The Type-O Carrier System

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INTRODUCTION

While the sight of an open-wire toll line is a rarity in many parts of the East, considerable use is made of open-wire facilities in other sections of the country to provide toll and exchange service. At the present time there are about 170,000-route-miles of open-wire in the Bell System which carry some 1,400,000 pair-miles of wire used for toll service. It is estimated that about 60 per cent of this pair-mileage is used for carrier, although only about 10 per cent carries the full fifteen carrier channels, which is possible by employing type-C and type-J carrier systems. It is obvious that some of the remaining line pairs are available for additional carrier growth, provided, of course, the demand for additional circuits exists, and there are carrier systems which can meet these demands economically. Type O is a multi-channel, open-wire carrier system which has been designed to provide, economically, additional circuits in the range from a minimum of about 15 up to a maximum of 150 miles, or more. The type-O system is the open-wire counterpart of the type-N short-haul cable system.

Present open-wire toll lines vary from a single-arm line, with one or two pairs of wires, up to lines with five or six arms carrying thirty pairs. These lines may carry long-haul toll circuits up to about 1000 miles in length, short-haul toll circuits up to 150 miles, as well as tributary trunks and exchange circuits. Growth in the past of toll and tributary circuits on these lines has been provided by the addition of single-channel D or H systems, three-channel C systems, twelve-channel J systems or by other similar carrier systems.

The full development of a line for open-wire carrier has, in the past, required expensive line rearrangements. For instance, most lines reach terminal and repeater offices over entrance cables which may be several miles in length. Impedance matching at the junction of the open-wire and cable is required, and is provided by loading the cable at both voice and carrier frequencies, by employing junction line filters using non-loaded carrier pairs, or by the use of autotransformers. In addition, transposition schemes are needed to reduce the crosstalk coupling between open-wire pairs to tolerable amounts, and longitudinal and metallic filtering is necessary at repeater points to control interaction crosstalk. The C and J carriers have been designed essentially for long-haul use, and when the line transposition costs are added, these systems are likely to be more expensive than adding wire for providing relief for the shorter circuits, which are required in increasing number as the length decreases.

In contrast to the heavy back-bone toll lead carrying both long and short haul circuits is the one or two arm line which may be a secondary route, or a line which terminates in a small town. The demands along this line are for short-haul toll service, trunks between tributary offices and their toll centers, and for exchange service. Because growth has been relatively slow, carrier has been employed only to a limited extent. Single-channel D or H systems may be found on these lines, or an adaptation of the M system for toll service, and possibly other miscellaneous systems. Only minor rearrangements of the line and entrance cables has been necessary because of the small percentage of circuits equipped with carrier facilities.

A typical need for expansion on this type of line occurs when a manual tributary office is cut over to dial operation, and the operators are moved to the toll center. Additional circuits are immediately needed from the toll center to the tributary office because of certain factors introduced when the operators are moved some miles away. Experience has shown the desirability of being able to reach an operator a fairly large percentage of the time because of special services, such as directory information, reports on the availability of toll circuits, service complaints, etc. This requires a substantial increase in the number of circuits to the tributary office in such instances. Development of this line, then, proceeds by adding single-channel carrier systems, until a point is reached where it is necessary to string more copper wire, which is costly and may be in short supply, or to add multi-channel carrier systems.

The situation in Iowa is typical of many areas in the Southern and Western parts of the country. Fig. 1 shows the principal open-wire and cable routes in Iowa used by the Bell System for toll business. The type-K transcontinental cable crosses the state, passing through Davenport and Des Moines on its way to Omaha. Small branch cables serve Muscatine, Cedar Rapids and Atlantic, where the circuits are extended by open-wire facilities. In general, the transcontinental TD-2 radio relay system follows the K carrier route. A coaxial cable route extends north from Des Moines to Minneapolis, connecting at Iowa Falls with short

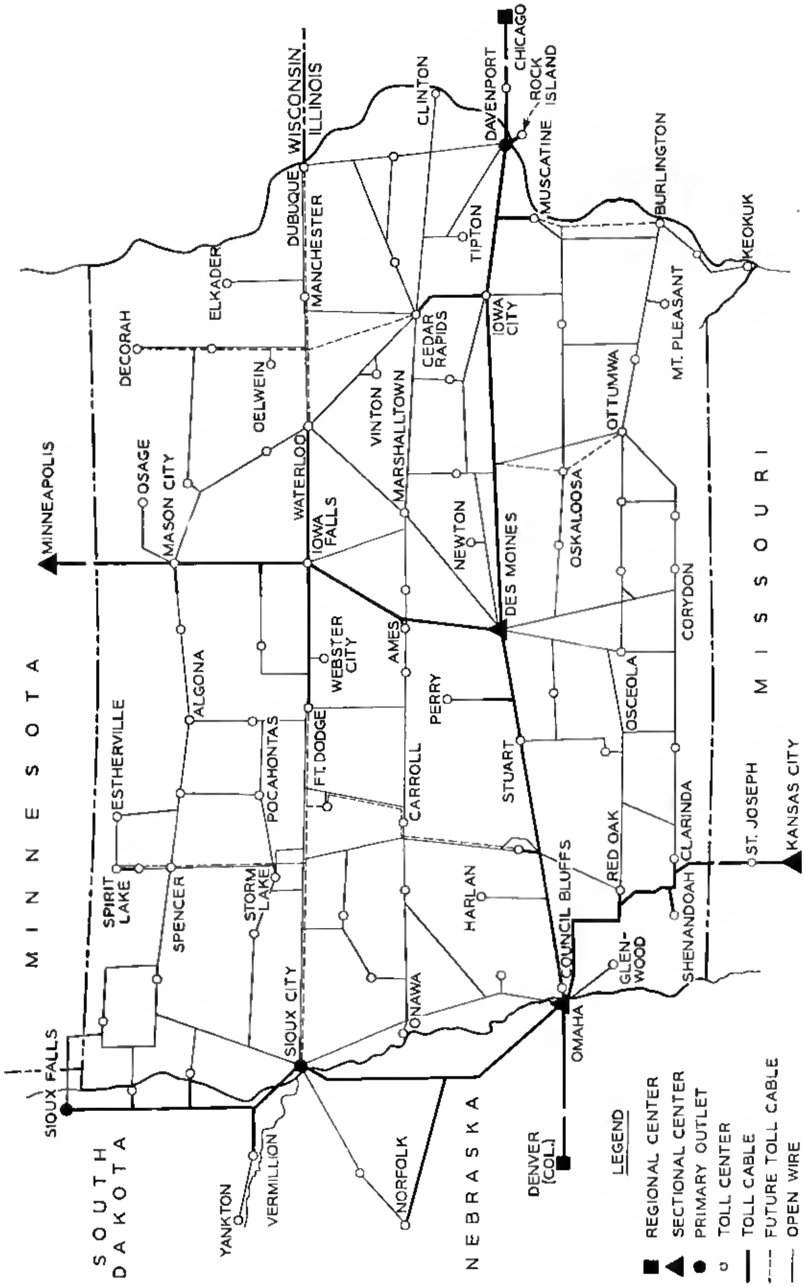


Fig. 1—Principal open-wire and cable routes in Iowa.

K cables to Fort Dodge and Waterloo. Eventually a second cable route will extend across the state through Waterloo and Fort Dodge, as shown by the dashed lines. A second coaxial route cuts across the southwestern corner on its way to Kansas City and a third coaxial route connects Sioux City with Omaha. The rest of the state is served by open-wire lines.

Fig. 2 shows the distribution with length of the Bell System open-wire short-haul toll and tributary circuits in Iowa in 1950, including both voice-frequency and carrier facilities. It will be noted that 95 per cent of the circuits are less than 100 miles in length, while 90 per cent are less than 70 miles, the point where type C systems just become economical. For tributary circuits 98 per cent are less than 30 miles in length. There are a total of some 2700 toll and tributary circuits in Iowa. In addition, there is also a sizable connecting company development. Fig. 3 is a distribution of the number of circuits per group, where a group is composed of the circuits used for via or terminating business between two towns. There are about four circuits per group for short-haul toll and two circuits per group for tributary service in the median case. As the dial conversion program proceeds the average number of circuits per tributary group is expected to increase.

Because of the short distances involved, and the small number of circuits per group, carrier development in Iowa has been restricted, to a large extent, to single-channel systems, and type M. Only four or five M channels can be operated on a given open-wire line, and while these systems have some transmission disadvantages, they have been employed to a large extent. However, further M development is blocked because of the expense of isolating M systems from adjacent lines. There are a few C systems on such routes as Sioux City-Spencer-Mason City, Waterloo-Dubuque, Muscatine-Keokuk, and Atlantic-Spencer.

The type-O system, therefore, is being made available to provide short-haul toll and tributary circuits on open-wire lines in the range from 15 to 150 miles. When completely developed it will provide four four-channel systems in the frequency range from 2 to 156 kc, as shown on Fig. 4. The use for separate channels of both sidebands of a single carrier, called a "twin-channel," results in economical use of the frequency space. The four channel systems are designated OA, OB, OC, and OD respectively, and cover substantially the same frequency range as the C and J systems.

Considerable attention has been given to keeping the line rearrangements as simple as possible. The use of non-loaded entrance cable is proposed, and simple arrangements are available for adding O groups

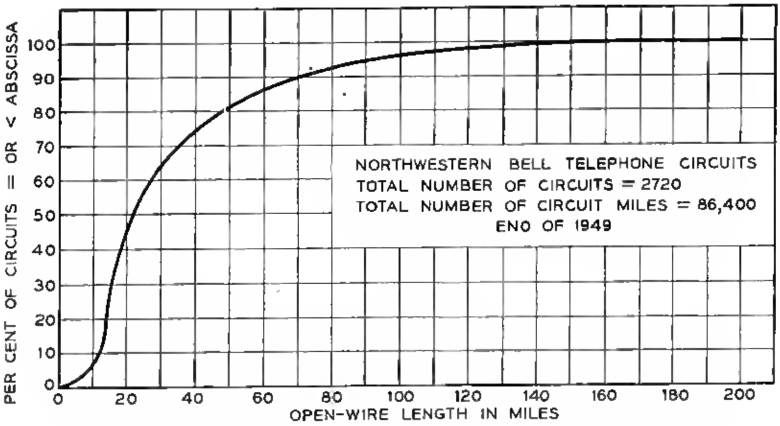


Fig. 2—Distribution of circuit lengths in Iowa in 1950.

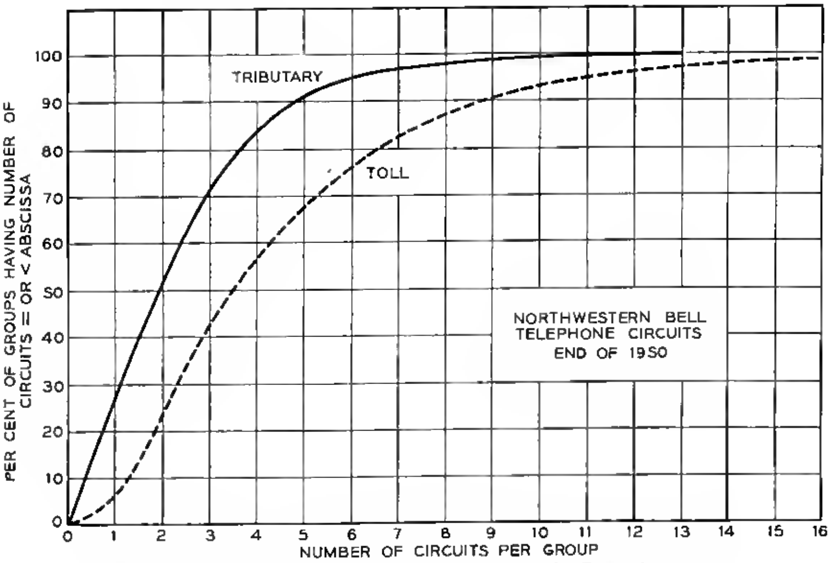


Fig. 3—Distribution of circuits per group in Iowa in 1950.

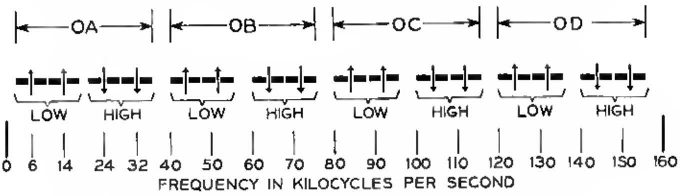


Fig. 4—O carrier telephone—frequency allocation.

above existing carrier systems, such as C, which has a top frequency of 30 kc. With the aid of the compandor, it is possible to apply the OB system to practically any open-wire pair transposed for C carrier operation, thus nearly doubling the number of circuits without additional line rearrangements. Transposition arrangements which are expected to be less expensive to apply are being made available where the higher-frequency type-O groups are involved. Line losses of the order of 35 to 40 db can be spanned under normal wet weather conditions, and 50 db loss under sleet conditions with some transmission impairment, since sleet is relatively infrequent in occurrence. This will result in repeater spacings of the order of 50 miles in sleet areas for the OB group, and 100 miles in other areas. For the higher frequency groups (OC and OD) these spacings will be approximately halved.

CHOICE OF DEVELOPMENT APPROACH

The type-O carrier system followed the type-N system closely in time, and, in effect, covers the same range of circuit lengths for open wire lines that N provides for cables. It was botb natural and expedient that many of the N features were carried over directly into the O design. It was necessary, however, to make important distinctions as well. These similarities and differences will be discussed in some detail.

The transmitting and receiving voice frequency subassemblies are reused with substantially no modification. This provides the O system with the same compandor and the same 3700 cycle signaling system as used in N.

An important difference between tbe two systems is concerned with the use of single sideband in the O rather than double sideband as in the N. This choice is an economic one. The double sideband system is relatively easier to design and less expensive than the single sideband arrangement. The use of double sideband in cables is practicable in many cables because of the relative abundance of conductors as compared witb open wire pairs. In some cases the use of single sideband in cables may be attractive as compared with the cost of new outside plant for certain length ranges.

Another distinction between the two systems is the provision of circuits in smaller groups in O. In N the basic group is 12, although systems may in some instances be partially equipped. In O, the desire to furnish smaller circuits groups resulted in the choice of a basic four-channel group. The full complement per pair for O, including a channel replacing the voice circuit, is sixteen channels.

The regulation problem is more severe in the O design. It is necessary to provide sufficient regulator range to accommodate line variations due to wet or icy lines. The repeater and receiving group regulator range common to four channels is in the order of 40 to 50 db, or approximately four times the regulating range of an N repeater. The range of the twin-channel regulator is comparable to the N individual channel regulator, but the O regulator is shared by two channels forming adjacent sidebands of the same carrier.

The use of a single sideband imposes more severe requirements on channel band filters. The use of a material called ferrite, in combination with a crystal, affords an efficient channel band filter in a small space when compared to previous single sideband channel filters employing air-core coils. Ferrite coils are employed in a coil-condenser type of filter to provide separation for the various four-channel groups. While the N system employs only receiving channel band filters, O has filters in both the transmitting and receiving terminals.

The O system employs the double modulation principle for all groups. This arrangement permits the use of only four channel band filter designs for all of the 32 channel frequency allocations. The frequency range for these basic channel bands has been selected to provide the most economical overall filter design.

The use of die-castings has been extended in a number of ways. Notable among these is a die-cast framework, used in both the terminal and the repeater. The plug-in technique has been expanded to provide plug-in filters for channel and group band filters.

DESCRIPTION OF THE SYSTEM

The system will be described first by block schematics, second, by transmission characteristics, and finally by photographs. This description will show representative features rather than describe the system completely.

While the description will cover the complete O plan, it should be pointed out that the OB system is the first to be made available. It will be followed by the other O systems.

In the schematic description, where a unit is common to all systems the designation is "Type O." Where the arrangement is different for the several systems, a particular designation is used, such as "Type OB," etc.

Schematics

The O modulation plan is shown on Fig. 5. The single-sideband channel filters for all groups are in the frequency range from 180 to 196 kc.

By the use of different group carrier frequencies the several four-channel groups are placed in their various locations. As indicated by Figs. 4 and 5, high and low group assignments are used for the two directions of each four-channel system. A repeater is provided for each four-channel system and, except in the case of OA, the high and low frequency groups are "frogged" at each repeater, as in the N system.

Figure 6 shows a block diagram of a complete O system. On this figure, and in general on other figures showing filters, a letter code is assigned to designate the kind of filter, with a subscript letter to indicate the particular system in which the filter is used. The several filter designations and number codes are collected for reference in Table I. Much of the apparent complexity of the system, particularly as regards filters, arises out of the use of a single pair for both directions of transmission. Another complexity is occasioned by the requirement that a complete complement of O systems will not always be provided. For example, OB, OC, and OD systems may be used above an existing C system, or similar systems.

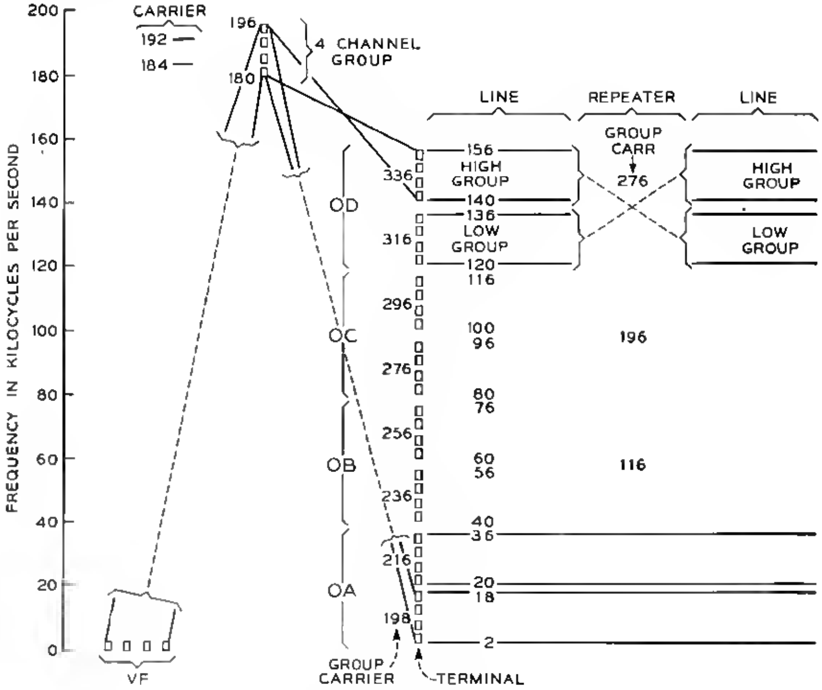


Fig. 5—Type-O modulation plan.

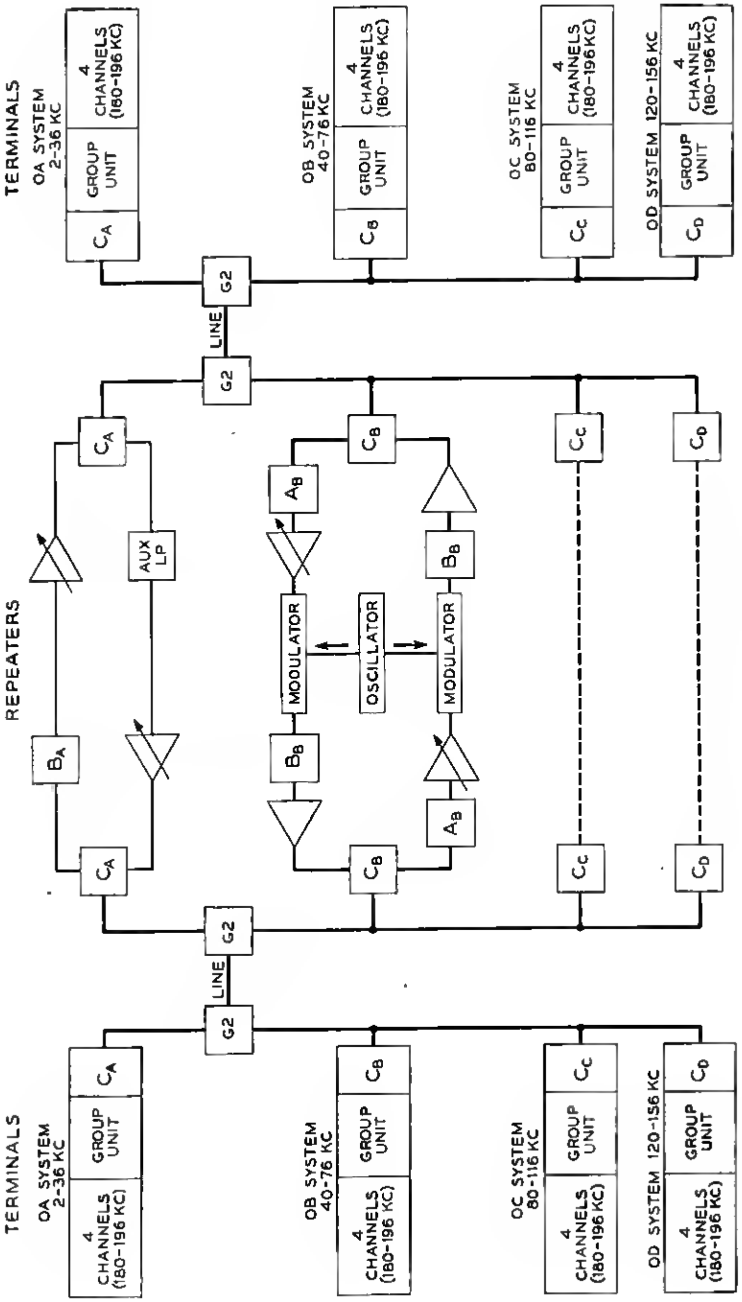


Fig. 6—Type-O carrier system.

Line filters (G) are provided to separate the OB, OC, and OD Systems from the OA frequency ranges. Because of the lower attenuation and slope in the OA frequency range, and the better line coupling factors, the repeaters do not "frog" the high and low groups.

The OB Carrier Terminal

A block diagram of a typical carrier terminal is shown on Fig. 7, in this case the OB terminal. The terminal is comprised of four channel units, two twin-channel units, group transmitting and receiving units, and a group oscillator. An oscillator in each of the twin channel units supplies carrier to the transmitting channel modulators. The same oscillator supplies transmitted carrier for two associated sidebands. The original carrier is balanced out in the transmitting modulator. This method results in a more accurate control of the transmitted carrier. level. The group oscillators supply the necessary frequencies to the

TABLE I

Location and Function	Filter Symbol	Filter Codes for Each System				
		Common	OA	OB	OC	OD
TERMINAL ONLY						
Transmitting low pass	None	168F				
Receiving low pass	None	169G				
Carrier pickoff (184kc)	F1	532A				
Carrier pickoff (192kc)	F2	532B				
Signal pickoff	None	169A				
Channel band pass	None	529A				
Channel band pass	None	529B				
Group transmitting	E	540A*				
Group receiving	A + D		530J	531B	530C	530F
Group receiving	B + D		531F	531C	530D	530G
TERMINAL AND REPEATER						
Directional	C		530H	530A	530B	530E
Line	G C2	219S†				
	C1	537A‡				
	C1	538A				
REPEATER ONLY						
Auxiliary	A + B			531A	531D	531E
	A		530K			
	B		530L			

* Except OA system. † Cut-apart region between 36 and 40 kc. ‡ Cut-apart region between 30 and 40 kc. 538A is a 537A filter with housing and protectors for pole mounting.

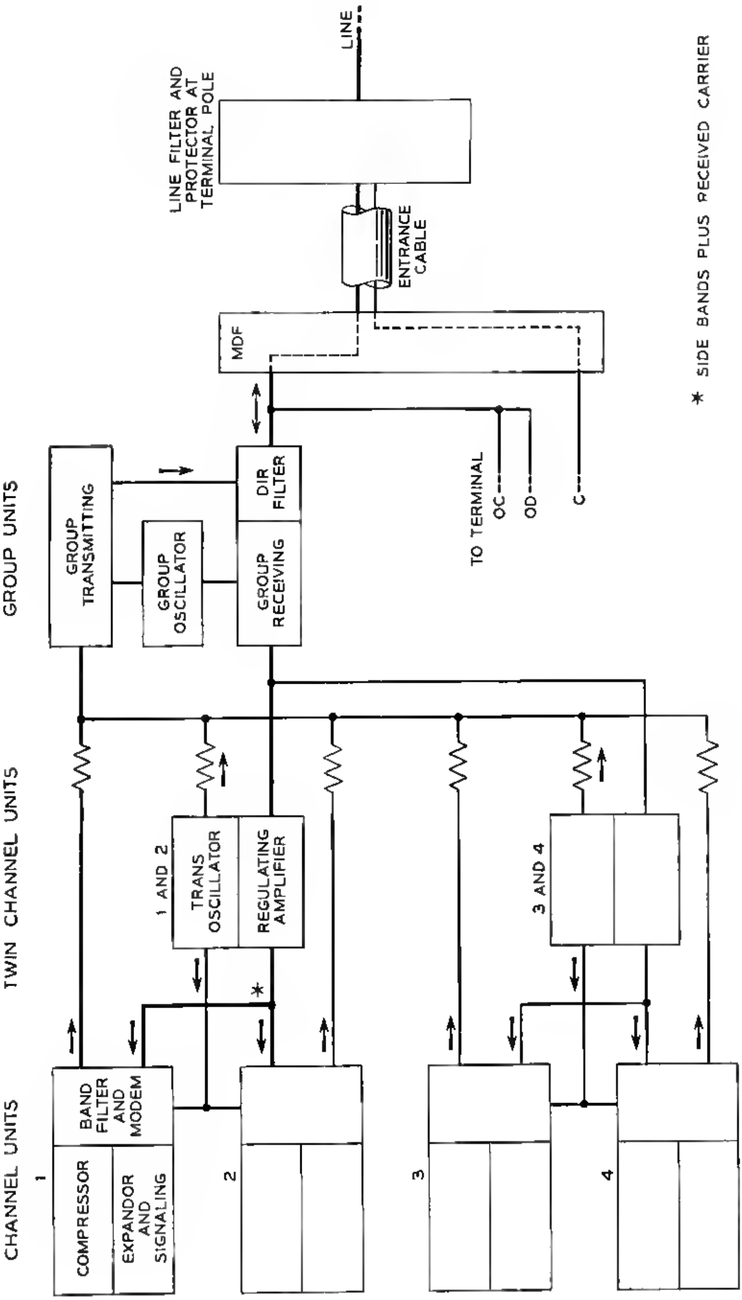


Fig. 7—Type-OB carrier terminal.

transmitting and receiving group units to translate the sidebands between the frequency range of the channel band filters and the correct line frequency allocation. The group receiving unit contains the directional filter for separating the four-channel transmitting and receiving groups at line frequencies. Multiple points are indicated for the connection of other O carrier systems on the same pair.

Channel Unit

A block diagram of the channel unit is shown on Fig. 8. As indicated by the dashed line, the channel unit is comprised of four parts which are interconnected by plugs and jacks. These are:

1. The Compressor Sub-Assembly. This unit contains the compressor and a terminating arrangement to permit the system to be used for four-wire termination, or for two-wire termination at non-gain locations, i.e., those without switching pad control.

2. The Expandor Sub-Assembly. This unit contains the expandor as well as the signal transmitting and receiving equipment.

3. The Carrier Frequency Sub-Assembly. This unit contains the transmitting and receiving modulators, and is arranged to receive the plug-in transmitting and receiving channel band filters.

4. The Transmitting and Receiving Band Filters. These are combined in a single plug-in unit.

Items 1 and 2 are practially identical to the corresponding sub-assemblies for N carrier. Each channel receives its carrier supply for the transmitting side from an oscillator in the twin channel unit. On the receiving side the carrier is obtained by selecting and amplifying the transmitted carrier.

The frequencies indicated on Fig. 8 are the same for all O systems, and apply to two of the four channels in the group. Figs. 4 and 5 show go and return channels in high and low frequency assignments in the same O system. However, as shown on Fig. 9 covering the OB system, the frequency assignments applying to the channel band filters are above any of the O line frequencies and are in the frequency range from 180 to 196 kc for both transmitting and receiving channel band filters.

Transmitting and receiving channel band filters are paired in a single plug-in unit. In order to reduce the number of kinds of paired channel band filters (transmitting and receiving in the same plug-in unit) the pairing has been done in a special way. If, for example, transmitting assignment 180–184 were paired with receiving assignment 180–184, etc., four different kinds of paired filters would result. Instead, assignment 180–184 is paired with assignment 192–196, and by making the

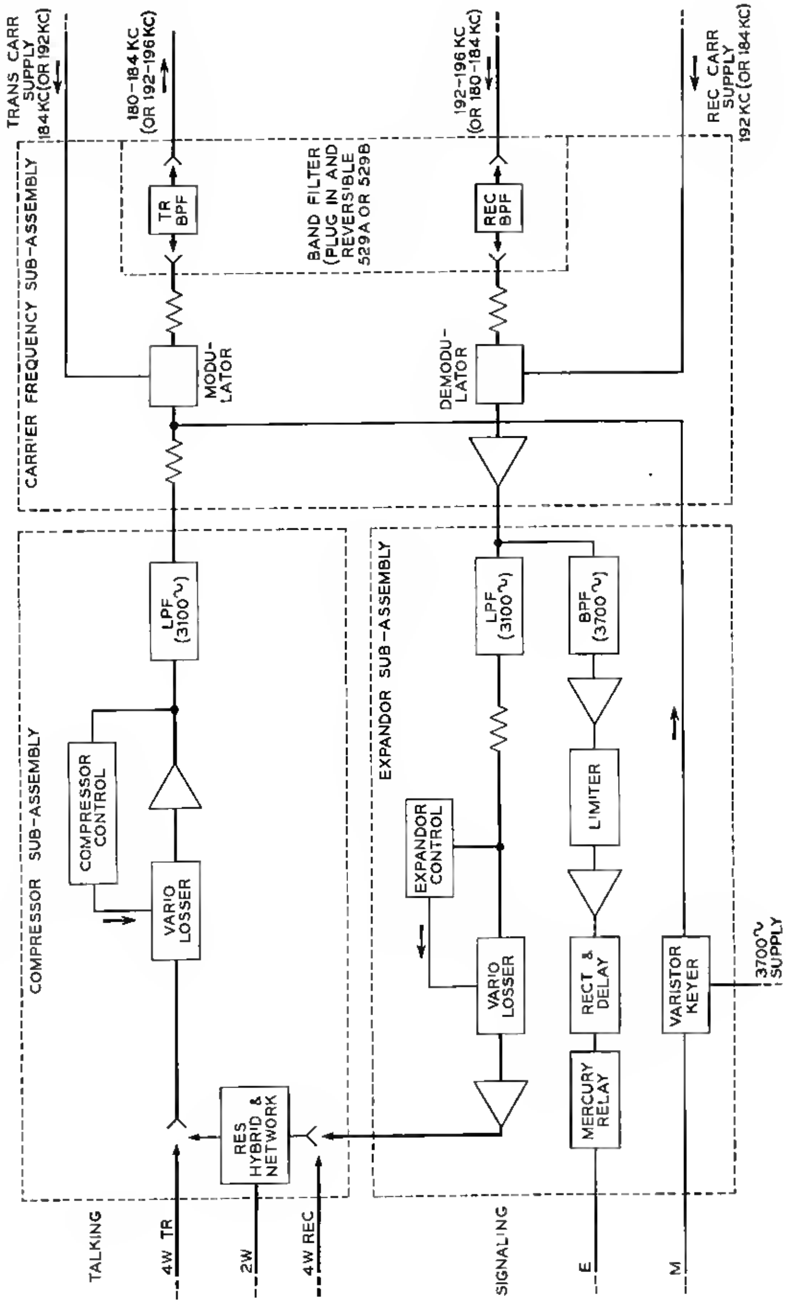


Fig. 8—Type-O channel unit.

plug-in filter reversible in its socket, this grouping can be made to serve two channels as follows:

$$\left\{\begin{array}{l}\text{180–184 Transmitting}\\ \text{192–196 Receiving}\end{array}\right\} \text{ and } \left\{\begin{array}{l}\text{192–196 Transmitting}\\ \text{180–184 Receiving}\end{array}\right\}$$

A similar paired filter serves

$$\left\{\begin{array}{l}\text{184–188 Transmitting}\\ \text{188–192 Receiving}\end{array}\right\} \text{ and } \left\{\begin{array}{l}\text{188–192 Transmitting}\\ \text{184–188 Receiving}\end{array}\right\}$$

Thus only two basic kinds of paired channel band filters are required, rather than four kinds. In these filters, as well as the reversible group filters, the filter designations are so arranged that when the filter is in place the proper filter designation is in view.

Twin Channel Unit

The twin channel unit is shown in somewhat more detail in Fig. 10. There are two kinds of twin channel units to serve the four channel assignments, and the frequencies shown on Fig. 10 correspond to those shown on Fig. 8. (and Fig. 9). A transmitting carrier adjustment permits the transmitted carrier level to be set properly in relation to the sideband levels. In order that the group regulators may function primarily on the carrier, and thus be substantially independent of voice or signaling sidebands, the carrier is transmitted approximately 6 db above the sideband level.

On the receiving side of the twin channel unit a regulating amplifier controls the received level of both sidebands. It does this from the carrier

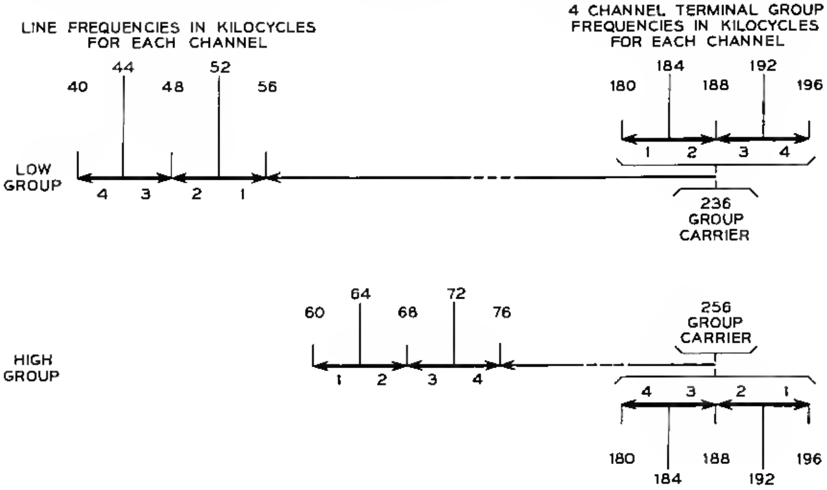


Fig. 9—Type-OB system frequencies.

picked off by a narrow band crystal filter. This same carrier is supplied to the receiving side of the channel units for demodulating the associated sidebands.

Group Transmitting Unit

The OB group transmitting unit is shown on Figure 11. It receives the four sidebands and two transmitted carriers and places them in the proper high or low line frequency assignment. The transmitting group unit, depending on the optional connection to the group oscillator (Fig. 11), can be either a high group transmitting unit or a low group transmitting unit.

For convenience the noise generator is contained in the group transmitting unit. On very quiet circuits this noise source provides a means of masking crosstalk. In ordinary usage the noise thus provided is not noticeable on the circuit, but is sufficient to reduce the chance of hearing intelligible crosstalk to a small value.

Group Receiving Unit

The OB group receiving unit is shown on Fig. 12. It is comprised of an amplifier and a regulator-modulator arrangement equipped with plug-in filters. The same basic arrangement is used for all receiving group units, as well as for all repeaters. Only the plug-in filters, and the frequencies from the associated oscillators are different. The directional

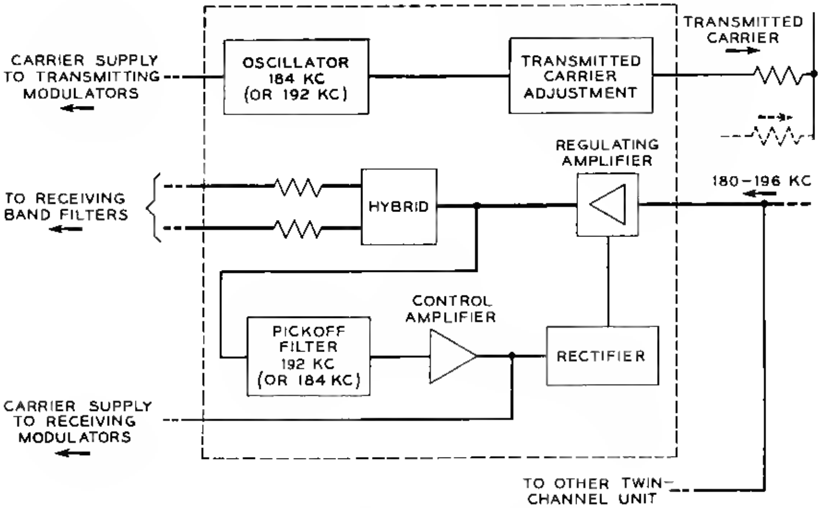


Fig. 10—Type-O twin channel unit.

filter is reversible as well as plug-in and thus serves either high or low groups. The receiving group band filter and its associated auxiliary filter have the same physical arrangement as in the repeater but they are never reversed.

A dc feedback type regulator controls the gain of the regulating amplifier, and operates principally on the two received carriers, although the sidebands are fed back also.

Group Oscillator

The group oscillator contains two oscillators for supplying the group transmitting and group receiving units. These oscillators are interchangeable (by strapping) and permit the group units to operate in either the high or low groups. For conveneince the 3700 cycle signaling oscillator, common to all four channels, is contained in the group oscillator.

Repeater

As indicated on Figs. 5 and 6, a repeater is provided for each four-channel system. An amplifier, regulator and modulator arrangement serves each direction. The directional bands are routed through the repeater by directional and auxiliary band pass filters as indicated on Figs. 13 and 14. At each repeater (except OA) the high- and low-frequency groups are "frogged" to improve transmission, particularly as

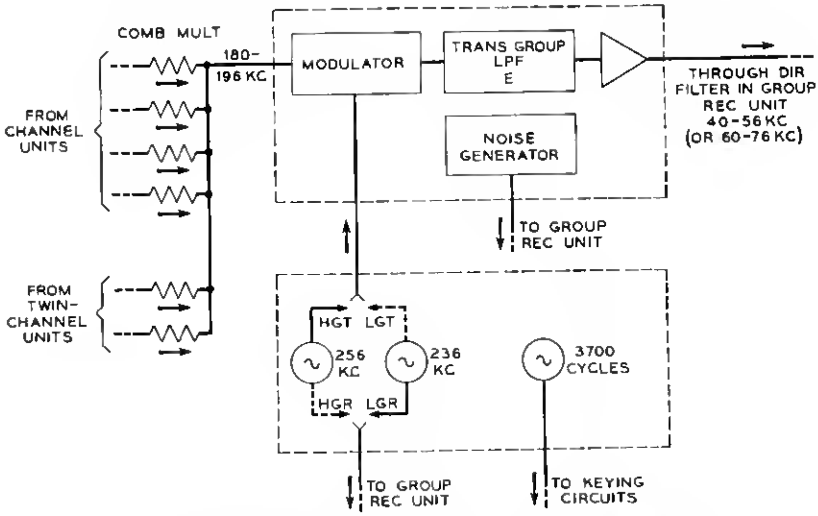


Fig. 11—Type-OB group transmitting unit and group oscillator unit.

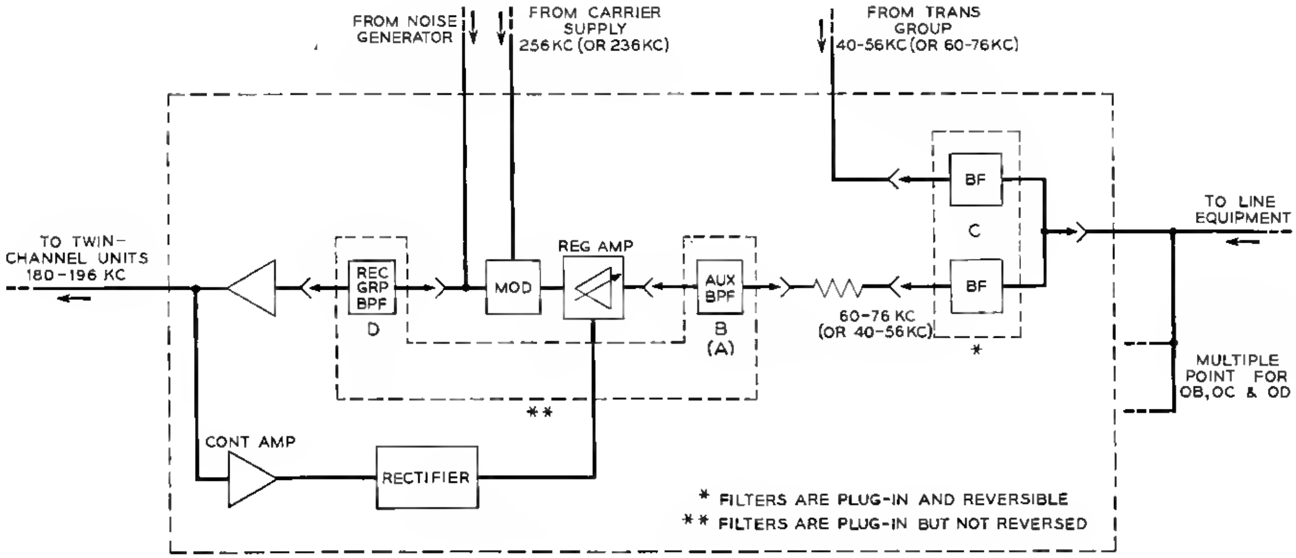
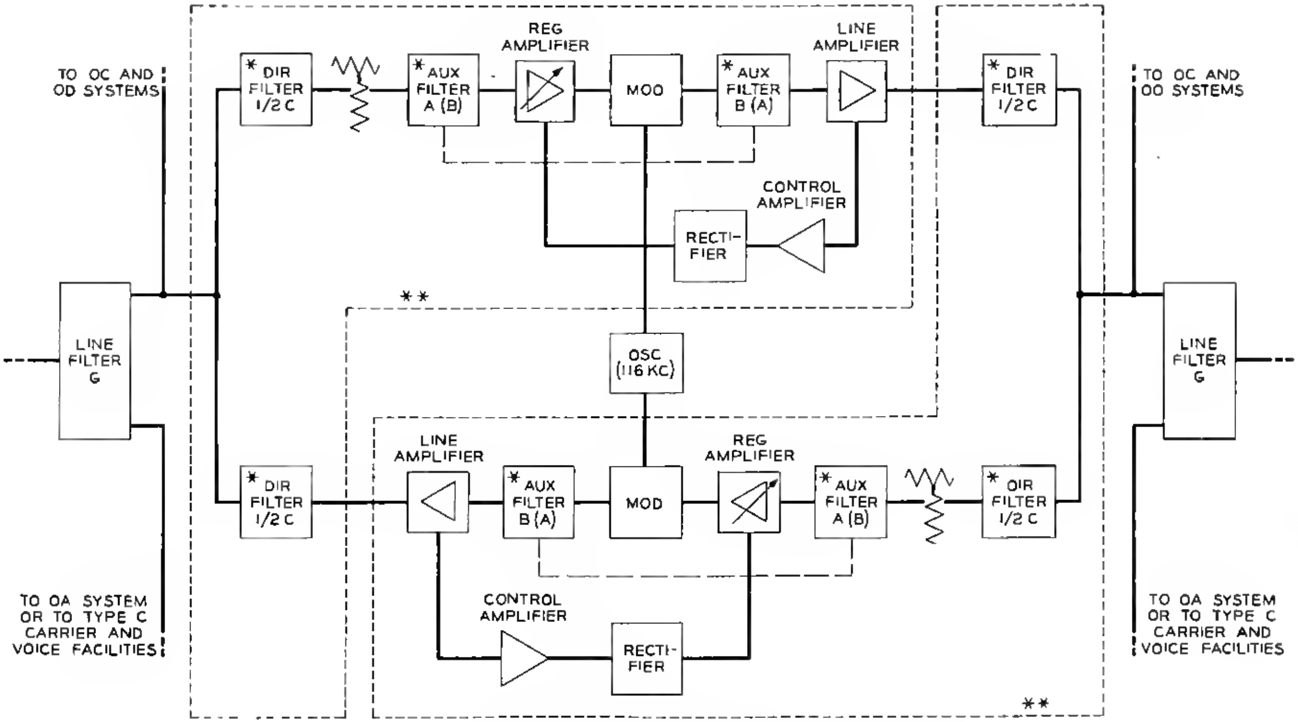


Fig. 12—Type-OB group receiving unit.



* FILTERS ARE PLUG-IN AND REVERSIBLE ** BASIC AMPLIFIER USED FOR OB, OC AND OD FOR REPEATERS AND GROUP RECEIVING UNITS

Fig. 13— Type-OB repeater.

regards automatic equalization of attenuation slope with frequency, and to obviate the necessity for additional line treatment.

Some repeaters receive low group frequencies and transmit high group frequencies for both directions. Other repeaters receive high group frequencies and transmit low group frequencies. In N two kinds of repeaters were required. In O the reversal of the filters in their sockets provides both kinds of repeaters, and presents the proper designation to view. A regulator is provided in each direction of the same kind as in the group receiving unit.

It should be noted at this point that the filters internal to the repeater (as opposed to directional filters) differ from the filters used in the receiving group units. This is because the repeater always accommodates line frequencies on both sides of the amplifier, while the receiving group unit accommodates line frequencies on one side (which correspond to the repeater line frequencies) but always must supply channel band filter frequencies at the group amplifier output.

Fig. 14 shows in somewhat greater detail than Fig. 13 the filter arrangement for an OB repeater.

TRANSMISSION CHARACTERISTICS

The overall channel band width is illustrated in Fig. 15. The approximate frequency cutoffs are similar to N but for various reasons the several channels may show somewhat greater differences. The O system, being a single sideband system, has a filter cutoff at low (voice) frequencies, which the N does not have. Differences may exist between

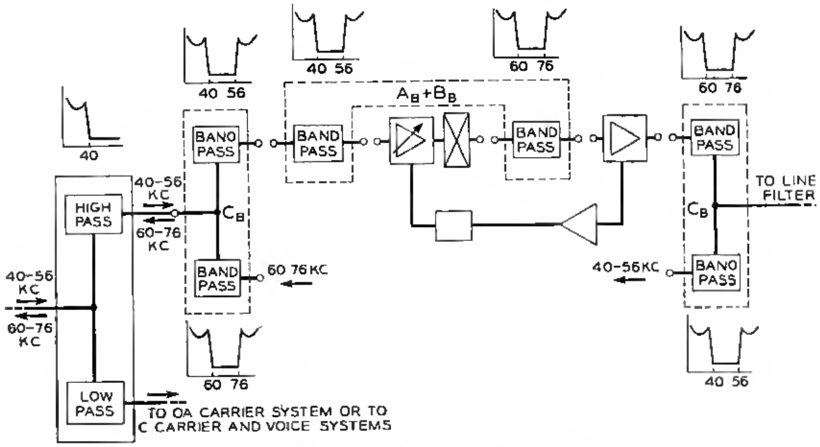


Fig. 14—Type-OB repeater filter arrangement.

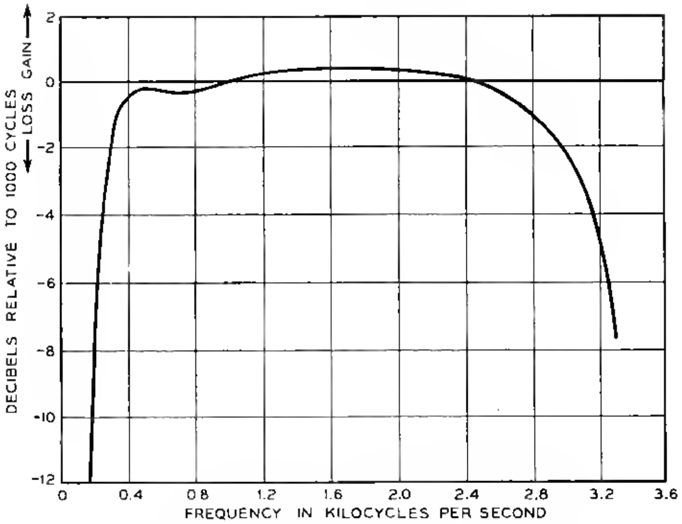


Fig. 15—Net loss frequency charactieristic.

upper and lower sideband filters. In addition, O has transmitting band filters while N does not.

A situation is of interest which applies to both N and O, as well as to any other system employing the type of compandor controlled from the voice energy. Different frequency characteristics will be obtained with the compandor operating and with the compandor controls locked. Neither of these necessarily corresponds to the operating condition with speech or music. With the compandor controls free and using single frequency test tone, the characteristic obtained is a combination of the frequency characteristics of the line and control circuits. With the controls locked, the characteristic is that of the line only. If the control circuit is substantially flat, there will be little distinction between the measurements. The curve of Fig. 15 is of the type obtained with free controls and with a substantially flat control circuit.

A typical overall channel load characteristic is shown on Fig. 16. This characteristic includes not only the load curve of various amplifiers, modulators, etc., but shows also the order of match of the compressor and expandor load characteristics. This is a match of curves having 2:1 slopes on a db basis over a wide range of volumes.

A typical overall net loss variation for a non-repeatered circuit is shown on Fig. 17. Principally because of the line regulator in the group receiving units (Fig. 18) a wide range of line loss is covered. A similar regulator is included in each repeater, and the extension of a system

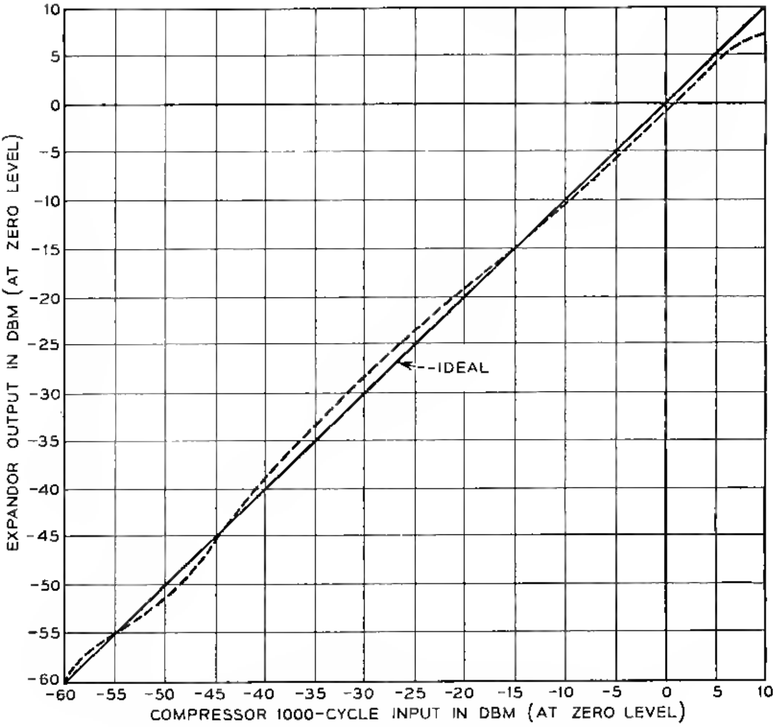


Fig. 16—Typical over-all channel load characteristic.

with repeaters will not result in a substantial change of the net loss variation, assuming the repeater section losses do not exceed the range of the regulators.

The line regulator is assisted by the twin channel regulator, for which a characteristic is shown on Fig. 19. This regulator is similar to the individual channel regulator of N, and serves two channels having a common carrier. This fact alone does not materially change the effectiveness of regulation since the carrier is adjacent to the sideband which

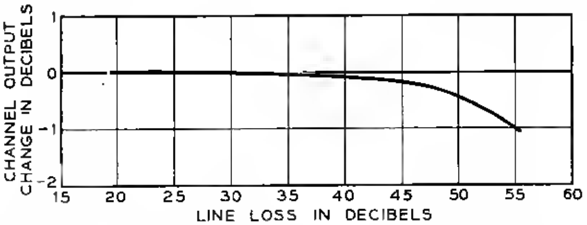


Fig. 17—Typical over-all channel net loss variation, nonrepeatered.

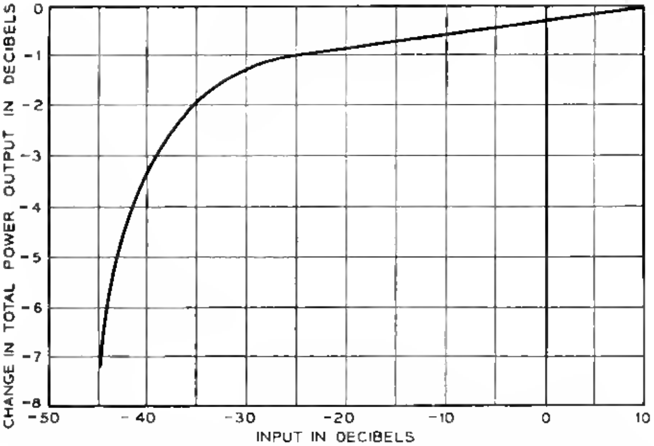


Fig. 18—Typical group receiving and repeater regulator characteristic.

it controls in any case. There are other important differences, however, between N and O channel regulators. In N the channel regulator follows the channel band filter and thus tends to compensate for its flat transmission variations. Also the N regulator is controlled from the demodulator dc output and thus compensates in some degree for demodulator variations. In O, the twin-channel control is ahead of both the channel band filter and the channel demodulator, and therefore does not make up their variations.

A statement might be interpolated at this point to emphasize that the relative advantages of single-sideband and double-sideband transmission are by no means easily listed and evaluated, since the differences are many and devious, some necessarily and some fortuitously. An example worthy of note is that in N it is necessary to be concerned about relative phase shift of the sidebands and in the instances of longer cir-

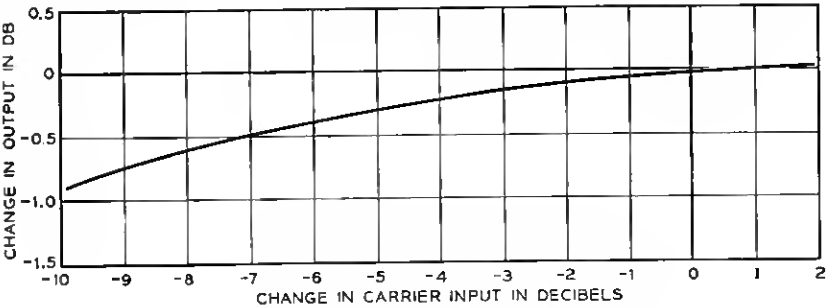


Fig. 19—Typical twin-channel regulator characteristic.

cuits, perhaps to equalize this phase shift in order to prevent serious reduction of signal output, or variation in channel net loss with frequency. No such concern applies to O.

In regard to filter characteristics, it seems obvious that complete coverage is not feasible in this description. Instead typical curves only will be shown.

Fig. 20 shows the general characteristics of filters for separating the wanted sideband from the carrier and unwanted sideband. The transmitting and receiving filters have similar shapes. The carrier pick-off filter characteristic is shown in the same figure. Fig. 21 shows the filter characteristics for separating the voice and signaling (3700 cycle) functions.

Another filter case of interest is the line filter for separating, for example, the OA system from the OB system, and from the OC and OD systems, as well, if they are employed. Fig. 22 shows the configuration and loss characteristics of the G1 (537A or 538A) filter. A C_B directional filter (530A) characteristic is shown on Figure 23. This filter assembly includes two filters to accommodate the OB high and low group assign-

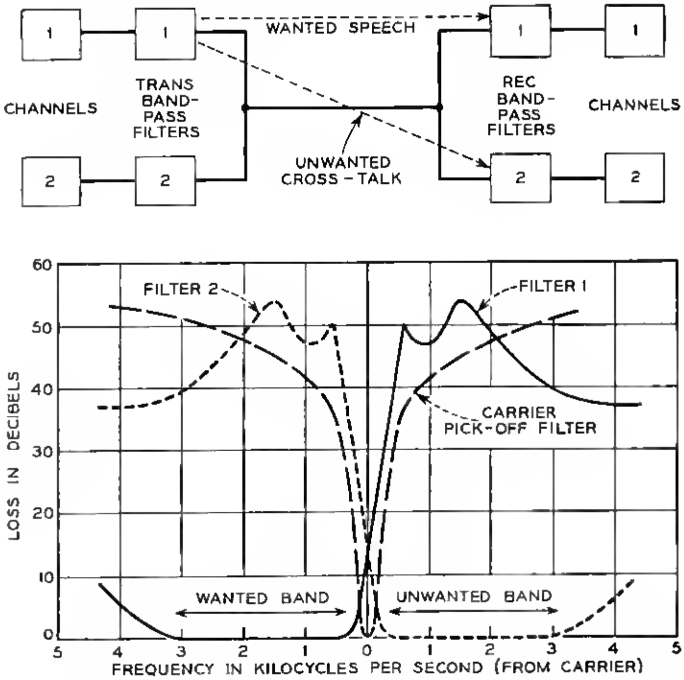


Fig. 20—Typical channel band and carrier pick-off filter characteristic.

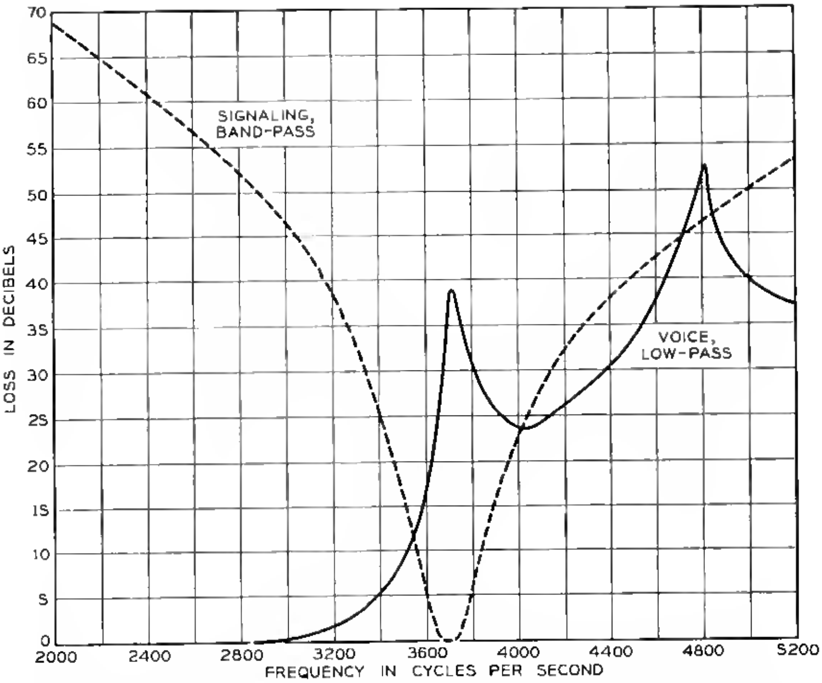


Fig. 21—Typical receiving low pass and signaling filter characteristics.

ments. Similar characteristics apply to the $A_B + B_B$ auxiliary filter (531A). The A and B characteristics are used in the group receiving filters $A_B + D_B$, (531B) and $B_B + D_B$, (531C). The D filter is a band-pass filter with relatively gradual cutoff to pass the 180–196 band for the channel filters, and has peaks at the group carrier frequencies of 236 kc and 256 kc. These filter characteristics are not shown.

PHYSICAL ARRANGEMENTS

A four-channel carrier terminal is shown on Fig. 24. This terminal includes four channel units shown in detail on Figs. 25, 26, 27 and 28. In Fig. 28 the unit is separated into the three sub-assemblies, of which as noted above, the two voice frequency sub-assemblies are substantially the same as for N carrier. The carrier sub-assembly with its plug-in channel band filters is shown on Fig. 29.

The interior arrangement of the plug-in unit containing the transmitting and receiving band filters is shown on Fig. 30. This assembly contains an adjustable ferrite inductance, a miniaturized transformer, and a crystal with the necessary fixed and adjustable capacitors. The small size is made possible partly by the high Q ferrite coil, and partly by the circuit configuration employing it. As compared with filters employing air-core coils and having comparable cutoffs, the reduction in size of these filters is very striking.

The group receiving unit is shown with its plug-in filters on Fig. 31. The filters are held in place by stud screws and nuts. The arrangement shown on Fig. 31 is also used with different filters for the repeater ampli-

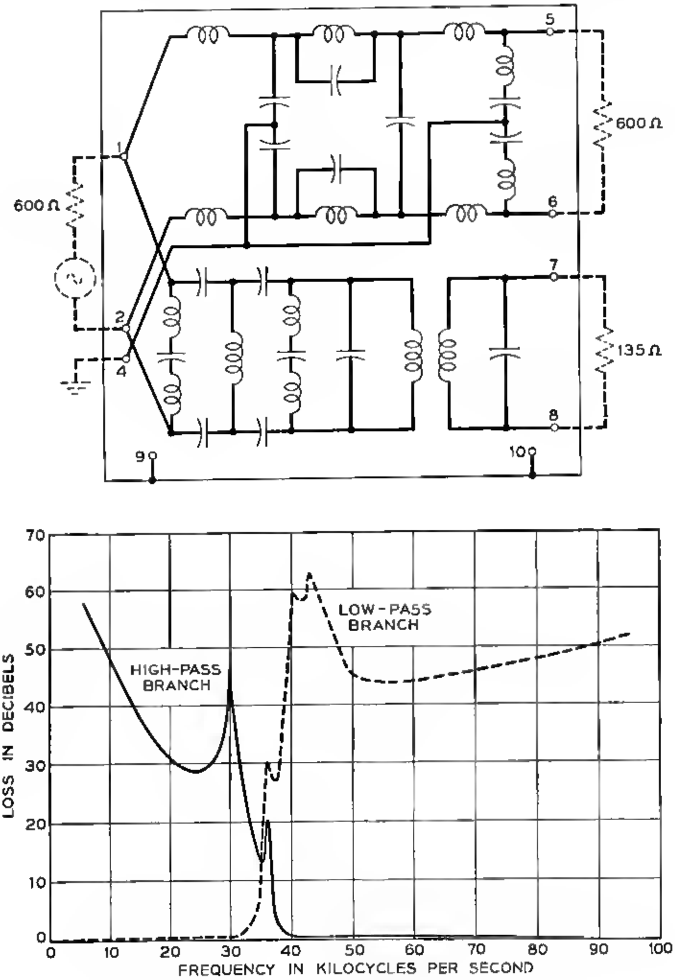


Fig. 22—Typical line filter characteristics (G1, 537A or 538A).

fiers. The filter construction is shown on Fig. 32. This filter employs ferrite coils and condensers, having no crystals because of percentage band width considerations. These filters employ a form of printed wiring for interconnection of components.

The terminal framework is shown on Fig. 33. This framework employs aluminum die-castings in contrast to the frabricated framework of N. This method permits the inclusion of a slide arrangement which guides the units into place, and insures proper registration of the plugs and jacks. Some units are above the framework; others are suspended from it. The same die-casting, inverted, serves both upper and lower

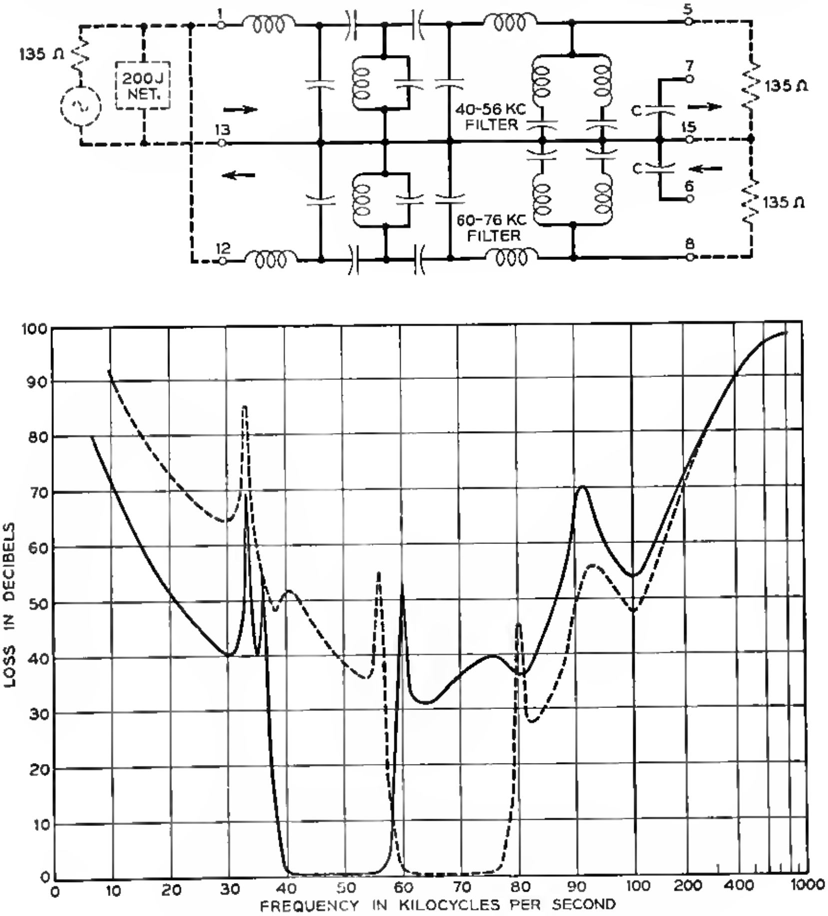


Fig. 23—Typical directional filter characteristics (C$_B$, 538A).

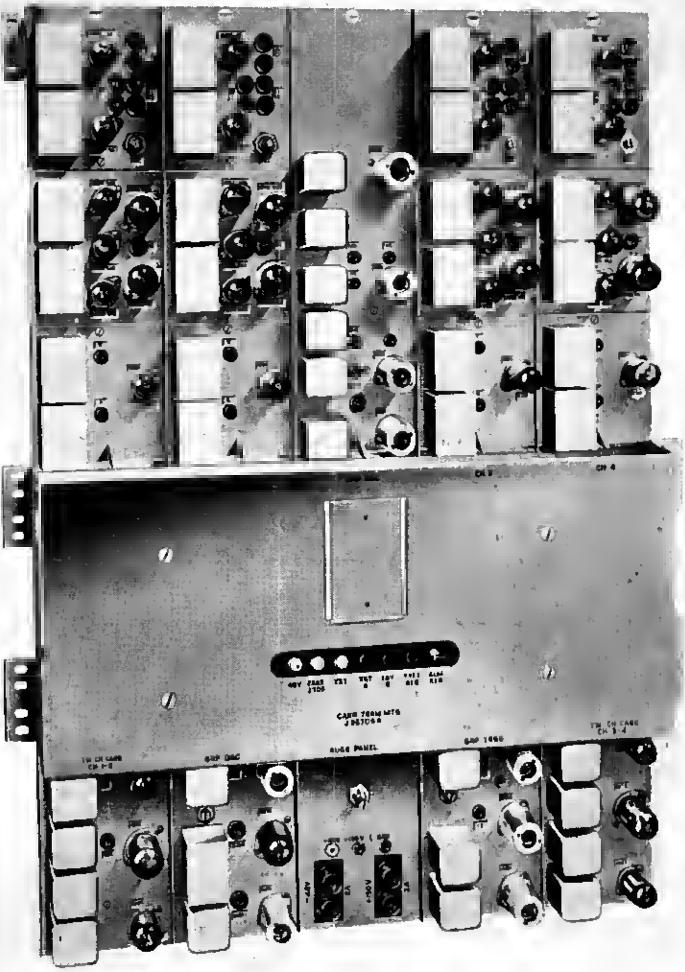


Fig. 24—Four-channel O terminal.

plug-in units. Since there is no interference between plug-in units in inserting and removing them, can covers have been eliminated. This fact, and the somewhat wider distribution of units having a high concentration of vacuum tubes, result in a relatively low temperature rise for O as compared with N. Blower facilities are not provided in the terminal.

Typical of the units suspended from the framework is the twin chan-

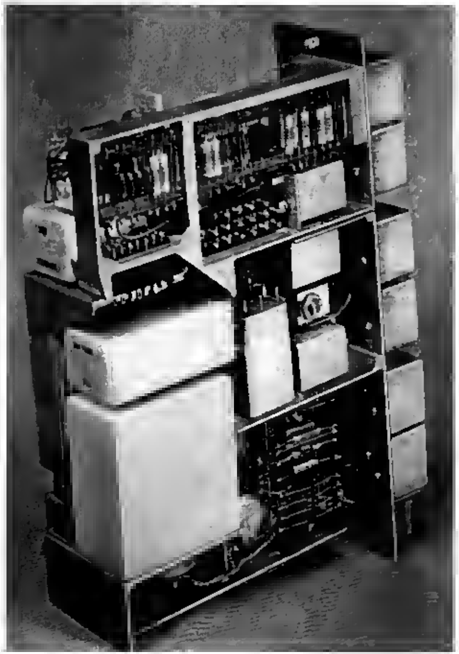


Fig. 25—Channel unit-left side view.

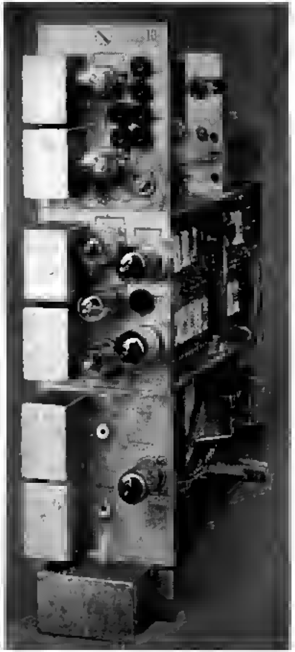


Fig. 26—Channel unit-front view.

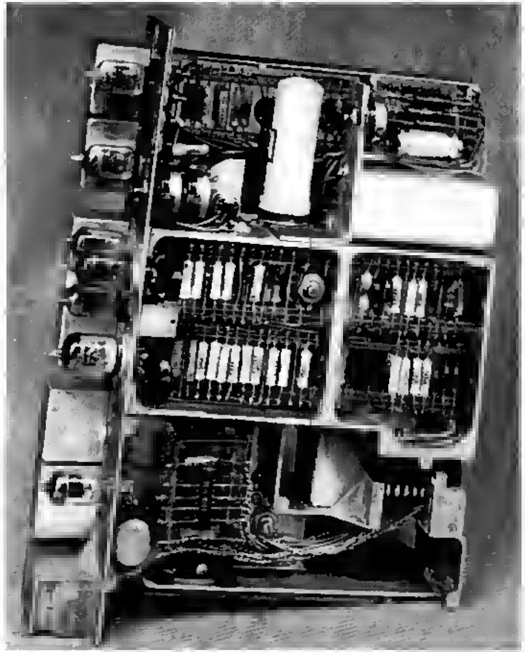


Fig. 27—Channel unit-right side view.

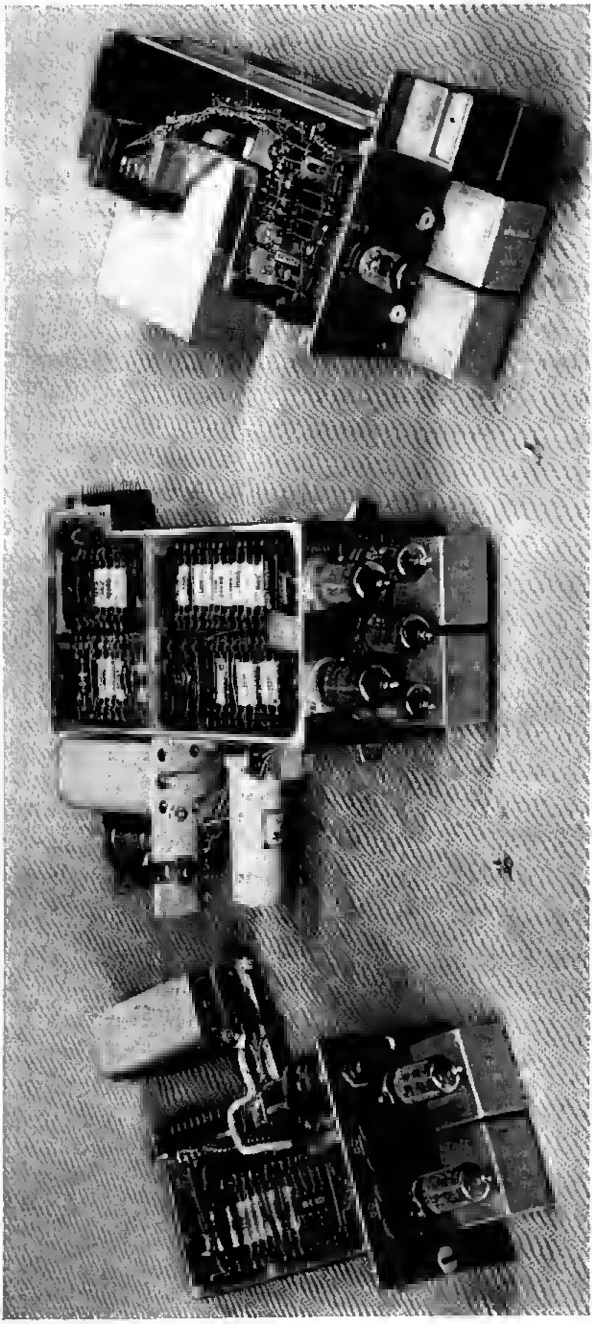


Fig. 28—Channel unit subassemblies.

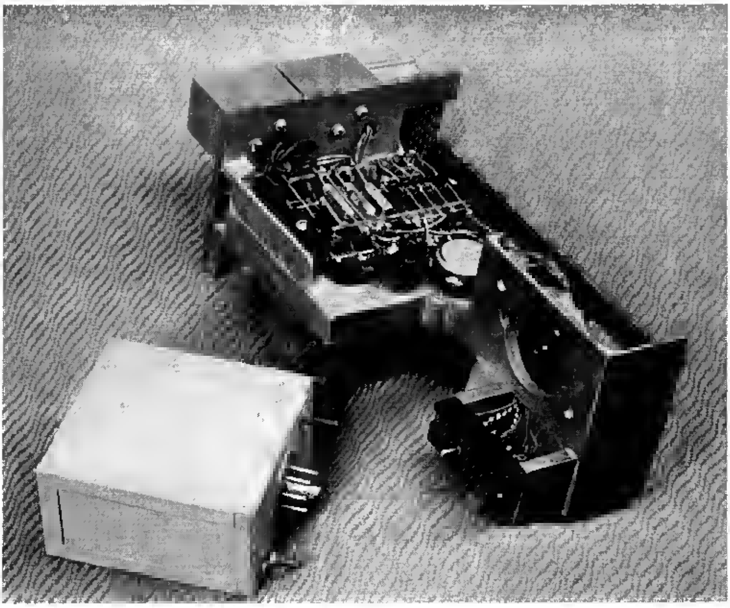


Fig. 29—Carrier subassembly and channel band filter.

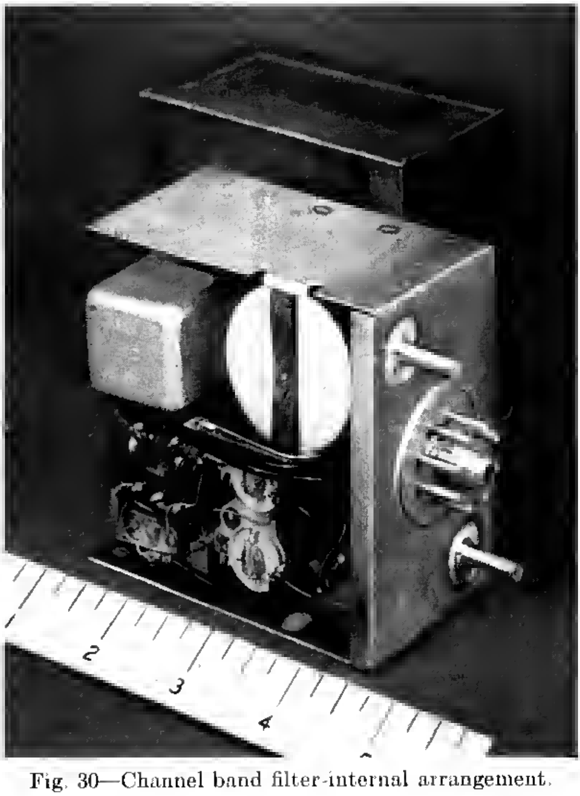


Fig. 30—Channel band filter-internal arrangement.

nel unit, shown on Fig. 34. The same basic die-casting is employed, with minor rearrangement of the die, for the two twin channel units, the group transmitting unit, and the group oscillator. The part of the slide arrangement associated with a plug-in unit is shown at the top of the twin channel unit.

All plug-in units are held in by a common cover (Fig. 24) which encloses the handles of the units. For additional support a rapid action fastener holds the tops of the channel and receiving group units.

Repeaters may be either pole mounted or placed in a central office. A group of two repeaters is shown on Fig. 35. This assembly employs a framework, shown on Fig. 36, which includes the same slide die-casting as the terminal. A central unit (also plug-in) accommodates the two

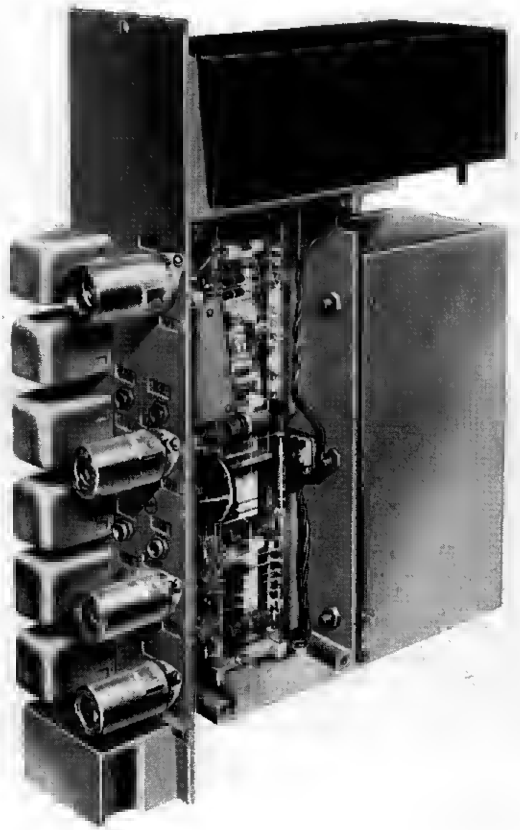


Fig. 31—Group receiving or repeater unit.

Fig. 32—Typical directional or auxiliary band filter—internal view.

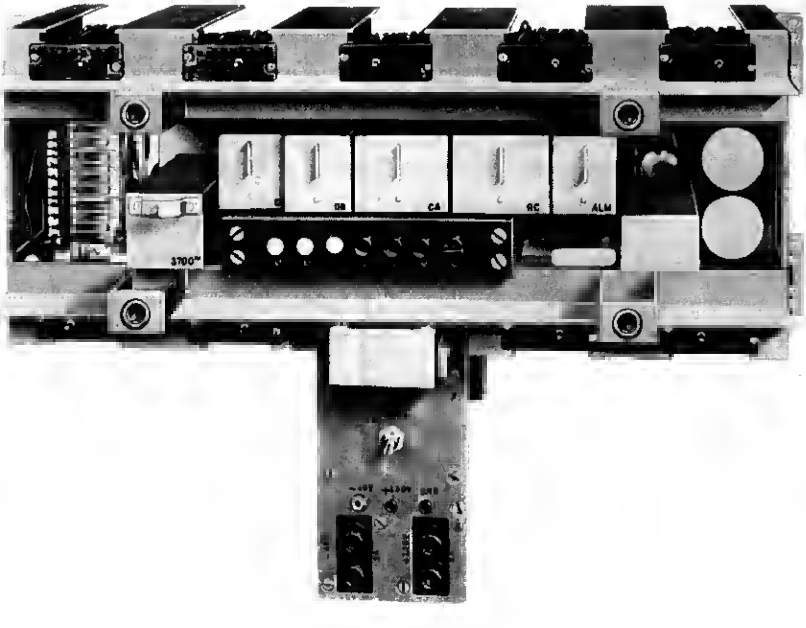


Fig. 33—Terminal framework.

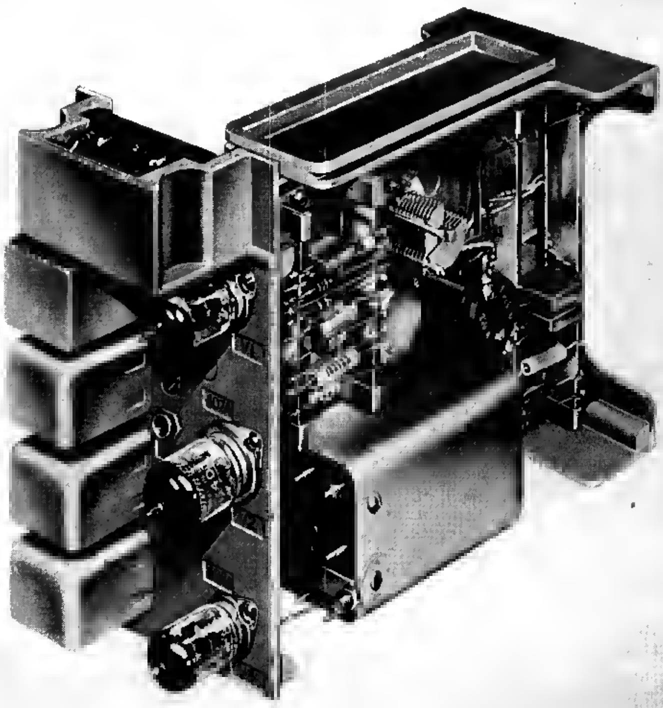


Fig. 34—Twin-channel unit.

plug-in group oscillators, which are also shown in the photograph, together with fuses, alarm lamps, etc.

Pole mounted repeaters are housed in a cabinet, similar to that used for N. Such a cabinet, equipped with four repeaters is shown on Fig. 37.

Since a maximum of four repeaters would have to be supplied by one pair of wires, it is not feasible to transmit power for the repeaters over line pairs. Instead the cabinet contains rectifiers and a line voltage regulator for obtaining 130 volts dc from commercial ac supply. For reserve power supply, a cabinet is available containing a 24-volt storage battery and a dynamotor to supply 130 volts dc to two repeaters (or two dynamotors to supply four repeaters) in case of power failure.

ALARMS

At terminals a common alarm, operating from carrier failure, performs the functions of: First, dropping all connected subscribers to prevent

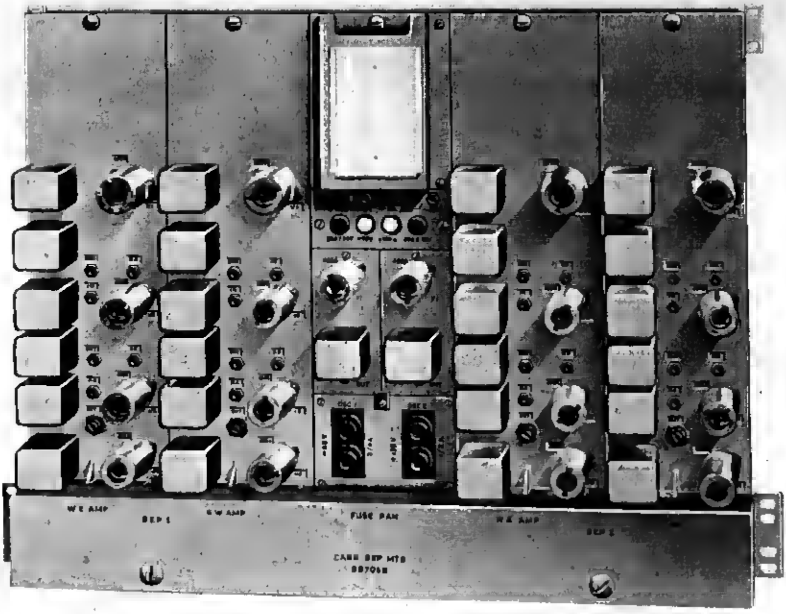


Fig. 35—Two repeater assembly.

Fig. 36—Repeater framework with oscillators.

Fig. 37—Typical arrangement of pole mounted repeaters.

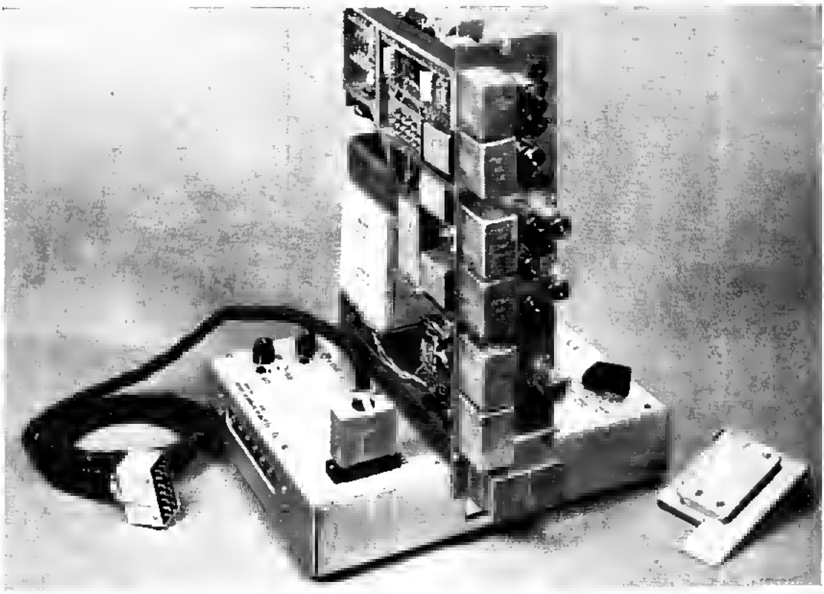


Fig. 38—Test stand.

their being held during the interval of failure; and second, to make all circuits busy at both terminals, to prevent false seizure by operators or automatic switching equipment. Since many O systems may be employed in situations where one terminal is unattended, facilities are included whereby, after failure, the system can be tested from either end, through the use of one of the signaling channels. If it is indicated that the system is operable it can be placed in service again without the necessity of a trip to the unattended terminal.

SPECIAL SIGNALING FEATURE

Arrangements are provided by which two O circuits can have their E and M signaling control leads interconnected without the use of the signaling converter, which is otherwise required. This feature is employed when two circuits are connected together on a permanent or semi-permanent basis to form a single trunk.

TESTING

To facilitate testing at terminal points a test stand (Fig. 38) has been provided which supports an O, or N, channel unit during test and adjustment. By a patch cord, the channel unit can be connected to its original framework if desired. Built in pin jacks permit bridging measurements to be made at selected points in the transmission circuit.