BROAD BAND CARRIER TELEPHONE SYSTEMS

A1 AND A2 12-CHANNEL BANK

WITH VOICE FREQUENCY TERMINATING ARRANGEMENTS

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1. GENERAL

1.01 This section describes the A1 and A2 12-channel banks and their associated voice frequency terminating arrangements. The 12-channel bank, formerly referred to as the 12-channel terminal or 12-channel MODEM unit, provides the first step of modulation (and final step of demodulation) for existing broad band carrier telephone systems, types J, K, and L.

1.02 Overall circuit diagrams of the A1 and A2 banks, each showing a representative channel and 4-wire terminating equipment, are shown in Figs. 11 and 12. In each channel, the 2-wire voice frequency circuit is connected through a hybrid coil to separate transmitting and receiving circuits. In the transmitting circuits, the 12 voice frequency bands are modulated with 12 carriers ranging from 64 to 108 kilocycles, at 4 kc intervals. Crystal-type band filters select the lower sidebands from the outputs of the modulators, which are of the suppressed carrier type. The 12 sidebands are combined in a single broad band from 60 to 108 kc, and from this point are treated as a unit in subsequent steps of modulation, transmission over a line, and demodulation, up to the point where they enter the receiving circuits of the far-end 12-channel bank. Here they are separated by crystal-type receiving band filters and demodulated individually with locally supplied carriers. Other sections describe the carrier supply and the intermediate steps of modulation and transmission over the line, which distinguish the three types of broad band systems.

1.03 The more recently developed A2 bank supersedes the A1 bank and performs the same general functions. The same standards of band width, output limitation, noise, and intra-channel modulation are maintained, and the same degree of adjustability is provided in the transmitting and receiving circuits. The A2 bank, however, provides additional adjustments by which the (MOD IN) level may be reduced from -13 to -16 db without impairment of transmission quality, and the (DEM OUT) level may be increased from +4 to +7 db with slight impairment. The band filters in the A2 bank are of a more compact design than in the A1 bank and the total floor space is about 1/3 less. Two A2 banks can be mounted in one standard 11'6" bay as against 1-1/2 A1 banks.

2. VOICE FREQUENCY TERMINATION

2.01 Voice frequency terminating arrangements can be used interchangeably with the A1 or A2 channel banks.

2.02 Each voice frequency channel may be terminated either 4-wire or 2-wire for connection to any other type of existing telephone facility.

2.03 A rheostat associated with the demodulator amplifier provides a range of adjustment in gain of approximately 10 db in the demodulator circuit. This rheostat provides means of compensating for slight differences in the channel bank or group circuit loss and in the received high frequency level of the various channels, so that the voice frequency receiving levels of all channels may be adjusted to the same value.

(A) 2-Wire Termination of Carrier Channels

2.04 In order to derive a 2-wire circuit from a carrier channel, a 4-wire terminating set is required. A schematic of a carrier channel terminated 2-wire is shown in the lower portion of Fig. 1. As will be noted, this terminating set includes two condensers of 2.16 mf., a hybrid coil, a 3 db impedance improving pad and a repeating coil in the transmitting leg, plug type pads to adjust both the transmitting and the receiving levels, and a balancing network.

2.05 The 2.16 mf. condenser on the switchboard side of the hybrid coil is needed to prevent any d-c supervisory currents that may be present on the 2-wire line from flowing into the terminating set and also to make the impedance at the 2-wire side of the terminating set match that of other 2-wire circuits to which it may be connected. The 2.16 mf. condenser on the network side of the hybrid coil is needed to balance the one on the line side.

2.06 The theory of the hybrid coil is covered elsewhere. Briefly, when a signal is delivered by the 2-wire line to the hybrid coil, the energy is evenly divided with only half being delivered to the modulator circuit where it is transmitted along its regular path through the circuit. The other half (transmitted to the receiving branch) is blocked

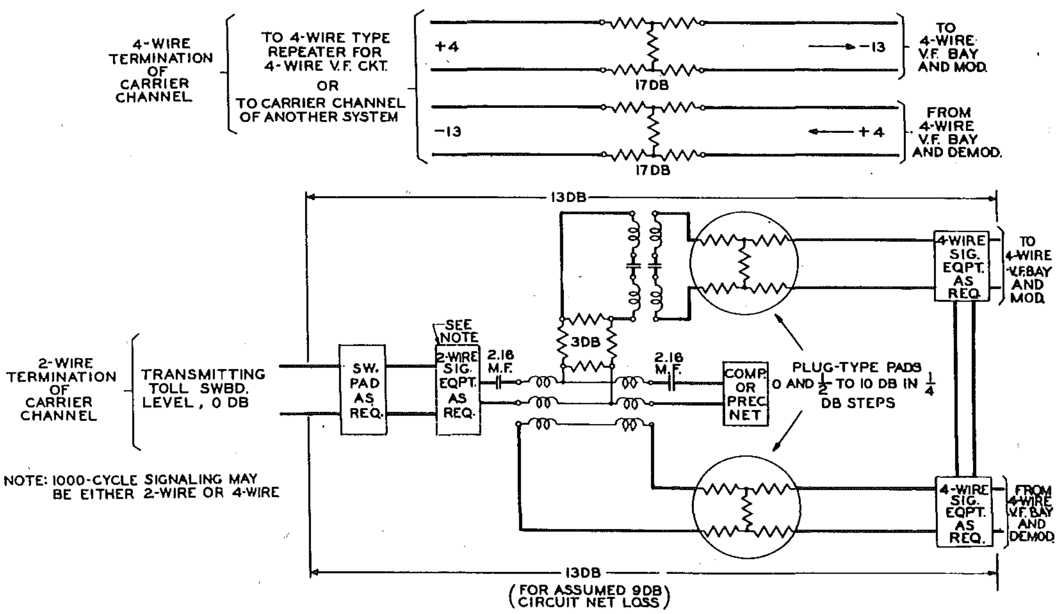


Fig. 1 - Voice Terminating Circuit

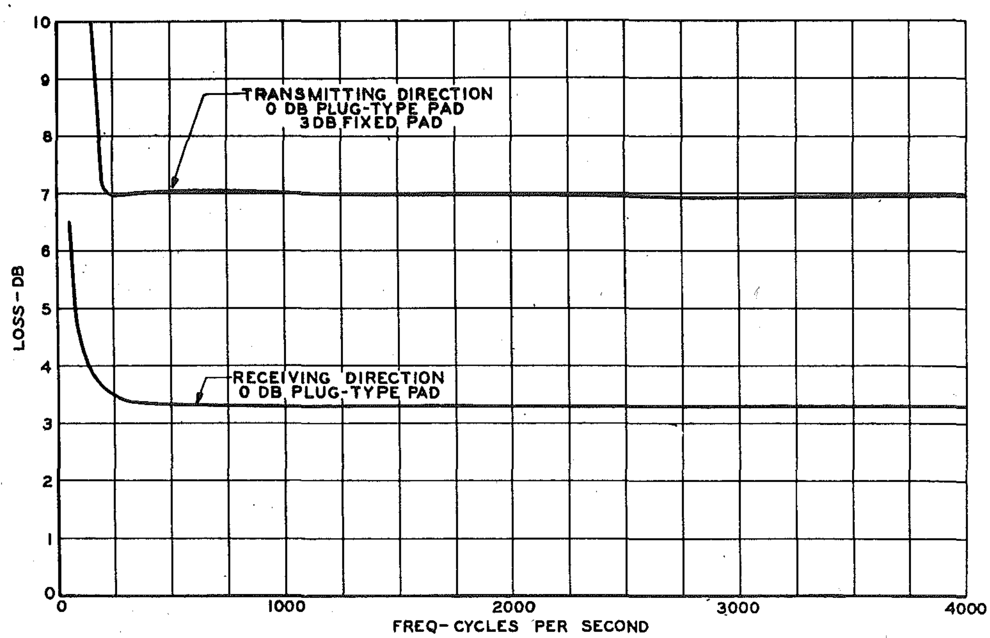


Fig. 2 - 4-Wire Terminating Set - Typical Transmission Frequency Characteristics Up to 4000 Cycles

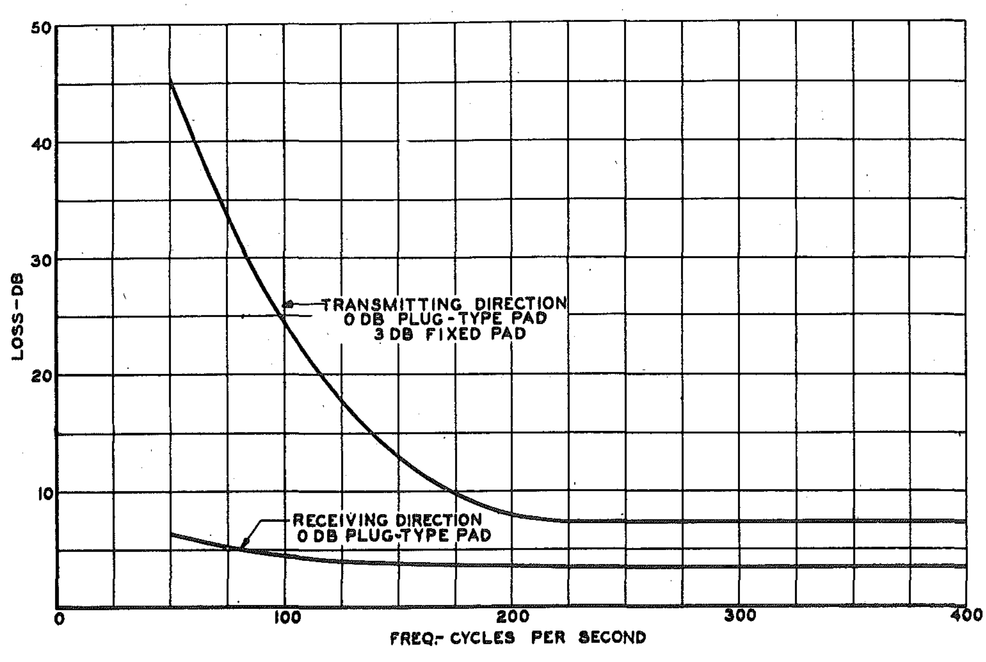


Fig. 3 - 4-Wire Terminating Set - Typical Transmission Frequency Characteristics Up to 400 Cycles

from further transmission at the output of the demodulator amplifier. When the receiving branch of the circuit delivers energy to the hybrid coil, this energy is evenly divided between the 2-wire line and the balancing network.

2.07 If the balancing network achieved a perfect balance, no energy at all would be fed across the hybrid coil from the receiving to the transmitting side. Actually, a compromise network provides adequate balance in most cases. A precision network can be used when needed.

2.08 A 3 db pad is used in the transmitting branch of the 4-wire terminating set in all cases where it does not produce too low a level at the modulator input. This pad helps maintain the correct impedance in this part of the circuit. If this pad is omitted to permit a longer extension of the circuit over 2-wire facilities without the use of voice frequency repeaters, the 2.16 mf. condensers are increased to 3.24 mf. to maintain the desired impedance.

2.09 The repeating coil in the transmitting branch of the circuit together with the two condensers across the midpoints of the windings forms a high pass filter to suppress signaling and switchhook interference. See Fig. 3 for the discrimination of this filter below 200 cycles.

2.10 The plug type pads are used as a convenience to facilitate setting up the correct levels. They are available with loss values of zero and 1/2 to 10 db in 1/4 db steps.

2.11 The signaling equipment and switching pad indicated on Fig. 1 are not a part of the terminating set and must be cross-connected as required. A 32C or 128C filter may be cross-connected in the transmitting path if required as shown on Fig. 11 for the A1 bank and on Fig. 12 for the A2 bank.

2.12 Representative transmission frequency characteristics of the 4-wire terminating set for both transmitting and receiving directions with zero db plug-type pads and with the 3 db impedance-improving pad in the circuit are shown in Fig. 2 for frequencies up to 4000 cycles. Similar transmission frequency characteristics up to 400 cycles are shown in Fig. 3.

2.13 The terminating set has a nominal impedance of 600 ohms as viewed from either the 2-wire or 4-wire sides. Fig. 4A shows the typical return loss curves measured against a compromise network of 600 ohms and 2.1 mf. from the 2-wire side of the terminating set for frequencies between 150 and 3600 cycles. These measurements were made with 600 ohms and 2.1 mf. in the balancing network and with the transmitting and receiving paths connected to either 600 ohm resistance termination or to the modulator and demodulator of the A1 or A2 channel bank. Figs. 4B and 4C repeat the same data with a 128C or a 32C filter added in the transmitting leg. Essentially these curves indicate that the return loss is affected more by the low pass filter than by the carrier channels.

(B) 4-Wire Connection of Carrier Channels

2.14 Fig. 1 shows schematically a carrier channel terminated on a 4-wire basis for connection to other 4-wire facilities such as a type K channel, a type J channel, a type L channel, a 4-wire voice frequency cable circuit or a type C carrier telephone channel arranged for 4-wire operation. For such connections fixed 600 ohm resistance pads of 17 db are provided in the transmitting and receiving circuits. These pads reduce the +4 level at the output of one circuit to -13 for the input of the succeeding circuit. Appropriate pads are provided if the output and input levels are different from +4 and -13.

(C) Mounting and Cabling of 4-Wire Terminating Sets

2.15 The 4-wire voice frequency terminating sets for two channels are mounted on a single equipment unit as shown in Figs. 5 and 6. The apparatus for the odd numbered channel is on the left-hand side of the unit and similar apparatus for the even numbered channel is on the right-hand side. This unit uses no local cable or terminal strips because all outside cabling connects directly to the apparatus terminals and the wiring on the unit is run directly between terminals.

2.16 Each unit occupies a space of three 1-3/4" mounting plates. 22 units (or a total of 44 channels) can be mounted in one 11'6" bay. This capacity will be reduced, however, by whatever space is required for cabinets for storing the spare "plug-in" type pads.

2.17 The 4-wire terminating set is arranged to connect to the 4-wire voice frequency test jacks (associated with each carrier channel) by means of cross-connections at the I.D.F. The bays mounting these sets are preferably located near this distributing frame. A compromise network is mounted on the panel with the terminating set and is used under the following conditions:

(a) when the channel terminates in the switchboard

(b) when the channel is connected to a 2-wire repeater, or

(c) when the channel is connected to another carrier channel on a 2-wire basis.

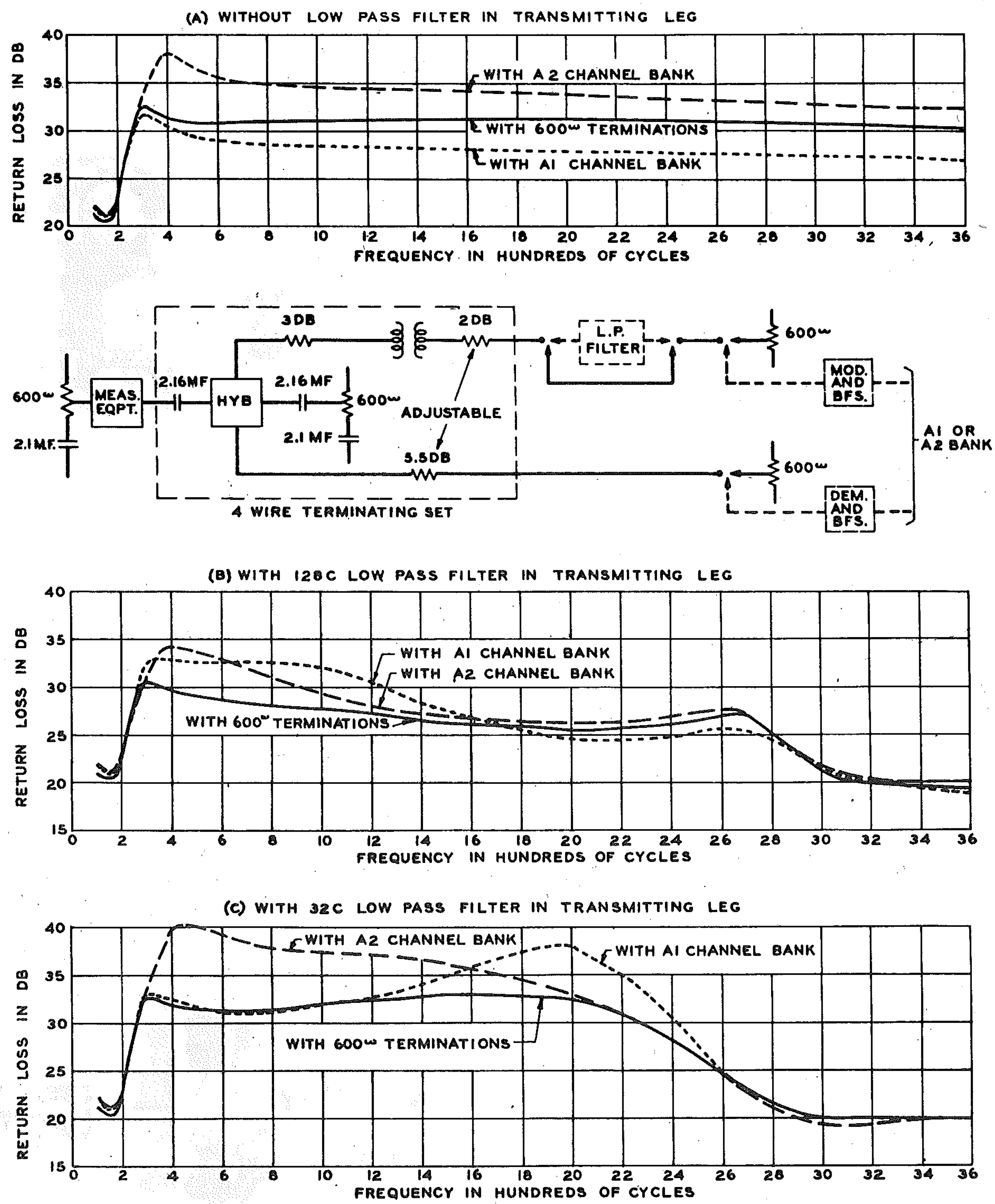


Fig. 4 - 2-Wire Return Loss of 4-Wire Terminating Set Against Compromise Network of 600$^{\omega}$ in Series with 2.1 MF.

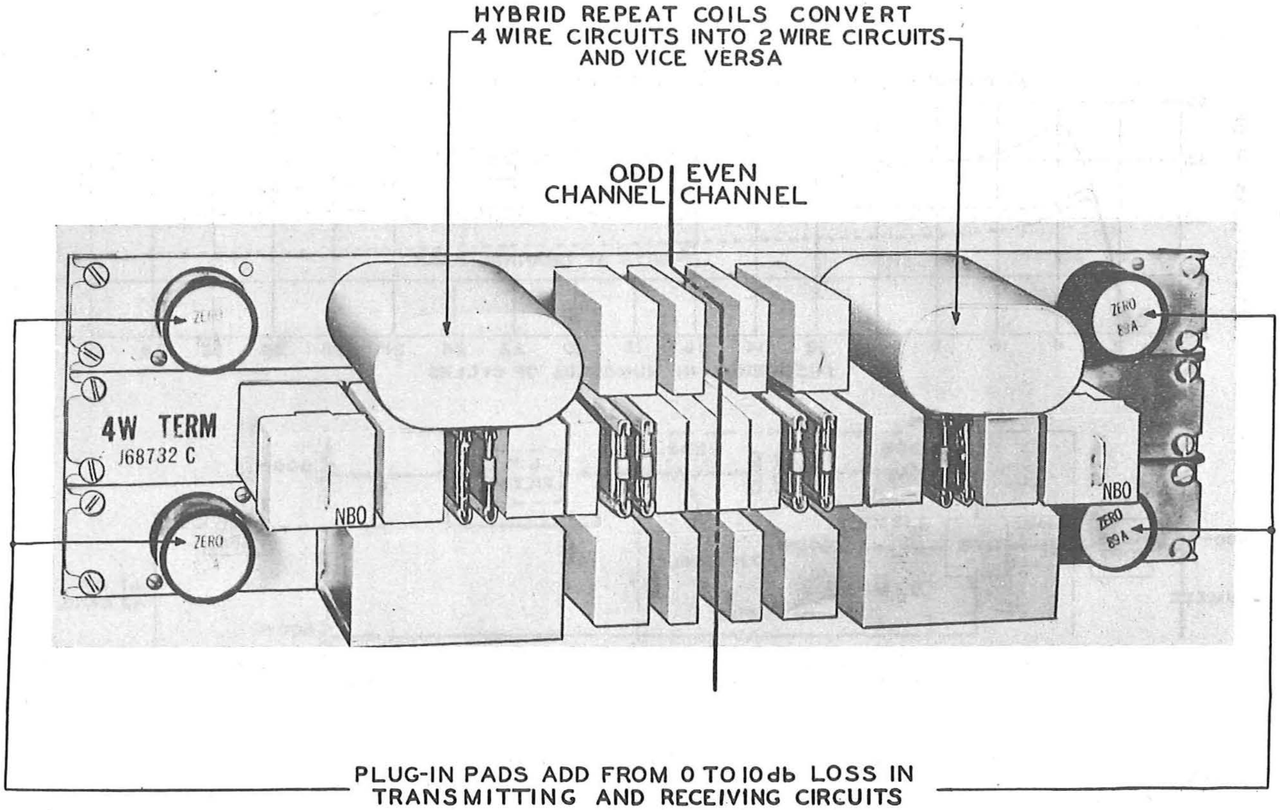


Fig. 5 - 4-Wire Terminating Unit Front View

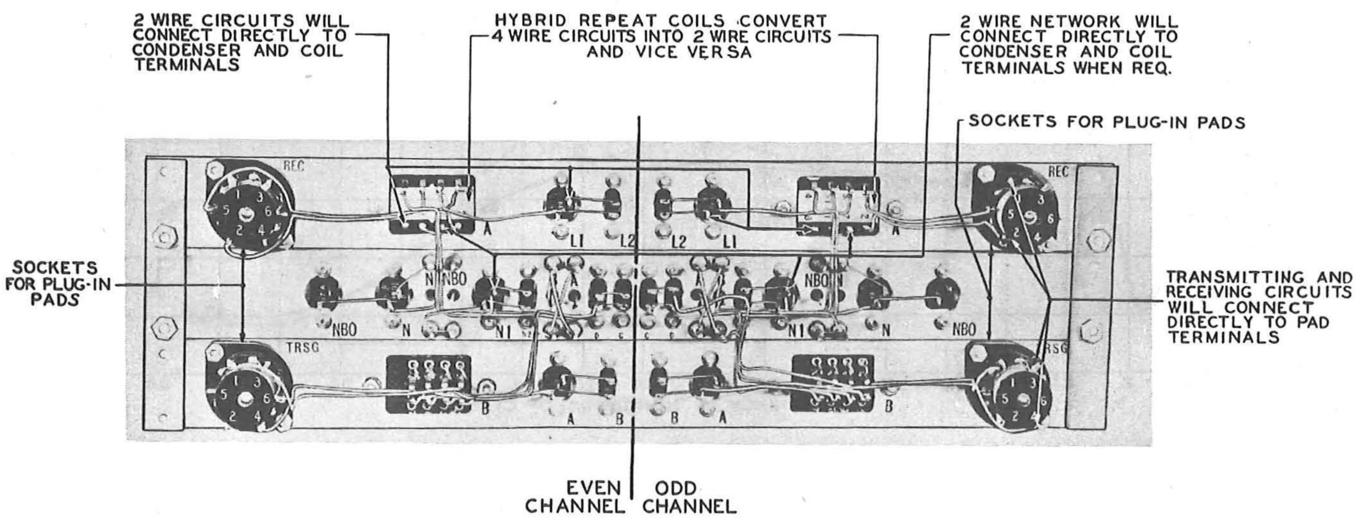


Fig. 6 - 4-Wire Terminating Unit Rear View

When the circuit is to be extended by a 2-wire non-repeatered toll line, a pair from the terminating set to the I.D.F. permits the use of a precision network in place of the compromise network. This network pair to the I.D.F. is optional, but if it is provided in all cases it will furnish complete flexibility for these circuits. A building-out unit for balancing the office cabling is provided on the terminating set.

(D) Signaling Arrangements

2.18 1000-cycle signaling is used over the carrier channels. Formerly, the ringing equipment was connected in the 2-wire path of the 4-wire terminating set, between the terminating set and the switchboard. The present standard ringing equipment is arranged so that it is normally connected in the 4-wire paths of the terminating set when used with carrier channels. Options are provided so that the equipment may be connected in the 2-wire path if desired. The present standard ringing equipment uses the same ringing impulse and performs the same circuit functions as the older equipment. However, the 215 type polarized relay is not used, about half as much space is required for the equipment, and the cost is less.

(E) Channel Band Width

2.19 The transmission band width is essentially the same for the A1 and A2 channel banks. The transmission band width of a typical A1 or A2 channel from voice terminal to voice terminal (as determined by the terminals and excluding any effect of the line) is shown in Fig. 7. The band width, measured at the points where the attenuation is 10 db higher than the attenuation at 1000 cycles is about 3400 cycles. The upper and lower 10 db points fall at about 150 and 3550 cycles respectively. The effect of the 4-wire terminating set is to sharpen the cut-off below 200 cycles.

2.20 The transmission band width of five typical channels connected in tandem, with and without two 4-wire terminating sets, is shown in Fig. 8. In this case, the band width at the 10 db points is approximately 3225 cycles. The lower and upper 10 db points come at approximately 175 and 3400 cycles respectively.

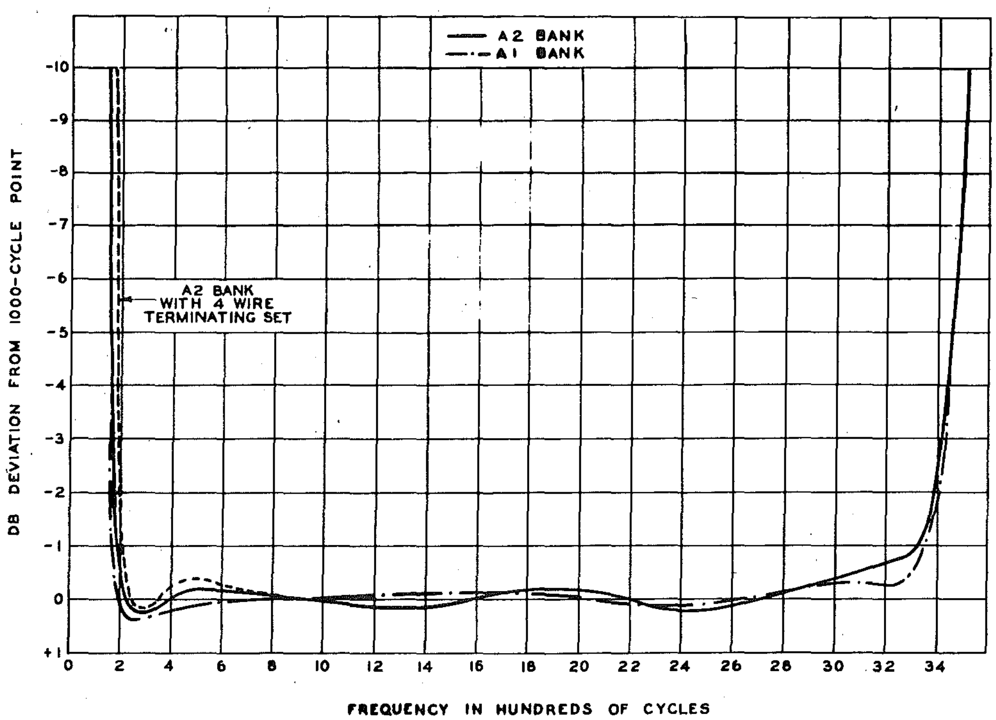


Fig. 7 - Typical Transmission Frequency Characteristic of One Channel With and Without 4-Wire Terminating Sets

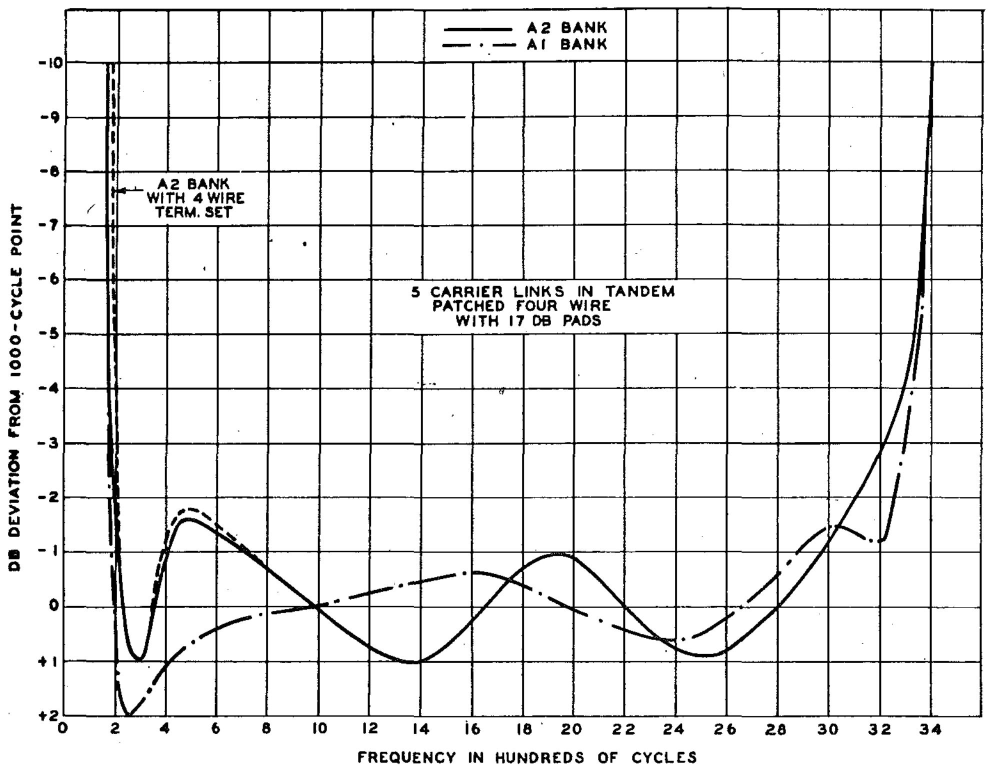


Fig. 8 - Typical Transmission Frequency Characteristic of 5 Channels Connected in Tandem, With and Without 4-Wire Terminating Sets

3. 4-WIRE VF MONITORING, TESTING AND PATCHING BAYS

(A) Bay Arrangement

3.01 The 4-wire VF bays provide centralized patching, level measuring, monitoring, and gain control for the voice frequency terminals of the carrier telephone circuits. There are two equipment arrangements for the VF test bays. The first arrangement provides jack equipment for 5 channel banks. The jack equipment for one bank is mounted on a panel containing 12 sets of VF patching and monitoring jacks and 12 demodulator amplifier gain control rheostats. In addition to these five jack panels the following testing equipment is also mounted in this bay: 4-wire monitor and talk equipment, transmission measuring equipment, spare attenuation pads and various jack equipment for access to patching, talking and test trunks, order wires, and other facilities. This bay arrangement is used where testing and monitoring equipment is to be provided. In general it will be required every third VF bay.

3.02 The testing and monitoring equipment on the above bay is usually sufficient to serve more than the five channel banks which have jack panels mounted there. Consequently, when more channel banks are added in the office, the next two VF bays added do not duplicate all of the test equipment. As a result, nine jack panels instead of five can be accommodated in one bay. However, more monitoring and talk equipment may be provided when desired. This group of 3 bays is repeated as additions are made in the office. See Fig. 9 for schematic of both types of bays.

3.03 Space is left on the bays which provides room for special equipment to suit the needs of each office. For instance, the 2-A sending panel which provides a 1000-cycle test current of 1 milliwatt may be mounted in one of these bays.

3.04 The various equipment units required for either the five or the nine system bay described above are arranged for mounting on duct type framework with rear covers for protecting wiring to the jacks.

3.05 The older type of jack equipment arrangement permitted only 4 channel banks to be terminated in the bay containing measuring equipment and 7 in the other bays.

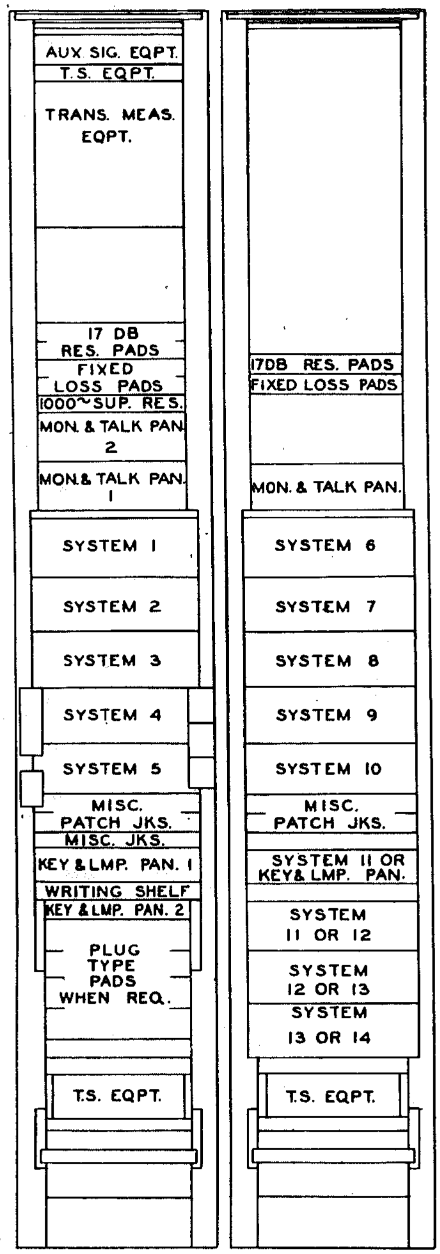


Fig. 9 - 4-Wire Voice Frequency Testing and Patching Bays

(B) Jack Panel with Amplifier Gain Controls

3.06 As shown in Figs. 11 and 12 jacks are provided between the 4-wire VF terminating sets and the channel modem circuits to permit testing, talking, and monitoring on a 4-wire basis. In the present layout, the entire set of 48 "410A" jacks, 24 "246" jacks, 12 gain control rheostats and the four designation strips are mounted on one plywood panel faced with fiber. This panel occupies only 6-3/32 inches vertical space as compared to 7-1/4 inches for the older equipment using 3 separate jack strips.

3.07 The jacks for each channel are associated in a vertical group, together with the gain control rheostat of the demodulator amplifier. This amplifier is part of the channel modem and is covered in part 4(D) of this section. The holes for the rheostat shafts are recessed. A slot is provided in the ends of these shafts so that the rheostat may be adjusted by means of a screwdriver.

3.08 Separate jacks are provided for monitoring. The monitoring jacks are smaller in diameter than the test jacks to reduce the hazard of wrong patching. The tip and sleeve connections are used on the monitoring jacks to eliminate the possibility of clicks on the circuit when patching to these jacks.

3.09 Referring to Figs. 11 and 12, one side of these patching jacks is cabled directly to the channel banks while the other side is cabled to the I.D.F. for cross connection, as required.

3.10 Formerly arrangements were included whereby other 4-wire facilities could be brought direct to this bay to facilitate setting up emergency circuits by means of patches. This practice has been discontinued in favor of providing trunks between the facilities in the office. Jacks designated "MISC. A & B" provide connections to spare 4-wire terminating sets, trunks to repeater and "C" carrier bays, and trunks to testboards. Trunks are also provided to other bays in the same and in different lineups, and also to the tandem patching board. In case of emergency, 6 ft. or 15 ft. patch cords may be used between bays in the same lineup.

(C) Talking and Monitoring Arrangements

3.11 The talking and monitoring arrangements together with associated testing provisions provide a wide range of very flexible facilities that greatly minimize the work in maintaining the carrier channels. Talking and testing can be done on a 4-wire high impedance basis. The talking set can also be used on a 2-wire basis. 1000-cycle signaling is provided for the sending direction. The key and jack panel just above the writing shelf contains the switching features of this talking, monitoring and testing equipment. The coils and amplifier equipment are mounted on a separate panel located near the top of the bay. Ordinarily one of these talking and monitoring sets will serve 3 VF bays, but extra sets can be provided if needed. The extra talking and monitoring set may be provided with or without connections to the testing equipment. This circuit is discussed in detail in an E40 section.

(D) Transmission Measuring Equipment

3.12 The key and jack panel controls several features of transmission measuring in close association with the 4-wire high impedance talking and monitoring arrangements. Transmission, Noise and Crosstalk measurements may be made on a high impedance bridging basis or a 600-ohm terminated basis. Testing current of 1000 cycles is provided at 1 milliwatt and at -13 dbm. Jacks are also provided for a source of multi-frequency for use in measuring transmission-frequency response. One set of this equipment can serve a group of VF bays, since the control feature can be multipled and a projection type of db meter can be provided. The details of this equipment are discussed fully in an E40 section.

(E) Spare Attenuation Pads

3.13 In addition to 17 db pads that are wired to the I.D.F. for permanent connections, various spare pads are provided with connections to jacks so that temporary interconnections may be set up on a 4-wire basis between the various voice circuits in the office. Where certain fixed values such as 6 db, 17 db, or other values are commonly used, these fixed pads are made up and mounted in a VF bay with cabling to jacks in the same bay. Where many different values are used, then the 1C pad with the 89 type "plug-in pad" is used.

(F) Trunks and Miscellaneous Circuits

3.14 Various patching trunks, testing trunks, order wires, miscellaneous circuits, and multiples of some of these facilities require jack appearances in the VF bay.

3.15 The patching pads, spare 4-wire terminating sets, trunks to repeater and type C carrier bays, and trunks to test-boards are terminated in jacks designated "Misc. A & B" and are connected to terminal strips located at the bottom of the bay.

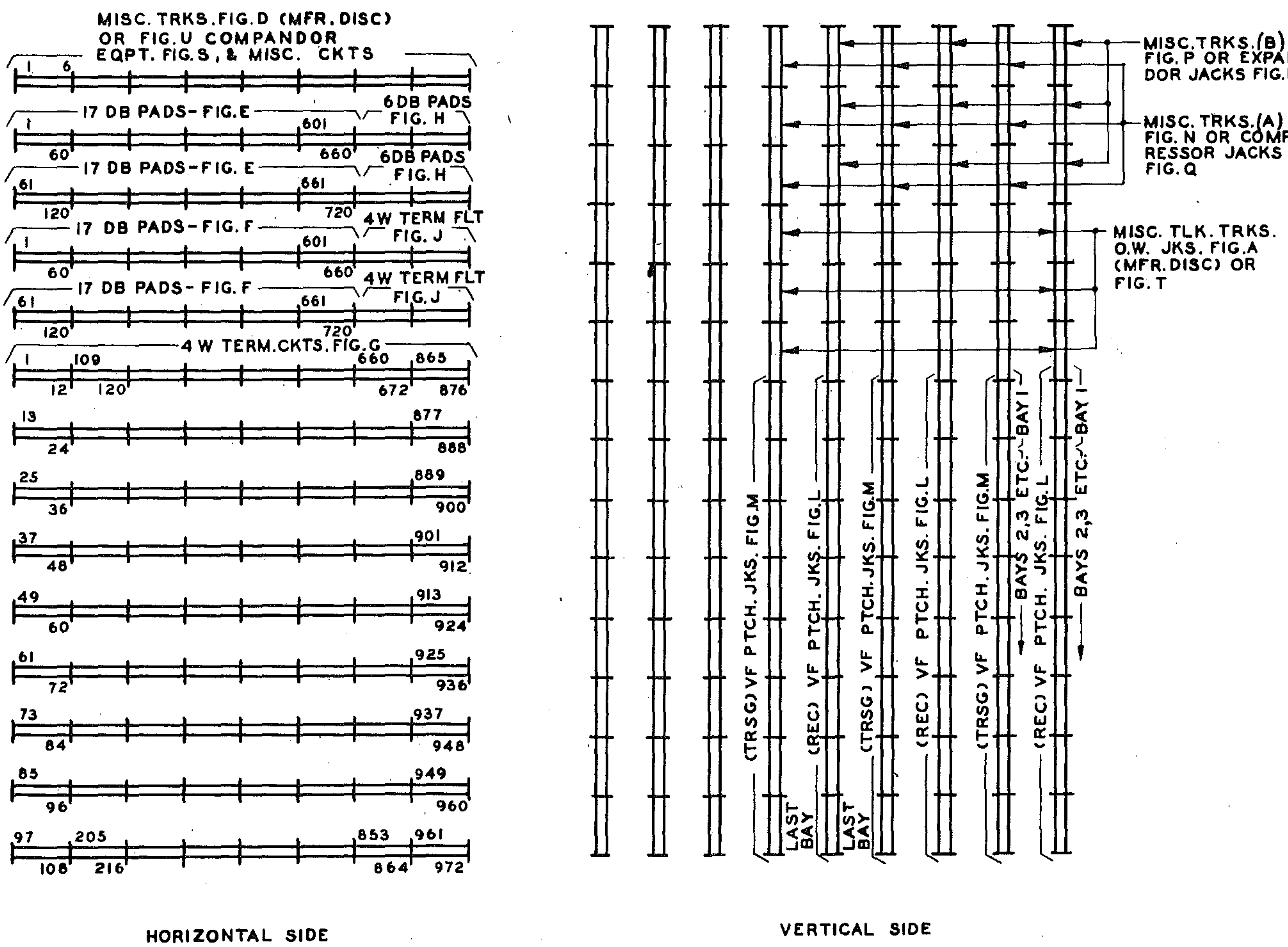


Fig. 10 - Typical I.D.F. Arrangement of 4-Wire Voice Frequency Circuits for an Ultimate of 100 Carrier Systems

3.16 Patching trunks may be provided between bays in the same lineup, between separate lineups, or between the patching bays and the tandem patching board. When these trunks have multiple appearances, a busy test feature is provided to prevent selecting a multiple trunk already in use.

3.17 The order wires and miscellaneous circuits appear on a jack strip just above the writing shelf. Multiple appearances of these jacks can be provided at other bays.

(G) I.D.F. Arrangement for Voice Circuits

3.18 Fig. 10 shows a typical I.D.F. arrangement for the voice circuits that connect to the broad band carrier systems. The high frequency circuits are not wired through the I.D.F.

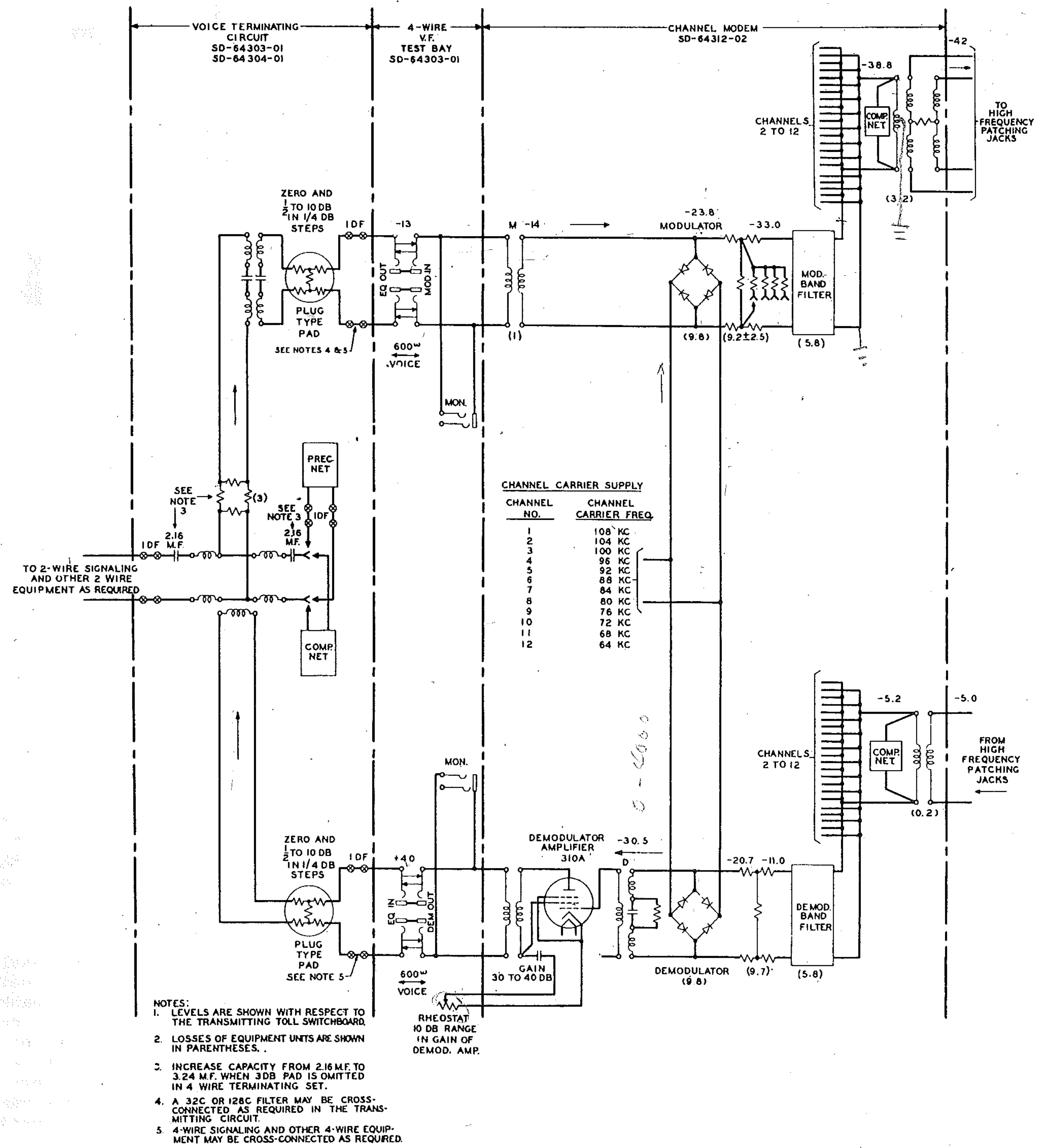
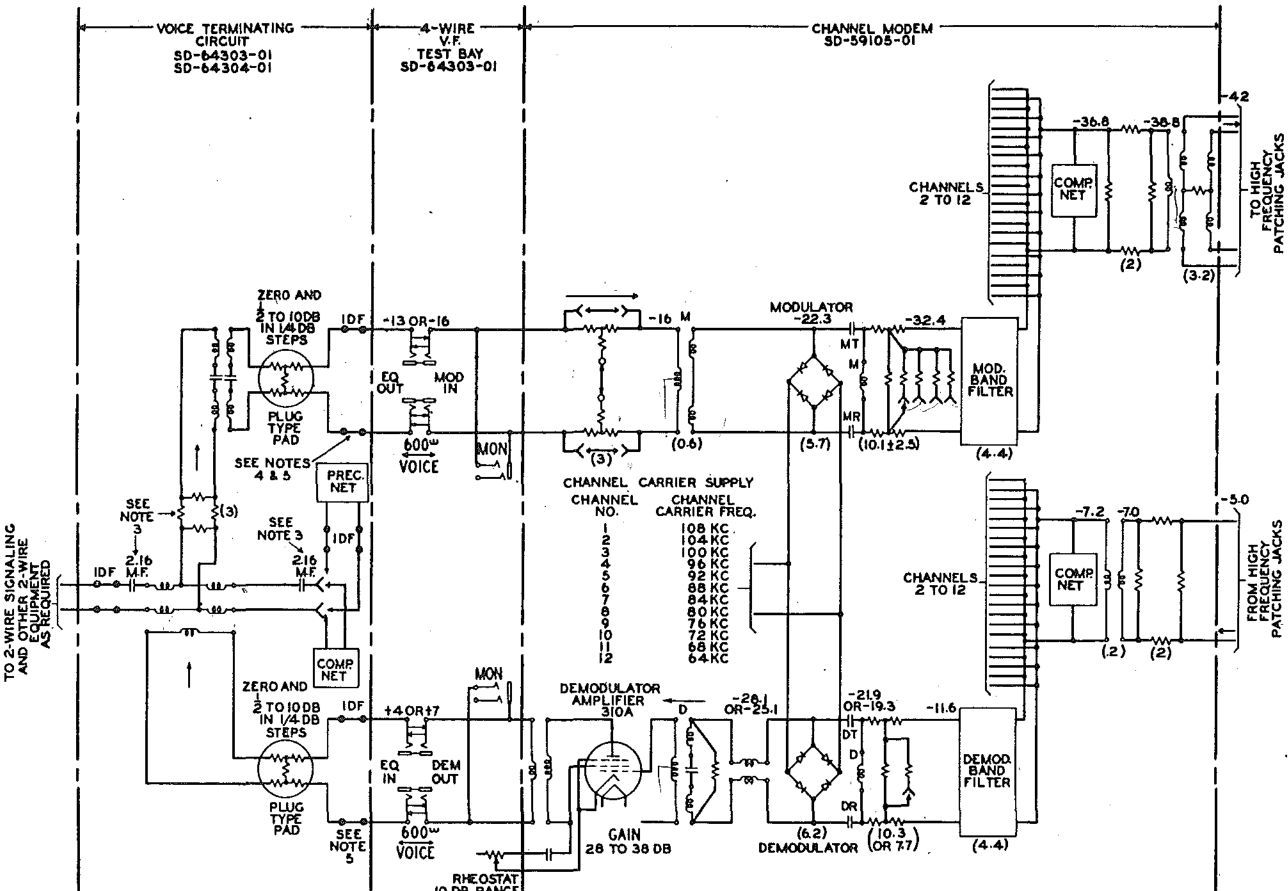


Fig. 11 - Channel Schematic - A1 Bank



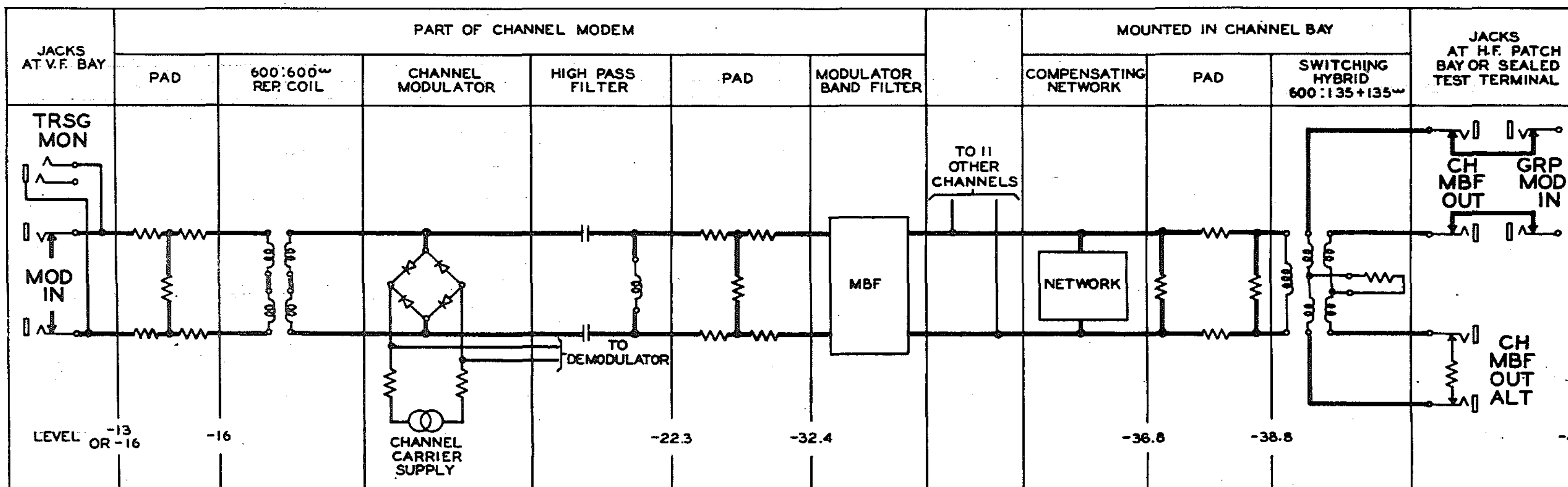
NOTES:
1. LEVELS ARE SHOWN WITH RESPECT TO THE TRANSMITTING TOLL SWITCHBOARD.
2. LOSSES OF EQUIPMENT UNITS ARE SHOWN IN PARENTHESES.
3. INCREASE CAPACITY FROM 2.16 M.F. TO 3.24 M.F. WHEN 3 DB PAD IS OMITTED IN 4-WIRE TERMINATING SET.
4. A 32C OR 128C FILTER MAY BE CROSS-CONNECTED AS REQUIRED IN THE TRANSMITTING CIRCUIT.
5. 4-WIRE SIGNALING AND OTHER 4-WIRE EQUIPMENT MAY BE CROSS-CONNECTED AS REQUIRED.

Fig. 12 - Channel Schematic - A2 Bank

4. CHANNEL MODEM

4.01 The channel modulator and demodulator (together known as a "modem") translate voice frequency bands to carrier frequency bands, and vice versa. General schematics of the A1 and A2 channel banks are given in Figs. 11 and 12 respectively. At the transmitting terminal, the voice currents received from 12 voice frequency circuits are translated by the channel modulators to carrier frequency bands ranging from 60 to 108 kc for the first step of modulation. The channel carrier frequencies, supplied to the channel modulators for modulation with the voice frequencies, range from 64 to 108 kc spaced 4 kc apart. At the receiving terminal, the reverse action takes place, i.e., the carrier channel bands ranging from 60 to 108 kc which are received from the group demodulator (described in another E44 section) are translated to voice currents for connection to 12 voice frequency circuits.

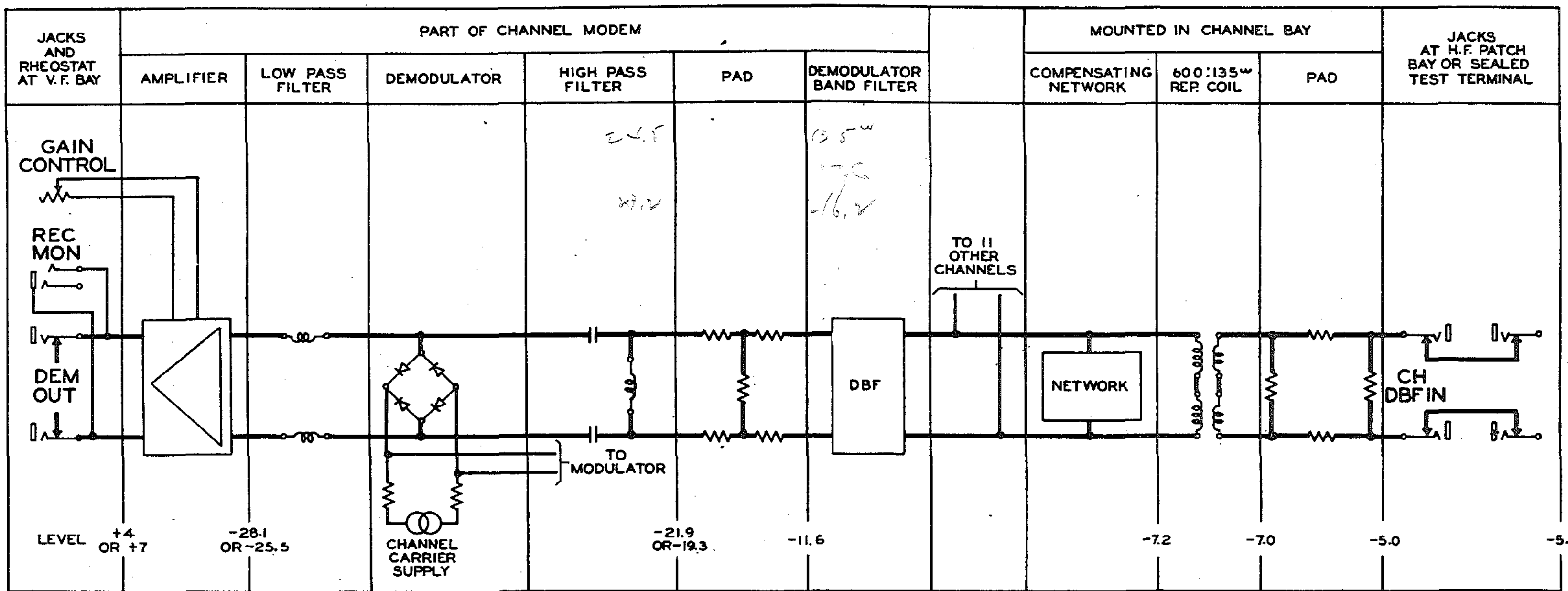
4.02 The A1 and A2 channel banks are closely identical and interchangeable in their operation and performance when the A2 banks are set up with the normal transmitting and receiving levels of -13 and +4. The A2 bank provides additional options of operating at -16 transmitting level and +7 receiving level. The theory of their operation is shown diagrammatically in Figs. 13 and 14 and is discussed in the following paragraphs.



JACKS AT V.F. BAY	PAD	600:600∿ REP. COIL	CHANNEL MODULATOR	HIGH PASS FILTER	PAD	MODULATOR BAND FILTER		COMPENSATING NETWORK	PAD	SWITCHING HYBRID 600:135+135∿	JACKS AT H.F. PATCH BAY OR SEALED TEST TERMINAL
FUNCTIONS											
PERMITS PATCHING AND TESTING AND MONITORING	ADJUSTS INPUT LEVEL	BALANCES MODULATOR CIRCUIT. PASSES ONLY VOICE FREQUENCIES. PRESENTS HIGH IMPEDANCE TO CARRIER FREQUENCIES.	COMBINES VOICE FREQUENCIES WITH CHANNEL CARRIER. BALANCED CIRCUIT SUPPRESSES CARRIER.	PRESENTS HIGH IMPEDANCE TO VOICE FREQUENCIES	ADJUSTS TRANSMISSION LEVEL. IMPROVES IMPEDANCE RELATIONS BETWEEN FILTER AND VARISTOR.	SELECTS LOWER SIDE BAND. REJECTS OTHER FREQUENCIES.	OTHER CHANNEL CURRENTS ENTER HERE.	ADJUSTS IMPEDANCE OF END BAND FILTERS	ADJUSTS LEVEL	MATCHES 600∿ IMPEDANCE TO 135∿. PROVIDES 2 OUTPUTS OF 135∿ IMPEDANCE.	PERMITS PATCHING FOR TEST OR TO USE OTHER GROUP EQUIPMENT
TRANSMITS											
VOICE FREQUENCY	VOICE FREQUENCY	VOICE FREQUENCIES ONLY	VOICE. CARRIER PLUS VOICE. CARRIER MINUS VOICE. OTHER MODULATION PRODUCTS.	CARRIER FREQUENCIES ONLY	CARRIER FREQUENCIES	CARRIER MINUS VOICE (LOWER SIDE BAND) ONLY	CHANNEL FREQUENCIES (LOWER SIDE BANDS, OF ALL 12 CHANNELS, 60 TO 108 KC)				

DIRECTION OF TRANSMISSION →

Fig. 13 - Simplified Schematic of Type A2 Channel Modulator



JACKS AND RHEOSTAT AT V.F. BAY	AMPLIFIER	LOW PASS FILTER	DEMODULATOR	HIGH PASS FILTER	PAD	DEMODULATOR BAND FILTER		COMPENSATING NETWORK	600:135ω REP. COIL	PAD	JACKS AT H.F. PATCH BAY OR SEALED TEST TERMINAL
FUNCTION											
ADJUSTS RECEIVING LEVEL. JACKS PERMIT PATCHING AND TESTING AND MONITORING.	AMPLIFIES VOICE FREQUENCIES RECEIVED FROM DEMODULATOR. SUPPRESSES CARRIER FREQUENCIES.	PRESENTS HIGH IMPEDANCE TO CARRIER FREQUENCIES. PASSES ONLY VOICE FREQUENCIES.	COMBINES RECEIVED SIDE BAND WITH CARRIER TO PRODUCE VOICE FREQUENCY	PRESENTS HIGH IMPEDANCE TO VOICE FREQUENCIES	ADJUSTS TRANSMISSION LEVEL. IMPROVES IMPEDANCE RELATIONS BETWEEN FILTER AND VARISTOR	SELECTS ONLY CURRENTS ASSOCIATED WITH THIS CHANNEL	OTHER CHANNEL CURRENTS LEAVE HERE	ADJUSTS IMPEDANCE OF END BAND FILTERS	MATCHES IMPEDANCE OF GR. DEM. AMP. TO 12 CHANNELS	ADJUSTS LEVEL	PERMITS PATCHING FOR TEST OR TO USE OTHER GROUP EQUIPMENT
TRANSMITS											
VOICE FREQUENCY	VOICE FREQUENCY	VOICE FREQUENCIES ONLY	LOWER SIDE BAND AND VOICE	LOWER SIDE BAND	LOWER SIDE BAND	LOWER SIDE BAND	CHANNEL FREQUENCY BAND (60 TO 108 KC.)				

← DIRECTION OF TRANSMISSION

Fig. 14 - Simplified Schematic of Type A2 Channel Demodulator

(A) Modulators and Demodulators

4.03 The A2 channel bank has the same circuit elements as the A1 bank and performs the same circuit operations in the same manner. The apparatus is different in the two cases, with substantial savings of space, together with some cost savings in favor of the A2 equipment. However, the various design objectives are met with some margin to spare with both types.

4.04 The modulator and demodulator are identical in operation and in circuit elements between the input to the varistor bridge and the common side of the band filters. See Figs. 13 and 14. This much of the circuit is "bilateral", i.e., it will work either with a voice input to the varistor or a sideband input to the band filter. The size of pad used, the kind of coil, the demodulator amplifier, etc., are selected according to the needs of the circuit in setting up a transmitting or a receiving branch. In the transmitting circuit, modulation of the voice frequencies with the channel carrier frequency takes place in the modulator. In the receiving circuit, demodulation of the carrier frequency band with the channel carrier frequency takes place in the demodulator. The modulator and demodulator elements used in this system consist of copper oxide units, known as varistors, in a bridge arrangement as indicated schematically in Figs. 11 and 12. The theory of modulation by means of varistors 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. This alternate changing of the shunt impedance between a low and high value at the carrier frequency rate produces upper and lower sidebands in the output of the modulator and demodulator. In the modulator circuit, the lower sideband is selected by the modulator band filter, as mentioned below. The voice frequency input to the modulator is not balanced out in the output, but is suppressed by the modulator band filter and in the A2 bank by a high pass filter in addition. In the demodulator circuit, only the lower sideband (voice frequency) is amplified by the demodulator amplifier circuit, all other products of demodulation being greatly attenuated by the input and output circuit of this amplifier.

4.05 The M repeating coil in the modulator and the D input transformer in the demodulator perform two important functions. First, they both act as low pass filters to block the high frequency sidebands and carriers from entering the voice frequency circuits. Second, they both present a high impedance to the carrier sidebands present across the varistor bridge. If a 600 ohm impedance were presented to the carrier sidebands as well as to the voice frequencies, about 3 db more loss would occur in the circuit (both modulator and demodulator). The M coil at the modulator input performs the additional function of insuring a well balanced modulator circuit. Unbalance in the modulators could cause intelligible crosstalk between the VF pairs in the cable to the I.D.F.

4.06 The varistors are not adjustable and it is expected that ordinarily they will not require replacement during the life of the equipment.

4.07 The bridge arrangement employed in the modulator and demodulator circuits has a high degree of balance and is sufficiently stable so that the carrier frequency which appears in the output and which is referred to as "carrier leak" is relatively small. It is expected that the amount of this carrier leak from any modulator will not exceed -19 dbm at a zero level point for the A1 banks or -26 dbm for the A2 banks. In the average case it is considerably below this value. The 219 type band filters for the A2 banks are designed to give 7 db more suppression to the channel carrier frequency than the 75 type filters for the A1 banks. This extra suppression to carrier leak is of value to the J and L system but is not so important to the K system.

4.08 The channel carrier supply for the modulators and demodulators in all of the channel modems is obtained from a common carrier supply, as described in another E44 section. The same carrier frequency is supplied to the modulator and demodulator of a channel. No changes were necessary in the carrier supply to use it for the A2 banks.

(B) Band Filters and Resistance Pad

4.09 Between the varistor bridge and the band filters is a resistance pad of approximately 10 db. In the modulator of both the A1 and A2 banks this pad is adjustable over a range of ± 2.5 db to permit each channel to be brought to the same level (usually at the output of the transmitting amplifier). In the A1 banks the demodulator pad has no adjustment, since the potentiometer in the channel demodulator amplifier provides 10 db variation. However, the A2 demodulators are provided with a 3 db adjustment which will permit a +7 level at the output in place of the usual +4 level with a slight impairment of quality (higher modulation).

4.10 This resistance pad is provided to present a good impedance for the operation of the crystal band filters. The resistance pad stabilizes their performance. Grounds are placed at the midpoint of the shunt resistance of the pad and at the midpoint of the impedance matching transformer on the other side of the band filter. These center tap grounds are needed to balance the circuit for the operation of the crystal band filter. Otherwise the high suppression to unwanted frequencies may not be obtained.

4.11 In the case of the modulators and demodulators of the A2 banks, a half section of high pass filter has been added between the varistor and the resistance pad. This filter is used to present a high impedance to the voice frequencies in place of the impedance that the resistance pad would otherwise present. This feature provides 3 db less loss for the modulator and demodulator of the A2 bank as compared to the A1 bank. The MT and MR condensers together with the M retard coil make up this filter for the modulator. The DT and DR condensers together with the D retard coil make up this filter for the demodulator.

4.12 In the modulator of the A2 banks, a 3 db pad is added to secure a -13 input level at the MOD IN jacks. This pad can be strapped out so as to use a -16 input with no degradation of service.

4.13 In the case of the demodulator of the A2 banks, this 3 db (secured by the use of the high pass filter) is needed to compensate for 3 db that is lost by using a new input transformer with a lower step-up ratio in the demodulator amplifier.

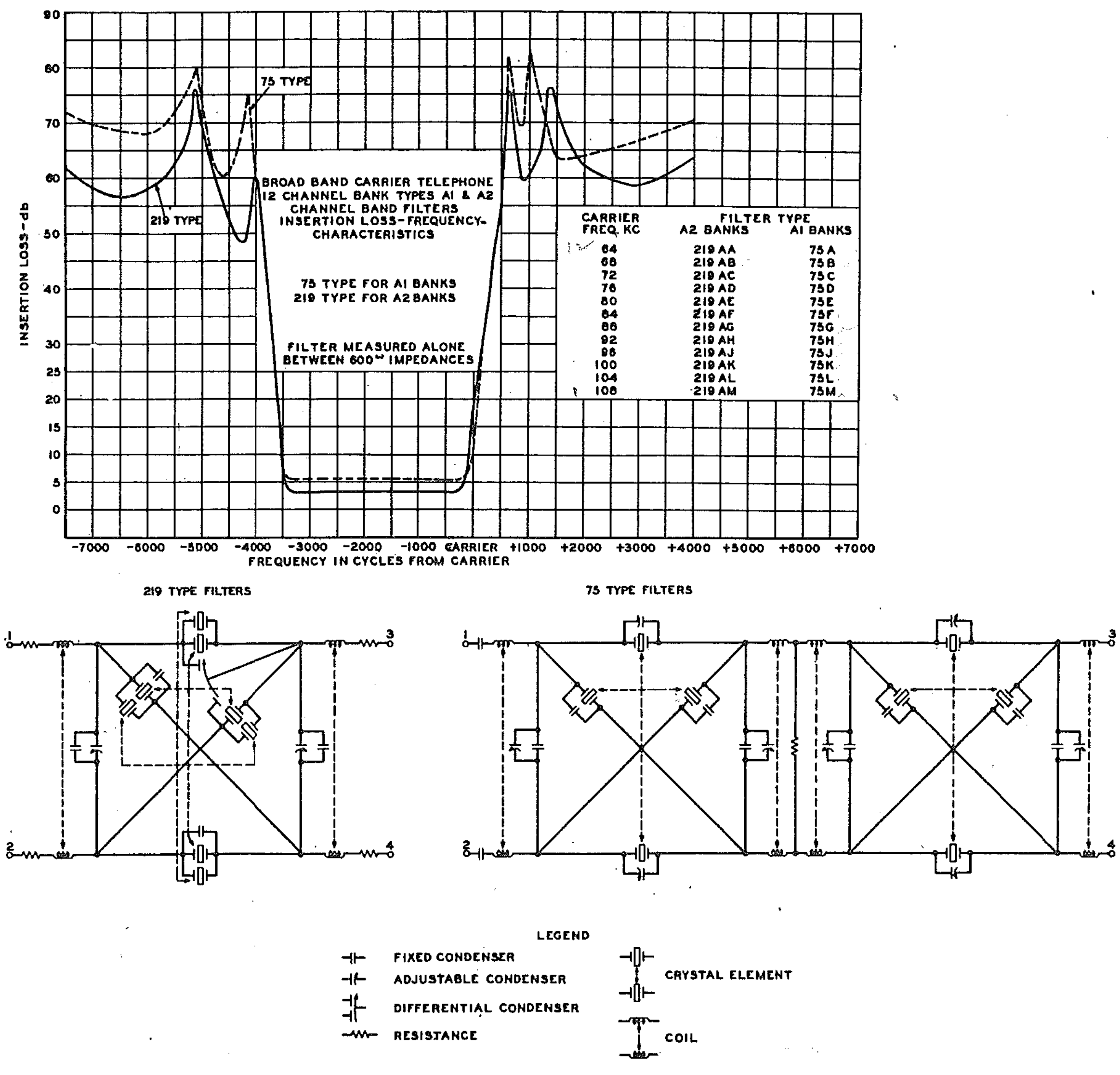


Fig. 15 - Loss Frequency Characteristics and Circuit Schematics of 75 and 219 Type Band Filters

4.14 The modulator and demodulator band filters are of the crystal type, and are designed for frequencies in the range between 60 and 108 kc. This type of filter permits a wider transmitted band for a given channel spacing, a more uniform attenuation over the band for a given transmission loss, and a smaller and more compact assembly than could be obtained with the coil and condenser type of filter. The modulator and demodulator band filters for the same channel are identical. The most suitable frequency range for the crystal type of filter is above about 50 kc. An additional step or steps of modulation are provided in the J, K or L group circuits to translate the carrier channel bands ranging from 60 to 108 kc to the appropriate line frequency range.

4.15 The 75 type filters for the A1 bank are sealed in cans that are filled with dry air. Two sections of crystals are used to secure the high attenuation provided against unwanted frequencies.

4.16 The 219 type filters for the A2 bank are considerably different from the 75 type. Only one section of crystals is used, but two crystals are used in each position in the lattice. Two less coils are used. Only the crystals are in sealed containers. The manufacturing procedure is greatly simplified. There is 2 db less loss in the transmitted band. A 2 db pad in the common part of the circuit restores all 12 channels to the normal working level at the common side of the band filters. The suppression of the 219 type filters to unwanted frequencies is somewhat less than that provided by the 75 type filters, but the present design objectives are met with some margin to spare. See Fig. 15.

4.17 In the transmitting circuit, the lower sideband is selected by the modulator band filter. The bands of 12 channels are transmitted as a group to the group modulator.

4.18 In the receiving circuit, the 12 bands received from the group demodulator are separated by the channel demodulator band filters. Each band is transmitted from its respective filter to its associated demodulator circuit.

4.19 Representative loss-frequency characteristics and the circuit schematics of the channel band filters are shown in Fig. 15 for the A1 and A2 banks. The characteristics of the band filters are sufficiently uniform so that a typical characteristic as shown gives the average performance of any one of the 12 channels, referred to the channel carrier frequency.

(C) Impedance Transformation Circuit

4.20 A compensating network is bridged across the common side of the modulator and demodulator band filter circuits to improve the transmission characteristics of the upper and lower channels. In the case of the A1 channels with the 75 type filters only channels 1 and 12 are affected (improved) by the compensating filter. However, in the A2 channel bank, Channels 1, 2, 3, 4, 9, 10, 11 and 12 are all affected by the compensating network. Without the compensating network, the channel transmission-frequency characteristic is likely to have unwanted slopes and rounded instead of sharp corners at 200 and 3400 cycles.

4.21 Associated with the modulator band filters and this compensating network is a 600 to 135 +135 ohm hybrid repeating coil. This coil provides a 600-ohm impedance for the operation of the band filters, and matches the 135 ohms of the group modulator circuit. One of the 135 ohm outputs feeds the regular group modulator while the other appears at the CH MBF OUT ALT jacks. This second output is provided to facilitate switching a working bank to other apparatus without interruption. The demodulator band filters have the same compensating network used in the same place, but the impedance matching repeat coil does not have the hybrid feature of two 135 ohm windings.

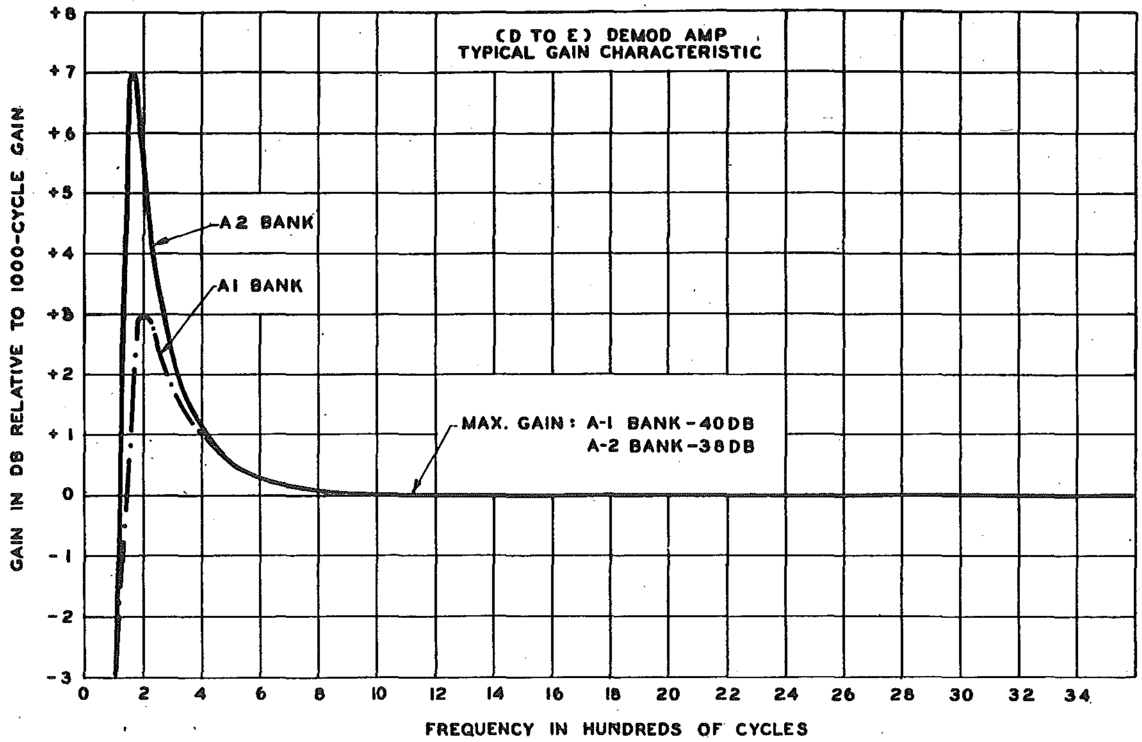
(D) Demodulator Amplifier

4.22 The demodulator amplifier for both the A1 and A2 banks is a single tube circuit using one 310A vacuum tube. The gain is controlled by a rheostat which varies the feedback and the grid bias simultaneously. With maximum gain the feedback is approximately zero db. With minimum gain it is about 7 db, with an additional reduction in overall gain of about 3 db due to a change in the grid bias. The rheostat for this purpose is mounted in the 4-wire voice frequency bay as discussed in Parts 2 and 3 of this section. This amplifier is capable of delivering a level of +4 db with normal quality to the voice frequency circuit from the DEM OUT jacks. A level of +7 db can be secured with the A2 bank at the expense of a slight increase in modulation. See Figs. 11 and 12 for simplified schematics.

4.23 The nominal working gain required by the demodulator circuit averages 33.6 db for the A1 bank and 32 db for the A2 bank. With new tubes, the actual gain provided ranges between 30 and 40 db for the A1 bank and between 28 and 38 db for the A2 bank. As the tube ages, the gain of the amplifier becomes less.

(E) Transmission Frequency Characteristics of Channel Banks

4.24 Fig. 16 shows typical transmission frequency characteristics of the transmitting and receiving paths through the channel banks. The characteristic from the input of the modulator to the output of the modulator band filter is similar to that from the input of the demodulator band filter to the output of the demodulator. Equalization is provided in the region between 200 and 800 cycles by



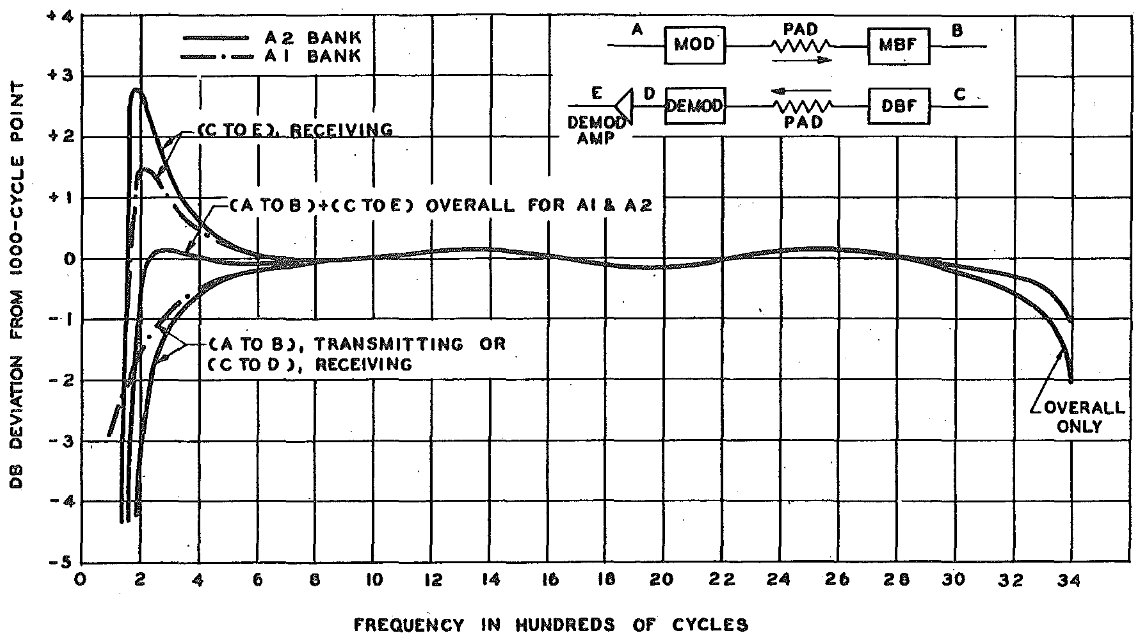


Fig. 16 - Transmission Frequency Characteristics of Channel Modem

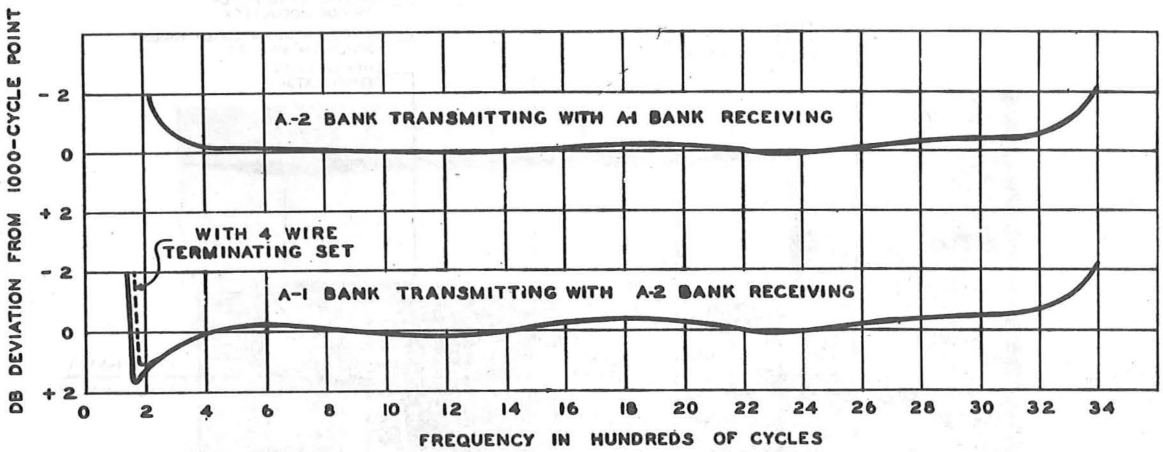


Fig. 17 - Transmission Frequency Characteristics With A1 Bank and A2 Bank at Opposite Ends of a System

tuning the input transformer of the demodulator amplifier at about 200 cycles. Because the A2 bank requires more correction than the A1 bank, the A2 amplifier has approximately 2.5 db more gain at 200 cycles than the A1 amplifier. In either case this equalization serves to correct for two similar filters, one transmitting and one receiving. Consequently when an A1 bank is used at one terminal (either transmitting or receiving) and an A2 bank is used at the other terminal, the equalization provided by this feature is slightly degraded. The resulting transmission frequency characteristic departs from that secured when the transmitting and receiving terminals use the same type of channel bank. See Figs. 7 and 17.

(F) Mounting Arrangements and Bay Assembly

4.25 An A1 channel bank unit is shown in Figs. 18 and 19. The modulators, demodulators, demodulator amplifiers, and band filters for two channels are assembled in one unit. Accordingly, six of these units each with its own can cover are required for a 12 channel bank. The equipment for each of the six units is identical with the exception of the band filters.

4.26 As indicated in Fig. 18, the apparatus for the A1 odd numbered channel is located in the upper half of the unit, and the apparatus for the even numbered channel is in the lower half, except for the band filters on the rear of the unit. The equipment is also arranged so that the demodulator and demodulator amplifier apparatus are on the right-hand side of the panel, while the modulator apparatus is on the left. In the case of the filters, this applies only to the filter terminals. This equipment layout permits the use of short direct leads, and also provides sufficient separation between the transmitting and receiving circuits and between odd and even channels. These considerations are necessary to minimize crosstalk.

4.27 Fig. 20 shows a 2-bay arrangement for three A1 channel banks together with the compensating networks. Each 12-channel bank, therefore, occupies the space of two-thirds of an 11'6" bay. One fuse panel at the top of one bay mounts the 24-volt and 130-volt fuses for the demodulator amplifiers of the three banks. This panel also provides space for the fuses for the carrier supply bay. When there are more than two bays of channel banks, the carrier supply fuses for the "regular" generator will be mounted on whichever of these fuse panels is nearest the carrier supply bay and the fuses for the "emergency", on the next nearest fuse panel. Banks 1, 2, 3, 7, 8, 9, etc., will be supplied by one set of power leads, and banks 4, 5, 6, 10, 11, 12, etc., will be supplied by a second set of power leads for protection purposes.

4.28 As mentioned above, the equipment for the A1 transmitting circuits is located on the left-hand side of the unit and the equipment for the receiving circuits is located on the right-hand side. This means that the wiring which is multipled between the band filters of these units and connected to the compensating filters can be on the left side in one case and on the right side in the other case and so need not be shielded. As this wiring is common to the band filters it has been made as short as possible so as not to impair the impedance characteristics of the filters.

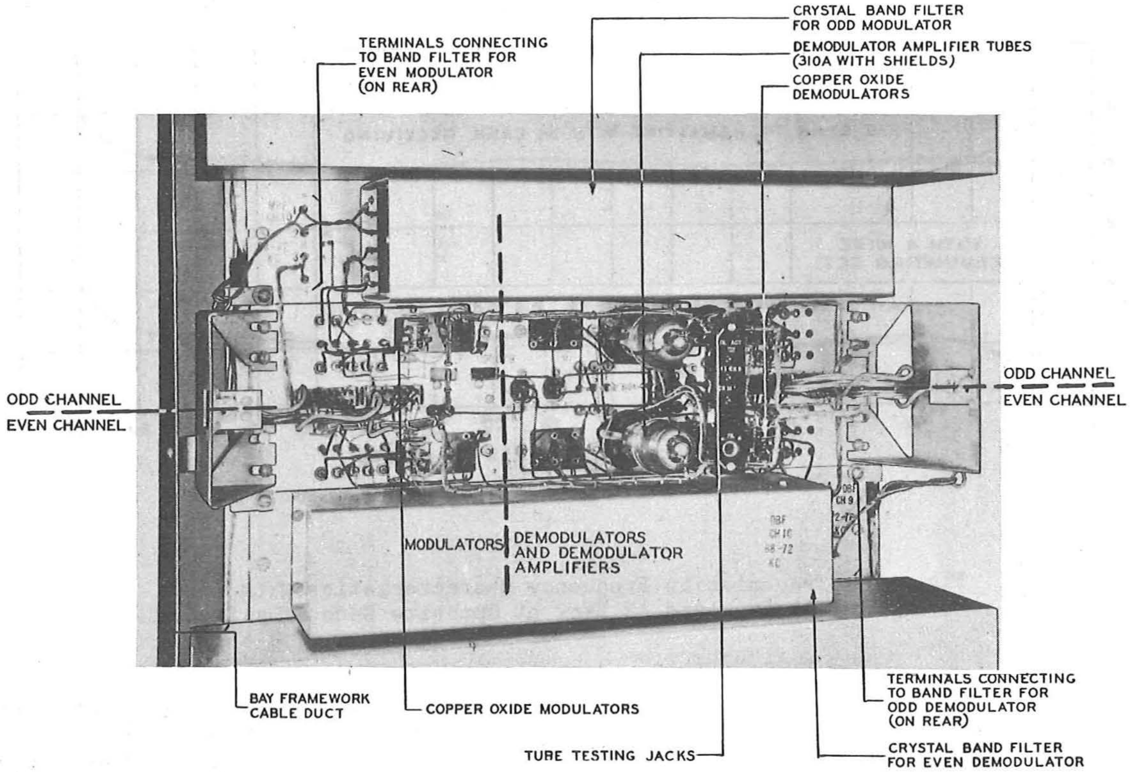


Fig. 18 - Channel Modem Unit - A1 Bank - Front View

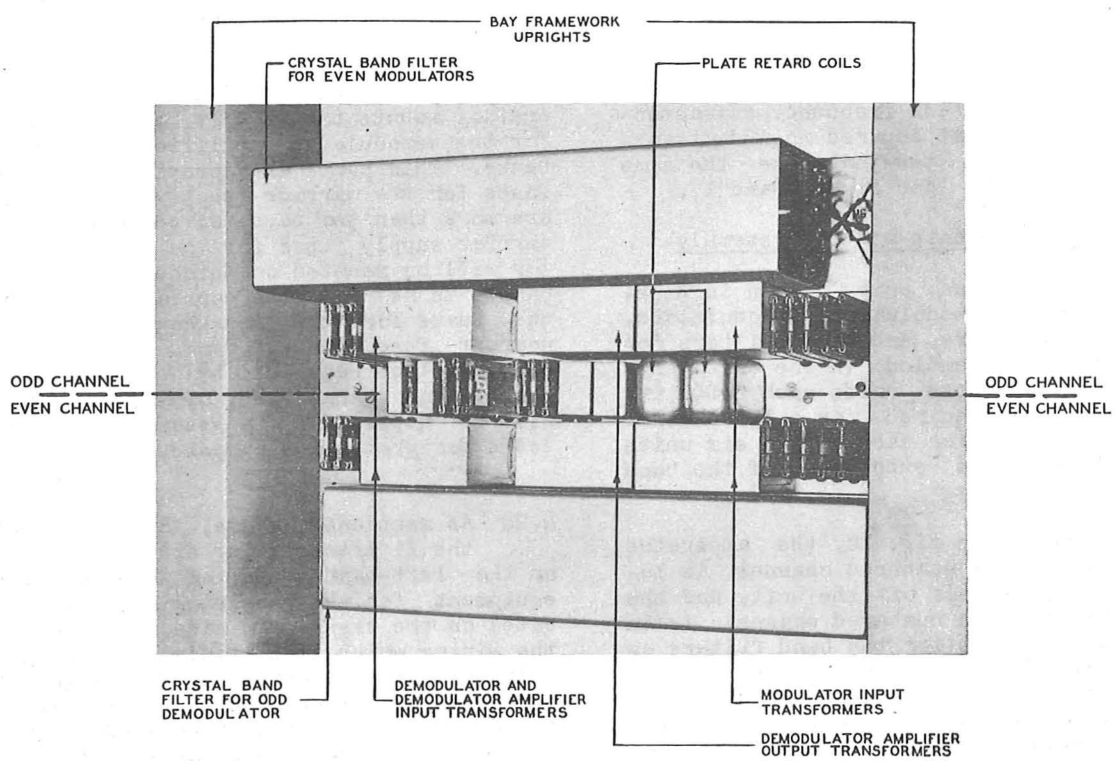
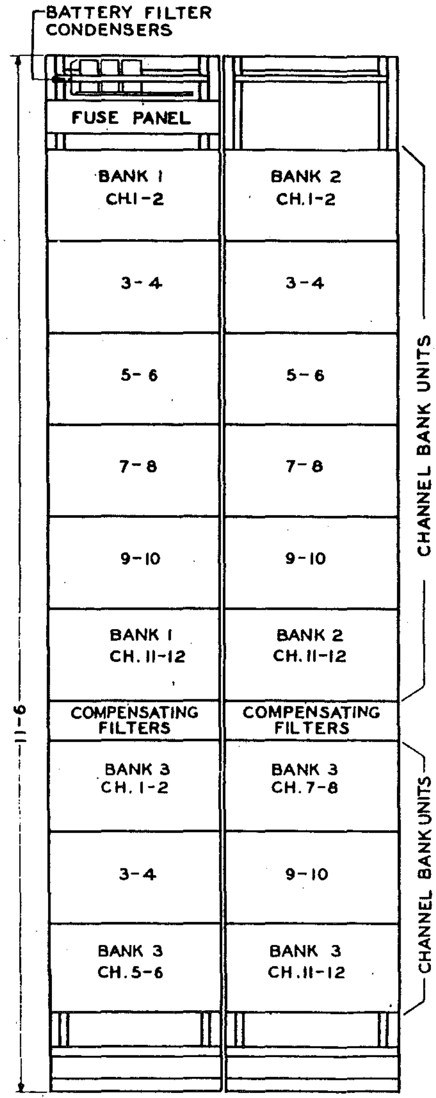


Fig. 19 - Channel Modem Unit - A1 Bank - Rear View



12 CHANNEL BANK TYPE A1
(FOR LEFT TO RIGHT GROWTH)

Fig. 20 - Bay Layout - A1 Bank

4.29 An A2 channel modem unit is shown in Figs. 21 and 22. The modulators, demodulators, demodulator amplifiers, and band filters for two channels are assembled in one unit. This unit occupies 8-3/4 inches of vertical space or five mounting plates of 1-3/4 inches. These units are made with two different arrangements of equipment so that one unit is a mirror image of the other. These units are alternated in mounting on the bay, with one large cover provided for each pair of units or 4 channels. The impedance transformation circuit which consists of a compensating network, a 2 db pad, and a repeating coil for each 12 modulators and for each 12 demodulators is made up as a unit occupying one mounting space of 1-3/4 inches. It is mounted between the two central units under the same cover. Three 4-channel units, one of which includes an impedance transformation unit, comprise a complete 12-channel bank. With the exception of the band filters and the small retard coil in the high pass filter, the equipment is the same for each channel.

4.30 As indicated in Figs. 21 and 22, the apparatus for the A2 odd numbered channels is located at the outer edge of the panel, while the even numbered channels are located toward the middle of the panel. Further, it will be seen that the modulator equipment is located on the left-hand side of the panel (when facing the front) while the demodulator equipment is located on the right-hand side of the panel. All equipment except the band filters for each modulator and each demodulator is made up as a separate small unit or subpanel that is mounted on the front of the main panel. The demodulator amplifiers for the two channels are mounted on the main panel along with the band filters. No wires or connections are located on the back of the panel. The overall layout requires a minimum of wiring in the field installation.

4.31 When a system is in service two adjacent covers in the same bay should not be removed at the same time. If this is done, two sets of demodulator amplifier tubes are left with no shielding between them. This permits some intelligible crosstalk.

4.32 Fig. 23 shows a 3-bay arrangement mounting six A2 banks in 11'6" bays. If 10'6" bays are used, then only five of the A2 banks can be mounted in the three bays. A set of fuse panels at the top of the left-hand bay provides the 24 volt and 130 volt fuses for the demodulator amplifiers of the six systems and also for a carrier supply bay. Filter condensers and associated fusing are provided for use in these bays when they are located in a station having decentralized filtering arrangements for the 24 volt filament battery. The upper fuse panel supplies the odd numbered banks and the lower fuse panel supplies the even numbered banks.

4.33 The A2 banks are compact and consequently the connections to multiple the band filters are quite short. By placing the transmitting equipment on the left-hand side and the receiving equipment on the right-hand side, the shielding problem is minimized.

4.34 The high frequency side of the channel bank unit (and the compensating network) is connected through the 600:135 ohm transformer to the high frequency patching jacks with #720 rubber covered shielded cable. The voice frequency side is cabled with two 500 CL type

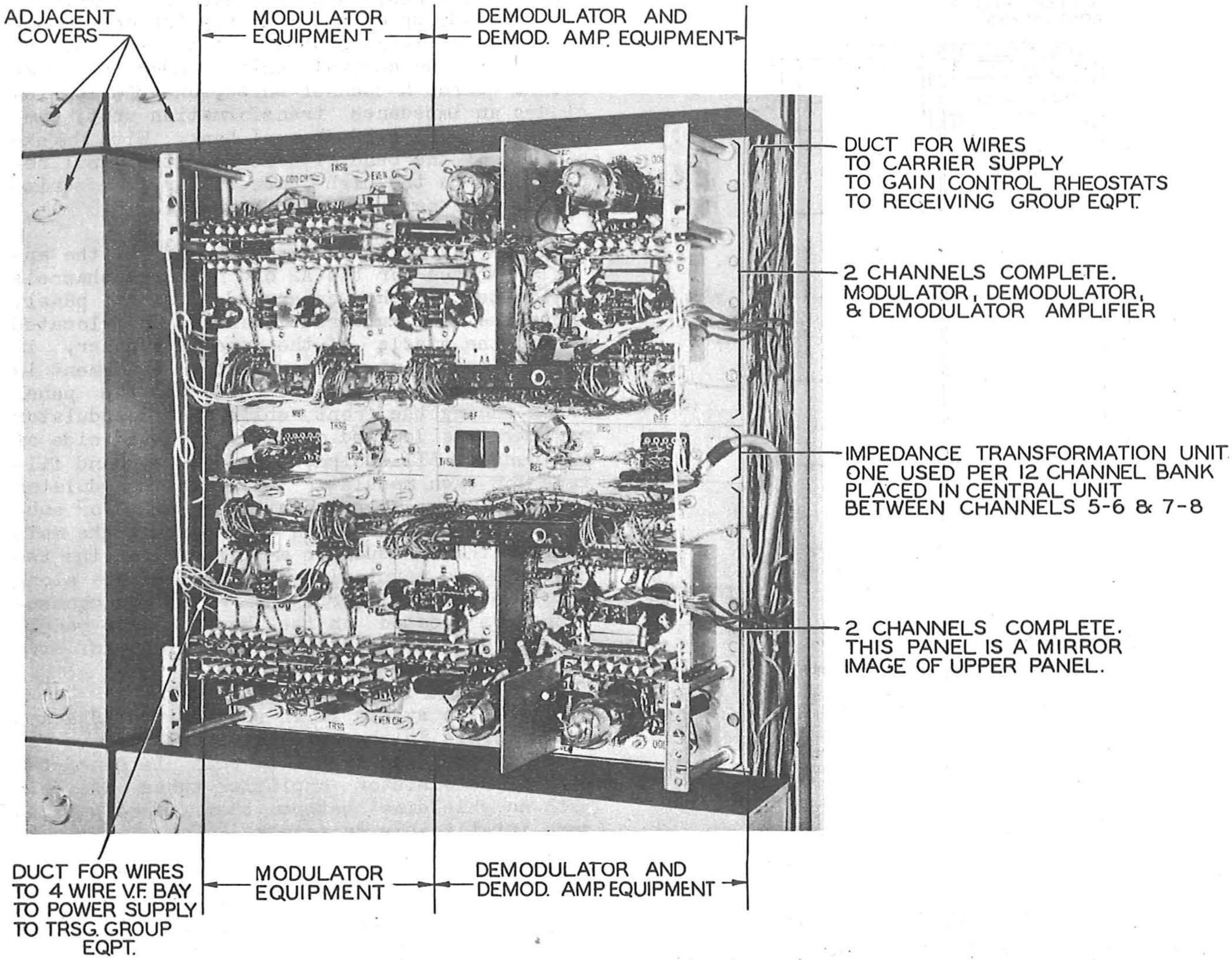


Fig. 21 - Channel Modem Unit - A2 Bank - Front View

switchboard cables (for 4-wire VF separation), directly to the 4-wire voice frequency testing and monitoring jacks described in part 3. The leads to the carrier supply bay and to the demodulator amplifier gain control rheostat (associated with the 4-wire voice frequency testing and monitoring jacks) are cabled directly with #1475 or #1476 shielded switchboard cable. The bays should be laid out so that the leads to this rheostat do not exceed 150 feet. A greater length of this lead affects the transmission frequency characteristic of the channel.

5. EQUIPMENT CONSIDERATIONS

5.01 The cabling arrangement and the single-side wiring and maintenance method of mounting the equipment have been fully covered in the section describing the line and twist amplifiers for the type K carrier system.

6. BATTERY SUPPLY CIRCUITS

6.01 The battery supply circuit of the demodulator amplifier is shown in Fig. 24. The central office 24-volt regulated battery is required for the heaters of the vacuum tubes. The heaters of the tubes in two demodulator amplifiers are connected in series. 130-volt battery ± 5 volts is required for the plate supply.

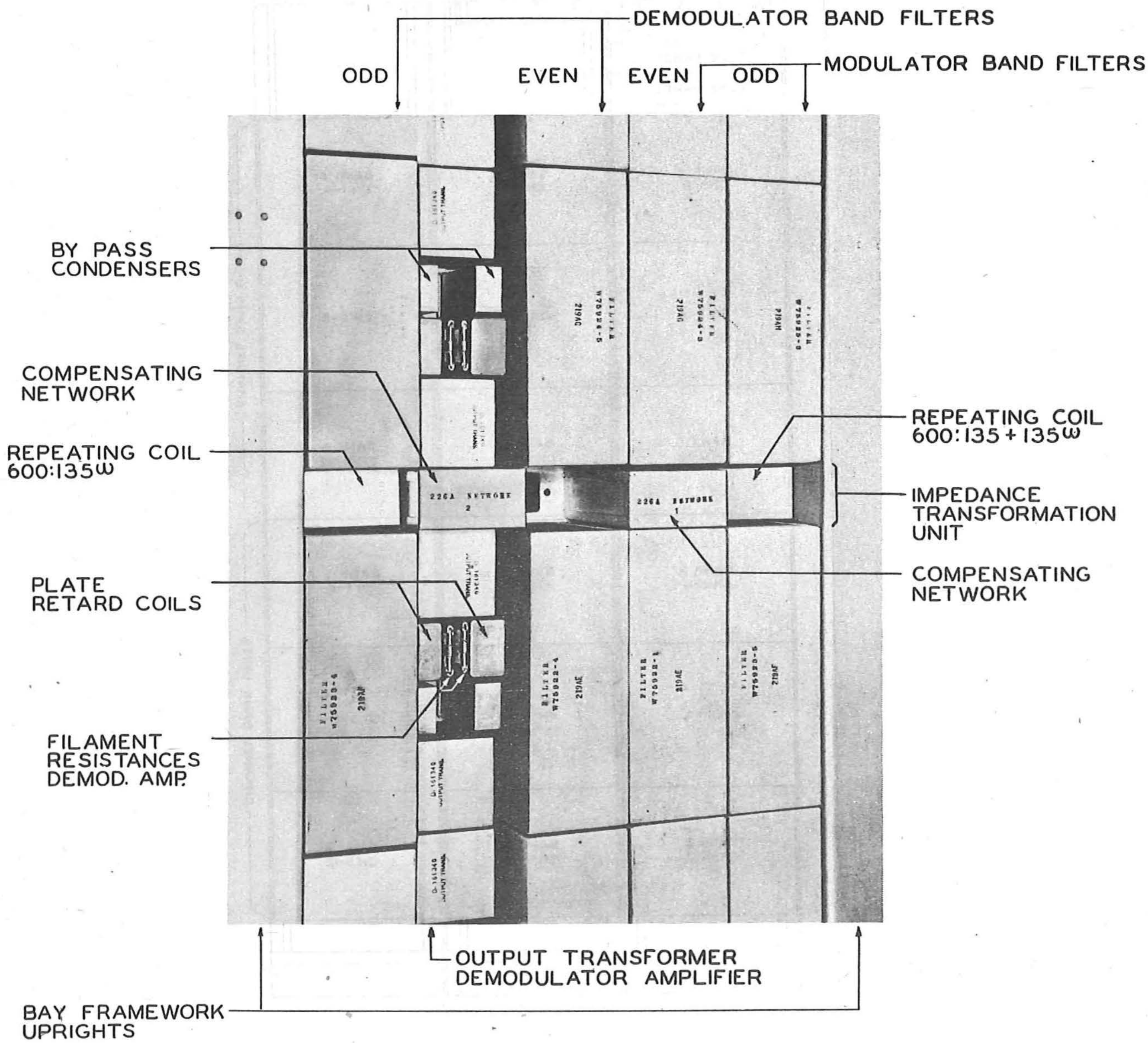


Fig. 22 - Channel Modem Unit - A2 Bank - Rear View

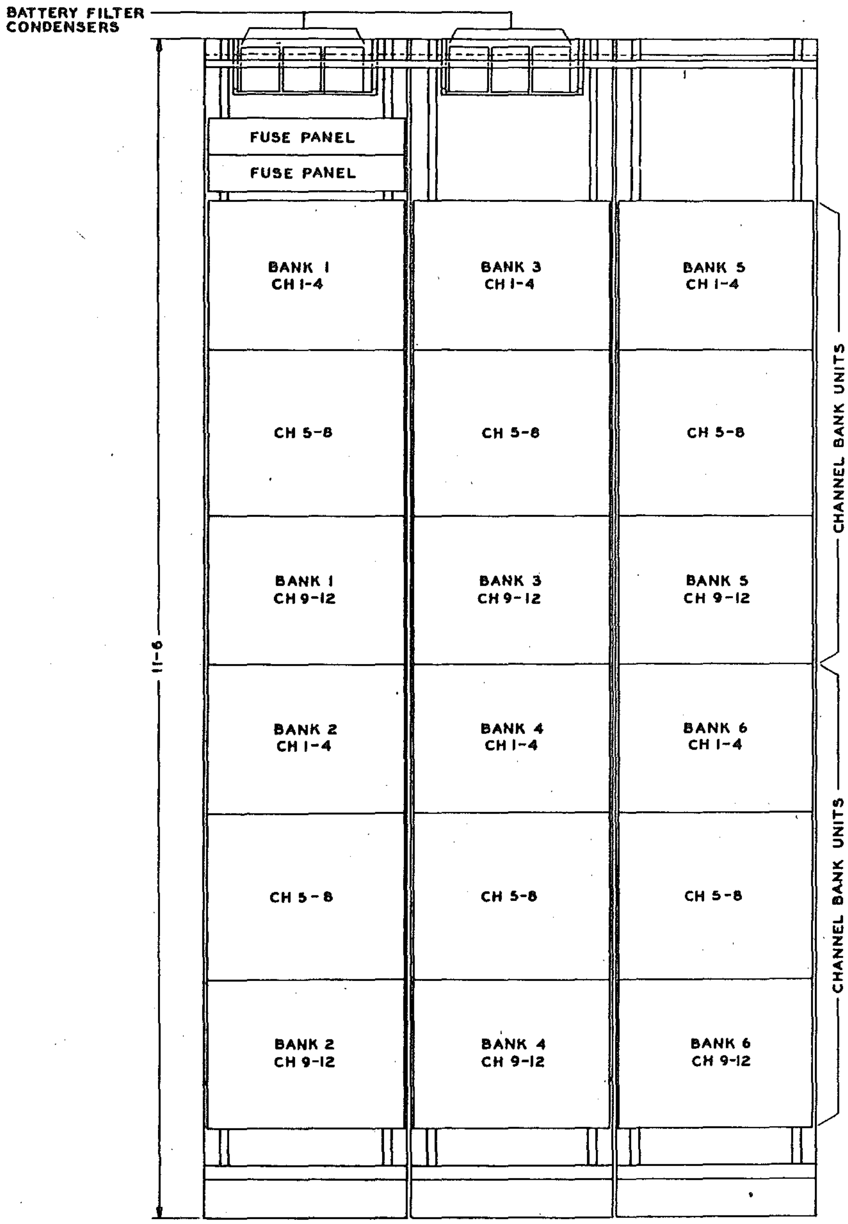
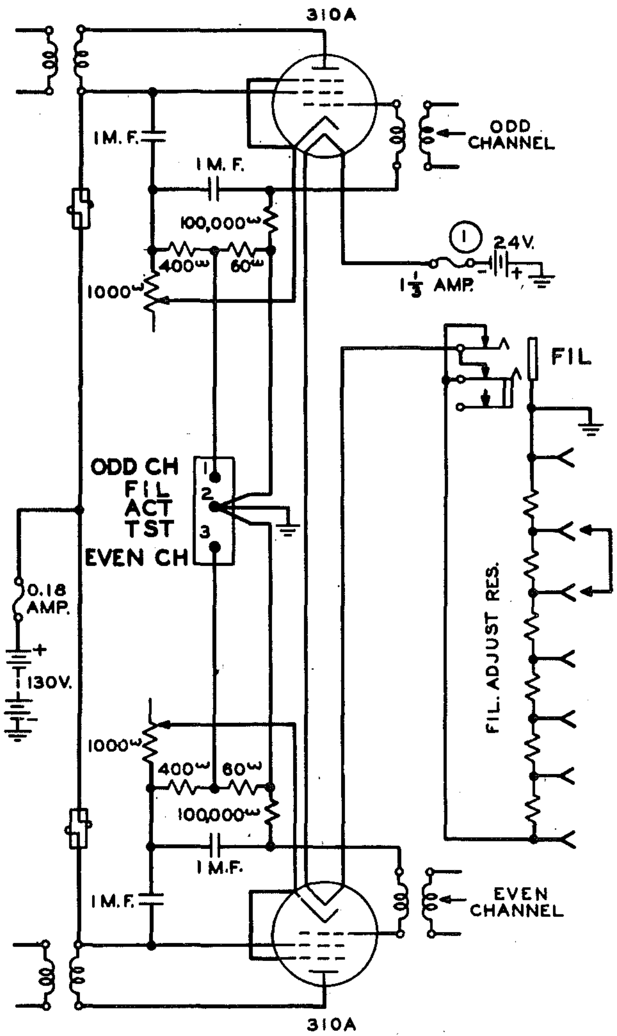


Fig. 23 - Bay Layout - A2 Bank



① SUPPLEMENTARY FILTER NOT PROVIDED.

Fig. 24 - Battery Supply Circuit for Demodulator Amplifier - A1 and A2 Bank

7. DRAWINGS

SD-Drawings (not attached)

SD-55348-01 - Two-Way Automatic Trunk
SD-55392-01 - 1000-Cycle Signal Receiving Circuit
SD-55393-01 - Cut-Off Relay for 1000-Cycle Signal Circuit
SD-59095-01 - Battery Supply Filter Circuit
SD-59105-01 - Channel Modem Circuit Type A2
SD-59106-01 - Application Schematic - 12-Channel Bank - Type A2
SD-64048-01 - 4-Wire Monitor and Talking Circuit
SD-64098-01 - 1U Amplifier Rectifier
SD-64303-01 - Voice Frequency Patching and Monitoring Jacks Amplifier Control and Pad Circuits
SD-64304-01 - 4-Wire Terminating Set
SD-64308-01 - Individual Alarm Circuit
SD-64311-01 - Application Schematic - 12-Channel Bank - Type A1
SD-64312-02 - Channel Modem Circuit - Type A1
SD-95100-01 - Transmission Measuring Test Trunks

ED-Drawings (not attached)

ED-62007-01 - 4-Wire VF Patching, Monitoring and Testing Bay
ED-62012-01 - Key and Jack Panel for 4-Wire VF Bay
ED-62037-01 - 4-Wire VF Jack Panel
ED-62233-01 - A2 Channel Modem Unit
ED-62234-01 - A2 Impedance Transformation Unit
ED-62309-01 - A2 Banks in 11'6" Bays
ED-62310-01 - A2 Banks in 10'6" Bays
ED-64303-04 - IDF Terminal Strip Layout
ED-61804-01 - A1 Channel Banks in 11'6" Bays
ED-61807-01 - A1 Channel Banks in 10'6" Bays
ED-64312-01 - A1 Channel Modem Unit