TYPE K CARRIER TELEPHONE SYSTEM

K-1 GROUP EQUIPMENT AND CARRIER SUPPLY

CONTENTS PAGE

1. GENERAL

1.01 This section prepared by the Bell Telephone Laboratories, describes the group equipment and carrier supply used at a terminal of the type K carrier telephone system.

1.02 A process of double modulation is used in the terminal apparatus to translate the voice bands to carrier frequencies. The first step of modulation occurs in the channel modem units, as described in another section. The second step of modulation, described herein, takes place in the group modem. The twelve carrier bands received from the channel modem units, lying in the range between 60 and 108 kc., are shifted as a group by modulation with the group carrier frequency of 120 kc. to the frequency range from 12 to 60 kc. for transmission over the cable. The frequency bands of the twelve channels on the cable, and in the channel modem units are shown in Fig. 1. At the receiving terminal a reverse process is employed; i.e., the twelve carrier bands received from the line, lying in the range of 12 to 60 kc. are modulated with the group carrier frequency of 120 kc., and translated as a group to the range of 60 to 108 kc. for transmission to the channel modem units. As described in another section, the demodulator band filters in the channel modem units separate the 12 bands from each other. Each band is demodulated with its associated carrier frequency ranging from 64 to 108 kc., and thereby produces the twelve voice frequency bands.

1.03 In Fig. 2 is shown a general schematic of the equipment required in the type K terminal. As noted in the figure, the terminal equipment consists of:

Voice frequency terminating sets

4-Wire voice frequency test bay

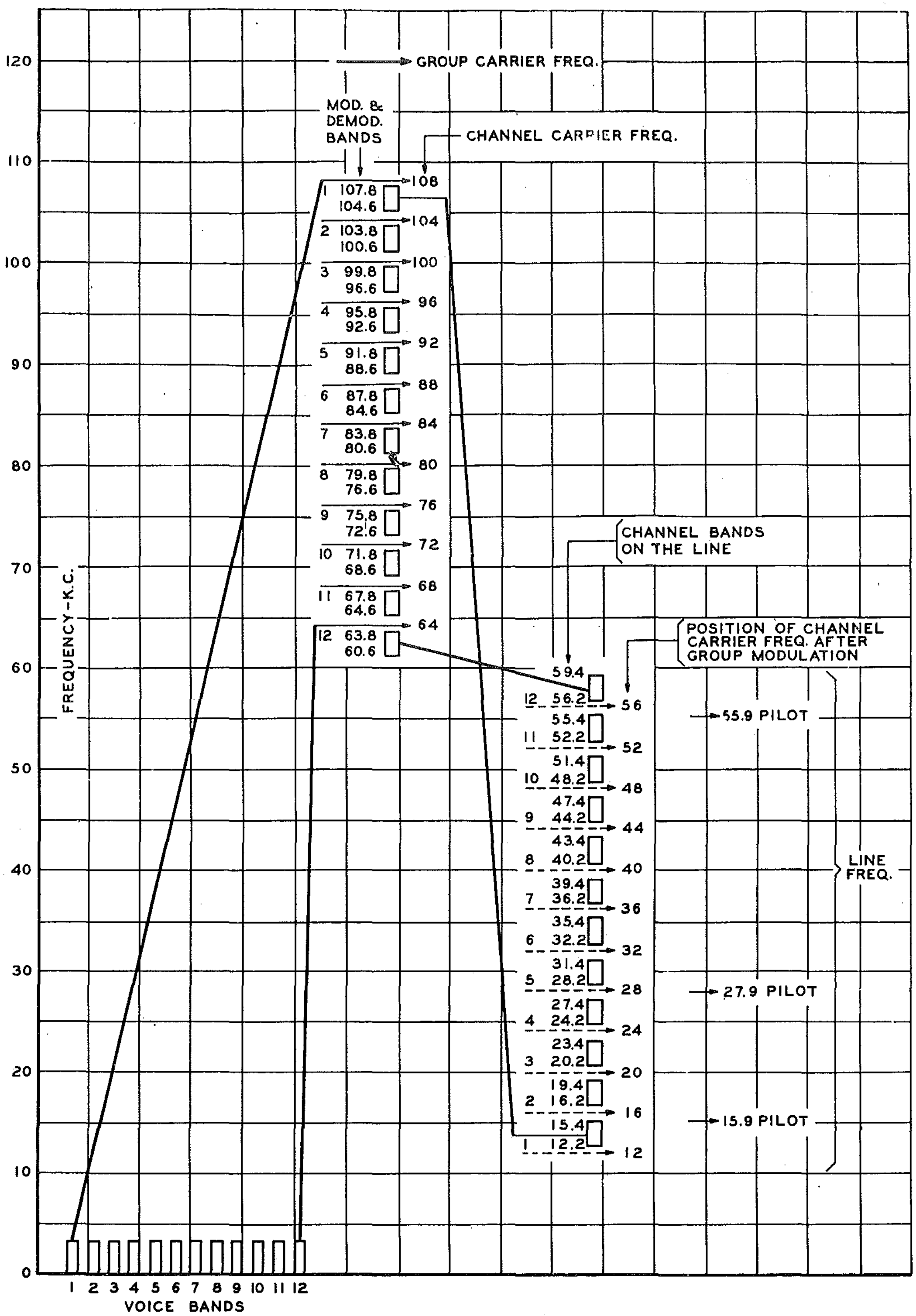


Fig. 1 - Frequency Allocation.

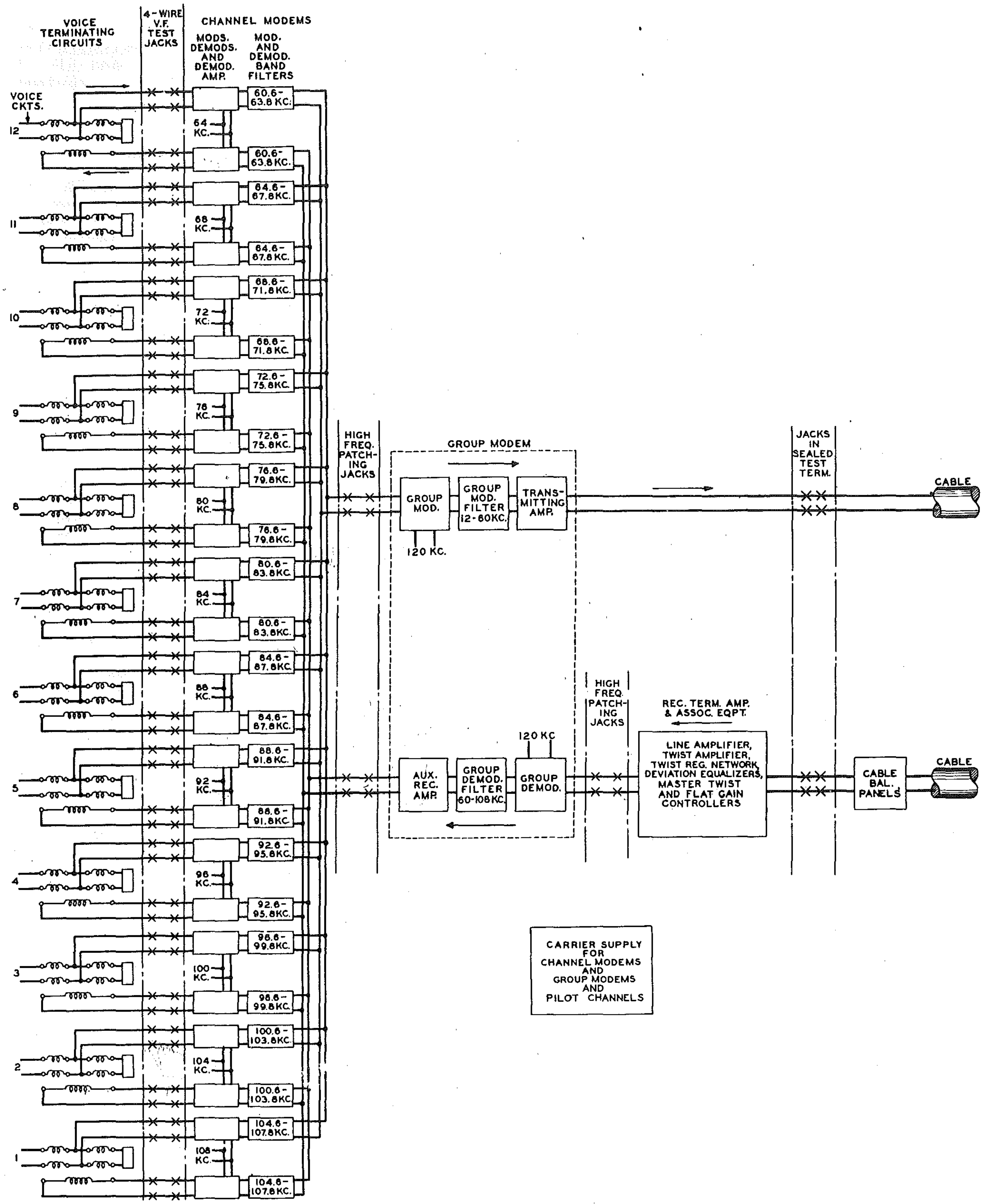


Fig. 2 - Terminal Schematic.

Channel modems, consisting of
- Modulators
- Demodulators
- Band Filters
- Demodulator Amplifiers

(The above equipment is described in another Section; the following equipment is described in this Section.)

High frequency patching jacks

Group Modem, consisting of
- Group modulator
- Group modulator filter
- Transmitting amplifier
- Group demodulator
- Group demodulator filter
- Auxiliary receiving amplifier

Carrier supply
- for channel modems, group modems and pilot channels

(The receiving terminal amplifier and other equipment at the terminal are described in other Sections.)

1.04 The group modem and carrier supply equipment uses a mounting arrangement which is known as single-side maintenance and wiring. The apparatus requiring routine maintenance, such as vacuum tubes and jacks, is mounted on the front of the panel together with the wiring, and all other apparatus, such as coils, condensers, etc., is mounted on the rear of the panel. The panels are mounted on framework which has cable ducts on the right and left-hand sides in which all cabling is run. This permits a separation of cables of high and low transmission level.

1.05 All the carrier frequencies for channel modems and group modems are obtained from a common source. One carrier supply system is adequate for supplying 10 terminals.

1.06 On Drawing ES-852378, page 101, is shown a schematic circuit of the group equipment which is common to all 12 channels of one system terminal. On this drawing the approximate transmission level at the various jacks is given, and also the gains and losses of the principal equipment units.

2. HIGH FREQUENCY PATCHING JACKS

2.01 Referring to Drawing ES-852378, page 101, it will be noted that jacks are provided at the input of the group modulator, at the input of the group demodulator, and at the output of the auxiliary receiving amplifier which forms part of the group demodulator circuit. The jacks at these points may be mounted in the same bay with the sealed test terminals, or in separate bays known as high frequency patching bays. The jacks in the output of the transmitting amplifier, which is part of the group modulator circuit, are located in the sealed test terminal as indicated on Drawing ES-852378.

2.02 The high frequency patching bays are located in the same lineup with the bays containing the sealed test terminals. The jacks in the high frequency patching bay, together with those in the sealed test terminals, make it possible to patch (with shielded patching cords) as required between channel terminal equipment and group terminal equipment, or between the group terminal equipment and the line equipment. These jacks are also used in connection with the line and amplifier switching circuits. Since this is the high frequency part of the circuit, the cabling to these jacks is made with rubber covered shielded wire.

3. GROUP MODEM

3.01 The term "Group Modem" was coined from the words "Group Modulator" and "Group Demodulator", but the assembly includes other parts of the circuit. Referring to Drawing ES-852378, page 101, it will be noted that the "Group Modem" panel includes the following elements:

- Group modulator
- Group modulator filter
- Transmitting amplifier
- Group demodulator
- Group demodulator filter
- Auxiliary receiving amplifier

(A) Group Modulator

3.02 The twelve sidebands received from the twelve modulator band filters in the channel modems are modulated as a group in the group modulator with a carrier frequency of 120 kc. This is the second step of modulation at the terminal and shifts the channel bands from the range of 60 to 108 kc. to the range of 12 to 60 kc. for transmission over the cable pairs. The group modulator consists of copper-oxide units, known as varistors, as indicated schematically on Drawing ES-852378, page 101. As will be noted, the arrangement of the varistors in the circuit differs from the arrangement employed for the modulator and demodulator on the channel modem, described in other information. The group modulator is so balanced that both the carrier supply of 120 kc., and the channel bands impressed upon the input are largely suppressed and do not appear in the output. This reduces the requirements placed upon the group modulator filter for suppression of unwanted frequencies above 60 kc.

3.03 The theory of operation of this copper-oxide modulator arrangement is covered in other information. Briefly, it may be explained as follows. The varistors have a low impedance when the carrier potential is applied in one direction across the elements during one-half of the carrier frequency cycle and a high impedance when the carrier potential is applied in the opposite direction during the other half of the carrier frequency cycle. The amplitude of the 120 kc. carrier frequency voltage applied to this circuit is very much larger than that of the input (channel band frequencies). With this circuit arrangement the application of the carrier frequency controls the resistance of the varistors in such a way that the input voltage is impressed across the output transformer in one direction during one-half of the carrier wave and in the opposite direction during the other half of the carrier wave. The result of this action is to produce upper and lower sidebands, that is, 120 kc. plus the 12 channel band frequencies and 120 kc. minus the 12 channel band frequencies, in the output of the group modulator. The lower sideband (120 kc. minus the 12 channel band frequencies) is transmitted by the group modulator filter, as mentioned below.

3.04 The carrier frequency of 120 kc. is obtained from a common source of carrier supply, described in Part 4.

3.05 The channel band frequencies enter the copper-oxide units at a comparatively low level of about -45 db. This low level is desirable in order to reduce interchannel modulation, but too low a level would result in undesirable noise from the units. The level chosen gives satisfactory results from both standpoints.

3.06 The pilot channel supply circuit is bridged across the group modulator input coil, so that the three pilot frequencies, namely, 104.1, 92.1, and 64.1 kc., form part of the input of frequencies to the group modulator. When the pilot frequencies are modulated with 120 kc., in the group modulator, they are translated to frequencies of 15.9, 27.9, and 55.9 kc. The three pilot frequencies are transmitted simultaneously and continuously over the system, and do not interfere with the 12 channels, because they are located between the channel bands. This is discussed further in Part 4(K).

3.07 Resistance pads are located in the circuit as shown to provide the correct transmission levels and to improve the impedance into which the various elements operate.

(B) Group Modulator Filter

3.08 The group modulator filter is a low pass filter which transmits freely all frequencies below about 66 kc., and suppresses higher frequencies, as indicated in Fig. 4. This permits the lower sideband generated by the group modulator to pass to the transmitting amplifier. In order to suppress any carrier leak of 120 kc. which may not be balanced out by the circuit arrangement, a minimum loss of 65 db is provided in the group modulator filter at this frequency. The nominal impedance of this filter is 600 ohms.

(C) Transmitting Amplifier

3.09 The transmitting amplifier is a stabilized feedback type amplifier providing approximately 66 db flat gain over the 12 to 60 kc. range. The feedback is about 34 db. It utilizes two 310A and one 311A vacuum tubes. No adjustment in gain is provided on this amplifier. The nominal input impedance is 600 ohms and the nominal output impedance is 135 ohms. It delivers an output level for each channel of +9 db with respect to the transmitting toll switchboard for transmission to the cable pair.

(D) Transmission Characteristics of Transmitting Circuit

3.10 In Fig. 3 is shown the gain-frequency characteristic of the transmitting circuit of the group modem from the input of the group modulator to the output of the transmitting amplifier. It will be noted that the gain is substantially constant over the range, i.e., 60 to 108 kc. up to the input of the group modulator, and 12 to 60 kc. from the output of the group modulator to the output of transmitting amplifier. This figure also shows typical losses introduced by the group modulator and group modulator filter.

3.11 In Fig. 4 is shown the transmission characteristics of the transmitting amplifier up to 130 kc. and the effect of the group modulator filter in the circuit.

3.12 In Fig 5 is shown a typical load characteristic of the transmitting amplifier measured at 60 kc. It will be noted that the output is constant up to an output load of about 31 db above one milliwatt. The variation in gain of the transmitting amplifier with the normal variations in 24-volt and 130-volt battery is negligible.

3.13 The amount of carrier leak of the 120 kc. carrier supply frequency measured at the output of the transmitting amplifier will ordinarily be well within the requirement of 15 db below 1 milliwatt.

(E) Group Demodulator

3.14 In the receiving side of the group modem the twelve channel bands (in the 12-60 kc. range) are received from the receiving terminal amplifier and twist amplifier at a level of +9 db. The group demodulator is designed for operation at an input level of approximately -45 db, as explained above for the group modulator, so that a resistance pad is inserted in the circuit at the input of the group demodulator. The arrangement of the varistors in the group demodulator circuit is the same

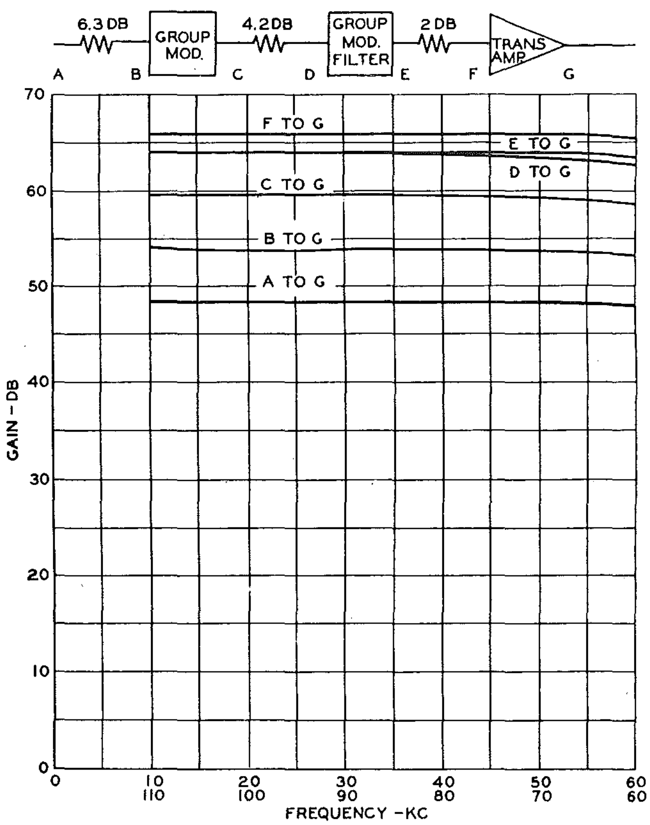


Fig. 3 - Transmission Characteristics of Group Transmitting Circuits - Group Modulator, Group Modulator Filter, Pads and Transmitting Amplifier.

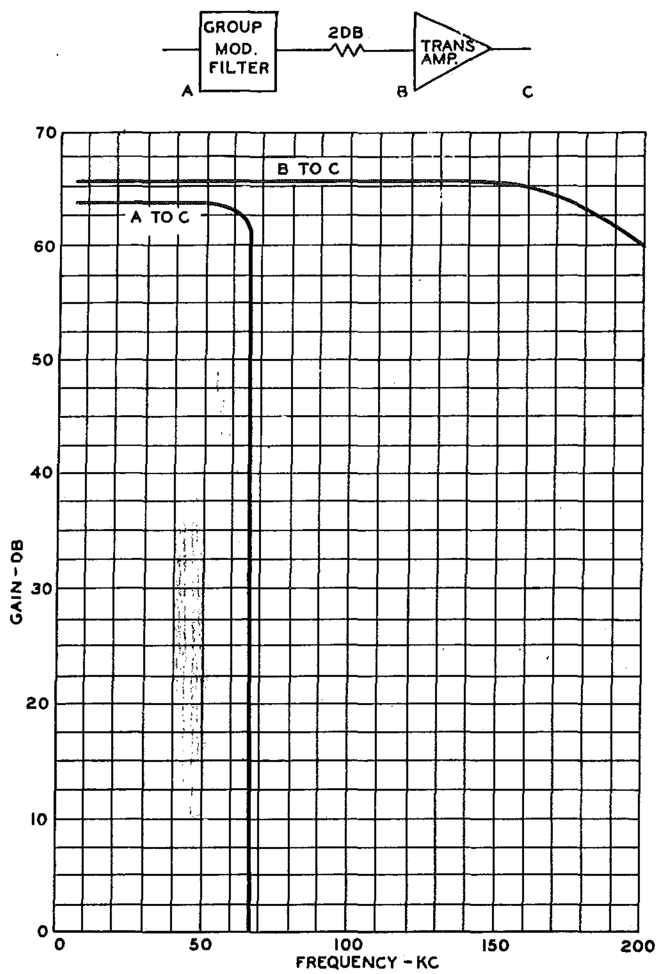


Fig. 4 - Transmission Characteristics of Transmitting Amplifier up to 130 kc., and Effect of Group Modulator Filter on Transmitted Band.

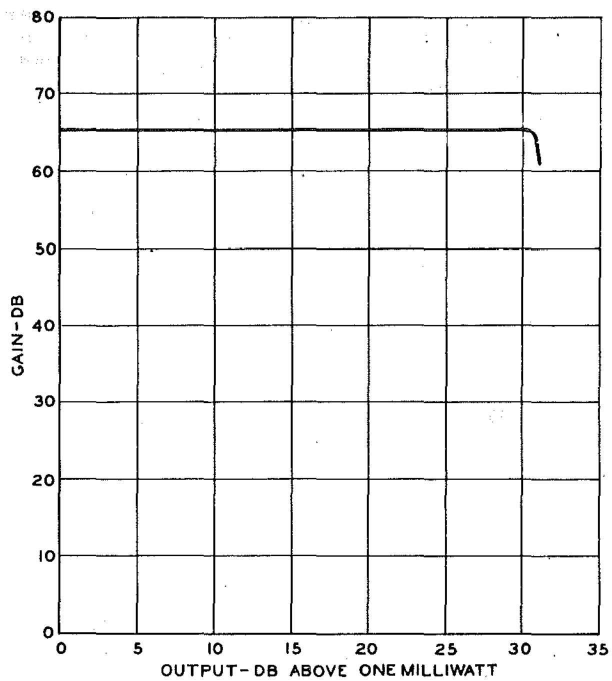


Fig. 5 - Typical Transmitting Amplifier Load Characteristic (Measured at 60 Kc.)

as in the group modulator, and the same carrier frequency of 120 kc. is employed.

(F) Group Demodulator Filter

3.15 The group demodulator filter is a low-pass filter which transmits freely the lower sideband and suppresses the upper sideband and the 120 kc. carrier frequency. It cuts off at about 117 kc. The 12 channel bands at this point in the circuit are in the frequency range of 60 to 108 kc. The nominal impedance of the filter is 600 ohms.

(G) Auxiliary Receiving Amplifier

3.16 The auxiliary receiving amplifier is a two-tube circuit using two 310A vacuum tubes, and providing a flat gain of approximately 45 db. It raises the level to about 4.5 db. The nominal impedance of the input is 600 ohms, and the output is 135 ohms.

(H) Transmission Characteristics of Receiving Circuit

3.17 In Fig. 6 is shown the gain-frequency characteristic of the receiving circuit of the group modem from the input of the group demodulator to the output of the auxiliary receiving amplifier. The characteristic is substantially constant over the working range, i.e., 12 to 60 kc., up to the group demodulator, and 50 to 108 kc. from the output of the group demodulator to the output of the auxiliary receiving amplifier. This figure also shows typical losses introduced by the group demodulator and group demodulator filter.

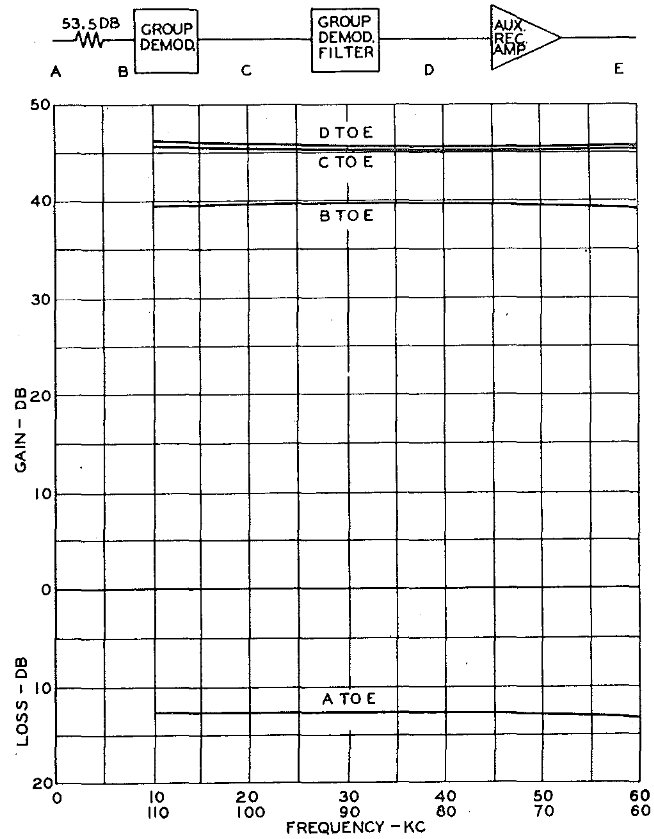


Fig. 6 - Transmission Characteristics of Group Receiving Circuit - Group Demodulator, Group Demodulator Filter, Pads, and Auxiliary Receiving Amplifier.

(J) Mounting Arrangement

3.18 The group modem unit is shown in Figs. 7A, and 7B. Referring to the front view (Fig. 7A), the upper panel mounts the transmitting amplifier on the right-hand side and the group modulator on the left. The group modulator filter which is connected between these two circuits, is located on the upper right-hand part of the lower panel. The lower panel also mounts the group demodulator, the group demodulator filter, and the auxiliary receiving amplifier. The group demodulator is mounted on the lower left-hand portion and the auxiliary receiving amplifier is in the lower right-hand portion. The group demodulator filter is located in the upper part of this lower panel with its terminals located so that the wiring to the group demodulator and the auxiliary receiving amplifier can be as short as possible. As shown in Fig. 7A the shielded cable connected to the input of the group modulator circuit is connected on the left-hand side of the panel and runs in the left-hand cable duct. The input to the group demodulator is also connected on the left-hand side of the panel but as this is at a high level the shielded pair must be run across the panel and out through the right-hand cable duct. The high level output leads from the transmitting and auxiliary receiving amplifiers are run in shielded pairs in the right-hand cable duct. These leads connect to transformers which are on the right-hand side of the panels.

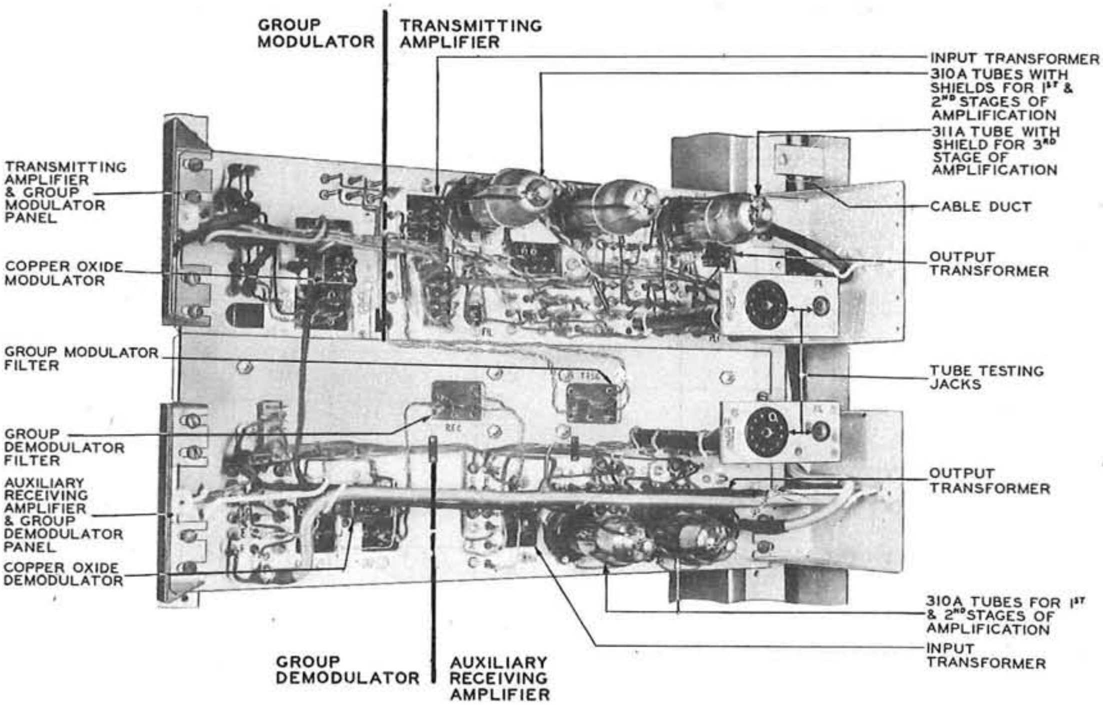


Fig. 7A - Group Modem Panel - Front View.

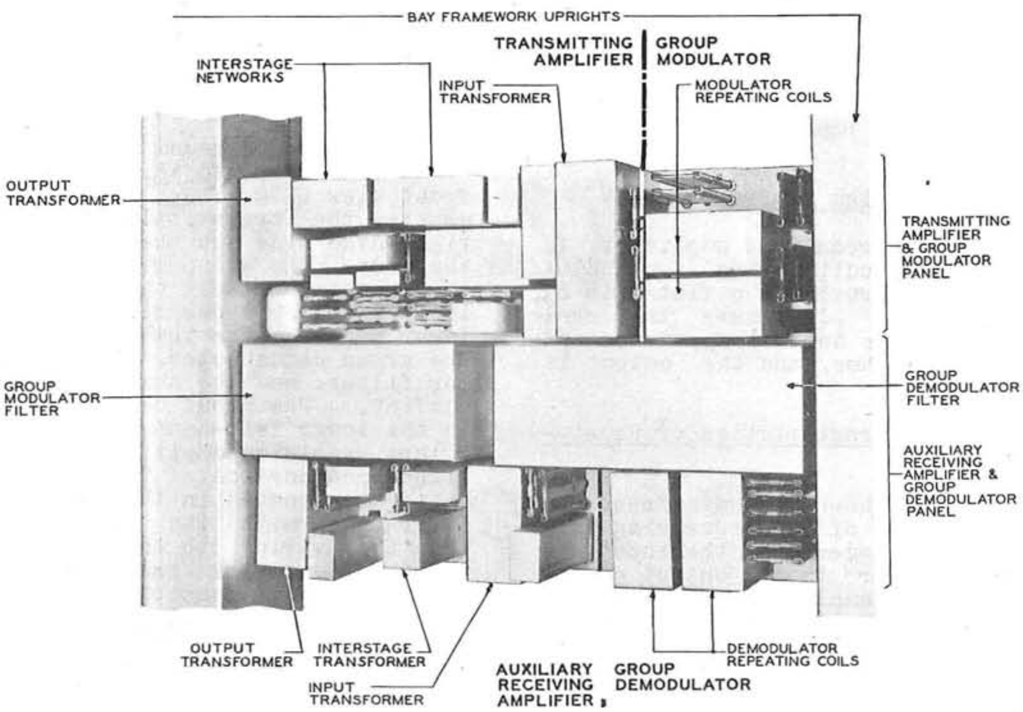


Fig. 7B - Group Modem Panel - Rear View.

3.19 The transmission leads to each of these units connect to the high frequency patching jacks, and to the jacks in the sealed test terminal, with rubber covered shielded wire.

3.20 Nine of these group modem units (for nine systems of 12 channels each) can be mounted in one bay as shown in Fig. 8. The fuse panels shown will mount the 24 and 130-volt fuses and the grid supply resistances for 18 systems and so these panels should be mounted in the first, third, fifth, etc., bays of a lineup. The upper fuse panel, which supplies systems 1, 3, 5, etc., is connected to one set of 24 and 130-volt power discharge leads, and the lower fuse panel, which supplies systems 2, 4, 6, etc., is connected to a second set of power discharge leads.

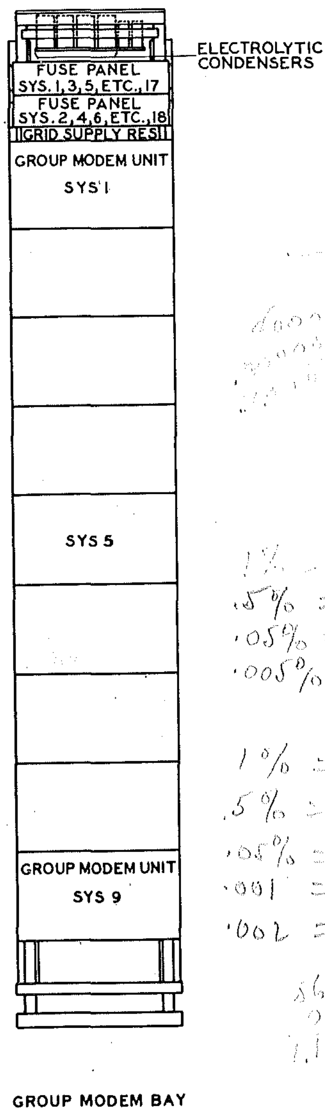


Fig. 8 - Group Modems - Bay Layout.

4. CARRIER SUPPLY

(A) General Features

4.01 The carrier frequencies which must be supplied to the modulators and demodulators are the 12 frequencies from 64 kc., in steps of 4 kc., to 108 kc. for the channel circuits, and 120 kc. for the group circuits. These frequencies are generated as the harmonics of a single fundamental frequency of 4 kc. Since harmonics are exact multiples of the fundamental, the required accuracy for all the carrier frequencies can be obtained by keeping the fundamental sufficiently accurate.

4.02 One carrier supply bay has the capacity to supply the carrier frequencies required by 10 carrier telephone terminals of 12 channels each. To reduce the likelihood of a failure of the carrier supply, two kinds of safety measures have been incorporated in the design as follows:

(a) Two carrier generators are furnished, together with a transfer circuit for automatically transferring the carrier load from one to the other in case of failure of the regular generator.

(b) Arrangements have been made to guard against accidental shorts or grounds at points where the carrier supply for a large number of circuits would be affected. The chief of these measures is the use of "protective resistances" in the leads supplying each modulator or demodulator circuit.

(B) Carrier Generator

4.03 The carrier supply circuit is shown in Fig. 9. The carrier generator unit (the larger of the two panels in Figs. 10A and 10B) contains the tuning fork oscillator and amplifier for the 4 kc. fundamental, and the retardation coil, associated condensers, and copper-oxide bridge for producing the carrier frequencies as harmonics of this fundamental. The "regular" and the "emergency" generators, shown in the circuit, Fig. 9, are identical.

4.04 The frequency of the 4 kc. vacuum tube oscillator is determined primarily by the mechanical tuning of the 4 kc. tuning fork. A small amount of frequency adjustment (about ± 0.005%) can be made with the variable condensers provided on the panel. This adjustment is for the purpose of setting the oscillator exactly at 4 kc. or at synchronism with a reference oscillator. Aging of the fork and other elements in the circuit may cause a change of this order of magnitude. However, the circuit oscillation frequency is not expected to deviate from its adjusted point by more than ± 0.002% over the temperature range usually encountered in an office, and for reasonably long periods of time. This gives a maximum variation of about ± 1 cy-

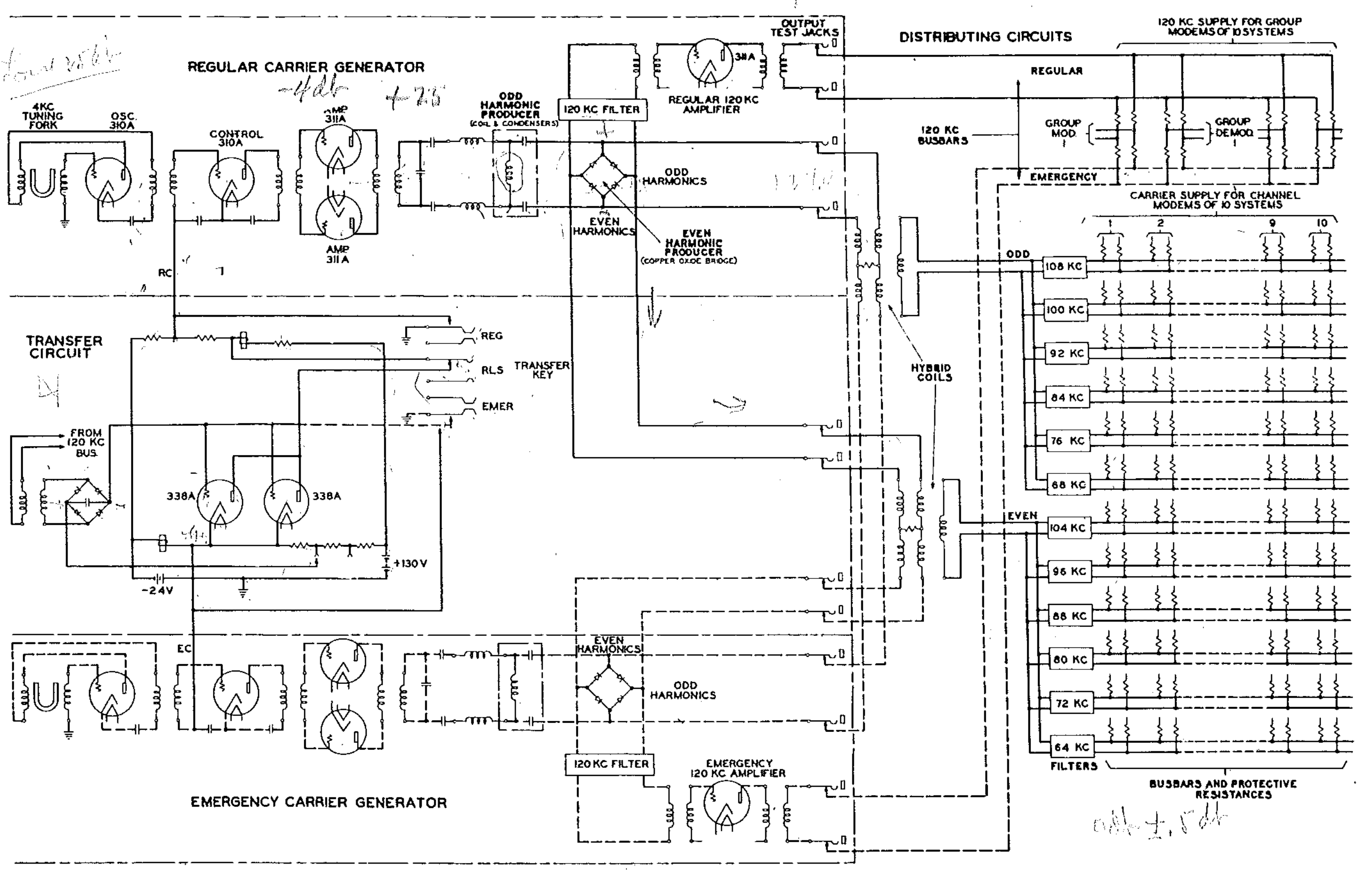


Fig. 9 - Carrier Supply Circuit.

cle at the highest carrier channel frequency on the line of 56 kc., and a smaller variation of the other carrier channel frequencies.

4.05 The 4 kc. output from the oscillator circuit is amplified by a 310A tube, and then by two 311A tubes in a push-pull amplifier circuit, in order to give the voltage required by the harmonic producing retardation coil. The output of the generator is under the control of the tube designated, "Control", Fig. 9. This is accomplished by placing the grid biases on the "Control" tubes of both regular and emergency generators under the control of the transfer circuit described in subheading (E).

4.06 The generation of harmonics of the 4 kc. fundamental may be briefly described as follows: The amplified 4 kc. is connected through a series tuned circuit, which is tuned to 4 kc., to the retard coil and condensers designated "Odd Harmonic Producer" in Fig. 9. The high-amplitude 4 kc. fundamental current forced through the retard coil will greatly "overload" the coil, since the material used for its core will attain magnetic saturation with a very small current. The action of the "overloaded" coil and its associated condensers results in an alternate charging and discharging of these condensers that takes place every half-period of the 4 kc. fundamental. The wave shape of this non-sinusoidal output current is such that it contains only the odd numbered harmonics of 4 kc. To obtain the even harmonics, part of this output current is rectified by the copper-oxide bridge, designated "Even Harmonic Producer" in Fig. 9, which converts it into a current whose wave shape is such that only the even numbered harmonics of 4 kc. will be present. The circuit elements in the harmonic producing circuit are chosen to give a comparatively uniform output level for the twelve frequencies between 64 and 108 kc.; the variation between the frequencies with the highest and lowest power output being less than 5 db. Provision is made, as discussed in Part 4 (F), for equalizing these outputs. A detailed description of the magnetic generation of a group of harmonics from a fundamental frequency has been published (see reference Note 1).

4.07 The "odd" and "even" carrier frequencies are connected through separate pairs of output jacks to the hybrid coils in the odd and even distributing circuits. The output of even harmonics is also connected directly to the 120 kc. filter described in Part 4(C).

(1) Bell System Technical Journal, page 437, October 1937, and Electrical Engineering, page 995, August, 1937.

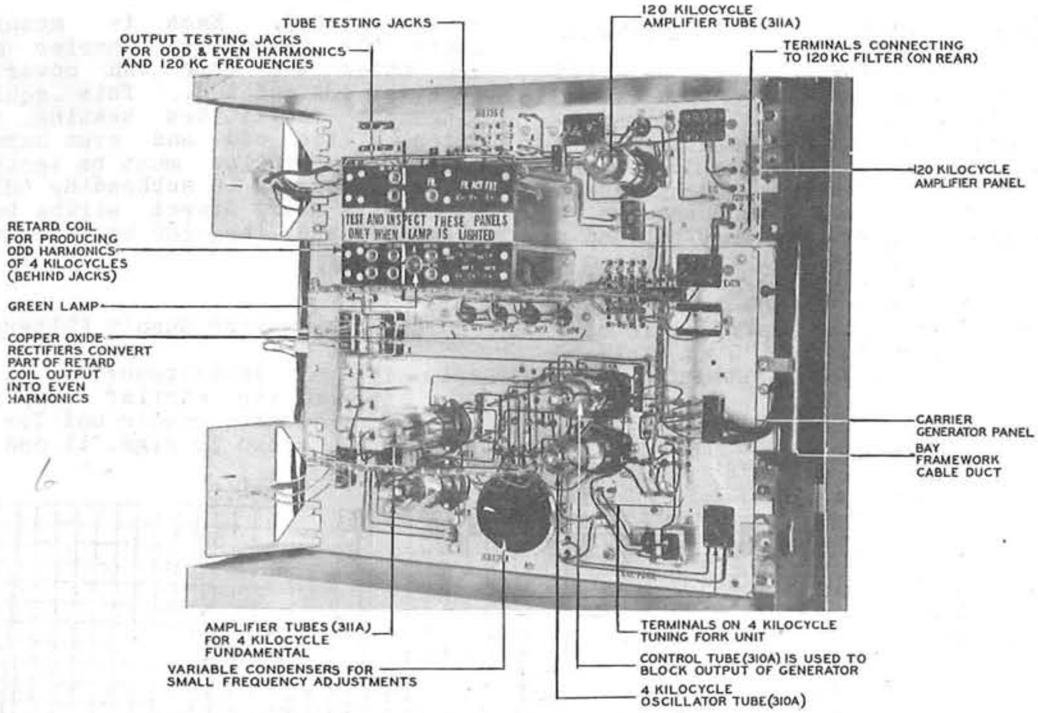


Fig. 10A - Carrier Generator and 120 Kc. Amplifier Panel - Front View.

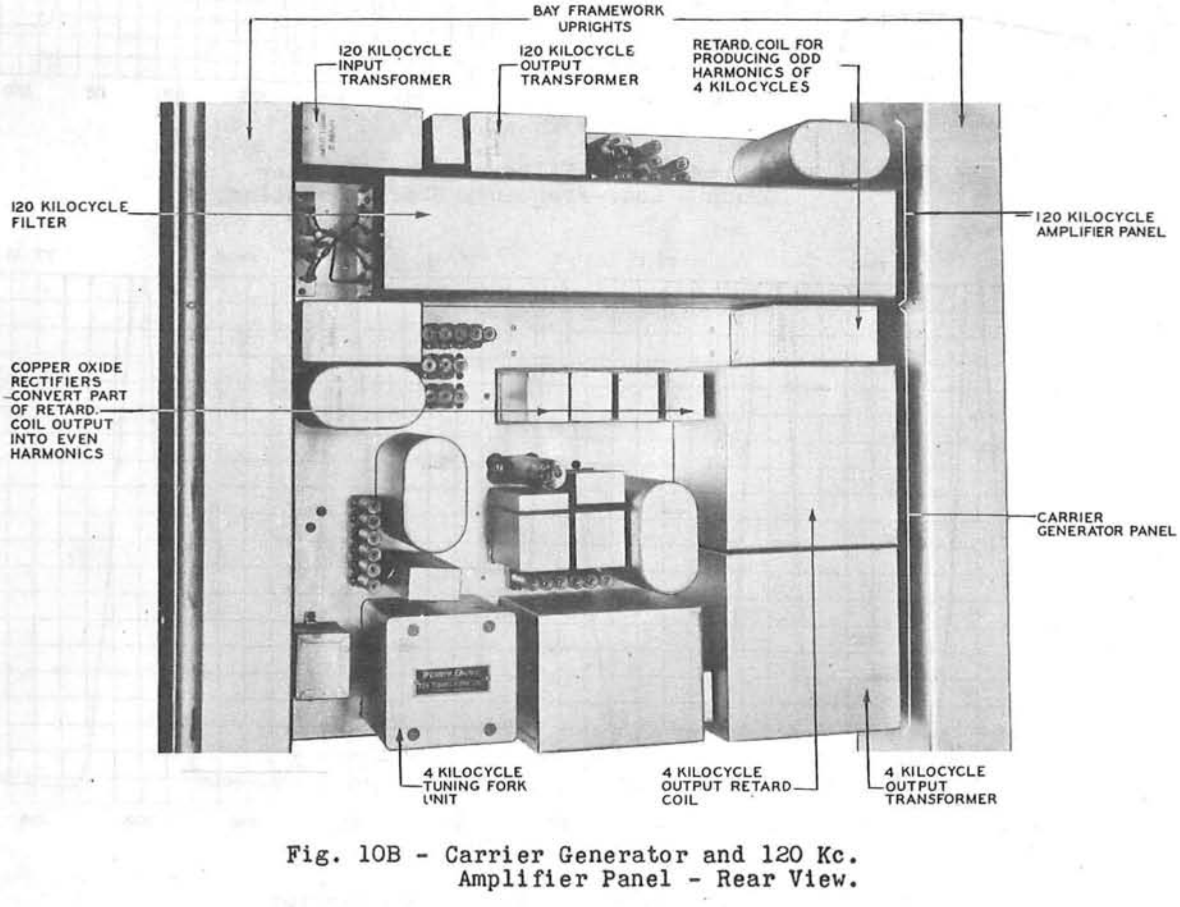


Fig. 10B - Carrier Generator and 120 Kc. Amplifier Panel - Rear View.

(C) Amplifier and Filter for 120 Kc. Supply

4.08 The 120 kc. frequency is selected from the even harmonics by a filter and is then raised to the level required by the group modulators and demodulators by a single stage amplifier, using a 311A tube. The gain of this amplifier can be adjusted in steps of approximately 2 db between a maximum value of approximately 27 db and a minimum of approximately 21 db. This adjustment is made by a soldered connection to one of 4 terminals on the input transformer. The output of the amplifier is connected through jacks to the 120 kc. distributing equipment described in subheading (G).

4.09 Duplicate 120 kc. amplifier and filter panels ("Regular" and "Emergency") are furnished. Each is mounted just above the associated carrier generator, and under the same can cover, as shown in Figs. 10A and 10B. This equipment arrangement facilitates testing, since the output of the odd and even harmonics and 120 kc. frequencies must be tested together, as discussed in subheading (H). It also permits short direct wiring between the generator and the 120 kc. filter on this panel.

(D) Channel Carrier Supply Filters

4.10 Typical loss-frequency characteristics of the carrier supply filters for the various channels and for the group carrier are shown in Figs. 11 and 12.

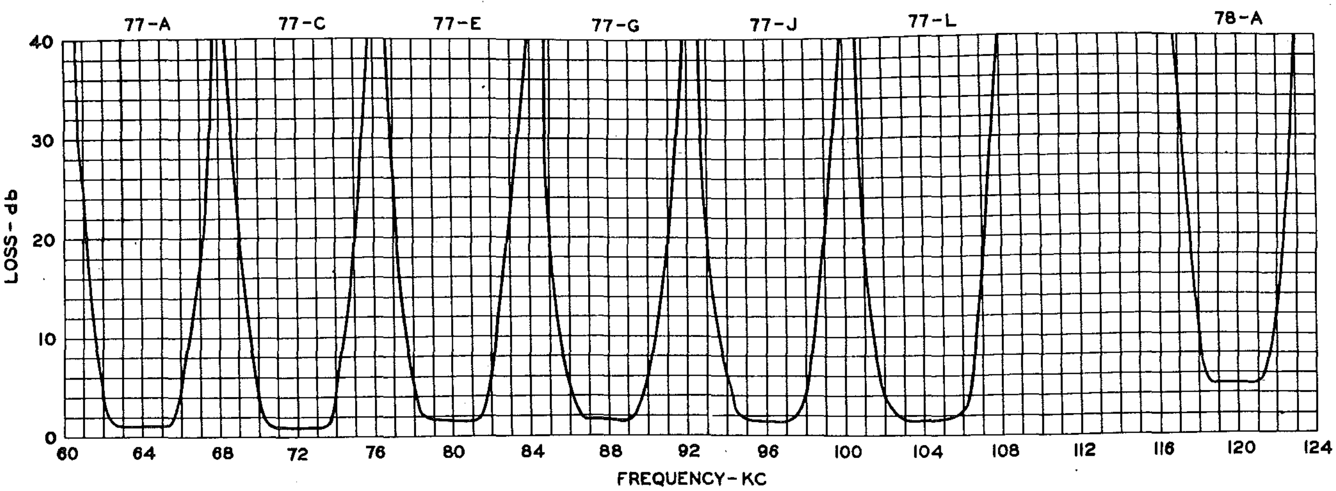


Fig. 11 - Carrier Supply Filters - Even Carrier Group - Loss-Frequency Characteristics.

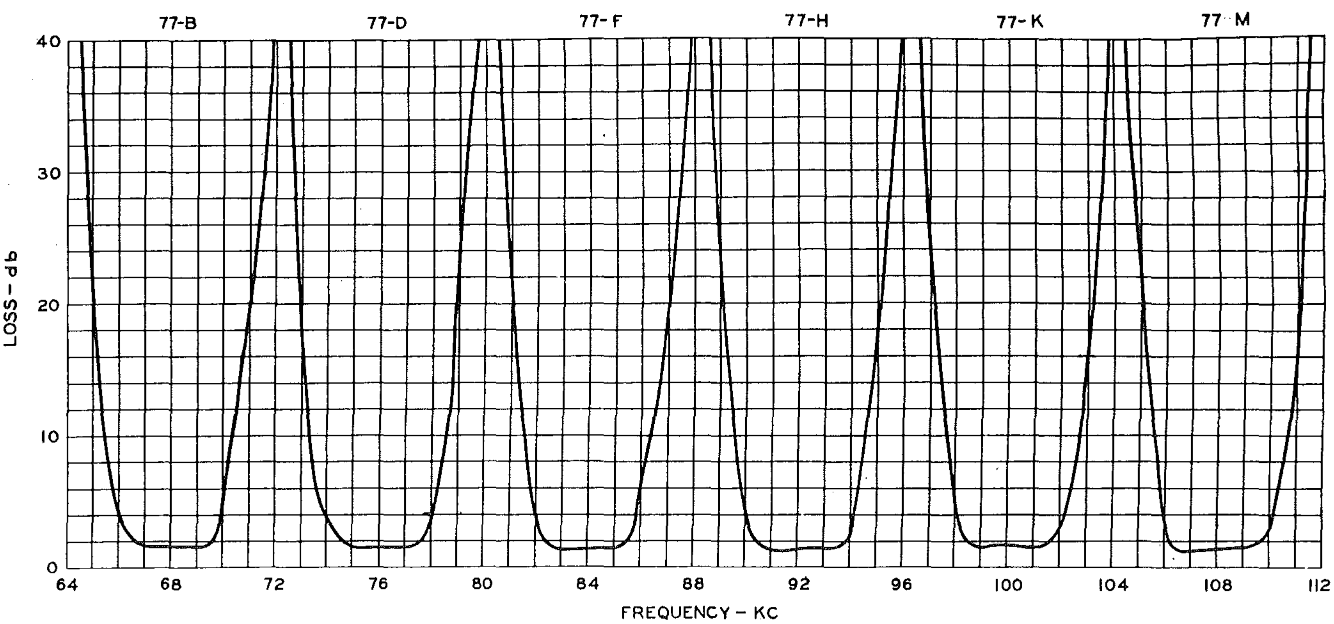


Fig. 12 - Carrier Supply Filters - Odd Carrier Group - Loss-Frequency Characteristics.

4.11 The requirements to be met in the design of the carrier supply filters in separating the carrier frequencies are materially reduced by the method employed of separating the odd and even harmonics.

(E) Generator Transfer Circuit

4.12 The generator transfer circuit is shown schematically in Fig. 9, and the panel is shown in Figs. 13A and 13B. The function of this circuit is to transfer the carrier frequency load (without interrupting service) from the regular to the emergency generator in case of trouble in the former. As shown in Fig. 9, both generators are connected to the distributing circuits, but the output of the emergency generator is normally blocked (at the vacuum tube designated "control") by a negative potential of

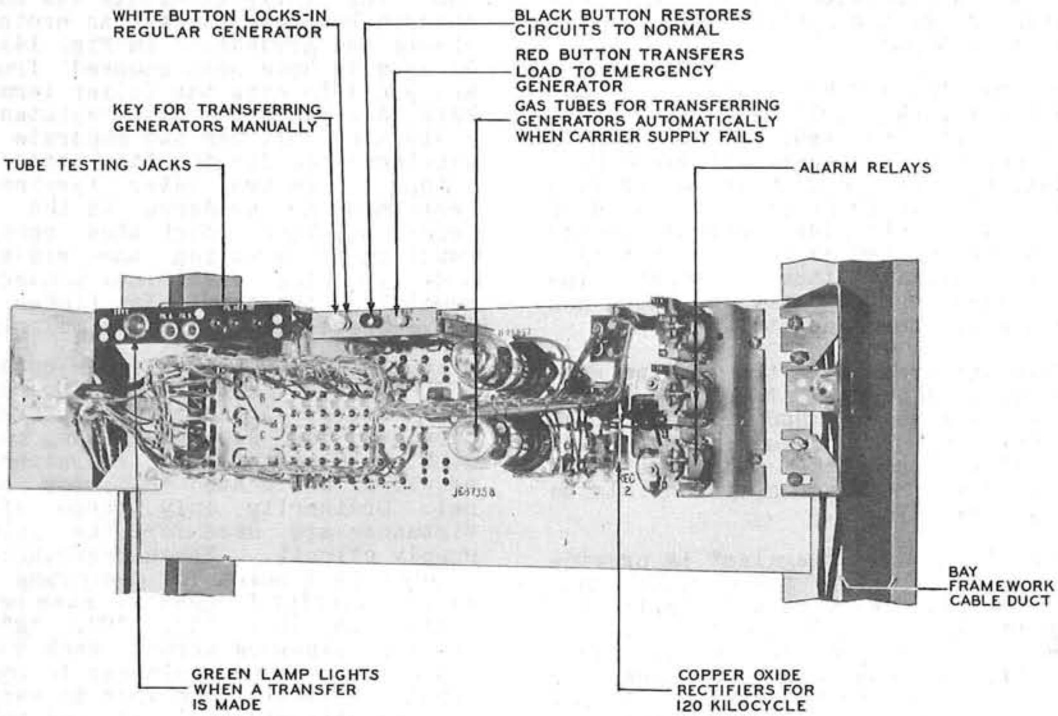


Fig. 13A - Generator Transfer Panel - Front View.

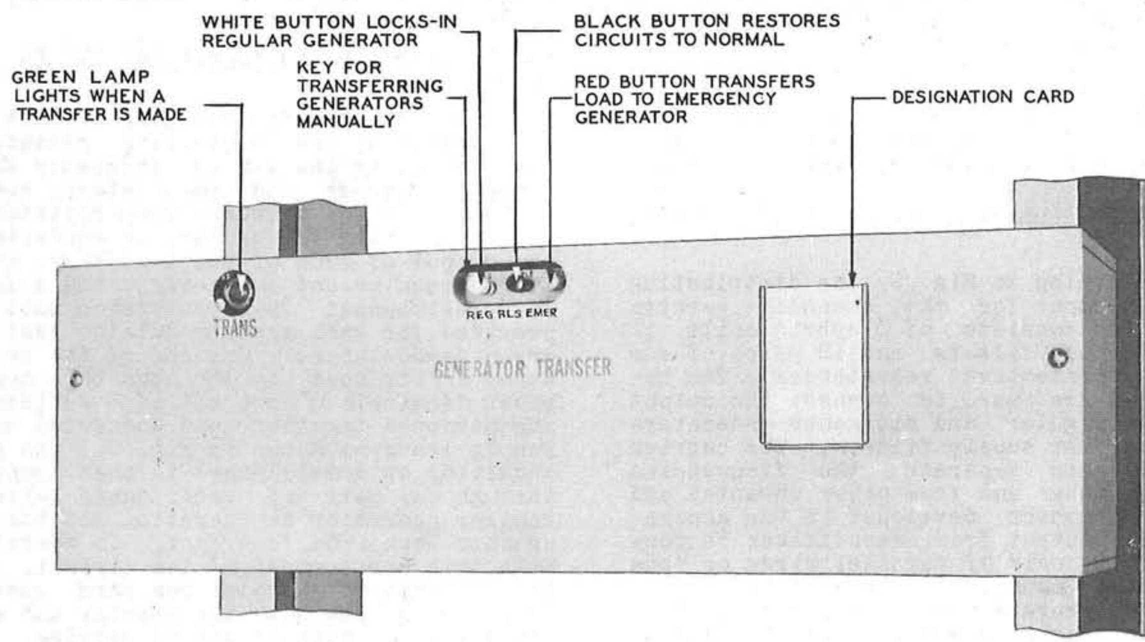


Fig. 13B - Generator Transfer Panel - Front View with Cover.

9 volts or more on the "EC" lead; a ground potential (0 volts) on the "RC" lead allows the regular generator to deliver its full output. The transfer circuit is arranged so that these potentials on the "RC" and "EC" leads are maintained as long as there is no plate current flowing in either of the two gas-filled tubes; and this in turn depends upon the proper functioning of the regulator generator, because part of the 120 kc. current from this generator is rectified by a copper-oxide varistor and used to maintain a high negative grid bias on the gas-filled tubes.

4.13. In case the 120 kc. fails, even momentarily, the grid bias on the gas-filled tubes will be reduced sufficiently to allow one or both tubes to break down and a plate current to flow in one or both of these tubes (two in parallel are used as a precaution). This plate current causes the potentials applied to the "RC" and "EC" leads to be reversed; thus allowing the emergency generator to carry the load and blocking the regular generator.

4.14 After the trouble in the regular generator is corrected, the normal condition must be restored manually, by momentarily operating the "Release" key. This opens the plate circuit of the gas tubes and thus restores the normal potentials to the "RC" and "EC" leads.

4.15 A key designated "regular" is provided for "locking-in" the regular generator to prevent a transfer while the emergency is being tested; and a key designated "emergency" is provided for transferring manually to the emergency generator when the regular is to be tested, as discussed in subheading (H). It is intended that only one key should be depressed at a time. The transfer circuit is also arranged to light a green lamp and bring in a minor office alarm whenever a transfer to the emergency generator has occurred automatically. When the transfer is made manually, the green lamp is lighted on the transfer panel. A cutout is provided in the cover of the transfer panel to permit access to the transfer keys (see Fig. 13B).

(F) Distributing Equipment for 12 Channel Frequencies

4.16 Referring to Fig. 9, the distributing equipment for the channel carrier frequencies consists of 2 hybrid coils, 12 carrier supply filters and 12 pairs of bus bars and protective resistances. The hybrid coils are used to connect the output from both regular and emergency generators to the carrier supply filters. The carrier supply filters separate the frequencies from each other and from other unwanted odd or even harmonics developed in the generator. The output from each filter is connected to a pair of parallel wires or "bus bars" which mounts the protective resistances. A separate pair of resistances (actually one resistance unit with 2 separate windings) is used to supply the required carrier frequency to each channel modulator-demodulator circuit. This prevents any trouble, such as a short on one circuit, from affecting the supply to other circuits using the same frequency.

4.17 The odd and even channel distributing units are identical except for the carrier supply filters. The unit for the 6 even harmonics is shown in Figs. 14A and 14B. The filter terminals and bus bars are covered by fibre guards to protect against shorts and grounds. In Fig. 14A these fibre guards have been removed from the 72 kc. panel to show the filter terminals, bus bars, and the protective resistances. Each resistance unit has two separate resistance windings; one for the "tip" and one for the "ring". The two outer terminals of this resistance are soldered to the "tip" and "ring" bus bars, which thus serve the dual function of mounting the resistance and providing the electrical connection. The remaining two terminals (inner terminals) are connected to a channel modem.

4.18 The output level of each frequency may be tested and adjusted at these resistances. In addition to the resistances provided for supplying the channel modems of 10 systems, a resistance is also provided, designated "PC", for each channel. Ordinarily only three of these resistances are used for the pilot channel supply circuit. These resistances provide a convenient point for measuring the output of each carrier frequency. Five resistances, designated "A", "B", "C", "D" and "E", are also provided across each bus bar. By strapping these resistances in various combinations, it is possible to vary the load on each pair of bus bars and thus compensate for the differences in level of the 12 frequencies as received from the generator, and also compensate for added load of more systems when installed.

(G) Distributing Equipment for 120 Kc. Frequency

4.19 The 120 kc. distributing circuit consists of the protective resistances for connecting the 120 kc. frequency to the group modulators and demodulators, and the 4 "bus bars" for mounting these resistances. A separate pair of bus bars is connected to the output of each of the two 120 kc. amplifiers (regular and emergency) and a set of four resistances (two resistance units) is provided for each group modulator and each group demodulator. One end of the resistances is strapped to the bus bars and the other terminals of each set of 4 resistances are strapped together and connected to the supply leads as shown in Fig. 9. The group modulator or demodulator is then supplied through one pair of resistances when the regular generator is operating, and the other pair when the emergency is operating. With this arrangement of the circuit, there is no "common" pair of bus bars where a short could put both the regular and emergency 120 kc. outputs out of service.

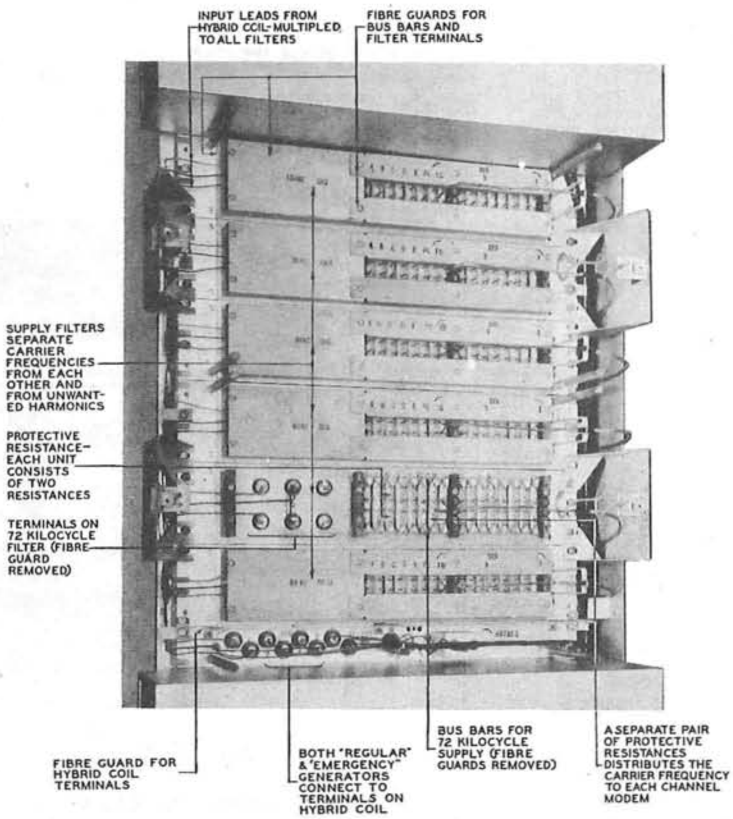


Fig. 14A - Channel Distributing Unit (Even Harmonics Only) - Front View.

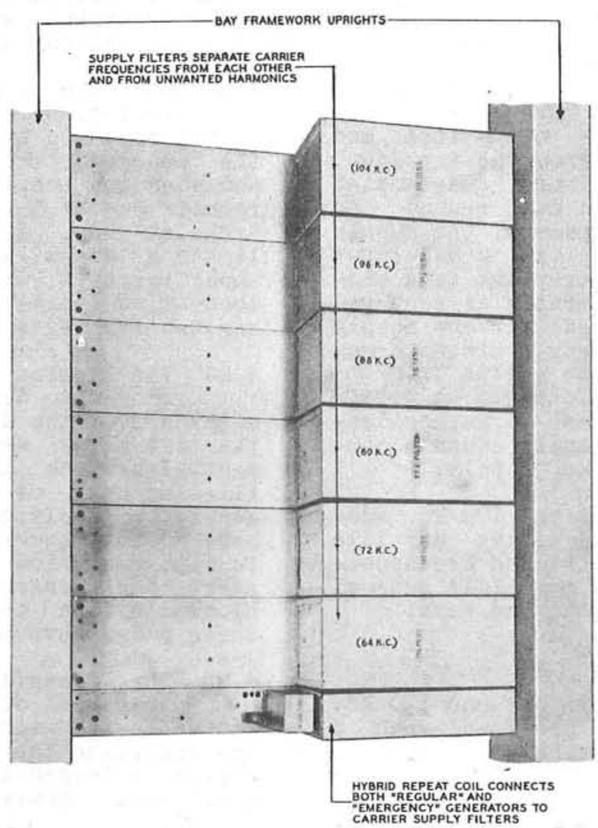


Fig. 14B - Channel Distributing Unit (Even Harmonics Only) - Rear View.

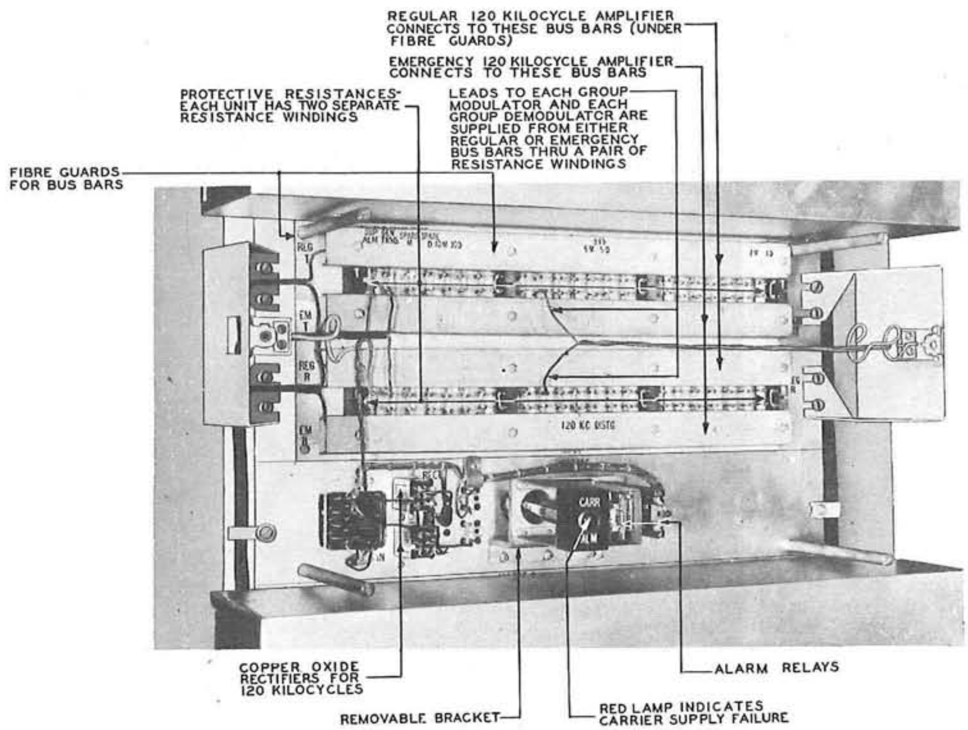


Fig. 15 - 120 Kc. Distributing and Alarm Unit - Front View.

4.20 The 120 kc. distributing panel is the top panel shown in Fig. 15. In this picture all 4 bus bars are covered by the fibre guards which protect them from shorts or grounds, but similar bus bars and resistances may be seen uncovered in Fig. 14A, for the channel distributing equipment. The "regular" bus bars (designated "REG. T" and "REG. R") are the first and third bus bars, counting from the top down, and the "Emergency" bus bars (designated "EM. T" and "EM. R") are the second and fourth. With this arrangement, the supply to a group modulator or group demodulator is obtained by merely strapping and connecting to the inner terminals of each resistance used, as indicated for one supply pair in Fig. 15. Since any resistance may be replaced by removing the guards from only two bus bars, it should never be necessary to expose four bus bars to an accidental short, which alone could cause a complete failure of the 120 kc. supply.

4.21 The output level of the 120 kc. supply may be measured across any idle set of four resistances. It can be adjusted by connecting one or more idle sets of resistances as a load on the bus bars.

(H) Testing Arrangements

4.22 Each carrier generator and 120 kc. amplifier unit is provided with 3 pairs of jacks for measuring the output of odd, even, and 120 kc. frequencies as shown in Fig. 10A (also see circuit, Fig. 9). Since duplicate units are furnished, it is possible to arrange the equipment and circuits so that these tests can be made without interfering with the carrier supply to the distributing circuits.

4.23 When the regular generator is to be tested, the load may be manually transferred to the emergency by operating the "emergency" key on the transfer panel; and when the emergency is to be tested, the regular may be "locked-in" by operating the "regular" key. Either of these operations lights a green lamp on the generator and amplifier unit which is not supplying the load as an indication that the cover may be removed for tests.

4.24 The 3 pairs of output jacks are arranged to disconnect their respective outputs from the distributing circuits when the test plugs are inserted. This is essential because these frequencies might at times be out of phase with those of the generator supplying the load. These jacks have an interlocking circuit (not indicated in Fig. 9) which will supply ground and start the generator working (although blocked by the transfer circuit) when all three plugs have been inserted.

4.25 The transfer panel is arranged so that most of the apparatus and wiring can be tested without affecting the generator supplying the load, if the regular generator is locked-in (by operating the "regular" key). However, if extensive tests are required on the transfer panel, a temporary strap can be made on a terminal strip on one of the carrier generators which takes it entirely out of the control of the transfer circuit.

(J) Carrier Supply Alarm

4.26 An alarm circuit is provided which brings in a major office alarm in case of a complete failure of the 120 kc. supply. This would occur only if both generators or 120 kc. amplifiers failed at the same time, or if one failed when it was locked-in as described in subheading (H). Part of the 120 kc. current is rectified by a varistor and used to hold a relay operated. A failure of the 120 kc. supply causes the relay to release, light a red lamp on the alarm panel, and bring in the alarm. This alarm is not brought in during a manual transfer from the regulator generator to the emergency.

4.27 This alarm panel is mounted below the 120 kc. distributing panel and under the same can cover. It can be tested or removed without disturbing the 120 kc. distributing bus bars as these are well protected.

(K) Pilot Channel Supply

4.28 In order to facilitate the maintenance of the system, three carrier pilot frequencies are transmitted simultaneously and continuously over the system. These pilot frequencies are used for observing the functioning of the system, usually at the receiving terminal and at main repeater stations. The pilots can be transmitted continuously without interference to the system because of their frequency location. The location of the pilot frequencies in the frequency spectrum is shown in Fig. 1. The pilot frequencies are bridged at the input of the group modulator, as discussed in Part 3 (A), and as shown on Drawing ES-852378, page 101. The three pilot frequencies are generated as indicated schematically in Fig. 16. The channel carrier frequencies of 108, 96 and 68 kc. are modulated in three copper-oxide units with the output of a 3900-cycle tuning fork oscillator circuit (similar to the 4 kc. oscillator circuit in the carrier generator). The lower side bands, i.e., frequencies of 104.1, 92.1, and 64.1 kc., are selected by three band filters. These three frequencies, when modulated in the group modulator by the group carrier frequency of 120 kc., produce pilot frequencies of 15.9, 27.9, and 55.9 kc. for transmission over the line. The level of pilot current employed is 20 db below a milliwatt at the zero level. A potentiometer having a range of adjustment of about 3 db is provided in each of the three pilot frequency circuits. Resistances having a range of adjustment of about 4.5 db are provided across the output of the pilot channel supply circuit (designated "Adjust Output" in Fig. 16), and may be bridged as required by strapping the inner terminals. The fre-

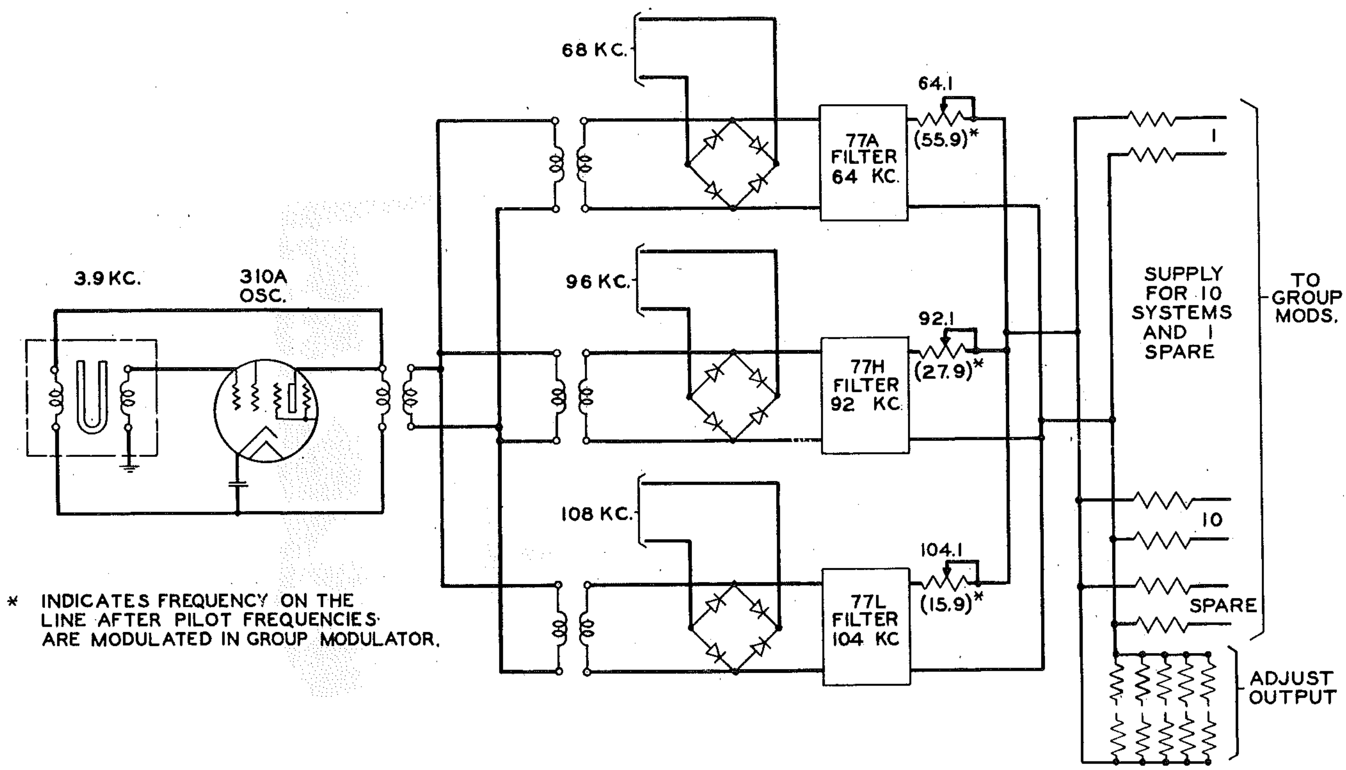


Fig. 16 - Pilot Channel Supply Circuit.

quency of the 3900-cycle oscillator is expected to vary less than ± 2 cycles, and the output is expected to remain stable within ± 1/4 db for the usual variations of battery voltages, and temperatures normally occurring in an office. The three filters used in the pilot channel supply circuit are the same as those used in the channel carrier supply, the loss-frequency characteristics of which are shown in Figs. 11 and 12.

4.29 The pilot channel supply panel is shown in Figs. 17A and 17B. Its capacity is adequate for supplying pilot frequencies for 10 systems.

4.30 Test equipment for measuring the pilot levels without affecting service may be provided at various stations, usually terminal and main repeater stations. A description of the pilot level measuring equipment is given in another Section.

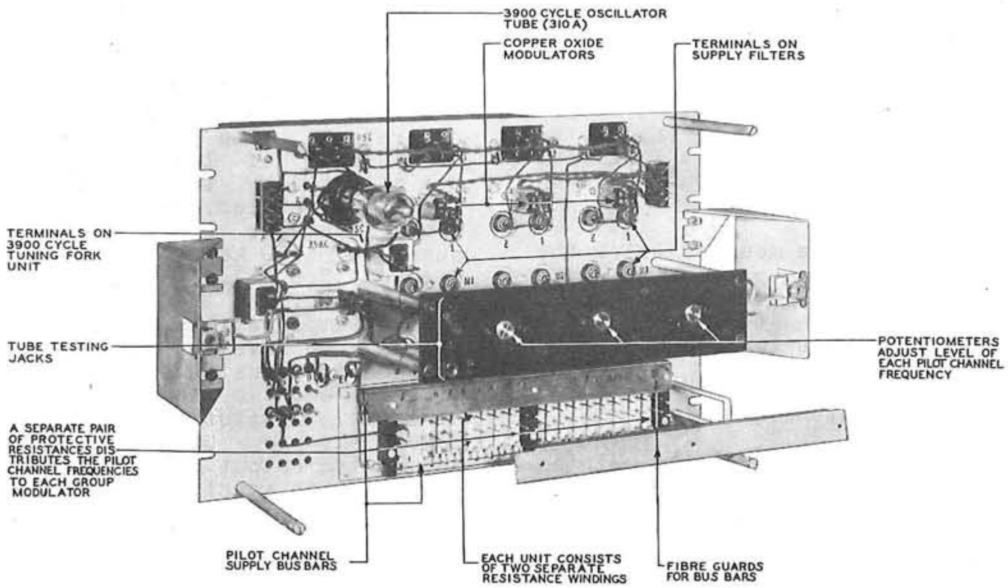


Fig. 17A - Pilot Channel Supply Panel - Front View.

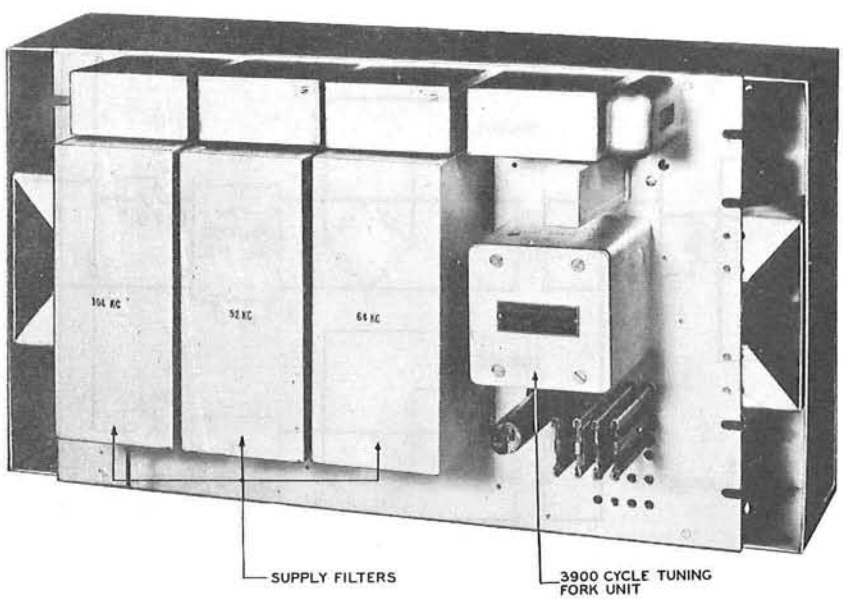


Fig. 17B - Pilot Channel Supply Panel - Rear View.

(L) Bay Arrangement

4.31 The arrangement of the carrier supply equipment on the bay is shown in Fig. 18. As mentioned in 4(A), this equipment has the capacity to supply the carrier frequencies for the channel and group modulators and demodulators for ten 12-channel terminals. The supply leads for the modulators and demodulators for 120 talking circuits are connected to the distributing equipment which is located in the upper part of this bay. Below this equipment are the "regular" and "emergency" carrier generator and 120 kc. amplifier units, with the generator transfer panel located between these two units. The pilot channel supply panel is located below this equipment near the bottom of the bay.

4.32 The supply leads from the distributing equipment and the pilot channel supply panel to the modulators and demodulators are run in 1475 or 1476 shielded pairs in the right-hand cable duct because these carrier frequencies are at a relatively high level. The 24 and 130-volt battery leads are run in the left-hand cable duct. The fuses for this carrier supply equipment are mounted on fuse panels in nearby channel modem bays as discussed in other Sections.

4.33 The carrier supply bay is mounted in the same bay lineup with the channel modem bays or in a row adjacent to them. This makes the supply leads to the channel modem units relatively short. The carrier and pilot channel supply leads to the group modem bays will be longer but a slight increase in length is permissible in this part of the circuit.

5. EQUIPMENT CONSIDERATIONS

5.01 The single sided wiring and maintenance method of mounting the equipment covered herein is described in the Section covering the line and twist amplifiers.

5.02 The cabling arrangements, including the method of separating the high and low transmission level leads, the method of cabling and tying the cables, etc., has been described in the Section covering the line and twist amplifiers.

6. BATTERY SUPPLY CIRCUITS

The regular central office 24-volt and 130-volt batteries are required for operation of the vacuum tubes required in this equipment.

The battery supply circuit of the auxiliary amplifier is shown in Fig. 19.

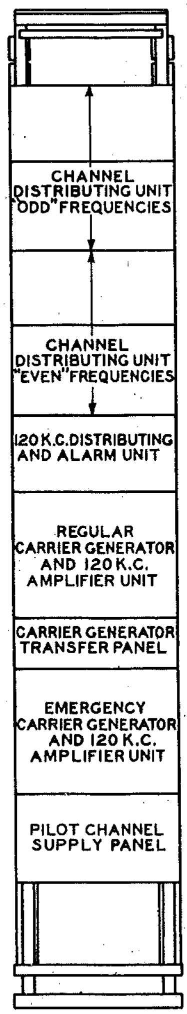


Fig. 18 - Carrier Supply - Bay Layout.

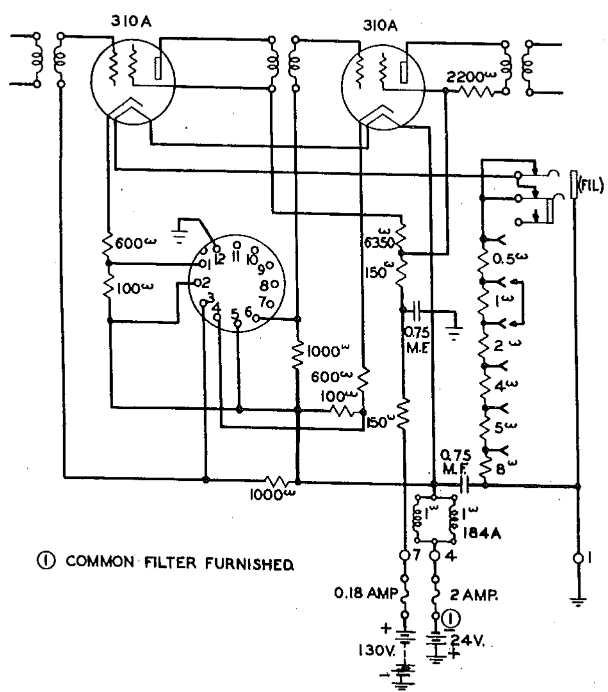


Fig. 19 - Battery Supply Circuit - Auxiliary Amplifier.

The battery supply circuit of the carrier generator is shown in Fig. 20.

The battery supply circuit of the 120 kc. amplifier is shown in Fig. 21.

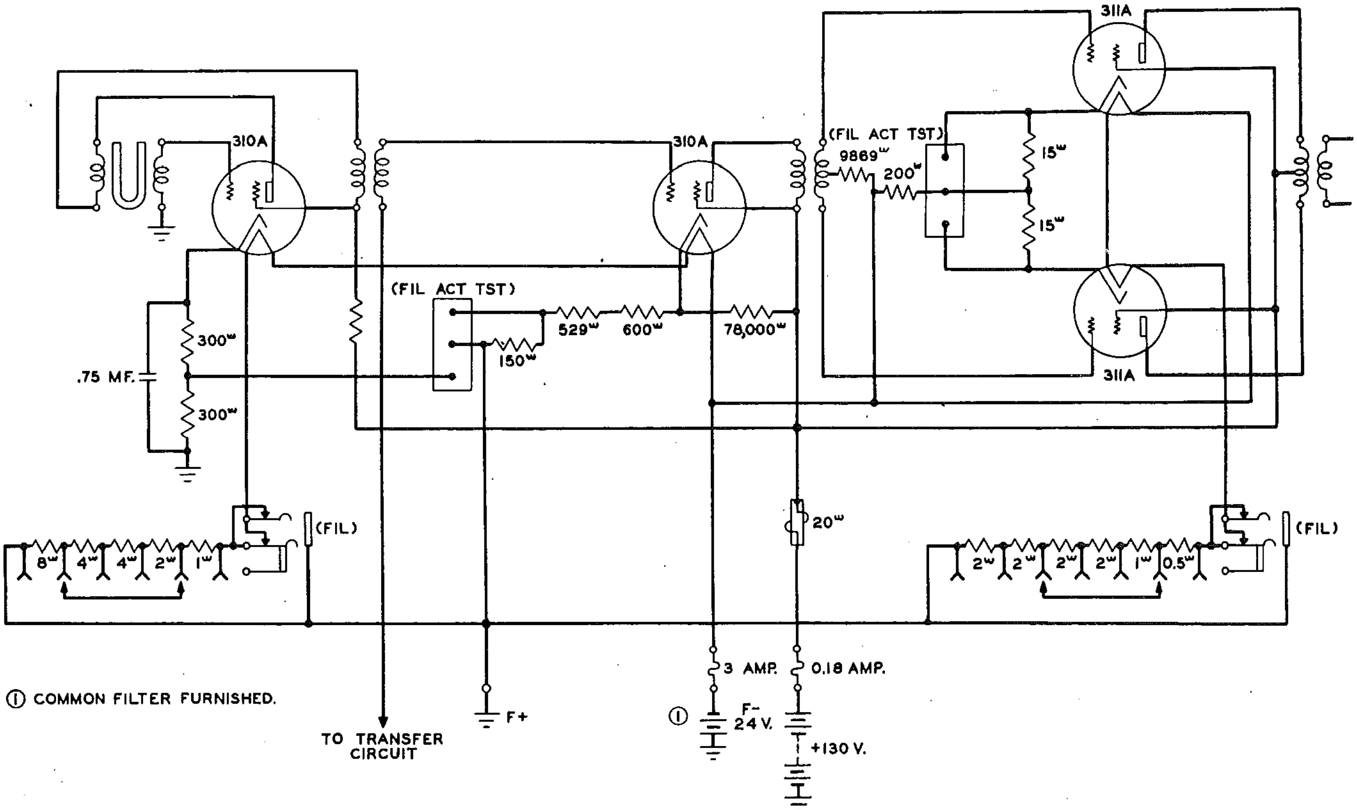


Fig. 20 - Battery Supply Circuit - Carrier Generator.

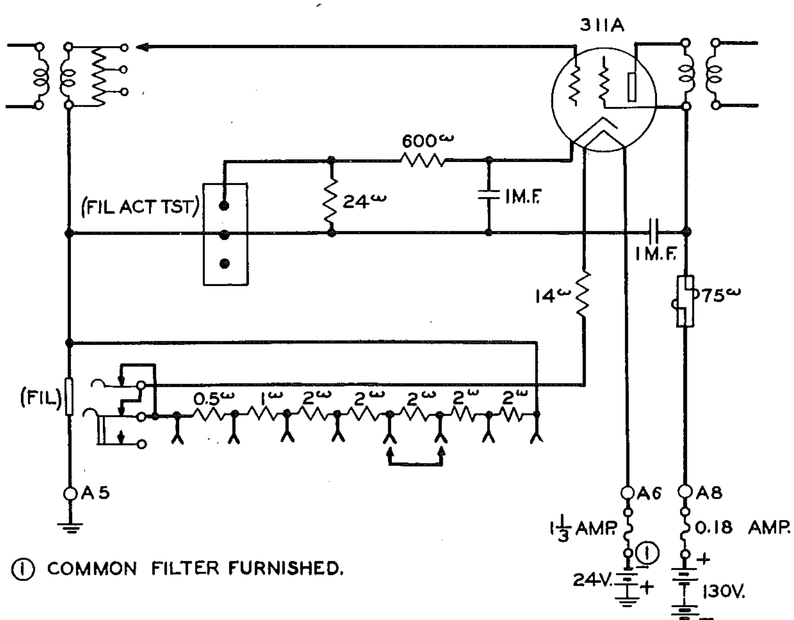


Fig. 21 - Battery Supply Circuit - 120 Kc. Amplifier.

The battery supply circuit of the carrier generator transfer circuit is shown in Fig. 22.

The battery supply circuit of the pilot channel circuit is shown in Fig. 23.

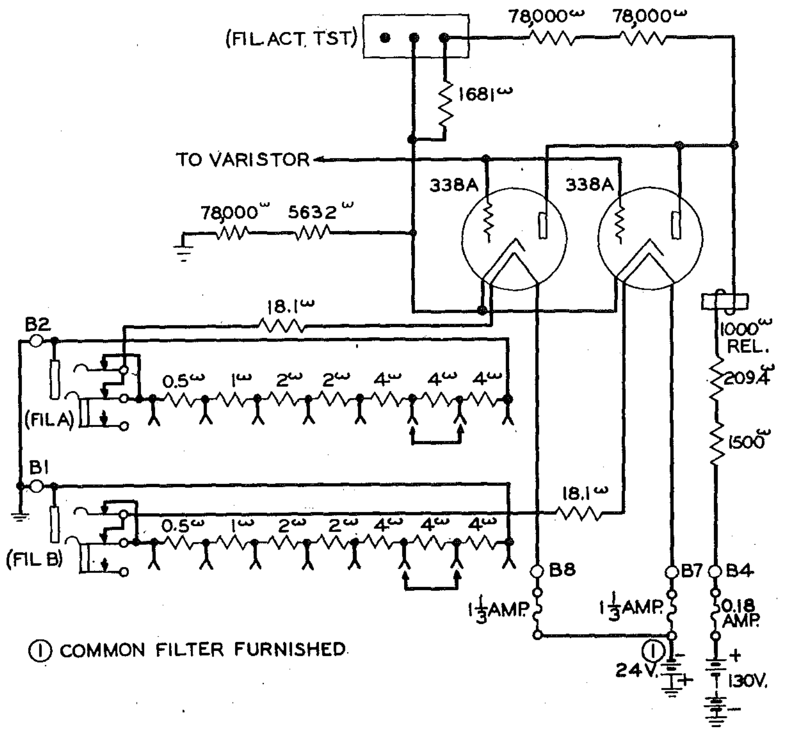


Fig. 22 - Battery Supply Circuit - Carrier Generator Transfer Circuit.

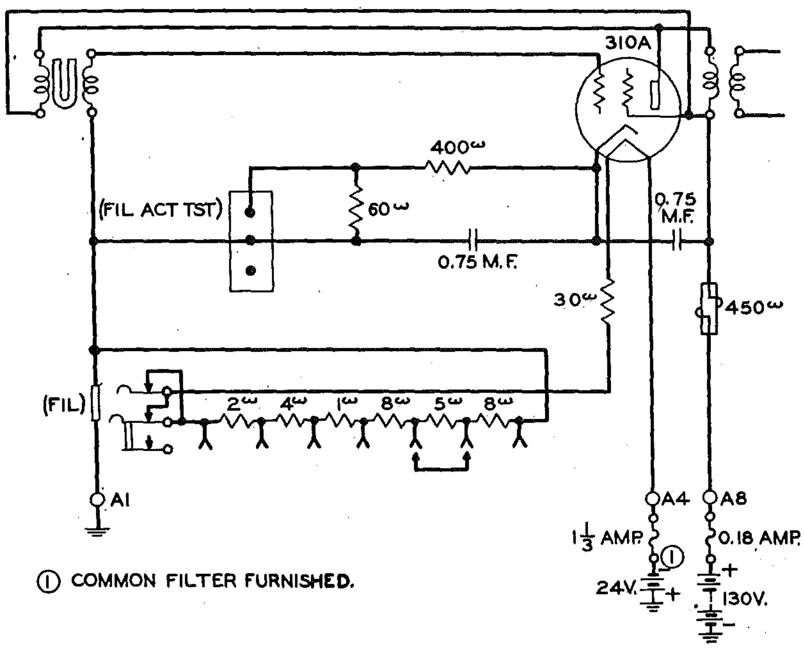


Fig. 23 - Battery Supply Circuit - Pilot Channel Supply.

Grid batteries are required to supply grid potential to the 311A vacuum tube in the transmitting amplifier. The arrangements provided are described in detail in the Section describing the line and twist amplifiers.

7. DRAWINGS

SD Drawings (Not Attached)

SD-64309-01	Carrier Supply Alarm Circuit
SD-64313-01	Application Schematic - Terminal Group Circuits
SD-64314-011 012	Group Modulator Circuit
SD-64315-011 012	Group Demodulator Circuit
SD-64316-01	Application Schematic - Carrier Supply
SD-64317-01	Carrier Generator Circuit
SD-64318-01	Carrier Generator Transfer Circuit
SD-64319-01	120 Kc. Amplifier Circuit - For Group Carrier Supply
SD-64320-011 012	Auxiliary Amplifier Circuit
SD-64321-01	Pilot Channel Supply Circuit
SD-64329-021 022	Transmitting, Auxiliary Switching, and Test Amplifier
SD-64330-01	Battery Supply Circuits - For Line, Twist and Transmitting Amplifiers

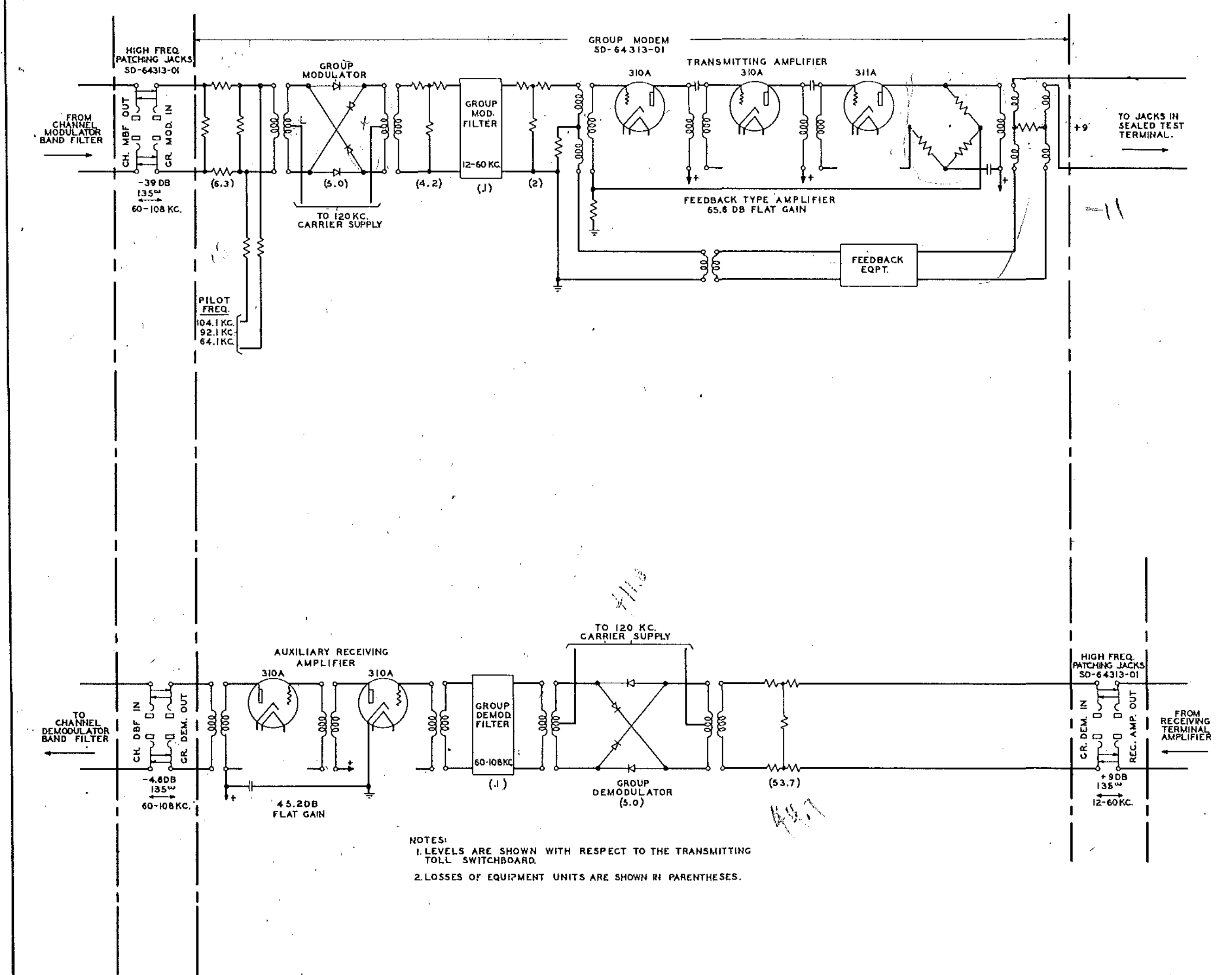
ED Drawings (Not Attached)

ED-64313-01	Group Modem Unit - Assembly and Equipment Transmitting and Auxiliary Receiving Amplifiers, Group Modulator Demodulator and Group Filters
ED-64313-02	Group Modem Bay Equipment
ED-64316-01	Carrier Supply Bay
ED-64316-02	Carrier Supply Bay - Cabling
ED-64316-03	Carrier Supply Equipment - 64-108 Kc. Distributing Equipment and Wiring
ED-64313-04	Carrier Supply Equipment - 120 Kc. Distributing and Alarm Unit - Equipment and Wiring
ED-64317-01	Carrier Supply Equipment - Carrier Generator Unit - Equipment and Assembly
ED-64317-02	Carrier Supply Equipment - Carrier Generator Unit - Wiring Plan
ED-64318-01	Carrier Supply Equipment - Carrier Generator Transfer Panel - Equipment and Assembly
ED-64319-01	Carrier Supply Equipment - 120 Kc. Amplifier and Filter - Equipment and Assembly
ED-64319-02	Carrier Supply Equipment - 120 Kc. Amplifier and Filter Panel - Wiring Plan
ED-64320-01	Group Terminal Equipment - 60-108 Kc. Auxiliary Receiving Amplifier, Demodulator, Transmitting and Receiving Filters - Equipment and Assembly
ED-64320-02	Group Terminal Equipment - 60-108 Kc. Auxiliary Receiving Amplifier - Output Bridge Equipment
ED-64321-01	Pilot Channel Supply Panel - Equipment and Assembly
ED-64329-02	Group Terminal Equipment - Transmitting Amplifier and Modulator Panel - Test or Auxiliary Switching Amplifier Panel - Equipment and Assembly
ED-64329-03	Transmitting, Twist, Test, or Auxiliary Switching Amplifier - Local Cable Layout

BELL TELEPHONE LABORATORIES, INC.

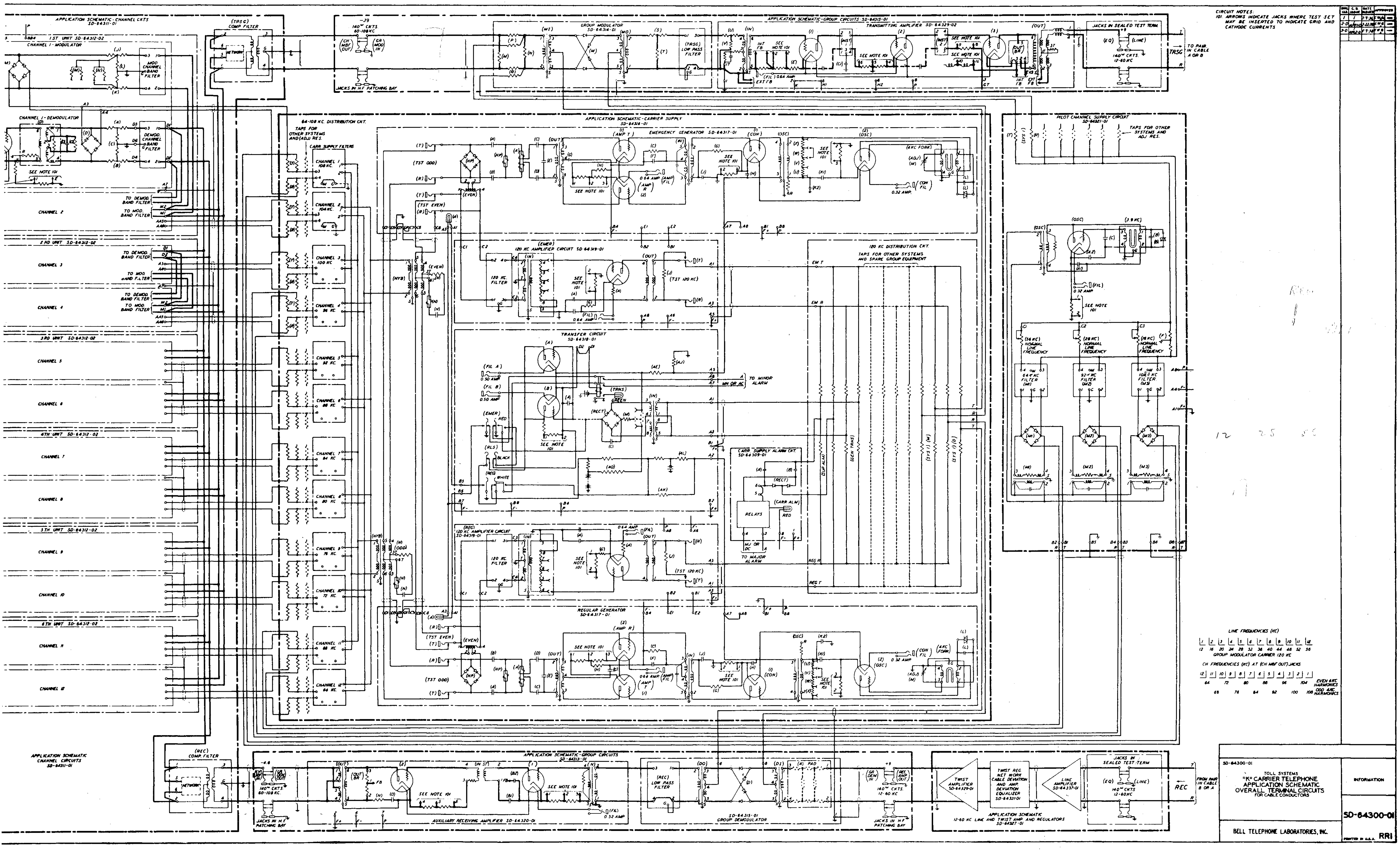
ES-852378
E.C.T. 2-3-38
O.H.L. 4-18-38
O.H.L. 5-5-38

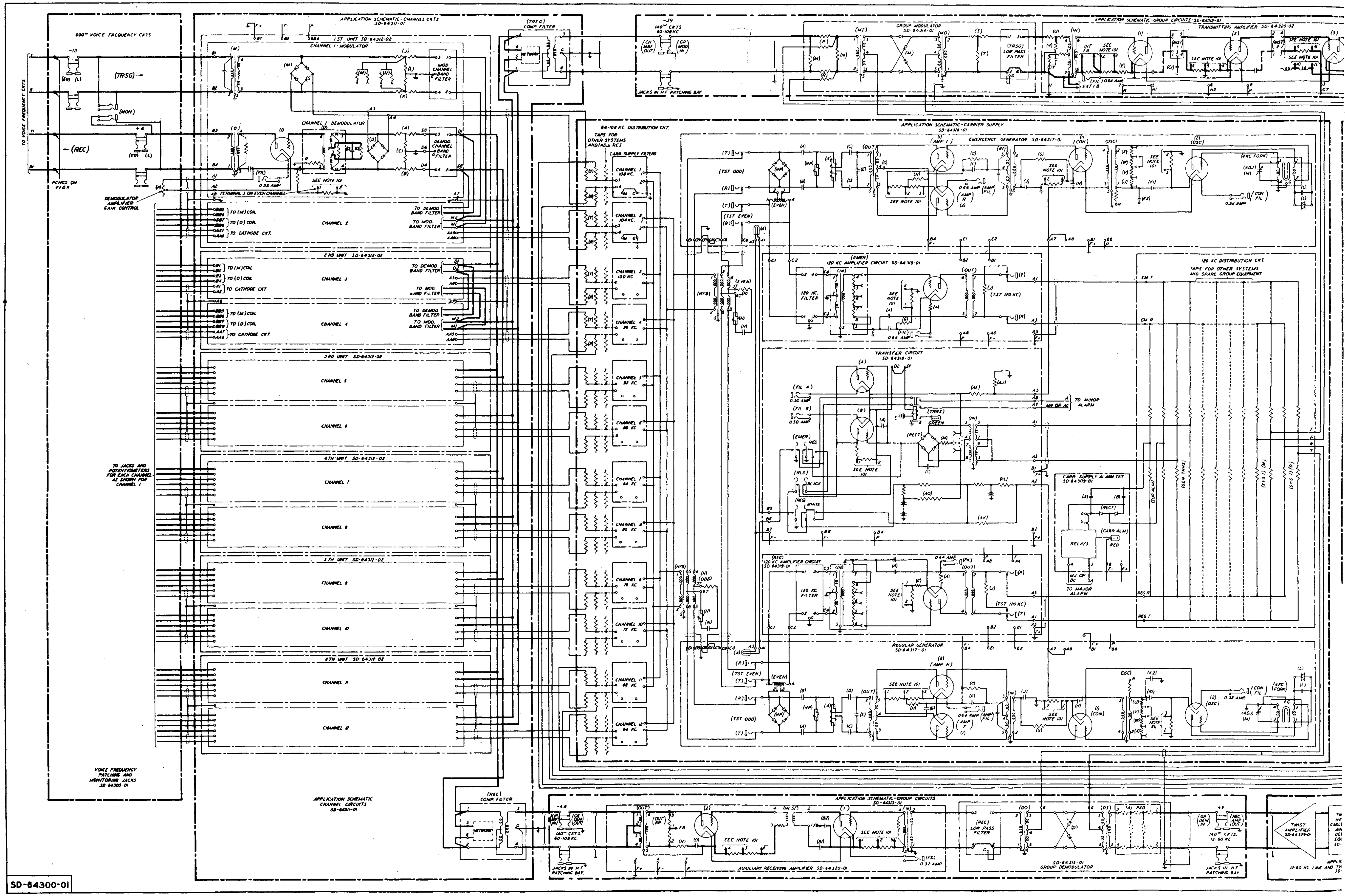
TYPE "K" CARRIER TELEPHONE SYSTEM
GROUP SCHEMATIC



NOTES:
1. LEVELS ARE SHOWN WITH RESPECT TO THE TRANSMITTING TOLL SWITCHBOARD.
2. LOSSES OF EQUIPMENT UNITS ARE SHOWN IN PARENTHESES.

PRINTED IN U.S.A.


CIRCUIT NOTES:
101 ARROWS INDICATE JACKS WHERE TEST SET MAY BE INSERTED TO INDICATE GRID AND CATHODE CURRENTS
APPLICATION SCHEMATIC-CHANNEL CKTS SD-64311-01
APPLICATION SCHEMATIC-GROUP CIRCUITS SD-64313-01
TRANSMITTING AMPLIFIER SD-64329-02
GROUP MODULATOR SD-64314-01
APPLICATION SCHEMATIC-CARRIER SUPPLY SD-64316-01
EMERGENCY GENERATOR SD-64317-01
PILOT CHANNEL SUPPLY CIRCUIT SD-64321-01
64-108 KC. DISTRIBUTION CKT.
120 KC AMPLIFIER CIRCUIT SD-64319-01
TRANSFER CIRCUIT SD-64318-01
120 KC DISTRIBUTION CKT.
CARR. SUPPLY ALARM CKT. SD-64309-01
REGULAR GENERATOR SD-64317-01
APPLICATION SCHEMATIC CHANNEL CIRCUITS SD-64311-01
AUXILIARY RECEIVING AMPLIFIER SD-64320-01
SD-64315-01 GROUP DEMODULATOR
APPLICATION SCHEMATIC 12-60 KC LINE AND TWIST AMP. AND REGULATORS SD-64327-01
JACKS IN SEALED TEST TERM.
LINE FREQUENCIES (KC)
GROUP MODULATOR CARRIER 120 KC
CH FREQUENCIES (KC) AT (CH MBF OUT) JACKS
SD-64300-01
TOLL SYSTEMS
"K" CARRIER TELEPHONE
APPLICATION SCHEMATIC
OVERALL TERMINAL CIRCUITS
FOR CABLE CONDUCTORS
INFORMATION
SD-64300-01
BELL TELEPHONE LABORATORIES, INC.
RR1


600Ω VOICE FREQUENCY CKTS
TO VOICE FREQUENCY CKTS.
APPLICATION SCHEMATIC-CHANNEL CKTS SD-64311-01
1ST UNIT SD-64312-02
CHANNEL 1 - MODULATOR
CHANNEL 1 - DEMODULATOR
MOD. CHANNEL BAND FILTER
DEMOD. CHANNEL BAND FILTER
DEMODULATOR AMPLIFIER GAIN CONTROL
2ND UNIT SD-64312-02
3RD UNIT SD-64312-02
4TH UNIT SD-64312-02
5TH UNIT SD-64312-02
6TH UNIT SD-64312-02
CHANNEL 2
CHANNEL 3
CHANNEL 4
CHANNEL 5
CHANNEL 6
CHANNEL 7
CHANNEL 8
CHANNEL 9
CHANNEL 10
CHANNEL 11
CHANNEL 12
TO JACKS AND POTENTIOMETERS FOR EACH CHANNEL AS SHOWN FOR CHANNEL 1
VOICE FREQUENCY PATCHING AND MONITORING JACKS SD-64303-01
APPLICATION SCHEMATIC CHANNEL CIRCUITS SD-64311-01
(TRSG) COMP. FILTER
(REC) COMP. FILTER
64-108 KC. DISTRIBUTION CKT.
CARR SUPPLY FILTERS
JACKS IN H F PATCHING BAY
GROUP MODULATOR SD-64314-01
(TRSG) LOW PASS FILTER
APPLICATION SCHEMATIC-GROUP CIRCUITS SD-64313-01
TRANSMITTING AMPLIFIER SD-64329-02
APPLICATION SCHEMATIC-CARRIER SUPPLY SD-64316-01
EMERGENCY GENERATOR SD-64317-01
120 KC AMPLIFIER CIRCUIT SD-64319-01
120 KC DISTRIBUTION CKT.
TAPS FOR OTHER SYSTEMS AND SPARE GROUP EQUIPMENT
TRANSFER CIRCUIT SD-64318-01
TO MINOR ALARM
CARR SUPPLY ALARM CKT SD-64309-01
RELAYS
TO MAJOR ALARM
REGULAR GENERATOR SD-64317-01
SEE NOTE 101
AUXILIARY RECEIVING AMPLIFIER SD-64320-01
(REC) LOW PASS FILTER
SD-64315-01 GROUP DEMODULATOR
TWIST AMPLIFIER SD-64329-01
12-60 KC LINE AND TR

SD-64300-01