M1 CARRIER TELEPHONE SYSTEM

DESCRIPTION OF EQUIPMENT AND METHOD OF OPERATION

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1. GENERAL

(A) Introduction

1.01 This section describes the M1 carrier telephone system which is a double-sideband, amplitude-modulated carrier system developed to provide rural telephone service over power distribution lines at the same time that these lines are used for the transmission of 60-cycle power. The system may also be used over telephone lines to provide simultaneous voice-frequency and carrier-frequency transmission. The carrier frequencies employed are in a band between 155 and 420 kc which provides for five 2-way channels over a given section of line. Each of these channels may be used to furnish party-line service to a number of subscribers. Each channel employs three carrier frequencies, two of them being used for opposite directions of transmission. The third frequency is available for use as the transmitting carrier for one of the parties when a revertive call is made between two parties connected to the same channel.

1.02 This section is reissued to bring the information up to date and to include information on the M1S2 multi-subscriber terminal. Due to the extensive nature of the

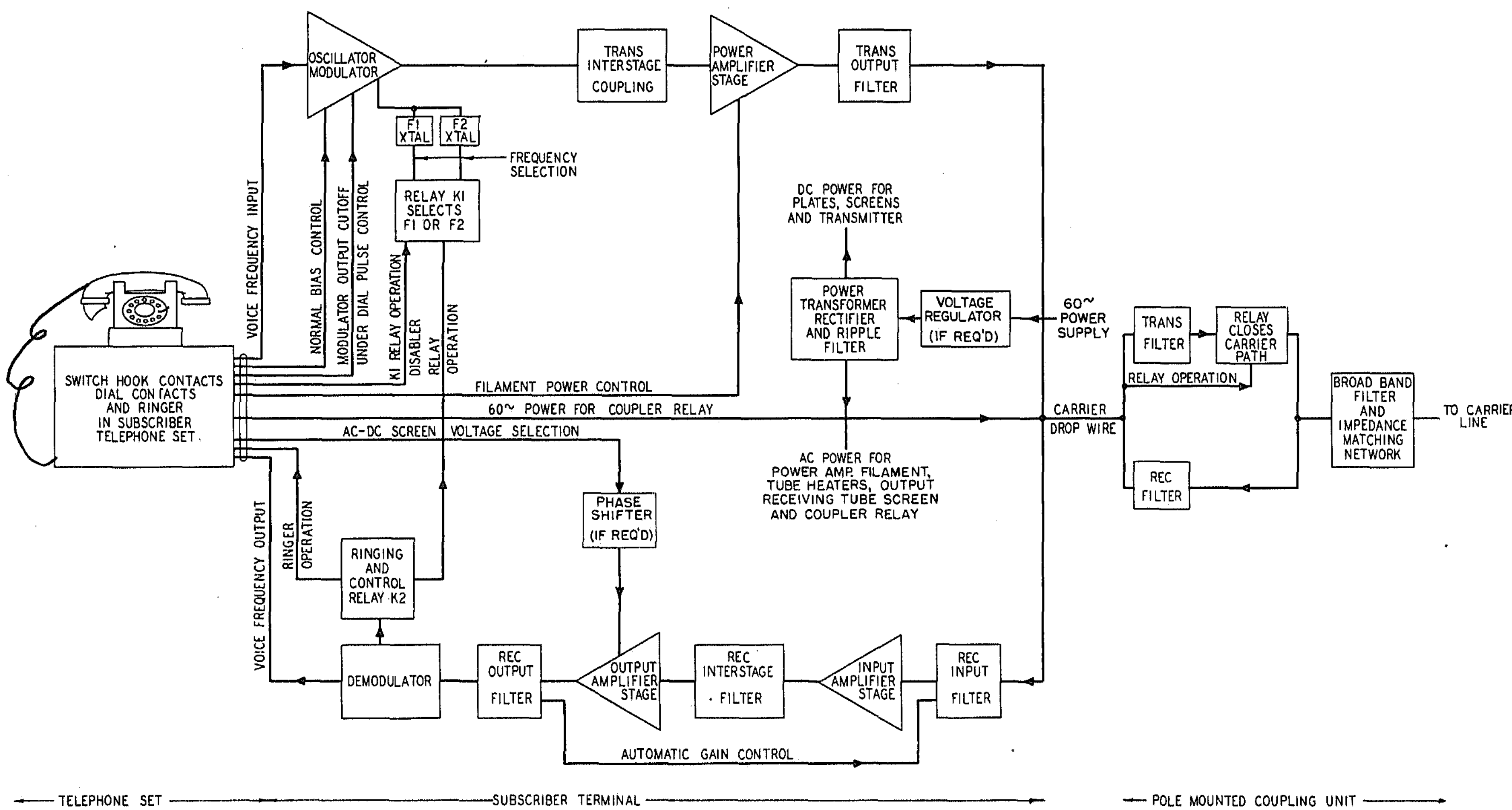


Fig. 1 - Block Schematic - M1S1 Subscriber Terminal, Coupling Unit and Telephone Set

changes made, arrows indicating alterations in the text have been omitted.

1.03 When the same phase of the 60-cycle power supply is common to both the subscriber or multi-subscriber terminal and the common terminal, full-selective ringing for two parties or divided-code ringing for more than two parties can be provided. When the same phase of the 60-cycle power supply is not common to both the subscriber or multi-subscriber terminal and the common terminal, but a fixed phase difference exists between the two, full-selective ringing for two parties or divided-code ringing for more than two parties is obtained by using a phase shifter at the subscriber or multi-subscriber terminal. The shifter is adjusted to shift the phase of the 60-cycle voltage by the amount required to permit the reception of signals from the common terminal. When different non-synchronous 60-cycle power supplies are used at the subscriber or multi-subscriber terminal and at the common terminal, only full-code ringing can be employed. Full-code ringing, of course, can also be provided, if desired, where the power supplies are in synchronism. Dialing from any subscriber station is provided for in cases where the common terminal works into a dial office. Operation with magneto offices is also possible with the use of an auxiliary circuit (see Paragraphs 3.03 and 4.07).

(B) Equipment Comprising System

1.04 The equipment for each system consists of:

(a) Equipment for adapting the line for carrier use, namely, (1) coupling capacitors through which carrier energy flows to and from the line, (2) isolating chokes for sectionalizing portions of the line used for carrier transmission, (3) tap chokes which are inserted at the junction of the tap and the main line in taps not used for carrier service, and (4) transmission chokes for insertion in taps at their junction with the main line where the taps are to be used for carrier transmission.

(b) Pole-mounted coupling units to provide transmission of carrier frequencies between the line and the carrier terminals.

(c) One or more subscriber terminals located on subscribers' premises comprising carrier frequency and signaling equipment, plus a combined telephone set for each subscriber. A block schematic of a subscriber terminal, subscriber coupling unit, and telephone set is shown in Fig. 1.

(d) One or more (up to five) multi-subscriber terminals located near a concentration of subscribers and serving a number of subscribers on a voice-frequency basis from the carrier channel, comprising carrier frequency, signaling and 4-wire to 2-wire connecting equipment. A block schematic of the multi-subscriber terminal, coupling unit and voice-frequency extension is shown in Fig. 2.

(e) One or more (up to five) common terminals comprising the carrier frequency, signaling, and 2-wire to 4-wire connecting equipment. The frequency allocation of the common terminals used for a system of less than the full complement of five channels must, of course, correspond to the allocations assigned for the respective subscriber or multi-subscriber terminals. A block schematic of a common terminal and common coupling unit is shown in Fig. 3.

(C) Design Features

1.05 Quartz oscillator crystals are used to provide stable carrier frequencies. The d-c power supply for plate and screen grid voltages and relay and transmitter currents is obtained by means of selenium rectifier units. Germanium varistors are used for demodulators, and copper-oxide varistors are used for deriving the automatic gain control (AGC) voltage. Double-sideband transmission is used. Each subscriber or multi-subscriber terminal is arranged to generate and modulate either of two frequencies spaced 10 kc apart, and each associated common terminal is arranged to receive one or both of these frequencies. This permits an arrangement whereby a 2-way talking circuit can be established between any two parties connected to the same channel, but employing different carrier terminals (revertive call), with each party using a separate transmitting frequency. This obviates any beats between their carriers.

(D) Frequency Allocations

1.06 The frequency allocations for the M1 system are shown in Table 1.

TABLE 1 - TRANSMITTING FREQUENCY IN KC

Channel Number	Common Terminal to Subscriber Terminal	Subscriber Terminal to Common Terminal: Normal (Y1 Crystal)	Subscriber Terminal to Common Terminal: Revertive (Y2 Crystal)
1A	155	410	420
3	185	290	300
4	200	320	330
5	215	350	360
6	230	380	390

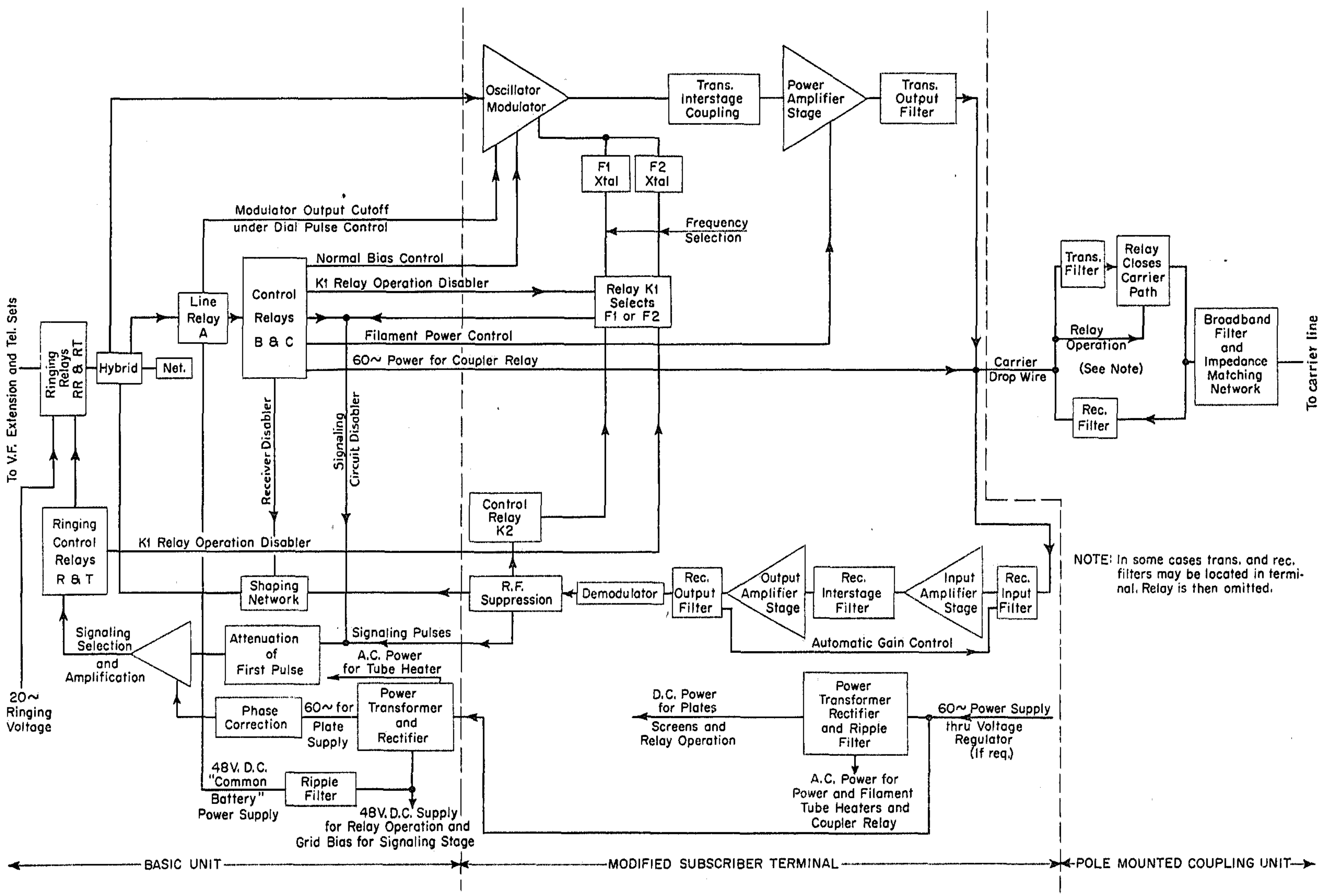


Fig. 2 - Block Schematic - Multi-Subscriber Terminal and Coupling Unit

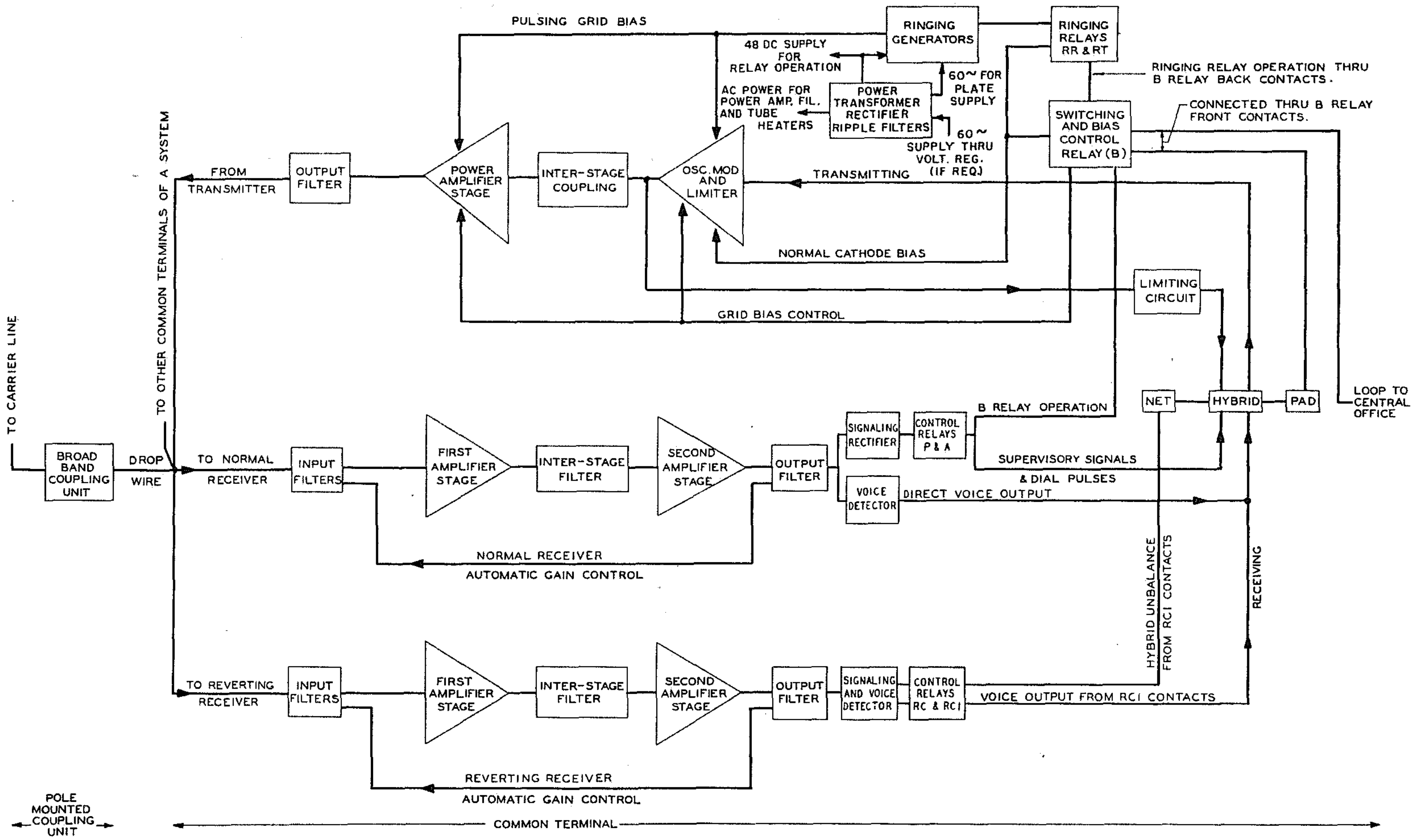


Fig. 3 - Block Schematic - M1C1 Common Terminal and Coupling Unit

(E) Equipment

Telephone Set

1.07 The combined telephone sets required for use with the individual M1 subscriber terminals are similar in appearance to existing standard sets. However, additional switchhook contacts are used for controlling the associated electronic unit and the relay in the subscriber coupling unit. Three resistors and one capacitor are included in the telephone set mounting and the usual induction coil is omitted. A 17-point terminal strip is employed for making the necessary internal and external connections and a 14-conductor cord is used between the telephone set and the subscriber terminal.

1.08 Conventional common battery telephone sets of the type generally used on common battery rural lines are employed with the multi-subscriber terminal. These are installed at the subscriber premises in the usual manner and connected to the carrier terminal, which may be located some distance away, by means of conventional open wire line construction.

Subscriber Terminal

1.09 The subscriber terminal is divided into separate transmitting and receiving chassis assemblies. These two assemblies are bolted together and housed under a common molded plastic cover 13" long, 8-1/2" wide, and 5-1/4" deep. A subscriber terminal assembly is shown in Fig. 4.

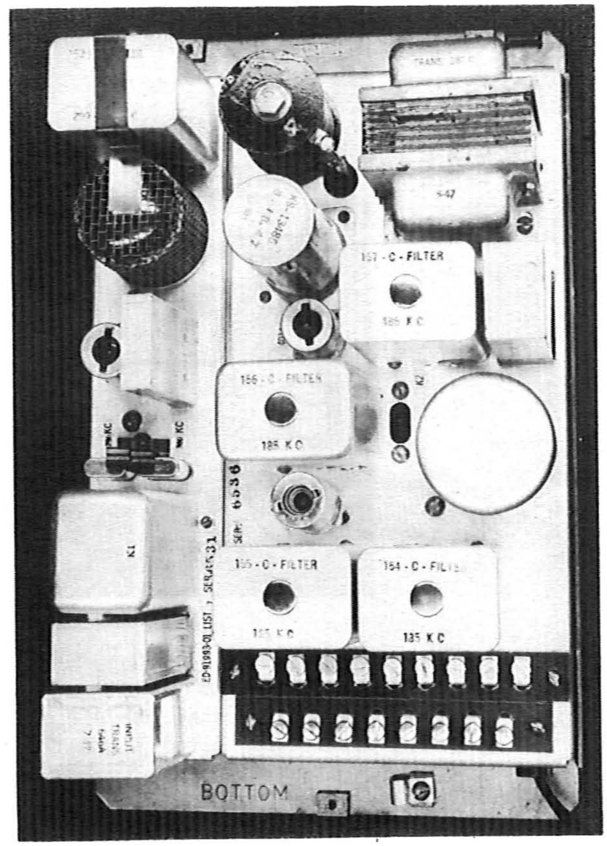


Fig. 4 - Individual Subscriber Terminal Equipment - Cover Removed

Multi-Subscriber Terminal

1.10 The multi-subscriber terminal consists of a modified subscriber terminal of the type described in Paragraph 1.09, mounted on a

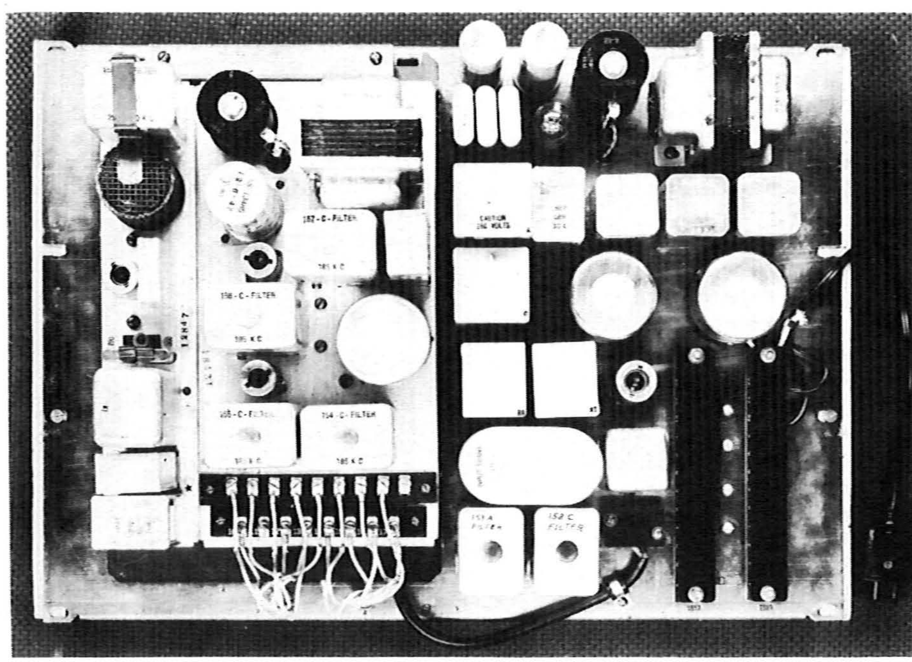


Fig. 5 - Multi-Subscriber Terminal Equipment

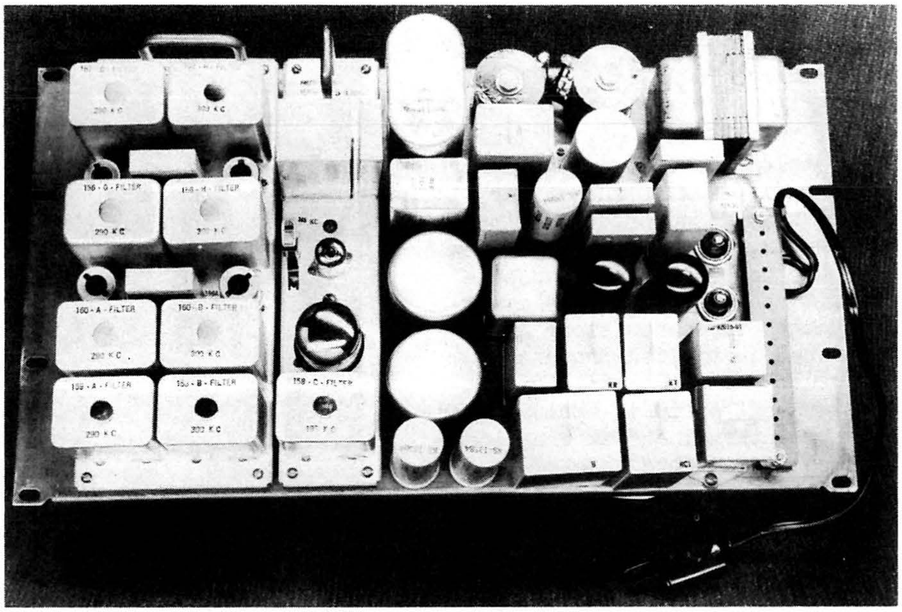


Fig. 6 - Common Terminal Equipment

basic unit panel containing the circuits and additional power supply required for its operation. A flexible multi-conductor cable connects the modified subscriber terminal to the basic unit circuits. The entire unit is arranged for 19" relay rack mounting and occupies 14" of relay rack space (eight mounting plate spaces). The M1S2 multi-subscriber terminal assembly is shown in Fig. 5.

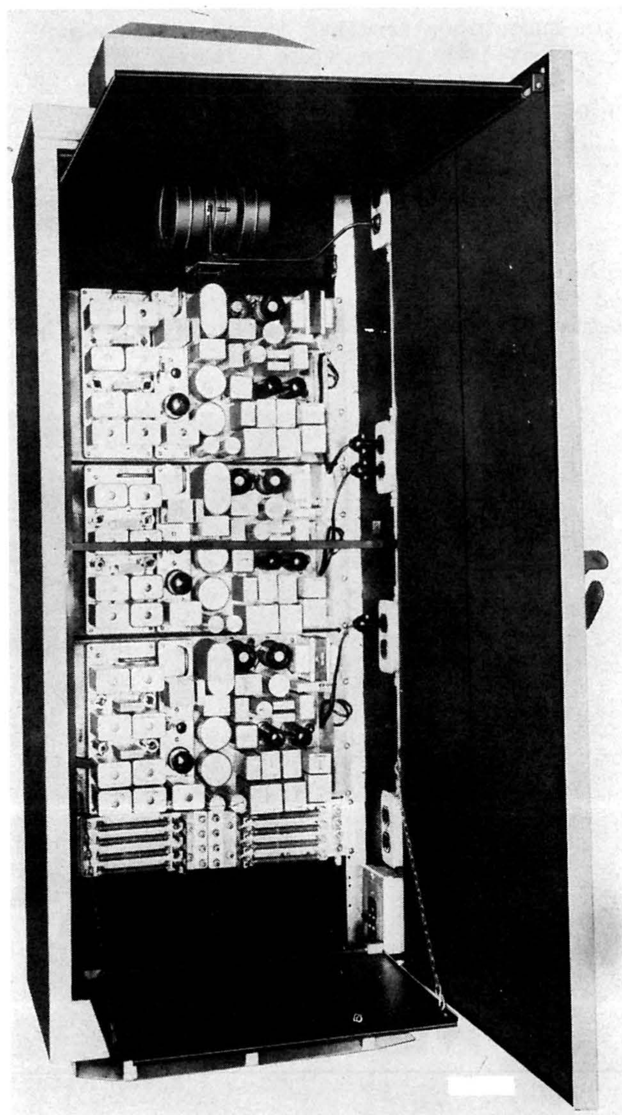


Fig. 7 - Cabinet for Outdoor Mounting

Common Terminal

1.11 The common terminal is mounted on a 19" mounting plate occupying 10-1/2" of relay rack space (approximately six mounting plate spaces). The common terminal equipment is shown in Fig. 6. The power supply, relay, and ringing equipments are mounted directly on one end of the panel. The electronic equipment for transmitting and receiving is mounted on two individual subassemblies which are plugged into jacks on the other end of the panel.

Housing

1.12 Cabinets arranged for pole mounting are provided for housing common terminal or multi-subscriber terminal equipments. Space is provided in the housing for three common terminals or two multi-subscriber terminals and the associated protectors, fuses, voltage regulator, soldering iron outlets, and heating and ventilating equipment, as required. A housing assembly containing three common terminals is shown in Fig. 7. Of course, common terminals or multi-subscriber terminals may also be housed in small unattended buildings of local design or in existing exchange or other available buildings.

Coupling Unit and Telephone Choke Unit

1.13 Each of the various coupling units and telephone choke units is housed in a standard galvanized steel protector box approximately 11-1/2" long, 7" wide, and 4" deep which is equipped with a bracket for pole or crossarm mounting. The box contains the necessary protectors as well as terminals for external connections. A detailed description of the coupling units and chokes is given in Part 2. A subscriber coupling unit is shown in Fig. 8.

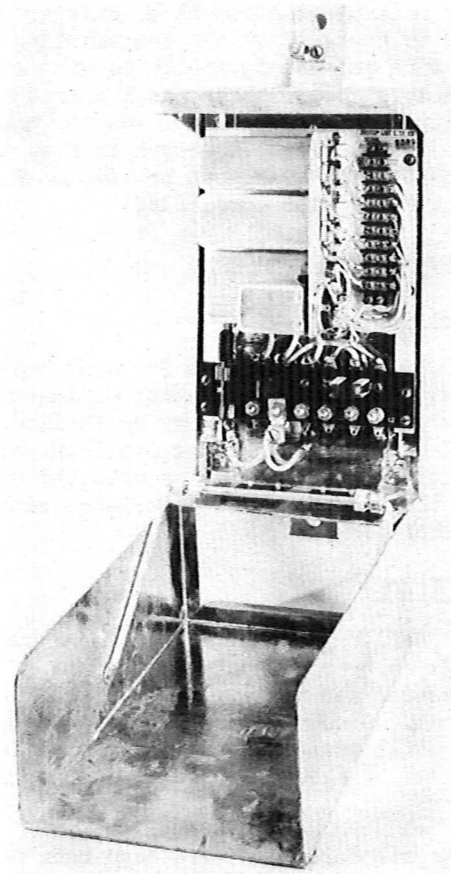


Fig. 8 - Subscriber Coupling Unit

Tubes

1.14 Each transmitting chassis for either a subscriber or multi-subscriber terminal or a common terminal requires two vacuum tubes. The receiver chassis for the subscriber or multi-subscriber terminal requires two tubes. The receiver chassis for the common terminal is equipped with dual receiving equipment and, hence, requires two pairs of receiving tubes for each channel. The types of tubes used consist of a transmitting oscillator-modulator tube, a transmitting power output tube, a receiving input tube and a receiving output tube for the carrier equipment; a cold cathode gas tube and neon lamp for the ringing generator circuit of the common terminal and a twin-triode for the ringing circuit of the multi-subscriber terminal. The transmitting oscillator-modulator tube and the receiving input tube, which were formerly filamentary types, have recently been changed to indirectly heated cathode types.

Voltage Regulators

1.15 In cases where fluctuation of line voltage, or sustained line voltage substantially higher or lower than nominal, is likely to be experienced, voltage regulators may be installed at the a-c power input to the carrier terminals. For the subscriber terminal, a small 30-volt-ampere regulator (KS-14209) is used. For multi-subscriber terminals and common terminals, a 120-volt-ampere regulator (Sola No. 30886 Constant Voltage Transformer) is employed. The latter will supply two multi-subscriber terminals or three common terminals and can be installed in the cabinet with the carrier equipment. Photographs of the two regulators are shown in Figs. 9 and 10.

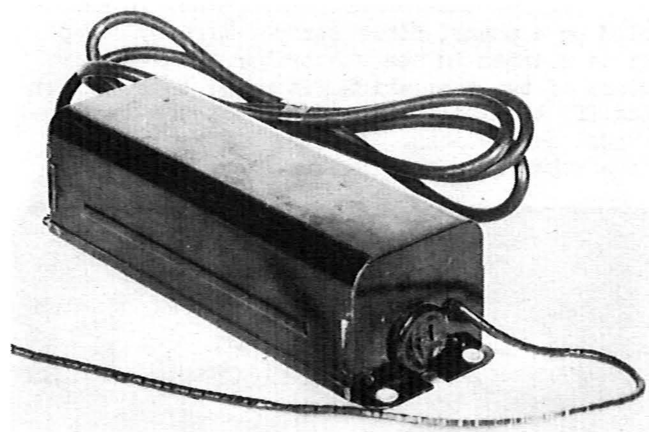


Fig. 9 - KS-14209 Voltage Regulator

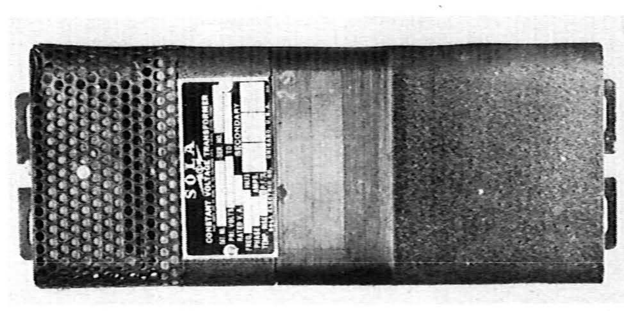


Fig. 10 - Sola No. 30886 Constant Voltage Transformer

Power Consumption

1.16 The approximate power consumption of the equipment, based upon the use of the heater type vacuum tubes, is as follows:

Type of Terminal	Power Consumption in Watts	
	Stand-by	In Use
Subscriber Alone	8	20
Subscriber with Regulator	19	29
*Multi-Subscriber Alone	13	33
*Two Multi-Subscriber with Regulator	55	90
Common Alone	18	32
Three Common with Regulator	75	99

* Connection of the phase shifter for any but 0 degrees will increase the power consumption per terminal as follows:

Phase Shift	Additional Power (Watts)
Leading 150° or Lagging 30°	4
Leading 120° or Lagging 60°	7
Leading 60° or Lagging 120°	10
Leading 30° or Lagging 150°	7

Phase Shifter

1.17 The apparatus comprising the phase shifter for the subscriber terminal is assembled on a phenol fibre strip 2-1/2" by 3-1/8". It is mounted in the subscriber terminal by means of two feet which fit under terminals on the TS3 terminal strip and also serve as electrical connections. A phase shifter mounted in a subscriber terminal is shown in Fig. 11.

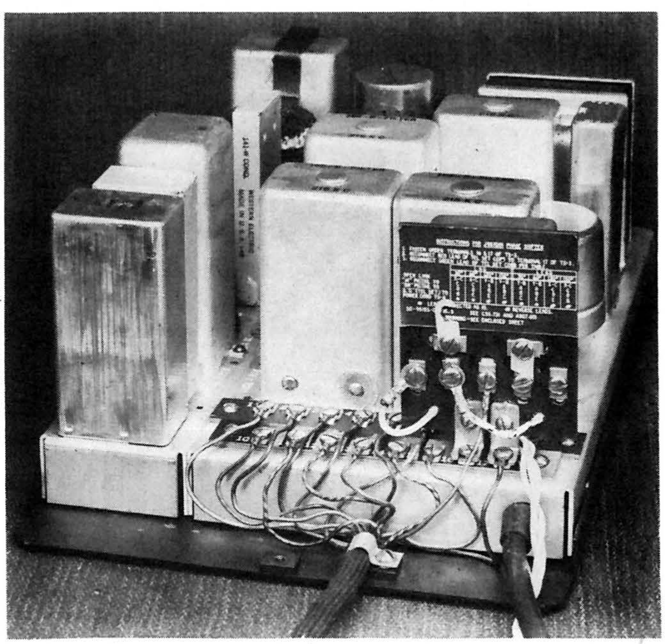


Fig. 11 - Phase Shifter Mounted in a Subscriber Terminal

The phase shifter for the multi-subscriber terminal is built into the terminal and is adjusted by changing straps on a terminal strip provided for that purpose.

Adjustment of Carrier Output

1.18 Normally no adjustment is provided for the carrier output of the M1 carrier terminals. However, in cases where the nominal output level must be reduced to minimize cross-signaling, crosstalk or overloading of the receiving circuits of the associated terminal, a gain control adapter (8GC) is employed. This adapter controls the amount of carrier voltage applied to the grid of the transmitting power output tube and is adjustable to give any desired level below the nominal output of the transmitter. A gain control adapter mounted on a subscriber terminal is shown in Fig. 12. This adapter, however, can be used with any of the type M1 carrier terminals.

(F) Special Applications

Coin Box Service

1.19 No provision is made for coin box service with prepay coin control equipment. Postpay coin box service may be engineered on a special basis by connecting the transmitter of the coin collector in series with the transmitter of the telephone set associated with the subscriber terminal.

P.B.X. Trunks

1.20 P.B.X. trunks may be furnished over M1 carrier channels by the use of the multi-subscriber terminal at the P.B.X. end of the trunk. A common terminal is then employed in the usual manner at the central office end.

Repeaters

1.21 No standard repeaters have been designed for the system nor have arrangements been made for their application.

2. DESCRIPTION OF CIRCUITS AND EQUIPMENT

(A) Power Line Equipment

General

2.01 The transmission of carrier frequencies over rural power distribution systems presents many problems not encountered heretofore in carrier-frequency transmission. Carrier systems have been used for many years by power companies for communication between substations, but in these applications the adaptations of

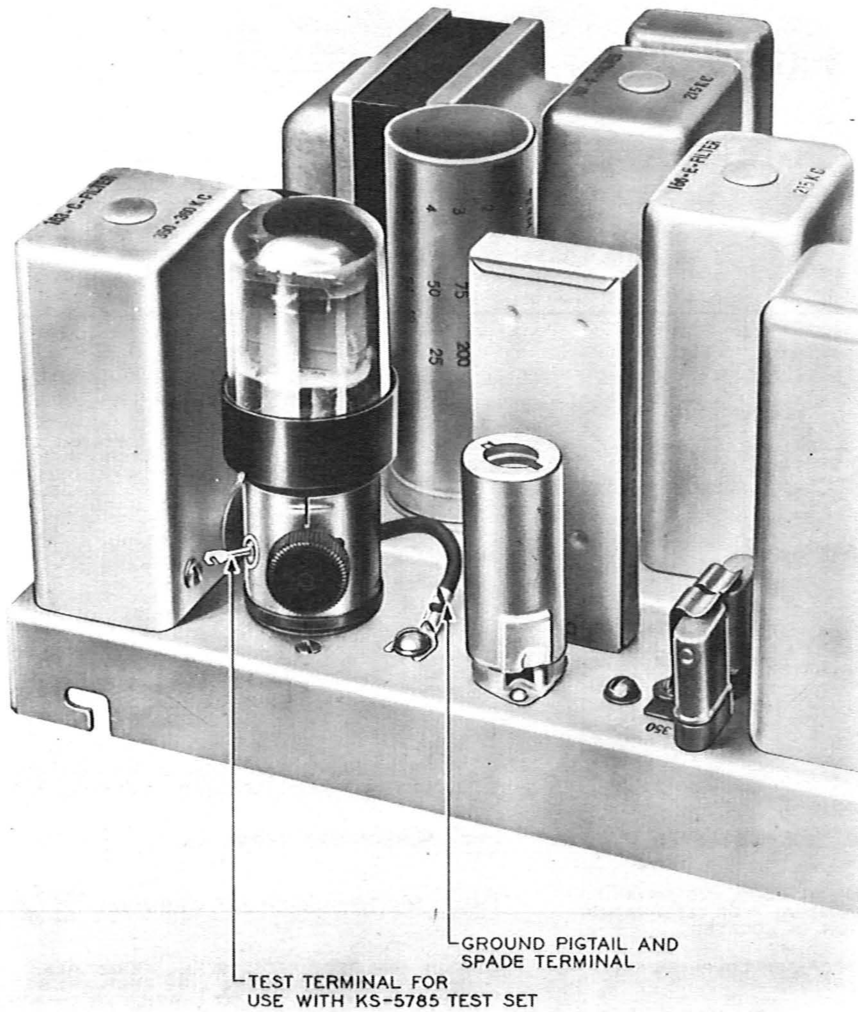


Fig. 12 - 8GC Adapter Mounted in a Subscriber Terminal

the power lines for carrier transmission were relatively simple, since lines between substations are usually electrically smooth and have few branch taps. Therefore, only terminal equipments and a few chokes were required. On the other hand, the usual 7-kv rural power distribution line involves a complex network of branch taps which must be specially treated to reduce carrier losses. Also, various sections of the power line must be isolated from each other at carrier frequencies in cases where the application of more than one carrier system on the power distribution system is necessary. Low loss bridging arrangements are required for the carrier taps, and the carrier line sections must be terminated in their characteristic impedance. Also, where pole-top oil circuit reclosers or sectionalizers are located within the carrier section, it may be necessary to provide by-pass circuits for carrier currents. The usual power distribution transformer employed at rural locations does not ordinarily require any treatment to reduce bridging or reflection losses. These transformers do contribute some bridging losses, however, which are taken into account in the transmission loss data used in engineering a power line carrier system.

2.02 This part of the practice describes the equipment which must be added to a power line installation in order to make the power distribution system a suitable transmission medium for carrier frequencies. Fig. 13 shows the application of various types of line equipment employed, including the coupling units.

Coupling Capacitor

2.03 The coupling capacitor has a maximum working voltage rating of 8700 volts and its nominal capacitance is 2000 mmf. The capacitor is designed to meet the wet and dry flashover requirements of 30 and 35 kv,

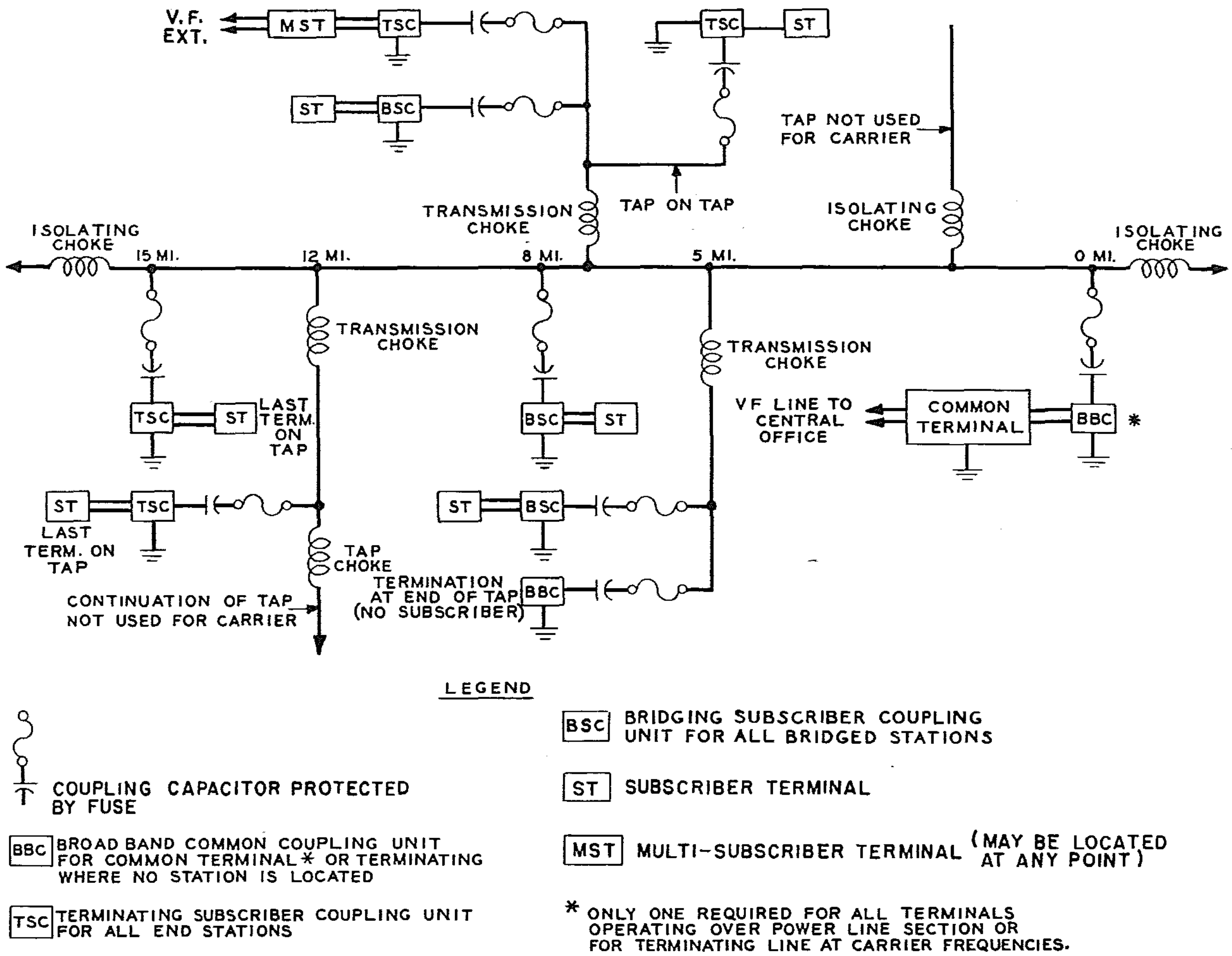


Fig. 13 - Typical Phase Wire Treatment for Applying a System to a Power Line

respectively, set up in A.I.E.E. Standard No. 31 and to withstand 150 kv on impulse, which substantially exceeds the 95-kv value of this standard. The capacitor is usually mounted on the same pole with either a power transformer or an isolating choke so that the lightning protection provided for either also provides protection for the capacitor. For additional protection, especially against the sudden polarity reverse impulse which occurs when the lightning protection operates, a 99A protector is installed between the lower terminal of the capacitor and ground. The 60-cycle impedance of the capacitor is sufficiently high to limit the normal current drain to about five milliamperes; however, at carrier frequencies, the impedance of the capacitor is relatively low and affords a means of receiving and transmitting carrier power from and to the power line without appreciable loss. The capacitor is of the oil-impregnated paper and foil type, immersed in oil and hermetically sealed in a glass or porcelain container. The container is about 2" in diameter and about 15" long. One type of capacitor which is being used is shown in Fig. 14. The capacitor is mounted directly on the pole by means of a galvanized steel bracket.

Fuse

2.04 Connection to the phase wire is made through a 2-ampere fuse in order to prevent a capacitor failure from damaging equipment or presenting a hazard to personnel. In case of capacitor failure, the fuse will open the circuit before the substation circuit breakers can operate or before the line fuses can blow. The fuse is hung from a hot-line clamp on the phase wire and supported by its own terminal lead; it is about 4-1/4" long and 1/2" in diameter. A flexible lead from the lower fuse terminal is connected to the capacitor. The fuse link is housed in a fibre tube

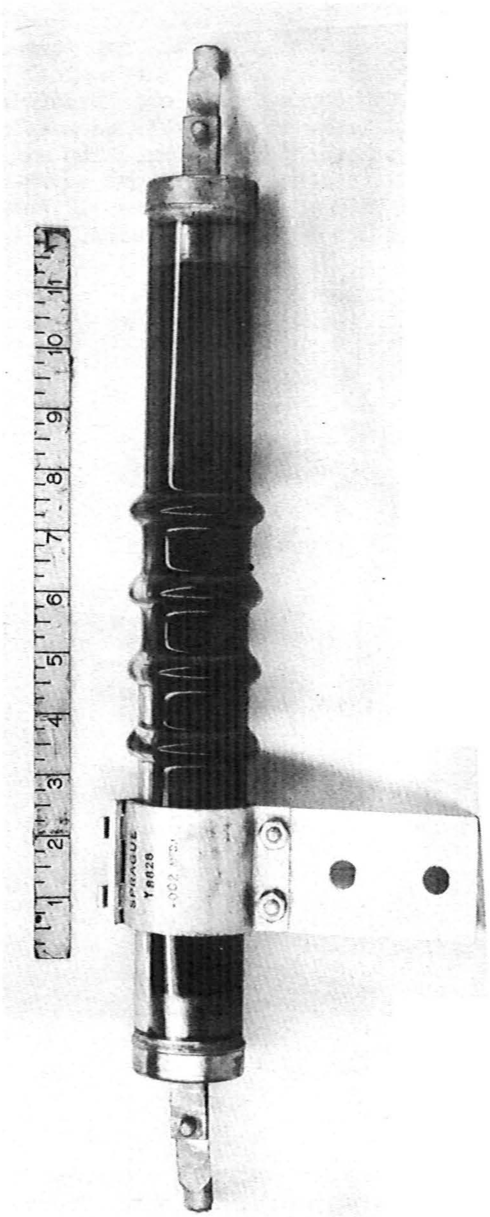


Fig. 14 - Coupling Capacitor

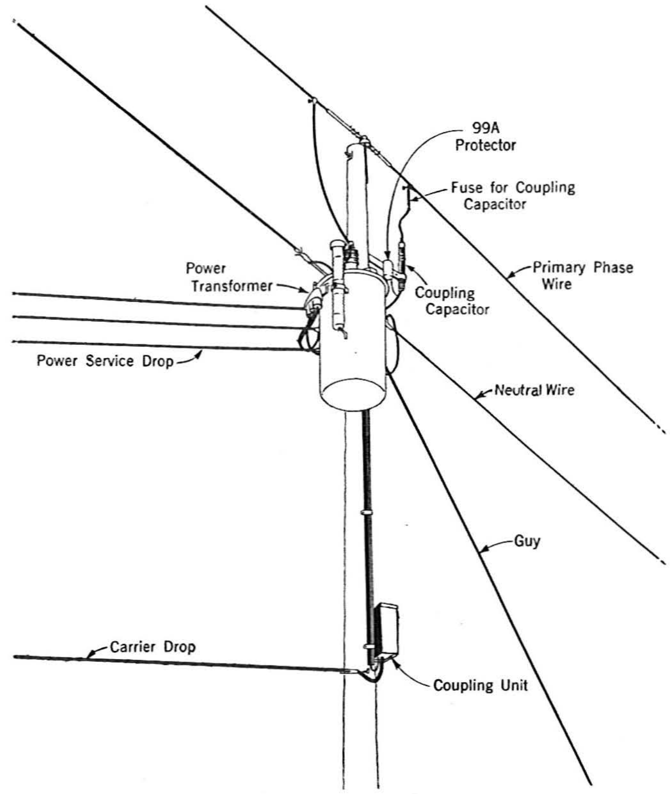


Fig. 15 - Typical Installation of Coupling Capacitor and Coupling Unit

in such a way that one terminal separates from the body when the link is blown, hence, a blown fuse can be observed from the ground. When a blown fuse is replaced by the power company, the associated capacitor should also be replaced. Fig. 15 shows a typical installation of a coupling capacitor, fuse and 99A protector.

Isolating Choke

2.05 An isolating choke is usually connected in series with the phase wire at each end of a section of line used for carrier transmission to isolate this section at carrier frequencies from the remaining portions of the distribution system. This choke is contained in an oil-filled steel tank as shown in Fig. 16 and is suitable for mounting on a pole or crossarm. A grounding lug is provided on the tank mounting bracket. The weight of the complete tank is about 60 pounds. This choke will carry 15 amperes continuously. Two chokes may be used in parallel when the continuous current is likely to exceed the limit of one. Peak loads slightly in excess of 15 amperes are tolerable for short periods. The short-circuit rating of the isolating choke is 500 amperes for one second. All existing isolation chokes have lightning gaps between terminals and expulsion lightning arresters between each terminal and the case. Due to difficulties experienced with the expulsion arresters, future chokes will be manufactured with terminal-to-terminal gaps only and will require distributional type lightning arresters, of the same rating as used for protecting transformers on the power line involved, connected between phase wire and neutral on the carrier section side of the isolating choke. The nominal inductance of this choke is 10 millihenries. Under installed conditions it may resonate, but at a frequency not lower than 270 kc. The minimum impedance is 9500 ohms anywhere in the frequency band between 150 and 420 kc. The maximum 60-cycle impedance is 5 ohms. When carrier systems are required to operate at the same frequencies on adjacent portions of a power network, isolating choke coils in combination with coupling capacitors are used to form sectionalizing networks.

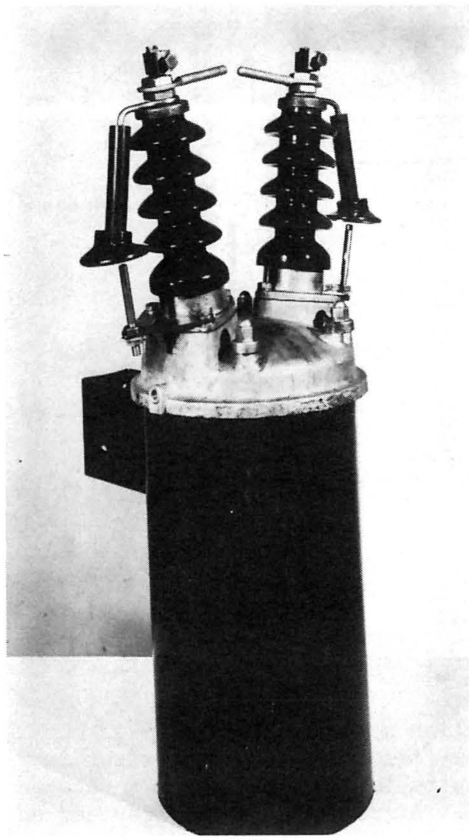


Fig. 16 - Isolating Choke

Tap Choke

2.06 A tap choke is connected in series with each branch phase wire or each section of a branch phase wire which is not used for carrier transmission. Its continuous current rating is 7 amperes, but like the isolating choke, the rated current may be exceeded slightly for short periods. In case the continuous current rating is not sufficient in a particular application, the isolating choke may be substituted. Except in a sectionalizing network, a tap choke may also be used in place of an isolating choke when its current rating is not exceeded. Tap chokes should not be used in parallel. The short-circuit rating of the tap choke is the same as for the isolating choke, namely, 500 amperes for one second. It is mounted on the pole by means of an insulator supported by a horizontal through bolt. The unit is equipped with a by-pass gap to protect the winding from lightning. The nominal inductance of the tap choke is 2.5 mh. Under installed conditions, it may self-resonate at a frequency not lower than 270 kc. The minimum impedance requirement is 2500 ohms anywhere in the band from 150 to 420 kc. Fig. 17 shows a tap choke and its mounting hardware.

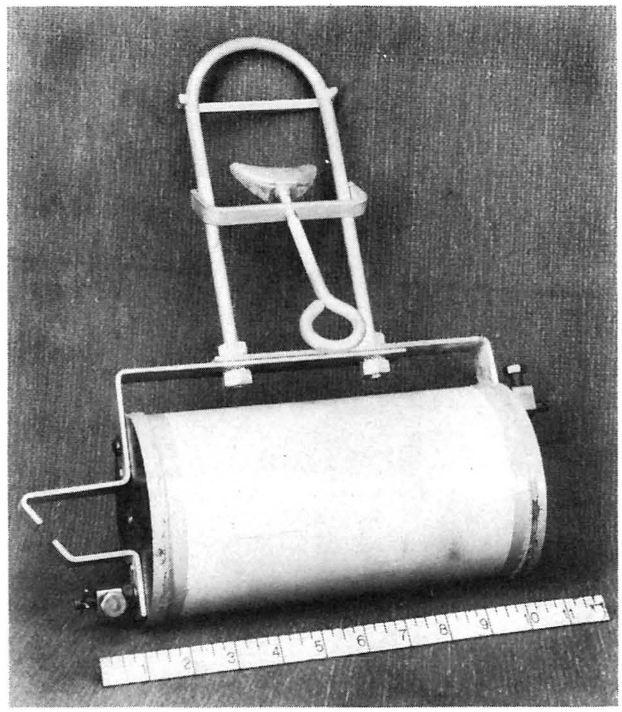


Fig. 17 - Tap Choke

Transmission Choke

2.07 A transmission choke is connected in series with a line tap which is used for carrier transmission and serves to reduce the bridging loss of the tap to carrier transmission on the through circuit. Two kinds of transmission chokes are available, one having 0.6-mh inductance and the other having 0.3-mh inductance. The continuous current rating of the 0.6-mh choke is 9 amperes and that of the 0.3-mh choke is 10 amperes. Here also, the rated current may be exceeded slightly for short periods. The short-circuit rating of the transmission choke is the same as for the tap choke. It is similar in physical design to the tap choke though about 2" shorter and is mounted in the same way as the tap choke. The 0.6-mh choke is identified by a single red band around its circumference and the 0.3-mh choke by a double red band. The tap choke has no identifying band. The self-resonance frequency of the choke is well above the highest carrier frequency used by the system. The impedance of the 0.6-mh choke is not less than 680 ohms at 200 kc and not more than 2200 ohms at 500 kc. The 0.3-mh choke has an impedance of not less than 340 ohms at 200 kc and not more than 1100 ohms at 500 kc. The 0.3-mh choke is employed in certain cases where the use of the 0.6-mh choke would produce excessive transmission loss.

(B) Telephone Line Equipment

2.08 The problems involved in adapting a telephone line for carrier transmission are somewhat simpler than for a power line because high-voltage capacitors are not required and because the isolating, tap, and transmission chokes need not carry large values of current or withstand high voltages. However, in general, comparable functional components are required for adapting a telephone line for carrier transmission. These consist of physically small inductances or filters for the isolating and tap chokes and small inductances for the transmission chokes. In order to maintain the telephone line balance, the chokes are connected in both sides of the line as shown in Fig. 18. A filter, also of balanced construction, is used instead of the inductances in cases where other carrier is employed on the telephone line, or if it is desired to minimize transmission of M1 frequencies beyond the carrier section. These small components make it feasible to mount them in pole-mounted boxes of the same type used for coupling units. Isolating chokes of filters for telephone line applications are included in the same box with the broad band coupling unit when it is used as a common or terminating coupling unit. They are also available, as are the transmission chokes, in separate boxes for use at locations where the common or terminating coupling unit is not used. When a power line is used for carrier transmission over part of the route and a telephone line is used for the remaining portion of the carrier line section, a broad band coupling unit, which includes a broad band filter and repeating coil or two repeating coils, is used to interconnect the power line and telephone line.

(C) Coupling Equipment

General

2.09 Carrier-frequency energy can not readily be transmitted to a power line through power distribution transformers. Hence, coupling units are used for this purpose, and separate drop wire is run for the carrier circuit between the coupling unit and a subscriber or multi-subscriber terminal or a common terminal. Similar arrangements are used for

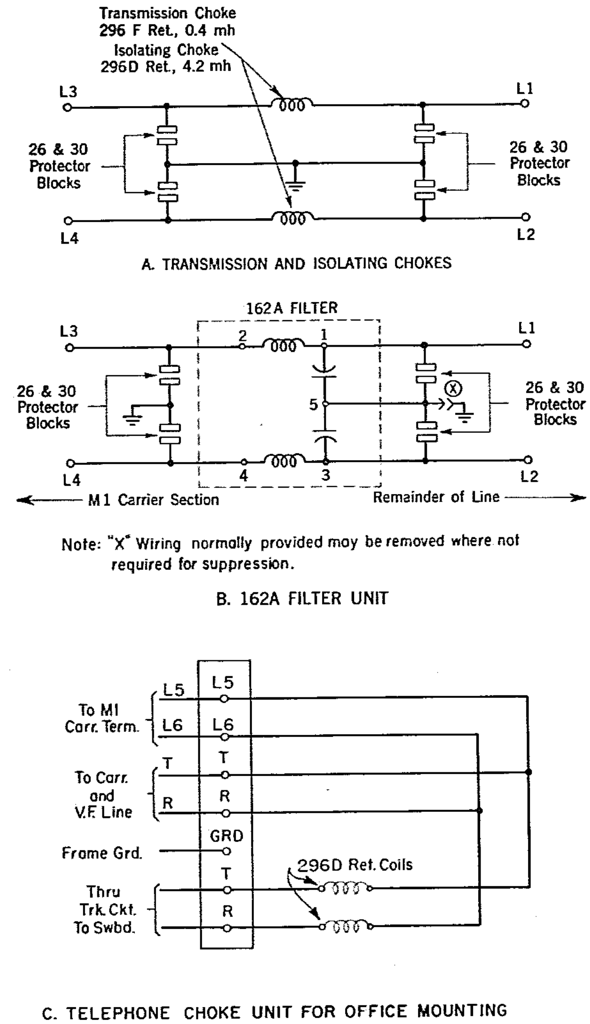


Fig. 18 - Isolating and Transmission Chokes for Telephone Line Application

connecting a carrier terminal to a telephone line. Three kinds of coupling units are employed in the system, as shown in Figs. 19 to 29, inclusive. These are:

(a) M1S3 Bridging Subscriber Coupling Unit (Fig. 19).

(b) M1S4 and M1S5 Terminating Subscriber Coupling Units (Figs. 20 and 21, respectively).

(c) M1C3 Broad Band Coupling Unit (Figs. 22 to 29, inclusive).

A subscriber or multi-subscriber terminal is connected by carrier drop wire to either a bridging subscriber coupling unit or to a terminating subscriber coupling unit. A common terminal and, in some cases, a multi-subscriber terminal, is connected by carrier drop wire to a broad band coupling unit. The broad band coupling unit may also be used as a line termination in case no carrier terminal is installed at the end of a line section which must be terminated. One form of the broad band coupling unit provides for interconnecting a power line and a telephone line so that each type of line provides a part of the carrier medium comprising the whole carrier circuit. Coupling units are so designed that suitable impedance matches are obtained in combination with the coupling capacitance. Fig. 8 shows the type of bridging subscriber coupling unit for power line applications. Other types are similar except for some of the internal components.

M1S3 Bridging Subscriber Coupling Unit

2.10 The M1S3 bridging subscriber coupling unit consists of three filters, a relay, and protector blocks as shown in Fig. 19. For power line applications a safety switch is included and the protector between the capacitor and power line neutral terminals consists of copper blocks with a mica separator. For telephone line applications the safety switch is omitted and the line protectors are the carbon block type. The protectors at the drop wire terminals are the carbon block type for both telephone line and power line applications. For telephone line coupling units the line coupling capacitance is included in the unit. The filters and relay equipment are identical for both applications. FL2 and FL3 are multipled to the carrier drop wire. FL3 is the receiving filter and is connected across the drop side terminals of FL1 at all times. The transmitting filter, FL2, is not multipled across the drop side terminals of FL1 unless relay K1 is operated. Both FL2 and FL3 are designed to have high impedance inputs and outputs outside the band of frequencies which they pass. FL1 serves as an autotransformer having an impedance ratio of about 750:100 ohms between the carrier line and carrier drop terminals, respectively. The carrier frequency impedance of the K1 relay winding is very high compared to the 100-ohm characteristic impedance of the drop wire. At the receiving frequency, the effective impedance which FL3, in combination with FL1 and the coupling capacitance, bridges across the carrier line is about 3000 ohms. Under stand-by conditions, the FL2 line terminals are opened by the relay and, hence, the impedance bridged across the carrier line at the transmitting frequencies is very high. Under transmitting conditions, a small amount of 60-cycle power is fed out over the carrier drop wire. This operates relay K1, the contacts of which connect the line terminals of filters FL2 and FL3 in parallel, thus connecting the line terminals of FL2 to the drop terminals of FL1. Under these conditions, at the transmitting frequencies, the carrier line is bridged with approximately 750 ohms. L2, L3 and L4 of FL1 are all parts of the same coil. L1 and L5 of FL1 are uncoupled to any other coils in the filter unit. For the power line

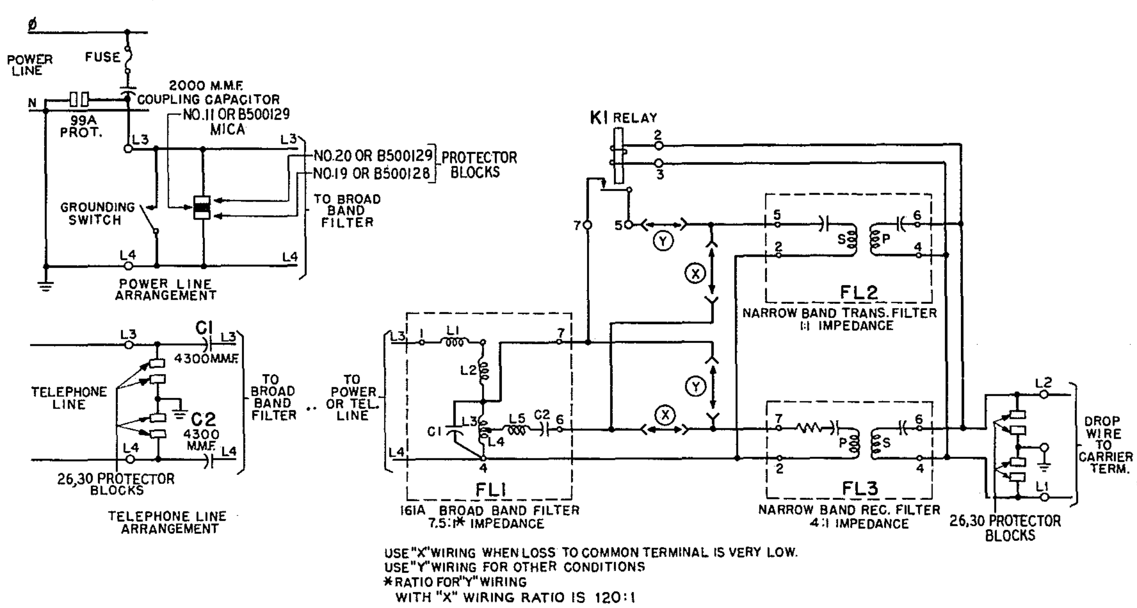


Fig. 19 - M1S3 Bridging Subscriber Coupling Unit

case, the 60-cycle current of about five milliamperes that flows through the coupling capacitor is drained to ground through L1, L2, L3 and L4. When a subscriber coupling unit is used at a point where the line loss to the common terminal is 12 db or less, "X" wiring is used. This effectively taps the autotransformer winding at a lower point and thus a higher transmission loss is effected between the carrier line and the transmitting and receiving filters of the coupling unit. This is done in order to prevent overloading of both the subscriber terminal and the common terminal receivers. This change of connection is provided for in the equipment by shifting each of two wires from one screw terminal to another. After the change is made, the contacts of K1 are effectively by-passed so that relay K1 is not needed and may be removed from the unit, if desired. Under these high loss conditions, it is not necessary to open the connection between FL2 and FL1 in the stand-by condition, since the bridging loss of the coupling unit to the carrier line with FL2 connected is only a few tenths of a db at all carrier frequencies, due to the large stepdown ratio when the lower tap on the autotransformer is used. The transmission loss through the autotransformer FL1 is about 12 db greater when this tap is used than when "Y" wiring is used. Filters FL2 and FL3 are designed upon the assumption that they will be connected across the L3 and L4 windings of FL1. When they are connected across L4 only, it is necessary to resupply the reactive components to simulate the L3 and L4 arrangement in order to preserve the band pass characteristics of the filters. C2 and L5 constitute the reactive impedance necessary to provide this compensation.

M1S4 and M1S5 Terminating Subscriber Coupling Units

2.11 The M1S4 and M1S5 terminating subscriber coupling units shown in Figs. 20 and 21, respectively, are similar to the bridging subscriber coupling unit except that FL1 in the M1S4 coupling unit is a different filter unit and, in the M1S5 coupling unit, it is a repeating coil. FL2, FL3 and relay K1 serve the same purposes in these coupling units that they serve in the bridging subscriber coupling unit and are identical with the components used in the latter. FL1 also serves the same purpose as FL1 in the bridging subscriber coupling unit but it is so designed that the approximately 600-ohm characteristic impedance of the carrier line is transformed to about 100 ohms. In the M1S4 unit, FL1 serves as an autotransformer between the carrier line and the FL2 and FL3 filters since L2 and L3 are parts of the same coil. L1 and L4 of FL1 in the M1S4 unit are not inductively coupled to the other coils in the filter unit. In the M1S5 unit, FL1 is a balanced repeating coil which accomplishes the same impedance transformation. The low impedance output appears at terminals 2 and 4 of the filter or repeating coil. To terminate the carrier line at the point where the terminating subscriber unit is applied, a 100-ohm resistor is connected directly across terminals 2 and 4 of FL1. The presence of this resistor terminates

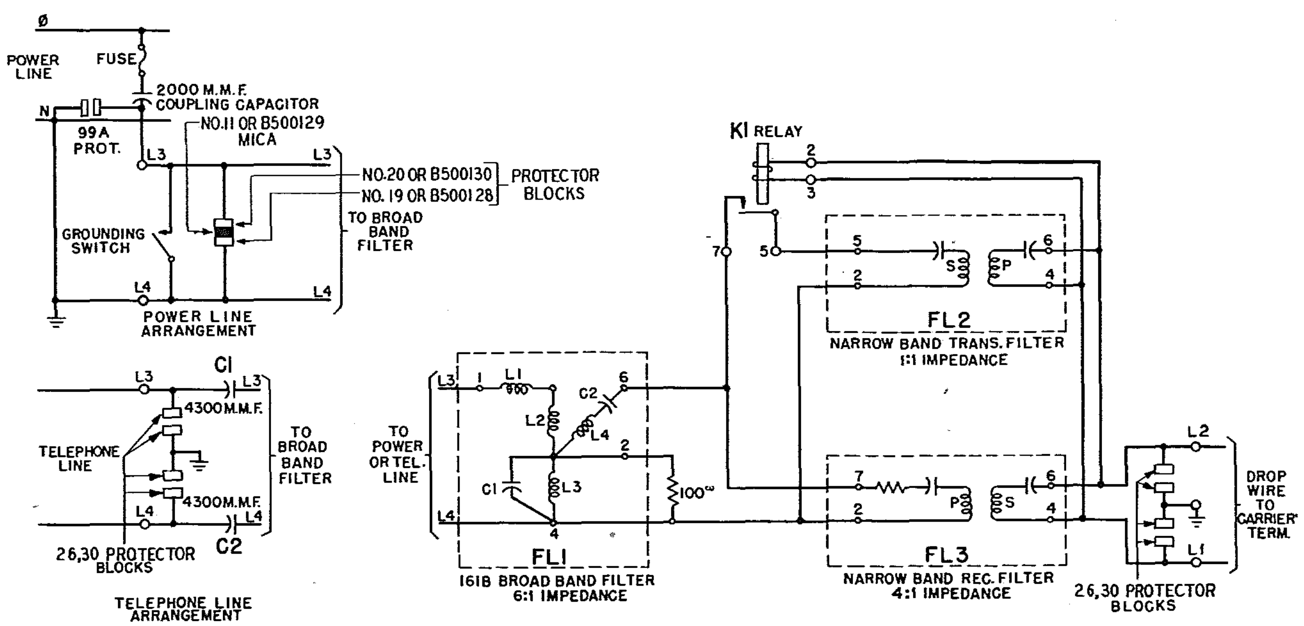


Fig. 20 - M1S4 Terminating Subscriber Coupling Unit with 161B Filter

the carrier line at all carrier frequencies from 150 to 420 kc and also reduces to very small proportions the reactive components which would otherwise be effective across terminals 2 and 4. Since FL2 and FL3 are the same type filters used with the bridging subscriber coupling unit, it is necessary, as mentioned above, to resupply the reactive components which are present at the normally used low impedance side of the FL1 of that unit. Reactances C2 and L4 in the filter and similar components in the repeating coil are employed in series between terminals 2 and 6 of FL1 to provide the necessary compensation. As shown in Figs. 20 and 21, FL3 is connected directly to terminals 6 and 4 of FL1. Filter FL2 is connected across terminals 6 and 4 of FL1 through the contacts of relay K1. The drop sides of both filters are multipled across the carrier drop wire. Under stand-by conditions, the carrier line is terminated in approximately 600 ohms at all carrier frequencies except the receiving carrier frequency, in which case the termination is slightly less than 600 ohms. With the carrier terminal in use, the line is terminated in 600 ohms at all frequencies except those in the transmitting and receiving bands. In the transmitting band, the termination will be in the order of 250 ohms, due to the paralleling effect of FL2 and the 100-ohm resistor operating through FL1. At the receiving frequency, the termination will be only slightly less than 600 ohms. For power line applications the 60-cycle current that flows through the coupling capacitor is drained to ground through L1, L2 and L3 of FL1 in the M1S4 unit, or through winding 1-3 of the FL1 repeating coil in the M1S5 unit. The M1S5 unit is intended to provide a balanced connection to telephone lines which is not possible with the autotransformer arrangement in the M1S4 unit. However, since the M1S5 unit will also function satisfactorily in power line applications, it is completely replacing the M1S4 unit and no more of the latter will be furnished.

2.12 The M1S4 and M1S5 coupling units do not contain the high loss option provided with the bridging subscriber coupling unit. Such an arrangement can be engineered on a special basis, however, by installing a pad of approximately 10 db between FL1 and the multipled connection to FL2 and FL3. With the pad installed, the filters FL2 and FL3 are slightly detuned since no use is made of the reactances C2 and L4. Also, in the transmitting and receiving bands, the termination provided for the carrier line will be approximately 600 ohms at all times instead of the values given in Paragraph 2.11. The method for installing the pad is as follows:

(a) Remove and discard the K1 relay.

(b) Remove and discard the 100-ohm resistor connected between terminals 2 and 4 of the 161B filter or 205A repeating coil. The remaining wire(s) on terminal 4 should not be disturbed.

(c) Disconnect and remove the wire connecting terminal 6 of the 161B filter or 205A repeating coil and terminal 7 of the K1 relay socket.

(d) Connect a 68-ohm resistor between terminal 2 of the 161B filter or 205A repeating coil and terminal 7 of the K1 relay socket.

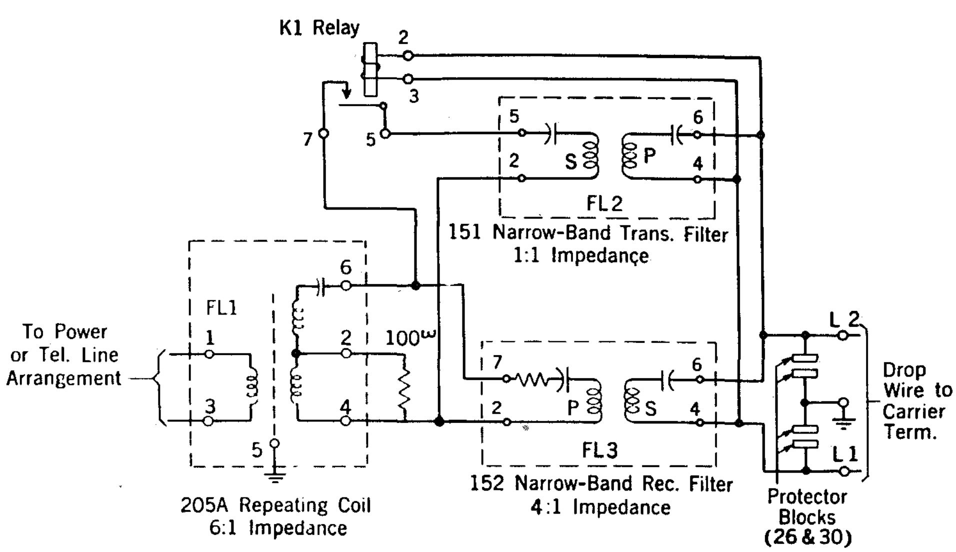


Fig. 21 - M1S5 Terminating Subscriber Coupling Unit with 205A Repeating Coil

(e) Connect a 33-ohm resistor between terminal 4 of the 161B filter or 205A repeating coil and terminal 7 of the K1 relay socket.

(f) Connect a 68-ohm resistor between terminals 5 and 7 of the K1 relay socket.

(g) Disconnect the second wire from terminal 6 of the 161B filter or 205A repeating coil and transfer it to terminal 5 of the K1 relay socket.

(h) Transfer the wire on terminal 7 of the 152-type filter to terminal 5 of the same filter.

M1C3 Broad Band Coupling Unit

General

2.13 The M1C3 broad band coupling unit is provided in four different forms, one for connecting a carrier terminal or a termination to a power line, two for connecting a carrier terminal or a termination to a telephone line, and a fourth for interconnecting a power line and a telephone line at a carrier junction point. One of the coupling units for connecting to telephone lines is for use on telephone lines carrying only voice-frequencies in addition to the M1 carrier while the other is for use on lines carrying other carrier frequencies as well. The latter is also employed where it is desired to minimize transmission of M1 frequencies beyond the carrier section.

2.14 The M1C3 coupling unit is shown in Figs. 22 to 29, inclusive. The purpose of filter FL1 is to transform the nominal 600-ohm characteristic impedance of the carrier line to approximately 100 ohms for connection to a common terminal, multi-subscriber terminal, to a terminating resistance, or to a repeating coil used for interconnecting a power line and a telephone line. FL1 in the broad band coupling unit is the same as FL1 in the terminating subscriber coupling unit except that in the broad band coupling unit, terminal 6 is not used. As in the terminating subscriber coupling unit, FL1 is of two types depending on the date of manufacture. In the early types an autotransformer was used while in the later types FL1 is a balanced repeating coil.

Power Line Application

2.15 When the unit is used to couple a carrier terminal to a power line, termination of the power line at carrier frequencies is effected by the impedance, as seen from the line side of FL1, of the carrier terminal which is connected via the carrier drop wire to terminals L1 and L2 as shown in Figs. 22 and 23. This carrier terminal provides an approximate termination only at its transmitting and receiving frequencies. At other frequencies the line is unterminated. If, in a given installation, several channels are used, the carrier terminals associated with the different channels are all multipled together and then connected via a single carrier drop wire across terminals L1 and L2. Thus, the line will be approximately terminated at all the frequencies associated with the different channels employed. Where the coupling unit is used merely to terminate a section of power line at carrier frequencies, a 100-ohm resistor R1 is connected across terminals L1 and L2 in place of the carrier terminal drop wire. This resistance

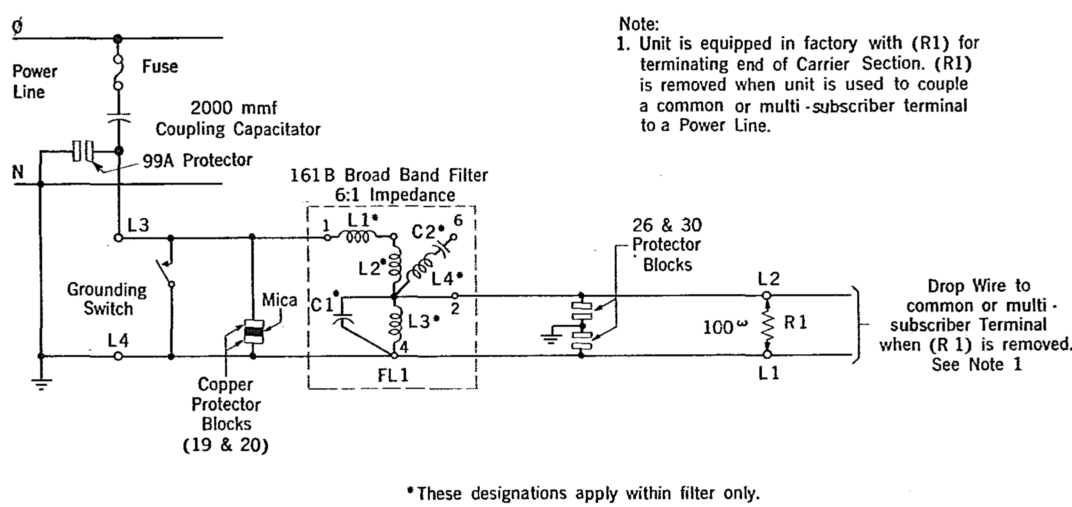


Fig. 22 - M1C3 Broad Band Coupling Unit with 161B Filter - Power Line Application

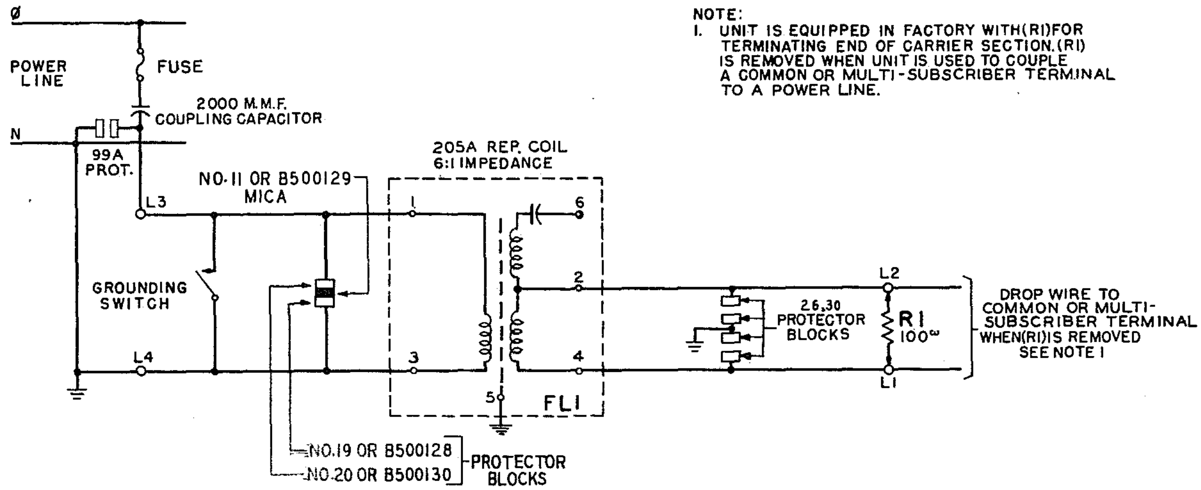


Fig. 23 - M1C3 Broad Band Coupling Unit with 205A Repeating Coil - Power Line Application

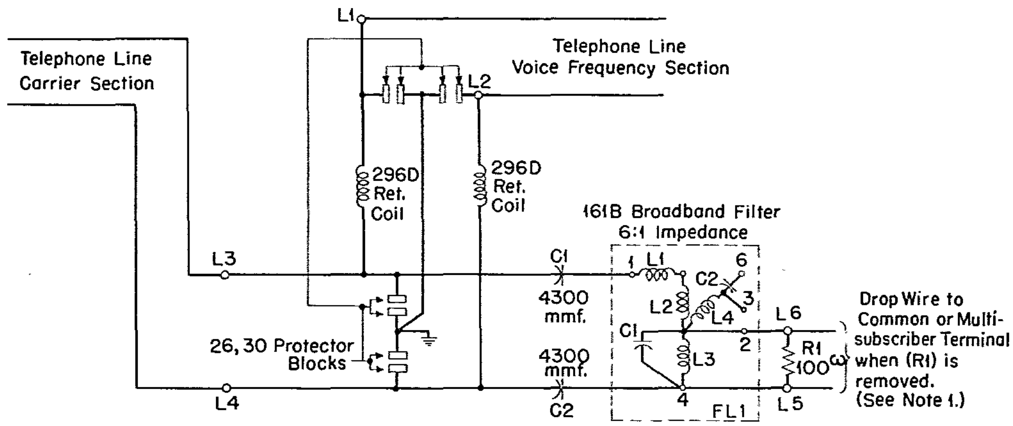
effectively terminates the power line in 600 ohms at all frequencies between 150 and 420 kc due to the transformer effect of FL1. In Fig. 22, coils L1, L2 and L3 supply 60-cycle drainage to ground whereas in the newer type, illustrated in Fig. 23, winding 1-3 of the repeating coil supplies this drainage. Protection on the power line side is provided by means of copper blocks with a mica separator and a safety switch is included as in the bridging subscriber coupling unit (see Paragraph 2.10). Carbon block protectors are provided at the carrier drop terminals.

Telephone Line Application

2.16 The features of the broad band coupling unit for telephone line application, shown in Figs. 24, 25, 26 and 27, are similar to the arrangements for power line applications previously described. As previously mentioned, the isolating coils or filters are included in the coupling unit housing. The coupling capacitance is divided between two capacitors, one in each side of the line, which are mounted in the coupling unit box. Carbon block protectors are provided on both line sides of the unit. No protection is included at the drop wire terminals. The protection normally furnished at the carrier terminal end of the drop wire is considered adequate when the carrier terminal is near the coupling unit pole and is connected to the same ground as the coupling unit. When the carrier terminal and its associated coupling unit are located in such a way that a common ground can not be obtained, a separate protector containing 26-30 protector blocks is installed at the coupling unit end of the drop wire. No grounding switch is provided. Where only voice frequencies are involved in addition to the M1 carrier, isolation of the carrier section is accomplished by the retard coils mounted in the coupling unit box as shown in Figs. 24 and 26. Where other carrier frequencies are employed on the telephone pair, or where suppression of M1 frequencies beyond the carrier section is required, a low pass filter is employed in place of the inductances as shown in Figs. 25 and 27. A 100-ohm resistor R1 serves the same function as in the power line application for terminating a line section at carrier frequencies at a location where no carrier terminal is provided. Figs. 24 and 25 show the early type of coupling unit employing the autotransformer. However, this arrangement causes unbalance both in the telephone line and drop wire. Therefore, in the later types shown in Figs. 26 and 27, a balanced repeating coil is employed. This coil also has a grounded shield between its windings to reduce longitudinal currents which might otherwise flow between the line and drop wire. The repeating coil is an air core transformer, thus modulation products resulting from the combining of several frequencies from the various terminals which might be connected to the coupling unit are reduced. In the early type coupling unit, the autotransformer contains a metallic core.

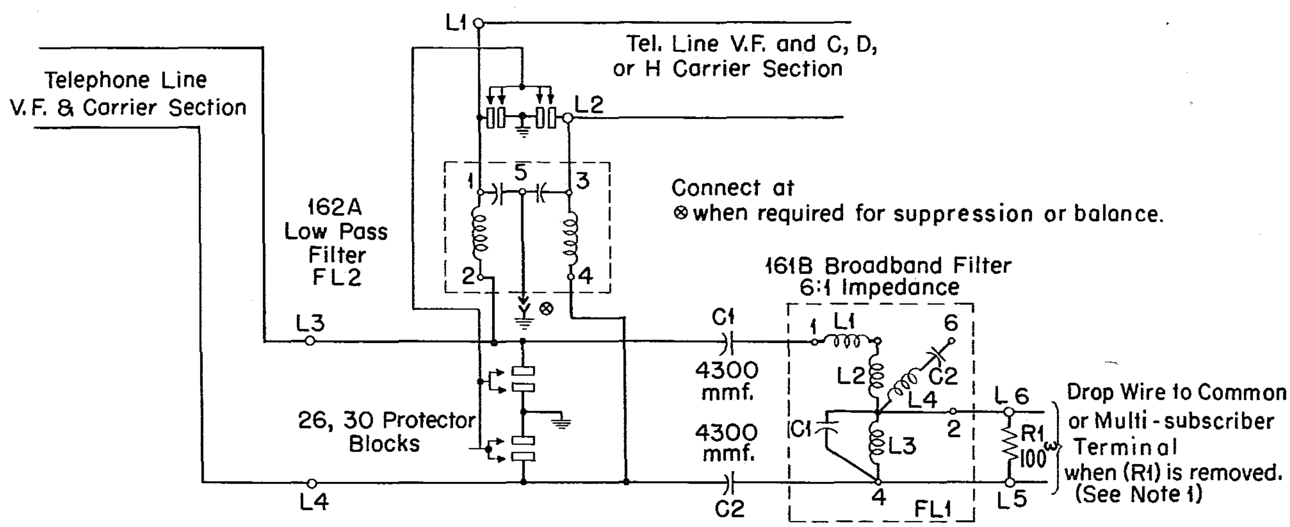
Interconnection of Power and Telephone Lines

2.17 For cases where a telephone line is available for part of a system route and a power line is used for the remainder of the route, a broad band coupling unit of the junction type is used to interconnect the two types of line as shown in Figs. 28 and 29. In the



NOTE:
1. Unit is equipped in factory with (R1) for terminating end of carrier section. (R1) is removed when unit is used to couple a common or multi-subscriber terminal to a telephone line.

Fig. 24 - M1C3 Broad Band Coupling Unit with 161B Filter - Telephone Line Application Where No Other Carrier Is Involved



NOTE:
1. Unit is equipped in factory with (R1) for terminating end of carrier section. (R1) is removed when unit is used to couple a common or multi-subscriber terminal to a telephone line.

Fig. 25 - M1C3 Broad Band Coupling Unit with 161B Filter - Telephone Line Application Where C, D or H Type Carrier Is Involved

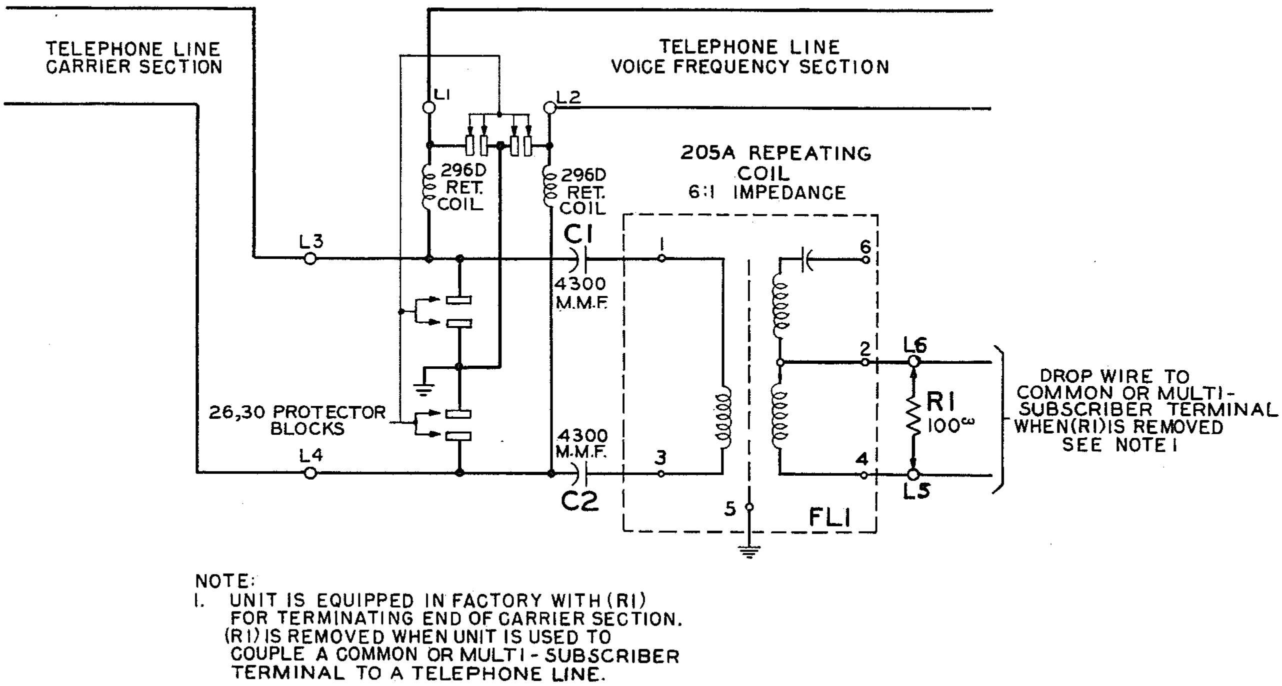


Fig. 26 - M1C3 Broad Band Coupling Unit with 205A Repeating Coil - Telephone Line Application Where No Other Carrier Is Involved

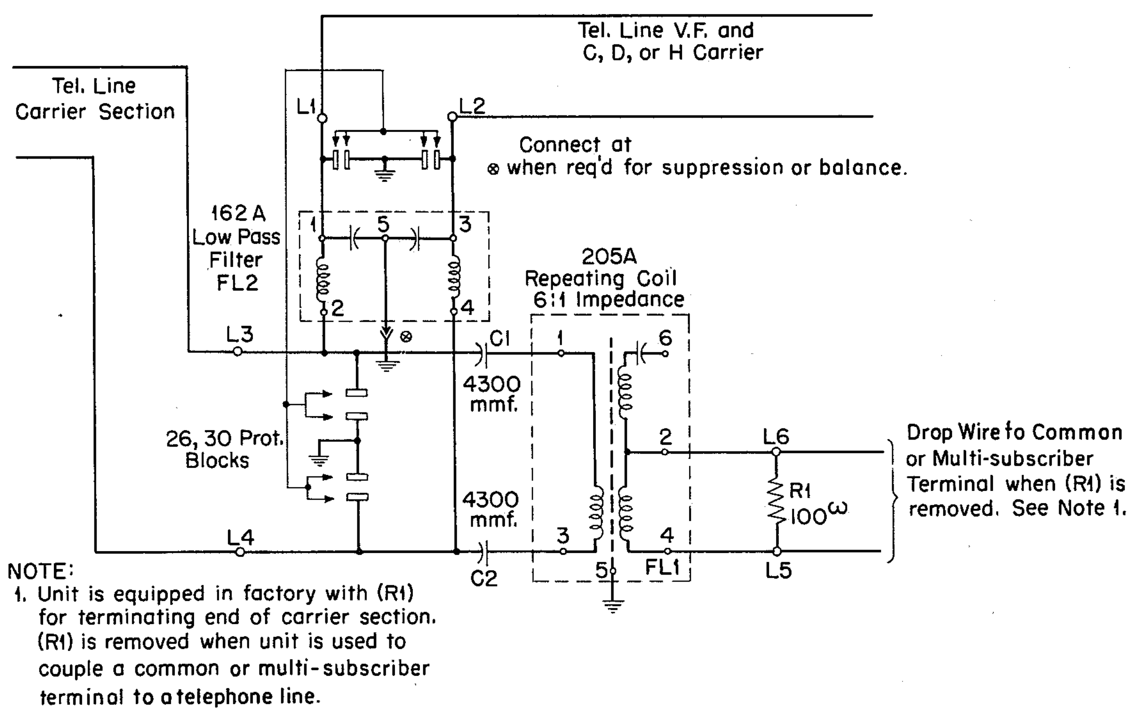


Fig. 27 - M1C3 Broad Band Coupling Unit with 205A Repeating Coil - Telephone Line Application Where C, D or H Carrier Is Involved

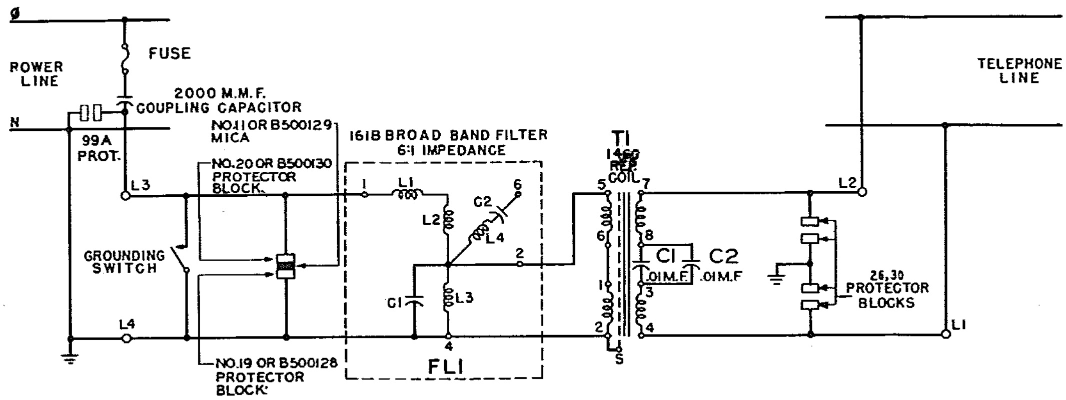


Fig. 28 - M1C3 Broad Band Coupling Unit for Interconnecting a Power Line and a Telephone Line (Early Type)

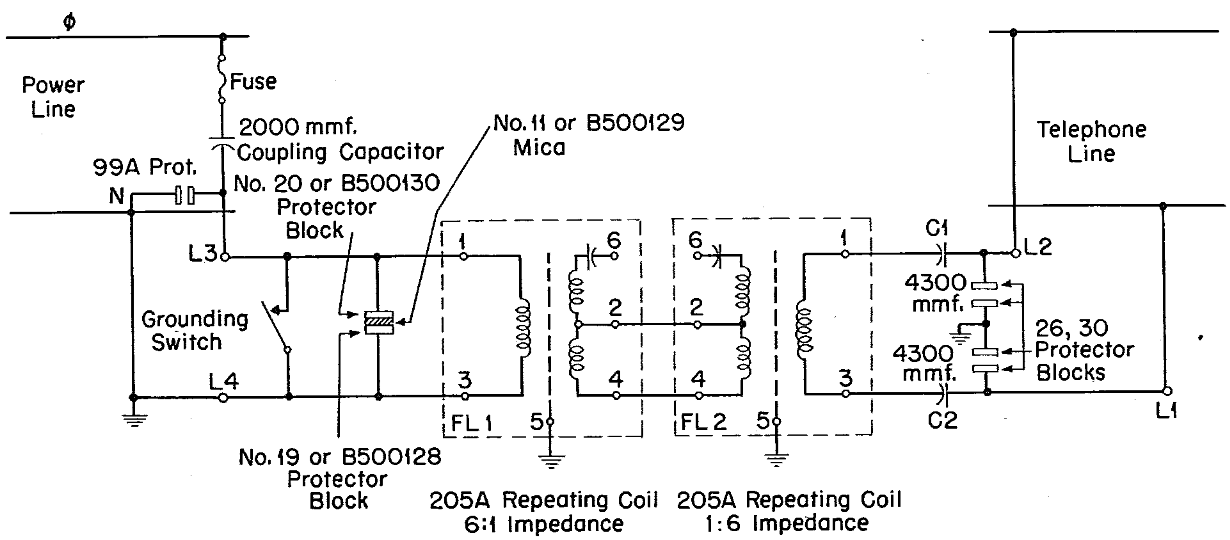


Fig. 29 - M1C3 Broad Band Coupling Unit for Interconnecting a Power Line and a Telephone Line Utilizing 205A Repeating Coils

early type, the power line side of this coupling unit is the same as the early type broad band coupling unit previously described for power line applications. In addition, an impedance matching and isolating repeating coil is used between the low impedance side of filter FL1 and the telephone line. In the later types, two balanced repeating coils, both of which are identical with the repeating coil employed with the other coupling units, are connected together with their low impedance windings facing each other. Both types contain the copper block and safety switch arrangement, described above, for protection of the power line side of the unit and carbon block protectors on the telephone line side.

(D) Subscriber Terminal Transmission Equipment

General

2.18 The subscriber station equipment consists of a station protector, carrier drop wiring, a subscriber terminal, a combined telephone set, a 14-conductor cord connecting the subscriber terminal to the telephone set and a voltage regulator if the latter is required. In a case where the 60-cycle power supplies to the subscriber and common terminals differ in phase by a fixed amount, a phase shifter is added to the subscriber terminal if divided-code ringing is required.

2.19 The subscriber terminal consists of a wall mounting plate, an electronic chassis assembly, and its housing (see Fig. 4). It is equipped with a power supply cord and a polarized plug for connection to 60-cycle, 110-120-volt outlet provided by the customer. The voltage regulator, if used, is connected between the outlet and the polarized plug of the subscriber terminal. Two transformer primary taps are provided for connecting the power cord either to line voltages below 115 volts or to line voltages of 115 volts or over. If the voltage regulator is used, the taps are connected for voltages below 115 volts. Some free air space is required around the housing of the subscriber terminal and voltage regulator to dissipate the heat.

2.20 A schematic of the terminal and telephone set is shown in Fig. 30 and an apparatus list is given in Tables 3 and 4, attached. The equipment uses a 328A3 telephone set for manual service or a 328C3 telephone set for dial service. The complete terminal chassis is made up of two subassemblies. The larger subassembly chassis is the receiver and power supply unit, and the smaller subassembly chassis contains the transmitter unit. The two subassemblies have adjacent terminal strips and are connected together with short soldered straps. One relay, K2, is mounted on the receiver chassis and performs signaling and switching functions as later described. Another relay, K1, is mounted on the transmitter chassis and performs signaling and switching functions in addition to selection of the appropriate transmitting frequency on revertive calls. If a phase shifter is furnished it is mounted by means of two terminal feet which are numbered 16 and 17, and fit under correspondingly numbered terminals on TS3 in the subscriber terminal. The green conductor in the telephone set cord is disconnected from terminal 16 on TS3 and connected to a terminal on the phase shifter. A schematic diagram of the phase shifter circuit showing its relation to the subscriber terminal circuit is seen in Fig. 31 and a description of the circuit is given in Paragraph 3.46. In order to obtain the correct phase shift, the subscriber terminal must include resistor R20 which is included in all late terminals for protection of the power transformer. Also resistor R19 must be 100,000 ohms instead of the 51,000 ohms furnished in early terminals to maintain the ringing sensitivity when the phase shifter is used. Use of the 100,000-ohm resistor for R19 will not affect the operation of the subscriber terminal when the phase shifter is not used.

Transmitter

2.21 The transmitter consists of a modulator-oscillator tube V1 and a power amplifier tube V2 coupled to the carrier line terminals through the output filter FL1. The transmitter is arranged to operate at either of two frequencies, one for normal calls, and the other for the use of one of two subscribers talking over the same channel (revertive call). The pairs of frequencies used for each transmitting channel are shown in Paragraph 1.06. The transmitter also provides supervisory signals to the central office and, when required, dial pulses to operate the office equipment. The presence or absence of carrier on the line is used to provide supervision and dialing as described in Part 3. Speech intelligence is transmitted by amplitude modulating the carrier with speech.

2.22 The oscillator portion of tube V1 consists of the cathode, grid G1, and grids G2 and G4, connected together, operating as the plate of a triode. The frequency of oscillation is controlled either by crystal Y1 or by crystal Y2. L1 and C4 are part of the oscillating circuit and are tuned to a frequency above that of the crystal to prevent spurious oscillations at unwanted frequencies. The amplitude of oscillation is limited by grid G1 which, when driven positive, draws current through resistor R3. The plate of V1 receives part of the electron stream which passes through these grids. This stream has been modulated by the carrier voltage on grid G1 and thus the carrier-frequency appears on the plate. Grid G3 is driven by voice-frequency voltages from the transmitter in the telephone set through step-up transformer T1. Thus, grid G3 further modulates the electron stream, adding its effect to that produced by grid G1. The result is a combination of audio and modulated carrier frequencies at the plate. The plate is resistance-fed through the dial pulsing contacts, and the modulated carrier output of V1 is coupled to the grid of V2 through the interstage network consisting of C8, R9, C22 and L2. L2 and C22 are tuned to a frequency between the Y1 and Y2 frequencies to offer high impedance to the carrier-frequency and sidebands from V1 and to provide a low impedance path to ground for the speech components and also the harmonics of the carrier-frequency voltage to effectively prevent the latter from reaching the line.

2.23 Tube V2 is used as a class A amplifier working into filter FL1 which acts both as a transformer and filter. It matches the plate impedance of V2 to the 100-ohm impedance of the carrier drop wire and acts as a filter to pass only the carrier and its sidebands.

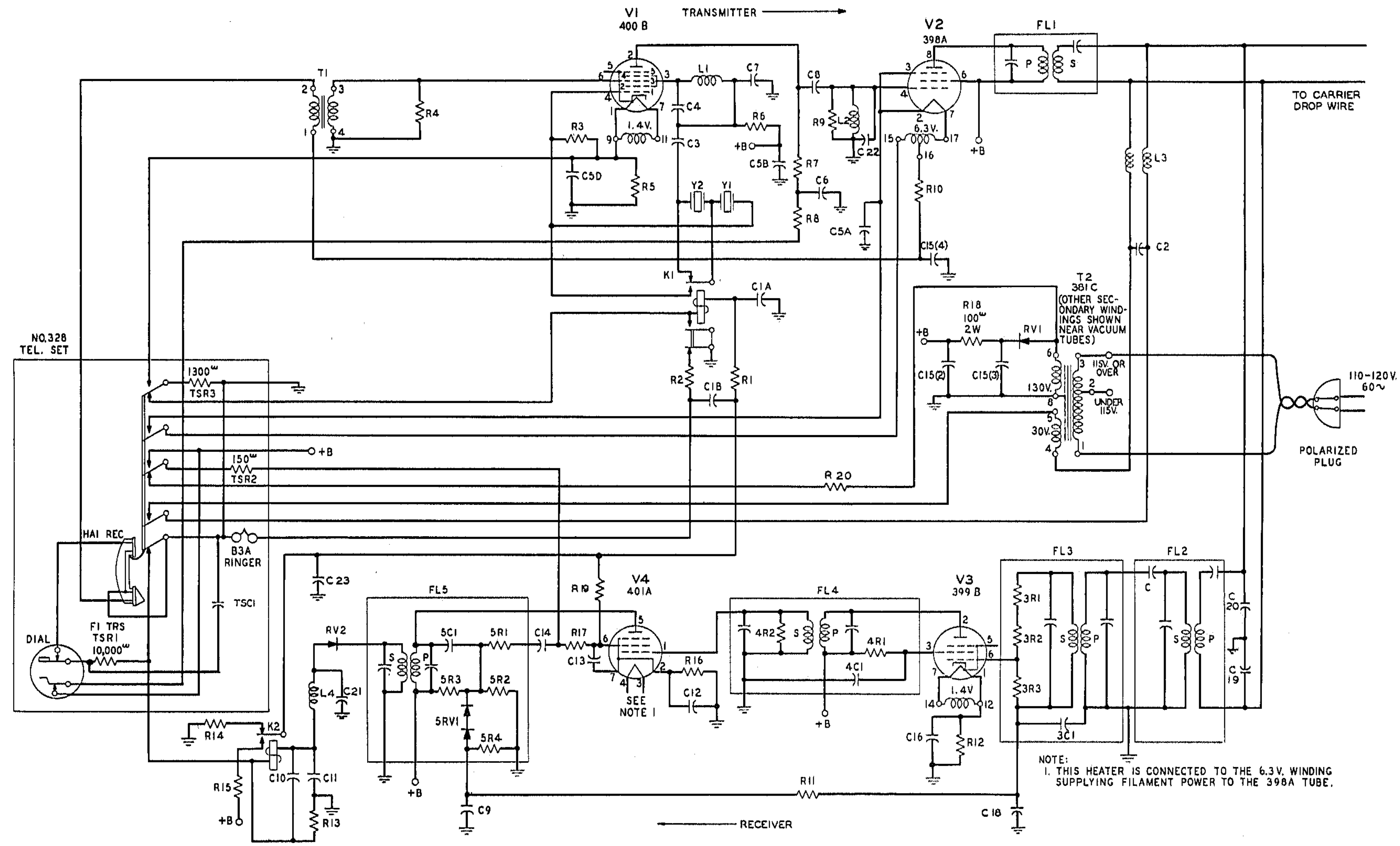


Fig. 30 - Schematic Wiring of M1S1 Subscriber Terminal and Telephone Set

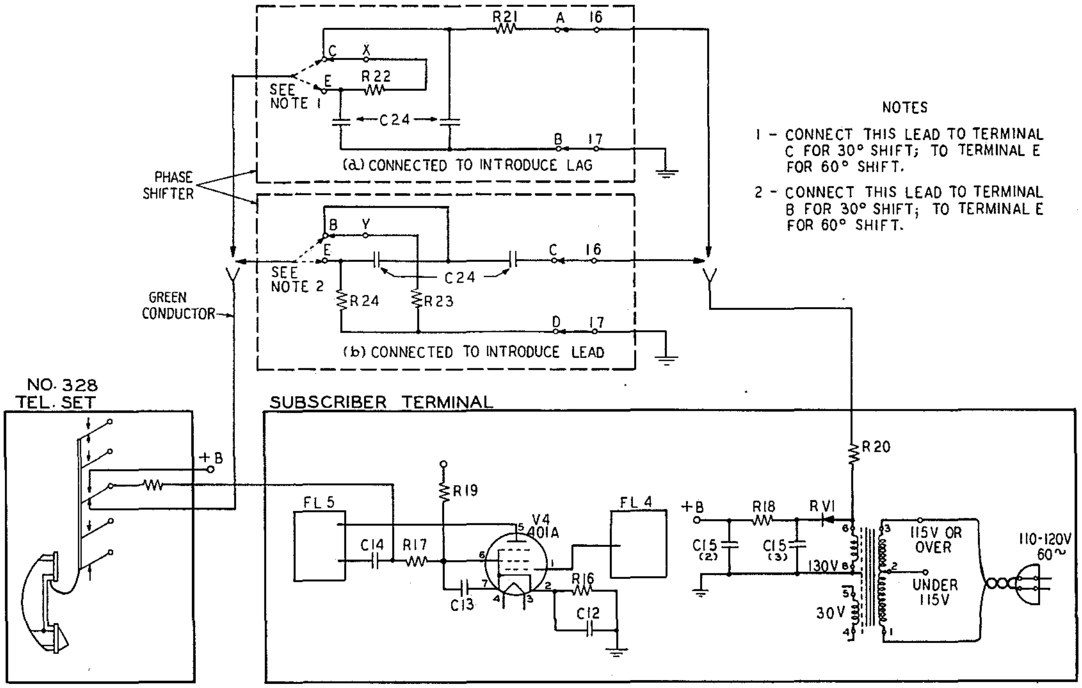


Fig. 31 - Schematic of Phase Shifter and External Connections - Individual Subscriber Terminal

Outside the pass band, the filter presents a high impedance to the carrier drop wire. Besides further reducing harmonic output, the filter minimizes cross-modulation with other channels of the system.

2.24 In the stand-by condition, with the handset on its cradle, the heater of V1 is energized, but the cathode return to ground through TSR3 in the telephone set is opened by the switchhook contacts. However, a small amount of cathode current flows through resistance R5 to ground during stand-by periods and the tube is allowed to oscillate at very low output. The voltage supply to the filament of V2 is opened by another set of switchhook contacts so that V2 can not amplify this small signal and pass it to the line.

2.25 Operation of the switchhook contacts, when the handset is lifted from the cradle, signals the central office by decreasing the cathode bias of tube V1, which allows it to oscillate at full output, and by closing the circuit to supply filament power to V2. After the contacts are closed, the filament of tube V2 reaches operating temperature in about one second. The cathode current of tube V2 returns to ground via the connecting cord and through the transmitter in the handset, thus providing the necessary current to energize the transmitter. When the switchhook is restored to stand-by condition, handset on cradle, the circuit to the filament of V2 is opened, but due to slow cooling of the filament, V2 will continue to amplify for several seconds. However, bias resistor TSR3 is also disconnected by the switchhook contacts thus reducing the output of V1 to a low value. At the same time, however, another pair of contacts completes the circuit to relay K1 which will operate momentarily, since relay K2 is still operated due to presence of carrier from the common terminal. This, in effect, changes the low output of V1 to the Y2 (revertive) frequency and assures the release of the common terminal relays which then remove the common terminal carrier from the line, allowing relays K2 and K1 to release. The small amount of output from V1 at the Y2 frequency is insufficient to cause operation of the common terminal revertive frequency circuits. By means of the above operations, prompt supervisory signals are produced in spite of the slow cooling time of the filament of V2. If the switchhook contacts are opened and closed too rapidly, the first operations will break the carrier intermittently but the filament of tube V2 will tend to cool down. Thus, the carrier output is reduced and may not be sufficient to control the supervisory relays in the common terminal.

2.26 Due to filament cooling and slow oscillator build-up, interruptions of carrier at the dialing rate can not be performed in the same way as switchhook interruptions. Accordingly, interruptions of the carrier for dialing purposes are accomplished by opening only the plate supply of V1. In dialing, voltage is continuously supplied to grids G2 and G4, acting together as the plate of the triode section of V1, hence, the triode portion of the tube oscillates without interruption during the dialing process. The network R7, R8 and C6 provides some shaping for the beginning and end of each dial pulse.

Crystal Switching

2.27 Whether crystal Y1 or Y2 is used depends on the operation of relay K1 which short-circuits the unused crystal. If no carrier is being transmitted from the common terminal (as a result of no carrier transmission from a terminal on the same channel), relay K2 at the output of the receiver remains unoperated and, hence, relay K1 can not operate. For this condition, crystal Y1 is connected to the oscillator circuit. Operation of the switchhook with no previous carrier on the line prevents relay K1 from operating so that the calling party remains on the frequency of Y1 regardless of the presence of carrier received from the common terminal after operation of the switchhook. If carrier from the common terminal is present on the line before the handset is removed from its cradle, relay K1 has already been locked up through its own contacts in series with the K2 relay contacts, hence, the oscillator is controlled by crystal Y2. If carrier from the common terminal disappears while the handset is off of its cradle, both K2 and K1 will release and the transmitted frequency will change to that controlled by Y1. Thereafter, the carrier from the common terminal will reappear and relay K2 will reoperate, but relay K1 will remain unoperated.

Receiver

2.28 The receiver subchassis is the larger of the two subchassis assemblies comprising the complete subscriber terminal unit. In addition to the receiving equipment, the power supply circuit for the transmitter, receiver, and line coupling unit relay are mounted on this unit.

2.29 The receiver operates at one of the carrier frequencies listed in Paragraph 1.06, depending on the channel employed. Carrier frequencies from the drop wire enter through filters FL2 and FL3, which attenuate unwanted frequencies and provide a high impedance input to the grid of tube V3 as well as a voltage step-up from the 100-ohm impedance of the drop wire. For normal gain, the grid of V3 is left connected to terminal 5 of FL3. Approximately 6 db additional gain may be obtained by connecting the grid of V3 to terminal 8 of FL3. The higher gain condition, however, increases the likelihood of false signals from static or other disturbances. Tube V3 is a remote cut-off amplifier. The output of tube V3 passes through the interstage coupling filter FL4, which provides additional suppression of unwanted frequencies, to tube V4 which provides further amplification. The output of tube V4 is coupled to a germanium demodulator RV2 through output filter FL5. The demodulator is followed by a filter consisting of inductance L4 and capacitors C11 and C21 which suppress the carrier frequency components and any harmonics thereof in order to minimize interference to radio broadcast receivers. The output of demodulator RV2 has a d-c component, which is used to energize relay K2 for operating the ringer and relay K1 and a voice-frequency component, most of which is by-passed around the relay winding by capacitor C10. When the handset is on its cradle, the d-c component flows through the relay to ground directly. When the handset is off its cradle, the d-c and voice-frequency components flow to ground through R13. The resulting voltage across the latter is applied to resistor TSR1 in the telephone set in series with the handset receiver. The receiver in the telephone set is shunted by capacitor TSC1 which, together with resistor TSR1, acts to produce the desired voice-frequency characteristic and level. The carrier receiving circuit is energized at all times for the receipt of ringing signals.

2.30 The AGC voltage for controlling the receiver gain is obtained by rectifying some of the output carrier voltage at the primary side of the output filter FL5. The copper-oxide varistors (5RV1) and associated resistors and capacitors are mounted inside the filter can. The derived d-c voltage is developed across resistor 5R4 and is returned through filter FL3 to the grid of tube V3 as negative bias for controlling the gain. The varistor control circuit is biased with a d-c voltage from the voltage divider 5R2 and 5R3 so chosen that automatic control does not become effective until the input signal voltage exceeds a predetermined value.

2.31 The detailed operation of relays K1 and K2 is discussed in Part 3, which gives an over-all system description of the signaling arrangements.

Power Supply

2.32 The power supply transformer T2 for the subscriber terminal is indicated in Fig. 30. The filament of V2 and the heater of V4 are supplied from winding 15-16-17. Separate windings on T2 are used to supply the heaters of tubes V1 and V3 in order to permit use of individual cathode bias voltages since, in each of these tubes, the cathode is connected internally to one side of the heater. Winding 9-11 supplies V1 and winding 12-14 supplies V3. Positive d-c plate voltage is supplied from winding 6-8 of transformer T2 in combination with varistor RV1 and a smoothing filter composed of R18 and two sections of C15. Power for operation of the K1 relay is obtained from the d-c plate supply. Winding 4-5 supplies 30 volts rms for operation of the coupling unit relay when one is used. Plate voltage is present on some of the wires in the telephone set connecting cord and appears on the dial contacts and some of the switchhook contacts.

Coupling Unit Relay

2.33 When the handset is removed from its cradle, the relay, if one is used, in the bridging subscriber coupling unit or in the terminating subscriber coupling unit at the pole, is energized, connecting the line side of the transmitting filter to the broad band filter, thus providing a transmission path for the subscriber terminal transmitting frequencies. In the stand-by condition, the path from the transmitting filter is open, thus reducing its bridging loss to carrier transmission for other subscribers. The operating voltage for this relay is obtained from the 30-volt winding of the power transformer mentioned above and wired through a pair of switchhook contacts. This 60-cycle voltage is connected to the carrier drop wiring through the network L3 and C2. L3 prevents carrier currents on the drop wire from being shunted by the 30-volt power transformer winding and, since it is a 2-winding coil, it also maintains the balance of the drop wire circuit to ground.

(E) Multi-Subscriber Terminal Transmission Equipment

General

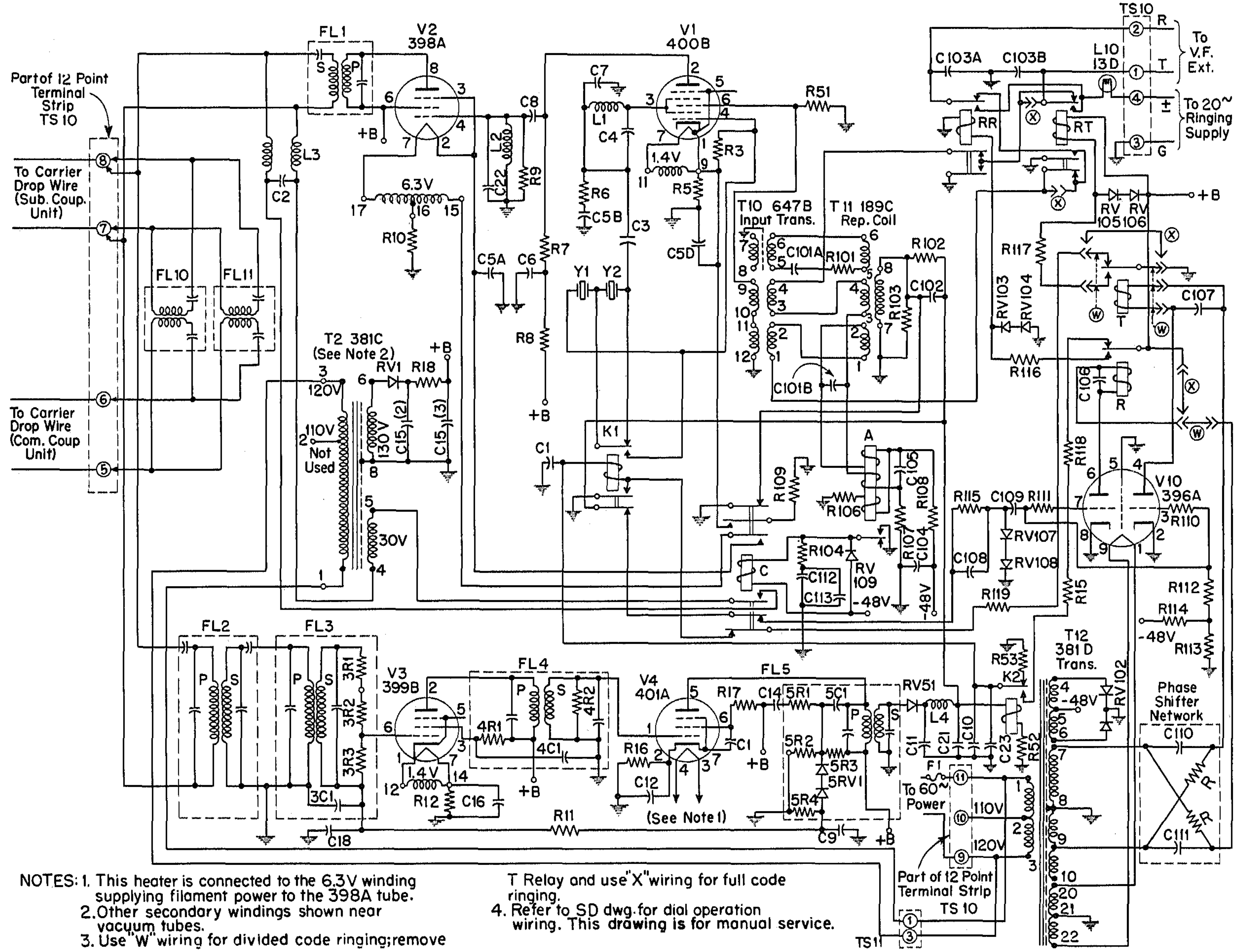
2.34 The multi-subscriber terminal consists of a basic unit and a modified subscriber terminal of the type described under (D) of Part 2. The basic unit contains the 2-wire to 4-wire terminating equipment, signaling and switching circuits, phase shifter and a part of the power supply. The modified subscriber terminal contains the carrier-frequency equipment plus the modulating and demodulating circuits, two relays, K1 and K2, and the remainder of the power supply. The modified subscriber terminal is mounted on the basic unit and connected to it by a local cable. A schematic of the multi-subscriber terminal is shown in Fig. 32 and Fig. 5 is a photograph of the equipment.

Carrier-Frequency Equipment

2.35 The carrier-frequency equipment of the transmitter and receiver together with the crystal switching feature and coupling unit relay supply are identical with that of the subscriber terminal described under Paragraphs 2.21 through 2.31. However, grid G3 of tube V1 in this case is driven by voice-frequency voltages directly from the 2-wire to 4-wire terminating equipment. Also, the demodulator RV51 is reversed in polarity as compared to RV2 in the subscriber terminal and the arrangement of relay K2 is slightly different. The circuit is enabled and disabled in the same manner as that of the subscriber terminal although a relay under the control of the subscribers' switchhooks is employed to perform the functions of the switchhook contacts of the regular M1 subscriber terminal. Dialing is accomplished by interrupting the plate voltage of V1 (as in the subscriber terminal) through the contacts of a relay which is under control of the subscribers' dials.

Voice-Frequency Transmission Equipment

2.36 Fig. 33 is a simplified schematic of the voice-frequency portion of the multi-subscriber terminal. The 2-wire to 4-wire terminating circuit consists of transformers T10 and T11. Windings 9-10 and 11-12 of T10 are connected in series and terminated in R51. Voice frequencies received from the subscriber stations over the 2-wire extension are stepped up through this transformer and applied between the modulating grid of V1 and ground. The value of R51 has been chosen to produce voice-frequency levels from subscribers close to the terminal which will modulate the carrier to about the same extent as is done in the subscriber terminal. A compromise balancing network of 910 ohms and 2 mf is employed. The return loss at this point will vary over a wide range due to the different distances to the several subscriber stations on the voice-frequency extension and the fact that two or more subscribers may have their receivers off the hook simultaneously. In the receiving direction, the voice frequencies are demodulated by RV51. The radio frequency suppression filter consisting of coil L4 and capacitors C11 and C21 is the same one used in the subscriber terminal. The voice-frequency voltage is



NOTES: 1. This heater is connected to the 6.3V winding supplying filament power to the 398A tube.
2. Other secondary windings shown near vacuum tubes.
3. Use "W" wiring for divided code ringing; remove T Relay and use "X" wiring for full code ringing.
4. Refer to SD dwg. for dial operation wiring. This drawing is for manual service.

Fig. 32 - Simplified Schematic of the Multi-Subscriber Terminal

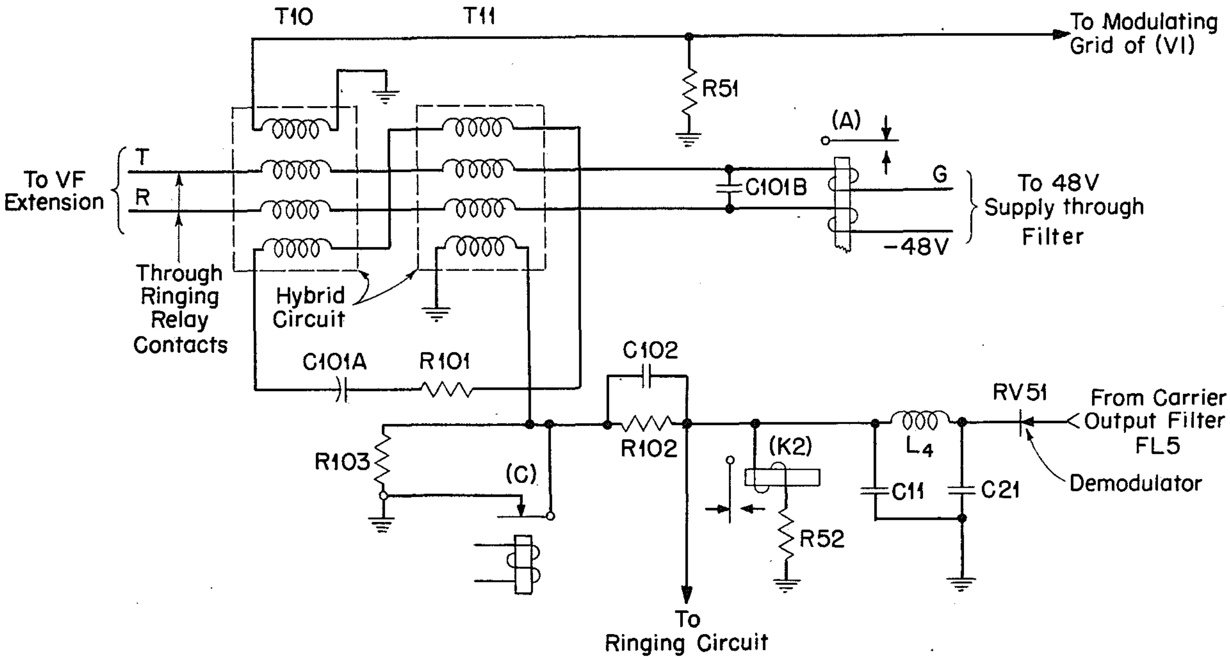


Fig. 33 - Simplified Schematic Showing Principal Features of Multi-Subscriber Terminal Voice Frequency Circuit

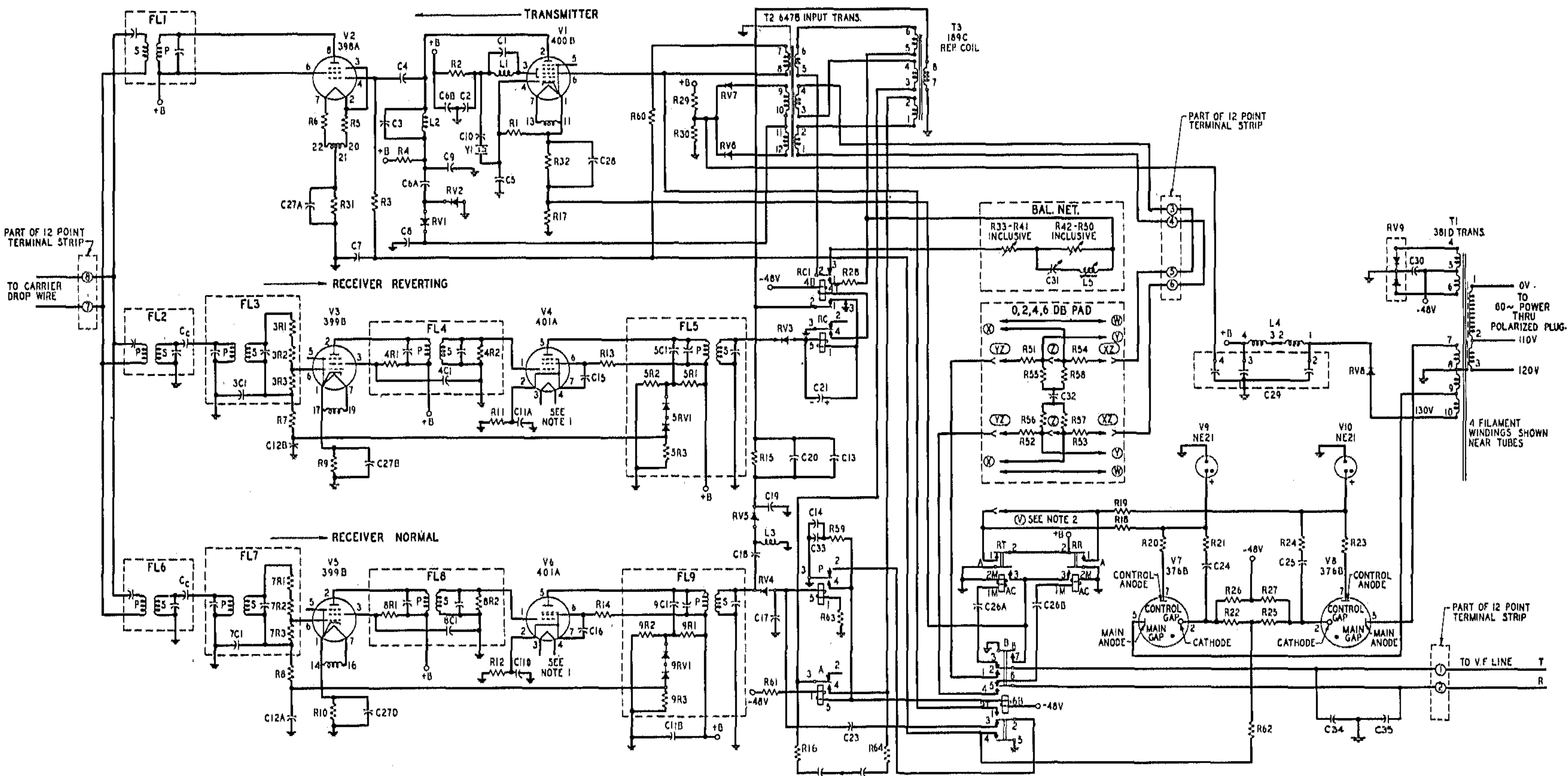
developed across the impedance of the K2 relay and R52 in series and is applied through a network consisting of R102 and C102 to the high impedance winding of T11 which is shunted by R103. This network has been designed to provide speech levels at subscriber stations close to the terminal which are slightly lower than those received by subscribers using subscriber terminals. This is necessary in this case to prevent singing of the system under certain conditions. The frequency characteristic is equivalent to that existing in the regular M1 system. The transmission loss to and from subscribers at greater distances from the terminal will be greater by the amount of loss in the voice-frequency line. During the idle condition, the high impedance winding of T11 is short-circuited to ground through a contact on the C relay. This is done to provide an impedance across which the signaling voltage is developed which will not be dependent on the impedance of the voice-frequency line as seen through T11.

Power Supply

2.37 There are two power supply circuits in the multi-subscriber terminal. One of these is the usual power supply circuit of the modified subscriber terminal unit which is described in detail in Paragraph 2.32. The d-c plate voltage supply also furnishes power for the operation of relays RR and RT in the basic unit and, where full-code ringing is employed, provides plate voltage to tube V10 in the basic unit.

2.38 The other power supply is included in the basic unit. The power supply transformer T12 is shown in Fig. 32. Winding 4-5-6 feeds into varistor RV102 to provide direct current at a nominal voltage of -48 volts for operation of the A and C relays and to provide common battery supervision and transmitter current to the subscriber stations on the voice-frequency extension. This voltage also provides bias for tube V10 in the basic unit and, in case a-c - d-c ringing is employed, it is used for the d-c bias of the ringing voltage. Winding 20-21-22 furnishes the heater supply for tube V10. In case of divided-code ringing, winding 7-8-9 supplies the a-c plate voltage through the phase shifter network to tube V10.

2.39 The primary windings of both power transformers T12 and T2 are connected in parallel with each other and connected to the high line voltage terminals 9 and 11 on terminal strip TS10. The low line voltage tap of the primary of power transformer T12 is connected to terminal 10 of terminal strip TS10. If the low line voltage connection is used, the power voltage is thus connected to the low line voltage portion of the primary winding of



NOTES:
1. THE HEATERS OF V4 AND V6 ARE CONNECTED ACROSS THE WINDING OF T1, SHOWN AS THE FILAMENT WINDING FOR V2.
2. USE V WIRING FOR BRIDGED RINGING.

Fig. 34 - Schematic of Common Terminal

transformer T12 only. The primary of transformer T12 then acts as an autotransformer to boost the voltage applied to the total primary winding of transformer T2. The low voltage tap of transformer T2 is never employed, and the power cord leads of the modified subscriber terminal are always left connected to terminals 1 and 3 of TS4.

(F) Common Terminal Transmission Equipment

General

2.40 A schematic of the common terminal equipment is shown in Fig. 34. The basic unit equipment of the common terminal, which consists of power supply, relays, gas tubes, and 4-wire to 2-wire terminating equipment, is mounted directly on the chassis at one end. The electronic equipment associated with the transmitter is mounted on a subassembly and is connected to the basic circuit equipment by means of a 15-contact plug. The electronic equipment associated with the two independent receiving circuits is mounted on another subassembly and is connected to the basic unit by means of another 15-contact plug. The two subassemblies are mounted at the opposite end of the chassis from the basic unit equipment. The transmitting and receiving circuits are essentially the same as in the subscriber terminal. However, the transmitter operates at only one frequency and two complete receiving circuits are employed. One receiving circuit is for the normal frequency received from any subscriber or multi-subscriber terminal and the other is for the revertive call frequency which is transmitted from one subscriber or multi-subscriber terminal when a call is in progress between two subscriber stations involving two terminals on the same channel.

Four-Wire Terminating Circuit

2.41 The 4-wire terminating circuit of the common terminal is shown in Fig. 35. This circuit is, in effect, a hybrid arrangement which is made up of transformers T2 and T3. Windings 9-10 and 11-12 of transformer T2 are used as part of the vario-losser circuit for the voice-frequency limiter associated with the transmitter of the common terminal. An adjustable balancing network is provided for balancing the voice-frequency line. This network provides resistance, capacitance, and inductance, all arranged for strapping in various values and combinations to match closely the impedance of any voice-frequency line over the voice-frequency range.

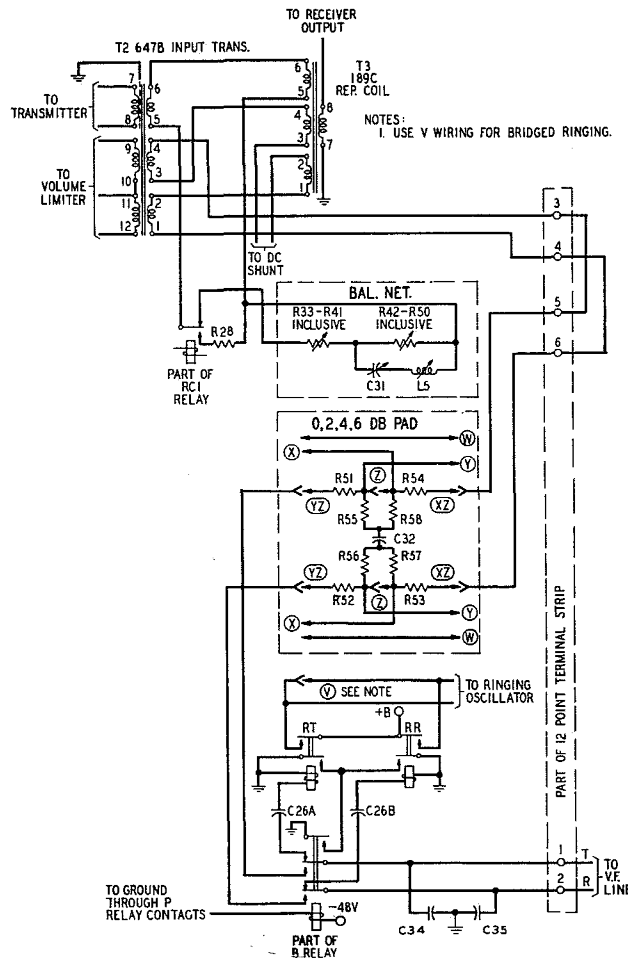


Fig. 35 - Four-Wire Terminating Set and Connection to Voice-Frequency Line - M1C1 Common Terminal

Pad

2.42 A balanced pad is provided for building out the attenuation of the voice-frequency line up to 6 db in 2 db steps. This provides for adjusting the total attenuation of the voice-frequency line to a nominal 6 db loss at 1000 cycles where the loss of the line itself is less than this value. A capacitor is connected in series with the shunt branch of the pad in order to avoid a d-c bridge on the line which would preclude signaling and dialing.

Transmitter

2.43 The circuits for the transmitter, normal receiver, and revertive receiver are shown in Fig. 36. The transmitter at the common terminal, like that at the subscriber terminal, produces amplitude-modulated output

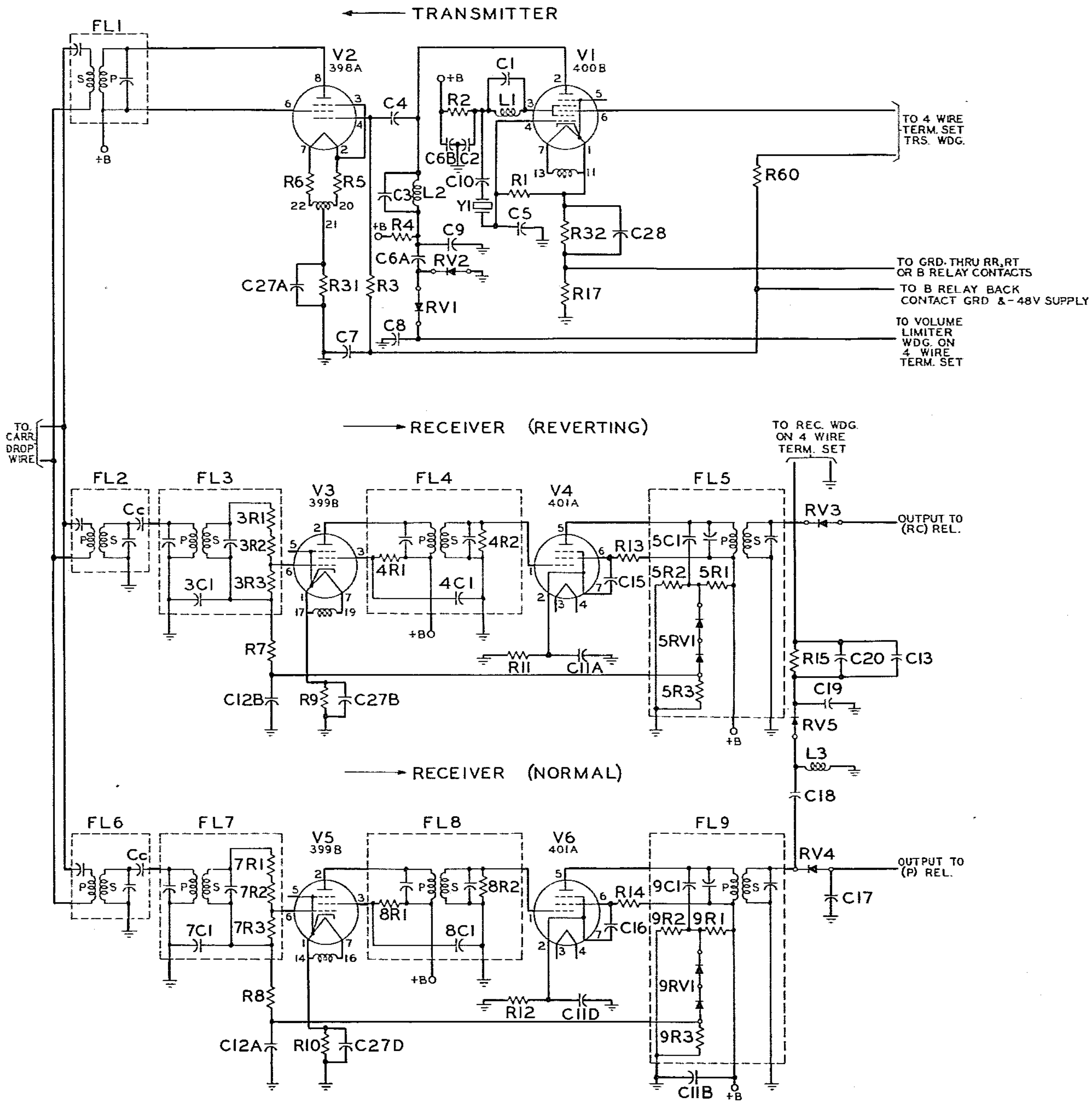


Fig. 36 - Schematic Wiring of Transmitters and Receivers - M1C1 Common Terminal

with unsuppressed carrier. The output from the transmitter is suppressed when the terminal is in the stand-by condition. The transmitter is enabled either when carrier is received from a subscriber or multi-subscriber terminal or when 20-cycle ringing voltage is received from the central office.

2.44 The oscillator-modulator tube V1 and its associated circuit are similar to those used in the subscriber terminal transmitter, except that only one frequency per channel is provided. The range of frequencies for the various channels is from 155 to 230 kc as shown in Paragraph 1.06. L1 and C1 are tuned to a frequency slightly higher than the crystal frequency to prevent spurious oscillations. The output voltage appearing on the plate of tube V1 is coupled to the grid of amplifier tube V2 through the tuned circuit, L2 and C3, and capacitor C4. L2 and C3 present a high impedance to the carrier and its sidebands, but effectively shunt out the voice-frequency components as well as any harmonics of the carrier, thus preventing the latter from reaching the line. The voice-frequency components pass through the network L2 and C3 to varistors RV1 and RV2. The rectified output voltage from this varistor combination controls a volume limiter circuit as described in Paragraph 2.48. Filter FL1 matches the plate impedance of V2 to the nominal 100-ohm impedance of the carrier drop wire and adds further suppression to unwanted frequencies. The pass band of FL1 is considerably narrower than the corresponding filter in the subscriber terminal, since it is required to pass only one carrier frequency and its sidebands. The output of this filter has a high impedance outside the pass band, which prevents bridging loss to other carrier frequencies being transmitted to the same carrier line.

2.45 Both of the common terminal transmitter tubes are continuously heated in order to provide for immediate response to ringing signals from the central office. As shown in Fig. 34, the cathode return of V1 is connected through the high resistance R17, which in addition to a high negative bias placed on the modulating grid G3 through R60 and winding 7-8 of T2 reduces the tube current to a low value during stand-by intervals. The tube therefore, can oscillate at only a very low level. The normal cathode path to ground is closed and the high bias removed from grid G3 by operation of the B relay, which occurs when carrier is received from the line which allows the tube to oscillate at full output. The normal cathode path may also be closed by operation of either of the ringing relays (RT or RR).

2.46 In the stand-by condition, plate current of tube V2 is greatly reduced by application of a high negative bias to the control grid. This bias voltage, like the bias for grid G3 of tube V1, is obtained from the negative 48-volt supply used to operate the A, B, and RC1 relays. The path is through R3, R62, R22, R25, R26, and R27, as shown in Fig. 34. Operation of the B relay short-circuits this high bias by closing the grid return path through to ground.

2.47 When ringing voltage is received over the voice-frequency line from the central office, one or both of the ringing relays (RT and RR) operate and positive pulses are generated by one or both of the gas tube ringing circuits associated with V7 and V9 and with V8 and V10, as shown in Fig. 37. The positive pulses are applied through R62 to both the modulating grid of V1 and the control grid of V2. Operation of either ringing relay has already applied the normal cathode biasing circuit to V1 as mentioned above, and carrier transmission occurs at the same time as, and as a result of, the positive peaks generated by the ringing circuit. Since the positive peaks are greater than the high negative bias on the grids of V1 and V2, the tubes actually are caused to overload so that the peak carrier output is substantially independent of the peak voltage of these positive peaks; thus the carrier pulses are approximately rectangular in shape. The peak value of the carrier pulse is about 5.5 db above the peak value of the normal carrier output of the terminal.

Volume Limiter

2.48 Since the common terminal may be connected through the central office to either local or toll circuits, a wider spread of input speech levels will obtain than at the subscriber or multi-subscriber terminal transmitter. With average talkers, the variation in received talking volumes between a limiting toll connection and a local connection over a short loop is about 35 db. Without automatic adjustment of high level input voltages to prevent overmodulation, the lowest input levels would not modulate the transmitter sufficiently to provide a desirable signal-to-noise ratio, especially during periods of high static noise. This condition is improved by the volume limiting rectifier and vario-losser circuit shown in Fig. 38. The volume limiting rectifier circuit, composed of varistors RV1, RV2, and capacitor C8, rectifies the amplified audio component from the plate of V1 through L2 and C3 and provides a d-c voltage across C8. L2 and C3 are anti-resonant at the carrier frequency and thus keep the carrier voltage

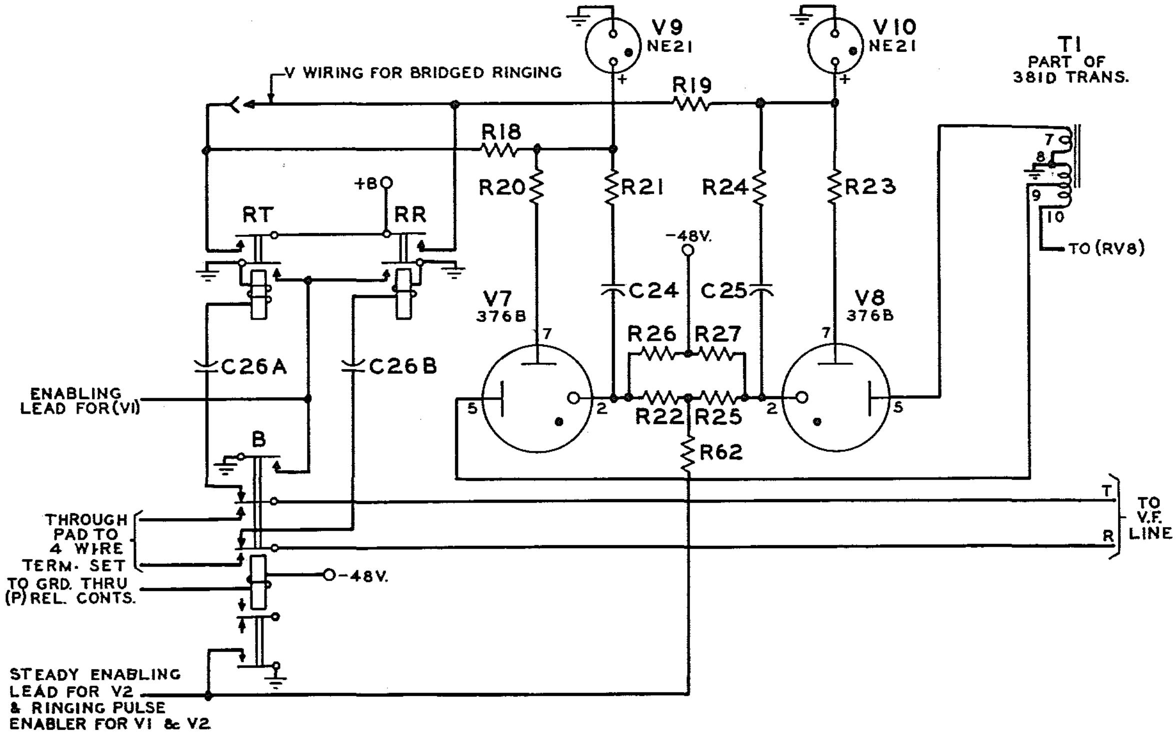


Fig. 37 - M1C1 Terminal Ringing Generator Circuit

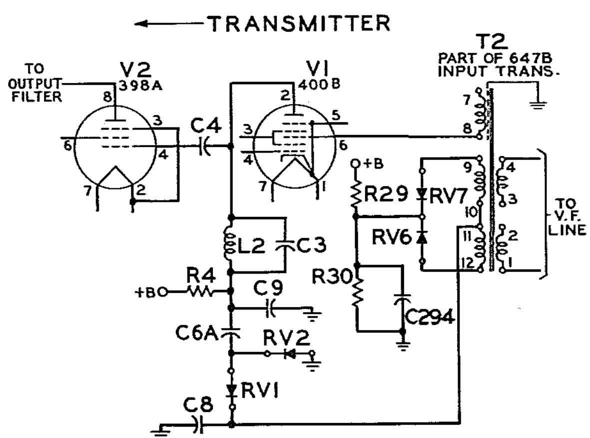


Fig. 38 - Volume Limiter Circuit - M1C1 Terminal

from the rectifier. The rectified voltage is applied through windings 11-12 and 10-9 of T2 to the two varistors RV6 and RV7 which act as a vario-losser across these windings. The common connection of RV6 and RV7 is biased with approximately 13 volts from the plate supply circuit, so that the varistors remain at high impedance until the rectified speech voltage supplied by RV1 and RV2 exceeds this value.

When the input level is high, direct current flows through RV6 and RV7 in the forward direction. Their impedance, which is high with no forward current, is thus greatly reduced under high input level conditions. A portion of the speech power through T2 is absorbed by the varistors, and the output voltage applied to the grid of V1 from winding 7-8 of T2 is thus reduced. The same action occurs also if speech input power is received either from the normal or revertive receiver through the hybrid circuit to winding 7-8 of T2.

2.49 The sensitivity and bias values of the vario-losser are designed so that the point where the output ceases to be directly proportional to the input occurs at about -30 vu at the line input to the hybrid circuit. At this level, the sensitivity is designed to produce about 50 per cent modulation in the transmitter output from speech peaks. Higher input levels, such as those resulting from strong talkers on short subscriber loops, increase the modulation by only about 5 db, and for extremely high input levels resulting from strong talker peaks, the vario-losser permits some distortion. Because of the limiter circuit, about 15 db more voice-frequency voltage step-up can be used without overloading on high-level incoming signals.

2.50 Capacitor C8 in the volume-limiting rectifier provides a time constant which prevents action of the vario-losser on individual cycles of voice frequencies but permits its action on speech syllables. The attack time of the volume limiter is shorter than the hangover or release time. The hybrid circuit not only transmits speech to the transmitter from the voice-frequency line, but also speech due to transmission across the hybrid from the normal receiver, or from both receivers if a revertive call has been set up over the carrier system. The speech levels from these paths may be greatly different, yet the volume limiter is fast enough to adjust for these differences, which may come in quick succession.

Receiver

2.51 In the normal frequency receiver, the carrier-frequency is received through filters FL6 and FL7 as shown in Fig. 36. These filters suppress unwanted frequencies and transform the carrier drop wire impedance of about 100 ohms to approximately 0.1 megohm at the grid of V5. This transformation also provides voltage gain for application to the grid of tube V5. For normal gain, the grid of V5 is left connected to terminal 5 of FL7. Approximately 6 db more gain can be obtained by connecting the grid of V5 to terminal 8 of FL7. Likewise, a similar change can be made on FL3 of the reverting receiver to increase its gain where necessary.

2.52 The two tubes V5 and V6 in the normal frequency receiver are coupled by means of an interstage filter FL8 which provides additicnal suppression of unwanted frequencies. The output of tube V6 is fed to output filter FL9. The output of filter FL9 is divided into two parts; one part actuates the signaling and dialing equipment, and the other provides the speech transmission. The speech output is demodulated and filtered by RV5, L3 and C19 and is then transmitted to the voice-frequency line via the 4-wire terminating set. A small part of this energy passes through the hybrid unbalance in the 4-wire terminating set to the voice-frequency grid of V1 in the transmitter and appears as sidetone at the subscriber or multi-subscriber terminal. The other output of FL9 is demodulated and filtered by RV4 and C17 and the d-c component is used to operate relay P.

2.53 The AGC voltage for controlling the receiver gain is obtained by rectifying some of the output carrier frequency voltage tapped off the primary side of output filter FL9. The copper-oxide varistors (9RV1) and associated resistors and capacitor are mounted inside the filter can, and the derived d-c voltage is returned through filter FL7 to the grid of V5 as negative bias for controlling the gain. The varistor control circuit is biased with a d-c voltage so chosen that automatic control does not become effective until the input signal voltage exceeds a predetermined value.

2.54 Both receivers are energized at all times. The operation of the revertive receiver is similar to that of the normal receiver just described except that the frequency allocation is different as shown in Paragraph 1.06. The output of FL5 is demodulated by RV3. The d-c component of this output is used for operating the revertive call relay RC as later described. The voice-frequency component of the output passes through the RC1 relay contacts, when operated, to the 4-wire terminating set. A portion of this speech output passes across the 4-wire terminating set, due to the hybrid unbalance, to the grid of transmitter tube V1 for transmission back over the carrier line. This speech is thus heard by the speaking subscriber as sidetone and by the listener as direct speech. The detailed relay operations for switching, signaling, and dialing are covered in Part 3.

Power Supply

2.55 The power supply transformer T1 is shown in Fig. 34. The filament of V2 and the heaters of V4 and V6 are supplied from winding 20-21-22 of transformer T1. The heater supply for tubes V1, V3 and V5 is provided by separate secondary windings in order to allow independent cathode biasing arrangements since, in each of these tubes, the cathode is connected internally to one side of the heater. Winding 4-5-6 feeds into sėlenium rectifier RV9, the output of which is filtered by capacitor C30, to provide a negative 48-volt d-c potential for operating the A, B and RC1 relays, for providing grid bias for transmitter tubes V1 and V2 and for bias voltage on the cathode of gas tubes V7 and V8 of the ringing oscillator circuit. Windings 7-8 and 8-9 supply the main anode voltages for V8 and V7, respectively. Winding 8-10 supplies rectifier RV8 and filter L4 and C29, the output of which furnishes the +B supply.

3. SIGNALING, DIALING AND SWITCHING ARRANGEMENTS

(A) General

3.01 Carrier transmission, interrupted by the subscriber's dial (nominally about 10 pulses per second), is used for transmitting dial pulses between a subscriber or multi-subscriber terminal and the common terminal.

Spurts of carrier at a rate of 30 pulses per second, synchronized with the 60-cycle power supply, are transmitted from the common terminal to the subscriber or multi-subscriber terminals for signaling the subscribers. Steady carrier transmission from a subscriber or multi-subscriber terminal is used for energizing the common terminal. Interruption of carrier transmission from a subscriber or multi-subscriber terminal to the common terminal by switchhook operation provides the recall and disconnect signal for the central office. The same carrier frequencies are used for dialing and signaling as are used for voice transmission over a given channel.

(B) Call from an M1 Subscriber to a Subscriber Not on the Same Channel

3.02 To signal the local manual office from an M1 station, the handset is lifted from its cradle in the usual manner as for any common battery station. As shown in Fig. 30, the switchhook contacts provide a normal cathode return circuit to ground for V1, closes the heater circuit of tube V2 and connects 30 volts a-c to the relay in the associated coupling unit. In the multi-subscriber terminal, relay C, as shown in Fig. 32, accomplishes the same function. Relay C operates as the result of lifting the handset from its cradle at any of the subscriber stations connected to the terminal. Hence, a steady carrier frequency is sent over the carrier line to the common terminal and it is there amplified and rectified by the normal receiver which is continuously activated for the receipt of carrier signals from any subscriber or multi-subscriber terminal of the channel. The rectified carrier operates relay P, which operates relays A and B as shown in Fig. 39. The operation of the B relay energizes the transmitter and switches the voice-frequency loop from its connection to the ringing circuit over to the 4-wire terminating circuit. The contacts of the A relay close the d-c path of the voice-frequency loop as shown in Fig. 39. This operates the line signal in a manual office to call in an operator or operates the line relay in a dial office to actuate the dial equipment as in the case of any voice-frequency subscriber. Since both the common terminal and the subscriber terminal are now energized and ready for speech transmission, the operator responds or dial tone is returned and the subscriber then requests or dials the called number. Further description of the dialing process is given in Paragraph 3.04; however, the connection to the called party is completed in the usual manner.

3.03 At the end of the conversation, the handset is returned to its cradle and the resulting switchhook operation at the subscriber terminal or release of the C relay at the multi-subscriber terminal disables the transmitting oscillator at that terminal (see Paragraph 2.25). The resulting absence of received carrier at the common terminal allows the P, A and B relays to release, which restores the common terminal to the stand-by condition. Release of the A and B relays opens the d-c path over the voice-frequency loop which brings in the disconnect signal at a manual office or restores the dial equipment to normal. When a magneto office is involved, an auxiliary line circuit, such as that shown in SD-14152-01, is required in the magneto office for actuating the supervisory signals.

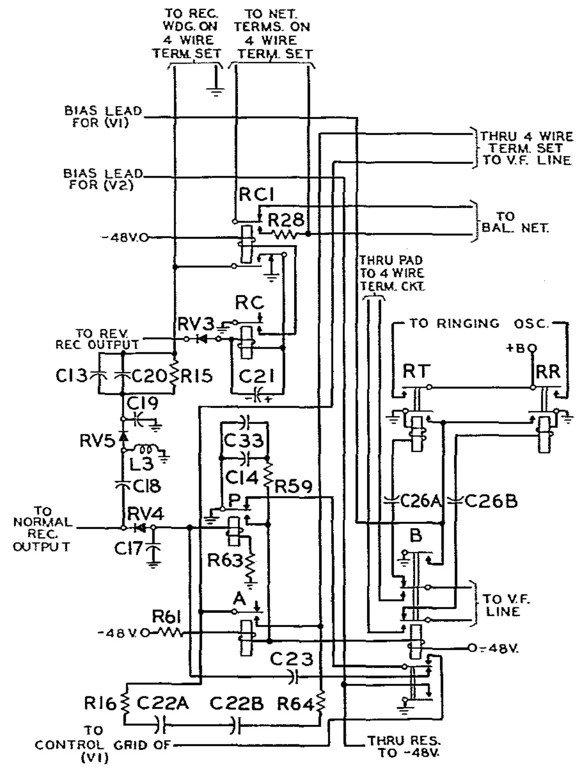


Fig. 39 - Relay Circuits for Common Terminal

3.04 As shown in Fig. 39, operation of the B relay removes the shunt capacitor C23 from resistor R63 and from the P relay winding, thus shortening the time constant of the P relay which allows it to follow dial pulses. When dial service is involved, and when a subscriber having an individual subscriber terminal operates his dial, its contacts periodically interrupt the plate supply to the oscillator-modulator tube V1. This periodically interrupts carrier transmission from the subscriber terminal in accordance with the dial pulses. In the case of the multi-subscriber terminal, operation of the dial causes the line (A) relay of the multi-subscriber terminal to pulse. Opening of its contacts opens the plate supply to tube V1 and causes the carrier to be pulsed in the same manner as described above. At the common terminal, the P and A relays release in response to every carrier interruption but the B relay remains operated since it is a slow release relay. The operation of the contacts of the A relay simulates the pulsing provided by dial contacts connected directly across any dial office loop, i.e., they periodically open the d-c circuit to the dial office.

(C) Call to an M1 Subscriber from a Subscriber Not on the Same Channel

3.05 In this case, the call is received by the operator or the dial equipment at the central office, and the ringing signal for the called subscriber is placed on the voice-frequency loop to the common terminal in the same way as for any voice-frequency subscriber. At the common terminal, the ringing system is connected to the voice-frequency loop during stand-by periods through normally closed contacts of the B relay. The ringing signal then operates one of the two relays (RT or RR) at the common terminal where conversion of the signal is made to provide synchronized spurts of carrier for transmission of the signal from the common terminal to the subscriber or multi-subscriber terminal. The details of ringing system circuits are discussed in Part 3(H).

3.06 At the common terminal, one of the ringing oscillators is enabled by the operation of the RR relay, and the other oscillator is enabled by the RT relay as shown in Fig. 37. The RT relay operates to furnish ringing for a tip party and the RR relay provides ringing for a ring party.

3.07 When the ringing signal from the local office operates the RT relay, the common terminal transmits short pulses of carrier synchronized with every alternate 60-cycle voltage wave. These pulses actuate the ringing circuits of those subscriber terminals which are so poled as to be enabled when the pulses arrive. Other subscriber terminals, so poled as to be disabled when the pulses arrive, do not respond. These latter subscriber terminals would respond to pulses sent out from the common terminal if the ringing current from the central office had operated the RR relay instead of the RT relay.

3.08 Multi-subscriber terminal station ringing employs the same principles as are described in Paragraph 3.07 except that the ringing pulses received from the common terminal are converted by the multi-subscriber terminal into 20-cycle ringing voltage. This signaling voltage is transmitted over the voice-frequency extension to the subscriber stations. The carrier pulses, generated by the common terminal as explained above, are received and demodulated at the multi-subscriber terminal where they become pulses of positive d-c voltage. They are then applied to the grids of a twin triode vacuum tube whose plates are energized with 60-cycle voltage, the two plates being of opposite polarity. If the plate of one of the triodes is positive at the time the pulses are received the triode passes current and causes a relay to operate. As a result of this, the proper ringing relay is operated in the multi-subscriber terminal which applies 20-cycle voltage from the local ringing supply to the tip or ring conductor of the voice-frequency extension depending on the party called.

3.09 If the ringing current from the central office is transmitted simultaneously over both the tip and ring wires to ground (as in the case of a guard ring in certain types of offices to inform parties called over one side of the line that a ring is progressing on the other side), both the RT and RR relays operate and pulses of carrier are transmitted for both 60-cycle polings and all subscriber stations of the channel respond. By the use of optional wiring, pulses of carrier may be transmitted for both 60-cycle polings when either ringing relay pulls up. This wiring provides full-code ringing if desired. Where full-code ringing is employed the ringing circuits of the subscriber or multi-subscriber terminal are energized with d-c instead of a-c and the relative phase of the 60-cycle supply voltages is therefore not important.

3.10 When an M1 subscriber lifts his handset in response to a ringing signal, the oscillator at the subscriber or multi-subscriber terminal is energized as explained above and carrier is transmitted to the common terminal. Here it operates the P relay which operates the A and B relays. The B relay energizes the common terminal oscillator for voice-transmission back to the subscriber and connects the voice-transmission equipment at the common terminal to the voice-frequency loop. The A relay provides a closure on the voice-frequency loop which trips the ringing from the central office and/or operates the supervisory signal therein and completes the connection for speech transmission.

3.11 When the M1 subscriber hangs up, the common terminal is restored to normal as previously described.

(D) Call Between Two Subscribers on the Same Carrier Channel

3.12 There is no difference between the operating procedure required of a subscriber on an M1 system and that required of a subscriber on the usual voice-frequency line. Any such subscriber can call any other subscriber connected to the same channel (party line). This type of call is known as a revertive call. This makes it necessary to use three frequencies instead of two frequencies for a given channel. If two subscriber terminals were to transmit to the common terminal on the same nominal frequency, the beat frequency between their carriers might make reception difficult. Also, the AGC would be under control of the stronger carrier received at the common terminal.

Case Where One Subscriber Is Not on a VF Extension of a Multi-Subscriber Terminal

3.13 Assume the use of channel 1A, that is, 410 kc (F1) or 420 kc (F2) transmission from the subscriber terminal to the common terminal and 155 kc (F3) transmission from the common terminal to the subscriber terminal. Subscriber A lifts his handset from its cradle. Carrier at frequency F1 is thereby sent to the common terminal as previously described. If the voice-frequency line terminates in a manual office, the number of the called party is given verbally to the operator, who requests the subscriber to hang up while party B is rung over the same channel. The ringing system operates the same for a revertive call as for a normal call.

3.14 If the voice-frequency line terminates in a dial office, party A dials the desired number in the same manner as for any other subscriber making a revertive call. Since the call is for a party on the same channel, party A then replaces his handset on its cradle. As soon as the dial office receives the signal that the subscriber has hung up, the dial apparatus transmits the ringing code for the called party B.

3.15 For divided-code ringing systems, if the calling party A does not have the same poling as party B, then a ringing signal poled for party A may also be sent out so that he can determine that party B is being rung. Assume that party B answers first. The presence of normal carrier F1 from his terminal will cause the operation of the P, A, and B relays at the common terminal. This connects the common terminal for a normal call through the central office and energizes the common terminal oscillator at frequency F3. The presence of carrier frequency F3 on the carrier line will operate relays K2 and K1 in all other subscriber and multi-subscriber terminals on the channel, including that of the calling party A. When relay K1 is operated previous to the time a subscriber answers, the transmitting oscillator frequency is controlled by crystal Y2, which provides the revertive frequency F2 for transmission to the common terminal. Thus, when party A answers, his frequency is F2.

3.16 At the common terminal, when frequency F2 is received by the revertive receiver, the RC relay is operated, which in turn operates the RC1 relay as shown in Fig. 34. The RC1 relay connects the demodulated output of the revertive receiver to the receiving leg of the hybrid circuit in parallel with that of the normal receiver and changes the balancing network to one that gives lower loss (better transmission) in the path across the hybrid which is used to complete the transmission path. The two subscriber terminals then receive frequency F3 from the common terminal, while the terminal of the called party B transmits F1 to the common terminal and that of party A transmits F2 to the common terminal.

3.17 Should party A answer first, his terminal transmits frequency F1 which locks up the K1 relay of the terminal of party B so that when party B answers, his terminal transmits at frequency F2. In other words, the first party to answer a ring is assigned the use of frequency F1 for transmitting and the other party automatically is assigned the use of frequency F2.

3.18 If either the calling or called party hangs up under these conditions, the party remaining on the line will either stay on, or revert to, the normal transmitting frequency.

Case Where Both Subscribers Are on Same VF Extension of a Multi-Subscriber Terminal

3.19 If a revertive call is made between two subscribers on a voice-frequency extension of a multi-subscriber terminal, the operation of the multi-subscriber terminal is the same as that described in Paragraph 3.02. If the voice-frequency line from the common terminal terminates in a manual office, the number of the called party is given verbally to the operator who requests the subscriber to hang up while the called party is signaled over the same channel. If the voice-frequency line terminates in a dial office, the calling party dials the desired number in the same manner as for any other subscriber making a revertive call and replaces the handset on its cradle to allow the dial apparatus to transmit the ringing code back over the channel.

3.20 The two subscribers talk to each other over two paths in parallel (1) between themselves over the voice-frequency line as in any common battery party line and (2) over the carrier circuit as follows: Speech currents from each subscriber are transmitted to the multi-subscriber terminal where they are modulated onto the carrier and transmitted to the common terminal. At the latter point, they are demodulated and a portion of the energy is transmitted across the hybrid circuit to the transmitter where it is modulated onto the common terminal carrier and transmitted back to the multi-subscriber terminal. Here the speech currents are again demodulated and transmitted over the voice-frequency extension to both subscribers. The relative times of transmission over both paths are not sufficiently different to degrade the transmission to any appreciable extent. Since the multi-subscriber terminal remains in the talking condition during this type of a call, supervision is maintained at the central office. The revertive frequency of the multi-subscriber terminal is not employed in this case.

(E) Ringing System - General

3.21 In general, the ringing system used for rural service is determined by the type of equipment installed in the central office which serves the subscribers. The common terminal differentiates between 20-cycle voltage on the tip side and on the ring side of the voice-frequency line. If the ringing voltage occurs at the same time on both the tip and ring, the common terminal ringing system will transmit the ringing code to both the tip and ring parties. The system will, therefore, operate with any divided-code grounded ringing method, and, with the addition of one strap wire, will operate on a bridged ringing basis for full-code ringing. No provision has been made for 8-party semi-selective, 4-party full selective, or harmonic ringing.

3.22 The ringing signals are transmitted between the common terminal and associated subscriber terminals by means of carrier pulses occurring at a rate of 30 per second. The timing for the signals is obtained from the 60-cycle power frequency which is used at the transmitting and receiving locations to supply power to the terminals. Although there may be a slight phase shift in the 60-cycle voltage between a common terminal and a subscriber or multi-subscriber terminal which are connected to the same phase of the power system, sufficient margin is available in the system to make it dependable. If different phases of the power supply are used at the two terminals, the required phase shift is introduced into the enabling circuit at the subscriber or multi-subscriber terminal by means of a phase shifter.

3.23 At the common terminal either or both of two sets of carrier spurts are generated at a 30-cycle rate. The first is controlled by a 20-cycle ringing voltage from the central office on the tip side of the loop to ground and is synchronized with the positive swing of the 60-cycle supply voltage. The second is controlled by a 20-cycle ringing voltage from the central office on the ring side of the loop to ground and is synchronized with the negative swing of the 60-cycle supply voltage.

3.24 The associated subscriber terminals are divided into two groups for divided-code ringing. Group A is poled to receive a ringing signal which only recurs during the positive swing of the 60-cycle supply, while group B is poled to receive a ringing signal which only recurs during the negative swing. During the opposite swing period for each group, the ringing signal is not amplified and detected due to intermittent and synchronous disabling of the receiver. In the multi-subscriber terminal, a selective circuit, one half of which is poled to receive the ringing signal generated at the common terminal during the positive swing of the 60-cycle supply and the other half poled to receive the ringing signal occurring during the negative swing, applies 20-cycle voltage to the tip or ring of the voice-frequency extension.

3.25 Fig. 40 shows the time spacing and associated circuit conditions for the various parts of the signaling system. Fig. 37 shows a schematic of the two oscillator circuits and the ringing relays. As shown in Fig. 40A, the 20-cycle ring is received from the central office which operates either the RT or the RR relay, depending on whether a tip party or a ring party is being called. The ringing relay operates shortly after the beginning of each ringing spurt and holds up for the duration of each short or long spurt used in code ringing as shown in Fig. 40B. When this relay is operated, its associated ringing oscillator and the transmitter are enabled. The oscillator then generates a series of transmitter enabling pulses at a 30-cycle rate and with the desired timing. A reference 60-cycle wave is shown in Fig. 40C, and the remaining parts of Fig. 40 are timed with respect to this wave. There need not be any synchronization between the 20-cycle ringing voltage from the central office and the 60-cycle supply voltage at the common terminal.

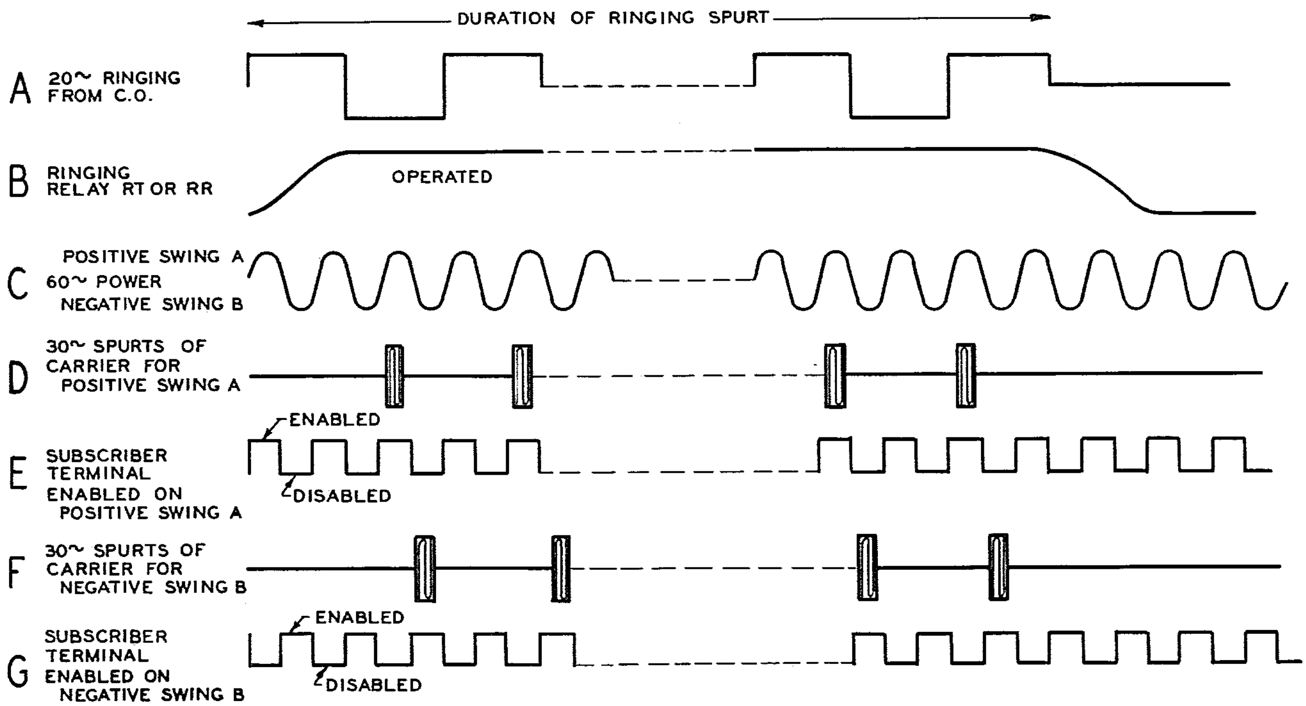


Fig. 40 - Timing Diagram of Ringing Signals

3.26 Assume that the RT relay is operated for a tip party and the ringing signal is synchronized with positive swing A, shown in Fig. 40C. Then the time spacing of the transmitter output is shown in Fig. 40D. This signal consists of pulses less than 8 milliseconds long (half of a 60-cycle wave) occurring at a 30-cycle rate. The detailed operation of the ringing oscillator is described in Part 3(H). In order for the ringer at a subscriber station to operate on the signal associated with positive swing A (Fig. 40D), the receiver of the subscriber terminal, or one half of the signaling receiving circuit of the multi-subscriber terminal is enabled as shown in Fig. 40E on each positive swing of the 60-cycle voltage. Alternate positive swings of the wave coincide with the 30-cycle pulses of received carrier shown in Fig. 40D. The demodulated output signal for operating the ringing relays will consist of d-c pulses coinciding in time with the carrier spurts.

(F) Individual Subscriber Terminal Ringing Circuit

3.27 The intermittent and synchronous enabling of the receiving circuit at the subscriber terminal is accomplished by applying to the screen grid of V4, during stand-by periods, the voltage from the 60-cycle supply with the selected poling. The tube then amplifies only during the time intervals when the 60-cycle supply provides a positive voltage to the screen grid. When the screen grid is negative, tube V4 of the subscriber terminal blocks from the detector any signal occurring during that interval. In order for the negatively poled parties to receive the ringing signal of Fig. 40F, their carrier receivers must be enabled as shown in Fig. 40G which corresponds to negative swing B. Their carrier receivers are disabled during the A periods and, therefore, will not respond to the signal which operates the ringing for the A subscriber group.

3.28 When a subscriber terminal receiver has 30-cycle spurts of ringing signals of the proper poling presented to it, tube V4 amplifies the signals and they are demodulated and appear as d-c pulses which are applied to the K2 relay. The K2 relay is operated by these pulses and, since it is a fast operating relay, it operates and releases at a 30-cycle rate. The K1 relay, which is a slow release relay, is operated from the contacts of the K2 relay and remains operated for the duration of each spurt of code ringing. The normally closed contacts of K1 are opened, disconnecting resistor R2 from the ringer in the telephone set. The pulsing of the K2 relay operates the ringer by charging and discharging capacitor C1B in series with the ringer. During stand-by periods the presence of R2 across the ringer reduces bell tapping which might be caused by bursts of heavy static from the line. Capacitor C10 shunted across the winding of K2 causes the relay to remain operated somewhat longer than the duration of each carrier pulse received from the common terminal (less than 8 milliseconds), thus the time of closure of the front and back contacts of the relay is equalized and approaches 16 milliseconds each.

3.29 It is necessary that the K2 relay circuit follow the 30-cycle pulses but hold up on 60-cycle pulses. The latter condition occurs at idle subscriber terminals when steady carrier is present on the line due to another subscriber using the channel. In the stand-by condition at the various subscriber terminals, the screen of V4 is connected to the 60-cycle voltage in order to amplify only one poling of ringing signal as mentioned before. The demodulated signal applied to K2 when steady carrier is present on the line thus consists of d-c pulses occurring at a 60-cycle rate which, if followed by the relay, would produce continuous ringing. Capacitor C10 together with the characteristics designed into the relay produces steady operation of the K2 relay on these pulses. Further assurance that the K2 relay will remain operated by these pulses is provided by the connection between the armature of the relay and the screen of V4 through R19. This adds positive d-c bias to the 60-cycle voltage on the screen of V4 which, under this condition, lengthens the intervals during which the receiver is enabled. During stand-by periods (60 cycles applied to screen of V4), the sensitivity of the K2 circuit is increased by the short circuit placed across R13 by the normally closed switchhook contacts. When the handset is removed from its cradle to receive speech and K2 operates on d-c, this short circuit is removed.

3.30 To disable the selective signaling at the subscriber terminal in order to arrange it for single-party service or full-code ringing, a simple wiring change is made by means of a screwdriver. Referring to SD-95105-01, the green connecting cord lead is removed from terminal 16 on TS3 and connected to terminal 6 on TS3. Under this condition, direct voltage from the +B supply is connected to the screen grid of V4 so that V4 will amplify all ringing signals regardless of polarity.

(G) Multi-Subscriber Terminal Ringing Circuit

General

3.31 Fig. 41 is a simplified schematic showing the principal features of the multi-subscriber terminal ringing circuit. The carrier pulses, generated at the common terminal during the ringing interval in synchronism with the 60-cycle supply voltage at a rate of 30 per second, are received and amplified by the carrier receiving circuit of the multi-subscriber terminal and demodulated by varistor RV51. The screen grid of tube V4 is always energized with d-c. Thus, all pulses are received and transmitted to the ringing circuit of the terminal regardless of their phase relationship with respect to the power voltage supplying the terminal. The resulting positive pulses after demodulation and filtering are impressed across the two circuits consisting of: (1) the K2 relay winding and resistor R52 in series and, (2) resistor R102 and capacitor C102 in parallel and are also applied to the network consisting of resistor R115, capacitor C108, and varistors RV107 and RV108; then through capacitor C109 and resistors R110 and R111 to the grids of the tube V10. Capacitor C109 prevents operation of the signaling circuit on d-c which would be produced by the receipt of continuous carrier from the common terminal. The network containing the varistors mentioned above attenuates the first pulse of the signal appreciably, but if these pulses continue at the 30-cycle rate, the attenuation due to the network decreases rapidly and allows the remaining pulses to be applied in nearly full magnitude to the grids of the tube V10. Thus, false operation of the ringing circuit due to bursts of static received from the carrier line is minimized. Tube V10 is biased beyond cutoff by a negative voltage of about 12 volts obtained from a voltage divider, consisting of resistors R113 and R114 connected to the 48-volt d-c supply. The plates of tube V10 are supplied with 60-cycle voltages of opposite polarity from windings of transformer T12, the supply to one plate passing through the winding of the T relay and the other through the winding of the R relay. Each of the two triodes in tube V10 can pass current only when its plate is positive. Thus the T and R relays can only operate on current received during opposite half-cycles of the power supply voltage. The incoming pulses of voltage are synchronized with either the negative or positive half of the 60-cycle supply voltage at the common terminal. If the power supply voltage at the multi-subscriber terminal is in phase with that at the common terminal and the power connections at the multi-subscriber terminal are properly poled, the plate of the triode whose circuit contains the proper relay (T or R) will become positive at the same instants that the pulses arrive at the grids of tube V10 and the resulting space current in that half of the tube will operate the relay. The T relay operates for subscribers signaled from the tip side of the line to ground and the R relay for subscribers signaled from the ring side of the line to ground.

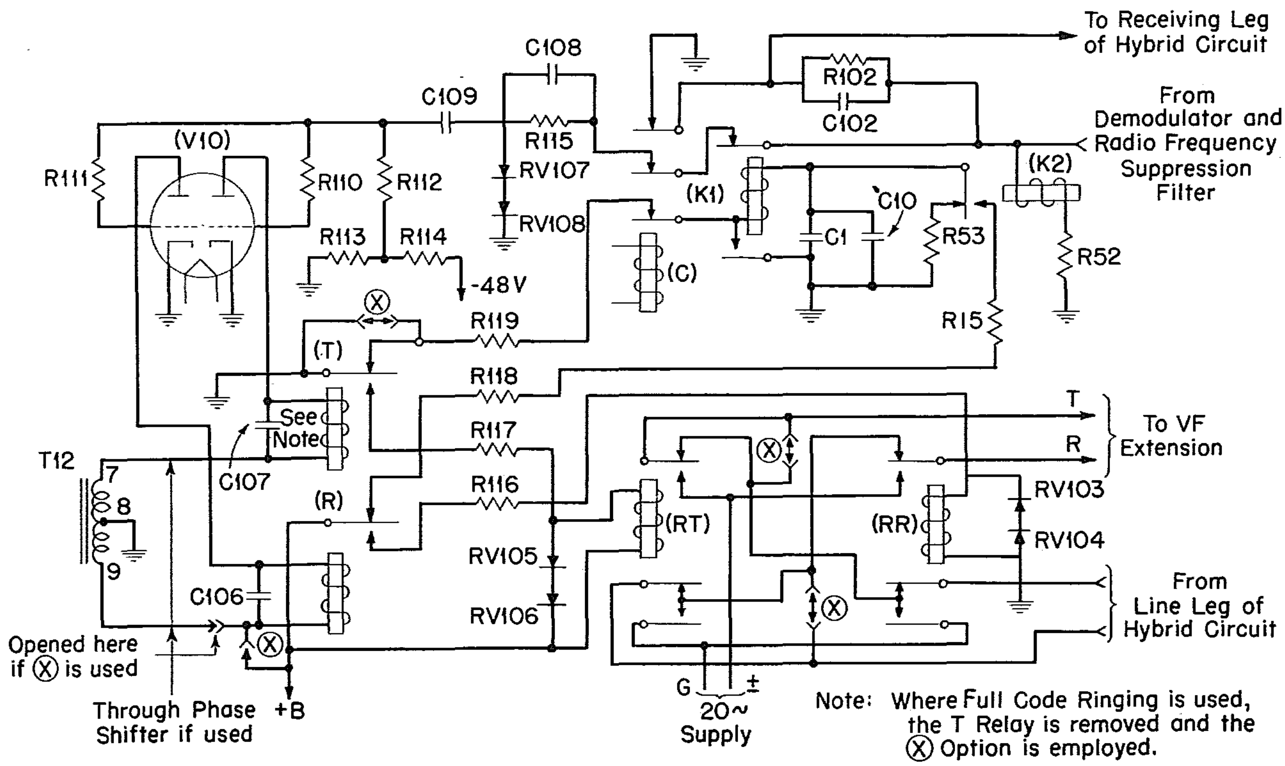


Fig. 41 - Simplified Schematic Showing Principal Features of the Multi-Subscriber Terminal Ringing Circuit

3.32 The T and R relays are each shunted by a 4-mf capacitor which not only smooths out the current through the relay winding and causes continuous operation of the relay during the ringing interval, but it also makes the relay insensitive to short transients and prevents false operation on static bursts or other interference which might not have been fully suppressed by the network at the input of tube V10.

Operation of Ringing Relays

3.33 Referring again to Fig. 41, whenever the R relay operates, a circuit is closed from the +B supply through resistor R116 and the RR relay winding to ground. The latter relay operates, opens the circuit from the line leg of the hybrid circuit and applies 20-cycle voltage to the ring side of the line and ground to the tip side through the back contacts of the RT relay. When the T relay operates, a circuit is closed from the +B supply through the winding of the RT relay, resistor R117 and the operated contacts of the T relay to ground. The RT relay operates, opens the circuit from the line leg of the hybrid circuit and applies 20-cycle voltage to the tip side of the line and ground to the ring side through the back contacts of the RR relay.

3.34 In certain types of central offices, when a revertive call is being established, the guard ring on the opposite side of the line from the party being signaled is sent out simultaneously with the regular signal. In such cases the R and T relays will be operated simultaneously resulting in simultaneous operation of the RR and RT relays. As shown in Fig. 41, these relays, when operated together, open the circuit from the line leg of the hybrid circuit. The RR relay applies 20-cycle voltage to the ring side of the line while the RT relay applies it to the tip side.

3.35 Varistors RV103 and RV104 in series and varistors RV105 and RV106 in series are shunted around the RR and RT relay windings, respectively, and are so poled that the relays are slow to release. As explained in Paragraphs 3.31 and 3.32, the network at the input to tube V10 together with the 4-mf capacitors across the R and T relay windings delay the operation of these relays until some time after the beginning of the ringing signal is received at the multi-subscriber terminal. The 4-mf capacitors also delay somewhat the release of these relays but actually the period during which the R or T relay remains operated is somewhat less than the ringing interval. The above-mentioned varistors, therefore, delay the release of the RR and RT relays for a further period in order that the signal transmitted to the subscriber will more nearly approach the length of that sent from the central office.

Full-Code Ringing

3.36 Where full-code ringing is employed, optional wiring is available in the multi-subscriber terminal. The T relay is removed from its socket and its back contacts are replaced by a strap. The 60-cycle voltage to the plate of the triode of tube V10 associated with the R relay is replaced by a direct voltage obtained from the +B supply of the terminal. These connections are illustrated as option X in Fig. 41. After this has been done, the triode of the tube V10 associated with the T relay is disabled due to the absence of plate voltage normally fed through the winding of T relay. Now all signaling pulses received from the common terminal regardless of their phase relationship with the local power supply will cause plate current to flow in tube V10 and through the winding of the R relay, thus causing the R relay to operate during each ringing interval.

3.37 Operation of the R relay results in operation of the RR relay which functions as it does in divided-code installations, placing the 20-cycle ringing voltage across the ring and tip of the line. Where full-code ringing is employed, the normally closed contacts of the RT relay are strapped externally since the relay never operates under this condition.

A-C - D-C Ringing

3.38 Where gas tube telephone sets are required on the voice-frequency extension, a-c - d-c ringing, which consists of 20-cycle a-c voltage biased with 48 volts d-c, is necessary. In this case, the 48-volt d-c supply of the multi-subscriber terminal is connected in series with the 20-cycle supply as indicated by option T of the schematic drawing for the terminal (SD-95568-01).

(H) Operation of the Ringing Oscillators - Common Terminal

3.39 Since it may be necessary in some installations to be able to transmit simultaneously to both the tip and ring parties, two relaxation-type ringing oscillators are used. A 3-element, cold cathode gas tube is used in each of the two oscillators. Its control gap breakdown voltage is about 75 volts. The circuits are energized only during the time a ringing signal is required.

3.40 As shown in Fig. 37, tube V7 and associated elements make up the oscillator which generates a signal with the correct timing to signal a tip party. A negative cathode bias of about 48 volts is obtained from the relay power supply. The main anode is also permanently connected to a 60-cycle voltage of about 130 volts rms from transformer T1. When +B voltage is connected to the starter anode by the closing of contacts on the RT relay, the relaxation oscillation is started in the resistance-capacitance circuit including C24, R18, R21 and R26. The charging voltage for C24 includes the negative 48-volt supply in series with the +B supply. When the voltage across C24 reaches about 75 volts, the control gap of V7 is ionized and current flows in the tube from terminal 7 to terminal 2. When the 60-cycle voltage on the main anode is positive and slightly greater than the voltage sustaining the control gap, current will flow in the main gap of the tube from terminal 5 to terminal 2.

3.41 After the main gap breaks down and as the instantaneous voltage of the 60-cycle supply builds up on the main anode, the decrease in current through the control gap of V7 raises the positive voltage applied to V9 and ionizes it. The potential across the electrodes of V9 is limited by it to about 65 volts, the sustaining voltage for this tube. When the instantaneous voltage of the 60-cycle supply of the main anode of V7 decreases to a point where the ionization in the main gap is not maintained, the cathode will return to its initial bias value of about -48 volts and, due to C24, the voltage on the control anode will also be reduced. Capacitor C24 then starts to recharge, but R18, R21 and R26 are so chosen as to prevent the re-ionizing of the control gap until after the succeeding positive swing of the 60-cycle voltage on the main gap has passed. Just before the second positive 60-cycle swing occurs at the main gap, the voltage on C24 is sufficient to ionize the control gap and as soon as the positive voltage on the main anode reaches the proper value, current again is allowed to pass through the tube and the cathode circuit. With the division of voltages provided by the resistors in the control and main-gap circuits, only the main-gap discharge will produce an appreciable drop in the cathode resistor R26. Therefore, the signal appearing across the cathode resistor R26 occurs at a 30-cycle rate, with the length of each pulse slightly less than one half of a 60-cycle wave as shown in Fig. 40D.

3.42 At the time when the pulse of positive voltage is not present across R26, the 48-volt bias in the cathode circuit will maintain the connected grids of V1 and V2 at such a potential as to nearly cut off these tubes. When the grid circuits for V1 and V2 have slightly positive bias provided by the pulse, the tubes are driven to their overload points and carrier frequency at about 5.5 db above the normal carrier level will be transmitted by the common terminal. These spurts will continue to be produced as long as the RT relay remains operated by the 20-cycle signal from the central office.

3.43 The function of glow lamp V9 is to stabilize the oscillator circuit against line voltage variations. Glow lamp V9 is deionized during the time capacitor C24 is charging from the +B voltage and also when the control gap is ionized without current in the main gap. Although V7 and V9 have nearly the same breakdown voltages, the 48-volt bias on the cathode of V7 will always insure its ionization at a lower voltage at the junction of R18, R20, and R21 than that required to ionize V9. When current flows in the main gap due to the alternate positive 60-cycle voltage swings on the main anode, the voltage on the control anode rises tending to follow the same potential as the cathode. This increase in voltage at the junction of R20 and R21 ionizes V9 which acts as a voltage limiter at this point. The difference between this voltage and the potential at the control anode during the alternate periods of 60-cycle positive polarity on the main anode appears as a voltage drop in R20. Just previous to the time when the ionization of the main gap in V7 ceases, the voltage on the cathode side of C24 is about 100 volts positive and that at the junction of R20 and R21 is about 60 volts positive. After V7 is de-ionized due to the reversal in polarity on the main anode, the potential on the cathode side of C24 falls to -48 volts and, consequently, the voltage on the opposite side of C24 at the junction of R20 and R21 will be greatly reduced from its previous value of about 60 volts.

3.44 All of the voltages used to operate the oscillator are obtained from the 60-cycle power supply; therefore, when the 60-cycle voltage supply is high, the +B and -48-volt bias voltages are both high. If the 60-cycle voltage applied to the main anode is high, the difference between the cathode voltage and that across V9, under conditions of main anode current, is greater than when the 60-cycle voltage is low. Because V9 limits at the same voltage above ground regardless of line voltage, the potential at the junction between R20 and R21 is reduced, when current ceases to flow in the main anode, to a lower value under high line voltage conditions than under low line voltage conditions. When the charging voltages are high and the initial potential from which C24 is to be charged is low, the time required for charging C24 to the ionizing potential of V7 will be nearly the same as when the charging voltages are low and the initial potential on C24 is high. Therefore, the frequency of oscillation is stabilized against supply voltage variations. The operation of the other relaxation oscillator, consisting of V8 and V10 and associated resistors and capacitor, is identical with that described above. However, the 60-cycle voltage applied to its main-gap is of the opposite polarity at a given instant.

3.45 In situations where full-code ringing is employed, tubes V8 and V10 are removed from their sockets and wiring option (V) shown in Fig. 37 is used. A positive potential is applied to R18 when either the RT or RR relay operates. The resulting operation of the oscillator circuit is the same as that described above with carrier pulses being sent out at a 30-cycle rate. Since in this case the signaling enabling circuits at the subscriber or multi-subscriber terminals are energized by d-c instead of a-c as in divided-code ringing, the resulting carrier spurts serve to operate the ringer of any subscriber station associated with the channel regardless of the poling of the 60-cycle power applied to it.

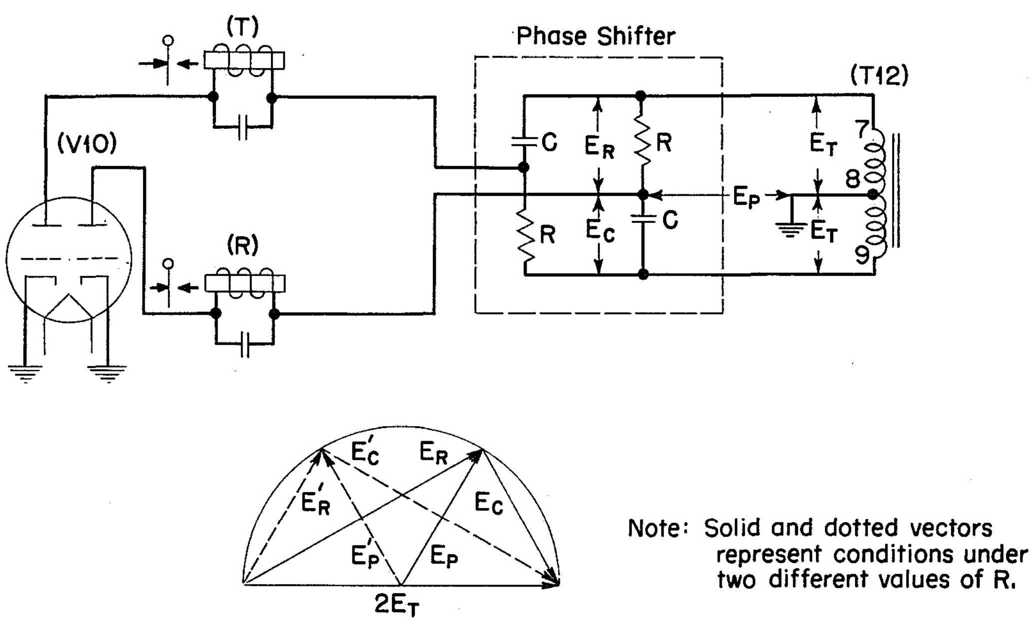
(I) Phase Shifter

Subscriber Terminal

3.46 The phase shifter for individual subscriber terminals consists of four resistors and a 2-unit capacitor wired to terminals for convenience in changing connections to obtain different degrees of phase shift. Fig. 31 shows a schematic of the phase shifter. The circuit elements are connected to terminals designated by the letters A, B, C, D, E, X and Y. Two numbered terminals, 16 and 17, serve the dual purpose of mounting feet for the unit and electrical connections to the subscriber terminal. Flexible pigtails with spade terminals facilitate connection between these terminals and terminals in the network circuit. Movable links are also provided for making connections X-C and Y-B. The two diagrams in Fig. 31 show schematically two circuit arrangements of the phase shifter. Diagram (a) shows the connections required to introduce a lagging shift in the phase of the voltage impressed on the screen grid of tube V4. A shift of 30 or 60 degrees is obtained by connecting the green conductor of the telephone set cord to terminal C or E, respectively. Diagram (b) shows the connections for a leading phase shift. A shift of 30 degrees is obtained by connecting the green conductor to terminal B; a shift of 60 degrees results from connecting the green conductor to terminal E. Thus, four different values of phase shift may be obtained from four different circuit arrangements in the phase shifter. These four arrangements also provide four additional values of phase shift when the power supply connections to the subscriber terminal are reversed. This reversal shifts the phase of the voltage by 180 degrees and the phase shift at the screen of V4 is the resultant of this 180-degree shift and the shift obtained in the phase shifter. For example, if the phase shifter is arranged for a lagging shift of 30 degrees, a reversal of the power supply results in a leading shift of 150 degrees. It should be noted that, whenever a specific value of phase shift is mentioned in this section, it refers to the insertion phase shift of the phase shifter with or without a power supply reversal. In the table of connections supplied with the phase shifter, the values of phase shift specified are differences in phase between the power supply voltage at the subscriber terminal and that at the common terminal, or the shift to be compensated for by the phase shifter network. When the phase shifter network has been connected to compensate for the phase difference between power supplies, the signaling system functions exactly as it does when the power supply voltages at both terminals are in phase.

Multi-Subscriber Terminal

3.47 The phase shifter for the multi-subscriber terminal is shown schematically in Fig. 42. It should be noted that this circuit is different from that of the phase shifter used with the individual subscriber terminal described above. The purpose of the phase shifter of the multi-subscriber terminal is to bring the voltage between plate and ground of each half of tube V10 into approximate phase with the voltage applied to each of the ringing generators of the common terminal. If there is a fixed phase difference between the voltage supply at the common terminal and that applied to transformer T12 of the multi-subscriber terminal, the phase shifter can be adjusted to produce an opposite and approximately equal phase shift between the 60-cycle voltage at transformer T12 and that of tube V10. As shown in Fig. 42 this is accomplished by utilizing the total voltage of both halves of the transformer secondary and shunting two identical networks, each containing a resistor and capacitor in series, across these windings. The function of one of these networks is shown in the vector diagram in Fig. 42. The voltage across the outer terminals of the winding of T12 or across the network is represented by $2E_T$, which is twice the voltage across each half of the transformer winding. The voltage drops across the resistor and capacitor are represented by the vectors E_R and E_C. These voltages will always be at right angles to each



Vector Relationship of Voltages

Fig. 42 - Multi-Subscriber Terminal Phase Shifter Network

other and their vector sum will always be equal to $2E_T$. The voltage impressed upon one plate of the triode (in series with the relay winding) is E_P and is the voltage from the junction of the resistor and capacitor to ground, or to the midpoint of the transformer winding. This is represented by the vector E_P which extends from the midpoint of the vector $2E_T$ to the intersection of the two vectors E_R and E_C. The phase shift is then equal to the angle between E_P and E_T.

3.48 In the phase shifter employed in the multi-subscriber terminal, the value of capacitance remains constant and the value of resistance is changed to vary the phase shift to any of the settings except zero. Changing the resistance varies the current through the capacitor; thus both voltages E_R and E_C are changed. Neglecting any impedance drop in the transformer winding, the vector sum of E_R and E_C will always be equal to $2E_T$, irrespective of their individual values. Thus the vector E_P will rotate about its axis at the midpoint of the vector $2E_T$ and its extremity will describe a semicircle as shown in Fig. 42 as the value of R is changed. The magnitude of E_P will remain constant and equal to E_T.

3.49 Four values of phase shift in addition to zero are provided in the multi-subscriber terminal by making appropriate strappings on the phase shifter terminal strip (TS12) as specified in Drawing SD-95568-01 or in the table below. Four additional values are obtained by reversing the power supply connections to the terminal.

Phase of Power Voltage at Multi-Subscriber Terminal Referred to That at Common Terminal	Strap Terminals of TS12
No phase difference	1-2 and 7-8
Leading 30° or lagging 150°	1-5 and 7-11
Leading 60° or lagging 120°	1-3 and 7-9
Leading 120° or lagging 60°	1-4 and 7-10
Leading 150° or lagging 30°	1-6 and 7-12

The two phase shifts in the left-hand column above are obtained with opposite polings of the power supply voltage. For zero phase shift, the networks are not employed and the R and T relay windings are connected directly to the transformer T12 winding terminals.

3.50 The second network in the phase shifter operates in the same manner as described above but since the positions of the capacitor and resistor are transposed, the voltage E_P obtained from this network will be 180° out of phase with the voltage E_P from the first network, thus maintaining voltages on the two plates of tube V10, which are opposite in polarity.

(J) Multi-Subscriber Terminal Dialing and Supervision

General

3.51 Fig. 43 is a simplified schematic of the multi-subscriber terminal relay circuits employed in dialing and supervision. Fig. 43A shows the arrangement when the terminal is employed in dial service. Fig. 43B illustrates the changes in this circuit when manual service is used. The connections to the A relay winding are the same in both cases.

3.52 When a subscriber on the voice-frequency extension lifts his handset from its cradle, the circuit across the tip and ring of the voice-frequency extension is closed causing the line or A relay to operate from the 48-volt d-c supply. Resistors R107 and R108 together with capacitors C104 and C105 comprise a filter to reduce the noise which might otherwise result from the harmonics produced in the rectifier supplying the 48-volt d-c power, since this power is transmitted along the voice-frequency extension for supplying transmitter current to the subscriber sets.

3.53 The A relay is a parallel- or sandwich-wound relay, depending on the type used (see SD-95568-01), designed to maintain the balance to ground of the two sides of the voice-frequency line. A third winding on the relay provides magnetic bias to keep the relay in its non-operated condition while the circuit across the tip and ring of the voice-frequency extension is open. Since this winding is energized from the same source as that used to operate the relay through its two primary windings, the effects on the operation of this relay due to changes in the voltage of the 48-volt d-c supply are minimized. The amount of current through this biasing winding will permit satisfactory operation and pulsing of this relay when the leakage resistance across the tip and ring of the voice-frequency extension is as low as 5000 ohms.

Dial Service

3.54 In dial service, when the A relay operates, a circuit is closed from the +B supply to the plate of tube V1. The +B supply is also connected through the A relay contacts to the winding of the B relay through resistor R105. Operation of the B relay causes the C relay to operate from the 48-volt d-c supply. When the C relay operates, its functions are similar to the switchhook in the telephone set associated with the individual subscriber terminal as follows: (1) to close the filament supply to tube V2, (2) to close the 30-volt 60-cycle supply

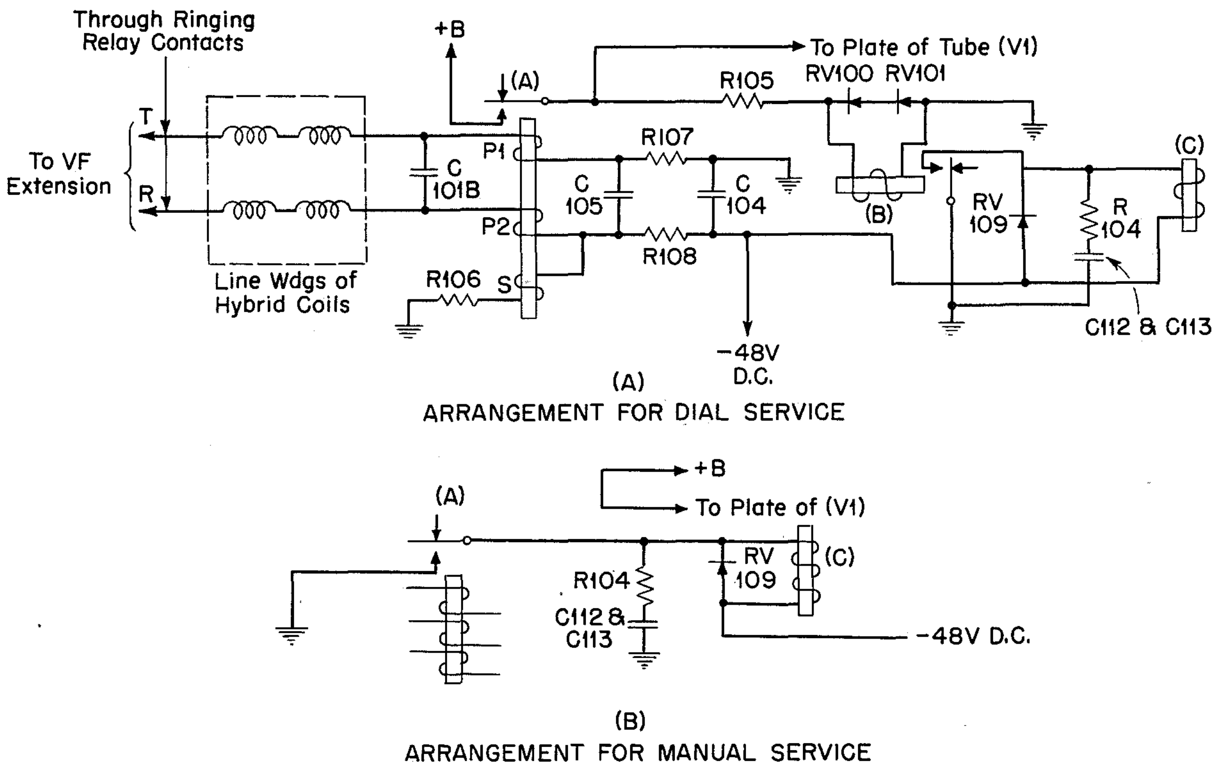


Fig. 43 - Simplified Schematic Showing Relays Used in the Multi-Subscriber Terminal for Dialing and Supervision

to the carrier drop for operating the relay in the coupling unit, (3) to shunt resistor R109 across the normal biasing resistor R5 of tube V1 so that the tube will oscillate at full output, (4) to remove the short circuit across the receiving leg of the hybrid circuit so that voice frequencies can be transmitted from the demodulator to the voice-frequency extension, (5) to open the input circuit to tube V10 to disable the signaling circuit and (6) to open the operating circuit of the K1 relay thus preventing its operation unless it has already been operated as explained in Paragraph 3.58. These various operations place the multi-subscriber terminal in talking condition and cause it to transmit carrier to the line.

3.55 When the subscriber dials, the dial contacts open and close the circuit across the tip and ring of the voice-frequency extension and cause the A relay to pulse. As the A relay contacts open and close, the plate voltage of tube V1 is interrupted and the carrier transmitted by this tube is pulsed in accordance with the pulsing of the dial contacts. The current through the B relay winding from the A relay contacts is also pulsed but the presence of varistors RV100 and RV101 across its winding cause the B relay to remain operated longer than the period during which the A relay contacts are closed. The B relay nevertheless does pulse under most conditions and it is therefore necessary to shunt the C relay winding with varistor RV109 so that the C relay remains operated continuously during dialing. Resistor R104 and capacitors C112 and C113 form a spark killer for protection of the B relay contacts. The high resistance R105 in series with the B relay winding make a spark killer across the A relay contacts in this circuit unnecessary. When the subscriber replaces the handset on its cradle, the A relay releases, releasing the B and C relays and restoring the terminal to its idle condition.

Manual Service

3.56 In manual service, as shown in Fig. 43B, the B relay and resistor R105 are removed from the circuit. The +B supply is connected permanently to the plate of tube V1 by strapping terminals 5 and 6 of terminal strip TS3. Ground is connected to the A relay front contact instead of the +B supply used in dial service, and the A relay armature is connected to the C relay winding instead of the plate of tube V1. Thus, when the A relay operates, it operates the C relay directly from the 48-volt d-c supply. In all other respects, except that no dialing is done, the operation of the terminal is the same as in dial service.

Operation of Other Relays

3.57 Referring to Fig. 41, when the ringing pulses are received from the demodulator in the multi-subscriber terminal, they are applied to the input circuit of tube V10, as explained previously, and also through the K2 relay winding in series with resistor R52. The pulses flowing through the K2 relay winding cause the relay alternately to operate and release, thus vibrating at the 30-cycle pulse rate. While the K2 relay contacts are closed, a circuit is completed from the +B supply through the back contacts of the R relay, resistors R118 and R15 in series, the operated contacts of the K2 relay, the winding of the K1 relay, a pair of back contacts of the C relay, resistor R119, the back contacts of the T relay to ground. However, the time constant of resistor R118 and capacitors C1 and C10 in parallel is sufficiently large so that the K1 relay does not receive enough energy to operate it during the short period that the K2 relay contacts are closed. When the K2 relay releases, capacitors C1 and C10 discharge through the back contacts of the K2 relay and resistor R53. The K1 relay, therefore, can not be operated during the first several ringing pulses that operate the K2 relay and, as either the R or T relay will operate after the first few pulses of the ringing signal have been received, as explained in Paragraph 3.31, the circuit to the K1 relay is opened for the balance of the ringing interval. The K1 relay is therefore prevented from operating on a ringing signal.

3.58 If an individual subscriber terminal on the same channel is in the talking condition or if a revertive call is established between an individual subscriber terminal on the channel and one of the subscribers on the voice-frequency extension in which the individual subscriber terminal party has answered first, carrier is transmitted back from the common terminal as discussed previously. In this instance, the K2 relay of the multi-subscriber terminal would be operated continuously as long as the carrier is received from the common terminal and the K1 relay would then be allowed to operate. As soon as the latter operates, its winding receives ground from a pair of its own contacts and the relay will remain operated as long as the K2 relay contacts are closed even though the C relay may later operate and open the operating circuit, as discussed below. Whenever the K1 relay is operated, it changes the frequency of the carrier transmitter from normal to revertive frequency as it does in the individual subscriber terminal. The frequency changing circuit is not included in Fig. 41.

3.59 As shown in Fig. 41, contacts on the K1 relay also open the circuit between the demodulator and tube V10; thus if an individual subscriber terminal on the channel is in use, speech modulated carrier, which would then be present on the carrier line and would be received and demodulated by the multi-subscriber terminal, could not accidentally operate the signaling circuit. When the C relay is operated during a call under conditions where the K1 relay is not operated, the former opens the circuit to the input of tube V10 and thus prevents speech modulated carrier from causing false operation of the signaling circuit. Should the C relay operate before the K1 relay, the latter can not operate since its operating circuit is opened by a pair of contacts on the C relay.

4. CONNECTION TO CENTRAL OFFICE

(A) Voice-Frequency Line Connections

4.01 The voice-frequency line from the central office is connected as shown in Fig. 35. The tip and ring voice-frequency line conductors are carried from the unit terminal strip through back contacts of the B relay to 1-mf capacitors, thence through the ringing relay windings to ground. In the stand-by condition, the common terminal is thus connected to respond to ringing current from the local office. In the talking condition, the B relay is operated and the tip and ring conductors are carried through front contacts of the B relay, thence through the voice-frequency pad, if used, to terminals 5 and 6 on the unit terminal strip.

(B) Pad

4.02 The pad incorporated in the common terminal is a balanced structure made up of resistors R51 to R58 and capacitor C32. "W," "X," "Y," and "Z" strapping options are provided for connecting the pad for 0-, 2-, 4-, and 6-db loss, respectively. The tip and ring leads from the pad are connected to terminals 5 and 6, respectively, on the unit terminal strip. The tip and ring leads to the 4-wire terminating set line terminals connect to terminals 3 and 4, respectively, on the unit terminal strip. These two pairs of terminals are strapped together by means of short leads clamped under binding head screws to complete the circuit between the 4-wire terminating set and the line. This provides for convenient segregation of the line from the equipment to facilitate testing. The proper strapping of the pad is used to build out the voice-frequency loop to a total of 6 db $\pm$ 1 db. The pad employs 1/2-watt, 5 per cent resistors.

(C) Balancing Network

4.03 A 4-element balancing network is provided in the common terminal for balancing the voice-frequency line. The elements of this network consist of two groups of series resistors, a capacitance element, C31, and an inductance element, L5, as shown in Fig. 35. The resistance elements consist of resistors R33 to R41 and R42 to R50. Each of the resistance elements can be strapped for 0 to 2220 ohms in 10-ohm steps. One-half watt, 5 per cent resistors are used.

4.04 The capacitive element is a multi-unit capacitor (187A) made from ten individual units with one side of each unit connected to a common terminal all of which are enclosed in a single can. The other terminal of each unit can be connected or strapped as required to obtain total values between 0 and 0.413 mf in about 0.002-mf steps. The values of the individual units and their manufacturing limits are shown below:

Unit No.	Nominal Value - mf	Maximum Value - mf	Minimum Value - mf
1	.002	.00266	.00133
2	.002	.00266	.00133
3	.004	.0048	.0032
4	.007	.0084	.0056
5	.012	.0141	.0094
6	.020	.0235	.0165
7	.034	.0400	.0280
8	.058	.0682	.0478
9	.100	.115	.085
10	.174	.200	.148

4.05 The inductive element is a 251B retardation coil consisting of a tapped winding on a toroidal core. The nominal inductance between various pairs of terminals is shown in the following table. The manufacturing tolerance on the inductance is $\pm$ 10 per cent between terminal 1 and any other terminal. For other terminal combinations the variation may be greater.

Terminal No.	1	2	3	4	5
2	17				
3	78	26			
4	100	40	2		
5	111	48	4		
6	122	56	7		
7	133	64	10	3	
8	145	74	14	6	3

Inductance - mh

The d-c resistance of the coil between terminals 1 and 8 is about 34 ohms.

(D) Signaling Range

4.06 With the M1 system, the limitation in the signaling range in either direction over the voice-frequency loop is the same as for any other loop in the office. As with any voice-frequency loop, whenever the nominal signaling range for the office is exceeded, a long line supervisory circuit is required for extending the range of d-c supervision. The same long line supervisory circuit used for voice-frequency lines is satisfactory, but lines sufficiently long to require its use are subject to the usual voice transmission degradation due to the additional loop loss introduced.

(E) Connection to Magneto Office

4.07 When the M1 system is used from a magneto office, it is necessary to use an auxiliary conversion circuit (SD-14152-01) for operating the incoming signal at the operator's position and to provide the divided-code ringing feature where required. This circuit is located in the magneto office and requires a battery (air cells or storage battery) of approximately 10 volts in the office for operation of the signals.

(F) Operation with Various Ringing Systems

4.08 The arrangements at the common terminal for receiving the ringing signal from the local office are designed primarily for those switchboards which transmit 20-cycle current over either the tip or the ring side of the line to ground. The application of ringing current at the central office over both the ring and tip side of the line to ground will operate both the ringing relays at the common terminal simultaneously and, hence, the bells of all parties of the carrier channel will ring. Offices which are equipped for transmitting superimposed ringing signals for 4-party full selective ringing could also operate the common terminal ringing relays but, of course, only two groups of subscribers could be rung selectively since the RR and RT relays are not able to differentiate between superimposed positive and superimposed negative rings over either side of the line to ground.

4.09 Offices equipped to transmit harmonic ringing over either side of the line to ground are also able to operate the ringing relays at the common terminal, provided that one of the frequencies near 20 cycles is used. Selective ringing based on frequency separation has not been provided.

5. TRANSMISSION FEATURES

(A) Frequency Allocation

5.01 The transmitting and receiving frequency allocations for each channel are such that interchannel crosstalk is minimized. The second harmonic of any frequency in the low group falls midway between the bands of two of the frequencies in the high group as shown in Paragraph 1.06. Also, interference from 2A-B modulation products is reduced in this system allocation.

5.02 Channel 1A uses frequencies below 200 kc and above 400 kc, hence this channel will not, in general, be subject to interference from air-navigation aid transmitters because the latter allocations usually lie between 200 kc and 400 kc.

(B) Common Terminal Receiving Filters

5.03 A typical loss-frequency characteristic, relative to mid-band loss, of the common terminal filters is shown in Fig. 44. The input filters provide the main part of the selectivity. This provision guards against the possibility of overloading the input tube with power from the adjacent normal or revertive frequency or from other high level frequencies which may be on the line. The filters also discriminate against crosstalk from the second harmonic of the common terminal transmitting frequencies. The interstage coupling filter and the output filter add further selectivity and shaping, which, added to that of the input filters, provide a flatter characteristic in the pass band and somewhat steeper cutoff than could readily be obtained by input filters alone. Each FL2 filter is tuned with a particular FL3 filter and the two are furnished as a pair. Likewise, an FL6 filter and an FL7 filter are tuned and furnished as a pair. Replacements of these units must be made in pairs in order to assure satisfactory over-all tuning.

(C) Subscriber Terminal Receiving Filters

5.04 A typical loss-frequency characteristic, relative to mid-band loss, of the subscriber terminal receiving filters is shown in Fig. 45. As in the common terminal, the input filters provide the main part of the discrimination and the interstage and output coupling filters contribute additional correction and selectivity to smooth out the pass-band characteristic and provide steeper cutoff. The pass band is slightly wider and less steep than that provided by the common terminal, since the adjacent frequencies are 15 kc apart instead of the 10-kc difference between the normal and revertive frequencies at the common terminal. Each FL2 filter is tuned with a particular FL3 filter and the two are furnished as a pair. Replacements of these units must be made in pairs in order to assure satisfactory over-all tuning.

(D) Subscriber and Common Terminal Transmitting Filters

5.05 The loss-frequency characteristic of the subscriber and common terminal transmitting filters, referred to mid-band loss, is shown in Fig. 46. Since the subscriber terminal transmits either the normal or revertive frequency, its pass band is considerably wider than that of the common terminal transmitting filter.

(E) Coupling Unit Filters

5.06 The broad band filters, FL1, in the various types of coupling units have step-down impedance ratios to adjust the line impedance to that of the other filters and carrier drop wire. The tuning of FL1, in combination with the coupling capacitance, is such that the band of frequencies for the entire system is passed and some selectivity is obtained against frequencies outside this band. Two types of broad band filters are used depending on the type of coupling unit. The 161A filter, used with the bridging subscriber coupling unit, has an impedance ratio of about 750:100 ohms between its line and drop terminals, respectively. The 161B filter or 205A repeating coil, used with the broad band coupling unit or with the terminating subscriber coupling unit, has an impedance ratio of about 600:100 ohms between the line and drop terminals, respectively.

5.07 The loss-frequency characteristics of filters FL2 and FL3 when associated with the broad band filter FL1 are shown in Fig. 47.

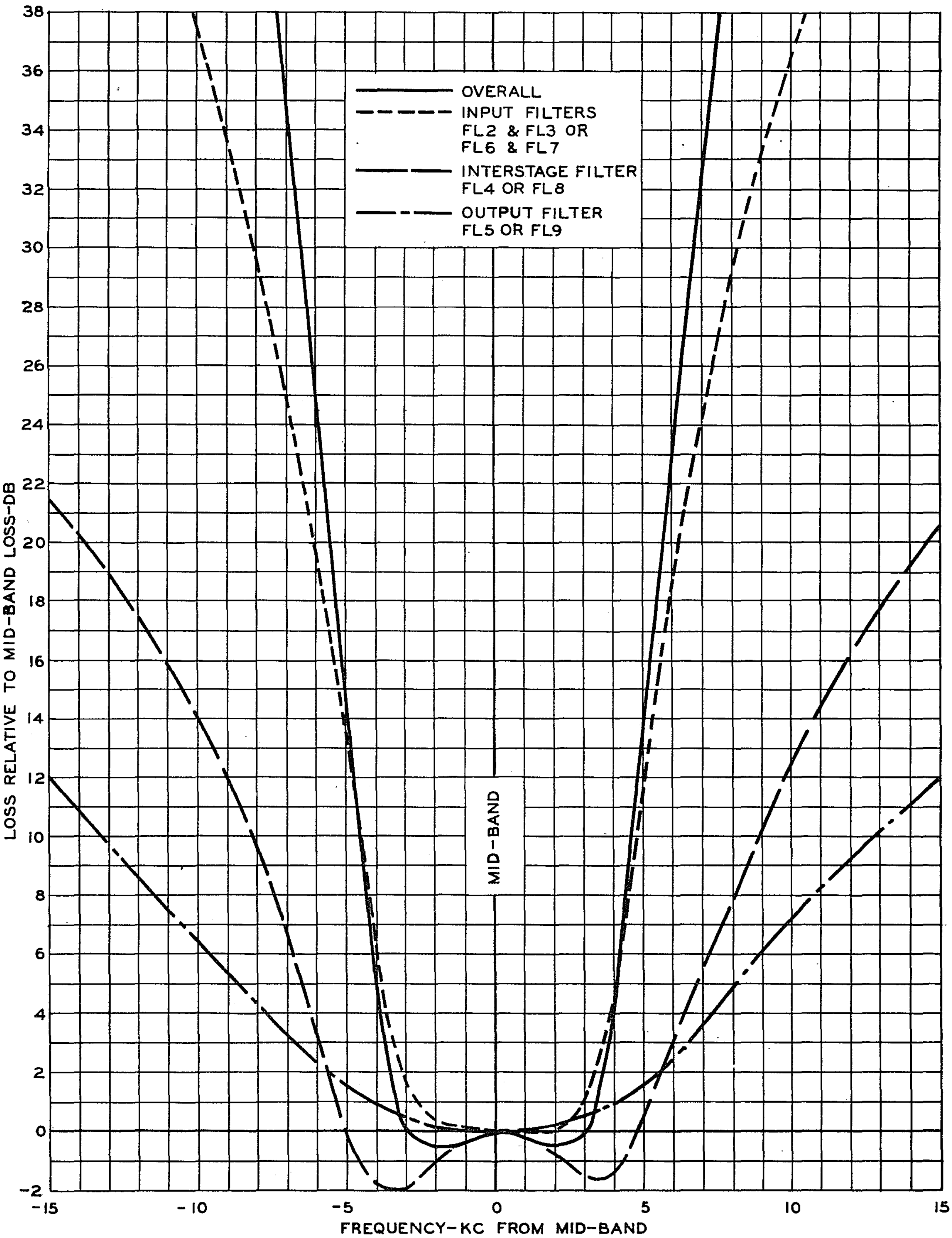


Fig. 44 - Typical Loss-Frequency Curves of Common Terminal Receiving Filters

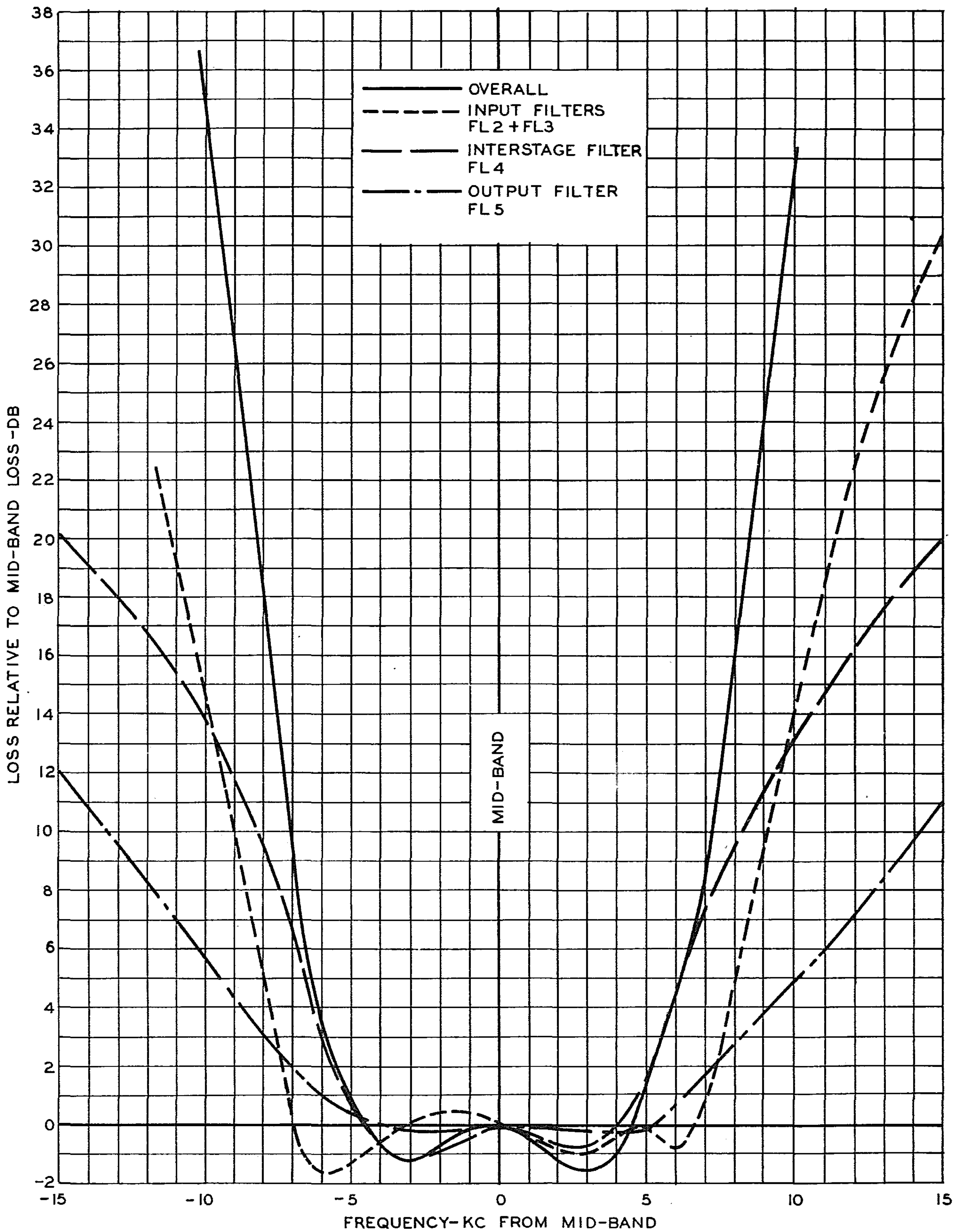


Fig. 45 - Typical Loss-Frequency Curves of Subscriber Terminal Receiving Filters

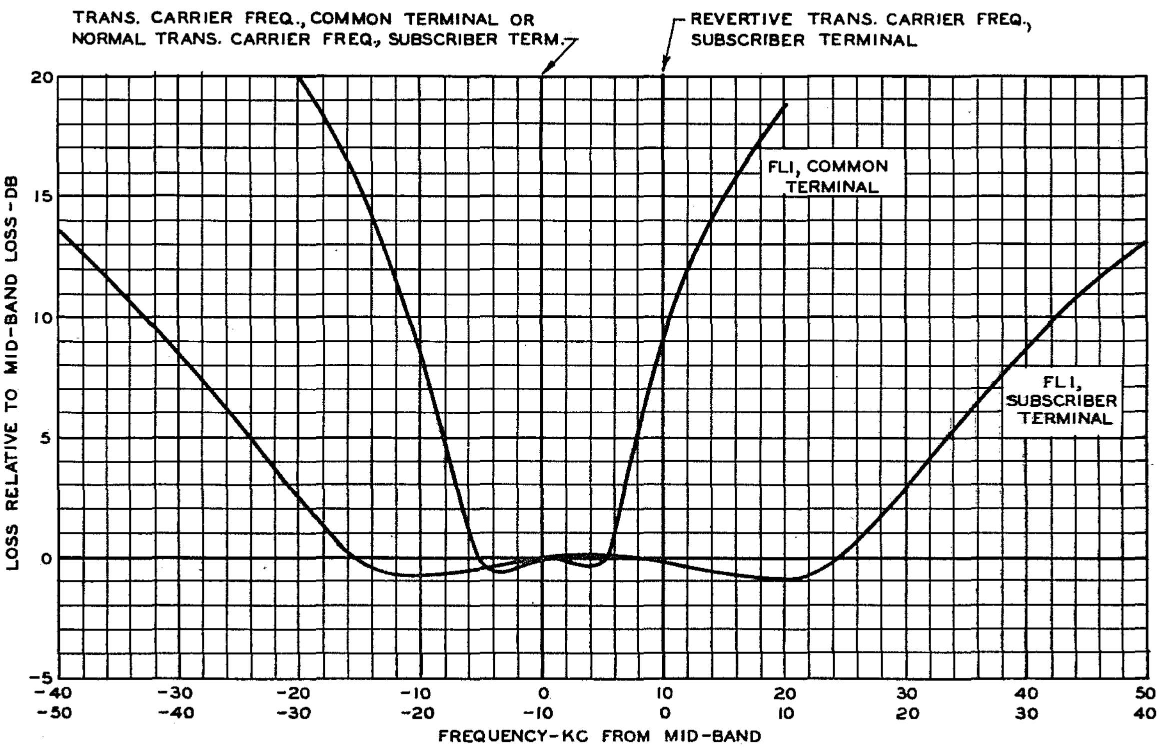


Fig. 46 - Typical Loss-Frequency Curves of Transmitting Filters

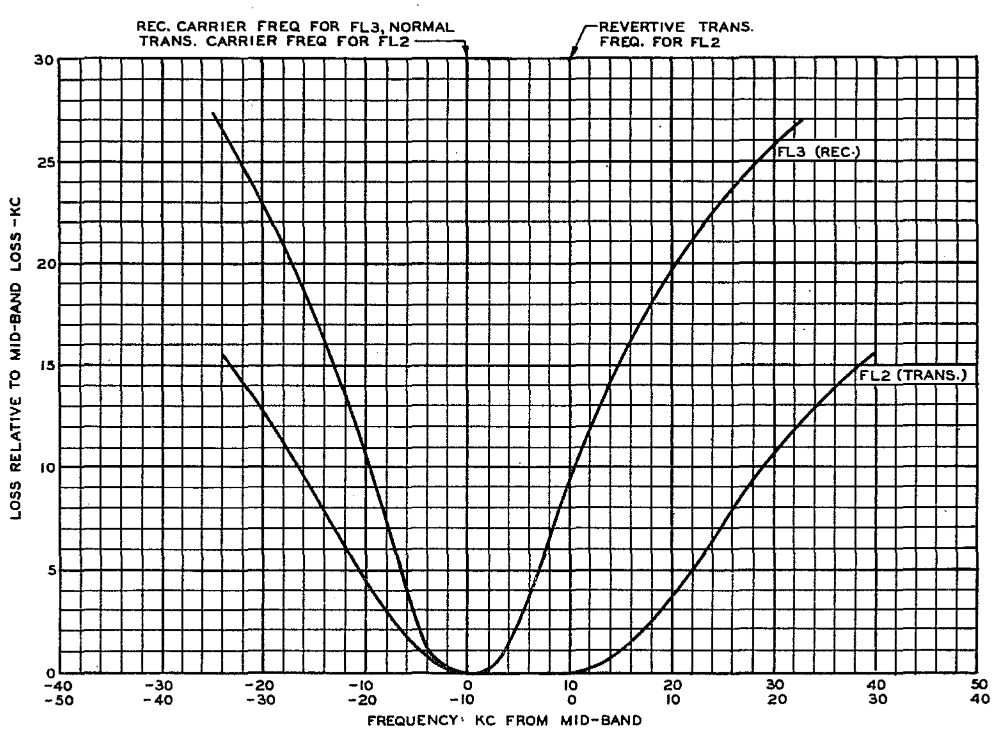


Fig. 47 - Typical Loss-Frequency Curves of Coupling Unit Filters

TABLE 2 - THROUGH AND BRIDGING LOSSES OF COUPLING UNITS

Type of Coupling Unit	Station Condition	Type of Loss	Loss - db: Receiving Freq. of Station	Trans. Freq. of Station	Other Freq.
Bridging Subscriber	Stand-by	Through	13.0	-	-
		Bridging	0.8	0.2 or less	0.2 or less
	In use	Through	13.0	6.0	-
		Bridging	0.8	3.0	0.5 or less
Terminating Subscriber	Stand-by	Through	11.0	-	-
	In use	Through	11.0	6.0	-
Broad Band (except transfer)	Any	Through	About 0.7 db at all frequencies		
Transfer	Any	Through	About 1.1 db at all frequencies		

In some cases, with the multi-subscriber terminal, these filters are installed in the terminal unit itself instead of in the coupling unit. The approximate absolute bridging and through losses of the complete coupling units are given in Table 2.

5.08 The comparatively high through loss of the coupling units at the receiving frequency results from a design such that a correspondingly low bridging loss is obtained. The subscriber terminal has enough receiving gain to compensate for this through loss, and the loss of the unit does not affect the signal-to-noise ratio. However, in the transmitting direction the signal-to-noise ratio is decreased by the amount of the through loss and hence it is kept as low as practicable.

(F) Over-All Frequency Characteristic

5.09 Typical over-all voice-frequency response curves are shown in Figs. 48, 49, 50 and 51 for each direction of transmission. For comparison, curves are included showing the frequency response of a local battery subscriber set circuit. The method of deriving these curves is shown in the figures.

5.10 In measuring the frequency characteristic in the direction from common terminal to subscriber terminal (Fig. 48) and from common terminal to multi-subscriber terminal (Fig. 50), an input level of -30 dbm is used (assuming no voice-frequency pad) in order to prevent the volume limiter from changing the shape of the derived curves. The shape of the curves will vary slightly for input level values higher than -30 dbm but will be substantially the same for lower levels. Because of the volume limiter action of the common terminal, the over-all net loss increases when the input level is raised. Hence at -5 dbm and at 1000 cycles, the over-all net loss will be approximately 15 db greater than the values shown for an input level of -30 dbm. Extreme tube and line voltage variations, especially when occurring in additive combinations, might change the carrier circuit net loss by as much as 5 db. The selectivity of the various filters in the carrier circuit accounts for the sharp high-frequency cutoff shown in Figs. 48 and 50.

5.11 At about -18 dbm input level, the 1000-cycle net loss is about the same for the two types of circuits shown in Fig. 48. For input levels in the region of about -30 dbm, the over-all net loss of the carrier circuit is

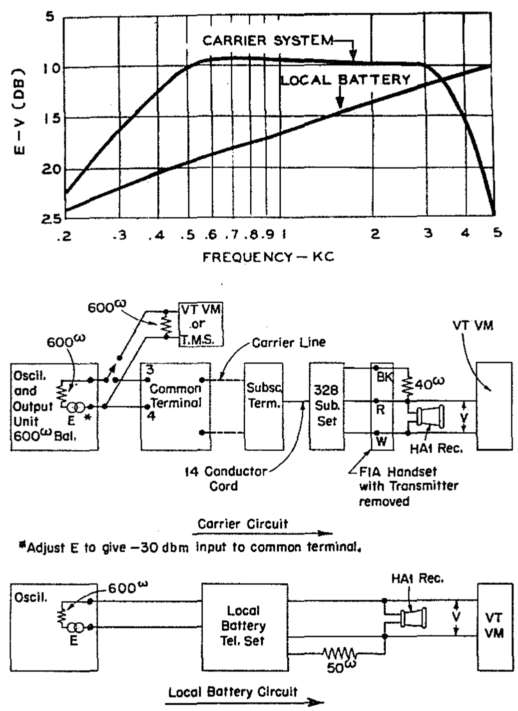


Fig. 48 - Typical Over-All System Frequency Response from Common Terminal to Subscriber Terminal Compared to Local Battery Circuit

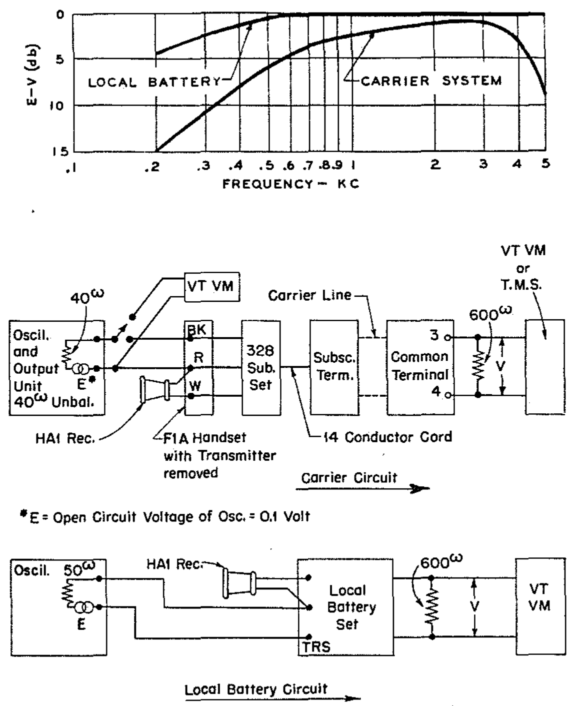


Fig. 49 - Typical Over-All System Frequency Response from Subscriber Terminal to Common Terminal Compared to Local Battery Circuit

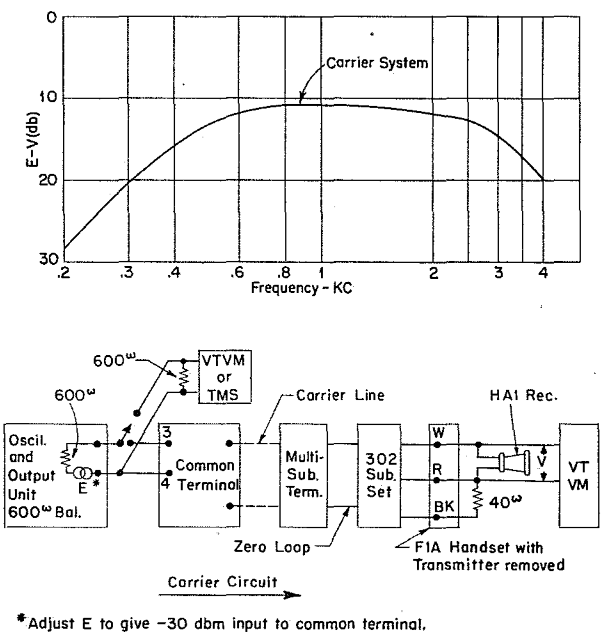


Fig. 50 - Typical Over-All System Frequency Response from Common Terminal to Multi-Subscriber Terminal

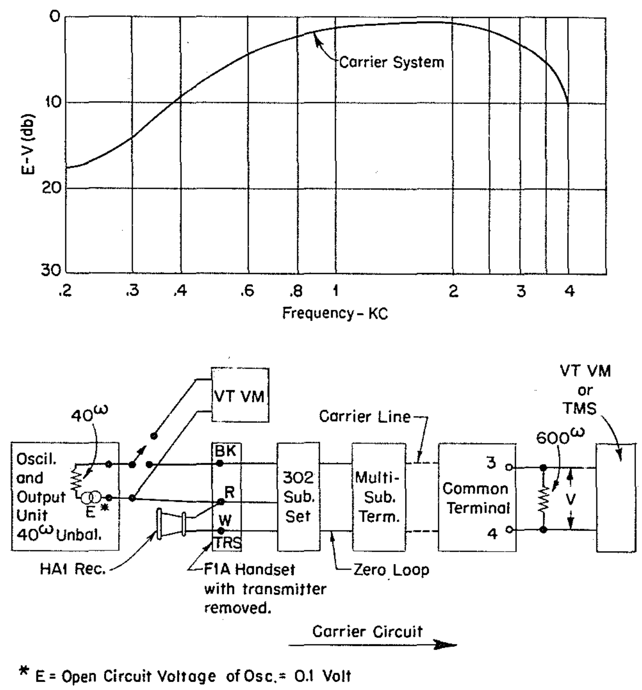


Fig. 51 - Typical Over-All System Frequency Response from Multi-Subscriber Terminal to Common Terminal

about 8 db less at 1000 cycles than that of a local battery circuit. For input levels in the region of about -5 dbm, the 1000-cycle net loss of the carrier circuit is about 7 db greater than that of a local battery circuit.

5.12 It is noted that the over-all net loss of a carrier circuit composed of a common terminal transmitting to a subscriber terminal (Fig. 48) is approximately 3 db less at 1000 cycles than that of a common terminal transmitting to a multi-subscriber terminal (Fig. 50). The additional loss of the latter circuit is due to the multi-subscriber voice-frequency circuit arrangement which is necessary to prevent singing under certain conditions.

5.13 In the direction from the subscriber terminal to the common terminal and from multi-subscriber terminal to common terminal also, tube and line voltage variations may change the over-all net loss by as much as 5 db for extreme cases. The sharp high-frequency cutoff in the carrier circuits shown in Figs. 49 and 51 is due to the various filters in the carrier circuit.

(G) Carrier Transmitting Levels

5.14 The transmitting level of the unmodulated carrier into 100 ohms terminating the subscriber terminal in place of the drop wire is approximately +27 dbm.

5.15 The transmitting level of the unmodulated carrier into 100 ohms terminating the multi-subscriber terminal, where the 151 and 152-type filters are not included on the basic unit (option V omitted), in place of the drop wire, is about +27 dbm. Where the filters are included on the panel, the unmodulated carrier level is approximately +25 dbm.

5.16 The transmitting level of the unmodulated carrier into 100 ohms terminating the common terminal in place of the drop wire is about +25 dbm.

5.17 The slightly lower transmitting level from the common terminal is due to the higher mid-band loss of the output filter at this terminal. The greater mid-band loss of the common terminal output filter as compared to that of the subscriber or multi-subscriber terminal output filter results from the narrower band providing for the transmission of only a single carrier frequency from the common terminal to the subscriber or multi-subscriber terminal.

(H) Volume Limiter Operation

5.18 The volume limiter characteristic is shown as the solid curve in Fig. 52. The dotted extrapolation of the straight line portion of the curve representing the input-output level relationship shows that severe overloading would result on many local calls if no limiting were used. The limiting circuit is designed to take effect at approximately the -30 vu input level point. The control exercised by the limiter prevents the carrier from being more than 100 per cent modulated by peaks in the voice input except for rare cases where exceptionally loud talkers are talking over short subscriber loops. The

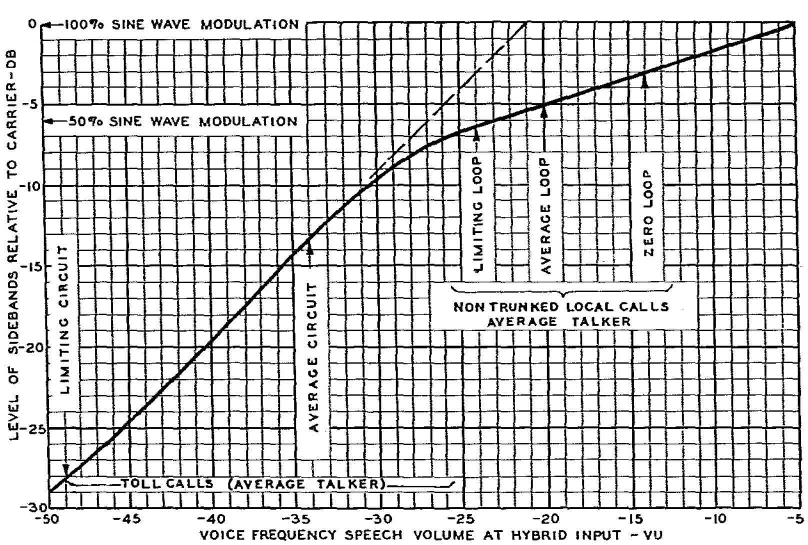


Fig. 52 - Typical Volume Limiter Performance

lack of limiting action in the low input range improves the sensitivity in this region by a little more than 15 db over what it would be without limiting. During speech transmission the signal-to-carrier-line-noise ratio is improved by nearly the same amount on calls through the central office, but is improved by only 3 or 4 db on revertive calls.

(I) Automatic Gain Control at Subscriber Terminal

5.19 A typical curve demonstrating the action of the AGC in the subscriber terminal receiver strapped for minimum (normal) gain is shown in Fig. 53. The automatic control starts to be effective at input levels of about -35 dbm. For input level changes of 50 db in the normal operating range of the receiver the output level change is in the order of 6 db. The action of the control in the multi-subscriber terminal is similar.

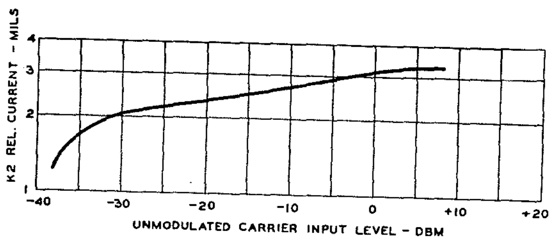


Fig. 53 - Typical Automatic Volume Control Performance - Subscriber Terminal Receiver

(J) Automatic Gain Control at Common Terminal

5.20 Typical curves demonstrating the action of the AGC in the common terminal normal and revertive receivers are shown in Fig. 54.

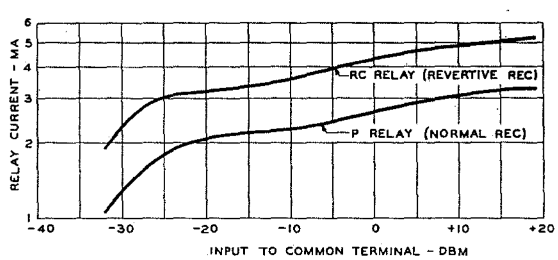


Fig. 54 - Typical Automatic Volume Control Performance - Common Terminal Receivers

These curves are based on minimum (normal) gain strappings of both receivers. The lower output of the normal receiver as compared to that of the revertive receiver is due to the division of output current over two paths (see Paragraph 2.52). For input level changes of about 30 db in the normal operating range of the receivers, the output level change is in the order of 3 db.

(K) False Operation

5.21 Heavy static voltages appearing at the input to a subscriber terminal may, in extreme cases, operate the K2 relay and result in bell tapping or false rings. However, the poling feature provided in the subscriber terminal receiver where divided-code ringing is used, whereby the receiver is energized only about half of the time for the receipt of incoming signals, assists in guarding against false operation. This is because it is unlikely that static surges are consistently synchronized with the 60-cycle supply. False operation of the ringer due to static is also reduced by the shunt placed across the ringer when K1 is unoperated. Both K2 and K1 have to operate and K1 has to remain operated during two or more operations of K2 in order for a false ring to occur.

5.22 With the multi-subscriber terminal, in addition to the poling feature, a network at the input of tube V10 attenuates the first one or two pulses. Also the T and R relays in the ringing circuit are each shunted by a 4-mf capacitor. This capacitor makes the relay insensitive to short transients and prevents false operation on static bursts or other interference which might not have been fully suppressed by the above-mentioned network. The features are described in Paragraphs 3.31 and 3.32.

5.23 In the direction from subscriber terminal to common terminal, static crashes have to be sustained long enough to operate the P, A and B relays in order to flash the operator or seize a line circuit. The capacitor shunt across the P relay winding in the stand-by condition makes it insensitive to short pulses of static. A similar shunt is employed across the RC relay winding.

(L) Frequency Stability of Crystals

5.24 The frequency stability of the crystals is in the order of ± 0.04 per cent including variations due to temperature changes over the widest likely range. This amounts to a maximum of about ± 62 cycles variation at 155 kc and about ± 168 cycles at 420 kc. Should a third party come on a carrier channel when it is in use for a revertive call, two frequencies of the same nominal value and of the revertive call allocation will be transmitted on the carrier line. The difference in the two actual frequencies, however, will appear as a beat at the output of the revertive call receiver at the common terminal. If this beat results from two subscribers located near each other on the carrier line, it may produce annoying interference but would not preclude emergency use of the channel to call medical aid or to report a fire. If one of the interfering subscribers is located near the common terminal and the other at the remote end of the line section, the gain of the revertive receiver is under control of the higher level carrier, and hence transmission from the remote subscriber to the common terminal is degraded by the difference in line attenuation between the two interfering subscribers and the common terminal. However, emergency interruption by the remote subscriber will be possible. The maximum frequency of the interfering tone for any case would be in the order of 336 cycles or twice the maximum deviation of the top channel frequency from its nominal value. Should the revertive frequency crystals of two interfering subscribers be within a few cycles of each other, the beat might be of such a low frequency that little annoyance from the note itself would be apparent. However, the gain of the revertive call receiver would be under control of the higher level carrier.

6. LIST OF SUPPLEMENTARY INFORMATION

(A) Circuit Drawings (Not Attached)

SD-14152-01 - Auxiliary Circuit for Magneto Office

SD-95105-01 - Subscriber Terminal

SD-95110-01 - Common Terminal

SD-95430-01 - Telephone Choke Unit

SD-95431-01 - Bridging Subscriber Coupling Unit

SD-95432-01 - M1S4 Terminating Subscriber Coupling Unit

SD-95433-01 - Broad Band Coupling Unit

SD-95550-01 - M1S5 Terminating Subscriber Coupling Unit

SD-95568-01 - Multi-Subscriber Terminal

(B) Equipment Drawings (Not Attached)

ED-10653-01 - Auxiliary Circuit for Magneto Offices

ED-91975-01 - Subscriber Terminal

ED-92011-01 - Common Terminal

ED-92031-01 - Cabinet for Outdoor Pole Mounting

ED-92032-01 - Modification Kits for Oil Circuit Reclosers

ED-92093-01 - Telephone Choke Unit

ED-92094-01 - Bridging Subscriber Coupling Unit

ED-92095-01 - M1S4 Terminating Subscriber Coupling Unit

ED-92096-01 - Broad Band Coupling Unit

ED-92256-01 - Phase Shifter

ED-92298-01 - M1S5 Terminating Subscriber Coupling Unit

ED-92312-01 - Bay Equipment Arrangements for Central Office Installations

ED-92464-01 - Multi-Subscriber Terminal

(C) J Specifications (Not Attached)

J98701 - Type M1 Carrier Telephone System

(D) List of Attachments

Table 3 - Carrier Terminal Circuit Elements Dependent on Frequency

Table 4 - Constants of Elements in Subscriber Terminal

Table 5 - Constants of Elements in Multi-Subscriber Terminal

Table 6 - Constants of Elements in Common Terminal

Attached:
Tables 3 through 6

TABLE 3 - CARRIER TERMINAL CIRCUIT ELEMENTS DEPENDENT ON FREQUENCY

Subscriber Terminal and Multi-Subscriber Terminal

Freq. KC	Y1	Y2	C4	C22	FL1	FL2	FL3	FL4	FL5	FL10	FL11
155	-	-	-	-	-	154A	155A	156A	157A	-	152A
185	-	-	-	-	-	154C	155C	156C	157C	-	152C
200	-	-	-	-	-	154D	155D	156D	157D	-	152D
215	-	-	-	-	-	154E	155E	156E	157E	-	152E
230	-	-	-	-	-	154F	155F	156F	157F	-	152F
290-300	22DG or 22DA	22DG or 22DA	510 mmf	680 mmf	153A	-	-	-	-	151A	-
320-330	22DG or 22DA	22DG or 22DA	430 mmf	550 mmf	153B	-	-	-	-	151B	-
350-360	22DG or 22DA	22DG or 22DA	360 mmf	453 mmf	153C	-	-	-	-	151C	-
380-390	22DG or 22DA	22DG or 22DA	330 mmf	380 mmf	153D	-	-	-	-	151D	-
410-420	22CG or 22CA	22CG or 22CA	270 mmf	325 mmf	153E	-	-	-	-	151E	-

Common Terminal

Freq. KC	Y1	C1	C3	FL1	FL2	FL3	FL4	FL5	FL6	FL7	FL8	FL9
155	21EG or 21EA	300 mmf	430 mmf	158A	-	-	-	-	-	-	-	-
185	21EG or 21EA	180 mmf	300 mmf	158C	-	-	-	-	-	-	-	-
200	21EG or 21EA	160 mmf	240 mmf	158D	-	-	-	-	-	-	-	-
215	21EG or 21EA	130 mmf	200 mmf	158E	-	-	-	-	-	-	-	-
230	21EG or 21EA	100 mmf	150 mmf	158F	-	-	-	-	-	-	-	-
290	-	-	-	-	-	-	-	-	159A	150A	156G	157G
300	-	-	-	-	159B	160B	156H	157H	-	-	-	-
320	-	-	-	-	-	-	-	-	159C	160C	156J	157J
330	-	-	-	-	159D	160D	156K	157K	-	-	-	-
350	-	-	-	-	-	-	-	-	159E	160E	156L	157L
360	-	-	-	-	159F	160F	156M	157M	-	-	-	-
380	-	-	-	-	-	-	-	-	159G	160G	156N	157N
390	-	-	-	-	159H	160H	156P	157P	-	-	-	-
410	-	-	-	-	-	-	-	-	159J	160J	156R	157R
420	-	-	-	-	159K	160K	156S	157S	-	-	-	-

TABLE 4 - CONSTANTS OF ELEMENTS IN SUBSCRIBER TERMINAL

Element	Description	Element	Description
R1	5100 ohms	C15	Terms 1 and 4, 50 mf, 25 v
R2	470 ohms		Terms 1 and 2, 75 mf, 200 v
R3	3.3 megohms		Terms 1 and 3, 75 mf, 200 v
R4	1000 ohms		
R5	0.22 megohm	C16	0.05 mf
		C17	27 mmf
R6	51,000 ohms	C18	0.05 mf
R7	10,000 ohms	C19	1000 mmf
R8	51,000 ohms	C20	1000 mmf
R9	18,000 ohms	C21	0.006 mf
R10	270 ohms	C22	See Table 3
		C23	0.01 mf
R11	3.3 megohms		
R12	820 ohms	T1	646A Input Transformer
R13	3900 ohms	T2	381C Transformer
R14	2200 ohms		
R15	470 ohms	V1	400B Vacuum Tube
		V2	398A Vacuum Tube
R16	1000 ohms	V3	399B Vacuum Tube
R17	51,000 ohms	V4	401A Vacuum Tube
R18	100 ohms		
R19	100,000 ohms	RV2	400A Varistor, Germanium
R20	3300 ohms	RV1	KS-13487 Varistor, 17 Selenium Discs, 1-1/2"
C1	Two 1-mf sections		
C2	0.01 mf	K1	UA79 Relay
C3	330 mmf	K2	KS-14499 Relay
C4	See Table 3		
C5	Three 0.1-mf units	Y2	See Table 3
		Y1	See Table 3
C6	0.01 mf	L1	296A Retard. Coil, 0.4 mh
C7	100 mmf	L2	296A Retard. Coil, 0.4 mh
C8	220 mmf	L3	296C Retard. Coil, 4.5 mh
C9	0.001 mf	L4	296B Retard. Coil, 5.3 mh
C10	2 mf		
		FL1	See Table 3
C11	0.006 mf	FL2	See Table 3
C12	0.01 mf	FL3	See Table 3
C13	0.01 mf	FL4	See Table 3
C14	0.01 mf	FL5	See Table 3

CONSTANTS OF ELEMENTS IN PHASE SHIFTER

Element	Description	Element	Description
R21	6200 ohms	C24	Two 0.1 mf Sections
R22	12000 ohms		
R23	0.1 megohm		
R24	0.1 megohm		

TABLE 5 - CONSTANTS OF ELEMENTS IN MULTI-SUBSCRIBER TERMINAL

Element	Description
R3	3.3 megohms
R5	0.22 megohm
R6	51,000 ohms
R7	10,000 ohms
R8	51,000 ohms
R9	18,000 ohms
R10	270 ohms
R11	3.3 megohms
R12	820 ohms
R15	470 ohms
R16	1000 ohms
R17	51,000 ohms
R18	100 ohms
R51	20,000 ohms
R52	3900 ohms
R53	470 ohms
R101	910 ohms
R102	51,000 ohms
R103	2200 ohms
R104	470 ohms
R105	33,000 ohms
R106	5100 ohms
R107	100 ohms
R108	100 ohms
R109	1300 ohms
R110	1.0 megohm
R111	1.0 megohm
R112	1.0 megohm
R113	11,000 ohms
R114	33,000 ohms
R115	0.51 megohm
R116	10,000 ohms
R117	10,000 ohms
R118	18,000 ohms
R119	470 ohms
R120	1330 ohms
R121	13,300 ohms
R122	1330 ohms
R123	1330 ohms
R124	13,300 ohms
R125	13,300 ohms
R126	13,300 ohms
R127	13,300 ohms
RV1	KS-13487 Varistor, 17 Selenium Discs, 1-1/2" Dia.
RV51	400C Varistor, Germanium
RV100	400B Varistor, Germanium
RV101	400B Varistor, Germanium
RV102	KS-13488 Varistor, 12 Selenium Discs, 1-1/2" Dia.
RV103	400B Varistor, Germanium
RV104	400B Varistor, Germanium
RV105	400B Varistor, Germanium
RV106	400B Varistor, Germanium
RV107	400C Varistor, Germanium
RV108	400C Varistor, Germanium
RV109	400B Varistor, Germanium
C1	Two 1 mf sections
C2	0.01 mf
C3	330 mmf
C4	See Table 3
C5	Three 0.1 mf sections
C6	0.01 mf
C7	100 mmf
C8	220 mmf
C9	0.001 mf
C10	2 mf

Element	Description
C11	0.006 mf
C12	0.01 mf
C13	0.01 mf
C14	0.01 mf
C15	Terms 1 and 4, 50 mf, 25 v Terms 1 and 2, 75 mf, 200 v Terms 1 and 3, 75 mf, 200 v
C16	0.05 mf
C17	27 mmf
C18	0.05 mf
C19	1000 mmf
C20	1000 mmf
C21	0.006 mf
C22	See Table 3
C23	0.01 mf
C101	Two 2 mf sections
C102	0.003 mf
C103	Two 0.01 mf sections
C104	200 mf, 100 v
C105	200 mf, 100 v
C106	4 mf
C107	4 mf
C108	0.5 mf
C109	0.05 mf
C110	0.5 mf
C111	0.5 mf
C112	0.05 mf
C113	0.05 mf
T2	381C Transformer
T10	647B Input Transformer
T11	189C Repeating Coil
T12	381D Transformer
V1	400B Vacuum Tube
V2	398A Vacuum Tube
V3	399B Vacuum Tube
V4	401A Vacuum Tube
V10	396A Vacuum Tube
L10	13D Resistance Lamp
K1	UA79 Relay
K2	KS-14499 Relay
A	280AJ or 239JK Relay
B	KS-13600 Relay
C	U189 Relay
R	KS-14499 Relay
T	KS-14499 Relay
RR	UA79 Relay
RT	UA79 Relay
Y1	See Table 3
Y2	See Table 3
L1	296A Retard. Coil, 0.4 mh
L2	296A Retard. Coil, 0.4 mh
L3	296G Retard. Coil, 4.5 mh
L4	296B Retard. Coil, 5.3 mh
FL1	See Table 3
FL2	See Table 3
FL3	See Table 3
FL4	See Table 3
FL5	See Table 3
FL10	See Table 3
FL11	See Table 3
F1	0.8 Amp. (3AG) Slo-Blo Littelfuse

TABLE 6 - CONSTANTS OF ELEMENTS IN COMMON TERMINAL

Element	Description
R1	1.0 megohm
R2	51,000 ohms
R3	4700 ohms
R4	51,000 ohms
R5	0.47 ohms
R6	0.47 ohms
R7	0.22 megohm
R8	0.22 megohm
R9	820 ohms
R10	820 ohms
R11	1000 ohms
R12	1000 ohms
R13	51,000 ohms
R14	51,000 ohms
R15	10,000 ohms
R16	200 ohms
R17	3.3 megohms
R18	0.2 megohm
R19	0.2 megohm
R20	51,000 ohms
R21	10,000 ohms
R22	18,000 ohms
R23	51,000 ohms
R24	10,000 ohms
R25	18,000 ohms
R26	12,000 ohms
R27	12,000 ohms
R28	1000 ohms
R29	0.1 megohm
R30	12,000 ohms
R31	270 ohms
R32	1200 ohms
R33	10 ohms
R34	20 ohms
R35	30 ohms
R36	51 ohms
R37	100 ohms
R38	200 ohms
R39	300 ohms
R40	510 ohms
R41	1000 ohms
R42	10 ohms
R43	20 ohms
R44	30 ohms
R45	51 ohms
R46	100 ohms
R47	200 ohms
R48	300 ohms
R49	510 ohms
R50	1000 ohms
R51	110 ohms
R52	110 ohms
R53	75 ohms
R54	75 ohms
R55	510 ohms
R56	510 ohms
R57	1500 ohms
R58	1500 ohms
R59	470 ohms
R60	200,000 ohms
R61	5100 ohms
R62	18,000 ohms
R63	10,000 ohms
R64	200 ohms
C1	See Table 3
C2	220 mmf
C3	See Table 3
C4	220 mmf
C5	27 mmf
C6	A, 0.125 mf - D, 0.075 mf
C7	0.001 mf
C8	4 mf
C9	0.001 mf
C10	3300 mmf
C11	0.1 mf 0.1 each A, B, and D
C12	A, 0.5 mf - B, 0.5 mf
C13	0.05 mf
C14	0.05 mf
C15	0.01 mf
C16	0.01 mf
C17	0.006 mf
C18	360 mmf
C19	0.006 mf
C20	0.05 mf
C21	200 mf, 100 v
C22	Two 1-mf units
C23	200 mf, 100 v
C24	0.265 mf min., 0.275 mf max.
C25	0.265 mf min., 0.275 mf max.
C26	Two 1-mf units
C27	0.1 mf each A, B, and D
C28	0.006 mf
C29	Two 75-mf units, 200 v One 50-mf unit, 25 v
C30	200 mf, 100 v
C31	Adjustable 0 to 0.346 mf
C32	2 mf
C33	0.05 mf
C34	0.01 mf
C35	0.01 mf
V1	400B
V2	398A
V3	399B
V4	401A
V5	399B
V6	401A
V7	376B
V8	376B
V9	G.E. NE21
V10	G.E. NE21
FL1	See Table 3
FL2	See Table 3
FL3	See Table 3
FL4	See Table 3
FL5	See Table 3

TABLE 6 - CONSTANTS OF ELEMENTS IN COMMON TERMINAL (Contd.)

Element	Description	Element	Description
FL6	See Table 3	RV6	D-170622 Varistor (Thallium copper oxide, 10-1/16" discs)
FL7	See Table 3	RV7	D-170622 Varistor (Thallium copper oxide, 10-1/16" discs)
FL8	See Table 3	RV8	KS-13487 Varistor (Selenium, 17, 1-1/2" discs)
FL9	See Table 3	RV9	KS-13488 Varistor (Selenium, 12, 1-1/2" discs)
L1	296E Retard. Coil - 2.06 mh	P	KS-14499 Relay
L2	296E Retard. Coil - 2.06 mh	A	KS-13600 Relay
L3	296B Retard. Coil - 5.3 mh	RC	KS-14499 Relay
L4	307K Retard. Coil - 0.4 h min., ave. 0.7 h	RC1	U1339 Relay
L5	251B Retard. Coil - Adjustable 0.25 mh to 150 mh in 28 misc. steps	B	Y302 Relay
L6	296C Retard. Coil - 4.5 mh	RT	J2 Relay
Y1	See Table 3	RR	J2 Relay
T1	381D Transformer	F1	0.5 amp. (3AG) Slo-Blo Littel-fuse
T2	647B Input Transformer		
T3	189C Repeating Coil		
RV1	400A Varistor, Germanium		
RV2	400A Varistor, Germanium		
RV3	400A Varistor, Germanium		
RV4	400A Varistor, Germanium		
RV5	400A Varistor, Germanium		