A New Single Channel Carrier Telephone System *

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The single channel carrier telephone system described in the following paper is designated the Type H. It is characterized by several new features, making it applicable not only to the needs of telephone companies but also to those of railroads, power systems and oil companies. It replaces the Type D single channel carrier system, more than 500 of which are now in operation in the Bell System, and, in addition because of its lower cost is applicable to shorter distances. It therefore marks another step in extending the use of carrier. Reduction in size and provision for operating on a-c supply simplify its installation, and its portability makes it well suited to provide emergency circuits.

ON open-wire lines where the growth is not rapid, there is frequently need for adding telephone circuits one at a time. When the Type D single-channel carrier telephone system was developed a few years ago it became possible to meet this need without stringing additional wires.[1] More than 500 of these systems have been placed in service in the Bell System plant. A new single-channel carrier telephone system, known as the Type H, has recently been developed and is now being applied. This new system offers improved performance, and also, because of its lower cost, is applicable to providing service over shorter distances than were economical with the earlier system.

The Type H system, which is characterized by a number of new features and special developments, is applicable not only to the needs of telephone companies but also to those of railroads, power systems, and oil companies.[2] In the first place it is designed to operate either on alternating current or on direct-current plate and filament supply. A repeater is available to extend the range of operation. Through the use of specially designed but simple filters the system can be employed on circuits which are equipped with bridged telephone

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[1] "Carrier Telephone System for Short Toll Circuits," H. S. Black, M. L. Almquist and L. M. Ilgenfritz, *A. I. E. E. Transactions*, Vol. 48, January 1929, pp. 117–140.

[2] "Carrier Telephone Systems—Application to Railroad Circuits," H. A. Affel, *Proceedings of the Association of American Railroads, Telephone and Telegraph Section*, October 1936, pp. 654–672.

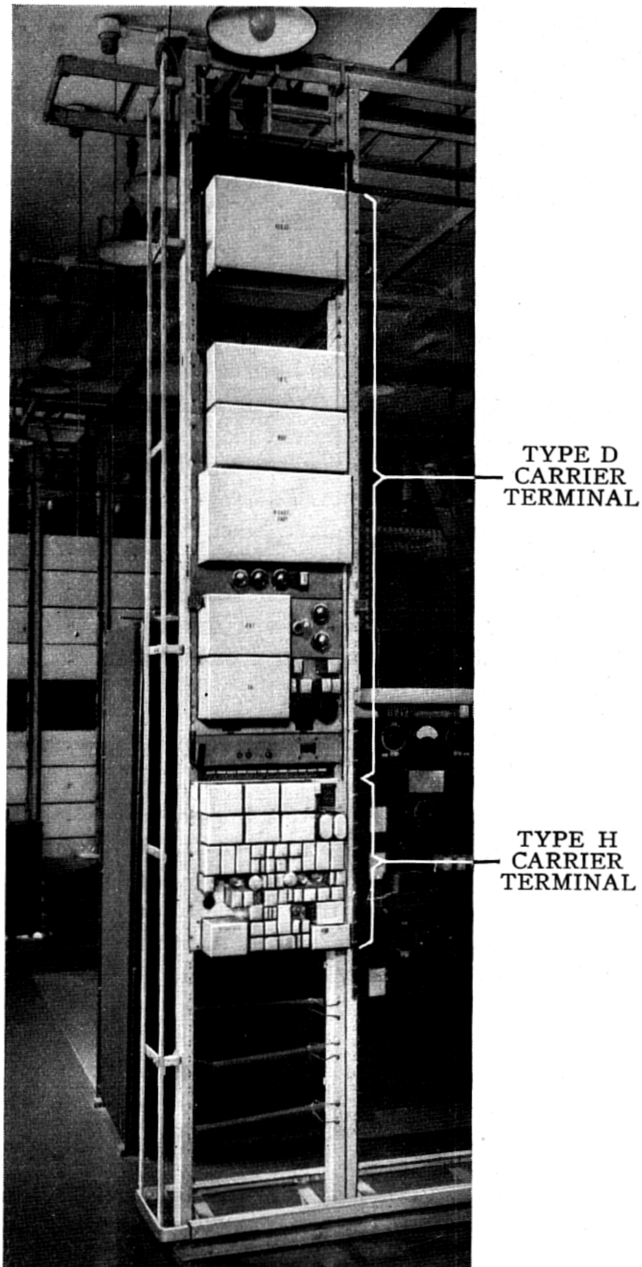

Fig. 1—Installation of Type H carrier telephone system at Charlotte, North Carolina.

stations at intermediate points as is frequently the case in railroad operation.

A unique feature is the use of opposite sidebands of the same carrier frequency for opposite directions of transmission. The upper sideband is used in one direction and the lower sideband in the other, the carrier being suppressed. For the modulators and demodulators copper oxide "varistors" are employed in place of vacuum tubes. The amplifiers are single stage, employ pentode tubes and are stabilized in performance by feedback. The filters have been simplified in construction by the use of coils with a new type of core material and by improved designs of paper condensers.

The size of the new terminal has been so reduced that it occupies less than 40 per cent of the space required for a Type D terminal, as indicated in Fig. 1. The equipment may be mounted on racks as is customary in telephone offices, or a complete terminal or repeater may be mounted in a small cabinet.

Single-channel carrier systems have been used in the Bell System principally for short open-wire toll circuits. Thus, the Type D systems are for the most part between 50 and 200 miles in length. The Type H system, since it includes a repeater, can be used for greater distances, and due to its lower cost is economical for shorter distances.

General Description of System

Basic System

The basic system consists of two terminals one of which is referred to as an "east" terminal and the other as a "west" terminal, as indicated in Fig. 2. The two terminals differ only in minor respects, the differences being due to the fact that at one terminal the upper sideband is transmitted and the lower sideband is received, while at the other terminal the reverse takes place. In order to simplify coordination between various types of carrier systems operating on the same pole line, the frequencies between 7400 cycles and 10,150 cycles are transmitted in the east to west (or north to south) direction, and the frequencies between 4150 cycles and 6900 cycles in the west to east (or south to north) direction. The frequency allocation of the Type H system and those for the Type D and the three-channel Type CS system are shown in Fig. 3. All three types may be operated on the same pole line.

The circuit arrangement is given in greater detail in Fig. 4, which shows a schematic diagram of one terminal, with the exception of the power supply circuit. Each terminal is made up of a transmitting

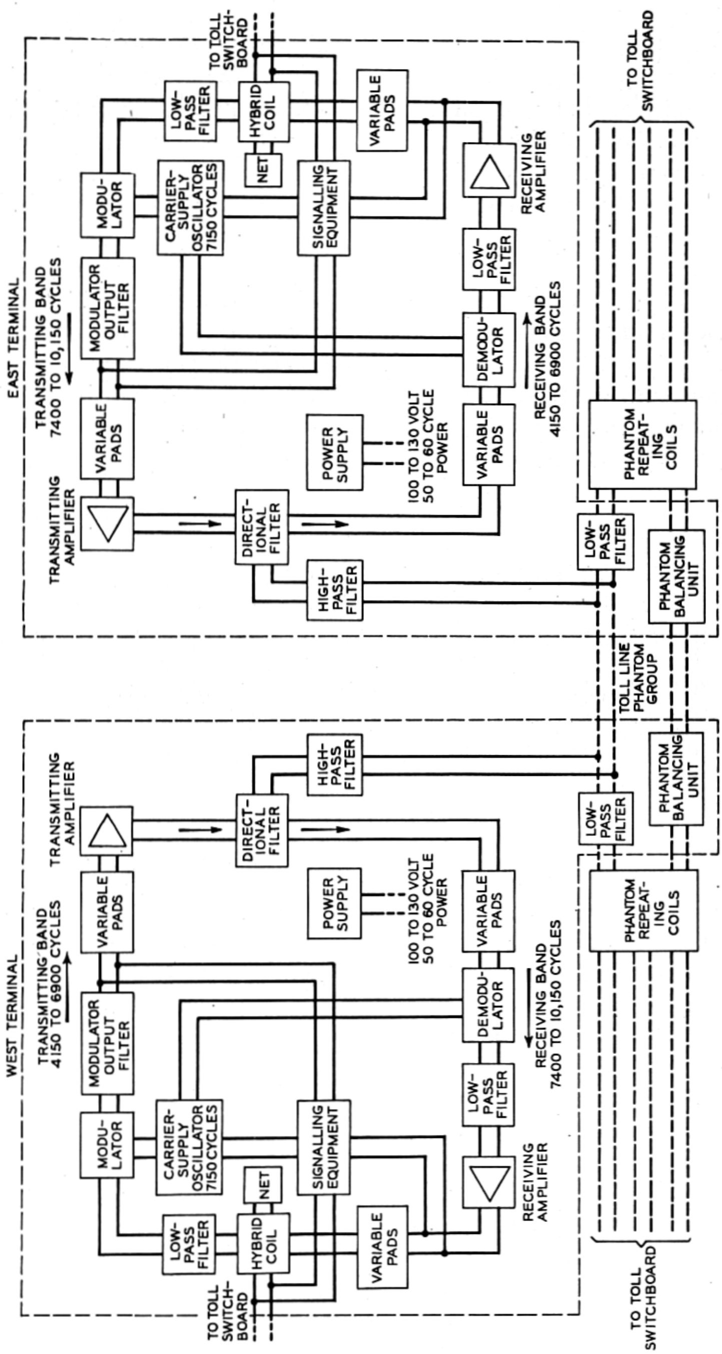

Fig. 2—General schematic of Type H system applied to side circuit of phantom group.

branch which includes a modulator, a receiving branch which includes a demodulator, and a hybrid coil to combine the two branches into a two-wire voice-frequency circuit. The carrier is generated by a vacuum tube oscillator which supplies both the modulator and demodulator. The output of the modulator, which is of the copper oxide type, consists principally of the two sidebands. The desired sideband is selected by the modulator output filter and an amplifier raises the level to that desired for transmission over the line. The demodulator is also of the copper oxide type; its output consists principally of the two sidebands, one of which is a reproduction of the original voice-frequency input. This is selected by means of a low-pass filter and applied to a voice-frequency amplifier which provides the necessary receiving gain. Adjustable pads serve as a means for adjusting the transmitting and receiving gains. The characteristics and functions of the various filters are described later.

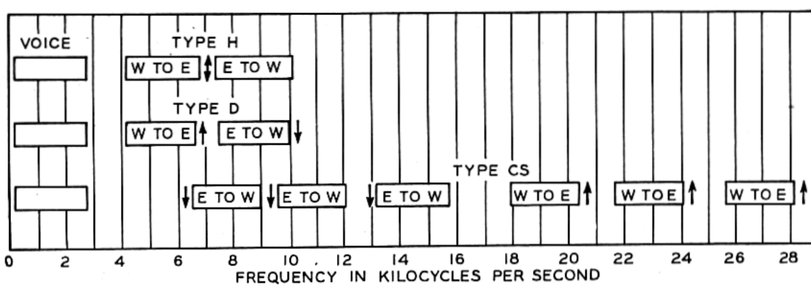

Fig. 3—Frequency allocation.

For signaling over the carrier circuit, a 1000-cycle signaling system is employed. The method is similar to that used on other types of circuits, but includes a number of simplifications. The number of tubes has been reduced, and the vibrating relays used in the older type circuits have been replaced by copper oxide rectifiers and simple d-c. relays requiring little maintenance. When 20-cycle ringing current is received from the switchboard, the frequency of the carrier supply oscillator is shifted by 1000 cycles and its output is interrupted at a 20-cycle rate, and applied to the input of the transmitting amplifier. At the receiving end this appears at the input of the signal receiving circuit as a 1000-cycle current interrupted at a 20-cycle rate. It is then demodulated in a copper oxide rectifier and the resulting 20-cycle current is amplified and applied to a second rectifier the output of which is connected to a d-c. relay. Operation of this relay causes 20-cycle current from a local source to be sent toward the switchboard.

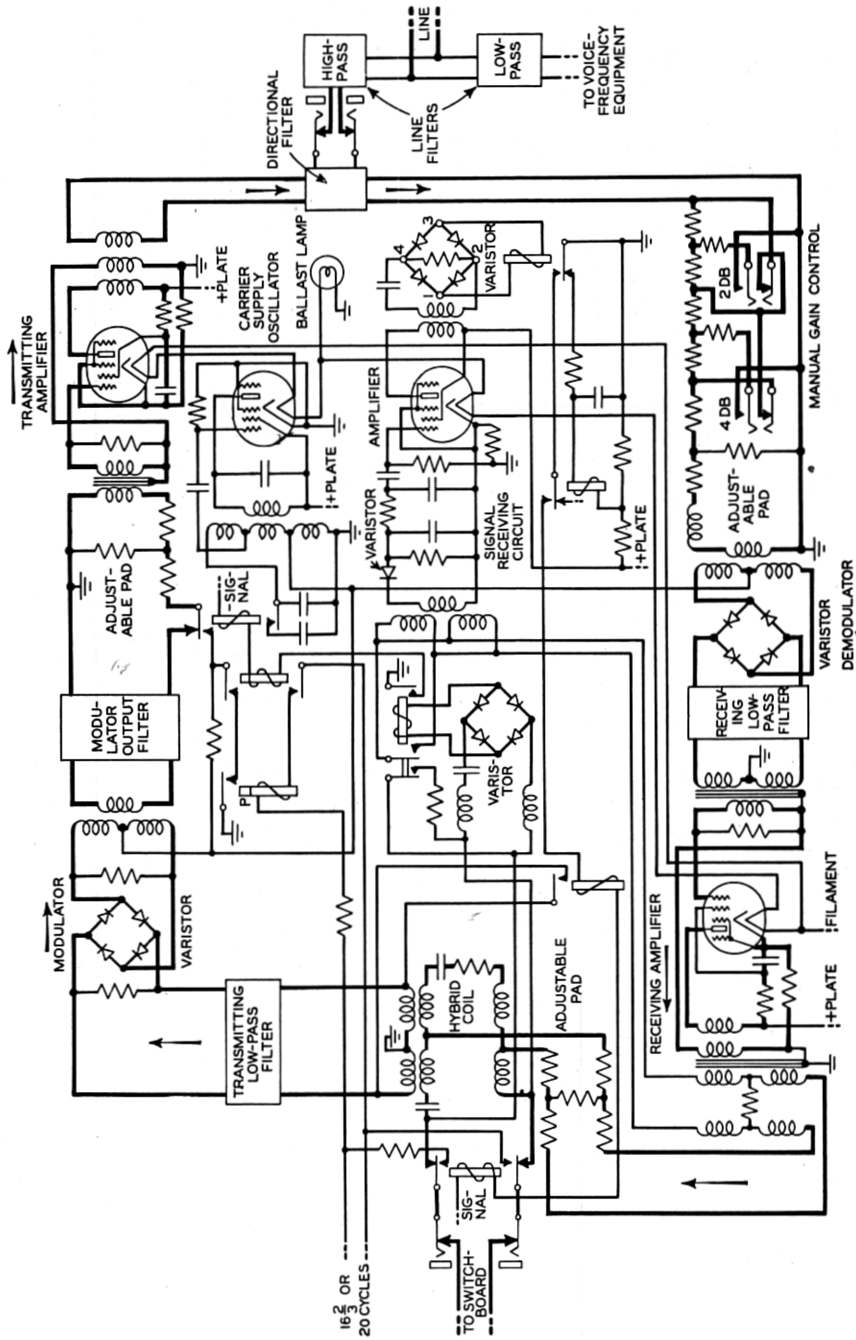

Fig. 4—Schematic of Type H terminal.

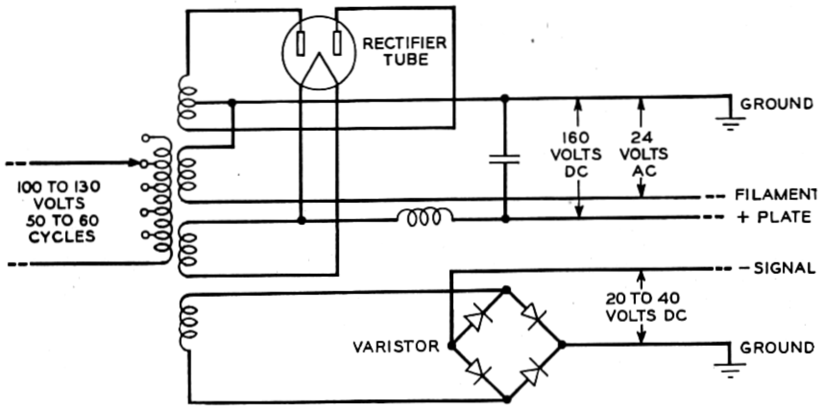

Fig. 5—Schematic of a-c. power supply for terminal.

Freedom from false operation on speech is obtained by tuning the receiving circuit to the rate of interruption and by providing a slow operating relay such that the signal must persist for several tenths of a second before 20-cycle current is passed to the switchboard.

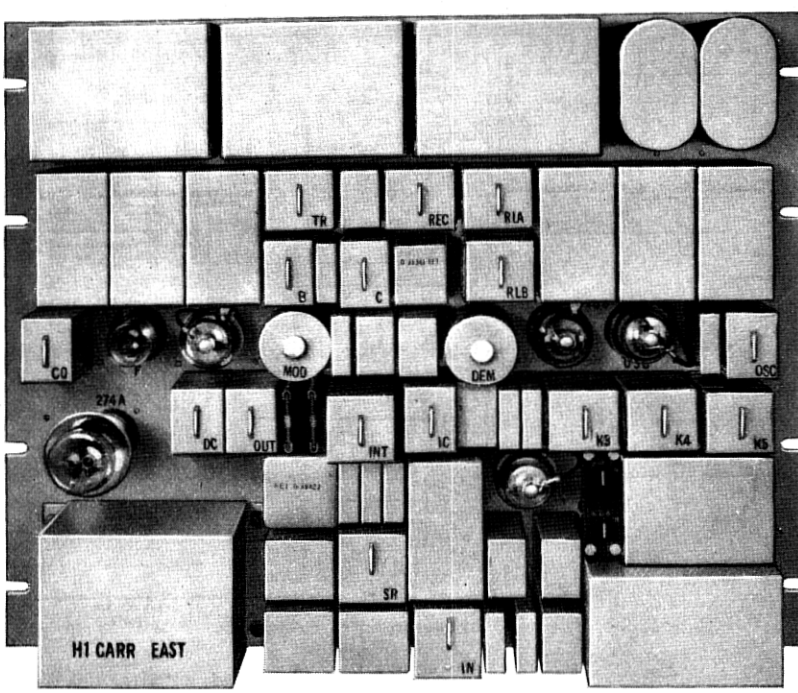

Fig. 6—Terminal panel—front view.

The power supply circuit, which is shown in Fig. 5, operates from an alternating-current source of 100 to 130 volts, 50 to 60 cycles, and requires about 50 watts. It supplies alternating current for the filament supply, 160 volts direct current for plate supply and 24 volts direct current for relay operation. Provision is also made for direct operation from 24-volt and 130-volt central office batteries.

The equipment for a terminal is mounted on two panels. One of these, shown in Fig. 6, is 15¼ inches by 19 inches in size and contains all the apparatus except the line filter circuit. The second panel, shown in Fig. 7, is 3½ inches by 19 inches and contains the line filters, and other equipment which is required for balancing purposes.

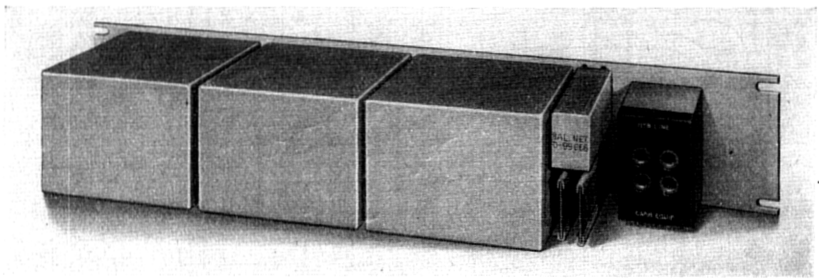

Fig. 7—Line filter and balancing panel—front view.

Repeater

A schematic of the repeater is shown in Fig. 8. The amplifiers are the same in design as the transmitting amplifier at the terminals. Two sets of line filters are required and are identical with those used at the terminals. The a-c. power supply circuit is substantially the same as the one used at the terminals except that the 24-volt supply for relay operation is omitted. The power required for operation is about 35 watts.

The complete repeater consists of three panels—the repeater panel, which is 10½ inches by 19 inches, and two line filter and balancing panels. The repeater panel is shown in Fig. 9.

Transmission Performance

Line Considerations

In outlining the transmission performance of the system, it is necessary to consider the characteristics of the lines as well as those of the equipment. At carrier frequencies the line losses and the variations in these losses with weather are considerably greater than at voice frequencies. This is illustrated in Fig. 10, which shows the

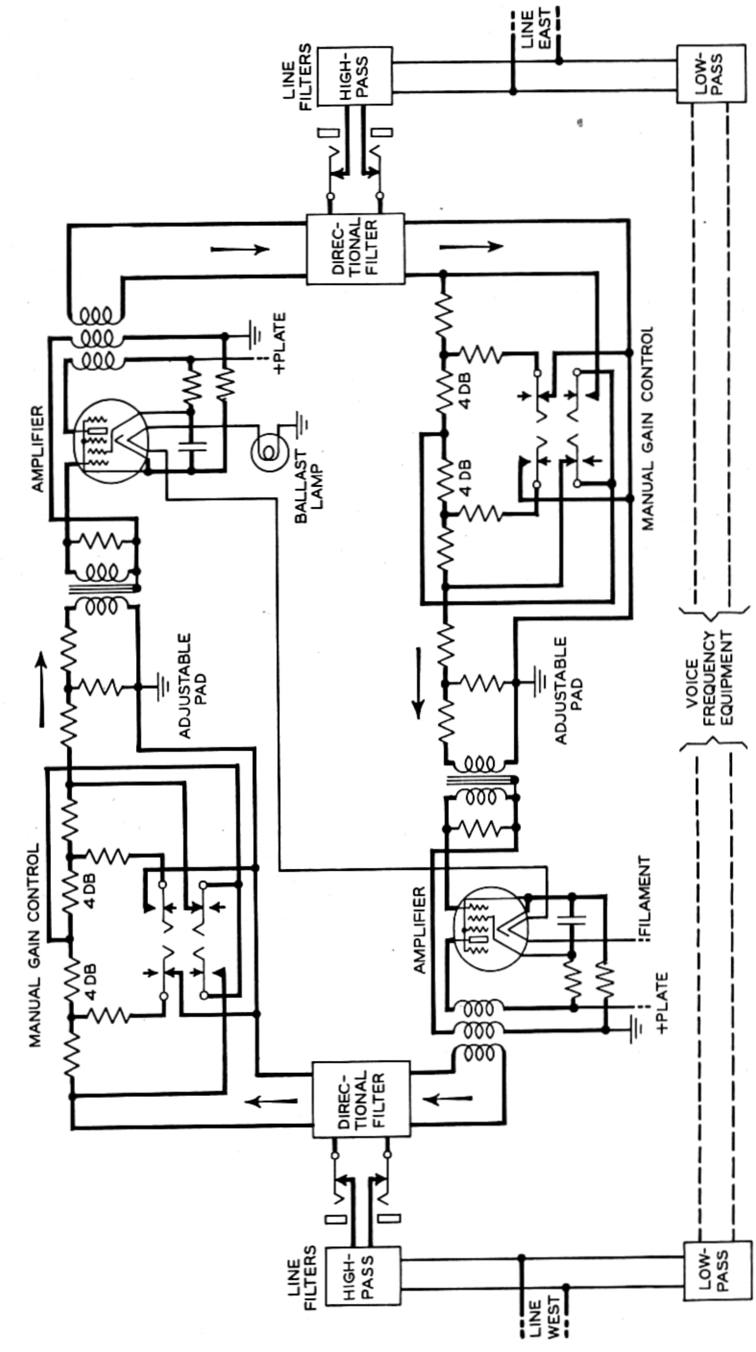

Fig. 8—Schematic of repeater.

attenuation-frequency characteristics for four commonly employed gauges of open-wire line under dry and wet weather conditions, respectively, at a temperature of 68° F. These curves are for 12-inch spaced copper wires equipped with the type of insulators ordinarily

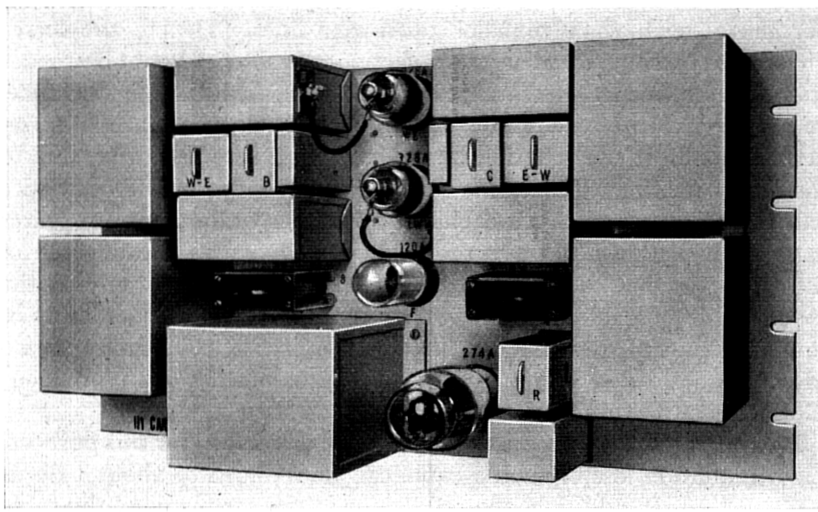

Fig. 9—Repeater panel—front view.

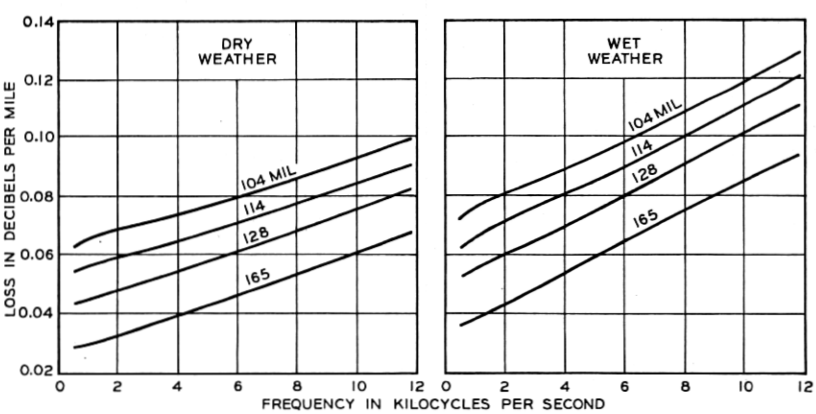

Fig. 10—Attenuation of open-wire side circuits—12-inch spaced copper wire with double petticoat glass insulators.

employed for toll circuits. Changes in temperature also affect the attenuation, the loss increasing as the temperature rises. The variations due to changes in temperature are, however, smaller than those due to changes from dry to wet weather and are more likely to occur gradually. It is apparent that the variations in attenuation with weather increase with the length of the system, and that more frequent adjustments will be required on the longer systems to maintain the overall circuit net loss within given limits.

The carrier frequency attenuation of cable circuits is much greater per unit length than that for open-wire lines. Hence, the losses introduced by comparatively short sections of cable, either at entrances to offices or at intermediate points, are of considerable importance. In addition to the attenuation of the cable itself, there are large reflection losses at the junction of the cable and the open wire, due to the difference between the characteristic impedance of the open-wire and that of the non-loaded cable. The carrier terminal and repeater have been designed to have the same impedance as the average of the open-wire line facilities, so the same considerations apply at the junction of the cable and the carrier equipment. As an example of the magnitude of these effects, the insertion loss at 8000 cycles of two miles of non-loaded 16-gauge cable is approximately 6 db, or about the same as that of 60 miles of 104-mil open-wire.

By applying carrier loading that has been developed for this purpose, the attenuation loss of such a cable can be reduced to about 1 db at 8000 cycles. In addition, the reflections at the terminals of the cable will be reduced to satisfactory low values by virtue of the impedance matching properties of the loading. This method of treatment has the important advantage that it improves the transmission characteristics in both the voice and carrier ranges.

In cases where substantial transmission margins exist, it is sometimes practicable to use impedance matching transformer networks at the cable terminals, as a substitute for carrier loading, with economies that are proportional to the length of the cables. At the present stage of development, this so-called transformer treatment is much less satisfactory in the voice-frequency range than in the carrier-frequency range. Certain inherent limitations in simple transformer treatment result from the fact that the ratio of the (non-loaded) cable impedance to the open-wire impedance varies widely over the frequency band to be transmitted, and the transformer impedance ratio that is optimum at carrier frequencies is distinctly disadvantageous in the voice-frequency range. The choice of optimum transformer ratio for the complete transmission band may thus involve different compromises for different sets of conditions and service requirements.

Where several carrier systems are to be placed on a pole line, crosstalk between systems becomes an important consideration. Where only a few single-channel systems are involved, it is sometimes possible, by separating the systems widely on the pole line, to operate with only the regular voice-frequency transpositions, but, in general, additional transpositions are required. A comparatively inexpensive transposition system for this purpose was designed at the time the Type D system was developed. It permits operation of Type H systems on all pairs of a four-crossarm line with the exception of the pole pairs, and Type C three-channel systems on the top crossarm. In addition to transposing it is important that reflections at junctions between open wire and cable be reduced as described above, in order that near-end crosstalk will not through reflection appear as crosstalk at the distant terminal of the system.

Range of Operation

The terminals and repeaters have sufficient load carrying capacity so that they may be operated at an output level 16 db above that at the transmitting toll switchboard. About 19 db transmitting gain and 14 db receiving gain are available at each terminal, of which a total of 20 db may be used at the east terminal and 22 db at the west terminal. The lower permissible loop gain (sum of transmitting and receiving gains) at the east terminal is not controlling, since the line loss is greater for the frequencies used in the east to west direction than for those used in the west to east direction. Thus, the terminals are capable of providing a 9 db circuit over a line the attenuation of which does not exceed 31 db at 8150 cycles and 29 db at 6150 cycles. These figures correspond roughly to the wet weather attenuation of about 280 miles of 104-mil open wire where no intermediate cable or equipment is involved. The presence of even a small amount of cable will considerably increase the attenuation so that in most cases the distance which can be spanned is not greater than 150 to 200 miles, and may be even less.

Where greater distances are to be covered, an intermediate repeater may be added. The repeater has a useful gain of about 23 db in each direction, with some flexibility as to allocation of gains between the two directions of transmission. More than one intermediate repeater can, of course, be employed, although as the system is lengthened maintenance effort will be increased, as more frequent adjustments of the overall net loss will be required to compensate for the variations in line attenuation with weather. No provision is made for a pilot channel such as is generally provided on the long multi-channel systems, and adjustments of overall net loss must be made manually. Also, no provision has been made for equalizing the variation in line attenuation with frequency. These factors are not important on the shorter circuits for which the system has primarily been designed.

Overall Transmission Characteristics

The circuit provided by a Type H system without a repeater has a band width of about 2750 cycles, extending from about 250 to 3000 cycles. This is somewhat wider than that for the Type D system. The introduction of repeaters will tend to narrow the band somewhat. Representative frequency characteristics are shown in Fig. 11. One

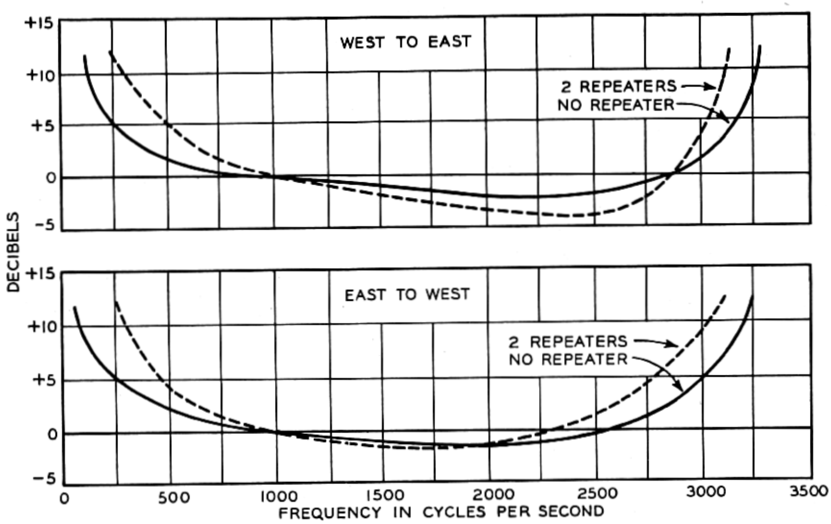

Fig. 11—Representative overall circuit net loss characteristic of system.

set of characteristics is for a typical circuit without a repeater, and the other for a circuit including two repeaters. It is assumed that the line conditions are such that no large reflection effects are present.

The band width is limited principally by the characteristics of the band filters. The small differences in the characteristics for the two directions of transmission are due partly to differences in the filters and partly to the fact that the attenuation of the line increases with frequency and is greater at the 3000-cycle point in the east-to-west channel than for the 3000-cycle point of the west-to-east channel. As the circuit is increased in length this difference tends to increase.

Variations in overall circuit net loss are due largely to variations in the loss of the high-frequency line. For a circuit 200 miles long these may amount to ± 3 db. The key controlled pads which are included at each terminal and repeater are provided for making adjustments to compensate for these variations. Variations due to the equipment are small in comparison with the line variations. The transmitting gain at a terminal may vary ± 0.5 db and the receiving gain ± 0.3 db for variations of ± 10 volts in the a-c. supply. With a more stable a-c. supply or when operated from regulated plate and filament batteries such as are employed in the larger telephone offices, these variations will be less than half the figures given above. With suitable maintenance it should be possible to maintain the overall circuit net loss within ± 2 db of its normal value.

A representative load characteristic, as measured with 1000-cycle current for a system without a repeater, is shown in Fig. 12. On a

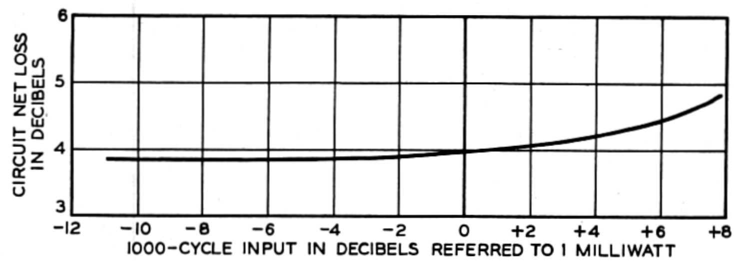

Fig. 12—Representative system load characteristic.

repeatered system some additional limiting of high inputs may occur. However, even on repeatered systems, there should be no noticeable distortion for input volumes such as are obtained directly from a switchboard.

Reactions on Voice Frequency Circuit

In superimposing a carrier system on a voice-frequency circuit, line filters are added to provide separate paths for the voice and carrier circuits. The introduction of a filter in one side of a phantom group requires the addition of a network on the other side to maintain the balance of the phantom circuit from a noise and crosstalk standpoint. It is also necessary for return loss reasons to balance these units in the network circuits of voice-frequency repeaters that may be located at the same point as a carrier terminal or repeater. The networks required to take care of these conditions are included with the carrier system.

In some cases it is desired to apply the Type H system to circuits equipped with bridged telephone stations at intermediate points. Such arrangements are common on railroad communication systems, and occur to a small extent in the Bell System. In such cases, excessive interference into the carrier system due to talking at the way station, and into the way stations due to talking on the carrier system, is likely to occur unless suitable filters are provided at each way station. A simple filter for this purpose has been developed for use with the 501 type subscribers set, and work is proceeding on a similar filter for use with other types of subscriber sets.

The line filters and the filters for use at way telephone stations each introduce a loss of about 0.15 db to the through voice-frequency transmission. Where the voice-frequency circuit is equipped with repeaters and return loss conditions permit, these additional losses may be taken care of by readjusting the voice-frequency repeater gains. In extreme cases, particularly where a considerable number of filters are to be added, it may be necessary to resort to other means of improving the transmission on the voice-frequency circuit, such as loading of incidental cables or the addition of a voice-frequency repeater.

On circuits equipped with way stations, selective signaling by means of selectors is sometimes used. Such signaling systems are generally arranged to apply an "answer back" tone to the line when a station has been called to indicate to the calling party that the selector has operated. This tone contains a considerable amount of high-frequency currents so that it is necessary to modify the selector circuit to filter out the high frequencies. The modification is a simple one and makes the answer back tone inaudible on the carrier circuit.

Design Features

In the development of the Type H system advantage was taken of many new devices which have been perfected in recent years, adapting them to the particular conditions of this application. A discussion of the more interesting features relating to the design of the various parts of the system is given below.

Modulators

The modulator and demodulator used in the Type H system are of the double-balanced copper-oxide type. Each modulator or demodulator consists of an input transformer, an output transformer, a copper-oxide "varistor" and a carrier supply. Although the modulators are bilateral, in the present application they are used in one direction only. The varistor consists of 48 copper-oxide discs assembled on a single bolt and connected as shown in Fig. 13.

The principal advantage of this type of modulator or demodulator is that in the ideal case (and to a lesser degree in the practical case) each modulation product appears only in one of the four branches of the circuit. For example in the case of the modulator, if a voltage of frequency "V" is applied to the input and a voltage of frequency "C" is applied by the carrier supply circuit, resulting products of modulation will appear in the ideal case as shown in Fig. 13. It is obvious that the only unwanted products in the output which cannot be suppressed by filters or balance are those which are of the frequency $(C \pm AV)$ which for some values of A and V fall in the frequency range of the desired sideband $(C + V)$ or $(C - V)$.

These components, however, are normally more than 50 db weaker than the sideband and are not noticeable. Of course, the term AV represents not only odd harmonics of V but odd order intermodulation

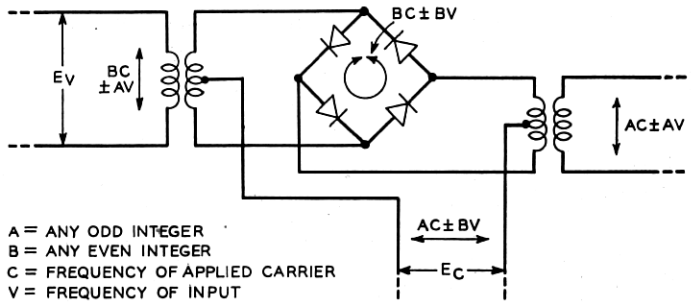

Fig. 13—Simplified schematic of copper oxide modulator.

products such as $(2V_1 \pm V_2)$. The relative amplitudes of the $(C \pm AV)$ terms increase with load in a similar manner to that for the distortion products of an amplifier as the overload point is approached, and the effect on articulation is the same.

For the actual case the modulator balance is not perfect and all products and the original frequencies do appear in all branches of the circuit including the output. However, the balance in most cases is greater than 30 db and the filter requirements are helped to that extent over some portions of the frequency range. This is particularly helpful in connection with suppressing the carrier from the output and input since it lies only about 200 cycles from the pass band and it would be costly to obtain all of the suppression required by means of filters.

With a single disc in each arm, taking the factory run of discs and making no attempt to select units, the balance for many assemblies would be less than 15 db. By selecting units, this balance could be improved to any desired amount. In the present design, however, to save the cost of selection, twelve discs were used per arm to obtain the better balance resulting from the averaging of the characteristics of a large number of discs. There is some sacrifice in efficiency due to using the large number of discs but in this application it was of minor importance.

The averaging obtained by using twelve discs in each arm is helpful in several other respects. First, the normal impedance, transmission and balance do not vary greatly from unit to unit. Secondly, although each disc has a negative coefficient of resistance *vs.* temperature and there is a variation in the coefficient among discs, the average coefficient of twelve discs chosen at random will be very nearly equal to the average of any other twelve discs chosen at random and the balance between arms will, therefore, remain practically constant with temperature, even though the impedance and efficiency vary. A similar advantage is obtained in the case of aging and a good balance is obtained throughout the life of the equipment.

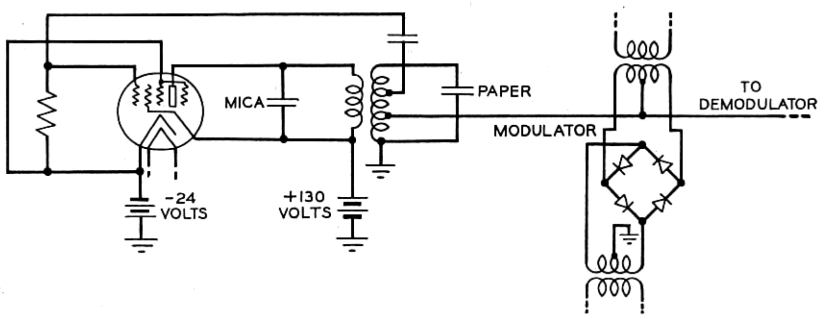

Fig. 14—Schematic diagram of oscillator circuit.

Oscillator

As mentioned previously the same carrier (suppressed) frequency is used for transmission in both directions, thus requiring a single oscillator instead of two as in the Type D system. The principal requirement for an oscillator for this use is that its frequency remain stable under the variations in power supply voltage and temperature which will occur. The new design, which is shown schematically in Fig. 14, provides a degree of stability such that no operating adjustments will be required due to these factors. Relatively high stability with changes in temperature is obtained by balancing the positive capacitance-temperature coefficient of the copper-oxide load and the mica tuning condenser against the negative coefficient of the paper tuning condenser.

The stability of frequency with plate voltage variations is about $5/10^6$ parts per volt. This is adequate and was obtained without the use of an expensive tuning inductance. The coil used, which also serves as output and feedback transformer, has a ratio of reactance to resistance of about 20 and is an air-core solenoid potted in a copper can.

Amplifiers

Both the receiving and transmitting amplifiers employ a single pentode with about 9 db feedback. For this amount of feedback, the variations of gain and impedance due to power supply variations are reduced to at least one-third of the amount of the variation obtained without feedback, and the load-carrying capacity is increased about 1 db.

The two amplifiers differ in that the frequency range transmitted is different and in that the output transformer of the receiving amplifier also acts as an inequality ratio hybrid coil to separate the receiving

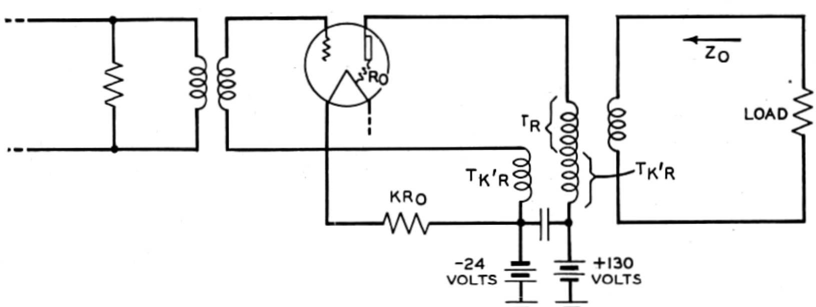

Fig. 15—Simplified schematic of amplifier.

signaling circuit from the two-wire voice circuit. The two circuits are shown in Fig. 4. In each case, the feedback is accomplished by means of a bridge circuit in the output and a series connection in the input. This can be more readily seen from Fig. 15, which is a simplified circuit representing both amplifiers. There is a considerable saving in circuit elements as compared to the familiar resistance bridge feedback connection. The output power loss due to shunt arms of the resistance bridge is eliminated. Furthermore, the impedance of the feedback circuit is relatively low, and consequently some wiring difficulties were avoided. In this application, the bridge is unbalanced, and the impedance Z_0 is a function of KR_0. As a result, it was convenient to adjust Z_0 to the optimum value by choosing the proper value of KR_0.

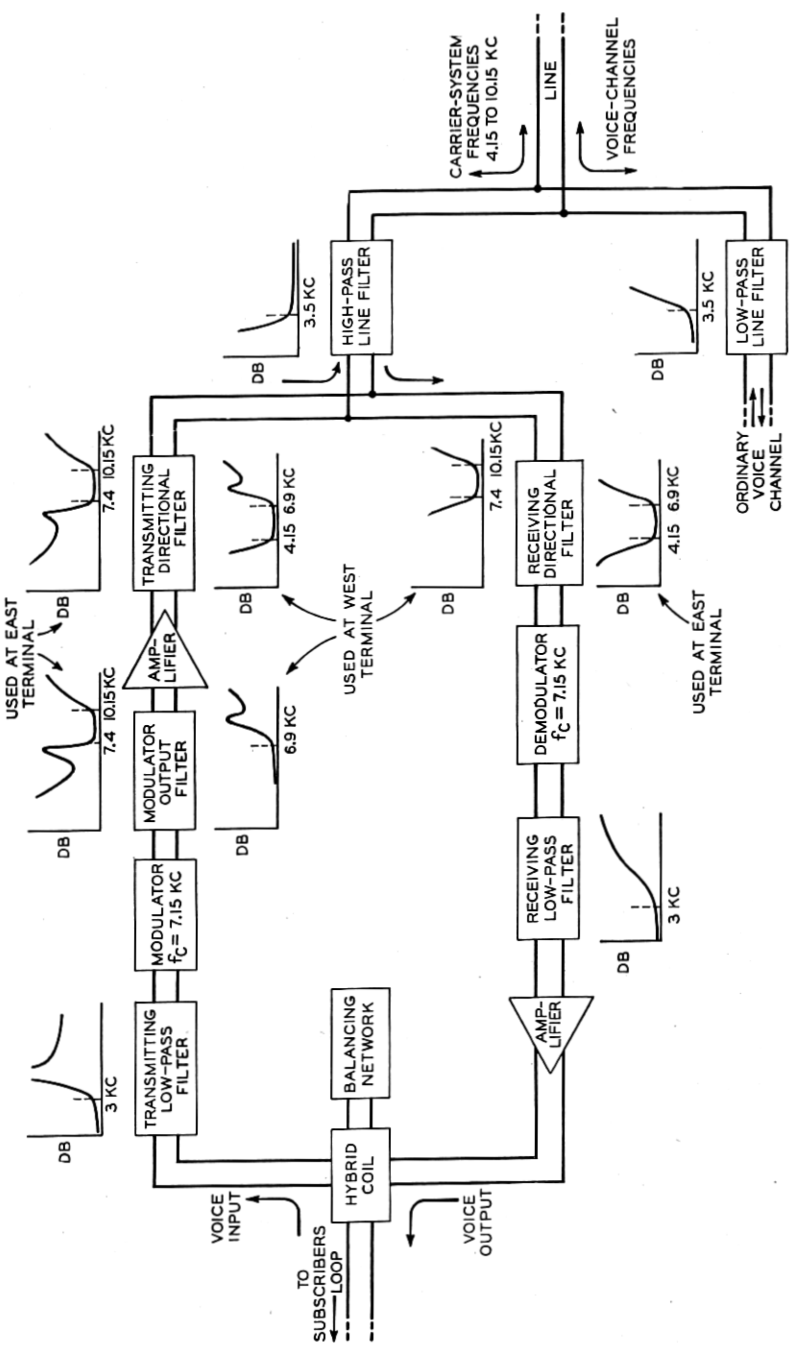

Fig. 16—Attenuation characteristics of filters at terminal.

Filters

Filters constitute an important part of the Type H carrier system. They represent about 30 per cent of the cost of the terminal and occupy about 25 per cent of the total space.

The various filters required at a terminal are indicated in Fig. 16. The transmission characteristic of each filter is given in miniature above or below the block representing the filter.

The high-pass and low-pass line filters separate the ordinary voice telephone channel and the added carrier telephone channel made available by this system. The low-pass line filter passes voice frequencies and suppresses all other frequencies. The high-pass line filter passes the carrier frequencies and suppresses the voice frequencies. Each filter offers a high impedance to the frequencies passed by the other, and bridges off only a very small part of the energy of these frequencies.

The remaining filters are associated with the carrier terminal proper, where they serve to separate the transmitting and receiving paths and suppress unwanted frequencies. The voice frequencies pass through the hybrid coil and the transmitting low-pass filter to the modulator. This filter limits the path between the hybrid coil and the modulator to voice frequencies only. Modulation of the voice with the carrier frequency of 7.15 kc. produces two sidebands extending from 4.15 to 6.90 kc. and from 7.40 to 10.15 kc. At an east terminal, the upper sideband is transmitted, and the modulator output filter passes this sideband and suppresses the lower sideband, together with other unwanted modulation products. In this manner it limits the load on the amplifier to the desired sideband. The transmitting directional filter offers further suppression to frequencies lying outside this band. The receiving directional filter will not pass this band but has a high impedance to these frequencies. The high-pass line filter passes all frequencies above roughly 3.5 kc. and, therefore, this band passes through it readily and out onto the line for transmission to the distant terminal. Transmission from a west terminal is identical in principle but here the lower sideband is passed by the modulator output filter and transmitting directional filter while the upper sideband is suppressed.

It is apparent from Fig. 16 that the received sideband coming in on the line from the distant repeater or terminal is operated upon by the filters in a reverse manner from that described above for the transmitted sideband. The incoming frequencies are directed through the receiving directional filter to the demodulator, where modulation with the original carrier reproduces the voice frequencies together with other modulation products. The desired voice-frequency band is then separated from these products by the receiving low-pass filter.

In addition to performing the function of selecting desired and rejecting undesired currents, a filter, if operating in parallel with another as in the case of the directional filters or the line filters, should offer a high impedance to the transmitted currents of the other and thus prevent an excessive drain of these currents. Since these filters are

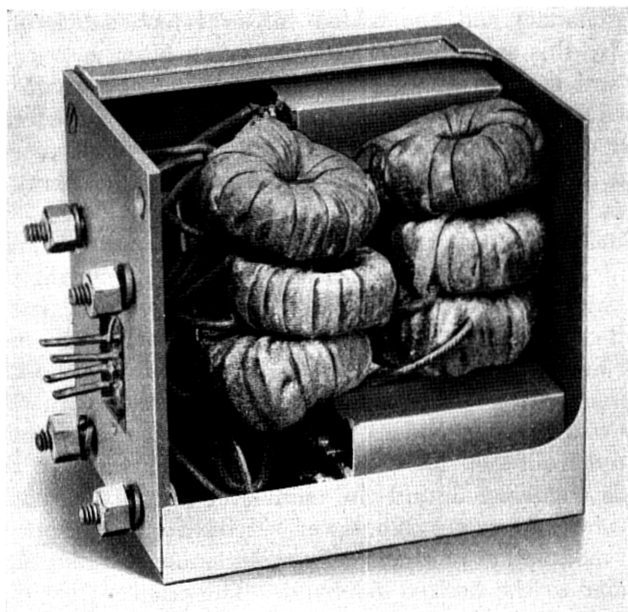

Fig. 17—Filter (with cover cut away) showing general method of assembly.

designed for operation in parallel, either filter operated without the other would have somewhat different electrical characteristics.

The economies and reduction in size of these filters as compared to those of the Type D system are due to several factors. Improved paper condensers having the required stability are used. Compared to mica condensers, these condensers are less costly and smaller for a given capacity. Moreover, at a very slight increase in cost paper condensers are used which will withstand 1000-volt line surges. Most of the condensers of the Type D system were designed for only 500-volt protection.

New types of coils with molybdenum permalloy cores having the necessary stability and low hysteresis losses are employed instead of the air core solenoidal coils used in the Type D system. Since these new coils have less dissipation, the filters have flatter and wider transmission bands which contribute to improve telephone quality in the system. These coils are toroidal in shape and have very small stray fields and therefore small coupling with any nearby coils. This permits them to be packed closely together, which results in a large decrease in the size of the filters. A further reduction in size and cost of the filters was effected by dispensing with individual containers for each coil. The elements of the filter are wired together and held in place in the filter can by a potting compound. This is poured around them, hermetically sealing the whole assembly.

The small size of the elements and the very low coupling between them permit the assembly of more than one filter in the same can. For example, by a careful placing of the elements it was possible to place the transmitting and receiving low-pass filters and the modulator output filter in one can approximately $3\frac{1}{4}$ inches by $4\frac{1}{4}$ inches by $4\frac{1}{4}$ inches in size. A photograph of a high and low-pass line filter with the can cut away is shown in Fig. 17. The filters for a terminal of this system require 70 square inches of mounting space or about 1/5 of that required for those of a Type D system.

Conclusions

The development of the Type H system is another step in extending the use of carrier systems. Improvements in performance and simplifications which are effective in reducing its cost as compared with the Type D system which it supersedes have been obtained. Reduction in size and provision for operation on a-c. supply simplify its installation, particularly in outlying offices where suitable d-c. power supply is not ordinarily available. Its portability makes it well suited to provide additional circuits required in cases of emergency. The Type H system is expected to have a large application in the Bell System telephone plant, and in addition to provide carrier circuits for the communication systems of other companies.