TYPE K CARRIER TELEPHONE SYSTEM

K-1 MASTER TRANSMISSION REGULATING ARRANGEMENTS

CONTENTS

1. GENERAL

1.01 This section prepared by the Bell Telephone Laboratories describes the master transmission regulating arrangements for the Type K carrier telephone system consisting of the master flat gain and the master twist controllers and associated circuits and equipment. The regulator equipment associated with the individual amplifiers is covered in the section describing the line and twist amplifiers.

2. FLAT GAIN REGULATION

(A) General Features

2.01 Flat gain regulation (which means a uniform change in gain of the line amplifier over the 12-60 kc. range to compensate for changes in attenuation due to variations in temperature) is provided in the line amplifiers. In the case of aerial cable, this regulation is provided in each line amplifier in both directions of transmission at carrier repeater stations, and at receiving terminals. In the case of underground cables, flat gain regulation may, with certain limitations, be provided in certain amplifiers only, such as every alternate amplifier, or every third amplifier, the remaining amplifiers being provided with fixed gains. The system of flat gain regulation requires a pilot wire in each section of cable for each direction of transmission. This pilot wire controls a master flat gain controller which in turn controls the setting of the flat gain regulator condensers in a number of line amplifiers in an office. These condensers, located in the feedback circuit of each line amplifier, provide the flat gain regulation.

(B) Pilot Wire

2.02 One of the carrier pairs in each repeater section of each cable serves as a flat gain pilot wire, as indicated in Fig. 1. Means are provided to recognize changes in the d-c resistance of this pair as the cable temperature varies, and to make corresponding adjustments in the gain of the line amplifiers to compensate for changes in the attenuation of the cable pairs. The pairs are sufficiently uniform so that a single pair may be used as an index of the cable temperature, and adjustments on all amplifiers made accordingly. The master flat gain controller associated with each pilot wire controls simultaneously the gain of a maximum of 50 carrier line amplifiers in one direction. Separate master controllers and pilot wires are provided for the two directions of transmission which may differ in their characteristics as they are in separate cables.

2.03 A d-c by-pass filter is provided at each office to separate the d-c path of the pilot wire circuit from the carrier frequencies on that pair. The master flat gain controller is connected to the pilot wire at the receiving end of each regulating section, and the pilot wire is shorted at its opposite end through another by-pass set to form a closed d-c path. A second carrier pair in each cable is also equipped with by-pass sets and arranged to provide a spare flat gain pilot wire for emergency use. Jacks are provided in the pilot wire circuits so that the master flat gain controller may be readily patched to the spare

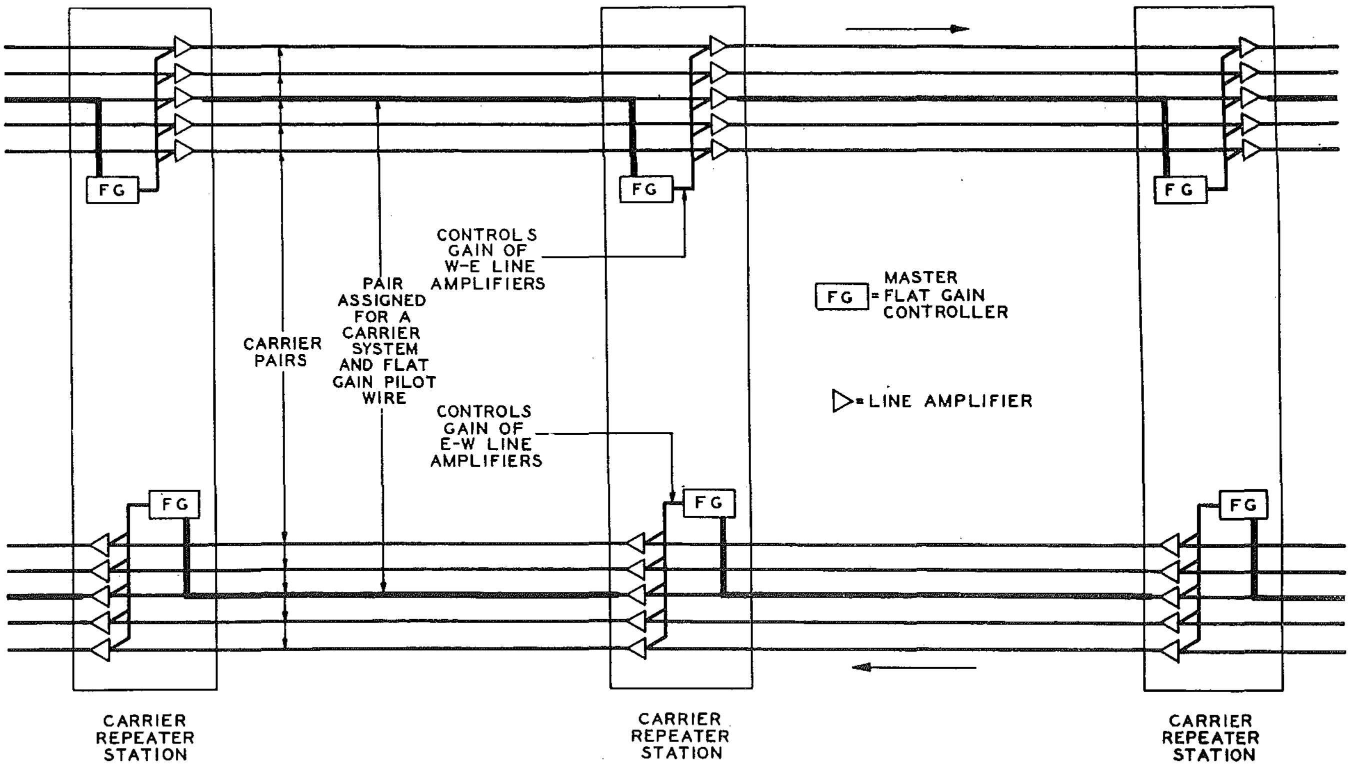


Fig. 1 - Pilot Wire Layout for Flat Gain Regulation.

pilot wire. Resistances of 2, 4, and 8 ohms are provided in each pilot wire circuit so that the resistance of the regular and spare flat gain pilot wires may be adjusted to approximately the same value (within an ohm). These resistances are mounted on the by-pass filter panels.

2.04 A schematic circuit layout of the carrier pairs assigned for regular and spare flat gain pilot wire use in the West-to-East direction is shown on Drawing ES-851726, page 101. A similar arrangement is required in the East-to-West direction. As noted on this drawing, the carrier pairs are assigned for flat gain pilot wire use as follows (for cables with ultimate capacity of 100 systems):

D-C Path Obtained From Pairs Assigned For	Used For
Carrier System No. 3	Flat gain pilot wire for carrier systems Nos. 1-50
Carrier System No. 4	Spare flat gain pilot wire
Carrier System No. 5	Flat gain pilot wire for carrier systems Nos. 51-100

2.05 This assignment of carrier pairs for pilot wire use provides an arrangement in the sealed test terminals which is convenient from a wiring standpoint, since the jacks in the by-pass filter circuit are bridged by short leads to the line jacks immediately above. Due to the uniformity of cable pairs, a uniform assignment of pairs for pilot wire use is expected to be satisfactory. On underground cable where flat gain regulators may be omitted at certain points, the pilot wire is connected through by means of by-pass sets to cover two (or in some cases, three) repeater sections.

(C) Master Flat Gain Controller

2.06 A schematic of the master flat gain controller circuit associated with the flat gain pilot wire is shown in Fig. 2. The controller equipment is shown in Figs. 3A and 3B.

2.07 Referring to Fig. 2, the principle of operation is based on a self-balancing Wheatstone bridge, with the pilot wire forming part of one arm of the bridge. The total resistance of 15.5 miles of 19-gauge cable, for example, at 55°F. is approximately 1293 ohms (83.4 ohms per loop mile), and the change in resistance for a temperature change of ± 55° (0° to 110°) is about ± 161 ohms (.1892 ohm per degree Fahrenheit per mile). It is this change in resistance of the pilot wire which the controller

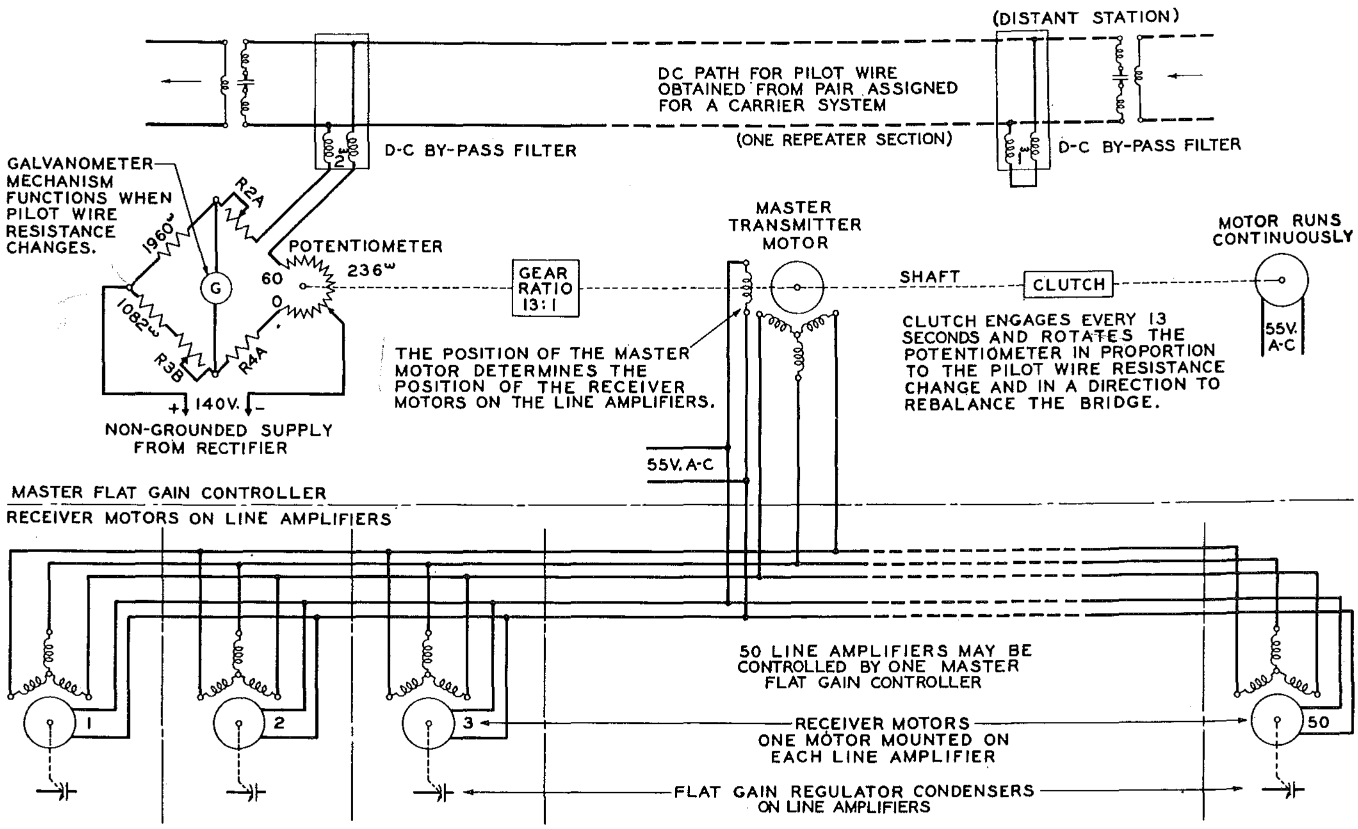


Fig. 2 - Master Flat Gain Controller and Connection to Individual Receiver Motors on Line Amplifiers.

mechanism recognizes and translates into a change in gain of the line amplifiers. The change in attenuation of 15.5 miles of cable at 28 kc. for a temperature change of ± 55° (0° to 110°) is about ± 4.5 db (assumes a typical temperature-attenuation coefficient of 0.00532 db per degree Fahrenheit per mile). An aerial cable occasionally undergoes a temperature change of as much as 50° within one day. Temperature changes of 15° frequently occur, and changes of 30° occasionally occur within one hour. The regulating equipment has adequate margin for following these temperature changes.

2.08 Briefly, the master flat gain controller functions as follows:- a master transmitter motor is connected mechanically to a potentiometer which is in the bridge circuit. A motor, which runs continuously, is connected intermittently (every 13.7 seconds) by means of a friction clutch to the shaft associated with the master transmitter motor and the potentiometer. When the bridge circuit is balanced, the galvanometer pointer is at rest in the center, and no change results in the position of the potentiometer and the rotor of the master transmitter motor when the clutch is periodically closed. When a change in cable temperature occurs, with a corresponding change in pilot wire resistance, the bridge circuit becomes unbalanced and produces a deflection of the galvanometer needle. An engagement of the friction clutch then causes the potentiometer to be rotated in a direction which will rebalance the bridge. Simultaneously, the rotor of the master transmitter motor is rotated an appropriate amount, and (as will be explained) this causes a sufficient rotation of the flat gain regulator condensers on a group of line amplifiers to compensate for the change in attenuation of the cable pair. The friction clutch part of the controller, referred to as the "clutch and balancing mechanism," and the galvanometer are shown in Fig. 3B, and can also be seen in more detail in Fig. 6C (which shows the same mechanism for the master twist controller).

2.09 The master transmitter motor is wired to a maximum of 50 receiver motors, one motor being mounted on each line amplifier. The master transmitter motor and receiver motors are electrically connected in such a manner that a rotation in either direction of the shaft and rotor of the master transmitter motor will cause a corresponding rotation of the rotor of each receiver motor, i.e., the receiver motors keep in step with the master transmitter motor. Each receiver motor on each line amplifier panel is geared to a condenser which adjusts the amplifier gain. Accordingly, the position of the rotor of the master transmitter motor determines the position of the flat gain regulator condensers on a group of 50 line amplifiers operating in the same direction. An adjustment is provided in the backlash of the gears between the master transmitter motor and the potentiometer to compensate for any lag between the master transmitter motor and the receiver motors.

2.10 The sensitivity of the galvanometer can be adjusted by a potentiometer located in the controller as shown in Fig. 3B. This potentiometer determines the amount of current flowing in the galvanometer for a given unbalance of the bridge, and accordingly determines the amount of deflection of the pointer produced by a given unbalance. The optimum condition is to adjust the sensitivity so that each rebalancing movement carries the galvanometer pointer through mid-position to a distance equal to 1/2 the previous deflection. For underground cables where the master controller regulates more than one repeater section, the higher sensitivities may not be attained and for such cases the galvanometer pointer may not pass mid-position, but will approach it on each rebalancing movement until zero is finally reached.

(D) Range of Operation

2.11 The flat gain regulating system has been designed to operate the "GR" condensers in the line amplifiers over a range of about 14.3 db. The length of cable section and range of temperature for which this range of adjustment will compensate depends on the cable temperature-attenuation coefficient. For a typical cable coefficient of .00532 db per degree Fahrenheit per mile, and a repeater section length of 18.5 miles of aerial cable, the gain range of 14.3 db will compensate for a temperature range of 145° (.00532 db x 145° x 18.5 mi. = 14.3 db). For the same cable coefficient, and a repeater section length of 57 miles of underground cable, the gain range of 14.3 db will compensate for a temperature range of 47°. (.00532 db x 47° x 57 mi. = 14.3 db.) For cable coefficients of .004 db and .006 db, the lowest and highest cable coefficients ordinarily encountered, the temperature range which can be covered by the range of adjustment of 14.3 db is shown in the table below. The temperature range which can be cared for is greater than ordinarily encountered. The bridge circuit in the controller limits the maximum cable length to 57 miles. Adjustments are provided in the bridge circuit to cover the above range of cable coefficients.

Cable Coefficient (db/°F./mi.)	Aerial Cable Temperature Range °F.	Aerial Cable Miles	Underground Cable Temperature Range °F.	Underground Cable Miles
.004	193	18.5	62	57
.00532	145	18.5	47	57
.006	129	18.5	42	57

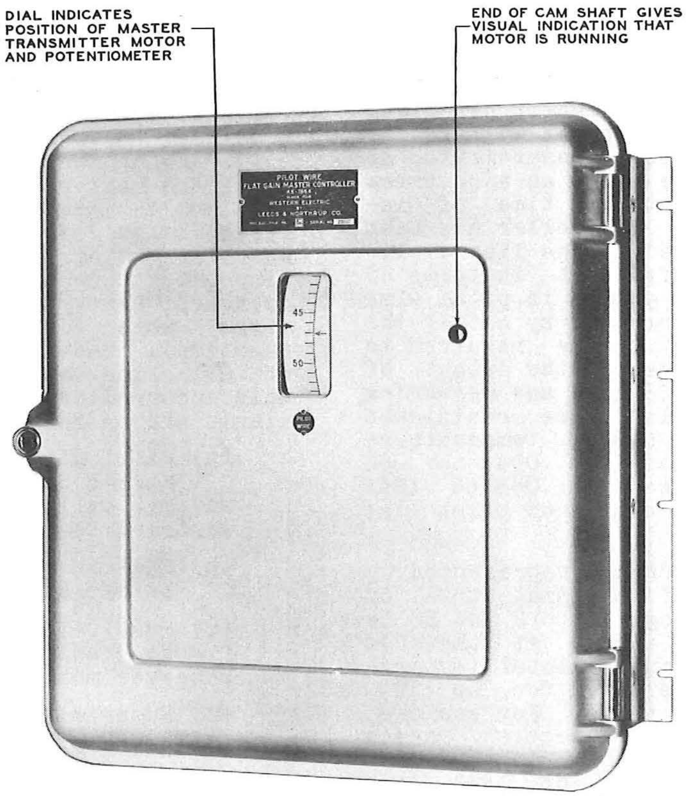


Fig. 3A - Master Flat Gain Controller Front View - Casing Door Closed.

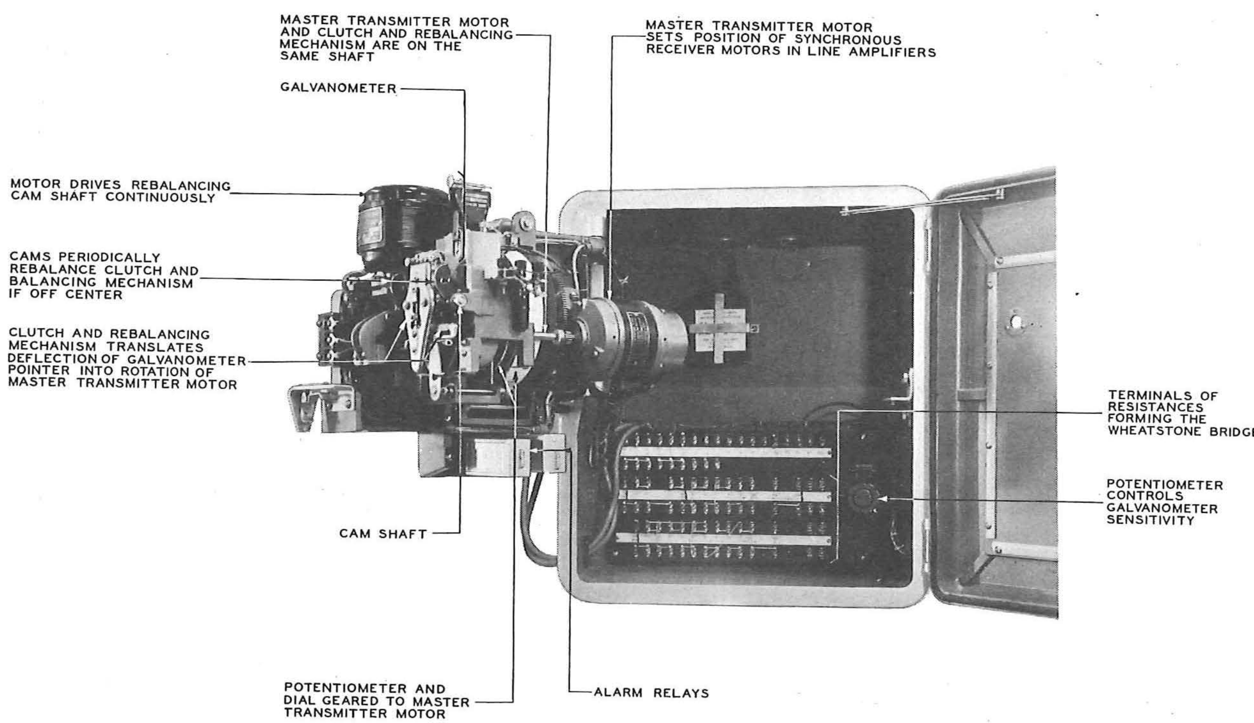


Fig. 3B - Master Flat Gain Controller - Front View - Casing Door Open and Equipment Swung Out on Hinged Gate.

2.12 The temperature-attenuation coefficient for a given cable can be obtained from attenuation measurements on the cable pairs over a sufficient range of temperature to determine the average change in attenuation per degree Fahrenheit per mile. In the usual case, however, it will not be practicable to make such measurements, so the controller may be given an adjustment for the average cable at the time of installation. After the controller has been installed and connected to the line amplifiers, the cable coefficient in terms of dial divisions per ohm change in pilot wire resistance may be obtained by noting the master controller dial change required to maintain a constant level at the output of a line amplifier at 28 kc., and measuring the corresponding pilot wire resistance change. The range of cable temperature-attenuation coefficients from .004 to .006 db corresponds to values from .085 to .1245 dial division per ohm change of pilot wire resistance.

2.13 The temperature change represented by each division of the dial (total of 56 divisions useful range; 0 to 2 and 58 to 60 provides mechanical margin at the ends of the range) depends on the total temperature range which can be cared for, as indicated in the above table. For example, with an 18.5 mile repeater section, having a cable coefficient of .00532, and a permissible temperature range of 145°, each division of the dial represents about 2.6° (145° ÷ 56 dial divisions = 2.6° per dial division).

2.14 The resistance R4A in the bridge circuit, Fig. 2, may have three values, namely, 1860 ohms, 3500 ohms, or 5300 ohms, depending on the cable coefficient and the length of pilot wire. For example, with a cable coefficient of .0053 db per degree Fahrenheit per mile, the following values are ordinarily used:- 1860 ohms for a pilot wire length of one repeater section (typical aerial cable case); 3500 ohms for two repeater sections; 5300 ohms for three repeater sections (the latter two cases applying to underground cable).

2.15 Resistance R2A, Fig. 2, is used to build out the pilot wire resistance so that the bridge will be balanced and the potentiometer will be approximately in the middle of its range (dial reading 30) when the cable temperature is at its average value of 55°F. This resistance may be strapped to have values from 0 to 3840 ohms, in steps of 5 ohms. In certain cases where the repeater section length is short and the full regulating range is not required, an average value lower than dial reading 30 may be specified as a means of reducing the amplifier gain.

2.16 The resistance R3B, Fig. 2, is adjustable by strapping to adjust the ratio of the bridge circuit. The ratio to use depends on the cable coefficient, determined in either of two ways mentioned above, and determines the change in gain produced per ohm change in pilot wire resistance. This resistance may be strapped to have values from 0 to 1280 ohms, in steps of 2.5 ohms.

(E) Protection and Alarm Features

2.17 Arrangements have been provided in the master controller circuit so that an alarm is given under the conditions listed below. When these alarms occur, all receiver motors remain fixed in the position which they occupied when the trouble occurred (except in the case of the end alarm, when the controller continues to function). Under these conditions the gain of all line amplifiers, associated with this controller, remains fixed. These alarms are as follows:

(a) Pilot wire opened or shorted. The master controller resumes operation automatically when the pilot wire is restored to normal.

(b) Failure of 140-volt supply to the bridge circuit.

(c) Fuse failure in the 55-volt supply to the master controller and the receiver motors.

(d) Fuse failure in secondary leads.

(e) End alarm which indicates that the potentiometer has reached the upper or lower end of its range of adjustment.

(F) Equipment Arrangements

2.18 The master flat gain controller equipment is mounted in the aluminum casing shown in Fig. 3A. This casing is mounted by means of angle brackets on both sides which are slotted like mounting plates. The angle mounting bracket on the right-hand side can be seen in Fig. 3A. The door of this casing can be swung open and the equipment swung out on a hinged gate, as shown in Fig. 3B, thus making the equipment accessible for maintenance. The outside wiring is brought in through holes in the casing from both the right and left-hand sides and connected to terminals in the fixed part of the casing.

2.19 A dial which rotates with the potentiometer indicates the position of this potentiometer and the master transmitter motor. It can be seen when the door is closed, as indicated in Fig. 3A. The end of the cam shaft, which is painted half red and half white, and which is visible through an opening in the casing door, Fig. 3A, gives a visual indication that the rebalancing mechanism drive motor is running.

3. TWIST CORRECTION

(A) General Features

3.01 "Twist" correction (described in the Section covering the line and twist amplifiers) is required at less frequent intervals than flat gain correction. The method of choosing the stations at which twist correction is to be located is covered in another section. The system of twist correction requires a pilot wire for each twist section (several repeater sections) for each direction of transmission, which controls a master twist controller located on the receiving end of the pilot wire. The master twist controller controls the setting of the twist regulators in a number of systems. The equipment required in each individual system, i.e., the twist regulator, twist regulator network, and twist amplifier, is described in the section covering the line and twist amplifiers.

(B) Pilot Wire

3.02 One of the carrier pairs in each cable serves as a twist pilot wire, as indicated in Fig. 4. As will be noted, this pilot wire extends over all repeater sections to be regulated. The transposition of the carrier pairs (required for crosstalk reasons) between two cables is not shown in Fig. 4, but it is to be understood that the pilot wire is transposed between cables in the same manner as the other carrier pairs, and accordingly is always in the same cable in each section as the carrier pairs with which it is associated. The twist pilot pair is separate and distinct from the flat gain pilot pair used for flat gain regulation. Means are provided to recognize the change in resistance of the pilot wire as the temperature varies and to translate this change into suitable adjustments of the twist correction equipment in a group of circuits operating in the same direction. The master twist controller controls simultaneously the twist correction equipment in a group of 50 carrier pairs as discussed in the section covering the line and twist amplifiers.

3.03 A d-c by-pass filter is provided at each station to separate the d-c path of the twist pilot wire circuit from the carrier frequencies on that pair. The master twist controller is connected to the pilot wire at the receiving end of each section for each direction of transmission, and the pilot wire is shorted at its opposite end through another by-pass set to form a closed d-c path. At intermediate points, by-pass sets connect the pilot wire through. A second carrier pair in each cable is also equipped with by-pass sets and arranged to provide a spare twist pilot wire for emergency use. The by-pass filter has a resistance of about 3 ohms (total series resistance of all windings).

3.04 Resistances of 2, 4, and 8 ohms are provided in each pilot wire circuit so that the resistance of the regular and spare twist pilot wires may be adjusted to approximately the same value (within an ohm). These resistances are mounted on the by-pass filter panel.

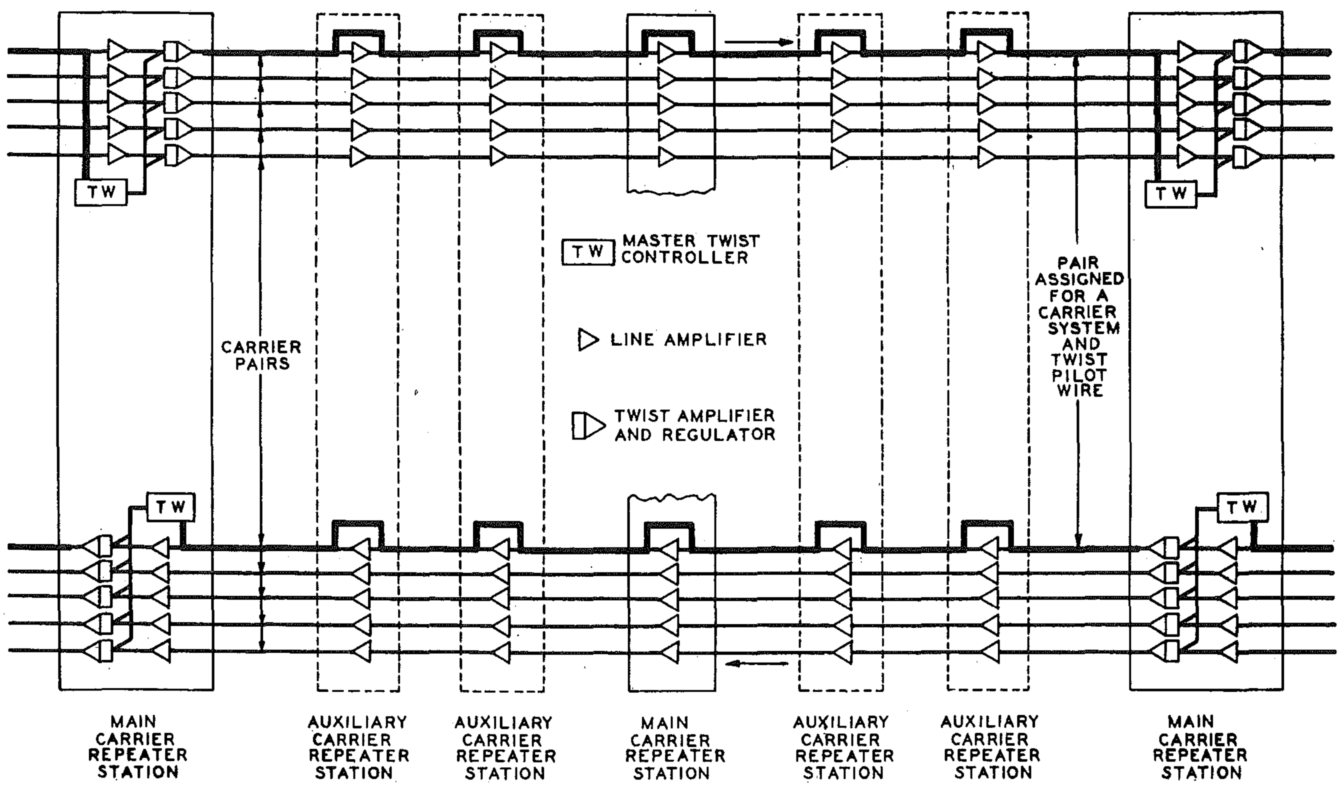


Fig. 4 - Pilot Wire Layout for Twist Regulation.

3.05 A schematic circuit layout of the carrier pairs assigned for regular and spare twist pilot wire use in the West-to-East direction is shown on Drawing ES-851726, page 101. A similar arrangement is required in the East-to-West direction. As noted on this drawing, the carrier pairs are assigned for twist pilot wire use as follows:

D-C Path Obtained From Pairs Arranged For	Used For
Carrier System No. 6	Twist pilot wire for carrier systems Nos. 1-50
Carrier System No. 7	Spare twist pilot wire
Carrier System No. 8	Twist pilot wire for carrier systems Nos. 51-100

3.06 On underground cable, more repeater sections may be included in a twist section, but otherwise the pilot wire arrangements are the same for both aerial and underground cables.

(C) Master Twist Controller

3.07 A schematic of the master twist controller circuit associated with the twist pilot wire is shown in Fig. 5. Four views of the master twist controller are shown in Figs. 6A, 6B, 6C and 6D.

3.08 Referring to Fig. 3, the principle of operation is based on a self-balancing Wheatstone bridge with the pilot wire forming part of one arm of the bridge. The total resistance of 100 miles of 19-gauge cable, for example, at 55°F. is approximately 8340 ohms (83.4 ohms per loop mile), and the change in resistance for a temperature change of ± 55° (0° to 110°) is about 1041 ohms (.1892 ohm per degree Fahrenheit per mile). It is this change in resistance which the master twist controller mechanism recognizes and translates into a change of setting of the twist regulators in a group of systems.

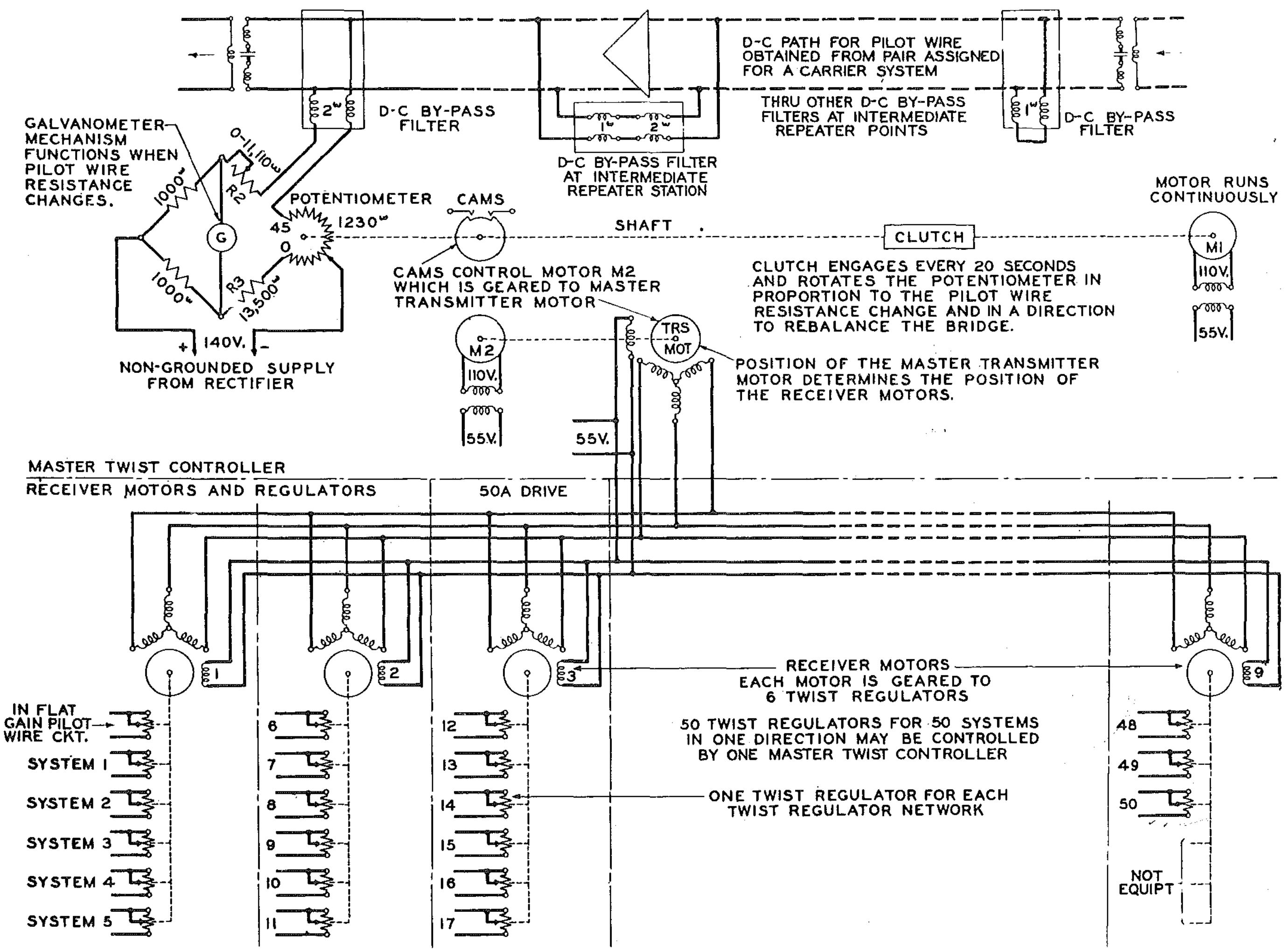


Fig. 5 - Master Twist Controller Circuit and Connection to Receiver Motors.

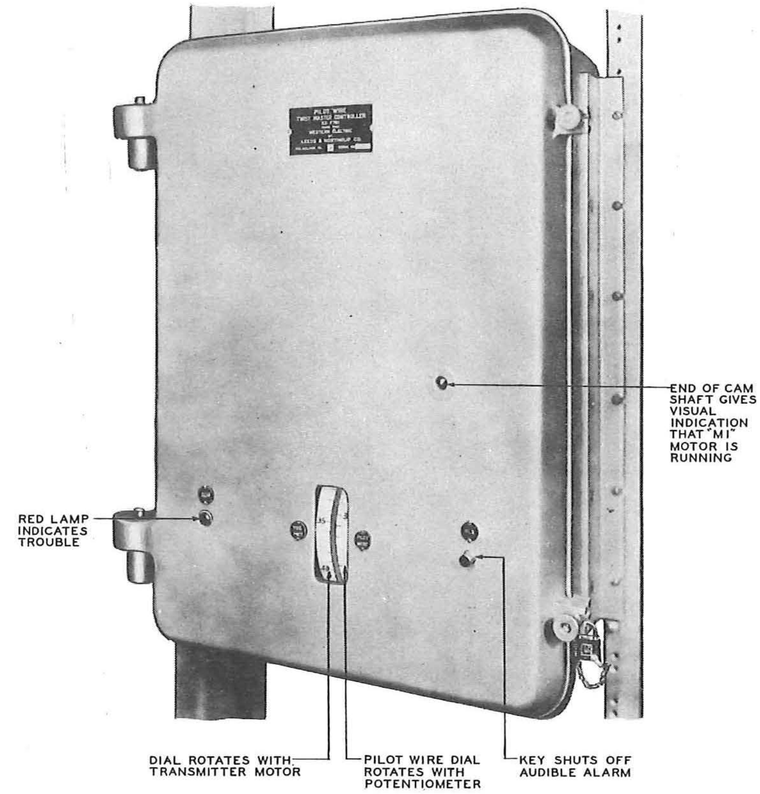


Fig. 6A - Master Twist Controller - Front View - Casing Door Closed.

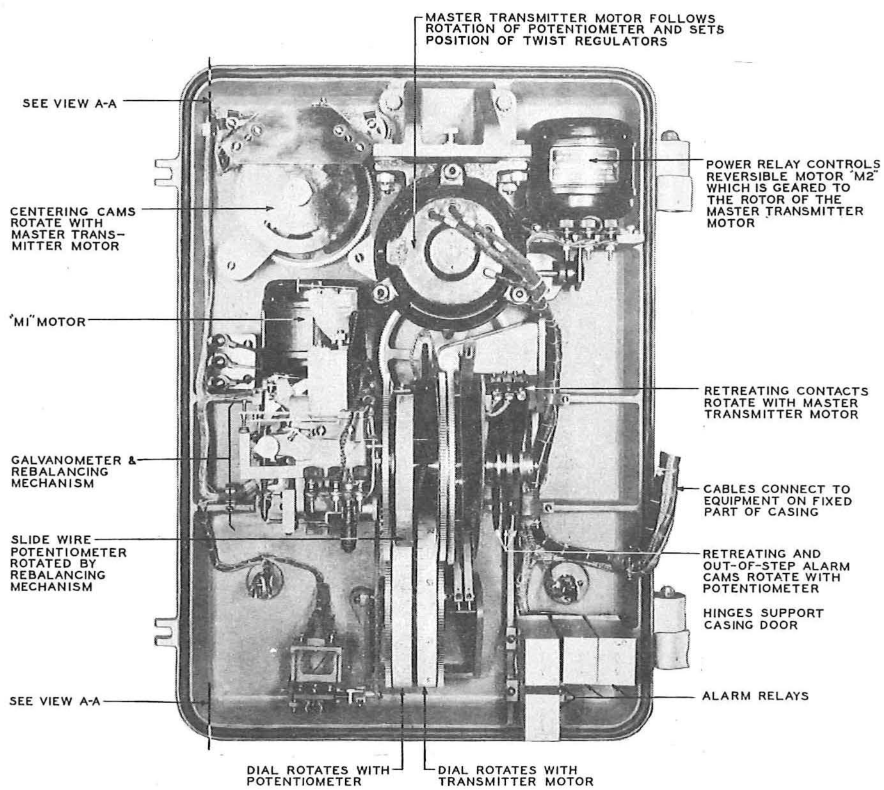


Fig. 6B - Master Twist Controller - Equipment on Rear of Casing Door.

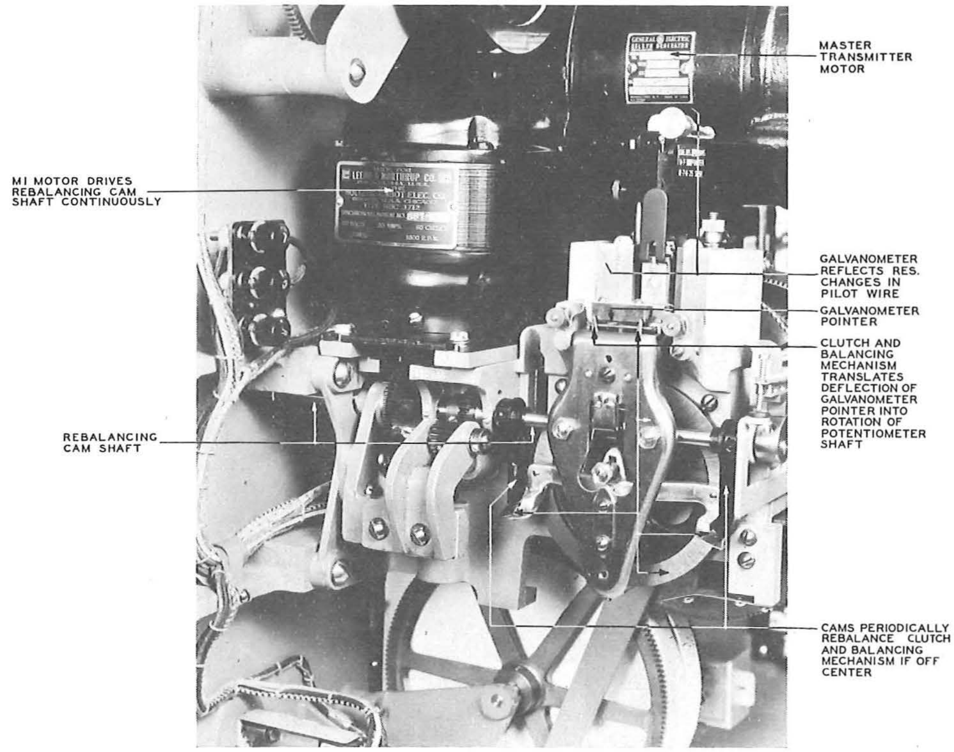


Fig. 6C - Master Twist Controller - View AA of Fig. 6B.

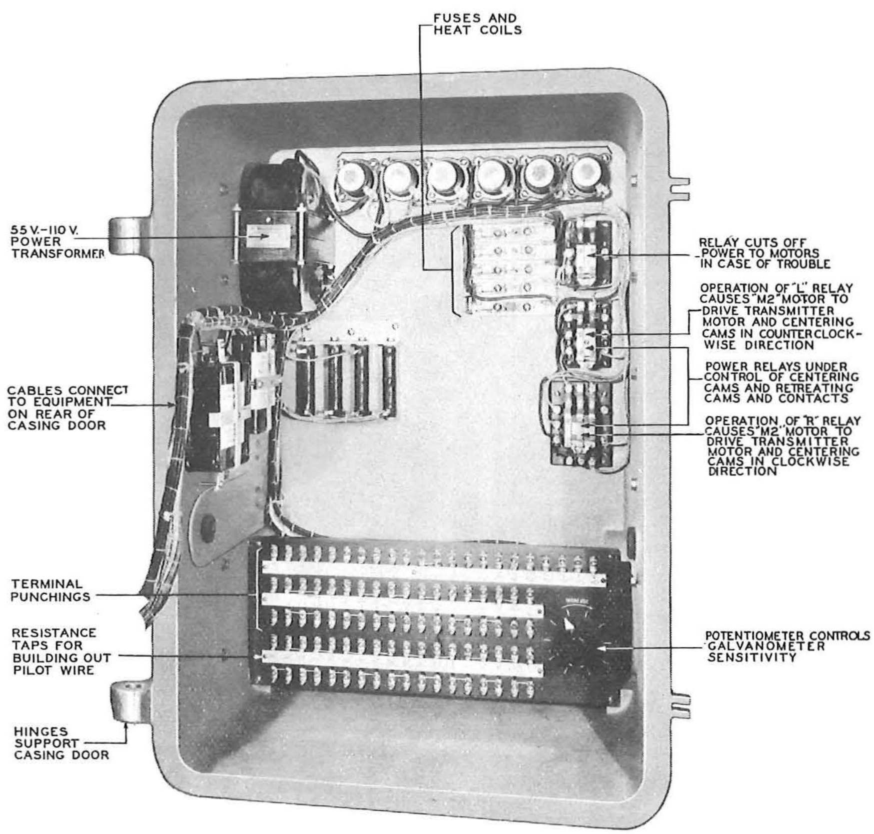


Fig. 6D - Master Twist Controller - Equipment on Fixed Part of Casing.

3.09 Briefly, the master twist controller functions as follows:- A master transmitter motor, "TRS. MOT." is connected mechanically to a motor, "M2," which is under the control of cams associated with the potentiometer in the bridge circuit. Motor "M1," which runs continuously, is connected every 20 seconds by means of a friction clutch to the control cams and the potentiometer. When the bridge circuit is balanced, no change results in the position of the potentiometer, control cams, motor "M2," and the master transmitter motor when the clutch is periodically closed. When a change in cable temperature occurs with a corresponding change in pilot wire resistance, the bridge circuit becomes unbalanced and produces a deflection of the galvanometer pointer. An engagement of the friction clutch then causes the potentiometer to be rotated in a direction which will rebalance the bridge. When these rebalancing movements become sufficient to cause a division on the "Pilot Wire" dial to get out of step .5 of a division above or .7 of a division below the corresponding division on the "TRS. MOT." dial, contacts on the control cams and relays close a circuit to operate the "M2" motor. This motor drives the rotor of the transmitter motor, which in turn causes a corresponding rotation of a group of twist regulators to compensate for the change in twist of the cable pair. The requirement of 1.2 dial division (from .5 above to .7 below) movement of the potentiometer before a reversal of the transmitter motor, is necessary to avoid an immediate reversal after a twist correction step in case the potentiometer reverses a very small amount or even remains stationary during the correction. The .2 of a dial division is, however, corrected for when the reversal occurs by cutting in or removing a small resistance in the pilot wire arm of the bridge circuit. Provision is also made for compensating for lost motion on reversals of the mechanism. The galvanometer and the "clutch and balancing mechanism," which is the same as for the flat gain controller, is shown in Fig. 6C.

3.10 Two dials are provided in the controller as shown in Fig. 6A. The dial designated "PILOT WIRE" is associated with the potentiometer and follows closely each rebalancing movement of the balancing mechanism. The other dial designated "TRS. MOT." is associated with the transmitter motor and shows its position. The two dials seldom read exactly alike because the transmitter motor moves in full steps (one full division on the dial). The "TRS. MOT." dial moves one step when the "PILOT WIRE" dial is slightly more than one-half step from the former dial. This feature is obtained by the so-called "retreating contacts" associated with cams on the potentiometer shaft. Under normal operation the dials should never show more than one step difference in reading.

3.11 An increase in pilot wire resistance causes the dials to move toward division "45," and a decrease, toward "0."

3.12 The sensitivity of the galvanometer can be adjusted by a potentiometer located in the controller as shown in Fig. 6D. This potentiometer determines the amount of current flowing in the galvanometer for a given unbalance of the bridge circuit, and accordingly determines the amount of deflection of the pointer produced by a given unbalance. In order to prevent hunting of the regulator (50A drive), it is desirable to adjust the sensitivity so that the galvanometer will not swing beyond mid-position on a rebalancing movement.

3.13 The master transmitter motor is wired to a maximum of nine receiver motors. Each receiver motor is geared mechanically to a maximum of six twist regulators. This unit, coded the 50A drive, is covered in the section describing the line and twist amplifiers. One twist regulator is provided in each carrier system at the twist correction station. The master transmitter motor and receiver motors are electrically connected in such a manner that a rotation in either direction of the rotor of the master transmitter motor will cause a corresponding rotation of the rotor of each receiver motor, i.e., the receiver motors keep in step with the master transmitter motor. The master twist controller, therefore, controls nine receiver motors which in turn control a total of 51 twist regulators (50 twist regulators in one direction; one twist regulator in the flat gain pilot wire, mentioned below; three twist regulators not equipped in the ninth 50A drive).

3.14 One of the regulators (having different resistance values) associated with each group of 50 regulators is connected in the flat gain pilot wire circuit, as indicated in Fig. 5. This regulator varies the total resistance of the flat gain pilot wire in the repeater section adjacent to the twist correction station, as the regulators operate over their range. When the master flat gain controller rebalances to compensate for the resistance introduced by the above regulator, it varies the gain of the line amplifiers in the twist correction station to compensate for the variation in 28 kc. loss of about ± 2 db in the twist regulator networks (in each system) as the regulators operate over their complete range. The transmission characteristics of the twist regulator network for different adjustments are discussed in the section covering the line and twist amplifiers.

<u>(D) Range of Operation</u>

3.15 The bridge circuit of the master twist controller is designed to operate up to a maximum length of pilot wire of 200 miles, when a 3400-ohm resistance is strapped in series with the 13,500-ohm resistance, R3, Fig. 5, giving a total resistance in this arm of 16,900 ohms. (200 miles x 83.4 ohms per loop mile = 16,680 ohms.) When this 3400-ohm resistance is strapped out, the bridge circuit will operate up to a maximum length of pilot wire of 160 miles (160 x 83.4 = 13,344 ohms). The total change in resistance which the bridge circuit is designed to handle is twice the resistance of the potentiometer (1230 ohms), or 2460 ohms, which is the change in resistance occurring in 13,000 degree-miles of cable (product of cable length and range of cable temperature), based on a change in resistance of .1892 ohm per degree Fahrenheit per mile. The master controller mechanism is accordingly capable of handling a maximum of 13,000 degree-miles of cable having an average amount of twist. This corresponds to 100 miles of cable, and a temperature range of 130 degrees. Because of the possibility of encountering cables having greater than average twist, the usual layout is such that each twist controller is required to handle only about 11,000 degree-miles. (The amount of twist correction available in the twist regulator network is the amount required in approximately 13,000 degree-miles of average cable, or 11,000 degree-miles of greater-than-average cable.) In the case of underground cables, which ordinarily operate over a range of approximately 36° (about 37° to 73°F.), 200 miles of cable require 8000 degree-miles of twist correction, which accordingly require only 8/15 of the range of the potentiometer. In this case, the resistance of the pilot wire (16,680 ohms) places the limitation on its length at about 200 miles. For cable which is part aerial and part underground, the above limitations apply, i.e., 200 miles of cable and 11,000 degree-miles.

3.16 A building-out resistance, R2, Fig. 5, is strapped so that its value, plus the resistance of the pilot wire, equals 13,500 ohms (or 16,900 ohms if the 3400-ohm resistance is provided in series with the R3 resistance in accordance with the above).

(E) Protection and Alarm Features

3.17 Arrangements have been provided in the master twist controller circuit so that an alarm is given under the conditions listed below. When these alarms occur, all receiver motors remain fixed in the position which they occupied when trouble occurred. Under these conditions, the setting of the twist regulators, associated with this controller, remains fixed. All alarms light a lamp on the controller instrument, and operate the office alarm system. These alarms are as follows:

(a) Out of step.

This alarm occurs when the "TRS. MOT." dial and the "PILOT WIRE" dial are more than 1.5 steps apart.

(b) Pilot wire.

This alarm occurs when a large unbalance occurs in the bridge circuit due to an open or shorted pilot wire.

(c) 140-volt d-c bridge supply.

This alarm occurs when the 140-volt supply fails, due either to a failure of the a-c supply to the rectifier or fuses in this circuit, or to an open in the contact brush on the slide wire.

(d) Fuse failure.

(e) Limit alarm.

This occurs when the retreating contacts are moved above position "45," or below position "0."

3.18 The master controller must be restored to operation manually when the source of trouble has been cleared.

(F) Equipment Arrangements

3.19 The master twist controller equipment is mounted in an aluminum casing similar to that used for the master flat gain controller described in Part 2. The method of mounting the casing and connecting the wiring to equipment inside the casing is the same. Fig. 6A shows this casing (with the door closed) mounted on the framework. Figs. 6B, 6C and 6D show interior views.

3.20 As in the case of the master flat gain controller, there is a visual indication on the front of the cover that the "M1" motor is running. The "PILOT WIRE" dial and "TRS. MOT." dial can both be seen with the door closed, as shown in Fig. 6A. The red lamp (on the front of the door) lights when the alarm is operated, in addition to the audible alarm elsewhere in the office. The audible alarm can be cut off by the "RLS" key, also on the front of the cover, though the lamp remains lighted until the trouble is cleared.

4. POWER SUPPLY CIRCUITS

(A) 140-Volt D-C Power

4.01 140-volt d-c non-grounded power supply is used on the bridge circuit in each master controller circuit, as indicated in Figs. 2 and 5. This voltage is obtained from a rectifier of the copper-oxide type in the power supply equipment provided with the master controller. A separate rectifier, operating directly from commercial 60-cycle power, is provided for each bridge circuit.

(B) 55-Volt A-C Power

4.02 55-volt, 60-cycle power is required for all master controller circuits, as indicated in Figs. 2 and 5. This power supply is obtained from 110-55-volt transformers connected directly to the commercial power (105-125 volts).

5. BAY ARRANGEMENTS

5.01 The master controllers are mounted on the framework for the single-side wiring and maintenance arrangement which is used for the associated amplifiers and twist correction equipment. This permits the controller bays to be mounted in the same lineup with the amplifier bays or in an adjacent lineup, which is desirable as the leads between the transmitter motors in the controllers and the receiver motors in the amplifiers should be as short as possible, because of a resistance limitation placed on these leads. The controllers, of course, fit in with this arrangement since they can be maintained from only one side. This framework, which is described in the notes covering the line and twist amplifier, has a cable duct on the right and left-hand side of each bay, and so the wiring connects to these controllers from either side.

5.02 There are two bay arrangements for the master controllers, one with flat gain controllers only, for offices which do not require twist correction, and another for both flat gain and twist controllers.

5.03 Fig. 7 shows the bay arrangement for flat gain controllers only. The four controllers which are mounted in this bay will control the flat gain of 100 amplifiers in the E-W direction and 100 amplifiers in the W-E direction. The capacity of each bay is, therefore, 100 two-way systems. Fuse panels, and resistances for the alarm circuits, are mounted at the top of the bay. The two fuse panels mount fuses which are in the common leads from each master transmitter motor to the receiver motors on the line amplifiers, through distribution terminal strips at the top of the amplifier bays. The primary leads and fuses are common to a maximum of 21 amplifiers. The secondary leads and fuses are common to a maximum of 50 amplifiers. These leads, and the 55-volt a-c leads from the associated power supply bays, are run in the right-hand cable duct. The only wiring run in the left-hand cable duct is the rubber covered shielded pair connecting to the sealed test terminal for the pilot wire, and the 140-volt d-c supply for the Wheatstone bridge circuits in the controllers.

5.04 Fig. 8 shows the bay arrangement used for both flat gain and twist controllers. Two such bays are required for 100 systems. The first bay contains two master twist controllers and two master flat gain controllers required for 100 amplifiers in the E-W direction, and the second bay contains four controllers for 100 amplifiers in the W-E direction. The four fuse panels and the miscellaneous alarm equipment shown at the top of the bay are required in the first bay only. The fuse panels mount fuses in the leads from the master flat gain controllers to the distribution terminal strips at the top of the line amplifier bays as discussed for Fig. 7. Similar fuses are not provided on this bay for the common leads between the master transmitter motors in the twist controller and the receiver motors on the 50-A drives in the line amplifier bays, because they are distributed to each of these receiver motors through individual fuses at the top of these amplifier bays. As in the case of the bay arrangement shown in Fig. 7, the leads for the 140-volt d-c supply and for the several pilot wires are run in the left-hand cable duct, and all the other leads are run in the right-hand cable duct.

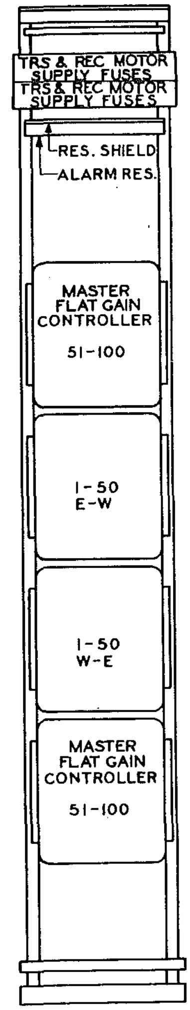


Fig. 7 - Master Flat Gain Controllers - Bay Layout.

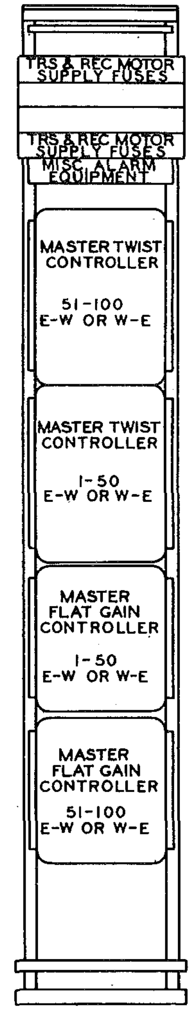


Fig. 8 - Master Flat Gain and Twist Controllers - Bay Layout.

5.05 The power supply for these master controllers is obtained from equipment in a separate bay. The power supply bay shown in Fig. 9 is associated with the bay for flat gain controllers only (Fig. 7) and the power supply bay shown in Fig. 10 is used with the bay arrangement for both the master twist and flat gain controllers (Fig. 8). The panels designated 55-volt and 140-volt power supply in these two bay layouts are identical. The 60-cycle 110 to 55-volt transformer is mounted on the front of this panel and two copper-oxide rectifiers for two ungrounded 140-volt d-c supplies are mounted on the rear of each panel.

5.06 Fig. 9 mounts two of these power supply panels, one of which is used to supply the E-W and the W-E controllers for amplifiers 1 to 50, and the other panel supplies the controllers for amplifiers 51 to 100. Two panels for supplying 115 volts a-c under emergency conditions in an auxiliary repeater station are also mounted in this bay, one for repeaters 1-50, and one for repeaters 51-100. A dynamotor is mounted on this panel and connected automatically during intervals of a-c power failure to the 152-volt battery and this furnishes the emergency a-c supply for the flat gain controllers. To limit the drain on the battery during a-c failure, the dynamotor is operated by means of control relays for a period of one-half minute at 10 minute intervals. This interval is sufficient for the flat gain controllers to adjust the line amplifiers.

5.07 Fig. 10 shows four of the 55 and 140-volt power supply panels. As shown, both the twist and the flat gain controllers for 50 circuits in one direction are supplied from the same panel. The cabinets for the two grid battery supply equipments (one for odd numbered circuits and one for even numbered circuits) are mounted at the bottom of this bay. These are not shown in Fig. 9 because in offices without twist correction these grid battery supply cabinets are mounted in the lower part of the bay containing the sealed test terminals. Unlike the controller bays and the power supply bay for flat gain controllers only, the power supply equipment shown in Fig. 10 is mounted on the usual channel relay rack framework instead of the single-side wiring and maintenance framework.

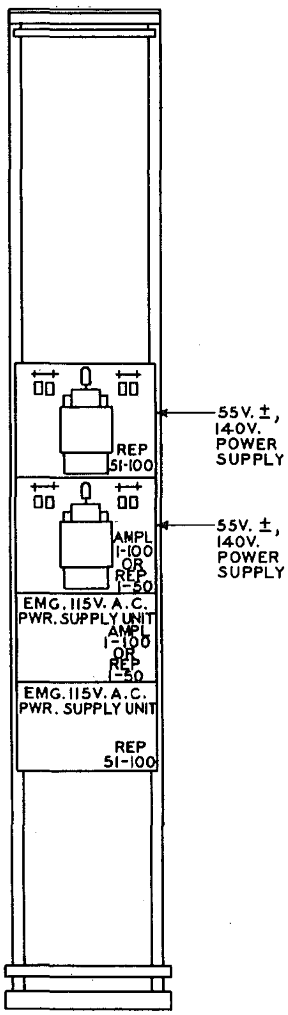


Fig. 9 - Power Supply Bay for Flat Gain Controllers.

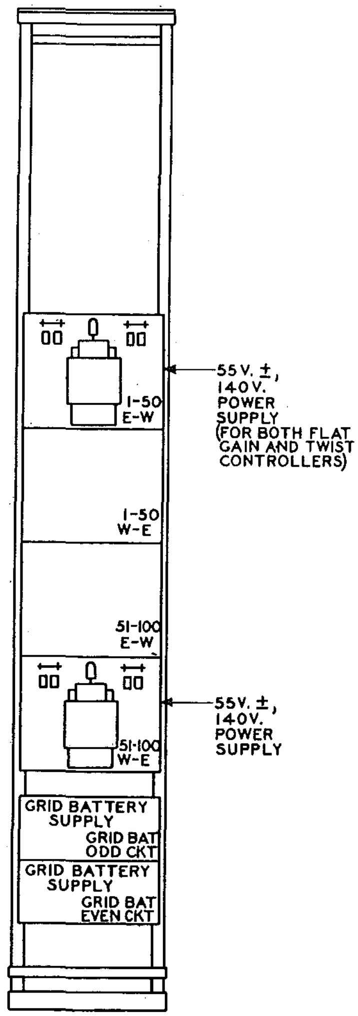


Fig. 10 - Power Supply Bay for Flat Gain and Twist Controllers.

6. DRAWINGS

Drawing Attached		Page
ES-851726	Pilot Wire Layout Showing Carrier Pairs Assigned for Flat Gain and Twist Pilot Wires	101

SD Drawings (Not Attached)

SD-64332-01	Master Flat Gain Controller Circuit
64333-01	Supply and Distribution Circuit for Master Flat Gain Controllers
64335-01	Master Twist Controller Circuits
64336-01	Supply Distribution Circuit for Master Twist Controller and Drive Equipment
80624-01	Power Supply Circuit - Pilot Wire Twist and Flat Gain Controllers - 55-Volt A-C and 140-Volt D-C Bridge Supply.

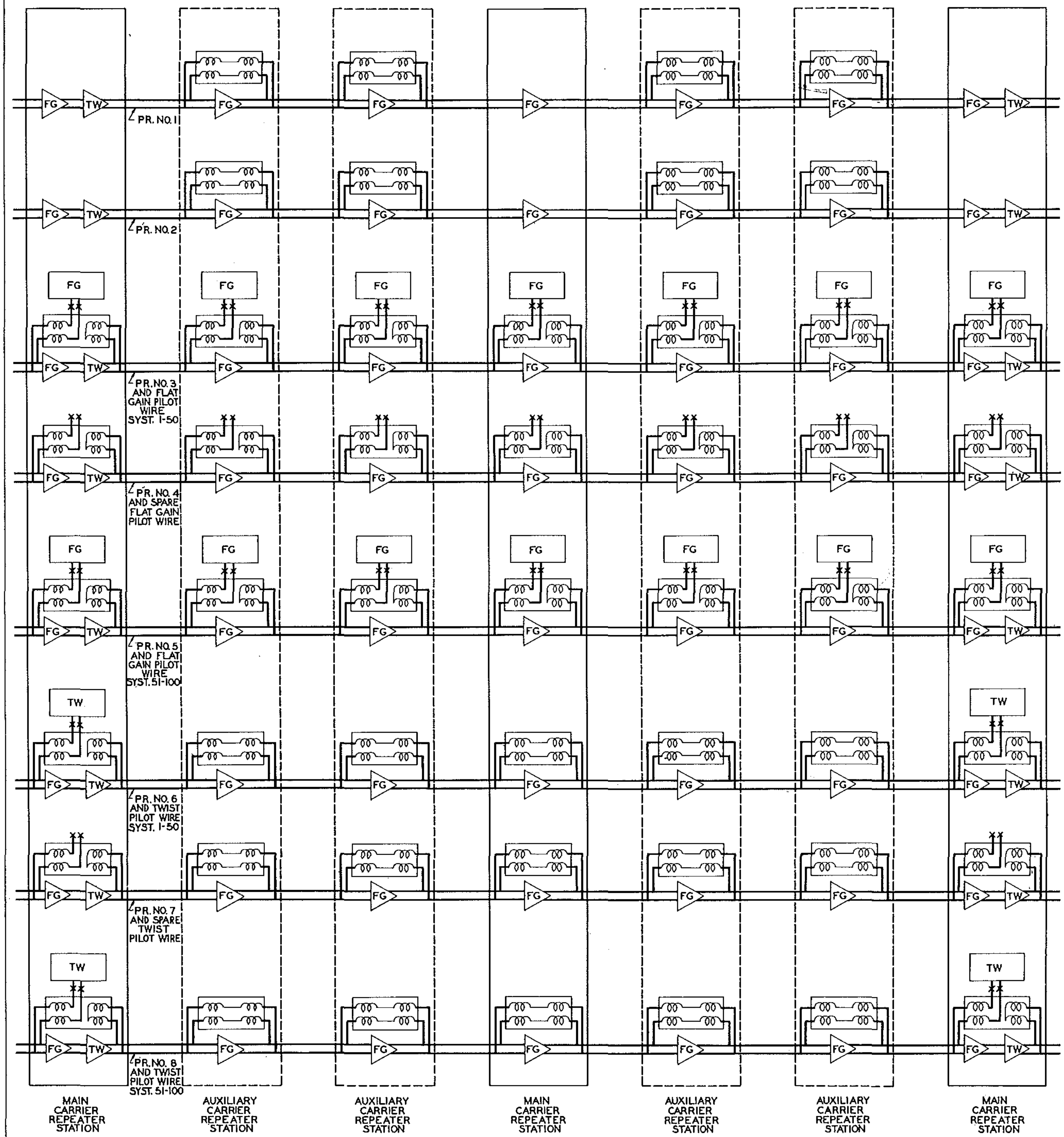
ED Drawings (Not Attached)

ED-64333-01	Master Flat Gain Controller Bay Equipment for Stations Without Twist Regulation
64333-02	Master Flat Gain Controller Bay Cabling Plan - For Use in Main and Auxiliary Stations Not Requiring Twist Regulation
64336-01	Master Flat Gain and Twist Controller Bay Equipment for Repeater Stations Requiring Flat Gain and Twist Regulation
64336-02	Master Flat Gain and Twist Controller Bays; Cabling Plan for Repeater Stations Requiring Flat Gain and Twist Regulation

BELL TELEPHONE LABORATORIES, INC.

ES-851726
E.C.T. 1-19-38
O.H.L. 4-16-38

TYPE K CARRIER TELEPHONE SYSTEM
PILOT WIRE LAYOUT SHOWING CARRIER PAIRS ASSIGNED FOR FLAT GAIN AND TWIST PILOT WIRES



LEGEND

TW — MASTER TWIST CONTROLLER

FG — MASTER FLAT GAIN CONTROLLER

TW▷ — TWIST AMPLIFIER INCLUDING TWIST REGULATOR NETWORK

FG▷ — LINE AMPLIFIER HAVING FLAT GAIN CONTROL

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