

TYPE K CARRIER TELEPHONE SYSTEM
K-1 LINE AND TWIST AMPLIFIERS

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(D) Line and Twist Amplifiers, Amplifier Deviation Equalizer, and Cable Deviation Equalizer	3	1.01 This section, prepared by the Bell Telephone Laboratories, describes the line amplifier, twist amplifier, twist regulator network, and deviation equalizers used in the type K carrier telephone system.	
3. LINE AMPLIFIER	3	1.02 The master flat gain and twist controllers, which are associated with the line amplifiers and the twist regulators, are described in the section covering the master transmission regulating arrangements for the type K carrier telephone system.	
(A) Circuit	3	1.03 The receiving amplifier at a terminal station is identical with one-half of a repeater, as covered herein.	
(B) Line Equalizer	4	<u>2. TYPES OF STATIONS</u>	
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4. TWIST AMPLIFIER, TWIST REGULATOR NETWORK, AND DEVIATION EQUALIZERS	8	2.02 In this type of repeater station, as indicated in Fig. 1-A, no provision is made for twist regulation or for amplifier or cable deviation equalizers. This arrangement is used at all auxiliary carrier repeater stations, either with or without flat gain regulation, and at main repeater stations where twist regulating equipment and deviation equalizers are not required.	
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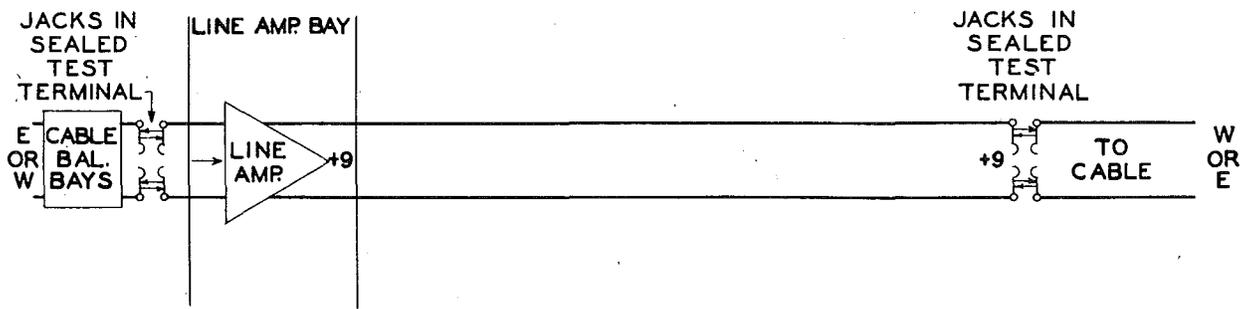


FIG. 1-A REPEATER STATION WITH FLAT GAIN LINE AMPLIFIER ONLY. NO TWIST AMPLIFIER OR DEVIATION EQUALIZERS.

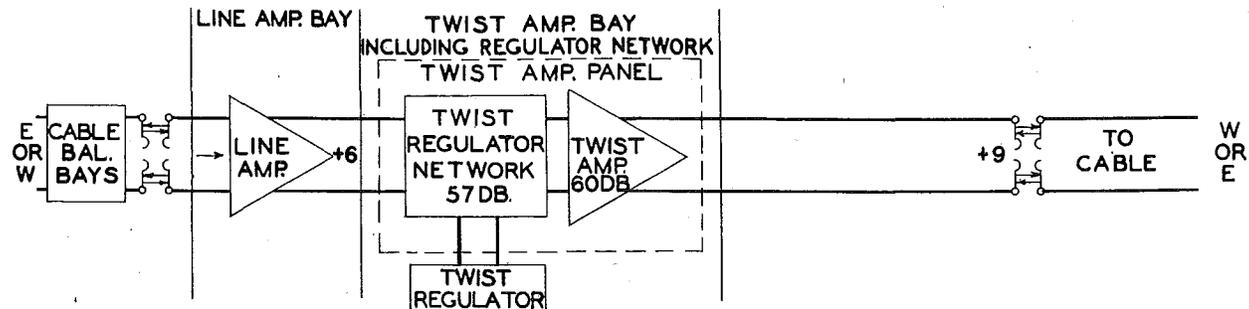


FIG. 1-B REPEATER STATION WITH FLAT GAIN LINE AMPLIFIER AND TWIST AMPLIFIER. NO DEVIATION EQUALIZERS.

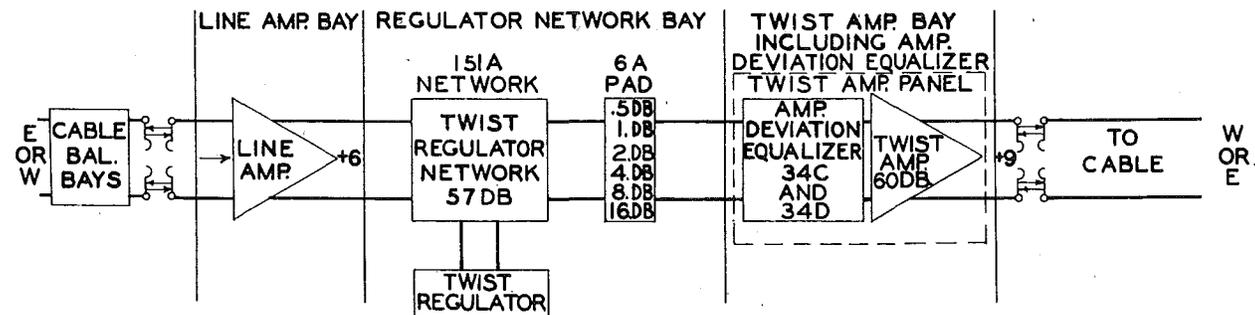


FIG. 1-C REPEATER STATION WITH FLAT GAIN LINE AMPLIFIER, TWIST AMPLIFIER AND AMPLIFIER DEVIATION EQUALIZER. NO CABLE DEVIATION EQUALIZER.

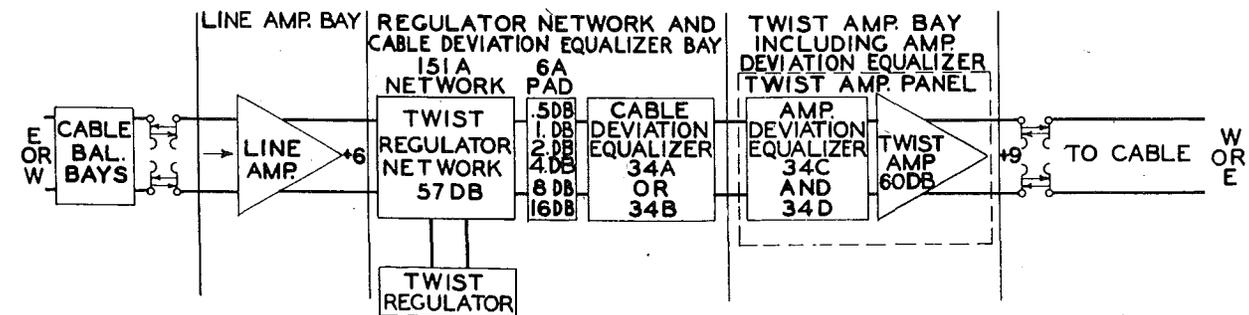


FIG. 1-D REPEATER STATION WITH FLAT GAIN LINE AMPLIFIER, TWIST AMPLIFIER, AMPLIFIER DEVIATION EQUALIZER AND CABLE DEVIATION EQUALIZER.

Fig. 1 - Typical Circuit Arrangement of Line Amplifiers, Twist Amplifiers, and Deviation Equalizers at Repeater Stations.

(B) Line and Twist Amplifiers

2.03 This type of repeater station involves line and twist amplifiers and twist regulating equipment as indicated in Fig. 1-B, but no amplifier or cable deviation equalizers, and is used at certain main repeater stations. As indicated in the figure, the line amplifiers are mounted in one bay, and the twist amplifiers and twist regulator networks are mounted in another bay. As discussed in paragraph 5.05, these may be arranged in a three-bay layout to facilitate the addition of equalizers which may be specified later.

(C) Line and Twist Amplifiers, and Amplifier Deviation Equalizer

2.04 This type of repeater station requires a group of 3 bays as indicated in Fig. 1-C, namely, (a) line amplifier bay, (b) twist regulator network and pad bay, and (c) twist amplifier, and amplifier deviation equalizer bay.

(D) Line and Twist Amplifiers, Amplifier Deviation Equalizer, and Cable Deviation Equalizer

2.05 This arrangement, as indicated in Fig. 1-D, is used at certain main repeater stations. A group of 3 bays is required, namely, (a) line amplifier bay, (b) twist regulator network, pad, and cable deviation equalizer bay, and (c) twist amplifier, and amplifier deviation equalizer bay.

3. LINE AMPLIFIER(A) Circuit

3.01 In Fig. 2 is shown a simplified schematic of the line amplifier circuit. The amplifier is a three-tube circuit of the negative feedback type using two 310A tubes and one 311A tube. The amplifier possesses unusual stability of operation with respect to tube variations and power supply fluctuations, which, of course, is very important when many amplifiers are connected in tandem in a long circuit. It is unusually free from any non-linear distortion which would produce interchannel crosstalk, a characteristic which is essential when many channels are operating through the same amplifier. Noise within the amplifier has been suppressed to approach the limit set by thermal agitation.

3.02 Provision has been made in the amplifier for adjustment of the absolute gain to compensate for different lengths of cable sections, and for differences in attenuation of the individual carrier pairs. The gain of the amplifier can be reduced by a 7 db and 14 db tap on the output bridge, and a 5 db tap on the input transformer. The "flat gain control condenser" (GC) provides an adjustment in gain over a 9 db range. It is adjusted by means of a screw-driver-type dial shown in Fig. 3.

3.03 The gain of the amplifier is automatically regulated by an air condenser in the feedback circuit to compensate for the attenuation change in the cable pair at 28 kc. due to temperature variations.

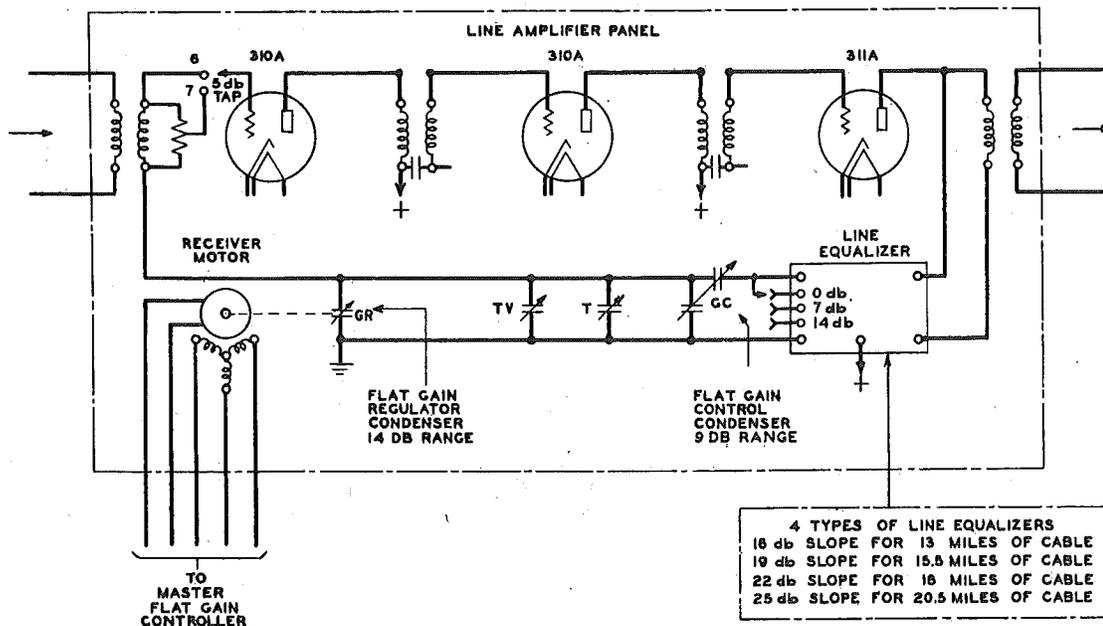


Fig. 2 - Line Amplifier - Simplified Schematic.

This condenser is called the "flat gain regulator condenser" (GR) and has a range of about 14.3 db. A dial is provided on the condenser to show its setting. The dial is divided into 60 divisions (56 divisions useful range; 0 to 2 and 58 to 60 provide mechanical margin). The condenser is geared to a receiver motor mounted on the amplifier panel. This motor is operated by the master flat gain controller as discussed in the section describing the master transmission regulating arrangements. Four db of the range of adjustment of the GR condenser is used in the case of the repeater section immediately preceding a twist correction station to compensate for the variable loss in the twist regulator network as explained in Part 4 (C). With systems on underground cable it is sometimes possible to omit flat gain regulation at certain stations, in which case the air condenser (GR), and receiver motor are omitted. In this case, the gain of the amplifier is reduced 7.1 db below the gain obtained with the GR condenser on mid-step (division 30 on the dial). In this case it is necessary to operate the repeater at a sufficiently reduced output level so that it will not overload at low temperatures when the line attenuation is a minimum.

3.04 The "trimmer variable" condenser (designated "TV" in Fig. 2) permits adjustment of the rate of regulation to the particular carrier pair with which the amplifier is associated. Its effect is to change the total range of the "GR" condenser about $\pm .2$ db. Condenser "T" is adjusted at the factory to obtain 0.255 db change in gain per division of the "GR" condenser. This condenser will not require readjustment in the field. ($0.255 \text{ db} \times 56 \text{ divisions} = 14.28 \text{ db}$.)

(B) Line Equalizer

3.05 In Fig. 2 it will be noted that the line equalizer is located in the feedback circuit. By this arrangement the overall gain of the amplifier is given a sloping characteristic which is approximately equal to the sloping loss characteristic of a cable pair for a repeater sec-

tion. Four types of line equalizers have been made available, which will compensate for approximately 13, 15.5, 18, and 20.5 miles, respectively, of 19-gauge cable. These provide a difference in gain between 12 and 60 kc. of approximately 16, 19, 22, and 25 db, respectively, or a difference in slope between equalizers of 3 db. Actual repeater section lengths will ordinarily differ somewhat from the above values, so that an equalizer will seldom equalize exactly a given repeater section. The equalizer is mounted on the amplifier panel as shown in Figs. 10A and 10C.

(C) Transmission Characteristics

3.06 The gain-frequency characteristics of the line amplifier with and without feedback are shown in Fig. 4. As indicated in this figure, the gain is shown for all four types of equalizers in the amplifier circuit. The gains shown for the amplifier with the equalizers are approximately equal to the loss of 13, 15.5, 18, and 20.5 miles, respectively, of 19-gauge circuit at 55° F. when properly adjusted for flat gain. The gain without feedback is obtained by grounding terminal 5 of the input transformer, connecting the variable input transformer lead to terminal 6, and closing straps X and Y (see SD-64337-01).

3.07 The change in gain of a line amplifier which is produced by the flat gain regulator condenser is shown in Fig. 5. This figure shows the gain over the 12 to 60-kc. range of an amplifier equipped with a 30A equalizer (19 db slope). A change in flat gain of ± 4.5 db is indicated, which corresponds to a temperature change of $\pm 55^\circ \text{ F}$. on a 15.5-mile circuit. As indicated in this figure, changes in the flat gain regulator condenser produce a constant change in gain at all frequencies.

3.08 The slopes of the four equalizers with the amplifier gain adjusted to the same value at 12 kc. is shown in Fig. 6.

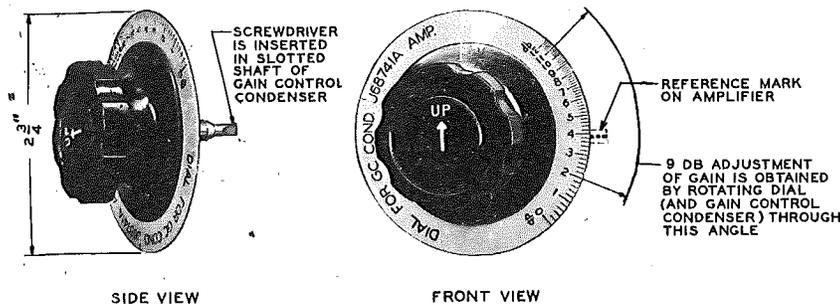


Fig. 3 - Screwdriver Dial for Adjusting GC Condenser on Line Amplifier.

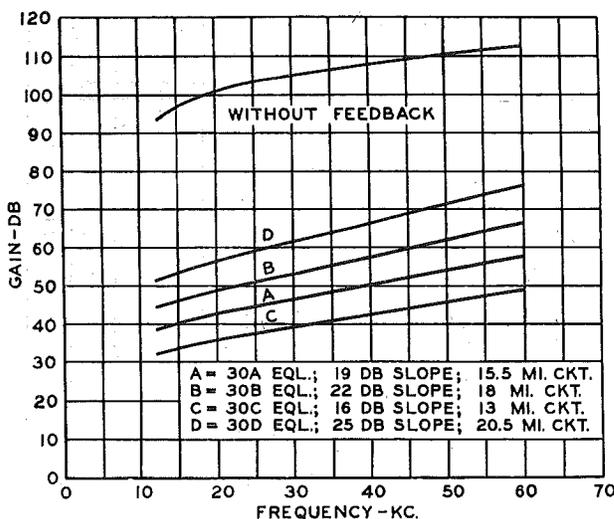


Fig. 4 - Line Amplifier Gain-Frequency Characteristics Without Feedback, and with 30A, 30B, 30C and 30D Line Equalizers in Feedback Circuit.

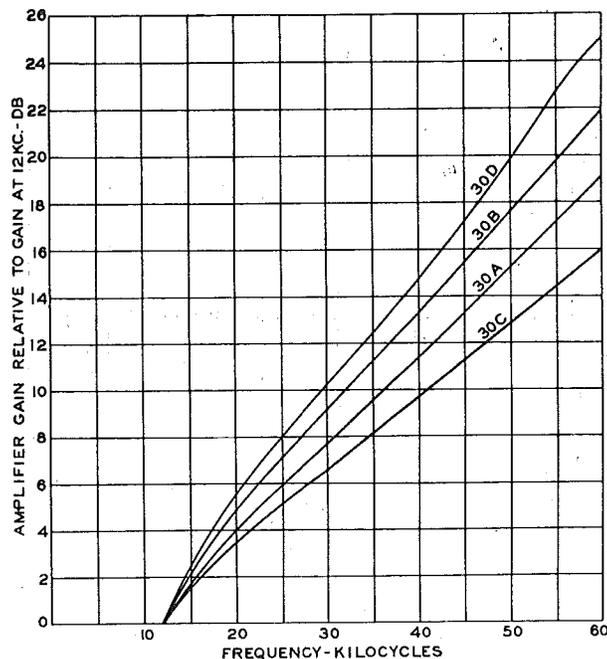


Fig. 6 - Slopes of Transmission Frequency Characteristics of Line Amplifiers Equipped with 30A, 30B, 30C and 30D Equalizers Adjusted to Same Gain at 12 Kc.

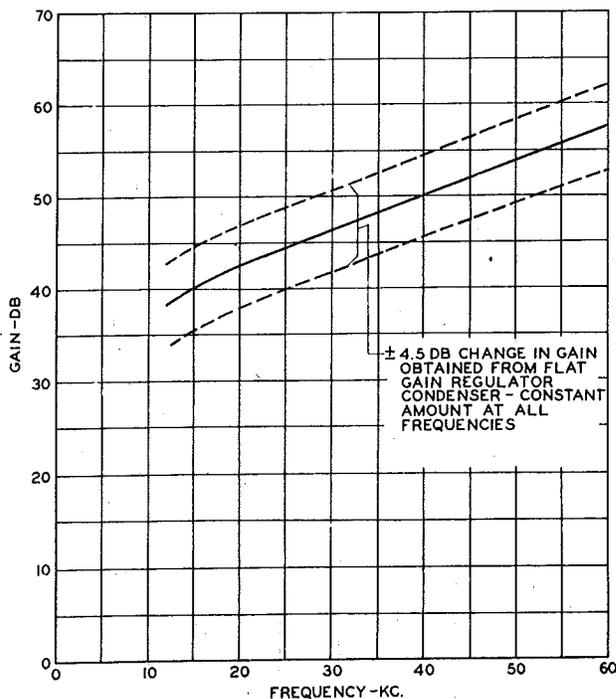


Fig. 5 - Line Amplifier Gain-Frequency Characteristics With 30A Equalizer (19 db slope) Showing Flat Gain Change of ± 4.5 db Corresponding to Temperature Change of $\pm 55^\circ$ F. on a 15.5-Mile Circuit.

3.09 A typical load characteristic of the line amplifier is shown in Fig. 7. The gain is practically constant up to loads of approximately 31 db above 1 milliwatt. The output level should be reduced about 1.5 db when terminal 10 is used on the line equalizer. Under this condition the grid bias for the 311A tube in the line amplifier is obtained from a drop across a resistance, instead of from grid batteries, and the plate potential is accordingly reduced about 16 volts.

3.10 Representative input and output impedances of the line amplifier are shown in Fig. 8.

3.11 Changes in gain of the amplifier due to filament and plate battery variations are negligible. Changes in gain due to temperature variations are not expected to exceed .01 db per amplifier, and about the same value for humidity variations.

3.12 The effect of feedback in the amplifier circuit on the reduction of the second harmonic modulation is shown in Fig. 9. In general, the generation of second harmonics in the amplifier is reduced by the amount of gain reduction (feedback) in the amplifier. In the typical case shown, the second harmonic is reduced about 45 db by feedback. There is a slight falling off in this suppression at the higher loads, as shown by the dotted curve in Fig. 9. All other harmonic products are similarly suppressed.

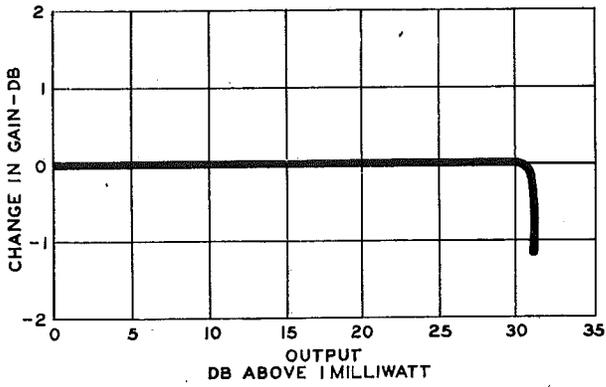


Fig. 7 - Line Amplifier - Load Characteristic (Measured at 15 Kc.).

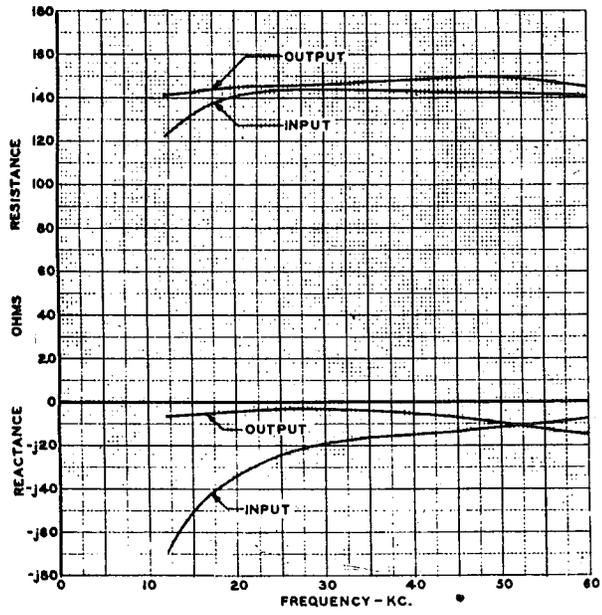


Fig. 8 - Line amplifier - Input and Output Impedances.

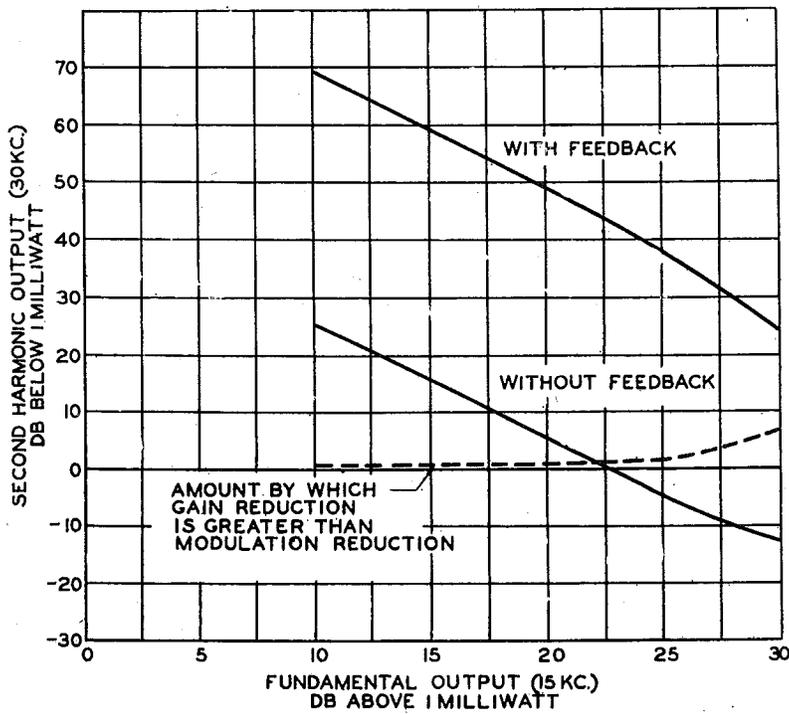


Fig. 9 - Line Amplifier - Second Harmonic Modulation.

(D) Panel Mounting

3.13 The line amplifier is shown in Figs. 10A, 10B, and 10C. As described more fully in Part 5, the transformers, networks and the line equalizer are mounted on the rear of the panel. Wiring and apparatus which are involved in the usual maintenance operation are mounted on the front of the panel. In addition to the vacuum tubes and jacks, this apparatus includes the trimmer variable, gain control, and gain regulator condensers in the feedback circuit, and the motor which sets the position of the flat gain regulator condenser. As indicated in

Fig. 10B, cutouts are provided in the cover so that adjustments and tests can be made without removing the cover. The tubes can be tested (by means of the jacks) and the dial indicating the position of the automatically controlled regulator condenser "GR" can be read while the amplifier is in service. The gain control condenser "GC" is adjusted by a screwdriver which is attached to a dial with a scale marked in "db's." By using this "screwdriver dial" in conjunction with the reference mark shown in Fig. 10B, the flat gain of the amplifier can be adjusted over a range of about 9 db.

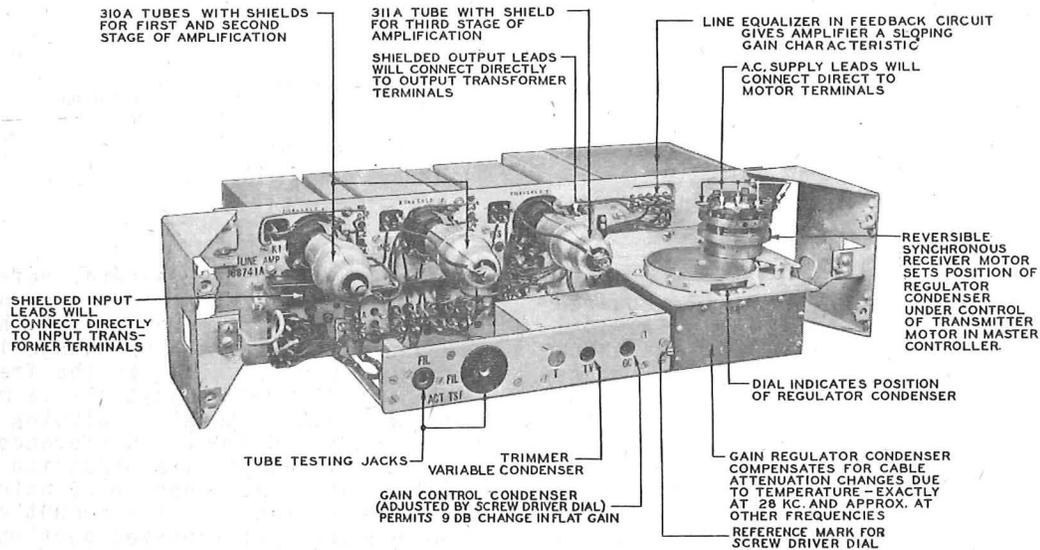


Fig. 10A - Line Amplifier Panel - Front View.

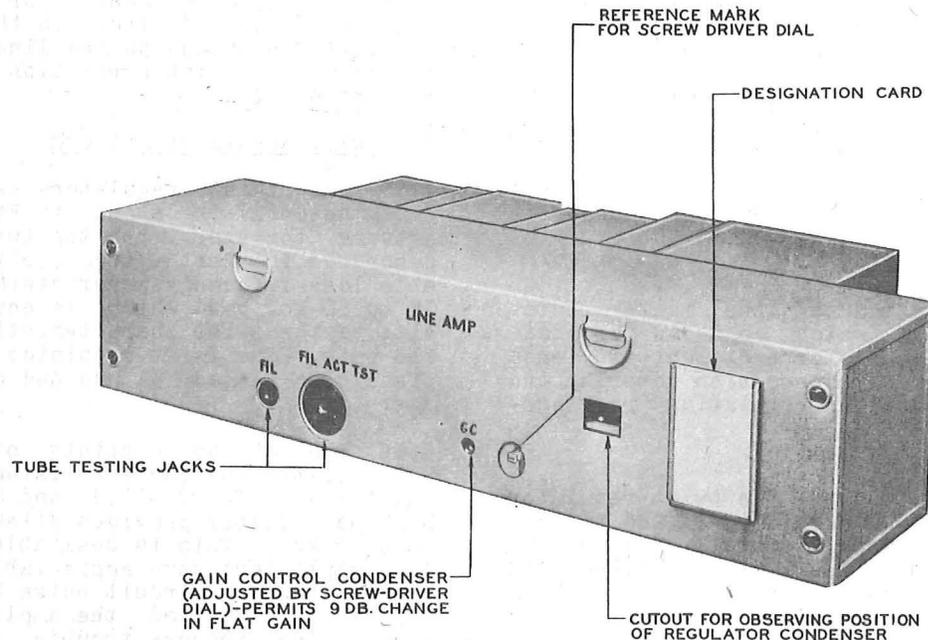


Fig. 10B - Line Amplifier Panel - Front View with Cover.

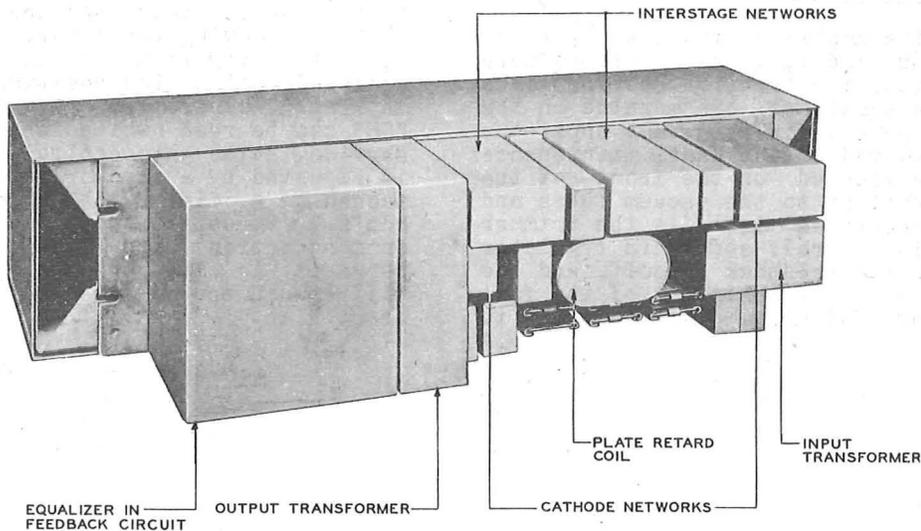


Fig. 10C - Line Amplifier Panel - Rear View.

3.14 The input and output leads to this amplifier are pairs in rubber-covered shielded cables (not shown in Fig. 10A) which are connected directly to the input and output transformers. Since these transformers are near the left and right-hand sides of the panel, the input and output leads connect from opposite sides and are well separated. The leads to the motor carry alternating current and they are therefore connected from the right-hand side of the panel to prevent these leads from introducing noise into the input of the amplifier. As the heater, plate and grid supply leads have to be free from any disturbing currents, they are connected to the left or input side of the panel.

4. TWIST AMPLIFIER, TWIST REGULATOR NETWORK, AND DEVIATION EQUALIZERS

4.01 The method of choosing twist correction stations is covered in separate information.

4.02 A description of the master twist controller which controls the individual twist regulator equipment in each system is given in the section covering the master transmission regulating arrangements.

4.03 A description of the twist regulator equipment which is provided at certain points in each system is given below. Referring to Fig. 1B, it will be noted that the equipment required for twist regulation consists of three parts:

- (1) Twist Regulator Network
- (2) Twist Regulator
- (3) Twist Amplifier

4.04 "Twist" as used herein, refers to the differences in rate of change of attenuation with temperature at the various frequencies. The rate of change is highest at about 28 kc., which is the frequency at which the flat gain adjustment is made. The purpose of the twist regulating equipment is to compensate for the differences between the rate of change of attenuation at 28 kc. and the rates at other frequencies in the 12 to 60-kc. range. The amount of correction required per repeater section is small and is, therefore, permitted to accumulate over several sections before correction is made. This adjustment for temperature changes is in addition to the flat gain regulation provided on the line amplifiers. The amount of twist correction is discussed in Part 4 (C).

(A) Twist Regulator Network

4.05 The twist regulator network (151A network) is shown in Fig. 11. This network, together with the twist regulator described in Part 4 (B), provides a variable loss-frequency characteristic in the 12 to 60-kc. band which is equal and opposite to the twist characteristic of the cable pair. The twist regulator network consists of a 3A-pad, 4A pad and a 31A equalizer.

4.06 The 3A pad consists of a high-pass filter and three resistance pads having losses of 20, 11.4 and 8.6 db. The high-pass filter provides attenuation below about 9 kc. This is desirable because the line amplifiers have appreciable gain below 12 kc., and any circuit noise below 12 kc., would tend to load the amplifiers. This filter also reduces trouble from singing. The resistance pads of 20 and 11.4 db are required for proper operation of the 31A equalizer. When the cable and amplifier

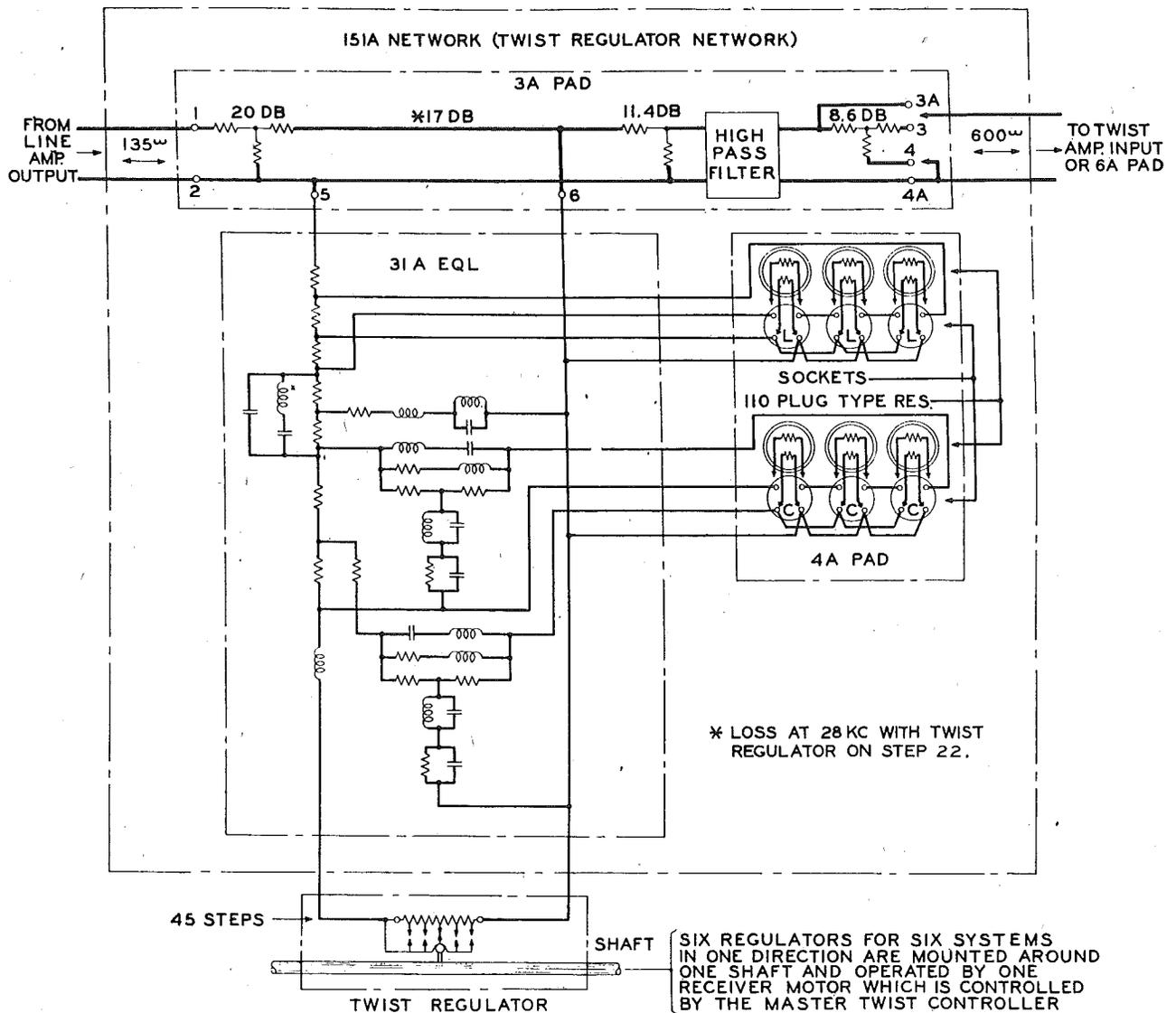


Fig. 11 - Twist Regulator Network and Twist Regulator.

deviation equalizers are not used, the 8.6 db pad is connected into the circuit, by connecting to terminals 3 and 4A, with a strap between terminals 4 and 4A. When either or both of the amplifier and cable deviation equalizers are used, the 8.6 db pad is left out of the circuit by connecting to terminals 3A and 4A, and the strap between terminals 4 and 4A is removed.

4.07 The 31A equalizer is the basic shape and control unit which is bridged on the circuit between the 20 db pad and 11.4 db pad mentioned above. This equalizer, together with the 4A pad and twist regulator described below, provides the required characteristic to compensate for the "twist" in the cable attenuation-temperature characteristic.

4.08 The 4A pad is principally a mounting with six sockets for an equal number of four-prong plug-type resistances. The sockets are wired to the 31A equalizer. Three of the sockets designated "L," and plug-type resistances used therewith, in association with the 31A equalizer, are referred to as "length" control, and the other three sockets designated "C," and plug-type resistances used therewith, in association with the 31A equalizer, are referred to as "Coefficient" control. They are used to adjust the regulator network to the individual twist of a particular carrier pair. 110-type resistances (plug-type) are used with each twist regulator network (for code numbers see SD-64331-011). Within each plug there are two separate resistances, as indicated in Fig. 11. The resis-

tance value designated for the plug is the resistance connected to the prongs having the smaller diameter. The circuit is designed so that the resistances within a plug are complementary to each other. For all plugs of this type the product of the two resistance values is approximately 30,060. The circuit is arranged so that one set of three resistances (see the "L" sockets in Fig. 11) is connected in series, and the other set is connected in parallel. The same arrangement applies to the "C" sockets.

4.09 The twist regulator network is mounted on the twist amplifier panel, as shown in Figs. 20A and 20B, when amplifier and cable deviation equalizers are not provided which is the condition indicated by Fig. 1B. When either or both of the amplifier and cable deviation equalizers are used, as indicated in Figs. 1C and 1D, the twist regulator network is mounted on a separate panel in a bay between the line amplifier bay and the twist amplifier bay, as shown in Fig. 28.

(B) Twist Regulator

4.10 In Fig. 11 is shown a schematic of the twist regulator connected to the 31A equalizer in the 151A network (twist regulator network). The twist regulator is in effect an adjustable resistance having 45 steps which operates under the control of the master twist controller described in a section covering the master transmission regulating arrangements. At 55°, which is approximately the middle of the cable temperature range, the twist regulator is set on mid-step (step 22) by the master twist controller. For higher and lower cable temperatures, the master twist controller operates the twist regulator to corresponding steps.

4.11 Six twist regulators, each of which is associated with a different twist regulator network, are geared to one receiver motor and this equipment is assembled on a panel as shown in Figs. 12A and 12B. Each of these six regulators actually consists of two units - a right-hand sector and a left-hand sector - mounted in the same compartment, as shown in Fig. 12B.

4.12 There are two roller arms in each compartment which are attached to the shaft driven (through speed reduction gears) by the motor. One of these arms in each compartment will operate the contacts on the left-hand sector of the regulator during the first 22 steps and the other arm will operate the contacts on the right-hand sector of the regulator during the other half revolution. Each pair of right and left-hand sectors of a regulator is so connected that the regulator resistance is varied in 45 steps by a full revolution of the shaft. The resistance of the regulator is determined by the contacts which are operated and this in turn is determined by the position of the shaft and roller arms. These resistances are graduated in such a manner that the correction inserted by the twist regulator network is the same for each step of the twist regulator.

4.13 As indicated in Fig. 12A, the contacts on the regulators are protected from dust by a cover. The entire assembly has another cover (not shown in Figs. 12A or 12B) which is of the same construction as the covers used for the amplifier panels. This latter cover has a cutout which permits the position of the roller arms, as indicated by the dial, to be read without removing this cover. The position of the shaft and roller arms may be adjusted by hand as indicated in Fig. 12A. The regulator units can be removed for maintenance or replacement, as shown in Fig. 12B, where both left and right-hand units have been removed from compartment No. 6.

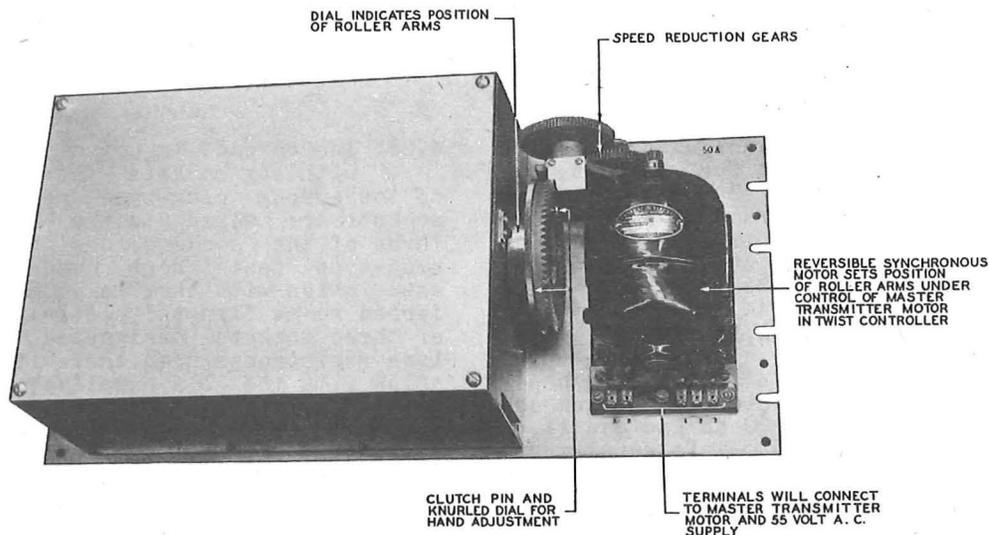


Fig. 12A - 50A Drive (Receiver Motor and Six Regulators)
Front View with Cover on Regulators.

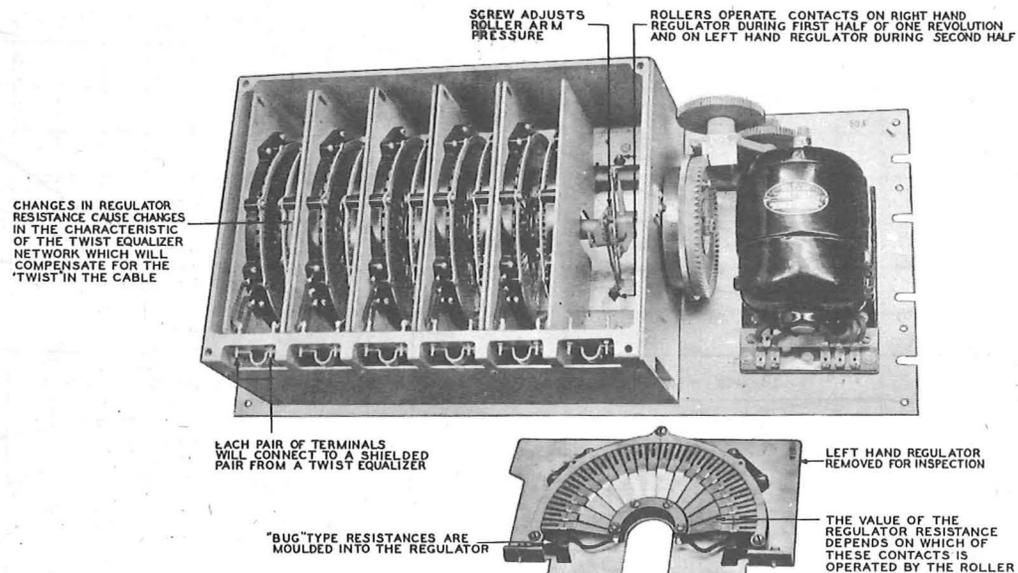


Fig. 12B - 50A Drive (Receiver Motor and Six Regulators)
Front View - Cover Removed.

(C) Transmission Characteristics of Twist Regulator Network and Twist Regulator

4.14 Referring to Fig. 11, the loss of the twist regulator network is shown as 57 db (20 + 17 + 11.4 + 8.6 db). This is the case when the twist regulator is on mid-step, step 22. When the twist regulator is operated over its range, however, the loss through the twist regulator network varies about ± 2 db at 28 kc. This is illustrated in Fig. 13, which shows the change in loss through the twist regulator network for several steps on the twist regulator with respect to the loss on step 22. As noted in Fig. 13, the loss through the twist regulator network is practically constant for the 12 to 60-kc. range on step 22 of the regulator. When the regulator is on steps between 22 and 44, the loss through the twist regulator network is increased and has a characteristic shape as indicated for regulator steps 33 and 44. Similarly, when the regulator is on steps between 22 and 0, the loss through the twist regulator network is decreased and has a characteristic shape as indicated for regulator steps 11 and 0. The characteristic of the twist regulator network, as indicated in Fig. 13, is designed to be equal and opposite to the so-called "twist" in the cable characteristic. The five curves of Fig. 13 correspond to five different cable temperatures for a particular cable pair.

4.15 The characteristics shown in Fig. 13 are for an adjustment of the twist regulator network using values of "L" (length control) of 0 ohms, and "C" (coefficient control) of 42.2 ohms. In Fig. 14 are shown the characteristics of the regulator network with the regulator on steps

0, 22 and 44 and with values of "L" = 0 ohms, and three different values of "C," namely, 0.4, 42.2 and 2110 ohms. From these curves it will be noted that the shape of the twist regulator network characteristic is determined by the value of "C," i.e., a smaller value of "C" produces a larger difference in attenuation through the network between 28 and 60 kc. The magnitude of the correction is controlled by adjusting the value of "L." As "L" is increased the total amount of correction per step at each frequency is reduced. This is illustrated in Fig. 15, which shows the twist regulator network characteristics with three adjustments of the "L" resistance. The values of "L" and "C" should be chosen which give a twist characteristic which most nearly matches the individual cable pair twist.

(D) Twist Amplifier

4.16 Referring to Fig. 1B, the loss of the twist regulator network, 57 db, is offset by the twist amplifier. Since the line amplifier is operated at 3 db lower output level at twist correction stations, because of the variation in loss through the twist regulator network of about ± 2 db, a fixed gain of about 60 db is employed in the twist amplifier to deliver an output level of +9 db to the cable pair. When either or both of the amplifier and cable deviation equalizers are used, as shown in Figs. 1C and 1D, the same gain in the twist amplifier (about 60 db) is provided, since under these conditions the 8.6 db pad in the twist regulator network (Fig. 11) is strapped out, and the 6A pad is strapped so that its loss, plus the loss of the amplifier and cable deviation equalizers at 28 kc., equals 8.6 db. There is an exception

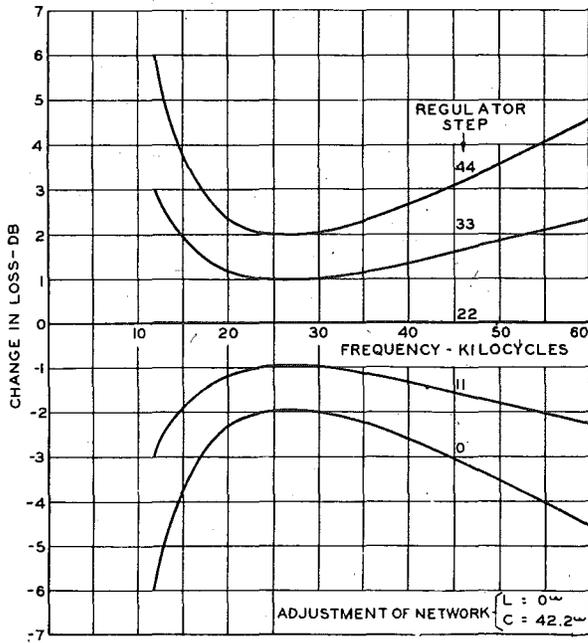


Fig. 13 - Twist Regulator Network Characteristics for Several Steps on the Regulator with a Given Adjustment of the "L" and "C" Resistance.

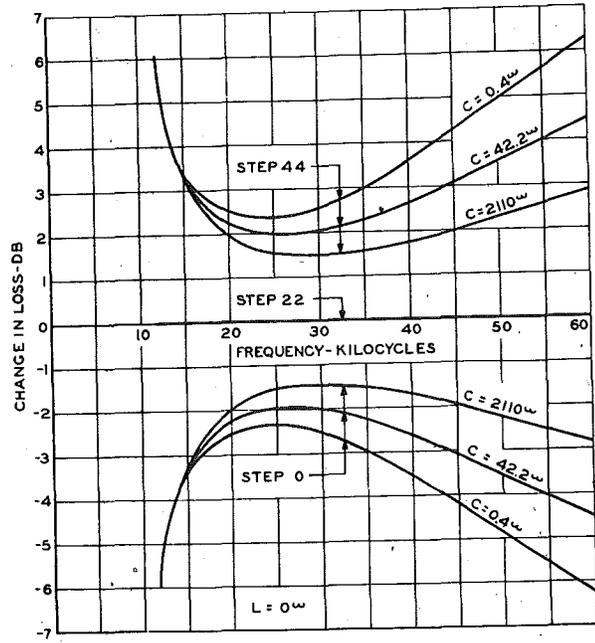


Fig. 14 - Twist Regulator Network Characteristics for Three Adjustments of the "C" Resistance.

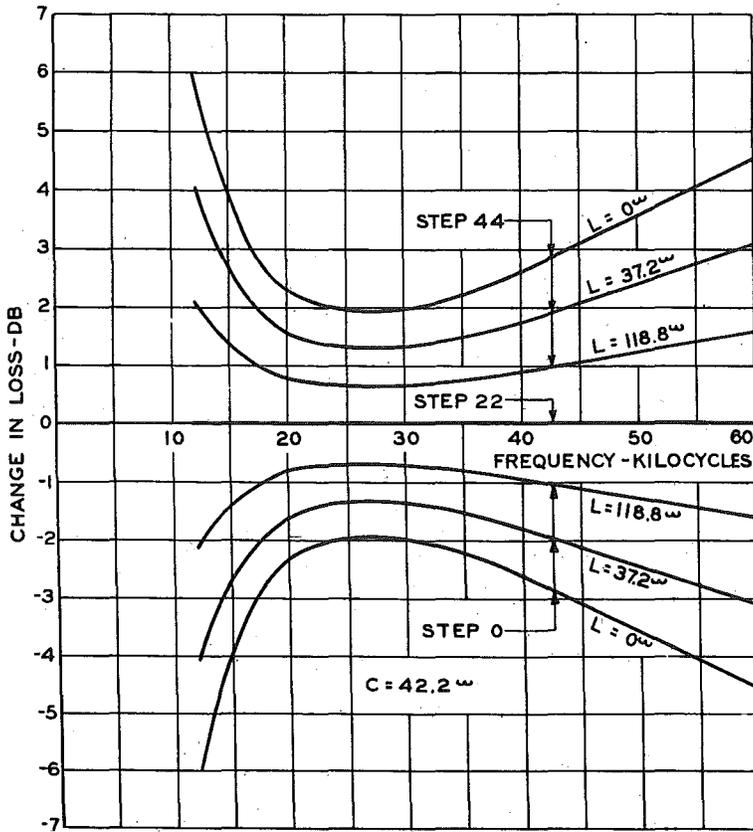


Fig. 15 - Twist Regulator Network Characteristics for Three Adjustments of the "L" Resistance.

when the "Z" strap is on terminal 10 of the line equalizer. In this case the output of the line amplifier will ordinarily be 1.5 db lower than normal, so that 1.5 db should be removed from the 6A pad.

4.17 In Fig. 16 is shown a simplified circuit of the twist amplifier, which is of the negative feedback type and possesses the same stable characteristics as the line amplifier. It also uses two 310A tubes and one 311A tube. Grid battery bias of 16 volts \pm .8 volt is used on the 311A tube. (A similar circuit and equipment panel are used as the transmitting amplifier at terminal stations, with a 2 db input pad; as an auxiliary switching amplifier in the line switching circuit, with a balanced input coil and 12.4 db input pad; and as a test amplifier in the 42A transmission measuring system, with a 2 db input pad. For these uses a gain of 66 db is obtained from the amplifier by strapping in a pad in the 164A network in the "outer" feedback circuit, strapping out a 36.5-ohm resistance

in the "inner" feedback circuit, and connecting to terminal 4, instead of terminal 1, on the input coil; see SD-64329-011 and SD-64329-021.)

4.18 At repeater stations, the output of the twist amplifier is connected through jacks in the sealed test terminal to the cable pair. At terminal stations, the output of the twist amplifier is connected through jacks in the high frequency patching bay to the group demodulator circuit in the group modem.

4.19 In Fig. 17 is shown the gain of the twist amplifier, with and without feedback. It will be noted that the gain is flat over the working range of 12 to 60 kc.

4.20 In Fig. 18, are shown representative input and output impedances of the twist amplifier. The input impedance is nominally 600 ohms (unbalanced), and the output impedance is nominally 135 ohms (balanced) over the range from 12 to 60 kc.

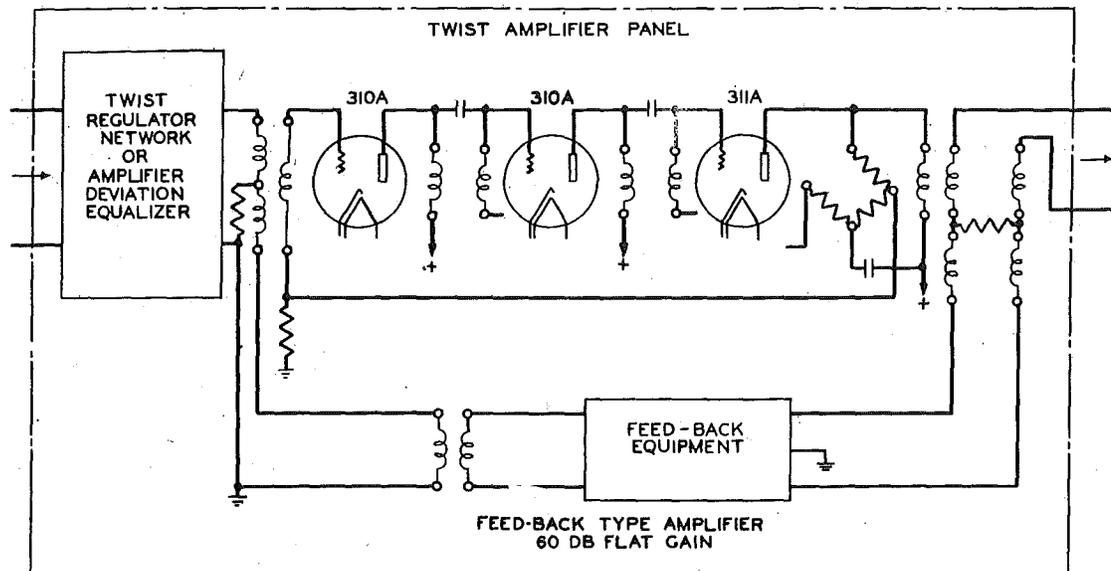


Fig. 16 - Twist Amplifier - Simplified Circuit.

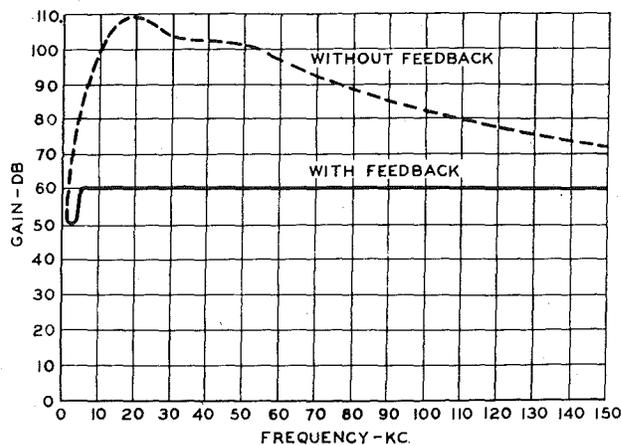


Fig. 17 - Twist Amplifier Gain With and Without Feedback.

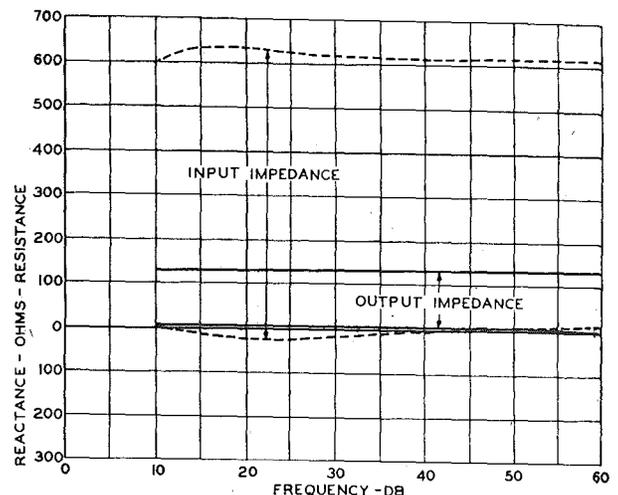


Fig. 18 - Twist Amplifier - Input and Output Impedances.

4.21 In Fig. 19 is shown a typical load characteristic of the twist amplifier. The gain of the amplifier is substantially constant for single frequency loads up to approximately 31 db above 1 milliwatt.

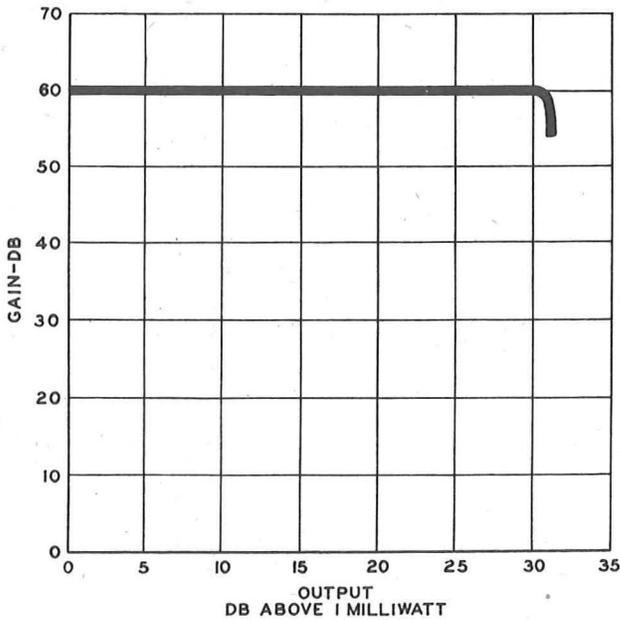


Fig. 19 - Twist Amplifier - Load Characteristic (Measured at 15 Kc.).

4.22 The twist amplifier panel is shown in Figs. 20A and 20B. The apparatus which requires maintenance, and is therefore mounted on the front of the panel (see Fig. 20A), consists of the vacuum tubes, jacks and the pads of the twist regulator network. (In this picture, the sockets of the 4A pad are shown without plug-in resistances.) The equalizer of this regulator network and the rest of the amplifier apparatus are mounted on the rear of the panel (see Fig. 20B). Cutouts are

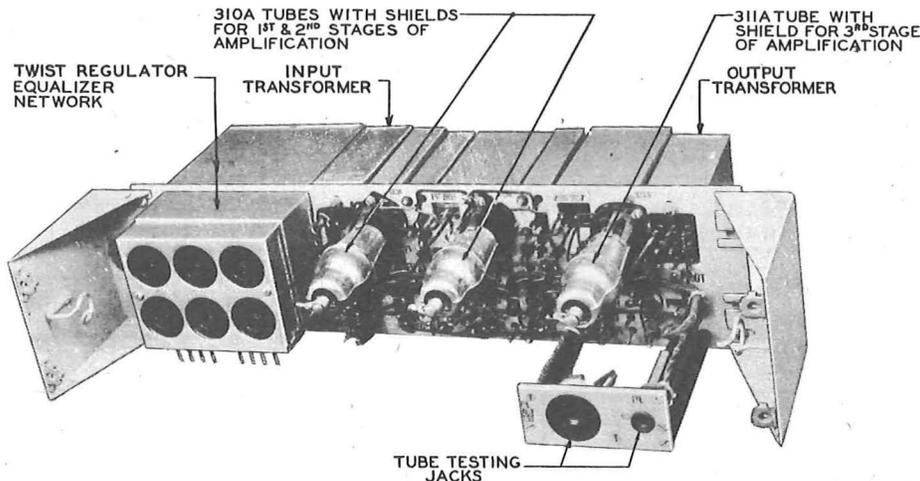


Fig. 20A - Twist Amplifier Panel - Front View.

provided in the cover so that the tubes may be tested (by means of the jacks) without removing the cover and while the amplifier is in service.

4.23 This panel is drilled so that the two amplifier deviation equalizers may be mounted in the space shown occupied in these pictures by the twist regulator network. In this case, the twist regulator network, together with cable deviation equalizers when required, are mounted on a separate panel in an adjacent bay (see Fig. 28 in Part 5). This panel is also drilled so that the group modulator may be mounted in the space occupied by the twist regulator network, when this amplifier is used as the transmitting amplifier and group modulator panel in terminal equipment (covered in a separate section).

4.24 The input leads connect from the left-hand side of the panel to the terminals of either the twist regulator network, the amplifier deviation equalizers, or the input transformer. The output leads connect from the right-hand side of the panel directly to the terminals on the output transformer. Both input and output leads are pairs in rubber-covered shielded cable.

(E) Amplifier Deviation Equalizer

4.25 The amplifier deviation equalizer compensates for a slight deviation of the line amplifier including the line equalizer from the desired characteristic. While it would have been possible to design an amplifier and line equalizer with a characteristic which would more closely match the cable shape, it is more economical to use a simple circuit in the line equalizer and permit a slight deviation from the required shape, and then compensate for the accumulated deviation of a number of amplifiers by one amplifier deviation equalizer. It is arranged to mount on the twist amplifier panel, and accordingly is located at a twist station.

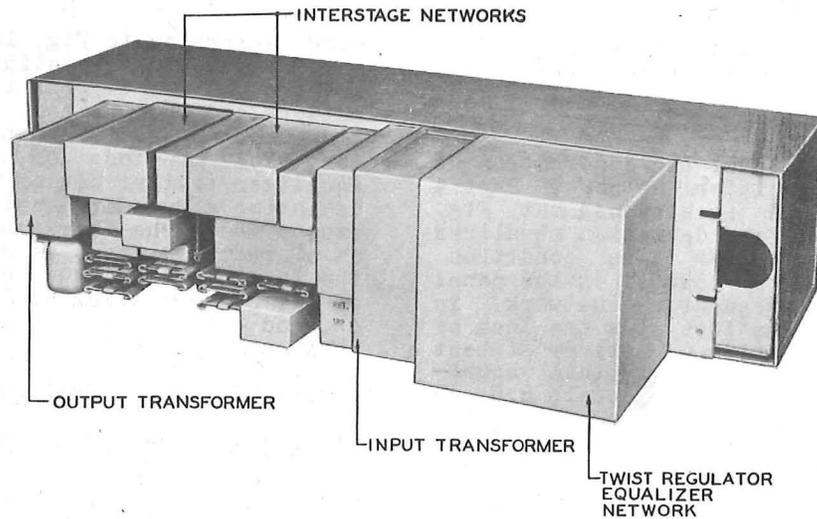


Fig. 20B - Twist Amplifier Panel - Rear View.

4.26 In Fig. 21 is shown the deviations of the line amplifier from the cable slope with the four types of line equalizers available. A study of the existing cable plant was made to determine the relative proportions in which different sizes of line equalizer would occur on the average, and the amplifier deviation equalizer was designed accordingly. The characteristic of the amplifier deviation equalizer is shown in Fig. 22. The characteristic shown is complementary to the systematic deviations of 15 line amplifiers in which the line equalizers occur in the following pro-

portions: 25 per cent. with 22 db slope, 50 per cent. with 19 db slope, 25 per cent. with 16 db slope, and only an occasional equalizer with 25 db slope. The exact number of line amplifiers which can be compensated for, and the accuracy of compensation, will, of course, depend on the relative proportions of the equalizers on the particular route.

4.27 The amplifier deviation equalizer consists of the 34C and 34D equalizers, which are always used together, and never used separately.

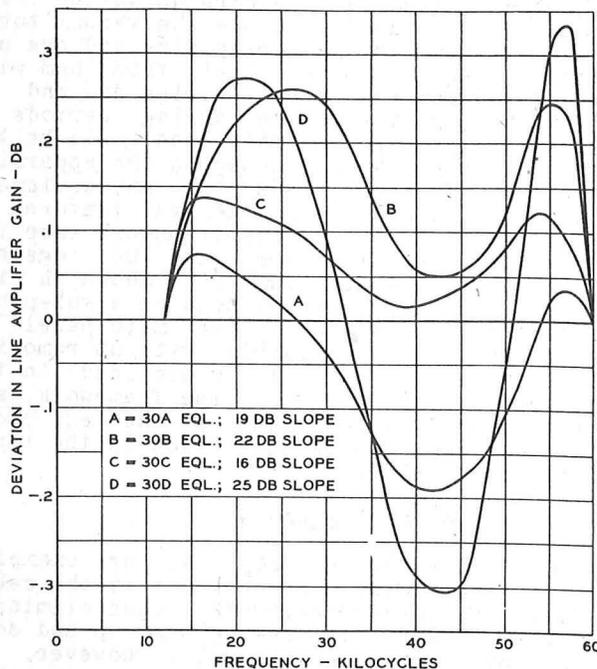


Fig. 21 - Deviations of the Amplifier Characteristic from the Cable Slope with Four Types of Line Equalizers.

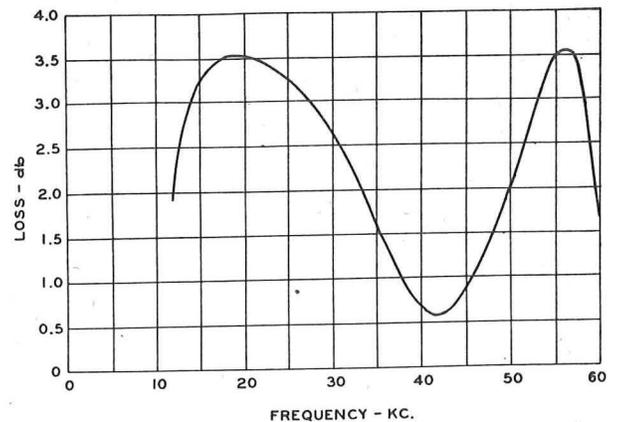


Fig. 22 - Amplifier Deviation Equalizer Characteristic.

4.28 The manner of mounting the amplifier deviation equalizer is covered in 4.23, and in Part 5.

4.29 As mentioned under the description of the twist regulator network, Part 4 (A), the 8.6 db pad is strapped out, Fig. 11, when the amplifier deviation equalizer is used, Fig. 1C. Under this condition, the 6A pad, which is mounted on the panel with the twist regulator network, is strapped so that its loss plus the loss of the amplifier deviation equalizer (about 2.8 db at 28 kc. for a typical equalizer as shown in Fig. 22) equals 8.6 db at 28 kc. The 6A pad is a resistance pad having values of .5, 1, 2, 4, 8 and 16 db. When the line amplifier is operated 1.5 db below normal because of operation on terminal 10 on the line equalizer, the loss of the 6A pad should be decreased 1.5 db.

(F) Cable Deviation Equalizer

4.30 Measurements have shown that the shape of the loss-frequency characteristic of some cable pairs may deviate slightly from the average shape. This deviation may be a small bulge upward, or a small bulge downward, when matched at 12 and 60 kc. In order to compensate for these deviations, two cable deviation equalizers have been made available. Only one type of equalizer is used in a cable pair at one point. However, it cannot be predicted in advance which type will be required in each cable pair, so one of each type is usually provided for each circuit at the station chosen for the cable deviation equalizers. It is expected that this equalizer will not be used more frequently than about once every 300 or 400 miles (about 20 repeater sections). It is located at a twist station, either terminal or repeater station, having amplifier deviation equalizers.

4.31 In Fig. 23 are shown the characteristics of the 34A and 34B cable deviation equalizers. Each equalizer produces a bulge (one upward and one downward) of approximately 1 db at 28 kc. with respect to 12 and 60 kc.

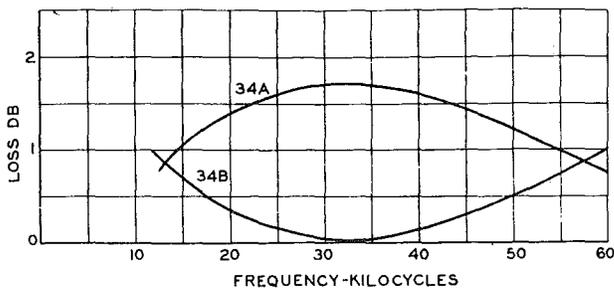


Fig. 23 - Cable Deviation Equalizers - Characteristics.

4.32 Referring to Fig. 1D and Fig. 28, the two cable deviation equalizers are mounted on a panel with the twist regulator network and the 6A pad. Under this condition, the 6A pad is strapped so that its loss plus the loss of the cable deviation equalizer (either 34A or 34B) and amplifier deviation equalizer equals 8.6 db at 28 kc. except where the line amplifier is operated at a reduced level as noted in 4.29. In the typical case shown in Fig. 23, the loss of the 34A equalizer at 28 kc. is about 1.7 db, and the loss of the 34B equalizer is about 0.1 db.

5. EQUIPMENT CONSIDERATIONS

(A) Single-Side Wiring and Maintenance Arrangement

5.01 Most of the type K carrier equipment bays are arranged so that all the usual maintenance work can be done on the front side and none is required on the rear or apparatus side except the removal of defective pieces of apparatus.

5.02 The new type of framework used for this single-side maintenance and wiring arrangement differs considerably from the usual channel or "I" beam framework. This framework provides separate cable ducts on the right and left-hand sides of each bay. Space is provided for this purpose by using 22-1/2" centers for the framework, whereas the panels are only 19" wide. The can covers on all of the panels are 22-3/16" wide; which means that they will cover the cabling in the ducts as well as the wiring and apparatus on the front side of the panels. Since the vacuum tubes are mounted on the wiring side and are under a can cover, the heat from them will tend to keep the panel wiring dry and so give better insulation during periods of relatively high humidity than would be the case if they were mounted on the apparatus side. The three views for any equipment panel will show the general features of this arrangement and the framework (see for example, Figs. 10A, 10B and 10C together with the typical plan view shown in Fig. 24). The jacks are mounted on a sub-panel which is set out from the main panel so that they are accessible without removing the cover. A cut-out is provided in the cover for this purpose. The framework, and the general arrangement of the equipment and cabling, can best be seen in the typical plan view of Fig. 24.

(B) Cabling Arrangements

5.03 Referring to Fig. 24, for example, the cables are run loose in the cable ducts of the new framework, thus eliminating the need for sewing them up and down the bay. The cables, will, however, be tied at the top of the bay and each cable will be fastened at the panel to which it connects. Since there are cable ducts on both right and left-hand sides, the equip-

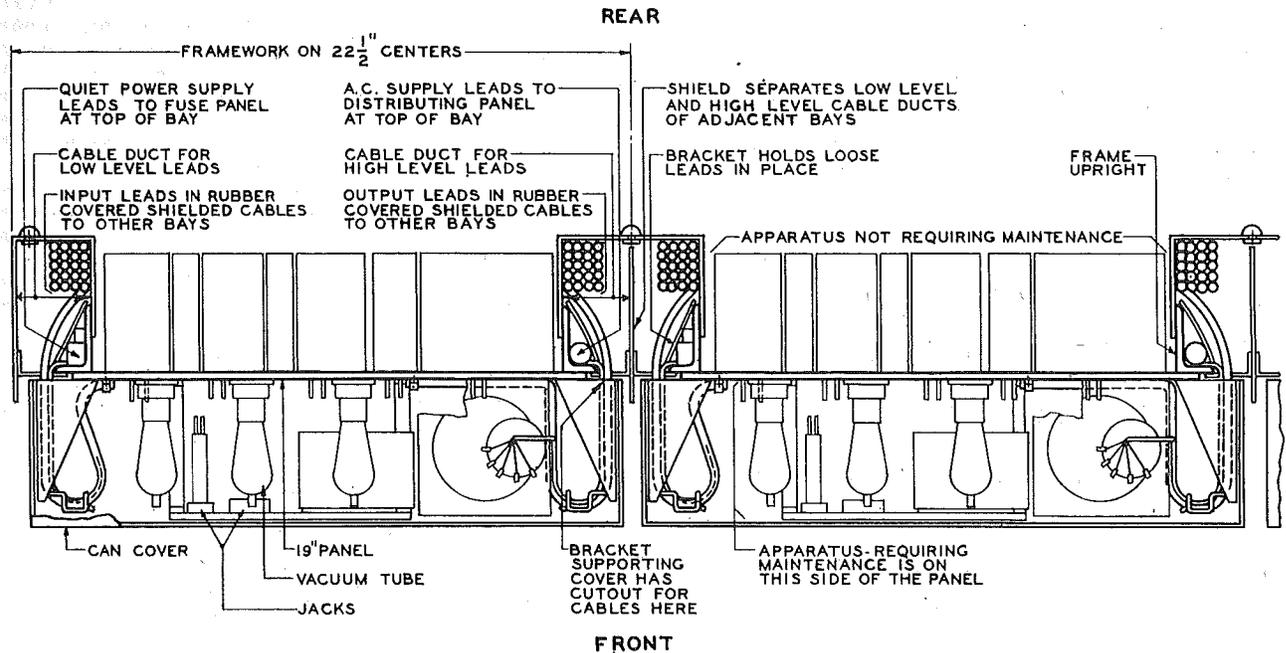


Fig. 24 - Single-Side Wiring and Maintenance Arrangement - Typical Plan View.

ment is arranged, for the most part, so that terminal strips or other apparatus connecting to cables in the left-hand duct are located on the left-hand side of the panel and apparatus connecting to cables in the right-hand duct are located on the right-hand side. The separation provided by these right and left-hand cable ducts is also carried out in running the cables between bays. The cables in the left-hand cable ducts are generally run on different cable racks from those used by the cables in the right-hand cable ducts. In those cases where the cables are on the same rack, or cross over each other, the cables are separated by at least two inches.

5.04 The cables containing high level leads (usually output circuits) are run in the right-hand cable ducts in all cases. The low level leads (usually input circuits) are run in the left-hand cable ducts. The battery leads are also run in the left-hand cable duct to avoid picking up noise from high level circuits.

(C) Bay Arrangements

5.05 Figs. 25 to 28 show the bay arrangements for the various types of stations covered schematically in Figs. 1-A, 1-B, 1-C and 1-D. There are two bay arrangements corresponding to Fig. 1-A where only the line amplifiers are required, - the bay for auxiliary stations shown in Fig. 25 and the bay for main stations shown in Fig. 26. The bay arrangement shown in Fig. 28 is suitable for use at all twist points. It provides for deviation equalizers per

Figs. 1-C and 1-D, and also makes provision for the future addition of equalizers when Fig. 1-B is used initially. In the latter case the twist regulator networks are mounted in the twist amplifier bay, and cabling supports are provided in the middle bay for the cables between the line amplifier and the twist amplifier bay. The 2-bay arrangement shown in Fig. 27 makes no provision for the latter addition of equalizers.

5.06 In main repeater stations which require only line amplifiers, Fig. 26, the first bay of a lineup will have 19 line amplifiers and one test amplifier. The latter is used in the 42-A Transmission Measuring System and is practically the same circuit as the twist amplifier, as mentioned in Part 4(D). The other bays will mount 20 line amplifiers. Two fuse panels, distribution terminal strips for the flat gain regulators on the line amplifiers, and grid supply resistances are mounted at the top of the first, third, fifth, etc., bays of a lineup. The terminal strips are used to distribute the leads from the master flat gain controller, and the 55-volt supply to the receiver motors on the line amplifiers. Each fuse panel will mount the 24 and 130-volt fuses for 20 amplifiers. Amplifiers Nos. 1, 3, 5, etc., to 39 are supplied from the upper fuse panel and amplifiers Nos. 2, 4, 6, etc., to 40 are supplied from the lower fuse panel. In order that all amplifiers will not be dependent on one set of power discharge leads, all the upper fuse panels in an office are connected to one 130-volt power lead and one 24-volt lead, while all the lower fuse panels are connected to a second set of power leads.

5.07 The bay arrangement for auxiliary stations, Fig. 25, is similar to that just described except that the fuse panels and grid supply resistances are located in the by-pass set bay (covered in separate information), and the test amplifier in the first bay is not required. The capacity of this bay arrangement is, therefore, 21 line amplifiers.

5.08 Fig. 27 shows a two-bay arrangement for 15 or 16 line and twist amplifiers without deviation equalizers. The left-hand bay of each group of two mounts the line amplifiers, and the right-hand bay mounts the twist amplifiers and the twist regulator networks. The first group of bays mounts 15 line and 15 twist amplifier

panels, a test amplifier (for the pilot level measuring circuit), and an auxiliary switching amplifier (for the line switching circuit covered in other information). The succeeding groups of bays mount 16 line and 16 twist amplifiers. The fuse panels at the top of the line amplifier bay mount the fuses for both line and twist amplifiers. The grid supply resistances and terminal strips for the leads to the motors on the line amplifiers are also mounted at the top of this bay. The fuse panel at the top of the twist amplifier bay mounts the fuses for the leads to the twist regulator motors on the 50A drive panels from the 55-volt supply and the master twist controller. Three 50A drive panels, each of which has a capacity of six regulators, are mounted at the bottom of the two bays.

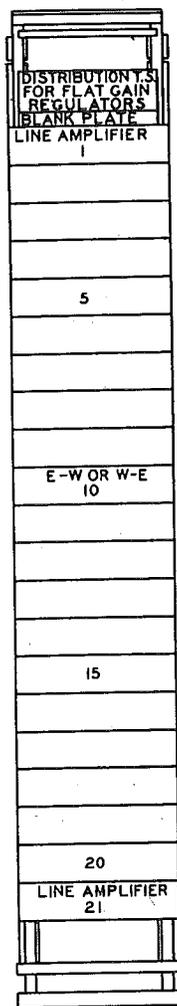


Fig. 25 - Bay Layout of Line Amplifiers in Auxiliary Repeater Station - E-W or W-E.

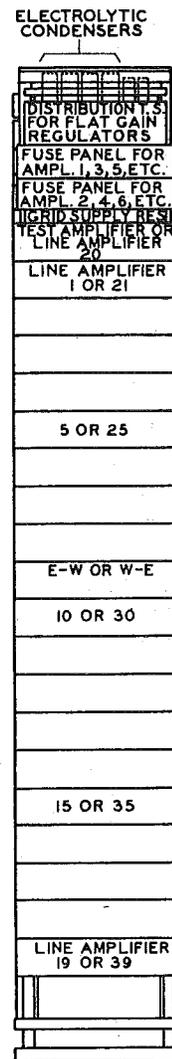


Fig. 26 - Bay Layout of Line Amplifiers Without Twist Amplifiers or Amplifier or Cable Deviation Equalizers in Main Repeater Stations - E-W or W-E.

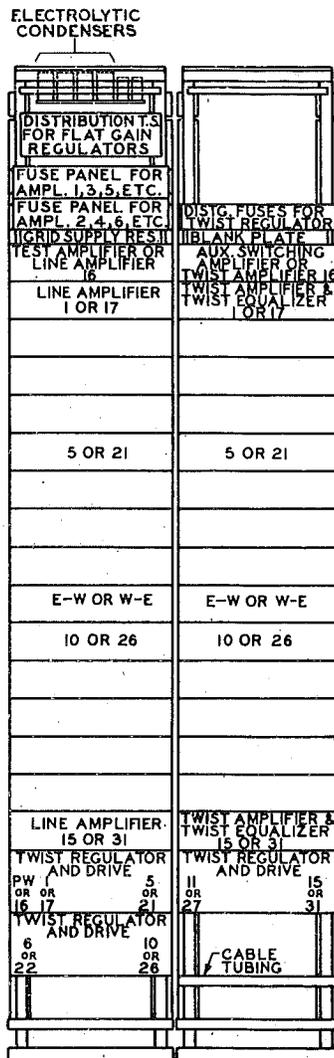


Fig. 27 - Bay Layout of Line and Twist Amplifiers, Including Twist Regulator Networks but no Amplifier or Cable Deviation Equalizers in Main Repeater Stations - E-W or W-E.

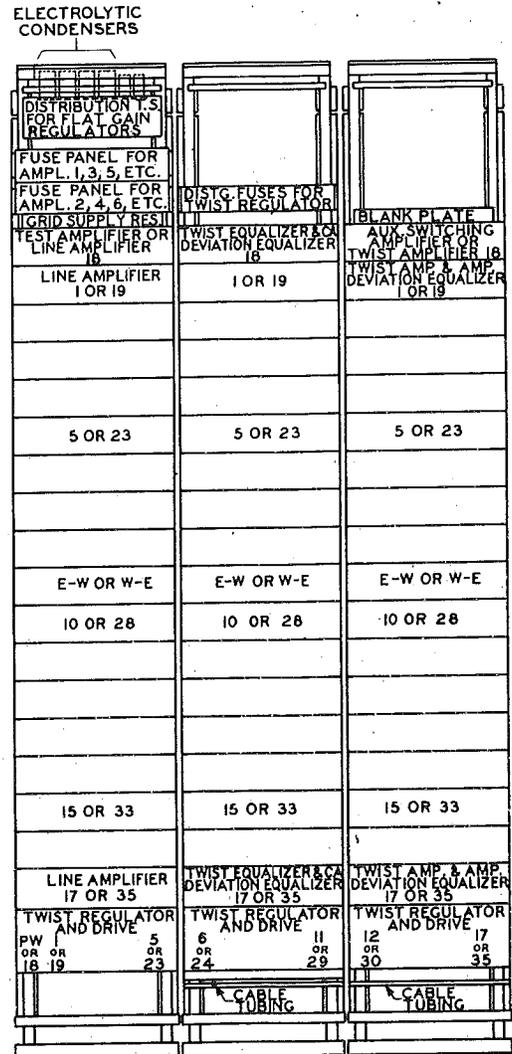


Fig. 28 - Bay Layout of Line Amplifiers, Twist Amplifiers, Twist Regulator Networks, Amplifier and Cable Deviation Equalizers in Main Repeater Stations - E-W or W-E.

5.09 Since the line and twist amplifier panels are the same size, the corresponding amplifiers of each circuit are mounted in a horizontal line in adjacent bays. Consequently the leads in shielded cable from the output transformer of each line amplifier are run directly across to the twist regulator network in the next bay without running up or down in the cable duct. The leads connecting the twist regulator networks to the regulator resistances on the 50A drive panels are run in shielded cables in the left-hand cable duct of the twist amplifier bay.

5.10 The three-bay arrangement, Fig. 28, which is required when equalizers are

used as well as twist amplifiers, follows essentially the same plan as the two-bay arrangement just described, except that it is necessary to add a bay in between the line and twist amplifier bays for the panels mounting the twist regulator networks, cable deviation equalizers, and 6A pad. This arrangement has capacity for one more circuit, however, because the three 50A drive panels are distributed in each of the three bays. The first group of three bays will therefore have a capacity of 17 one-way circuits, and will also mount the test and auxiliary switching amplifiers. Subsequent groups of three bays will have a capacity of 18 one-way circuits. The fuse panel for the motors on the 50A drive panels is located in the middle bay.

5.11 Since the panel for the middle bay is the same size as the amplifier panels, the same arrangement of cabling can be followed as for the preceding case. The leads (in shielded cable) from the output of the line amplifier to the twist regulator network, and the leads (in shielded cable) from the cable deviation equalizer to the amplifier deviation equalizers (on the twist amplifier panel) are run directly across the cable ducts between adjacent bays.

6. BATTERY SUPPLY CIRCUITS

(A) Line Amplifier in Main Stations

6.01 The battery supply circuit of the line amplifier used in main stations is shown in Fig. 29. The regular central office 24-volt battery is required for the heaters of the vacuum tubes and for relay operation at main repeater and terminal stations. 130-volt battery ± 5 volts is required for the plate supply at main repeater and terminal stations.

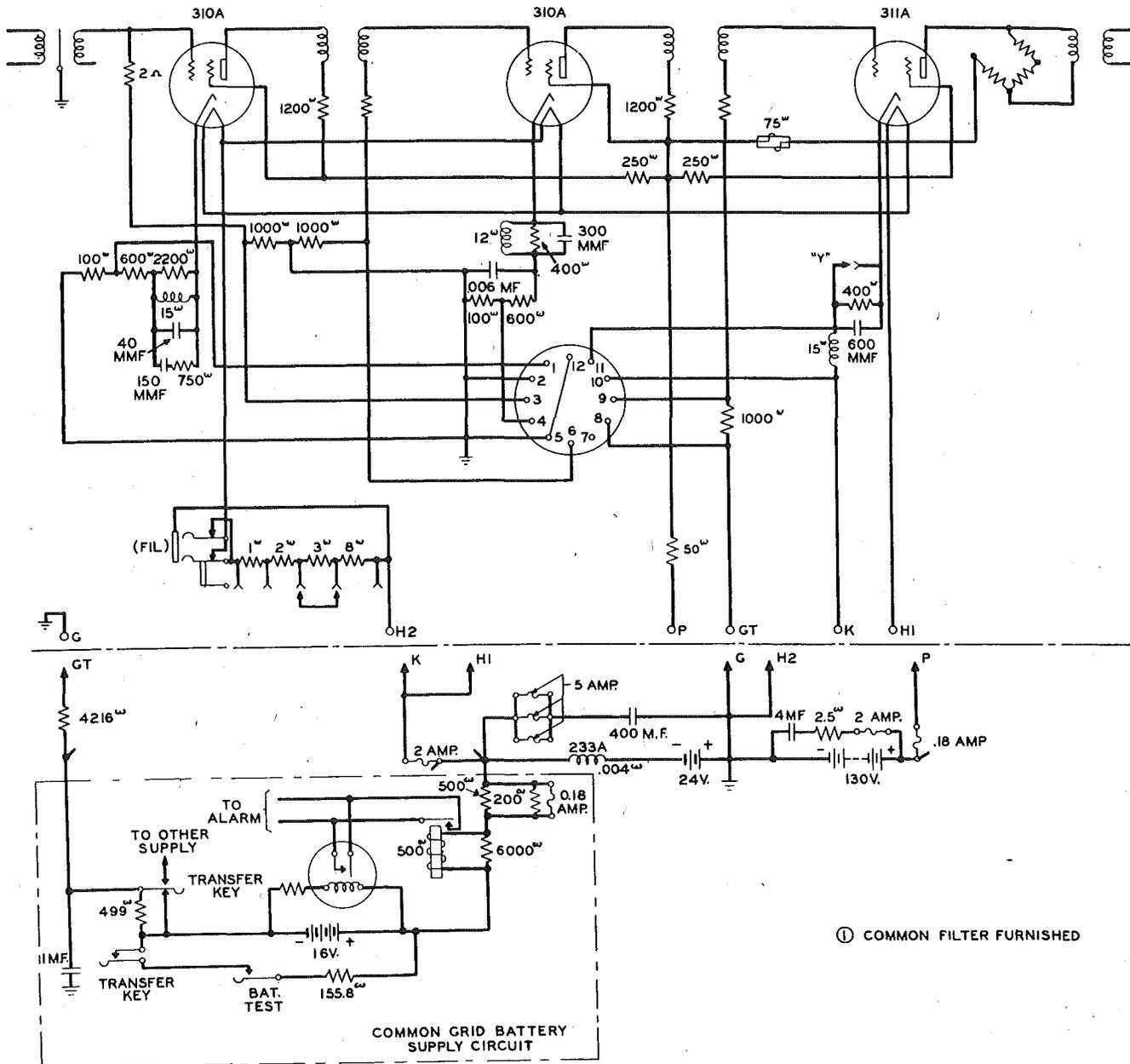


Fig. 29 - Battery Supply Circuit - Line Amplifier in Main Stations.

(B) Line Amplifier in Auxiliary Repeater Stations

6.02 The battery supply circuit of the line amplifier used at auxiliary repeater stations is shown in Fig. 30. At these stations, the line amplifiers operate on a single battery of 152-volts which supplies both heater current and plate cur-

rent. Seven amplifiers are operated in series. When the number of repeaters in the station is not divisible by 14, two resistance panels with suitable resistances are provided and connected as required in order to equalize the load on all sections of the battery. Because of the odd and even distribution of fuse panels, 14 repeaters (28 amplifiers) must be equipped before dummy resistances are not required.

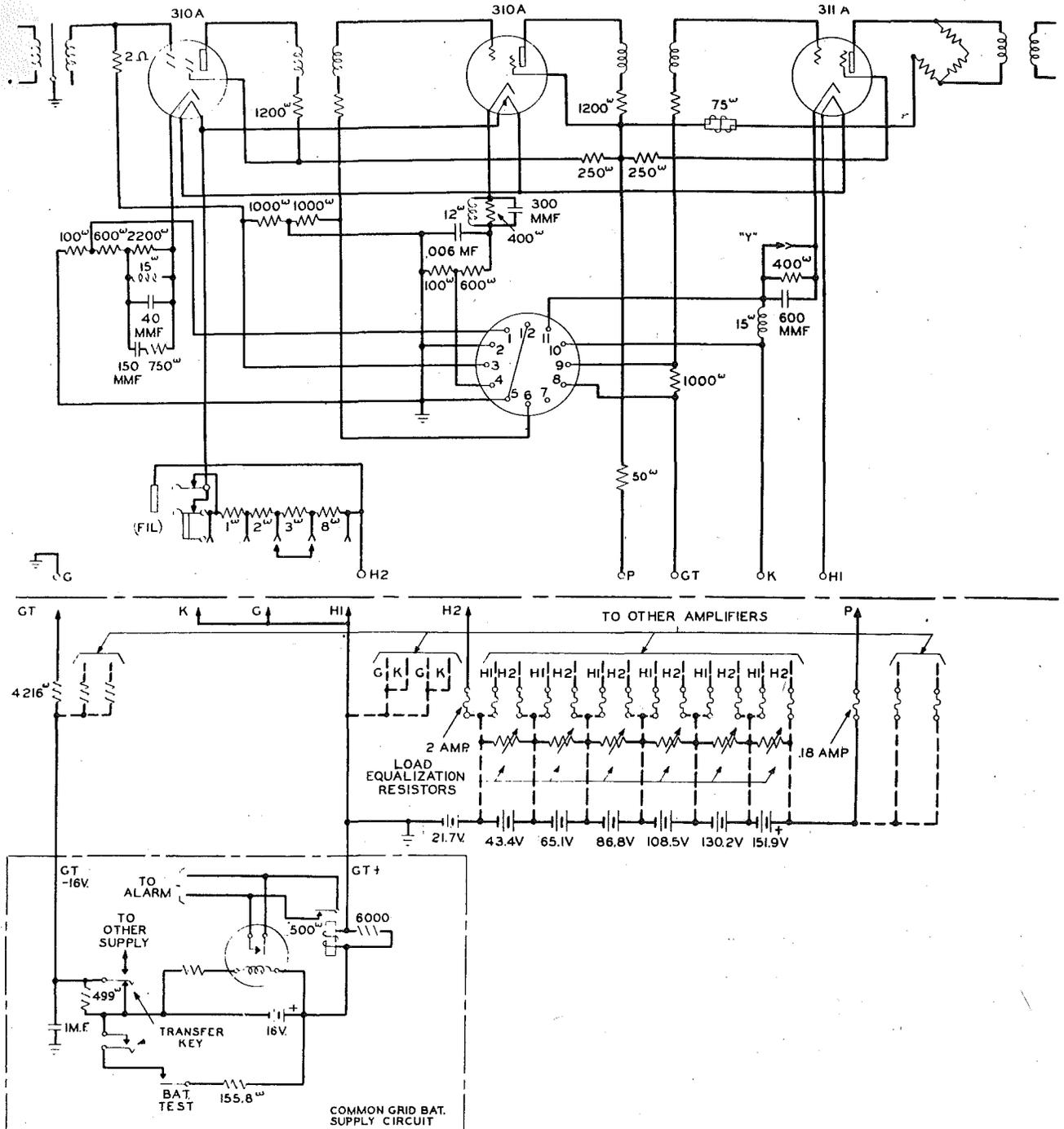


Fig. 30 - Battery Supply Circuit - Line Amplifier in Auxiliary Repeater Stations.

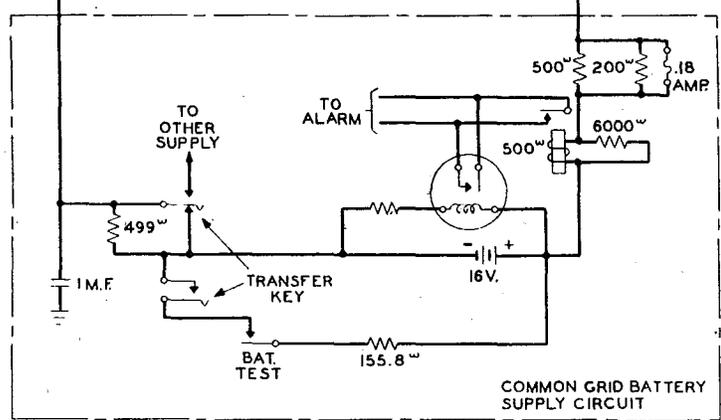
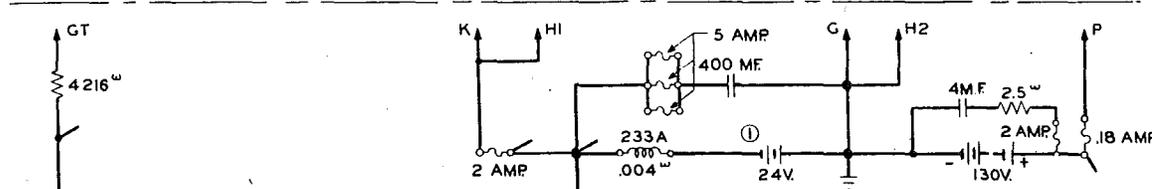
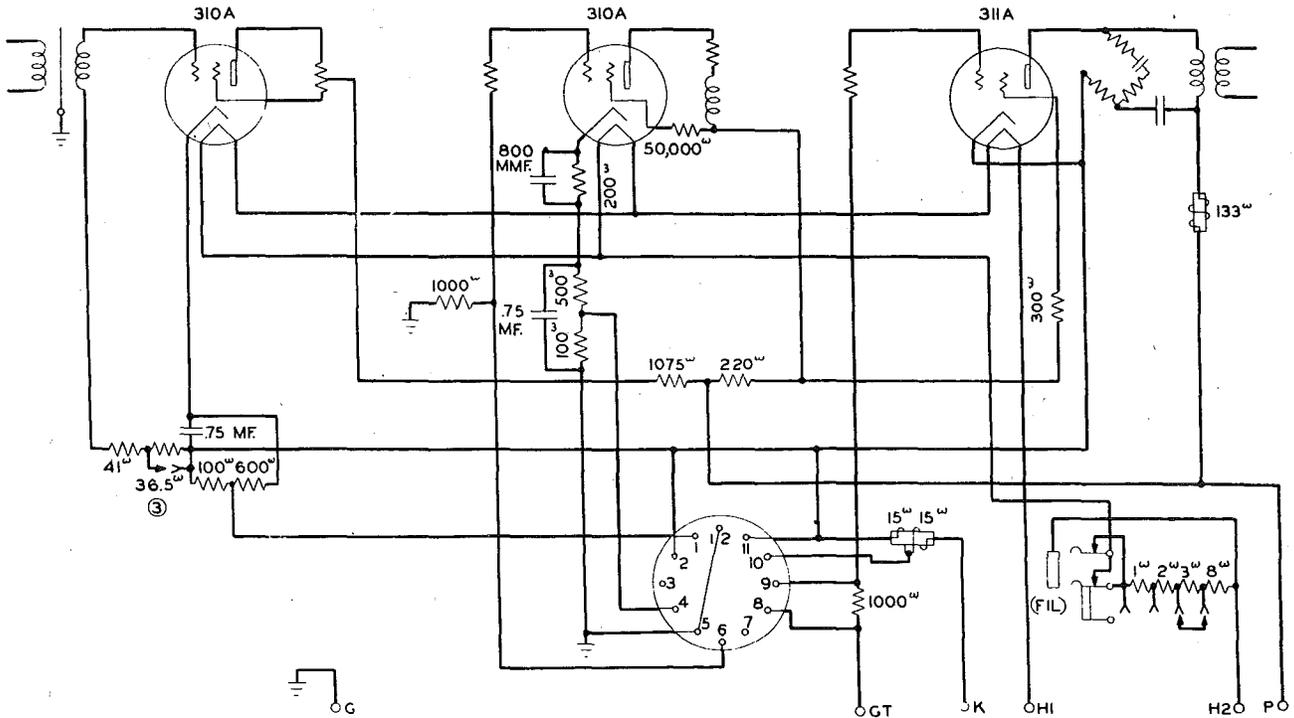
(C) Twist Amplifier

6.03 The battery supply circuit of the twist amplifier is shown in Fig. 31. It is not expected that this amplifier will be operated on 152-volt battery.

(D) Grid Supply Arrangements

6.04 Two sets of grid batteries, one for odd-numbered circuits and one for

even-numbered circuits, are required to provide grid bias on the 311A tubes in the line amplifier and twist amplifier circuits. 16 volts \pm .8 volt, are required for this purpose. The grid battery circuit provides an alarm arrangement so that an alarm is given when the grid voltage drops below 15.2 volts, or when a trouble condition occurs which produces a current flow in the grid supply circuit.



- ① COMMON FILTER FURNISHED.
- ③ 36.5Ω IN CIRCUIT OF TWIST AMPLIFIER AND OUT OF CIRCUIT IN TEST, AUXILIARY SWITCHING AND TRANSMITTING AMPLIFIER.

Fig. 31 - Battery Supply Circuit - Twist Amplifier.

6.05 Resistances are provided in the individual leads to each amplifier so that a ground on one grid lead will not affect any other amplifiers. The common lead between the grid batteries and the resistances is well shielded and protected so that there is very little likelihood of a ground occurring in this part of the circuit.

6.06 A transfer key is provided with each set of batteries (odd and even), so that both odd and even loads may be transferred to either battery supply. This releases the other battery for tests and replacement of cells. A key is provided for testing the battery by placing a resistance load across the battery when it is removed from the circuit by the battery transfer key.

6.07 An exception which occurs when grid batteries are not needed for grid bias on the line amplifiers was mentioned in paragraph 3.09.

7. DRAWINGS

SD Drawings (Not Attached)

SD-64326-01 Application Schematic 12-60 Kc. Line Amplifier and Regulator for Repeater Offices with Flat Gain Regulation Only

SD-64327-01 Application Schematic 12-60 Kc. Line and Twist Amplifiers and Regulators for Repeater and Receiving Terminal Offices with Flat Gain and Twist Regulation

SD-64337-011 12-60-Kc. Line Amplifier
-012

SD-64329-011 12-60-Kc. Twist Amplifier
-012

SD-64331-011 Equalizers and Twist Regulating Network for Use with 12-60-Kc. Twist Amplifier

ED Drawings (Not Attached)

ED-61443-01 50A Drive - Can Cover Equipment

ED-64326-01 Amplifier Bay Equipment for Use in Main Repeater Stations Without Twist Regulation, and Auxiliary Repeater Stations

ED-64326-02 Amplifier Bays - Cabling Main Repeater Stations Without Twist Regulation, and Auxiliary Repeater Stations

ED-64327-01 Amplifier and Equalizer Bay Equipment for Use in Offices With Twist Regulation

ED-64327-02 Amplifier and Equalizer Bay Cabling for Stations With Twist Regulation

ED-64328-01 12-60-Kc. Line Amplifier - Equipment and Assembly

ED-64328-02 12-60-Kc. Line Amplifier - Detailed Assemblies

ED-64328-03 12-60-Kc. Line Amplifier - Cathode and Feedback Equipment

ED-64328-04 12-60-Kc. Line Amplifier - Local Cable Layout

ED-64329-01 Twist Amplifier

ED-64329-03 Twist Amplifier - Local Cable Layout

ED-64329-04 12-60-Kc. Twist or Transmitting Amplifier - Output Bridge Feedback and Cathode Equipment

ED-64331-01 Equalizer Panel Arranged for Twist and Cable Deviation Equalizer and Building Out Pad - Equipment and Assembly