


FIG. 5. TYPE 1 REPEATING COILS SHOWING MOUNTING DATA. CURRENT FLOW IN DIRECTION OF ARROWS WILL MAGNETIZE CORE IN SAME DIRECTION FOR ALL WINDINGS.

Ring-and-talk-through repeating coils with an impedance ratio of 1:1 are used to connect lines of the same electrical characteristics, i. e., the same impedance. However, when connecting lines whose impedances are at variance, inequality coils of proper impedance ratios should be selected in order that "reflection losses" which occur at junctions of the non-matching lines are held to a minimum. Two unequal ratios are available and as a practical matter, the one nearest the required ratio should be used for optimum results. The 1-B has an impedance ratio of 1:1.69; and the 1-C an impedance ratio of 1:2.69. The 1-E is a 1:4 ratio coil designed for monitoring. Section 10 discusses the selection of the correct inequality ratio coil in practical applications.

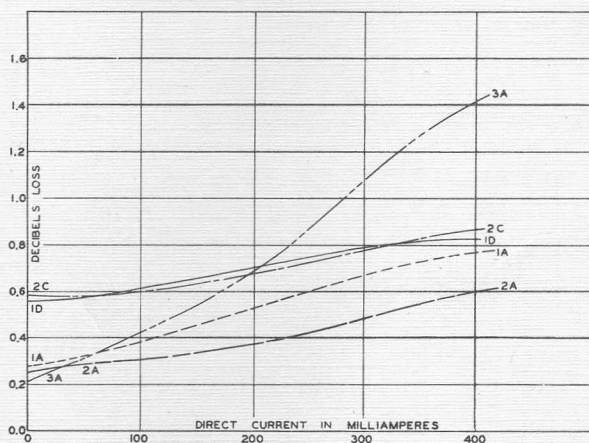


FIG. 6. TRANSMISSION LOSS IN EQUAL-RATIO REPEATING COILS, WITH VARIATIONS IN DIRECT CURRENT THROUGH PRIMARY WINDINGS, MEASURED BETWEEN LINES OF 600 OHM IMPEDANCE AT 1000 CYCLES.

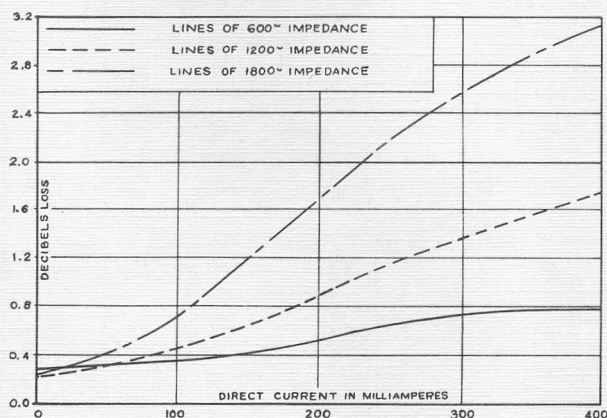


FIG. 7. TRANSMISSION LOSS IN TYPE 1A REPEATING COIL WITH VARIATIONS IN DIRECT CURRENT THROUGH THE PRIMARY WINDING.

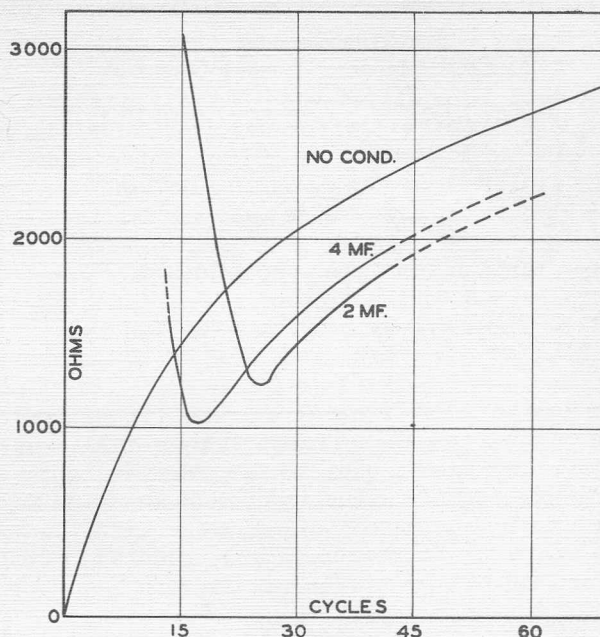


FIG. 8. TYPE 1A COIL FRONT CONNECTED VARIATION OF PRIMARY IMPEDANCE WITH RINGING FREQUENCY; 0, 2 & 4 MF. AT CENTER OF PRIMARY; SECONDARY OPEN.

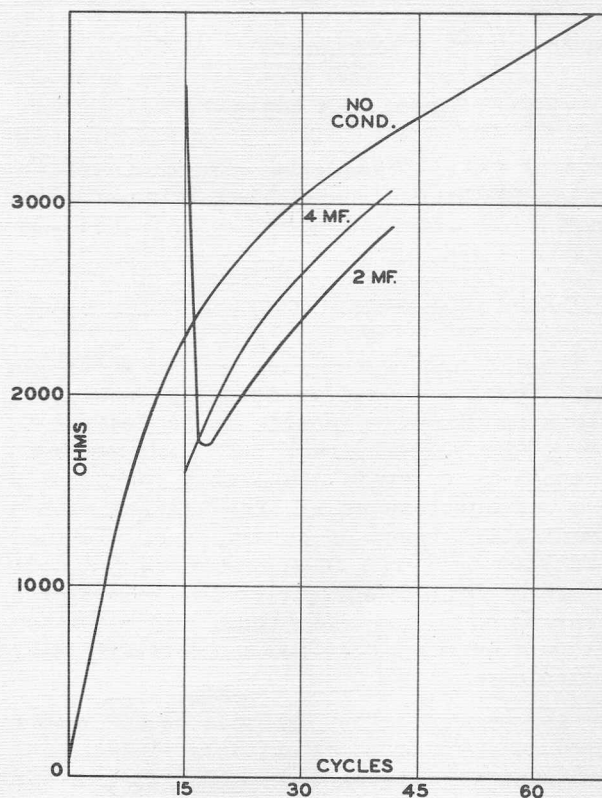


FIG. 9. TYPE 1D REPEATING COIL, FRONT CONNECTED. VARIATION OF PRIMARY IMPEDANCE WITH RINGING FREQUENCY; 0, 2 & 4 MF. AT CENTER OF PRIMARY; SECONDARY OPEN.

3.2 Type 2 - Non-Ring-Through (Fig. 11)

This coil is equipped with a slotted magnetic core and is primarily for use in cord circuits wherein it is desired to repeat voice-current frequencies from one line to another via the cord circuit but not ringing current frequencies. From the proper curve in Figure 4, note that the losses through the Type 2 coil are very high at 20 cycles due to the slotted core. Thus, at 20 cycles, the loss is 14.9 db. for the Type 2-A and 10.3 db. for the Type 2-C. Both have 1:1 impedance ratios, but Type 2-C has more turns on the windings. At ringing current frequencies, these Type 2 coils will not induce sufficient current from one winding to the other to operate a ring-off signal. Thus, double supervision may be had on a connection between two magneto lines. See Figure 15 for cord circuits, Figures 12 and 13 for performance at ringing frequencies.

Because of its slotted core, direct current does not saturate the core of Type 2 coils as readily as the related Type 3. With no condenser at the center of the primary, the 2-A primary has a very low impedance to ringing currents. Characteristics of Types 2-A and 2-C may be determined from Figures 4, 6, 12 and 13. These coils are smaller than the Type 1 having smaller cores. They are generally used in magneto cord circuits and in common battery cord and trunk circuits where direct current exceeds 100 milliamperes. The slotted core reduces direct current losses to a minimum. For values, see Fig. 6 for equal ratio coils and Fig. 10 for unequal ratio coils.

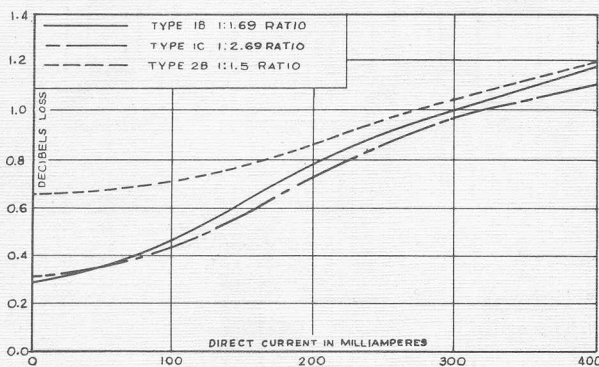


FIG. 10. TRANSMISSION LOSS IN UNEQUAL-RATIO COILS WITH DIRECT CURRENT THROUGH LOW IMPEDANCE SIDES. TEST FREQUENCY 1000 CYCLES BETWEEN A LINE OF 600 OHMS IMPEDANCE ON THE LOW IMPEDANCE SIDE AND A LINE HAVING A PROPORTIONAL IMPEDANCE ON THE HIGH IMPEDANCE SIDE.

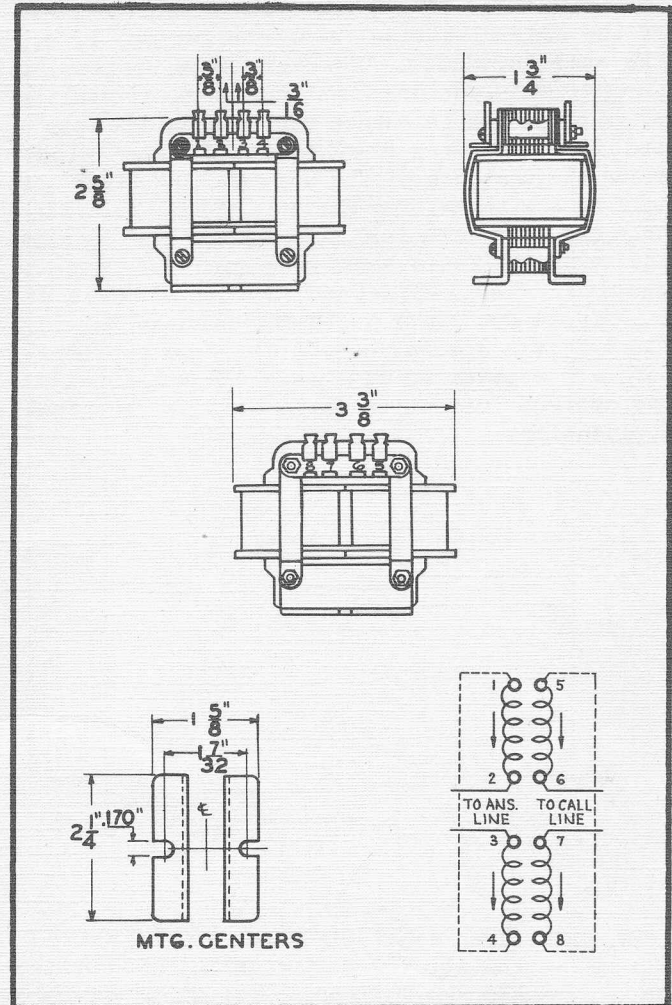


FIG. 11. TYPE 2 REPEATING COILS SHOWING MOUNTING DATA. FOR VERTICAL MOUNTING, SEE BRACKET IN FIG. 5. CURRENT FLOW IN DIRECTION OF ARROWS WILL MAGNETIZE CORE IN SAME DIRECTION FOR ALL WINDINGS.

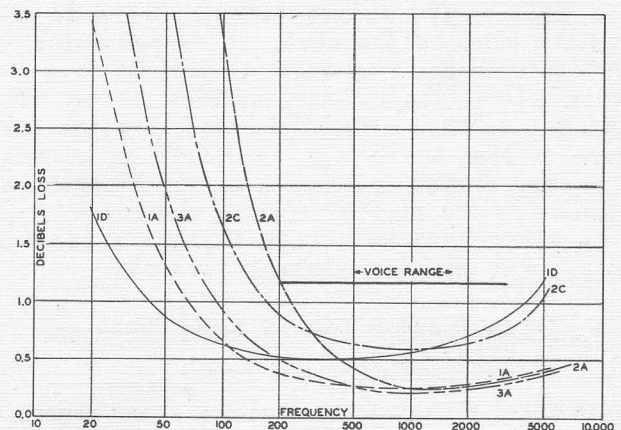


FIG. 4 (REPEATED). TRANSMISSION LOSSES IN EQUAL RATIO REPEATING COILS.

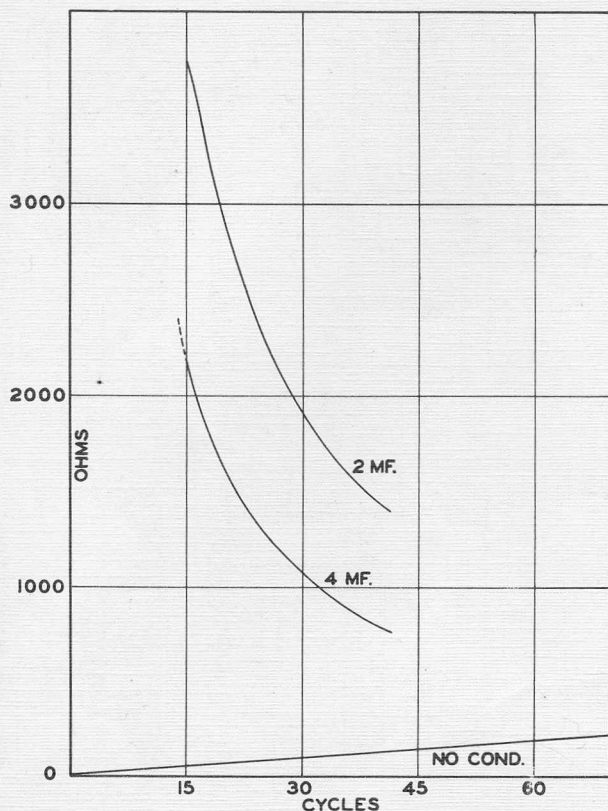


FIG. 12. TYPE 2A REPEATING COIL, FRONT CONNECTED. VARIATION OF PRIMARY IMPEDANCE WITH RINGING FREQUENCY; 0, 2 & 4 MF. AT CENTER OF PRIMARY; SECONDARY OPEN.

3.3 Type 3 Repeating Coils - Talk-Through

The Type 3 talk-through repeating coils are manufactured with a closed magnetic core for use in common-battery cord and trunk circuits in which direct current through the coil will not exceed 100 milliamperes. Owing to the smaller size of the core, it is not quite as efficient as the ring-and-talk-through Type 1-A especially at ringing current frequencies. The Type 3 does have a flatter curve at voice frequencies than the Type 2. For further information, see curves in Figures 4, 16. Therefore, because of its limited ringing qualities, Type 3 is designated as a talk-through repeating coil. For mounting, see Figure 14.

3.4 Types 4 and 5 (Relay Rack Mounting, Figure 17)

Types 4 and 5 are constructed for relay mounting and are the same electrically as Types 2 and 3, respectively. Thus Type 4 is a non-ring-through coil with a slotted core. Type 5 is a talk-through coil with a non-slotted core.

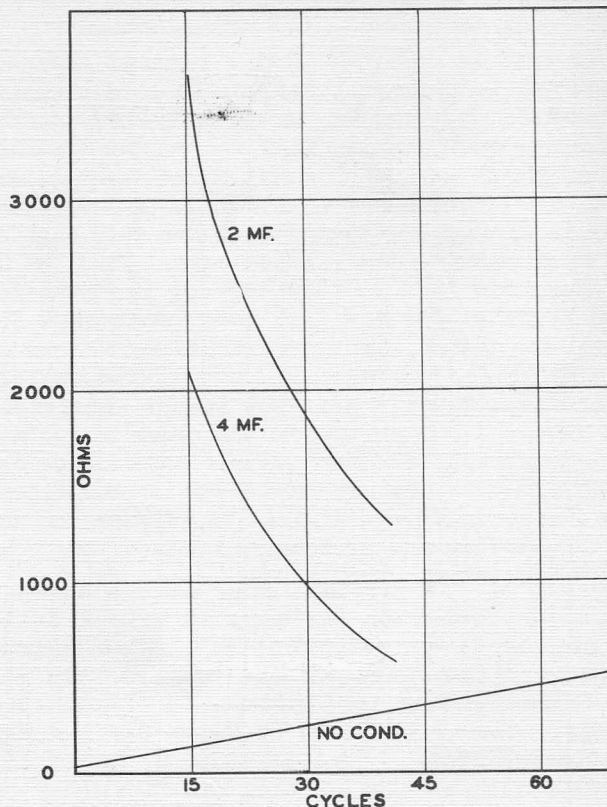


FIG. 13. TYPE 2C REPEATING COIL, FRONT CONNECTED. VARIATION OF PRIMARY IMPEDANCE WITH RINGING FREQUENCY; 0, 2 & 4 MF. AT CENTER OF PRIMARY; SECONDARY OPEN.

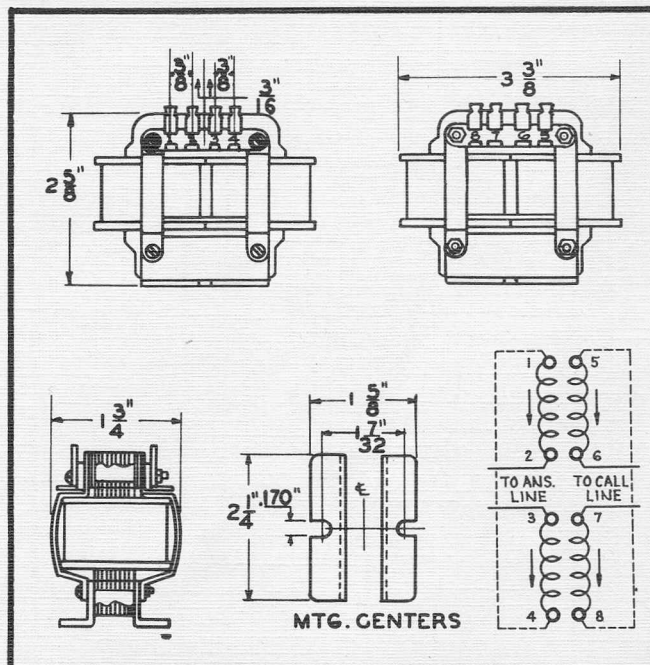


FIG. 14. TYPE 3 REPEATING COILS SHOWING MOUNTING DATA. FOR VERTICAL MOUNTING, SEE BRACKET IN FIG. 5. CURRENT FLOW IN DIRECTION OF ARROWS WILL MAGNETIZE CORE IN SAME DIRECTION FOR ALL WINDINGS.

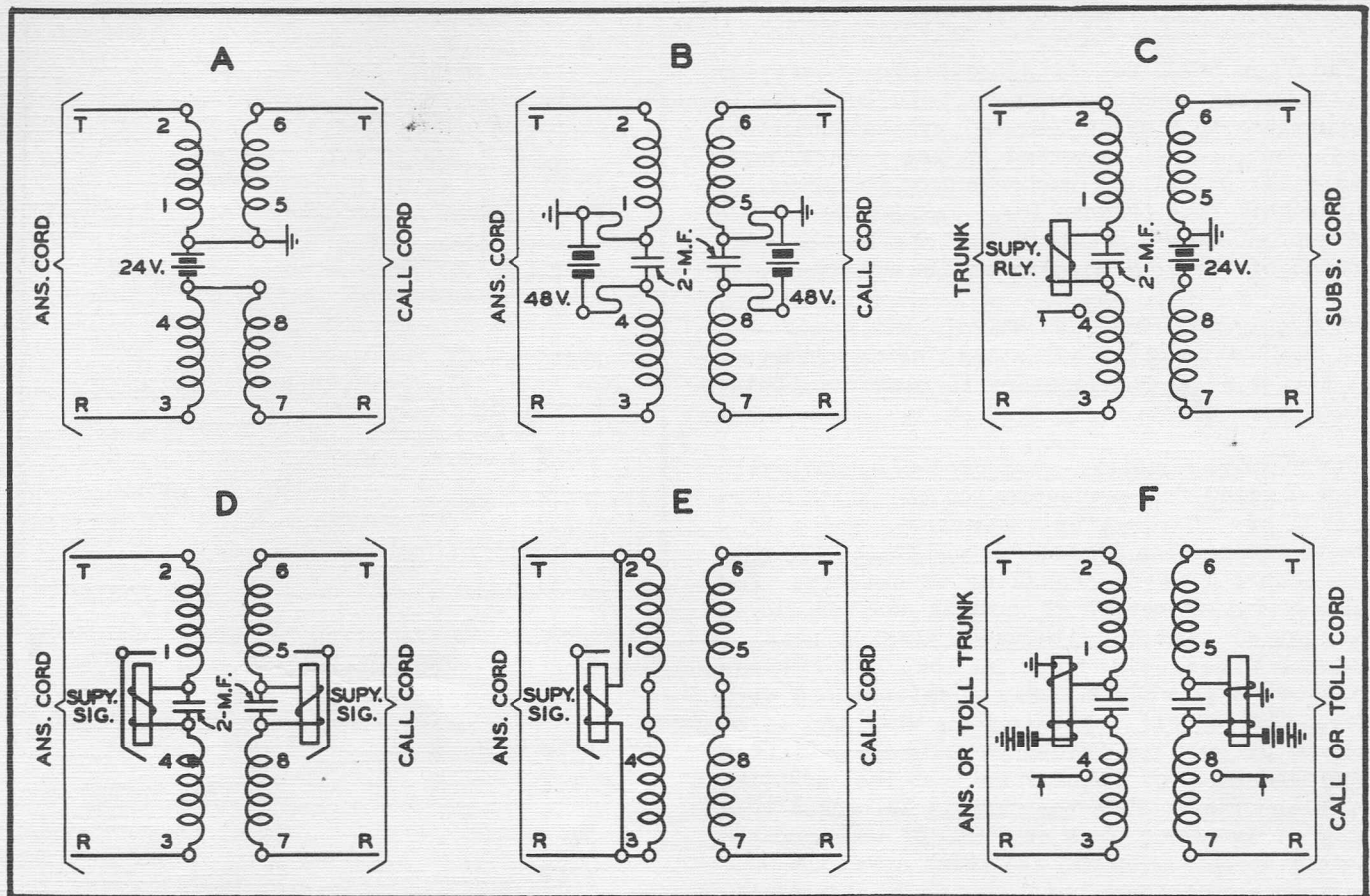


FIG. 15. REPEATING COILS EMPLOYED IN VARIOUS CORD CIRCUITS, MAGNETO AS WELL AS COMMON BATTERY.

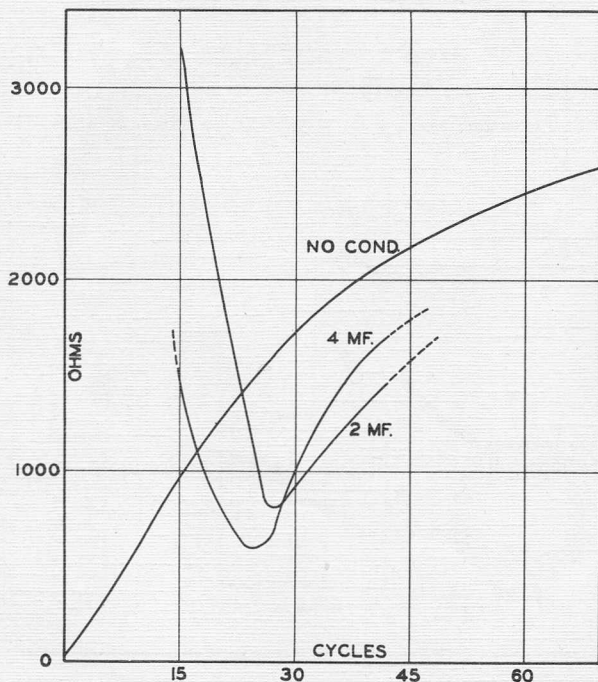


FIG. 16. TYPE 3A REPEATING COIL, FRONT CONNECTED. VARIATION OF PRIMARY IMPEDANCE WITH RINGING FREQUENCY; 0, 2 & 4 MF. AT CENTER OF PRIMARY; SECONDARY OPEN.

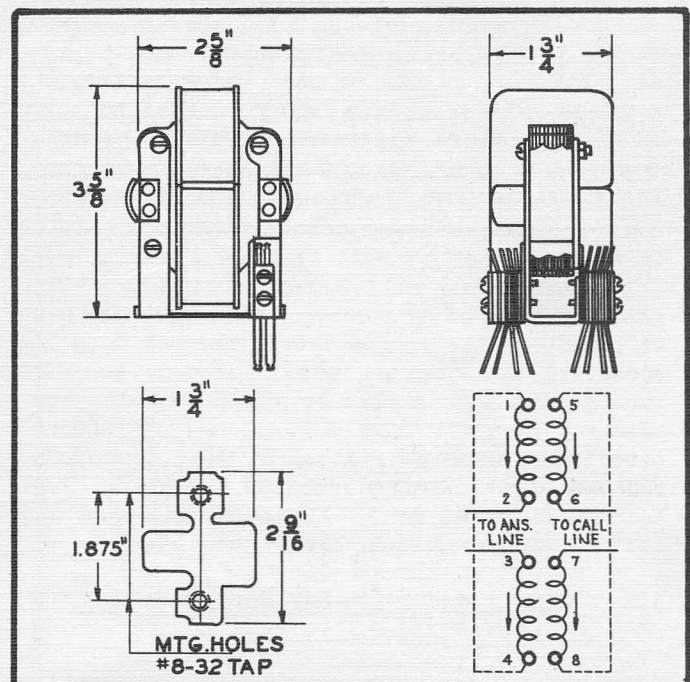


FIG. 17. TYPES 4 & 5 REPEATING COILS SHOWING MOUNTING DATA. CURRENT FLOW IN DIRECTION OF ARROWS WILL MAGNETIZE CORE IN SAME DIRECTION FOR ALL WINDINGS.

3.5 Type 3718 - Adapter for Magneto Lines

The Type 3718 repeating coil is an adapter permitting common battery telephones to be connected to a magneto-manual switchboard. The adapter coil is inserted in the subscriber's line circuit at the exchange - one adapter per converted line (Figure 18). Talking battery is supplied from a 24-volt battery to the mid-point of the line winding on the adapter coil.

In some cases, where the 24-volt battery is used in conjunction with a vibrating ringing converter, a filter will be necessary to eliminate noise from the converter.

The adapter consists of a repeating coil with one winding for connection to the switchboard (in place of the line conductors) and a balanced two-section winding through which the subscriber's line is connected to battery. For successful operation of such an adapter, it is essential that (1) the transmission loss at speech frequencies must be low, and (2) the coil must be able to trip a switchboard drop from the inductive kick set-up when the telephone circuit is opened or closed. It is a characteristic of inductances that the inductive kick is greater when the circuit is broken than when it is made. Thus on lines of considerable length extending beyond the local area, the subscriber should flash the operator by alternately depressing and releasing the cradle plunger.

This takes advantage of the greater inductive kick on the opening of the loop circuit. The adapter is primarily designed for one-party lines; however, it may be used on party lines, the number of telephones being limited by the number of ringers which can be rung through the coil. Transmission loss is 0.57 db. on Types A and B. For dimensions, see Figure 19.

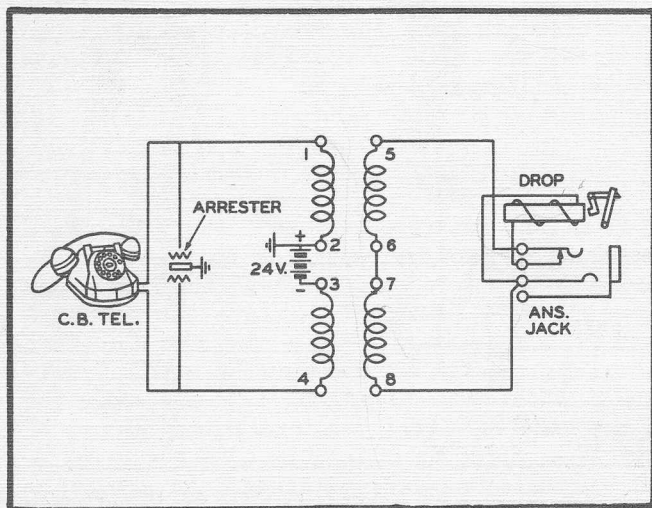


FIG. 18. ADAPTER FOR MAGNETO LINES

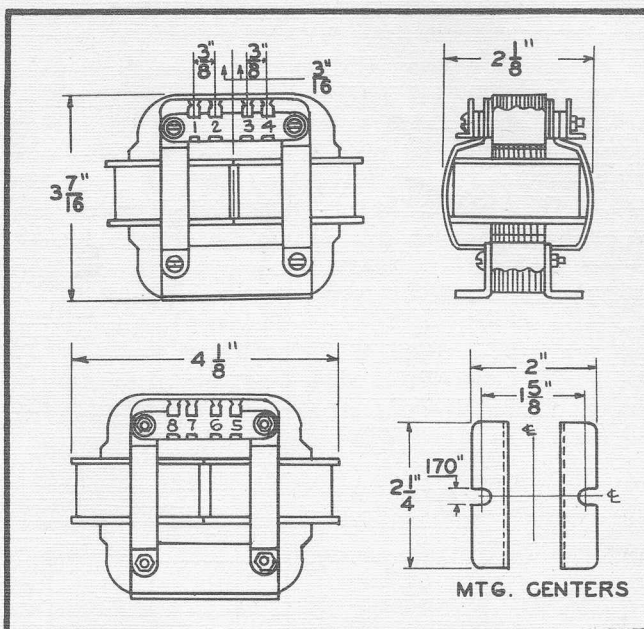


FIG. 19. MOUNTING DETAILS FOR TYPE 3718.

Repeating Coil	Impedance Ratio	Res. of Windings Per Quarter
3718A	1:1	21 Ohms, with cover
3718B	1:1	Same, less cover
3718C	1:1	46 Ohms, with cover
3718D	1:1	Same, less cover

Note: A and B for use on long lines (50 to 250 ohm loop).

C and D for use on short lines (50 ohm loop or less).

Cover Dimensions: 2-1/4" x 4-3/8" x 3-5/8"

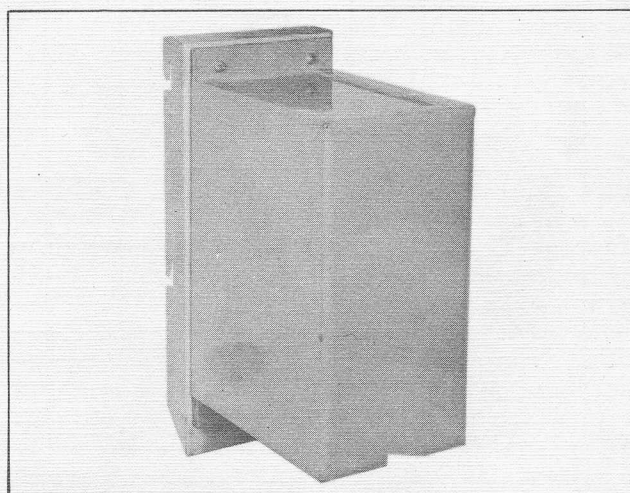


FIG. 20. LARGE-TYPE RETARDATION COIL FOR SWITCH-SHELF MOUNTING.

3.6 Retardation Coils (Figures 20, 21)

In order to obtain additional telegraph circuits, retardation coils, often called chokes, are required. Such a coil consists of one or more windings on an iron core. Retardation coils are inserted in composite legs to block out the higher frequencies of the telephone circuit and in order to smooth out telegraphic impulses so as to minimize interference (thumps) on the telephone circuit. See Section 7.

There are two types of retardation coils: (1) the large type which must be used on telegraph legs; (2) the small or relay structure coils suitable for dial legs only.

Large Type - for Telegraph Circuits: (Figs. 20 and 21)

D-281854-A - Floor-Type, Relay Rack, Wall Mounting

D-281853-A - Switch Shelf Mounting

Small Relay Structure Type:

R-3034-A1 - Relay Strip Mounting

R-3015-A1 - Left-Hand Coil for Switch Base Mounting

R-3034-A1 - Right-Hand Coil for Switch Base Mounting

4. EFFECT OF DIRECT CURRENT ON REPEATING COILS

When direct current flows through a repeating coil, the transmission efficiency of the coil is slightly decreased. The curves in Figure 6 show the transmission loss for the equal ratio coils with various amounts of d.c. current flowing through the windings. Note that the slotted core or non-ring-through type has greater efficiency than corresponding ring-through coils when current values exceed 100 milliamperes.

Figure 10 shows unequal ratio coils with various d.c. currents flowing. Frequently a 2 M.F. condenser is inserted on the switchboard side of a repeating coil not only to prevent direct current from reducing the transmission efficiency of the coil but also to prevent the winding from shunting the direct-current supervisory relay used in some cord circuits. In studying the magnetic effect of direct current flowing through an equal ratio repeating coil, the currents in both circuits of the coil should be considered, i.e., if the two circuits have currents flowing in such directions that the created magnetic fluxes aid each other, the

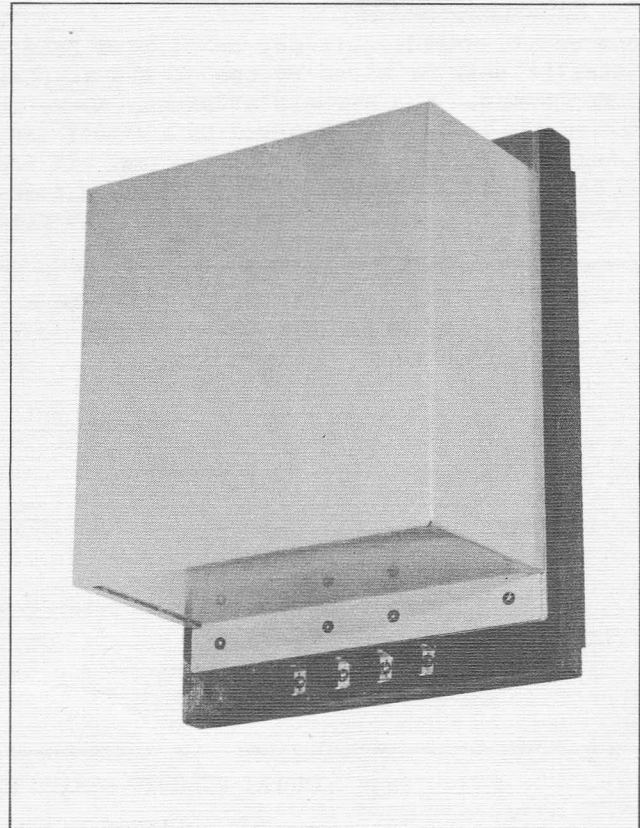


FIG. 21. LARGE-TYPE RETARDATION COIL FOR WALL OR RELAY RACK MOUNTING.

total current should be considered as the sum of the two currents. Conversely, if the two circuits have currents flowing in such directions that the created magnetic fluxes oppose each other, the total current should be considered as the difference between the two. For best transmission, the windings should be so connected that effects of the two direct currents oppose each other.

5. COUPLING GROUNDED AND METALLIC LINES

Where a long metallic pair is to be joined to a grounded circuit, a repeating coil may be inserted in the circuit connecting the two lines. The coil will serve to insulate the grounded line from the metallic line, and the inductive interference will be somewhat reduced. Terminals 2 and 3 of the repeating coil are connected to the metallic line; terminal 1 is strapped to 4; 5 is strapped to 8; terminal 6 is connected to the single conductor; terminal 7 is grounded. See wiring diagram, Figure 5. A lightning arrester should be placed in the lines on both sides of the coil.

ONE ADDITIONAL CIRCUIT FROM A METALLIC PAIR

6. SIMPLEX CIRCUITS

One additional circuit may be derived from a metallic pair of wires by use of the simplex arrangement. The circuit obtained, shown in Figure 22, is usually employed as a signal leg, a telegraph leg, or a toll dialing leg. It is, of necessity, a grounded circuit which is sometimes used as a grounded phantom. Current flow

in the grounded circuit does not affect the metallic circuit for the flow divides both ways at the mid-point of the repeating coil.

This causes no potential difference to appear in the primary winding at either end of the line. This condition assumes that the two sides of the line are balanced, and have minimum uniform leaks to ground.

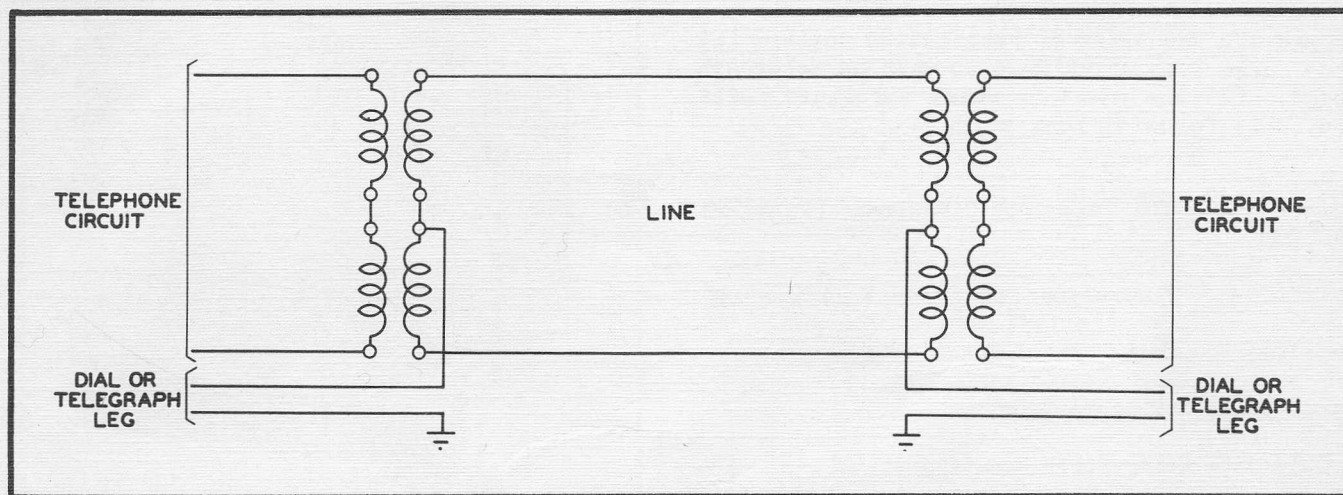


FIG. 22. SIMPLEX CIRCUIT GIVING ONE EXTRA CIRCUIT FROM A METALLIC PAIR.

TWO ADDITIONAL CIRCUITS FROM A METALLIC PAIR

7. COMPOSITE CIRCUITS

A composite circuit is a combination such that two telegraph or two toll-dialing legs may be obtained from a metallic telephone circuit, single pair (Figure 23A). When lines are composited for telegraphic legs, composite ringers requiring 135 or 1000 cycle current must be used for signaling as low frequency ringing current affects the telegraph instruments. Figure 24 shows a block diagram of such a line. Composited phantom circuits are discussed in Section 8.2. On these, the same principles and the same type of composite sets are employed.

7.1 Open-Wire Composite Sets (Figures 25, 26, 27 and 28)

The principle here is that of employing condensers ("X" and "Y") to separate the alternating voice currents from the direct-current pulsating signal circuits and a retard coil #1 to separate the direct current.

7.11 Terminal Set (Figure 25)

Thus, in Figure 25, alternating voice currents pass readily to and from the switchboard into the line through the 2 M.F. condensers "X" and "Y". The telegraphic legs are connected through the retard coil #1 to the line side of these condensers. Direct current pulses are prevented

from passing to the switchboard by the presence of the line condensers "X" and "Y". The retard coil and shunting condensers have been inserted in the telegraphic legs to smooth out the direct current pulses avoiding thumps on the telephone circuit. The #2 retard coil acts as a filter serving to by-pass any low frequency "thumps" which might pass into the telephone circuit. The retard coils offer a high impedance to voice frequencies but pass the lower frequencies. The condenser pack between the telegraph legs absorbs any inductive surges produced by the telegraph apparatus.

Cross-fire, the telegraphic equivalent of cross-talk, is the electrical effect which adjacent telegraph lines produce on each other. It is especially noticeable when grounded duplex telegraph circuits operate over cable pairs of considerable length. The close coupling of the wires permits small cross-fire currents to pass into the paralleling conductors and affect the polar relays used with grounded duplex telegraph circuits. In any case, the effect of cross-fire on the telephone circuit is minimized by the low impedance path to ground through retardation coil #1. For reliable telegraph service, it is sometimes desirable to use both legs to form a metallic circuit telegraph loop. This will, of course, be necessitated if excessive ground potentials exist.

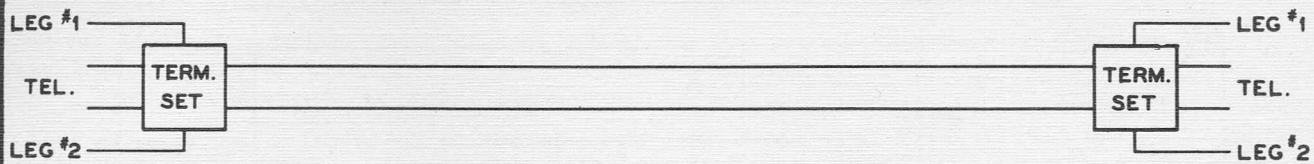


FIG. 23A. COMPOSITE SETS ON A METALLIC PAIR GIVING TWO SIGNAL LEGS.

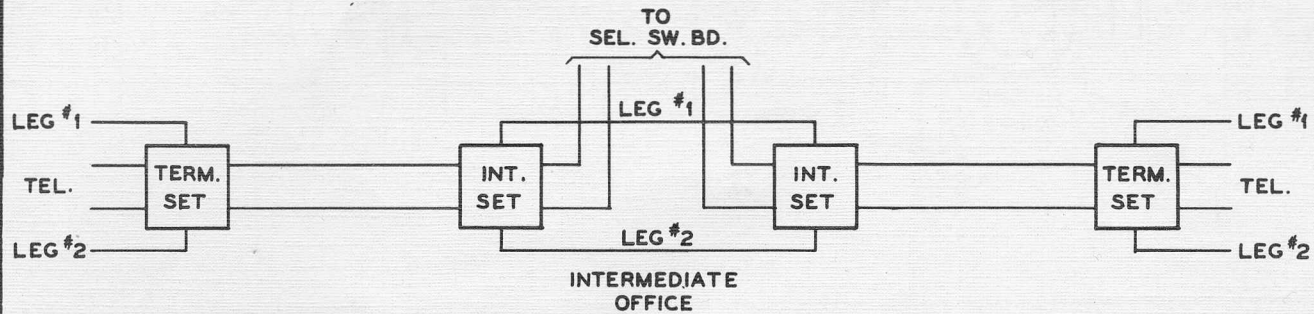


FIG. 23B. SAME AS A EXCEPT FOR INTERMEDIATE STATION REQUIRING INTERMEDIATE SETS TO CARRY THE COMPOSITE LEGS THROUGH THE OFFICE. NO SIGNALING APPARATUS MAY BE CONNECTED TO LEGS AT INTERMEDIATE OFFICE.

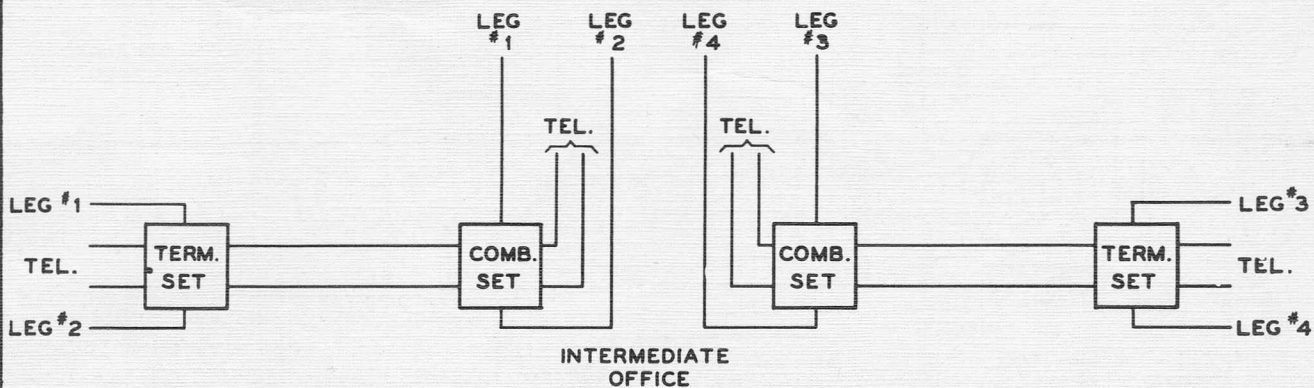


FIG. 23C. COMBINATION SETS ARE EMPLOYED AT INTERMEDIATE OFFICE SO THAT SIGNAL LEGS MAY BE TERMINATED THERE OR CONNECTED TOGETHER AS DESIRED.

FIG. 23. COMPOSITE CIRCUITS

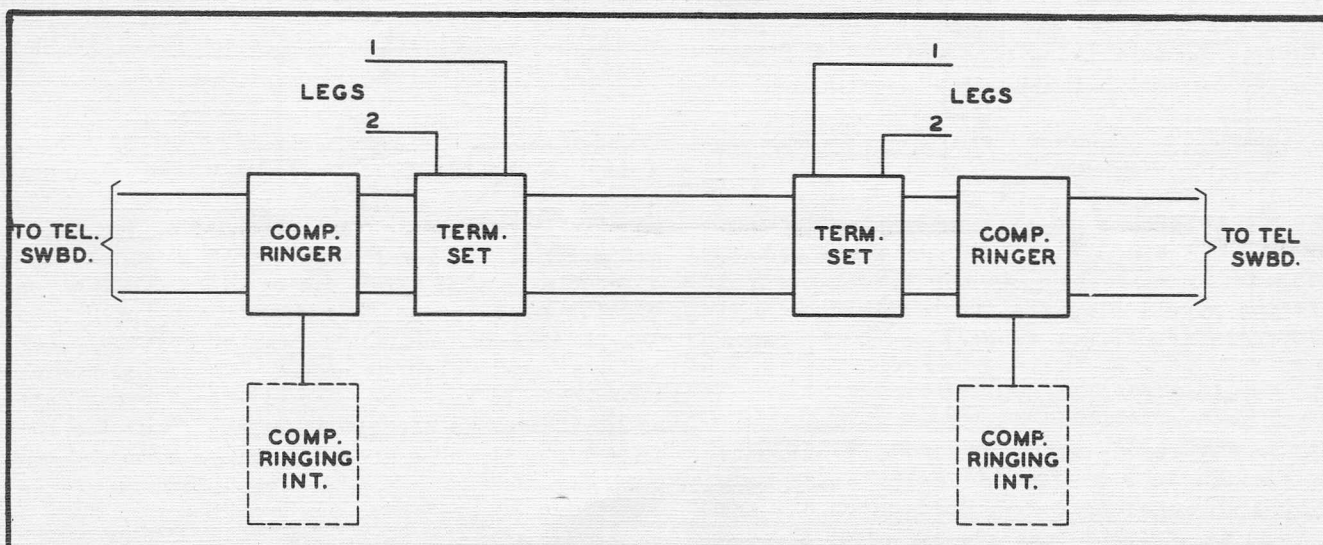


FIG. 24. COMPOSITE RINGERS APPLIED TO 23A, USING 135 OR 1000 CYCLES OVER THE LINE.

REPEATING COILS AND THEIR USES

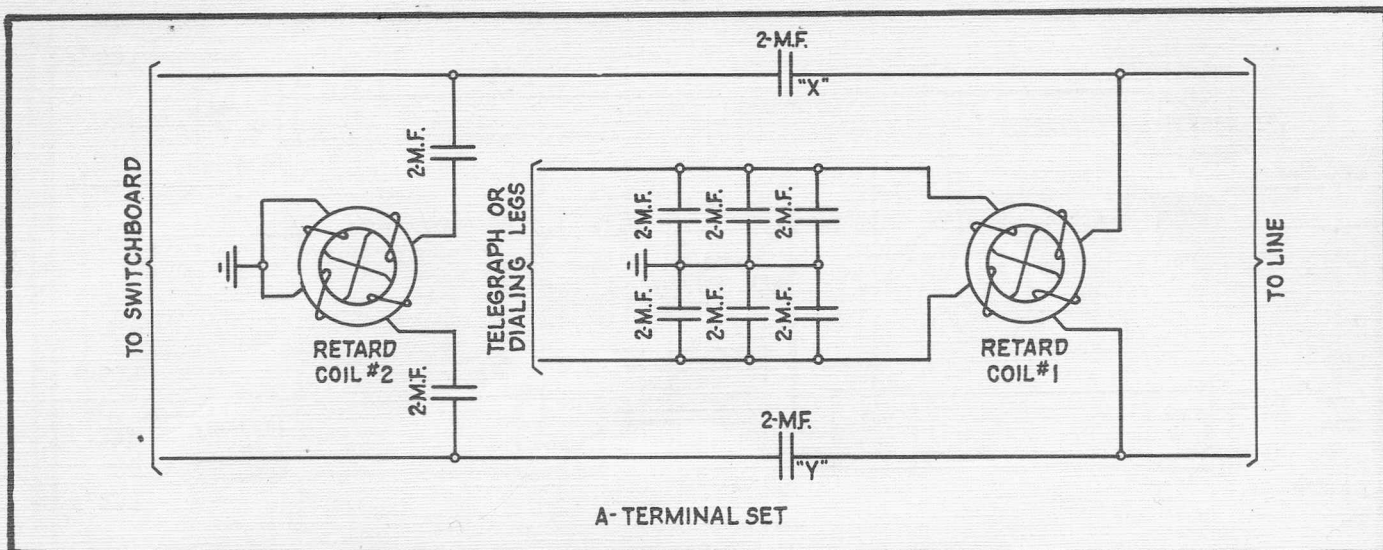


FIG. 25. TERMINAL SET.

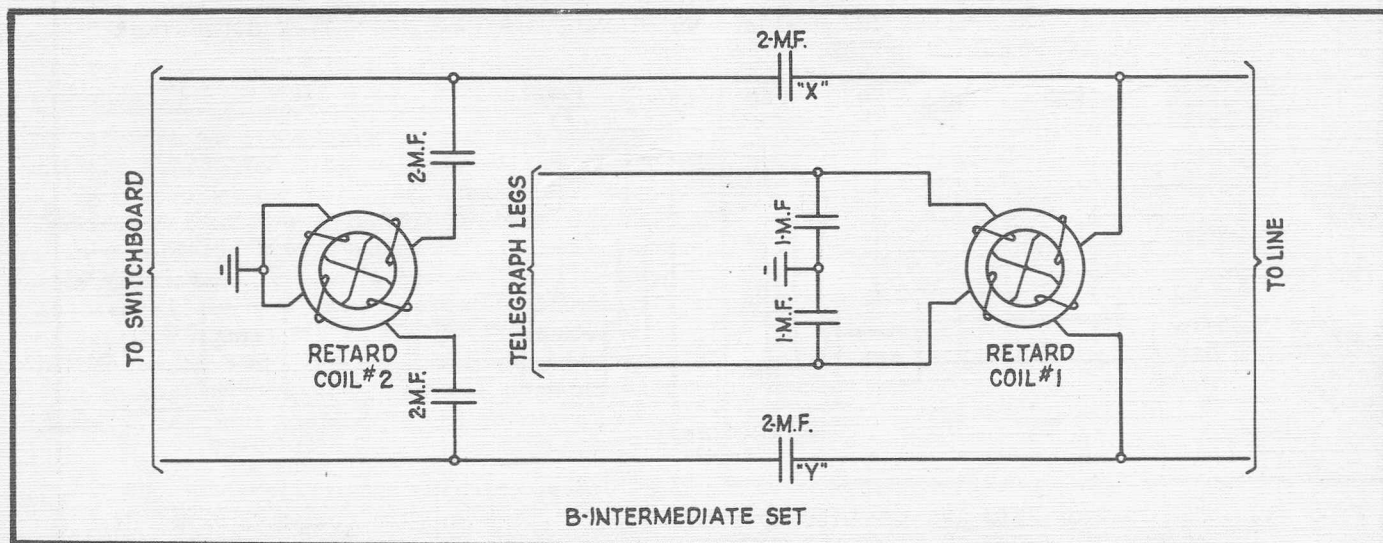


FIG. 26. INTERMEDIATE SET CONNECTING ONE COMPOSITE LINE TO ANOTHER WHEN NO SIGNALING APPARATUS IS AT INTERMEDIATE POINT.

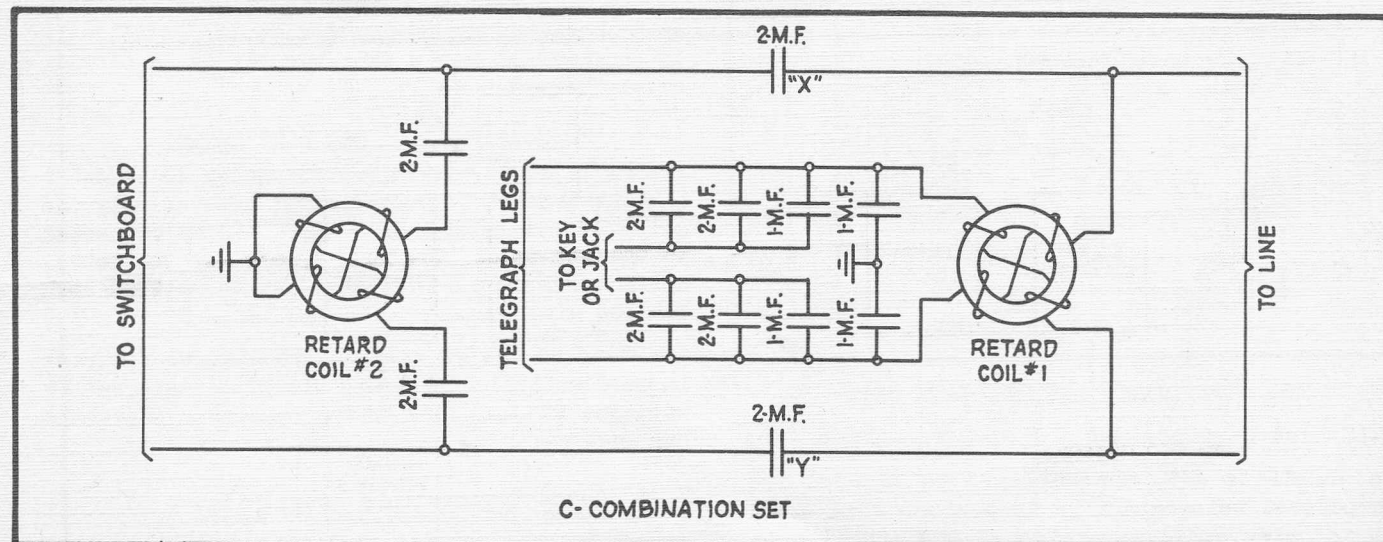


FIG. 27. COMBINATION SET SERVING AN INTERMEDIATE POINT AS EITHER TERMINAL OR INTERMEDIATE SET.

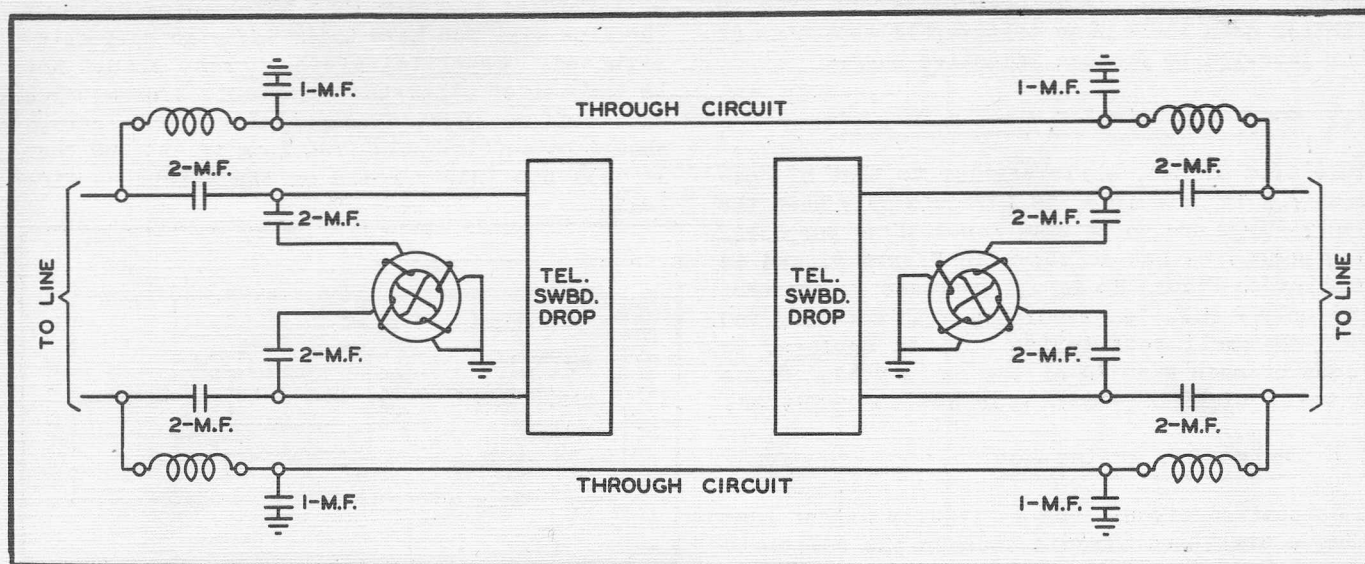


FIG. 28. TWO INTERMEDIATE SETS AS SHOWN IN FIGURE 26 CONNECTED TOGETHER AT AN INTERMEDIATE STATION.

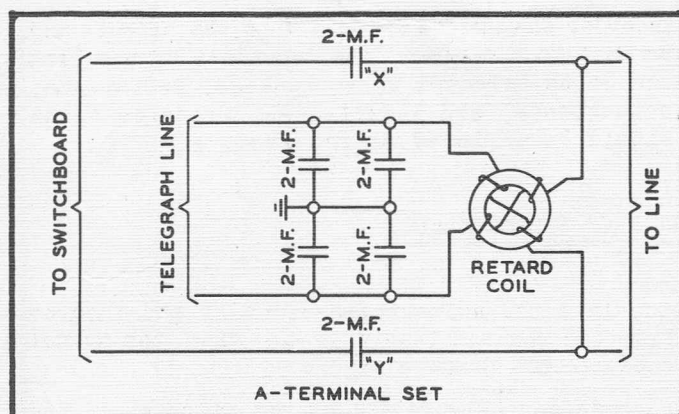


FIG. 29. CABLE TERMINAL SET.

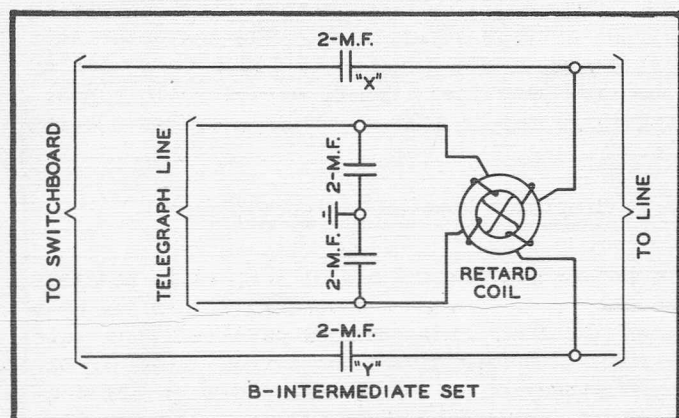


FIG. 30. CABLE INTERMEDIATE SET.

7.12 Intermediate Set - Open-Wire (Figure 26)

Intermediate sets are employed to connect one composited telegraph line to another when there is no telegraphic apparatus at the junction to produce inductive surges. For this reason, not more than 1 M.F. capacitance is required between each telegraphic leg and ground.

7.13 Combination Set - Open Wire (Figure 27)

The combination set, Figure 27, is designed so that it may be used at an intermediate station or as a terminal set. If it is required in terminal service, provision must be made through a key or jack for connecting a total of 6 M.F. between each leg and ground in conformity with Figure 25. However, when the set is used in intermediate service merely to couple one line to another, only a 1 M.F. condenser is connected between each leg and ground. The one microfarad condenser is permanently inserted as shown in Figure 27.

7.2 Cable Composite Sets (Figures 29, 30)

These resemble the open wire sets in principle, but because of interference being more readily established between adjacent ground-return polar duplex telegraph circuits, it is usually necessary to extend the telegraph circuits metalically through the cable when the run is of considerable length.

7.21 Cable Terminal Sets (Figure 29)

Figure 29 shows a terminal set which is somewhat simpler than that for open wire; however only one polar duplex telegraph circuit can be connected to the two legs. The set employs but one retardation coil and a 4 M.F. capacitance between each leg and ground.

Besides its use at terminal locations of superimposed metallic telegraph circuits, this set is employed at junctions where telegraph repeaters are employed.

7.22 Cable Intermediate Sets (Figure 30)

Figure 30 shows an intermediate set which is very similar to the cable terminal set except only 2 M.F. capacitance to ground is connected to each telegraph leg. This type of set is employed to

connect from one composited telegraph line to another when there is no telegraphic apparatus at the junction to produce inductive surges.

7.3 Composite Sets for Dialing Purposes

This type of set, while similar to that of Section 7.1 in principle, is suitable only when the desired legs are to be used for dialing purposes. The composite set is shown in Figure 31 and is similar to Figure 25 in all respects except two: (1) only 2 M.F. is associated with each leg and (2) one small retardation coil is employed in place of each winding of the large coil. Hence a total of four coils per set is required.

7.4 Telegraph Efficiency

A composited circuit has a slightly higher loss than a simplex circuit because the composite circuit offers a higher line resistance. This disadvantage is somewhat offset by the greater effect of leakage to ground on a simplex circuit--especially in wet weather.

7.5 Current Limitations

Maximum telegraphic current superimposed upon the telephone line should be approximately 100

milliamperes in order that any loading coils on the line will not have their magnetic properties affected. Usual telegraph current should not be excessive; otherwise telephonic transmission will suffer. Current supply for the telegraph should be sufficiently free from variations that it will not induce noise on the telephone circuit.

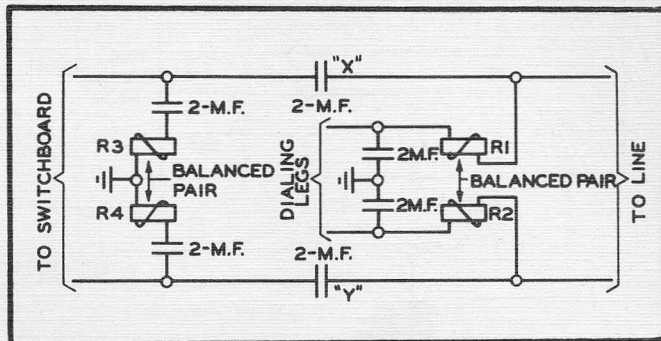


FIG. 31. COMPOSITE SET FOR DIALING LEGS ONLY.

7.6 Noise

In order that noise induced into the circuit may be kept to a minimum, the two sides of the line should be balanced as to leakage, resistance, capacitance, and inductance. Transpositions should be employed as required.

A THIRD METALLIC CIRCUIT FROM TWO METALLICS

8. PHANTOM CIRCUITS

It is possible to derive a third telephone circuit from two metallic ones. This derived circuit is called a phantom because no additional wires are required to carry it. At the same time the phantom is derived, the two physical circuits usually called side circuits may be composited in the manner described in Section 7, thus obtaining four signal circuits.

Figure 32 shows two physical circuits, each ending in a repeating coil, the windings of which are perfectly balanced. One side of the phantom circuit is connected to the midpoint of the line winding of the repeating coil (upper left) associated with line #1, while the other side of the phantom is connected to the midpoint of the corresponding winding of the repeating coil (lower left) associated with line #2. Thus both wires of line #1 serve together as one conductor of a third circuit. Since the current from the third circuit divides at the midpoint of the repeating coil line-winding and flows in equal amounts in opposite directions, nothing is induced in the switchboard side of the repeating coil. Thus, the total induced magnetic flux cancels out. The return path through the two conductors of line #2 is similar. Furthermore, if circuit requirements make it desirable, a third pair of repeating coils may be employed to

insulate the switchboard sides of the phantom from the phantom itself; i.e., from the actual conductors. Compare Figure 33 with 32.

A condenser (Figure 33) at the midpoint of the switchboard windings may be used to break the continuity of that part if it is desired to do so. This is necessary on cord circuits having direct current supervision. The characteristic impedance of the phantom is lower than that of the side circuits. Hence, uneven ratio repeating coils may be used to advantage. See Section 10.

8.1 Simplex Phantom (Figure 34)

To secure one dial or signal leg, it is possible to simplex a phantom as shown in Figure 34. Note that all four lines are in parallel when this circuit is used. Since the current flows in the same direction in equal quantities on all conductors, no interference with the regular circuits is caused if everything is balanced, but the very fact that there are four conductors in parallel must be kept in mind as it gives a high capacity on cable circuits and an excessive leakage on open wire. The principle of compositing discussed in Section 7 is the usual means of obtaining dial or signal legs from phantom groups.

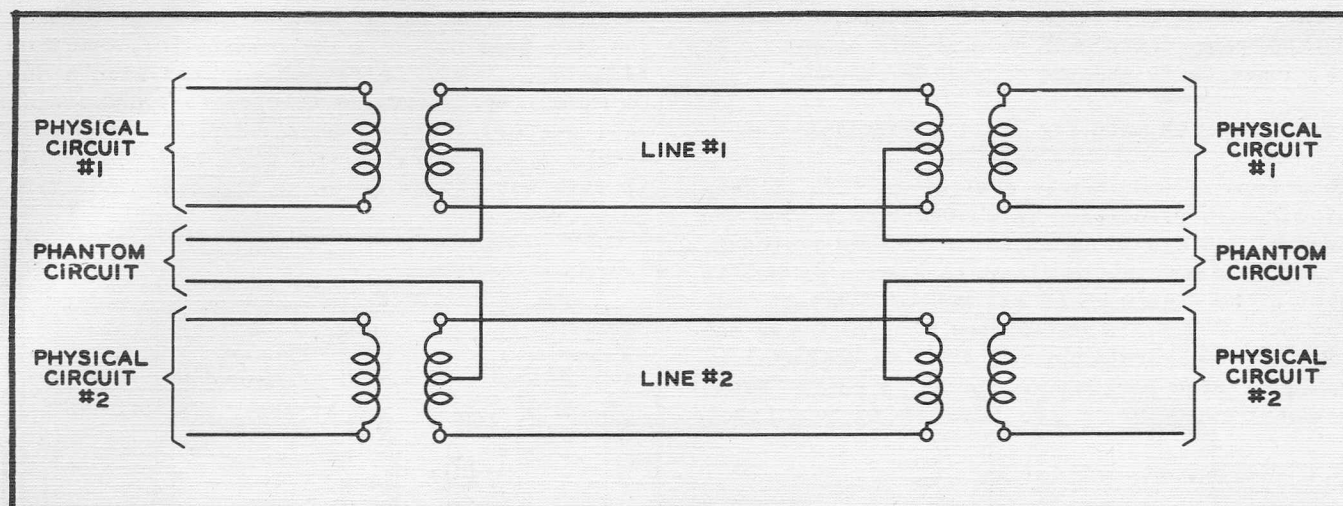


FIG. 32. PHANTOM TELEPHONE CIRCUIT DERIVED FROM TWO METALLIC PAIRS.

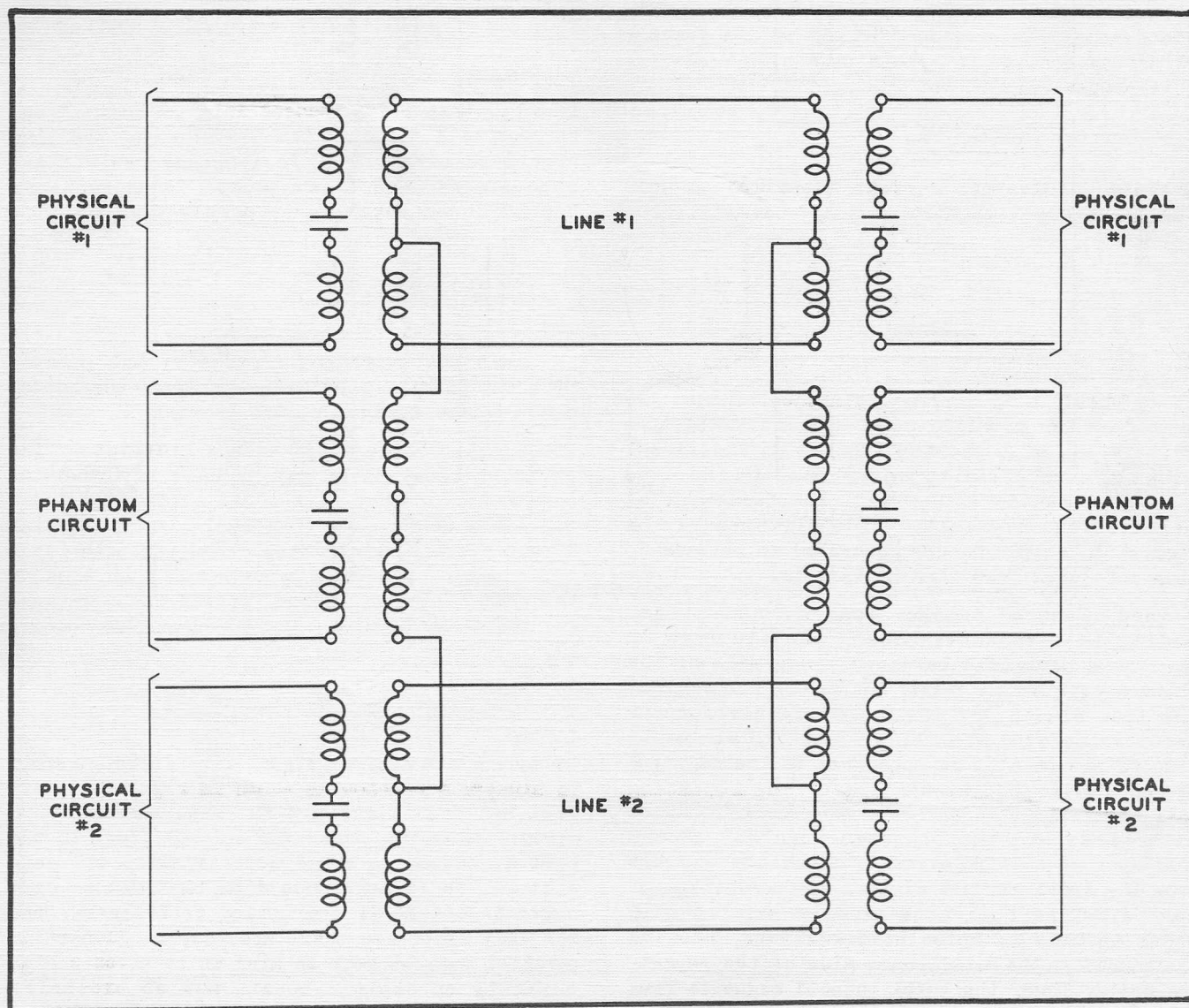


FIG. 33. PHANTOM CIRCUIT WITH REPEATING COILS TO INSULATE THE SWITCHBOARD SIDES OF THE PHANTOM FROM THE CONDUCTORS.

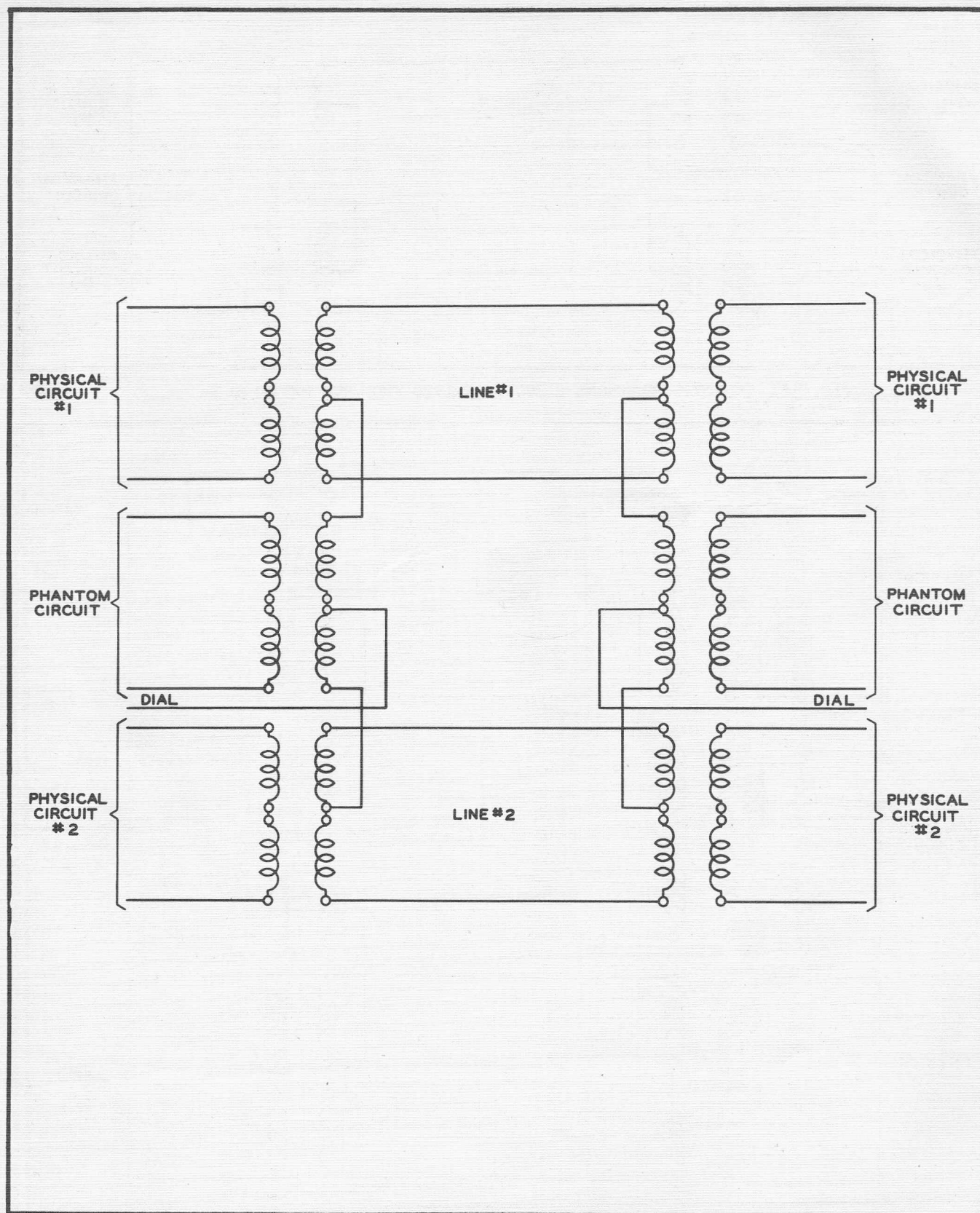


FIG. 34. SIMPLEXED PHANTOM. ONE DIAL OR SIGNAL LEG HAS BEEN SECURED BY USING ALL FOUR LINES IN PARALLEL WITH A GROUND RETURN FOR THE SIMPLEX CIRCUIT.

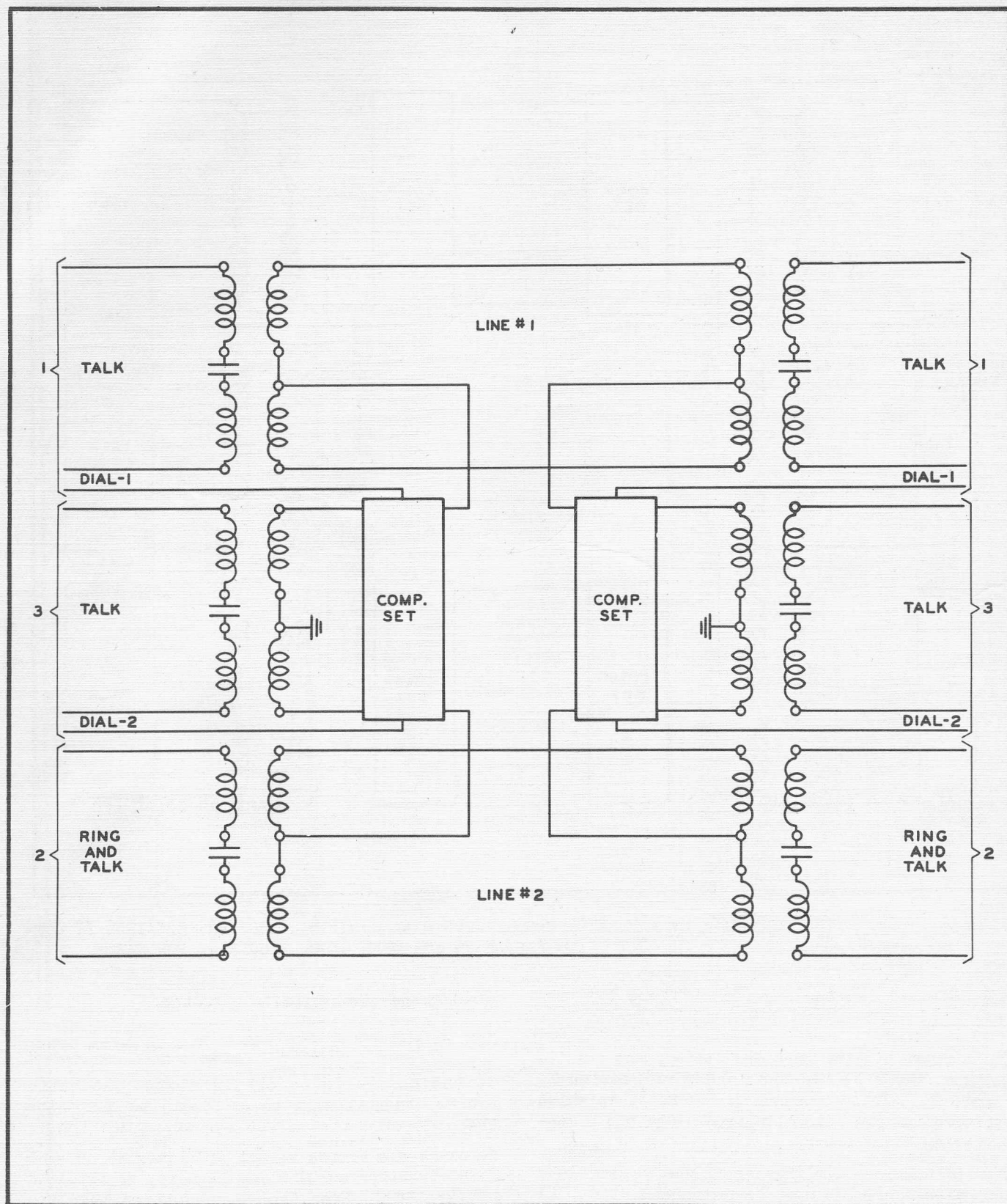


FIG. 35. COMPOSITED PHANTOM. TWO DIAL OR SIGNAL LEGS ARE OBTAINED BY COMPOSITING THE PHANTOM CIRCUIT USING FIGURE 25 FOR OPEN WIRE, FIGURE 29 FOR CABLE.

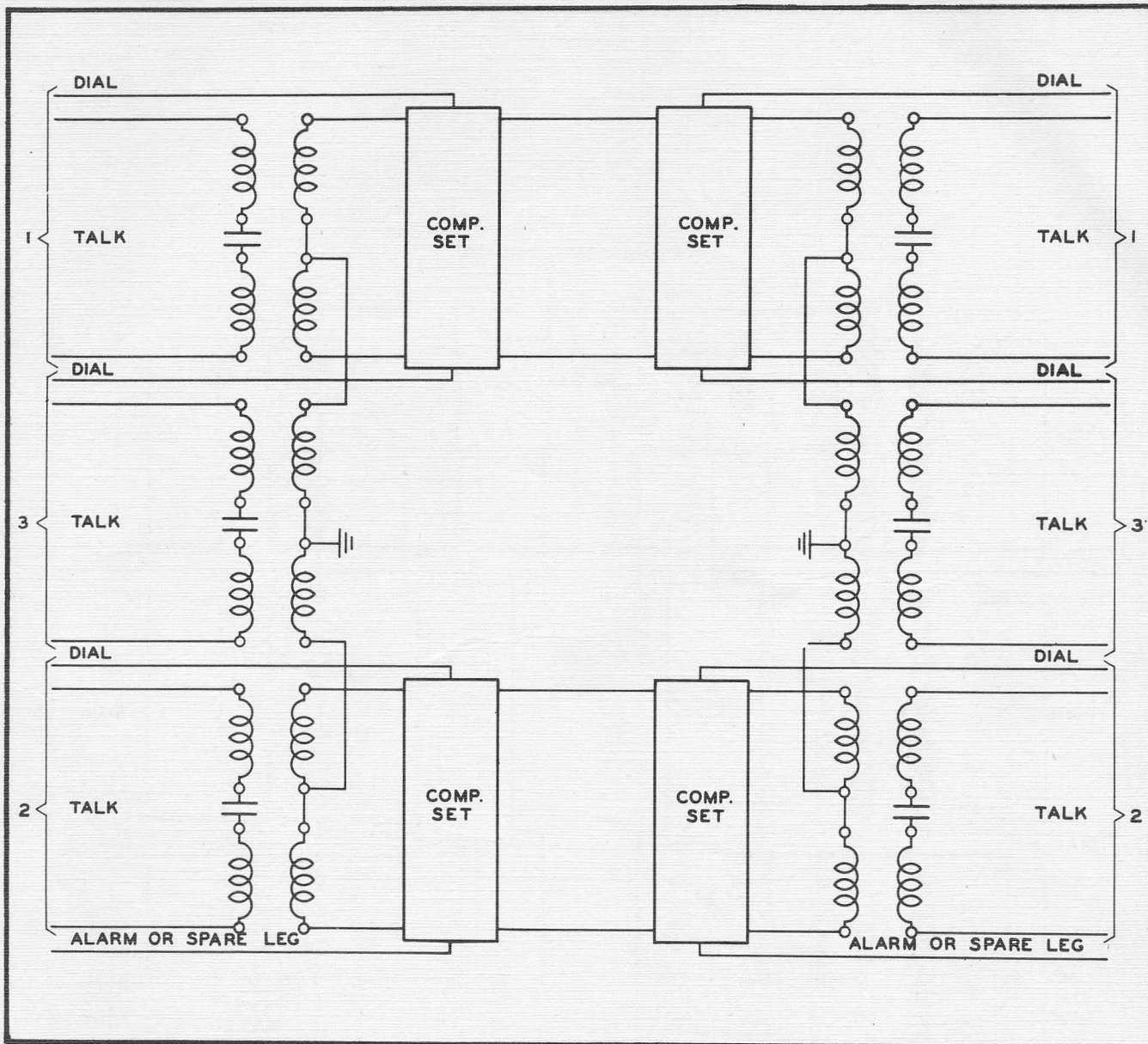


FIG. 36. COMPOSITED PHYSICALS OF A PHANTOM GROUP. FOUR DIAL OR SIGNAL LEGS ARE OBTAINED BY COMPOSITING THE PHANTOM CIRCUIT USING FIGURE 25 FOR OPEN WIRE, FIGURE 29 FOR CABLE.

8.2 Compositing the Phantom (Figure 35)

If only two dialing legs are needed, the phantom may be composited in the manner of Section 7, Figure 25. This is shown in Figure 35 in which two circuits are automatic trunks and one a manual (ring-down) trunk.

Even if only one dialing leg is needed, complete composite equipment must be provided in order to maintain circuit balance. The operation of a composited phantom is not so satisfactory as that of composited side circuits because the composited phantom is subject to the limitations of both the

phantom and the composite circuits.

8.3 Compositing Physicals of a Phantom Group

If the desire is to obtain three automatic trunks, then it will be necessary to composite the side circuits in the manner of Section 7.

By using the composite set of Figure 25 on each side circuit, four dialing legs may be obtained (Figure 36). Even though only three legs are required, it is necessary that all four be equipped in order that line balance may be maintained. The fourth leg may be used as an alarm circuit.

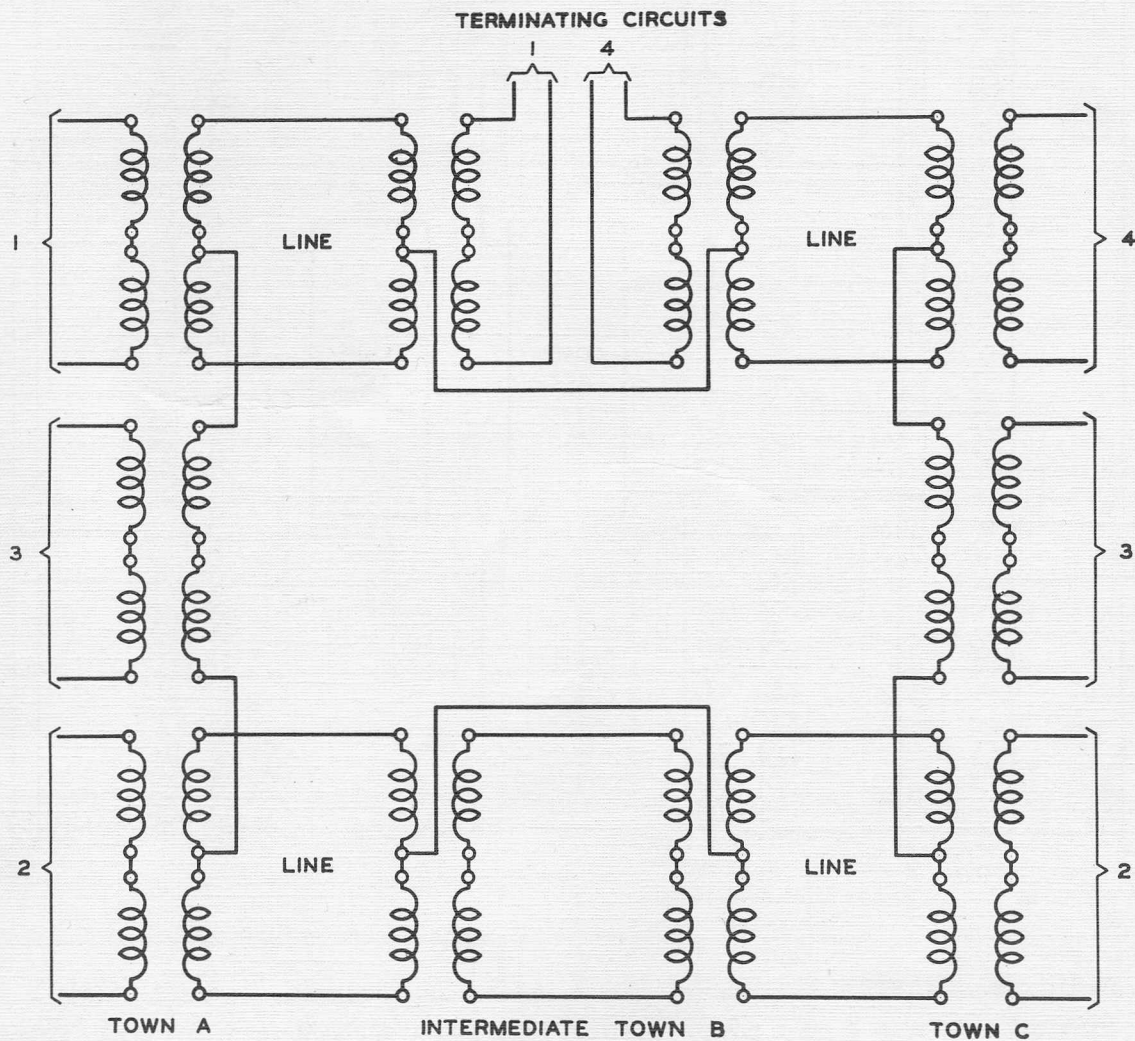


FIG. 37. INTERMEDIATE STATION ON A PHYSICAL CIRCUIT. LINE 1 IS A LOCAL CIRCUIT FROM TOWN A TO INTERMEDIATE TOWN B. LINE 4 IS A LOCAL CIRCUIT FROM INTERMEDIATE TOWN B TO TOWN C. PHANTOM 3 AND PHYSICAL 2 ARE THROUGH CIRCUITS, TOWN A TO TOWN C.

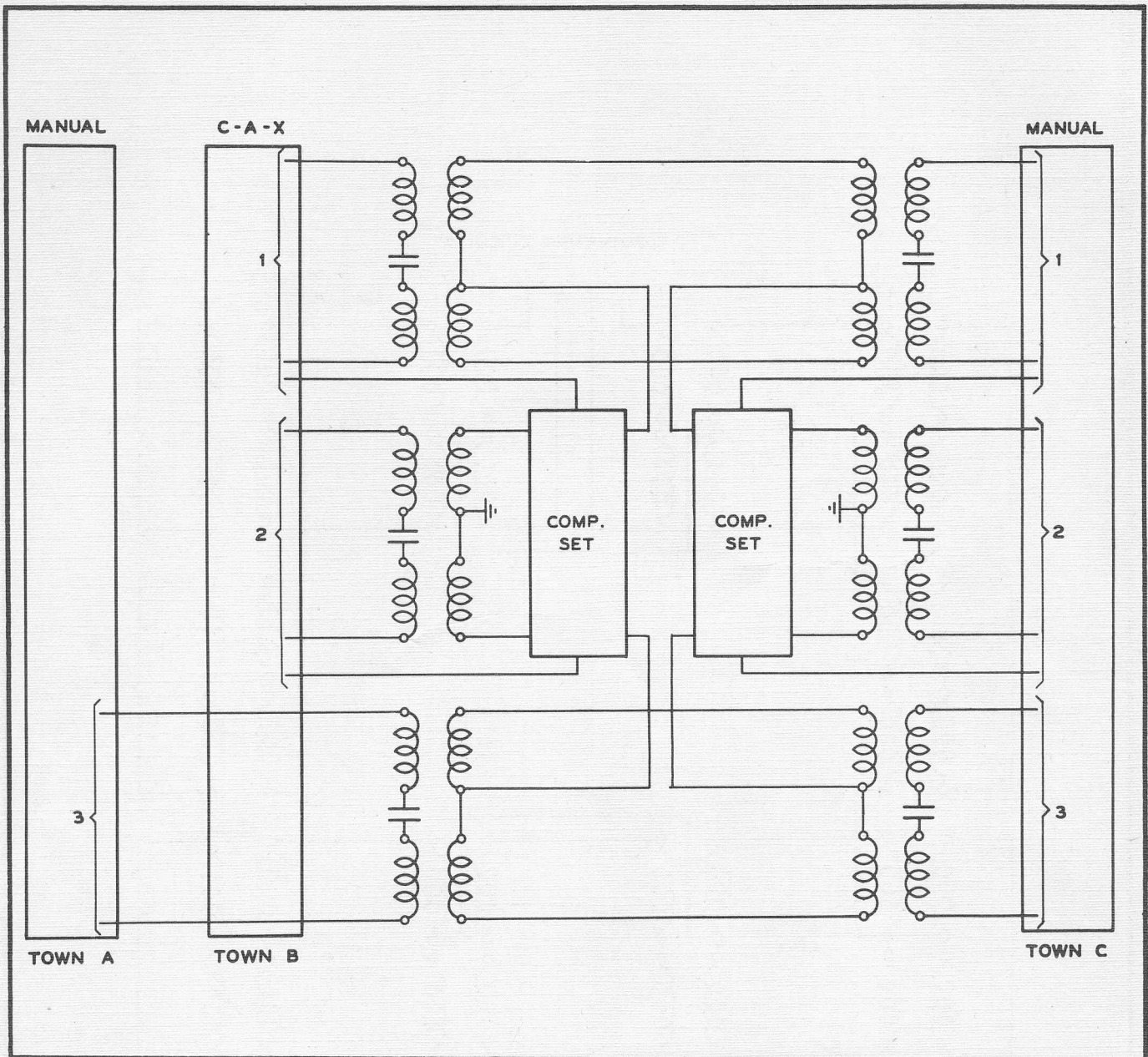


FIG. 38. INTERMEDIATE TOWN B ON A LOCAL PHYSICAL LINE AND A THROUGH PHYSICAL LINE. INTERMEDIATE TOWN B OBTAINS AN ADDITIONAL TELEPHONE CIRCUIT PLUS TWO DIALING OR SIGNALING LEGS BY ADDITION OF A PHANTOM AS SHOWN.

8.4 Intermediate Stations (Figures 37, 38, 39)

Where there is one through circuit from Town A to Town C (Figure 37) plus two local lines, one of which runs from A to the intermediate Town B and the other from B to C; a second through line, a phantom, can be obtained as shown. Two pairs of repeating coils are required at the intermediate Town B. One of the pairs is employed to separate the two local circuits from the top line which carries one side of the phantom. The lower pair of coils is introduced into the through metallic circuit in order to balance it with the top metallic. The phantom circuit is carried around the repeating coils by a jumper as shown.

The upper or local metallics can be easily converted to a through line.

A variation of this plan is shown in Figure 38. A through metallic circuit passes from Town A through B to Town C. Only one local circuit is present this time and it runs from intermediate Town B to C. Should Town B desire an additional circuit to C; this could be obtained by employing a phantom as shown in the figure. In this instance, B is a Community Automatic Exchange, requiring two dialing legs which are obtained by compositing the phantom. Repeating coils are required for this purpose.

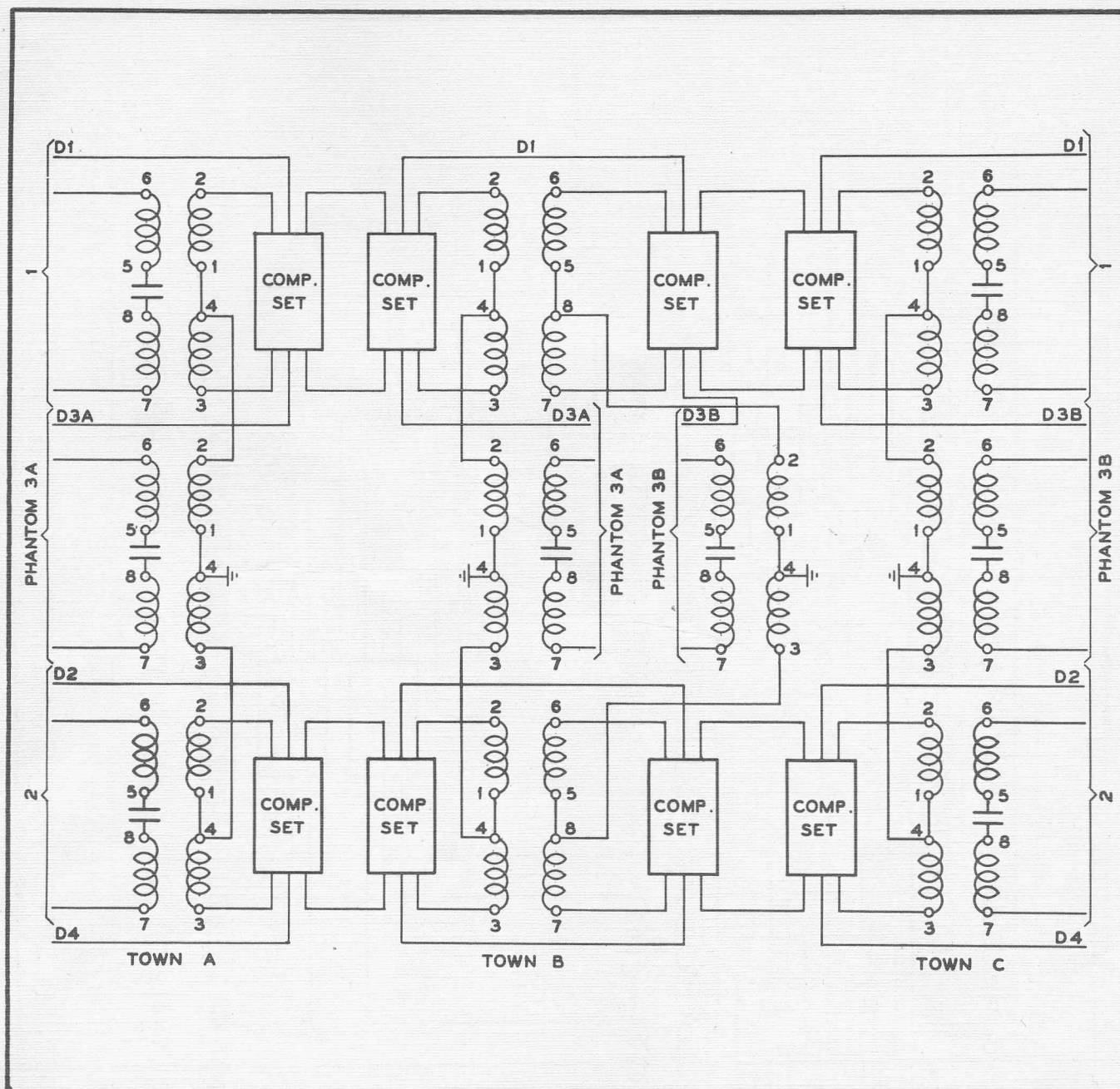


FIG. 39. INTERMEDIATE TOWN B ON TWO THROUGH PHYSICAL CIRCUITS UTILIZES PHANTOM 3A TO TOWN A AND PHANTOM 3B TO TOWN C.

A second variation places the intermediate town on the phantom as shown in Figure 39. Two repeating coils are employed in the side circuits at the intermediate station to separate the phantom. A terminal side of the phantom appears once from each direction, as shown in Figures 34, 3A and 3B. Two repeating coils are employed to couple these two phantoms to local circuits.

Sometimes it is desired to change at an intermediate point from composites on the side circuits to a composite on the phantom. This

change-over is shown in Figure 40. Three dialing legs are required from A to B, but only two dialing legs are needed from B to C. Therefore, for economy, the phantom has been composited from B to C. The phantom and side circuit #2 are through circuits from A to C. This particular side circuit has a repeating coil connected at B not only to balance it with #1 but to permit taking off the phantom so that this phantom could be composited. The short section of side circuit #1 from B to C is operated as a ring-down manual trunk and hence does not require a dial leg.

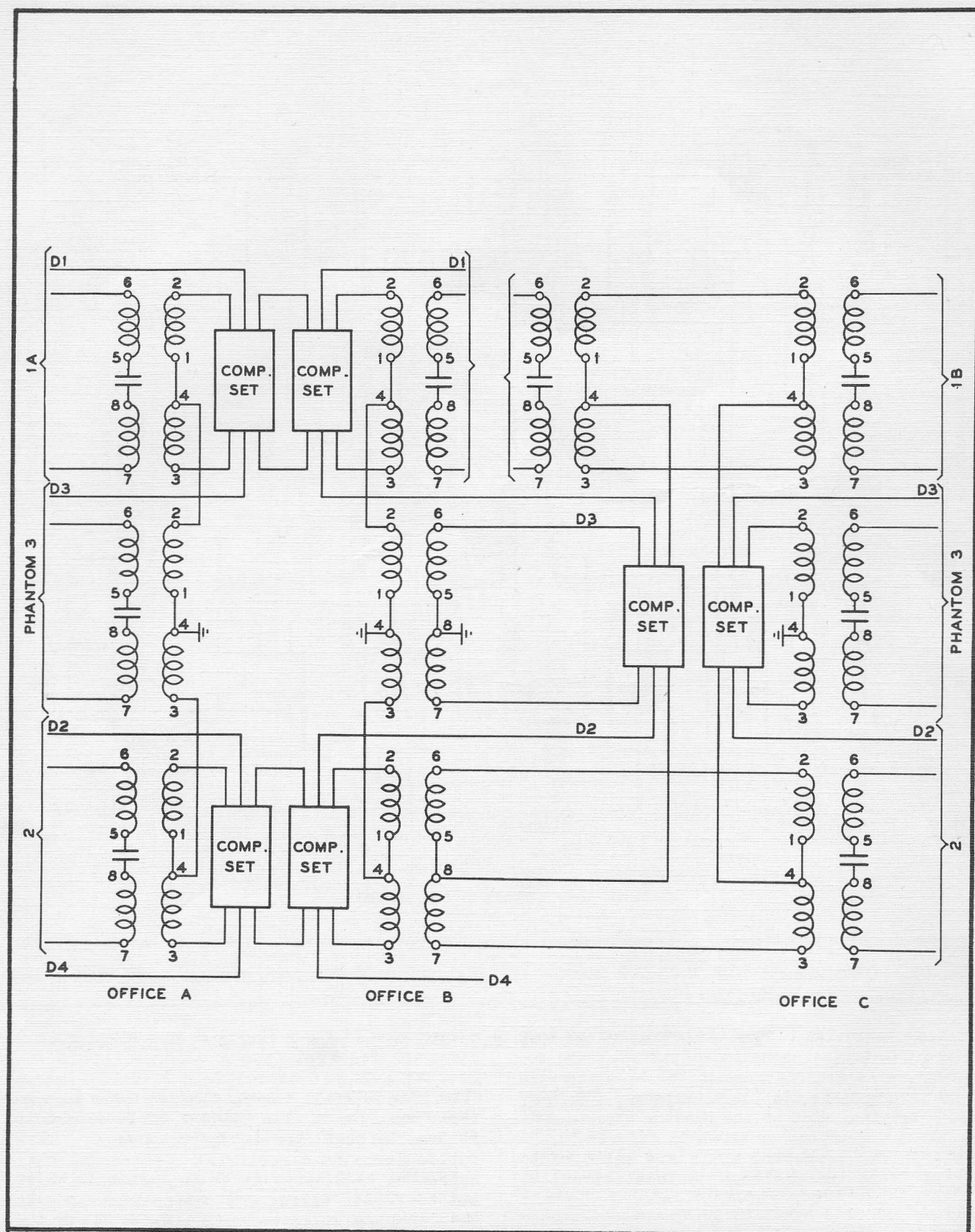


FIG. 40. COMPOSITES ON PHYSICAL CIRCUITS FROM A TO B, CHANGE TO COMPOSITES ON PHANTOM B TO C. THREE DIALING LEGS ARE REQUIRED FROM A TO B; ONLY TWO FROM B TO C.

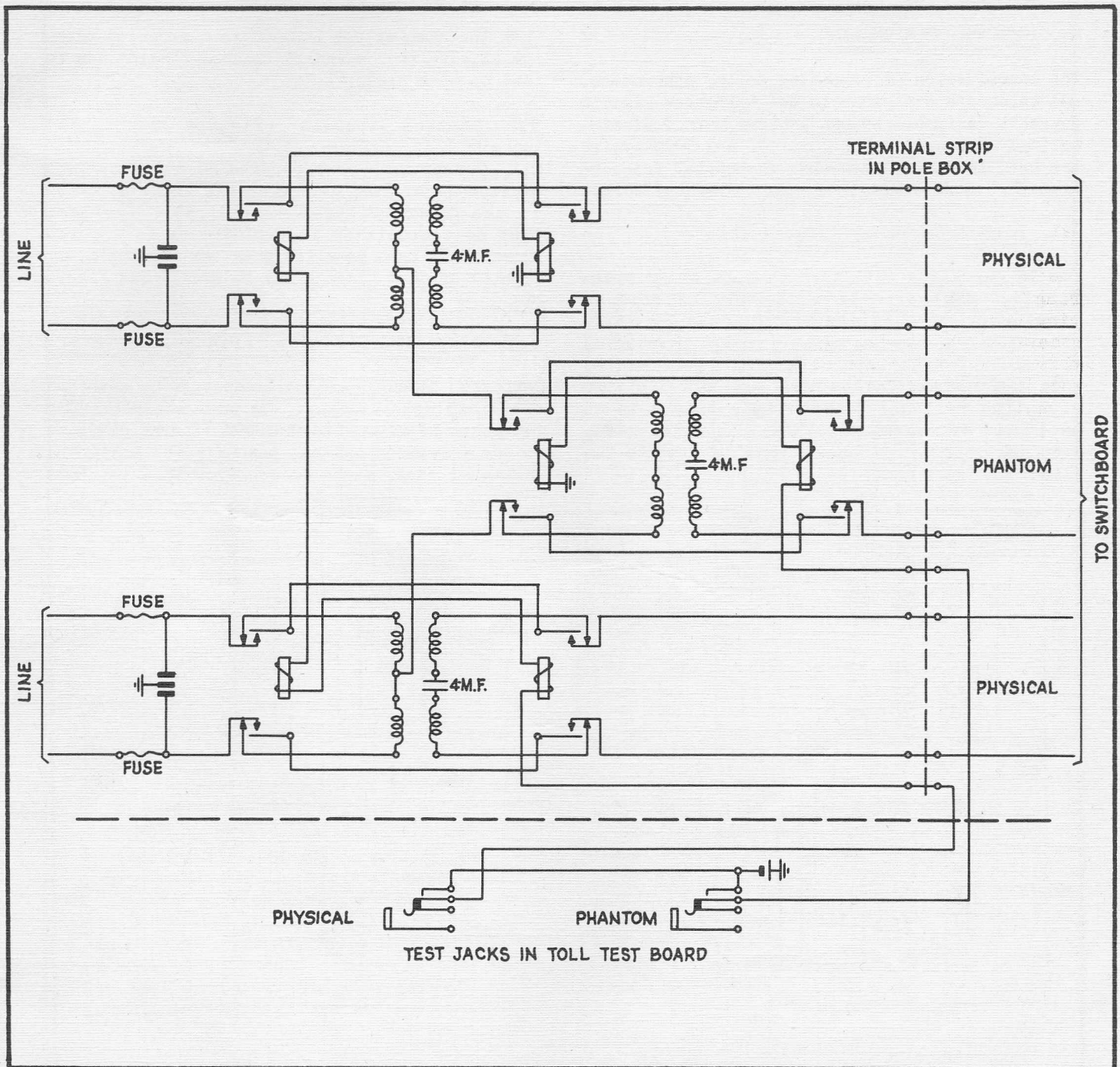


FIG. 41. CIRCUIT FOR CUTTING IN AND OUT REPEATING COILS FROM A DISTANT CONTROL POINT.

8.5 Pole Mounted Repeating Coils for Phantoms

Pole phantom is the name given to phantom equipment when it is located on a pole instead of within an office. The pole phantom enables phantom and side circuits to be brought into a town through non-quad cable by utilizing three pairs of wire--thus avoiding cross-talk. Other-

wise, when entering a town, quadded cable must be employed. Pairs from quadded cable should be tested and equalized for unbalances.

A typical circuit is shown in Figure 41 which incorporates relays in the phantom to enable the repeating coils to be cut in and out of the circuit. An extra pair of wires from the toll test board serves to accomplish this.

SIGNALING

9. METHODS OF SIGNALING

The introduction of repeating coils, condensers, and telegraph equipment in the telephone circuit makes it desirable to use another method of signaling. Frequencies of 20, 135, and 1000 cycles are used in various systems. The higher frequencies pass more readily through repeating coils.

9.1 Simplex Circuits (Figure 22)

The 1D repeating coil permits regular 20 cycle ringing current to be employed for bridged ringing. Only bridged ringing may be used; otherwise the ringing current would be shunted through the telegraph or signal instruments. When the simplex leg is used for toll dialing, signaling will not be involved, except in an automatic to manual direction; in which case, a splash of ringing current will be sent to the manual office.

When the simplex leg is used as a grounded phantom (Figure 22), standard bridged ringing can be used on both circuits.

9.2 Phantom Circuits (Figures 32, 33, 34)

The 1D repeating coil permits 20 cycle ringing current to be used on any or all three circuits in the group (Figures 32, 33, 34), provided that no compositing is employed as in Figures 35 and 36. When metallic phantoms are employed, regular bridged ringing may be used. See Figure 42.

9.3 Composite Circuits (Figures 23 to 31)

Composite circuits employ condensers to separate the lines metallically. On this account, more impedance is offered to standard ringing currents on the telephone systems than via the telegraph or signal legs, since 20 cycle current is close

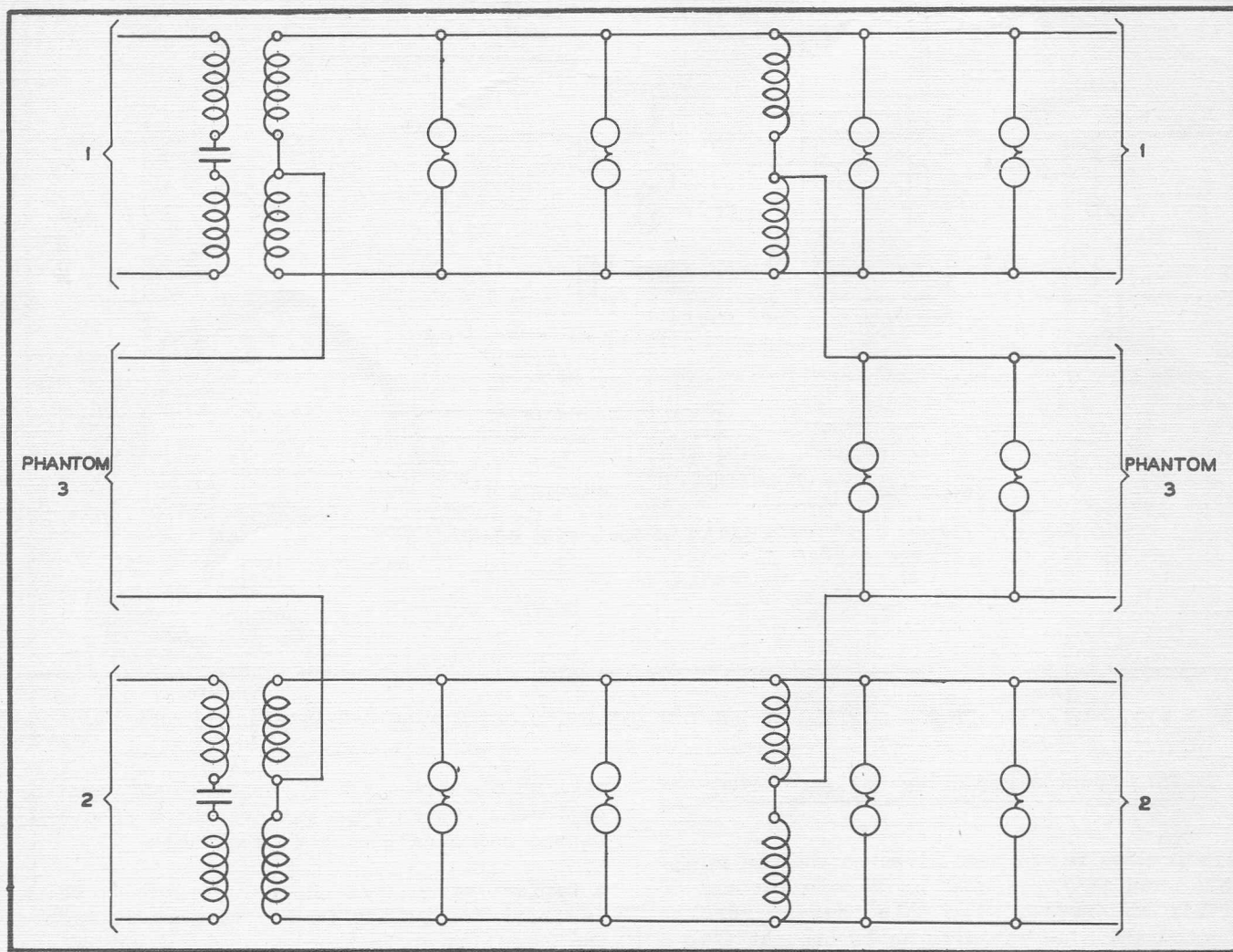


FIG. 42. PHANTOM WITH REGULAR RINGERS FOR RURAL APPLICATIONS. THE METALLIC PHANTOM MAY BE RUNG WITH REGULAR 20-CYCLE CURRENT.

to that of telegraphic impulses. But, if 135 cycle current is employed for ringing, no interference with the telegraph legs will occur. In fact, the impedance to current at this frequency is less in the telephone circuit than in the telegraphic.

The operation of composite ringers is as follows: the 20 cycle ringing current operates an A.C. relay which connects 135 cycle current to the line. At the distant end, a relay responding to 135 cycles pulls up and connects the 20 cycle current to the line in order to operate the telephone signaling apparatus at that end.

9.4 Types of Composite Ringers

Two types of composite ringers are available. Type A (D-857311) which consists of the necessary relays (Figure 43) and Type B (D-855617) which

includes a repeating coil (Figure 44). Thus, in general, the applicability of either depends on whether a repeating coil is needed in the circuit to which it is to be connected. The compositing of a circuit need not always require a repeating coil. Thus, in Figure 45, diagram B, phantom of diagram D, and phantom of diagram E do not necessarily require repeating coils; however, if the available legs are used for telegraph service in which a sensitive polar relay is employed, e.g., polar-duplex systems, a repeating coil will be required to minimize any spurts of 20 cycle current which might escape over the line before the A.C. and the switching relays associated with the ringer operate.

Summarizing then, the Type A composite ringer (without repeating coils, Figure 43) may be used on all composited telephone circuits on which simple telegraph or toll dialing circuits are

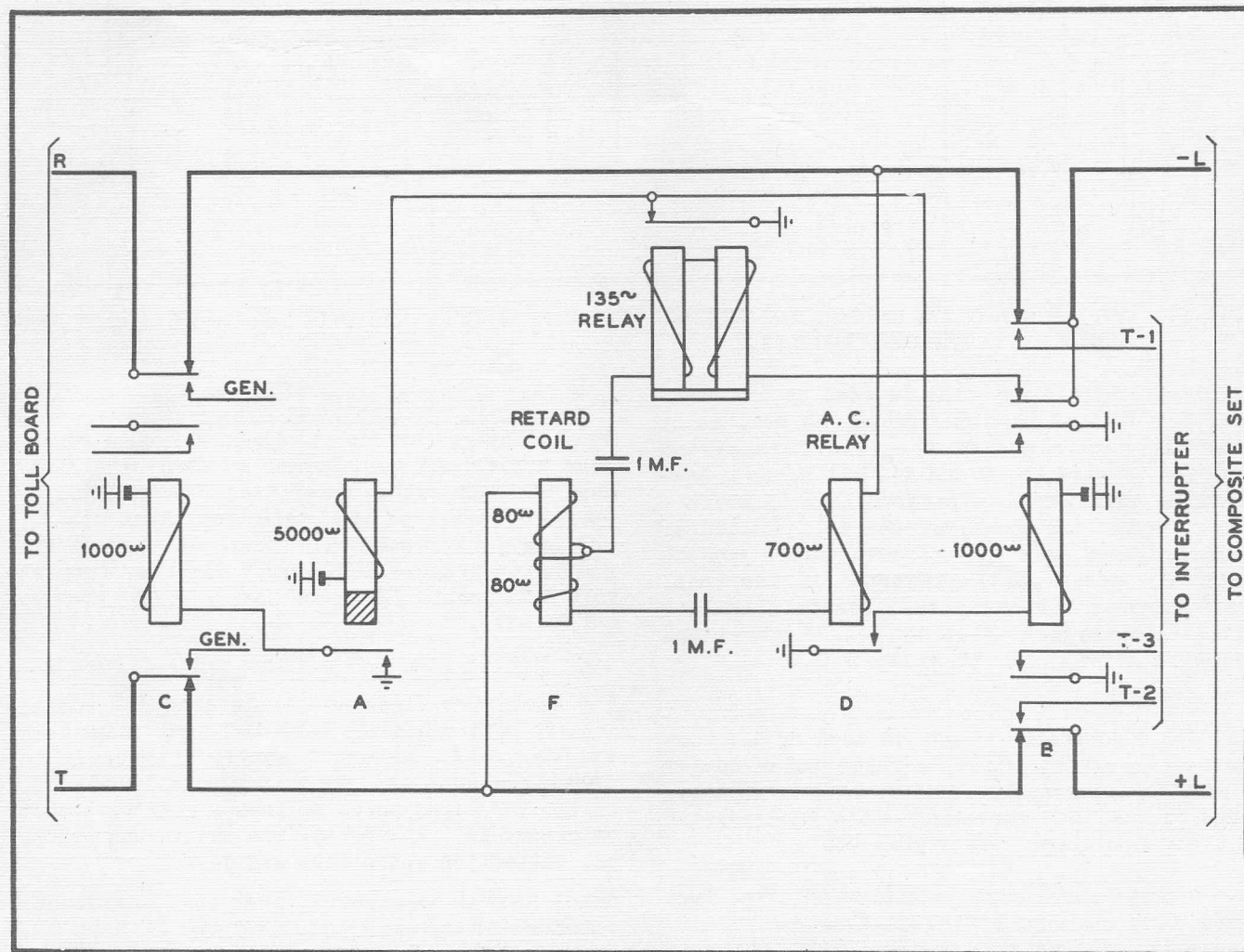


FIG. 43. TYPE A COMPOSITE RINGER, FOR RINGING OVER COMPOSITED LINES WITH 135-CYCLE CURRENT, 20-CYCLE BEING EMPLOYED LOCALLY.

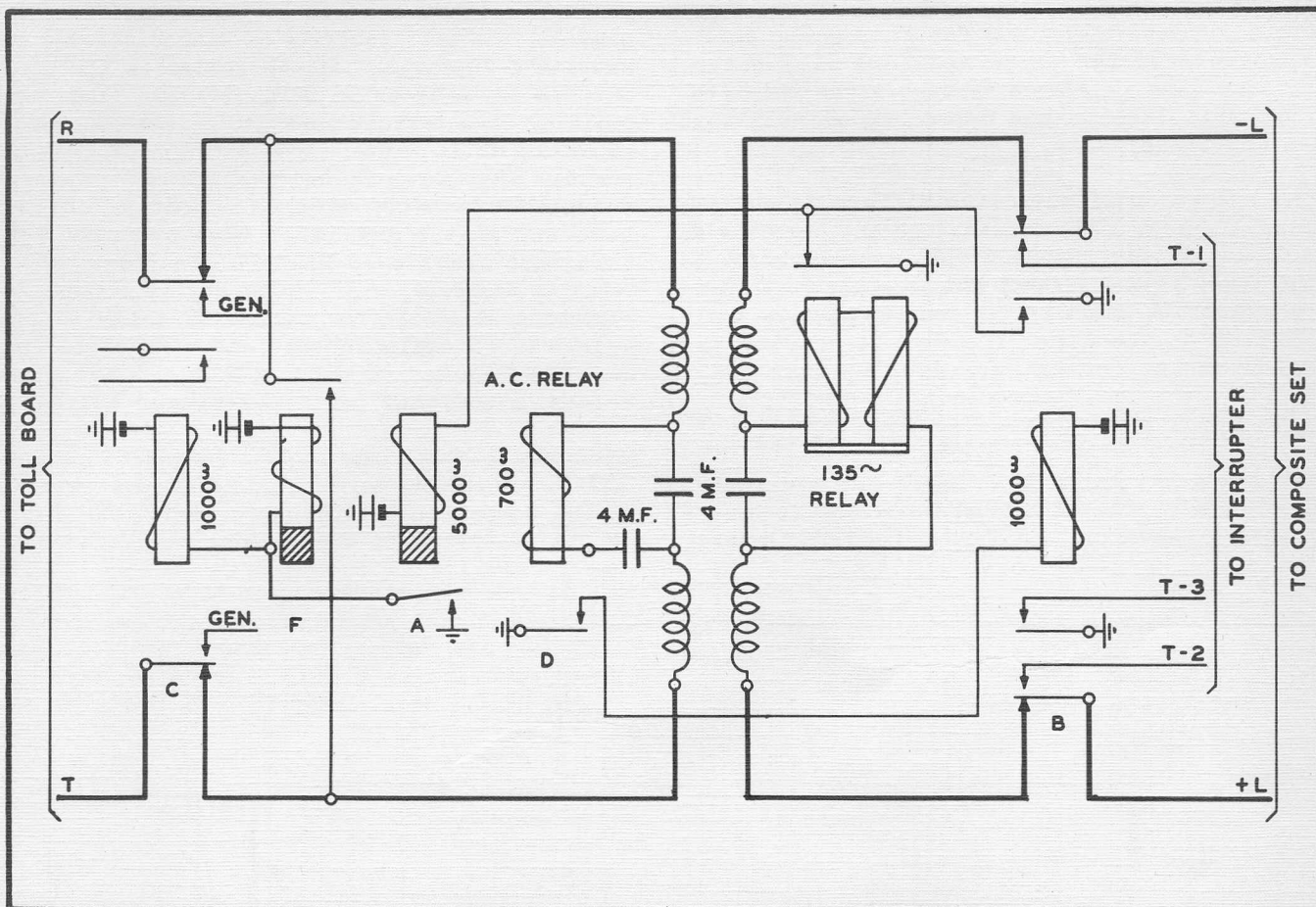


FIG. 44. TYPE B COMPOSITE RINGER, FOR RINGING OVER COMPOSITED LINES WITH 135-CYCLE CURRENT, 20-CYCLE BEING EMPLOYED LOCALLY.

employed. Type A may also be used on the physical circuits of phantom groups, as well as on simplex, regardless of the telegraph system employed (Figure 45, C and E). It cannot, however, be employed on a phantom line on which a polar duplex telegraph system is operated or on an ordinary telephone circuit unless repeating coils are properly inserted in the line. See Figure 45 for examples. The unit is jack mounted (7-13/16" high by 4-1/2" wide) and operates from 24 or 48 volts D.C.

The Type B composite ringer is used on all composited telephone lines on which polar duplex or complex telegraph systems operate--when these lines do not have repeating coils incorporated in their circuits. See Figure 44.

Type B is somewhat more sensitive than the Type A and is also more efficient from the transmission viewpoint than A, when the latter is used with a separate repeating coil. The unit is jack mounting 11" high by 4-1/2" wide and operates on 48 volts D.C.

9.5 Composite Ringing Interrupter

The 135 cycle current is obtained from a tuned-reed buzzer and transformer mounted on a standard Strowger switch baseplate. The interrupter operates only when 135 cycle current is needed, and one interrupter will serve as many as six composite ringers. D-855493 operates from 48 volt D.C. and is jack mounting, 7-13/16" high by 4-1/2" wide.

10. USE OF ODD RATIO COILS (See Figure 10)

The open wire lines and cable circuits coming into an office usually have different characteristics. When interconnecting lines, it is desirable that the characteristic impedances of the two lines match so that a maximum amount of energy is transferred from one to the other, and reflection losses are avoided.

Since most subscribers' lines have impedances somewhere in the neighborhood of 600 to 700 ohms, it is customary to call this the office standard and bring toll lines to this standard by the use of either a 1:1 or 1:1.69 or 1:2.69 repeating coil.

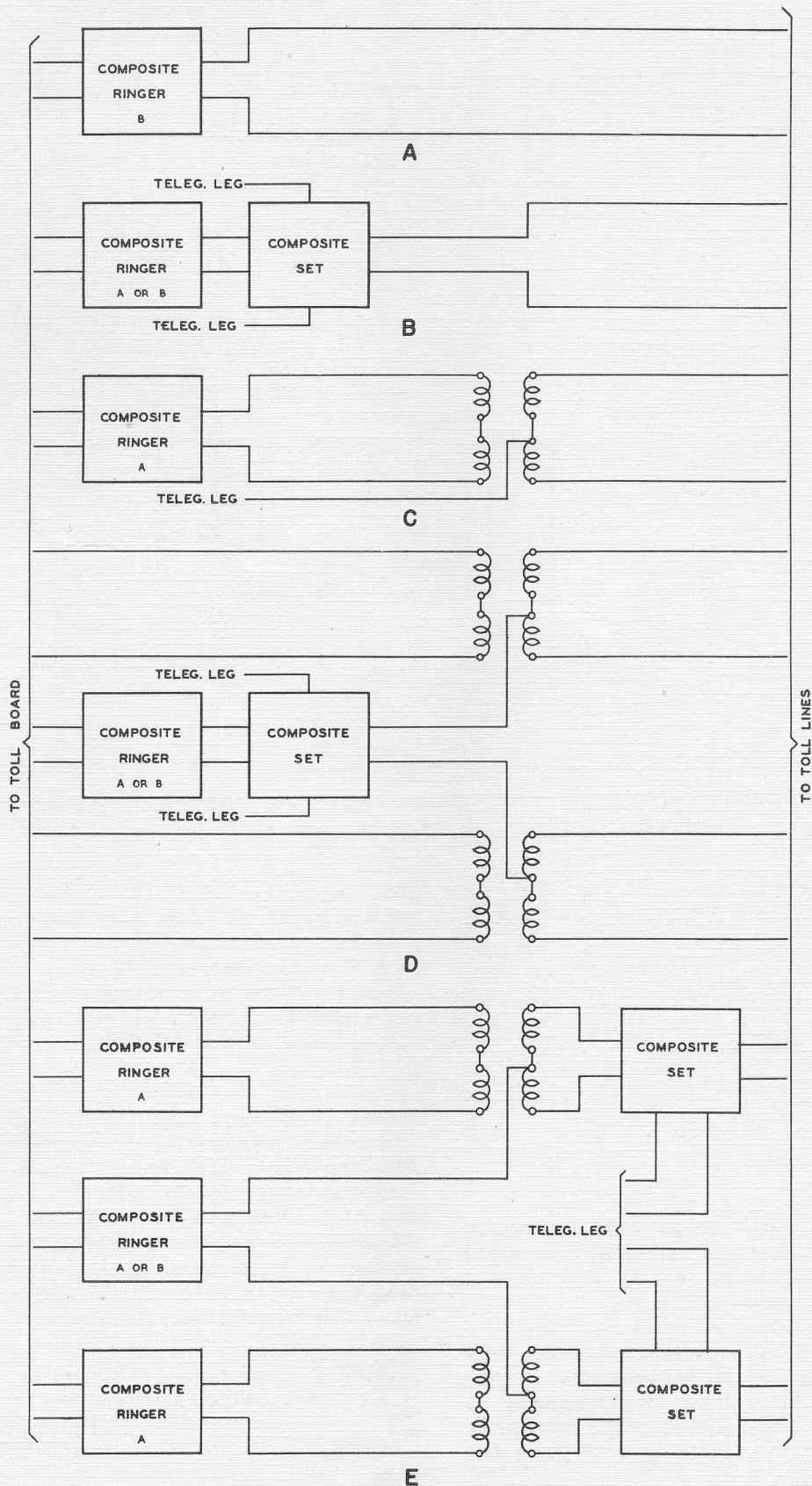


FIG. 45. VARIOUS APPLICATIONS OF COMPOSITE APPARATUS.

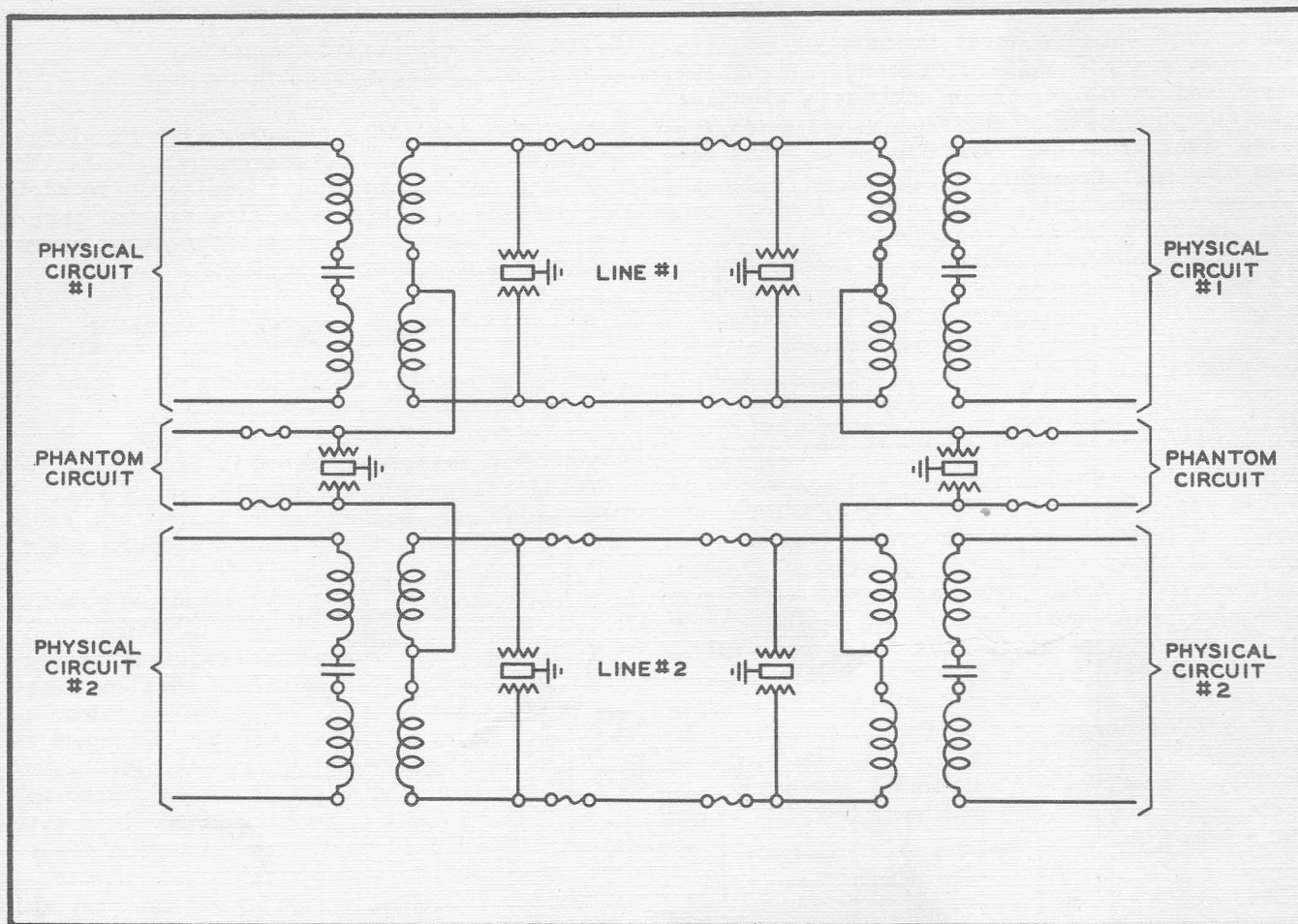


FIG. 46. APPLICATION OF FUSES AND PROTECTORS.

In practice, it is always easy to calculate the required impedance ratio by taking the line impedance and the office standard (600 ohms), and dividing the larger by the smaller. Thus, $1100 \div 700 = 1.57$; therefore, the impedance ratio is 1:1.57. Nearest ratio coil supplied is 1:1.69 which would be used. Many engineers would prefer to use a 1:1 coil up to ratios of 600 to 1000 ohms and accept the losses. The high side of the coil would then be connected to the line of highest impedance.

11. PROTECTION

Repeating coils should be protected against lightning and high tension current by the use of suitable protectors placed on the line side of the coil. Fuses, as an additional protection against stray currents, are placed in the line on the line side of the discharge blocks. See Figure 46. At the exchange, repeating coils will be suitably protected if they are connected to the office side of the regular protectors.

For maximum protection, protectors are used on both the office and the line side of each re-

peating coil. Fuses are placed on the sides of the protectors away from the repeating coil.

Where a grounded line is coupled to a metallic line by means of a repeating coil, protectors are placed on each side of the coil and the lines fused on the line sides of the protectors.

In addition to carbon blocks, heat coils, and fuses to protect against abnormal voltages and currents, steps are often taken to prevent acoustic shock caused by lightning, fallen high tension wires, or induction from a transient. Acoustic shock is merely the name applied to the "bat" given by a receiver when subjected to a sudden high current. A resistor which permits the flow of high currents but not of low may be bridged across the line or across the operator's headset. A heavy surge of current is diverted from the receiver into this special resistance. Another arrangement employs a neon tube placed in the secondary of a transformer bridged across the line. On voltage peaks above a given value, the tube will discharge and thus prevent the full current reaching the headset.

12. MOUNTING OF EQUIPMENT

There are three general methods of mounting phantom and composite equipment. The first, employed in M.A.X. (main automatic exchange) practice, consists of shelves mounted on double-sided rack mounting. Note Figure 48. The second used most frequently in C.A.X.'s (community automatic exchanges), also is of the shelf type but planned to go with the sectional type equipment supplied such exchanges. A shelf is shown in Figure 49. The third, usually supplied most often to manual telephone exchanges, railroads, and similar companies, is relay rack mounting. See Figure 50.

12.1 M.A.X. Rack Mounting (Figure 47)

Capacity - the 9'-0" board (H-45296-1) accommodates seven shelves per side while the 11'-8" board (H-45296-2) holds nine shelves per side. Figure 47 shows a typical arrangement of shelves on the 9'-0" board. Composite sets each consisting of three switch bases mounted three to a shelf making a total of nine bases per shelf. The third shelf from the bottom of the figure holds repeating coils for phantom circuits. These mount three to a switch base with nine bases per shelf. The bottom two shelves are devoted to composite ringers and interrupters. These mount six switches per shelf leaving space for a fuse panel.

Frames

H-45296-1 - Double-Sided Trunk Board, Seven Shelves per Side; Height, 9'-0";
H-45296-2 - Double-Sided Trunk Board, Nine Shelves per Side; Height 11'-8"

Shelves - Phantom Set (Repeating Coil)

D-240730-A-Left Side Mounting
D-240730-B-Right Side Mounting

Note: Shelves are wired for both two and three repeating coils per base; i.e., per two physical lines. Bayonet pins are located on selector-switch centers.

Shelves - Open Wire Composite Sets

D-240730-C-Left-Side Mounting
D-240730-D-Right Side Mounting

Note: Three sets per shelf each consisting of two retardation coils and one condenser pack may be mounted per shelf.

Shelves - Cable Composite Sets

D-240730-J-Left Side Mounting
D-240730-K-Right Side Mounting

Note: Six composite sets each consisting of one retardation coil and 1/2 of a condenser pack may be mounted per shelf.

Shelves - Composite Ringers

D-240730-E - Left Side Mounting
D-240730-F - Right Side Mounting

Note: Six composite ringers, with or without repeating coils, may be mounted per shelf. Not over six composite ringers can be operated in conjunction with one composite ringing interrupter. A fuse panel containing seven alarm-type fuses mounts on each shelf.

Shelves - Composite Ringing Interrupter

D-240730-G - Left Side Mounting
D-240730-H - Right Side Mounting

Note: Six interrupters, with or without repeating coils, may be mounted per shelf. A fuse panel, containing seven alarm-type fuses for the battery supply, mounts on each shelf.

12.2 Sectional -- C-A-X Equipment (Figure 48)

Phantom and Composite equipment (dialing legs only) for C-A-X installations of sectional type may be mounted on a shelf of 11 switch capacity. The shelf is approximately 5'-11" long and is equipped with a terminal strip for terminating the wiring from the shelf jacks. It also includes a fuse panel containing seven alarm type fuses, a test jack unit, and provision for an additional terminal strip which may be specified if desired. Jumpering facilities are provided between the shelf-jack terminal strip and the test jack terminal strip. A typical arrangement is shown in Figure 48.

Sectional Type Shelf - 5'-11" long.

D-240148-A - Without Test Jacks

Note: This shelf is used either when the two physical side circuits or the phantom is to be composited.

D-240148-B - With Test Jacks

Note: This is arranged for compositing the two physical side circuits.

D-240148-C - With Test Jacks

Note: This is arranged for compositing the phantom circuit.

The shelf has the eleven base-plate positions wired as follows:

- For connecting trunk repeaters;
- For phantom set (three coils);
- For composite set #1 consisting of two large retardation coils and one condenser pack;
- For composite set #2 (required only when the two physical circuits are composited);
- Spare

REPEATING COILS AND THEIR USES

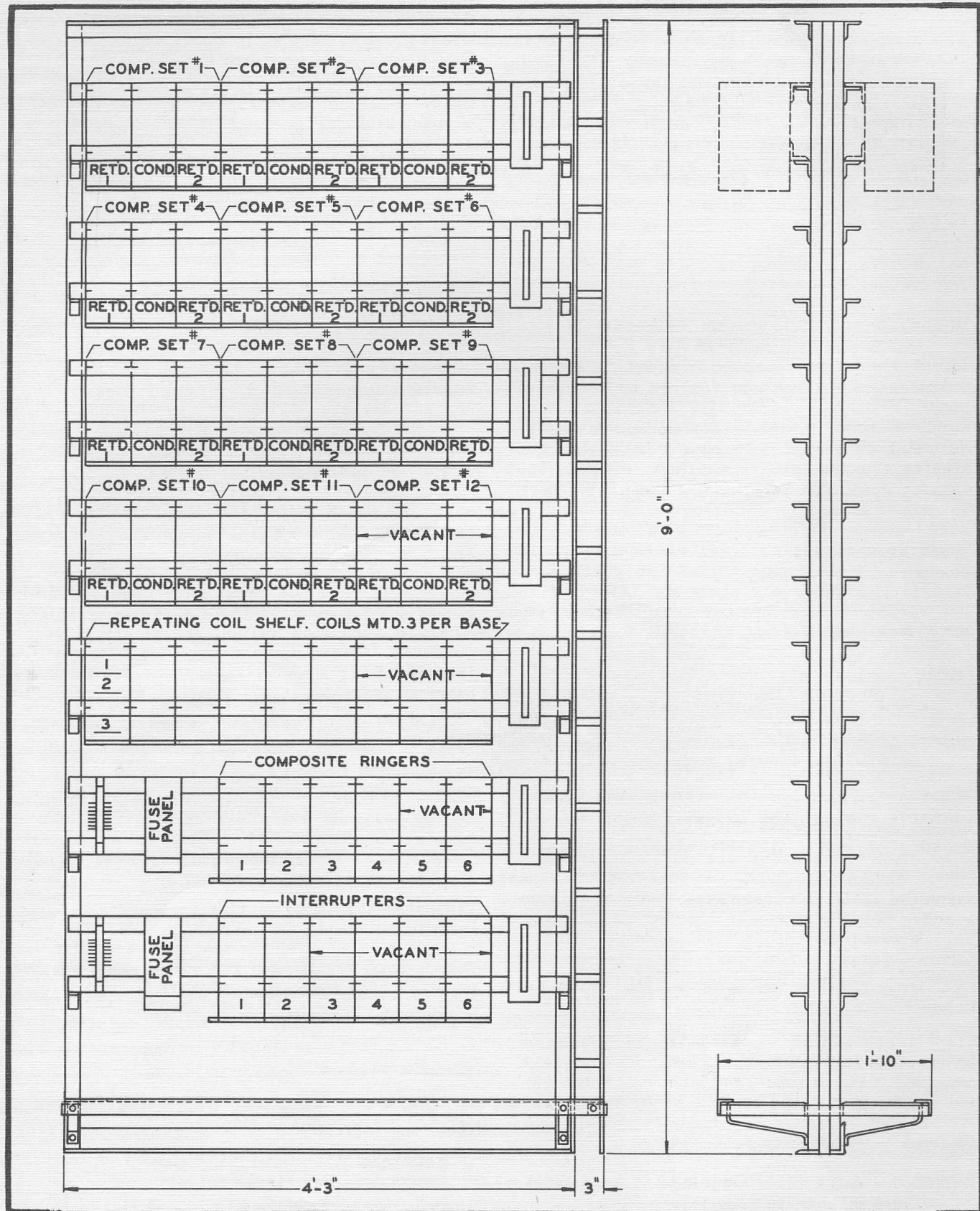


FIG. 47. MAIN-AUTOMATIC-EXCHANGE RACK MOUNTING SHOWING SHELVES, LEFT AND UPRIGHT, RIGHT.

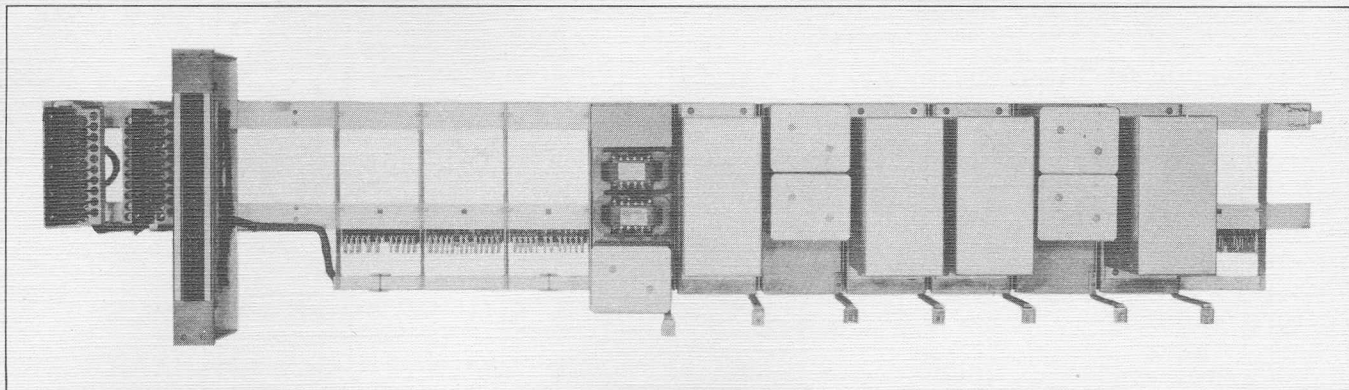


FIG. 46. COMMUNITY-AUTOMATIC-EXCHANGE SECTIONAL-TYPE EQUIPMENT. THE SHELF SHOWN IS 5' 11" LONG, HOLDS 11 JACKED IN BASE PLATES.

12.3 Relay Rack Mounting (Figure 49)

The shelves for mounting phantom and composite equipment on relay racks are of three-switch capacity equipped with a terminal strip at the right-hand end for terminating the wiring from the shelf jacks.

In addition to the standard racks below, the shelves will mount on standard railroad rack ARA-1A which holds six shelves.

Relay Rack (Angle-Steel Construction)

H-46590 - Accommodates seven shelves and a fuse panel or eight shelves. Width, 1'-7-1/2"; Height, 9'-0"; Depth 1'-0".

H-46591 - Accommodates ten shelves and a fuse panel. Width, 1'-7-1/2"; Height, 11'-8"; Depth 1'-0".

Shelves - Phantom Set (Repeating Coils)

D-240720-A - Coils for six physical lines

Note: The shelf is wired for both two and three repeating coils per base.

Shelves - Composite Set

D-240720-E - For either open wire or cable sets

Note: A shelf will accommodate one open wire set (two large-type retardation coils and one condenser pack) or two cable sets (two large-type retardation coils and one condenser pack).

Shelves - Composite Ringer

D-240720-G - Holds three composite ringers (with or without repeating coils)

Note: Not more than six ringers can be operated in conjunction with one composite ringer interrupter.

Shelves - Composite Ringing Interrupter

D-240720-J - Mounts three interrupters (with or without repeating coils)

Note: One interrupter may be used with six or less ringers.

Fuse Panel

H-45874-2 - Capacity 20 alarm-type fuses

Note: This panel is ordinarily required when composite ringers and interrupters are provided, and it is mounted at the top of the rack.

Test-Jack Shelf

H-46672 - Four 10-per-strip jacks and three designation strips for testing and patching two physical and one phantom circuits.

Note: This unit occupies the same space as a composite ringer shelf and is equipped with a terminal strip at the right-hand end in a similar manner. It is ordinarily mounted at the bottom of the rack.

Relay-structure type composite sets are ordered special.

12.4 Piece Numbers

Repeating Coil on Base for Mounting on Switch Shelves.

Piece No.	Base D-47	Coil	Ratio
D-856547-A	Conn. 667	1D	1:1
D-856789-A	Rept. 666	1D	1:1

Two-Coil Sets for Mounting on Switch Shelves

Piece No.	Base D-47	Coil	Ratio
D-856369-A	Sp. Rept. 731	1D	1:1
D-856491-A	Sel. 731	1B	1:1.69
D-856492-A	Sel. 459-A 731	1C	1:2.69

REPEATING COILS AND THEIR USES

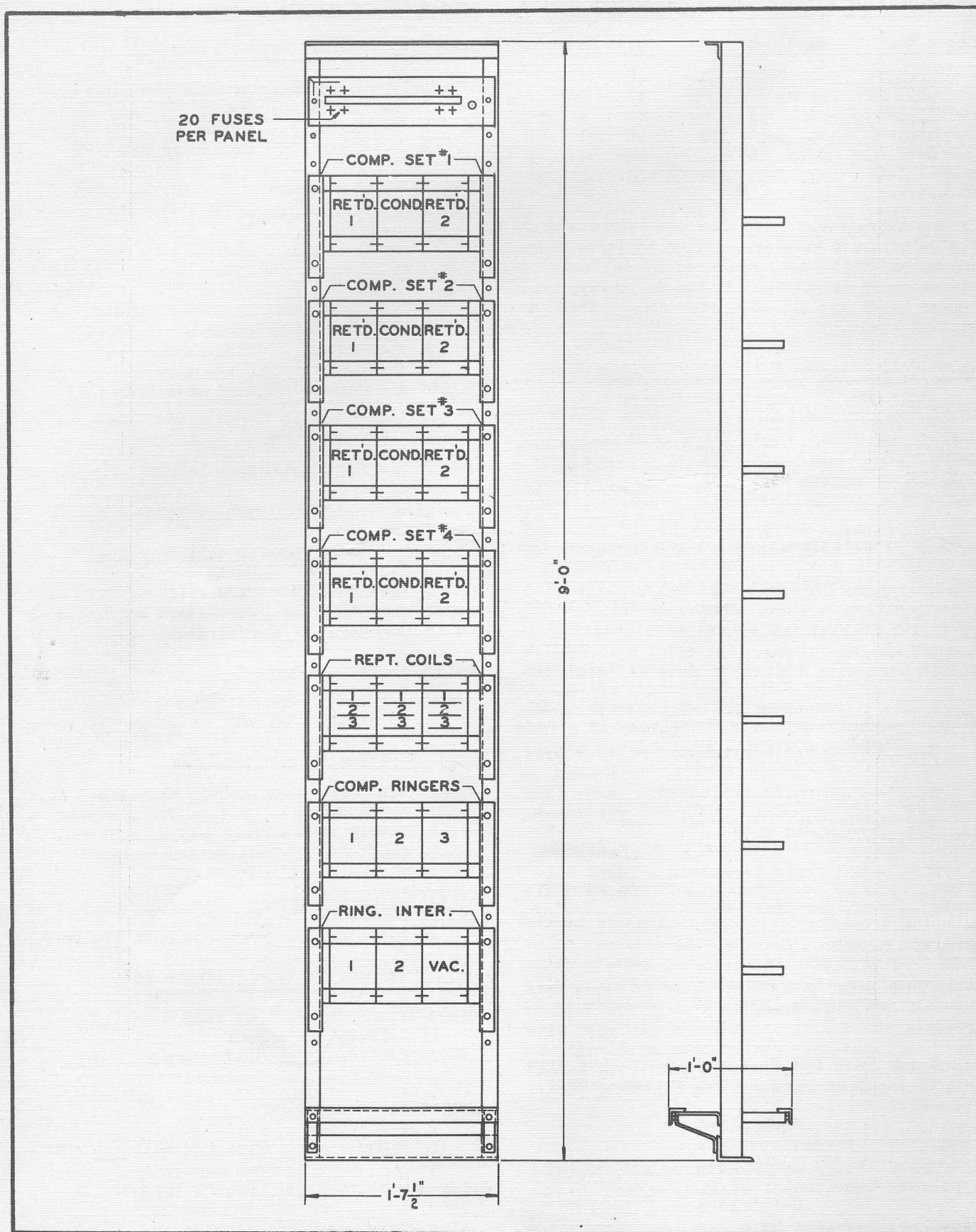


FIG. 49. RELAY-RACK-TYPE SHELVES AND UPRIGHT FOR PHANTOM-COMPOSITE EQUIPMENT.

Three-Coil Sets for Mounting on Switch Shelves

Piece No.	Base D-47	Coil	Ratio
D-855779-B	Sp. Rept. 731	1D	1:1
D-856881	Conn. 874	1D	1:1
D-855791-B	Sel. 731	2B	1:1.5
D-856383-B	Sp. Rept. 731	1B	1:1.69
D-856385-A	Conn. 667	1B	1:1.69
D-856333-A	Sp. Rept. 731	1C	1:2.69
D-857372-A	Conn. 667	--	--

In the above sets, leads for the condensers on the switchboard side are carried to jacks where straps or condensers required by switchboard circuits may be placed. In the following, condenser leads are not separated from the center winding leads.

Three-Coil Sets for Mounting on Switch Shelves

Piece No.	Base D-47	Coil	Ratio
D-855779-A	Sp. Rept. 731	1D	1:1
D-855715-A	Sp. Rept. 731	1A	1:1
D-855791-A	Sp. Rept. 731	2B	1:1.5
D-856383-A	Sp. Rept. 731	1B	1:1.69

The Sp. Rept. D-47731 base is 11" high and mounts on selector-switch mounting centers.

Repeater base D-47666 is 1' 1-1/2" high with above mounting centers. Connector base D-47667 is 1' 1-1/2" high and mounts on standard connector mounting centers. Connector base D-47874 is 11" high with connector mounting centers.

Condensers for Phantom and Composite Circuits

- 1 M.F. - 1000 volts breakdown - large type
D-6899
- 2 M.F. - 1000 volts breakdown - large type
D-68164-A
- 2-2 M.F. - balanced pair
D-68165-A
- 2 M.F. - 500 volts breakdown - large type
D-6891

Mounting brackets for these condensers permit grouping a number of units, the mounting holes then fitting the holes in switch base or relay strip mounting. When ordering brackets, specify quantity and catalog number of condensers to be grouped.

Condenser Pack for Telegraph Composite Sets (To mount on appropriate Switch Bases)

- Open-Wire Terminal Type
D-855510-A
- Open-Wire Intermediate Type
D-856503-A
- Open-Wire Combination Type
D-855725-A
- Two-Cable Terminal Type
D-856371-A
- Two-Cable Intermediate Type
D-856371-B

Components of Composite Sets

Open-Wire Terminal Type (Figure 25)

- Floor-Type Relay Rack or Wall Mounting
- 2 D-281854-A Coils
 - 8 D-68164-A Condensers
 - 1 D-68165-A Condenser Pair (XY)

Switch Shelf Mounting

- 2 D-281853-A Coils
- 1 D-855510-A Pack

Open-Wire Intermediate Type (Figure 26)

Floor-Type Relay Rack or Wall Mounting

- 2 D-281854-A Coils
- 2 D-68164-A Condensers
- 2 D-6899 Condensers
- 1 D-68165-A Condenser Pair (XY)

Switch-Shelf Mounting

- 2 D-281853-A Coils
- 1 D-856503-A Pack

Open-Wire Combination Type (Figure 27)

Floor-Type Relay Rack or Wall Mounting

- 2 D-281854-A Coils
- 6 D-68164-A Condensers
- 4 D-6899 Condensers
- 1 D-68165-A Condenser

Switch-Shelf Mounting

- 2 D-281853-A Coils
- 1 D-855725-A Pack

Cable Terminal Type (Figure 29)

Floor-Type Relay Rack or Wall Mounting

- 1 D-281854-A Coil
- 4 D-68164-A Condensers
- 1 D-68165-A Condenser

Switch-Shelf Mounting

- 1 D-281853-A Coil
- 1 D-856371-A Pack for each two sets

Cable Intermediate Type (Figure 30)

Floor-Type Relay Rack or Wall Mounting

- 1 D-281854-A Coil
- 2 D-68164-A Condensers
- 1 D-68165-A Condenser

Switch-Shelf Mounting

- 1 D-281853-A Coil
- 1 D-856371-B Pack for each two sets

Relay-Structure Type (Figure 31)

Relay Strip Mounting

- 4 R-3034-A1 Coils
- 4 D-68164-A Condensers
- 1 D-68165-A Condenser

REPEATING COILS AND THEIR USES

Switch-Shelf Mounting - One Set
1 D-856359 Set

Switch-Shelf Mounting - Two Sets
1 D-856343 Set

Retardation Coils

Large Type (Must be used for Telegraph Circuits)

Floor-Type, Relay Rack, or Wall Mounting
D-281854-A
Switch-Shelf Mounting D-281853-A

Small Relay Structure Type (For Dialing Legs Only)

Relay Strip Mounting R-3034-A1

Left-Hand Coil for Switch Base Mounting
R-3015-A1

Right-Hand Coil for Switch Base Mounting
R-3034-A1

13. ACCESSORIES

Pole-Mounting Metal Housing for Coils

Weather-Proof

Housing complete with one repeating coil (state desired type) and saw-tooth arresters for protecting incoming wires. Height 17" Weight 60 pounds.
Code No. 60

Weather-Proof

Housing complete with two repeating coils (state desired type) and saw-tooth arresters for protecting incoming wires. Height 29" Weight 72 pounds.
Code No. 72

14. PROTECTORS (FOR FULL DETAILS, SEE CAT. 6000)

Type 12 - Automatic-Sands Protector

This indoor protector consists of a pair of fuses and two Type 2105 discharge blocks. The base consists of two pieces of porcelain; one for the fuse clips only; one for the discharge blocks, fuse clips, and ground terminal. A metal cover encases the discharge blocks. The Type 2105 block is self-grounding and automatic resetting.

Cat. No.

Wt.

SA-74	Type 12 Protector - 3 Amp.	1-1/2 lbs.
SA-75	Type 12 Protector - 5 Amp.	1-1/2 lbs.
SA-76	Type 12 Protector - 7 Amp.	1-1/2 lbs.
SA-29	Asbestos Mat for Mounting	
	Type 12	

Type 15 - Automatic-Sands Protector

Indoors or Outdoors with fuses and the discharge blocks, Type 2105, described above for two conductors.

Cat. No.

Dimensions

Wt.

SA-81	8-1/2" x 2-1/4" x 2-7/8"	- 3 Amp. 3 lbs.
SA-68	" " "	- 5 Amp. "
SA-80	" " "	- 7 Amp. "

Type 35 - Automatic-Sands Protected Cable Terminal

Large terminal capacity with each pair protected by two 5-ampere No. 17 wood fuses and two No. 2105 discharge blocks. Carbon blocks with mica dielectrics can also be furnished. Supplied with a six-foot 22-gauge cable stub. Diameter of cover 9", height 22" to 34".

Cat. No.

Capacity

Description

SA-39	11 pair	With Stub
SA-41	16 pair	With Stub
SA-43	26 pair	With Stub

Type 40 - Automatic-Sands Protected Cable Terminal

Small capacity for pole or wall mounting. Each pair of protectors consists of two 5-ampere Type 17 fuses and two Type 2105 discharge blocks. Carbon blocks with mica dielectrics can be furnished if desired.

Supplied with six-foot 22-gauge cable stub. Width, 7-1/4"; length, 14" to 17".

Cat. No.

Capacity

Description

SA-31	3 pair	With Stub
SA-33	5 pair	With Stub
SA-35	7 pair	With Stub

CONVERSION TABLE

<u>Type No.</u>	<u>Piece No.</u>	<u>Catalog Number</u>
1A	D-281638-A	LA-34
1A	D-281638-B	LA-35
1B	D-281851-A	LA-36
1B	D-281851-B	LA-37
1C	D-281852-A	LA-38
1C	D-281852-B	LA-39
1D	D-281932-A	LA-40
1D	D-281932-B	LA-41
1E	D-282029-A	LA-42
1E	D-282029-B	LA-43
2A	D-281686-A	LA-44
2A	D-281686-B	LA-45
2B	D-281933-A	LA-46
2B	D-281933-B	LA-47
2C	D-281934-A	LA-48
2C	D-281934-B	LA-49
2A	D-282395-A	LA-50
2A	D-282395-B	LA-51
2B	D-282395-C	LA-52
2B	D-282395-D	LA-53
2C	D-282395-E	LA-54
2C	D-282395-F	LA-55
3A	D-281723-A	LA-56
3A	D-281723-B	LA-57
3A	D-282395-G	LA-58
3A	D-282395-H	LA-59
4A	D-281596-A	LA-60
5A	D-281724-A	LA-61
5A	D-281724-B	LA-62