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TRANSMISSION MEASURING EQUIPMENT DESCRIPTION, OPERATION, AND MAINTENANCE

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TRANSMISSION MEASURING EQUIPMENT
DESCRIPTION, OPERATION, AND MAINTENANCE

SECTION I - INTRODUCTORY DESCRIPTION

1. FUNCTIONS

1.01 The transmission measuring facilities covered herein may be used for testing a line from station to station, a circuit within a station, or an individual apparatus item.

2. GENERAL DESCRIPTION

2.01 Transmission measurements are made with this equipment by sending a known amount of 1000 cycle power into one end of a line, circuit or piece of apparatus and measuring the amount received at the other end, or by connecting the sending source to the receiving set and bridging the line, circuit or piece of apparatus to be measured to obtain the bridging loss. All lines, circuits or apparatus whose effect is not desired in the measurement should be disconnected during the test. The equipment consists of several distinct items, which are covered in detail in subsequent sections. A small 1000 cycle machine is available in portable form for supplying 1 milliwatt of testing power to one circuit at a time. A sending panel is required when simultaneous use is made of the source of testing power for several circuits. Portable transmission measuring sets are used for measuring the resulting power received at the circuit terminal. One of the sets has a loss range of 0-10 db. Another has a loss range of 0-20 db, while a third has a range of 0-25 db.

2.02 When any one of these sets is to be used for making repeater gain measurements, sending pads must be patched in the input of the repeater to limit the testing power. This repeater gain measurement is covered in detail in section VIII.

SECTION II - KS-5472 1000 CYCLE MACHINE

1. GENERAL

1.01 This section describes a 1000 cycle machine per KS-5472 for generating testing power for the sending circuits of transmission measuring systems. It operates from a 105-125 volt, 60 cycle source.

1.02 The machine is provided with or without a portable carrying case. It supplies 1 milliwatt of testing power at 1000 cycles to one 600 ohm circuit. It is also provided as an integral part of the J94002A sending panel for supplying more than one circuit as described in section III.

2. EQUIPMENT AND CIRCUIT FEATURES

2.01 The general features of the 1000 cycle machine without a carrying case is shown in Fig. 1 and the circuit features are shown in Fig. 2.

2.02 The terminal block to which the external connections are made is also used for mounting the output circuit network. With this network the machine supplies 1 milliwatt to a 600 ohm circuit from terminals 5 and 6. This

Fig. 1 - 1000 Cycle Machine.

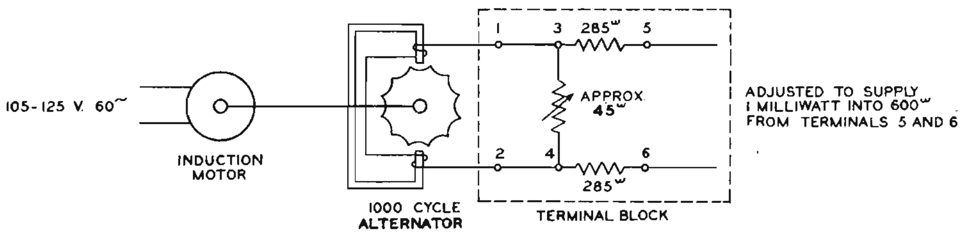


Fig. 2 - Schematic Diagram of Connections.

testing power may be used for transmission measurements with any receiving circuit calibrated in db on the basis of 1 milliwatt at 1000 cycles into a 600 ohm circuit such as the 9A, 12A, or J94020A transmission measuring sets described in sections IV, V, and VI.

2.03 The motor is a 2 pole split phase induction motor designed for quick starting when directly connected to a 105-125 volt, 60 cycle source. The alternator is of the inductor-alternator type with excitation furnished by a permanent magnet. No speed regulator or other accessories are required. The rotor has 17 teeth and turns at approximately 3530 rpm which results in an output frequency of 1000 cycles when the supply frequency is 60 cycles per second.

2.04 When assembled in a carrying case shown in Fig. 3 the combined weight is approximately 16 pounds and the dimensions are approximately 6" x 9" x 6".

2.05 The output leads are brought through a bushed hole in the end of the carrying case. The connection to the local a-c supply is made by means of an extension cord inserted in the receptacle in the side of the box.

2.06 The items available are as follows:

KS-5472, List 1 - Machine Only

KS-5472, List 2 - Machine mounted in carrying case complete with power supply extension cord.

3. TRANSMISSION PERFORMANCE

3.01 The output variation is not more than ± .2 db for ± 10 volt or ± 1 cycle frequency variations in a-c power supply. The correct power is available almost instantaneously since the motor reaches full speed within approximately one second after being turned on. The impedance of the sending circuit is 600 ohms ± 2.0%.

3.02 The harmonic and extraneous frequency content of the sending power includes in terms of the fundamental (1000 cycles) value, about

Fig. 3 - Carrying Case for 1000 Cycle Machine.

1% second harmonic, about 7% third harmonic and less than 1% of any frequency other than these, such as 20 or 60 cycles current.

3.03 The frequency accuracy is 1000 cycles ± 1% plus any deviations due to the local 60 cycle power supply.

4. OPERATING FEATURES

4.01 The portable and unmounted arrangements of this machine have no starting relay or switch, it being necessary to connect it to a source of 105-125 volt, 60 cycle power, and to disconnect it when tests are completed. Its power consumption is approximately 25 watts.

5. MAINTENANCE

5.01 With approximately one hour a day operation apply 2 or 3 drops of oil a month in each oil hole. This should not raise the oil level so that oil stands in the oiler. KS-2245 or any good lubricating oil between 130 and 190 Saybolt at 100 degrees Fahrenheit is satisfactory.

SECTION III - J94002A SENDING PANEL

1. GENERAL

1.01 This section describes the sending panel per J94002A and its associated circuits which constitute a milliwatt distributing system for supplying and distributing testing power of 1000 cycles to any number of circuits from 1 to 150 for making transmission measurements. The panel includes a 1000 cycle machine per KS-5472 List 1. The circuit arrangements are covered in detail in Fig. 6.

1.02 The equipment is installed in an office for automatic connection to a 105-125 volt 60 cycle source, by means of a starting relay.

2. EQUIPMENT AND CIRCUIT FEATURES

2.01 The sending panel includes a KS-5472 List 1 1000 cycle machine described in section II, four adjustable resistance units, a condenser, a repeating coil, and a relay for automatic starting control. This relay may be obtained for operation on either 24 or 48 volt direct current. The arrangement of this apparatus on the panel is shown in Figs. 4 and 5.

2.02 Each milliwatt supply pair requires two 296 ohm resistances to build out the sending circuit to 600 ohms. Each supply pair should be provided with a termination of 600 ohms either

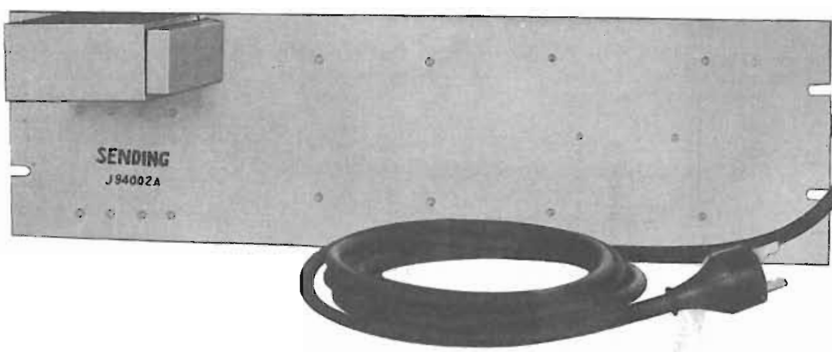
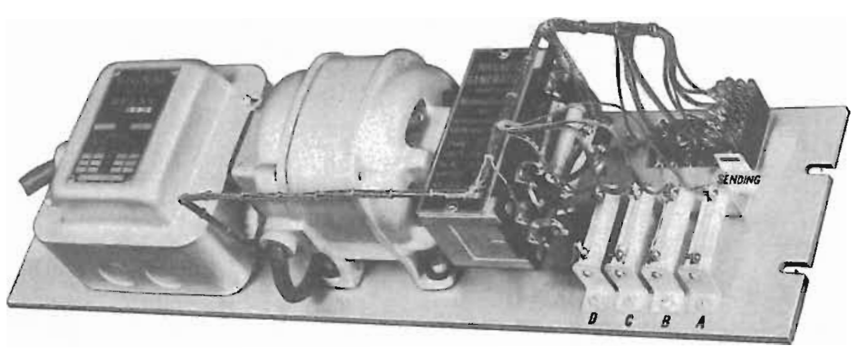


Fig. 4 - J94002A - 2A Sending Panel - Front View.



192.00

Fig. 5 - J94002A - 2A Sending Panel - Rear View.

FIG. 6
J94002A
SENDING PANEL

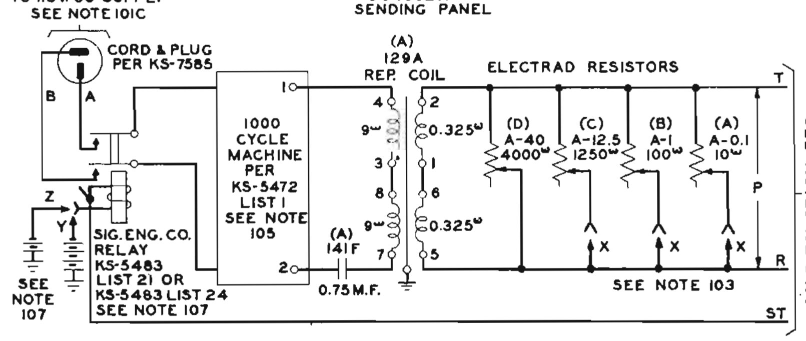
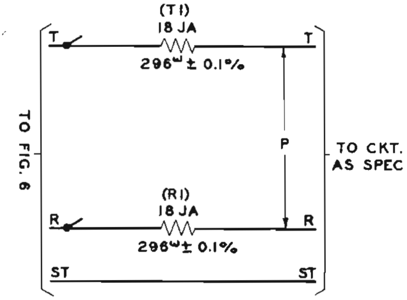
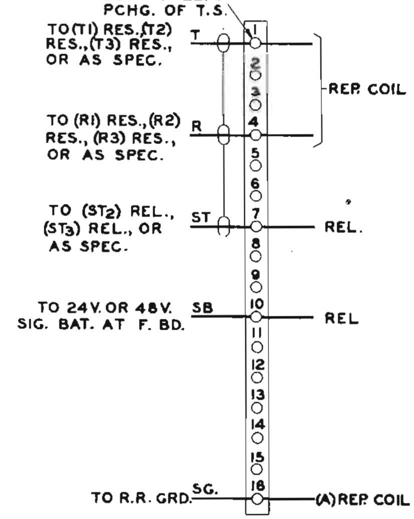


FIG. 6A
SEE NOTE 104

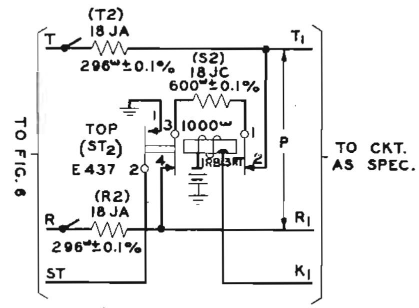


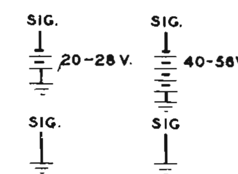
TOP OR LEFT
PCHG. OF T.S.



T.S. ON SENDING
PANEL

FIG. 6B
SEE NOTE 104





CIRCUIT NOTES:

101. (A) PROVIDE ONE LEAD FROM THE 24V. SIGNALING BATTERY BUSBAR EQUIPPED WITH 1 1/3 AMP. FUSE PER FIG.6 AND 50 FIGS. 6B AND 6C.
(B) PROVIDE ONE LEAD FROM THE 48V. SIGNALING BATTERY BUSBAR EQUIPPED WITH 1 1/3 AMP. FUSE PER FIG. 6.
(C) THE 115V. 60~ SUPPLY CAN BE OBTAINED FROM ANY STANDARD BRANCH CKT. EQUIPPED WITH A 1 AMP. FUSETRON IN THE UNGROUNDED LEAD.

102. NOT MORE THAN 150 FIGS. 6A, 6B, OR 6C OR COMBINATIONS THEREOF SHALL BE CONNECTED TO THE SENDING PANEL.

103. PROVIDE "X" WIRING AS REQUIRED TO MEET TRANSMISSION REQUIREMENTS.

104. USE FIG. 6A WHEN NORMALLY TERMINATED WITH AN IMPEDANCE EQUAL TO 600ω RESISTANCE. USE FIG. 6B WHEN ITS TERMINATION IS NORMALLY OPEN. USE FIG. 6C WITH CKTS. CONTAINING A 10db PAD WHICH IS NORMALLY NOT TERMINATED BY 600ω.

105. THE STRAPS BETWEEN TERMINALS ONE AND THREE AND BETWEEN TWO AND FOUR OF THE 1000~ MACHINE SHALL BE REMOVED.

106. WHEN THE MILLIWATT DISTRIBUTING EQUIPMENT PER FIGS. 6A, 6B, & 6C IS LOCATED IN THE SAME BAY AS THE SENDING PANEL, THE "T" & "R" LEADS MAY BE MULTIPLED AT THE RESISTANCES. OTHERWISE SEPARATE LEADS SHOULD BE FURNISHED FROM THE BAY CONTAINING THE SENDING PANEL TO THE RESISTANCES OF FIGS. 6A, 6B, OR 6C.

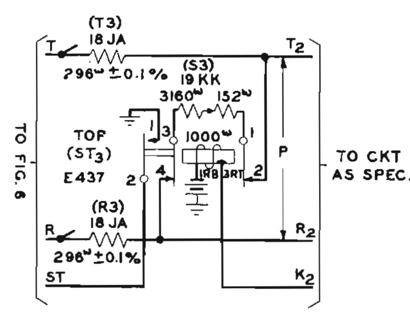
107. (A) FURNISH "Z" WIRING AND RELAY PER KS-5483 LIST 21 WHEN FIG. 1 IS OPERATED FROM 24V. BATTERY
(B) FURNISH "Y" WIRING AND RELAY PER KS-5483 LIST 24 WHEN FIG. 1 IS OPERATED FROM 48V. BATTERY.

TRANSMISSION REQUIREMENT NOTES:

301. ONE ADJUSTMENT OF RESISTORS A, B, C, AND D SHALL BE MADE SO THAT THE POWER DELIVERED TO EACH SENDING TERMINATION IS 1 MILLIWATT ± 0.1db INTO 600ω

302. WITH THE ABOVE ADJUSTMENT OF RESISTORS A, B, C, AND D THE COMBINED RESISTANCE OF THESE RESISTORS IN PARALLEL WITH ALL SENDING CIRCUIT TERMINATIONS SHALL NOT EXCEED 8ω. ANY CONDENSERS IN SERIES WITH THE TERMINATIONS SHALL BE STRAPPED OUT. THIS REQUIREMENT SHALL BE MET ONLY AT THE TIME OF INSTALLATION OF THE SENDING PANEL.

FIG. 6C
SEE NOTE 104



CURRENT DRAIN DATA
AMPERE HOURS PER BUSY HOUR USED

RELAYS	BAT. 24V.	GRD. AT R.R.
FIG. 6	.087	—
FIG. 6B OR 6C	.024	.087

Fig. 6 - Milliwatt Distributing System with 2A Sending Panel.

connected to relay contacts or to jacks. Resistors A, B, C, and D are adjusted as required to consume all excess power from the machine. Resistances and relays for each testing circuit are provided separately from the sending panel in several optional arrangements.

2.03 The items available are as follows:

J94002A, List 1 - Sending Panel (24 volt relay control)

J94002B, List 2 - Sending Panel (48 volt relay control)

3. TRANSMISSION PERFORMANCE

3.01 The sending power is constant to ± .05 db for variations of the power source within the 105-125 volt range and 59-61 cycle frequency range. The effect of being non-terminated at any one appearance does not exceed .05 db. The sending circuit is within 2% of 600 ohms impedance irrespective of the number of testing circuits to be supplied.

4. OPERATING FEATURES

4.01 When the starting relay is operated by grounding the ST lead, the 105-125 volt 60 cycle source is connected to the motor. The machine immediately starts and supplies 1 milliwatt of testing power to each 600 ohm termination of the sending circuit.

4.02 The testing power can be used for transmission measurements with any receiving circuit calibrated in db on the basis of 1 milliwatt at 1000 cycles in a 600 ohm circuit such as the 9A, 12A, or J94020A transmission measuring sets described in sections IV, V, and VI.

4.03 The sending circuit should be patched last in order to retain the termination, and minimize the effect on other milliwatt supply pairs.

5. MAINTENANCE

5.01 The power relay (KS-5483, List 21 or List 24) shall operate and give reliable contact on minimum battery voltage.

5.02 The start relay (E437) shall have an armature travel of approximately .015", contact follow on the make contact of .005", a perceptible gap between armature studs and the break contact armature springs, back contact pressure (approximately 15 grams) sufficient to give reliable contact, and the armature shall come all the way up to the core on minimum battery voltage or on .018 ampere or less.

5.03 The 1000 cycle machine shall be oiled in accordance with paragraph 5.01, section II.

SECTION IV - 9A TRANSMISSION MEASURING SET

1. GENERAL

1.01 This section describes the 9A transmission measuring set, a portable receiving set for measuring transmission losses from 0 to 10 db in the frequency range from about 300 to 4000 cycles. An external source of standard testing power is required for calibrating and for measuring.

2. EQUIPMENT AND CIRCUIT FEATURES

2.01 The 9A transmission measuring set consists of an input repeating coil shunted by a resistance, a rheostat, and a db meter with self-contained copper oxide rectifier, all assembled in a moulded bakelite case, the approximate dimensions of which are 3-3/4" x 5-1/2" x 2-1/4". It is equipped with a carrying handle and two binding posts to which external connections are made. Its total weight is 28 ounces.

2.02 The general arrangement and face view of the set is shown in Fig. 7 and the circuit diagram is shown in Fig. 8.

2.03 The repeating coil and the shunt resistance provide a d-c path of about 125 ohms for holding a circuit busy when necessary and an impedance of approximately 600 ohms at a frequency of 1000 cycles per second. The rheostat, adjustable by means of a screw-driver, provides the calibrating feature of the set. The Weston Model 301 rectifier type a-c milliammeter is calibrated in db as shown in Fig. 7, on the basis of 1 milliwatt in a 600 ohm circuit.

3. TRANSMISSION PERFORMANCE

3.01 The accuracy of the 9A set for 1000 cycle measurements in the 0-5 db range immediately after calibration at 0 db is ± .3 db, at normal room temperatures. Under the same conditions the accuracy for the 5-10 db range is ± .5 db. The copper oxide rectifying element of the meter in the 9A set, like all copper oxide rectifiers, varies in impedance and rectification efficiency with temperature. If the set is calibrated at 70° and the temperature is reduced to 60° or raised to 90°, the reading of the set will change a few tenths of a db, which change can be corrected by recalibration with the standard testing power source. As the temperature is reduced below 60° the error becomes increasingly greater until, at temperatures below freezing, it may be as much as 3 or 4 db, which is beyond the ability of the adjusting dial to correct. The set should, therefore, not

Fig. 7 - 9A Transmission Measuring Set.

be used in cold locations, and after exposure to cold should be allowed to warm up to at least 60° before using.

3.02 The frequency characteristic of the set is substantially flat between 300 and about 4000 cycles, so that when calibrated at 1000 cycles, the accuracy of loss measurements is not impaired

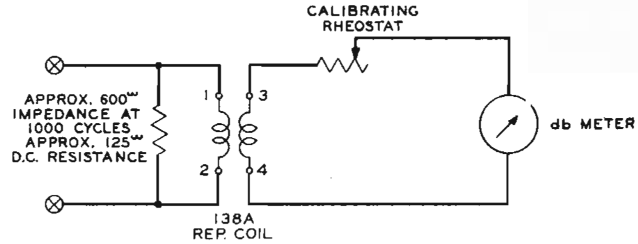


Fig. 8 - Schematic 9A Transmission Measuring Set.

more than .2 db if other frequencies are used in measuring. The frequency characteristic falls off below about 300 cycles thus limiting the use of the set to the range above that frequency.

3.03 The input impedance of the set varies slightly with both frequency and testing power. At 1000 cycles with a deflection near 0 db the impedance is approximately 600 ohms. The impedance decreases with the frequency below 1000 cycles, and increases as the testing power is reduced below 1 milliwatt. However, within the operating range of the set, between 300-4000 cycles and 0-10 db, the impedance is always within ± 100 ohms of the nominal 600 ohm value.

4. OPERATING FEATURES

4.01 The 9A set should be in a horizontal position when measurements are to be made.

4.02 The circuit to be tested is connected to the set by means of a cord with spade tips or with wire as required without regard to polarity.

4.03 The measurements in db is indicated directly on the meter.

4.04 To calibrate the set connect it directly to the standard testing power of 1 milliwatt and adjust the scale to 0 db.

4.05 Curves giving the performance characteristics of a particular 9A transmission measuring set can be prepared from calibration data to obtain better accuracy than the nominal values given above.

SECTION V - 12A TRANSMISSION MEASURING SET

1. GENERAL

1.01 This section describes the 12A transmission measuring set which is a small portable receiving instrument for measuring transmission losses from 0 to 20 db over the frequency range of 350 to 1000 cycles. This test set does not employ vacuum tubes and therefore external power is not necessary for its operation, except that an external source of standard testing power is required for calibrating and for measuring.

2. EQUIPMENT AND CIRCUIT FEATURES

2.01 The 12A transmission measuring set is assembled in an aluminum alloy box which, excluding hardware, measures 8-3/4" x 5" x 5". The total weight of the set including a cover, which is provided for protecting the panel equipment when not in use, is 7 pounds.

2.02 The face view of the measuring set panel is shown in Fig. 9. The equipment as shown

Fig. 9 - 12A Transmission Measuring Set.

consists of a meter, two lever type keys, two binding posts, ten jacks, and an adjustable resistance for calibration.

2.03 This set is similar in principle to the 9A but has a more sensitive meter which measures in the 10-20 db range below 1 milliwatt although the scale is graduated from 0 to 10 db. This meter operates in conjunction with a 10 db pad which is removed from the circuit for readings in the 10-20 db range.

2.04 The meter used is a Weston Model 643 microammeter employing a copper oxide unit. It has two scales, one black (upper) and the other red (lower) each graduated in db from 0 to 10. The black (upper) scale is used for loss measurements, and the red (lower) scale for gain measurements of repeaters and repeater circuits. The black scale is calibrated in 0.2 db steps between 0 and 5 db and in 0.5 db steps from 5 to 10 db. The line between 10 db on the black scale and the arrow indicating no input current is 5 db below the graduated scale range, thus indicating 15 db.

2.05 The jacks are provided for making the various dialing and measuring connections between the set and the various circuits to be measured. Jacks are provided to receive 109, 110, and 241 type plugs and for connection to a dialing set when required. The MEAS and DIAL jacks are on separate multiples that may be connected together by means of the dial key. The group of jacks designated MEAS provides for connecting the set to the circuit being measured; the group designated DIAL provides for connecting a hand set or other testing facilities when required for controlling or establishing connections. The SM and SD binding posts are in the measure and dial sleeve circuits, respectively, and are normally connected together through an auxiliary contact on the X jack.

2.06 The X jack is provided for facilitating measurements at a PBX where 1000 cycle testing power is supplied from the central office. Cord circuits can be measured in both the trunk to extension and extension to extension conditions. In addition, the X jack is associated with a circuit which provides for holding the central office trunk supplying the testing power while the cord circuits are being changed.

2.07 The DIAL-SLV key is provided for setting up dialing and holding conditions. When this key is normal the MEAS jacks are connected to the retardation coil and the meter circuit and the X jack is connected to the dial jacks. The tip and ring of the X jack are reversed with respect to the DIAL and MEAS jacks. This is done to supply ground to the ring side of the trunk for holding the connection to the testing power when the SLV key is operated. In the DIAL position, the measure and dial jacks are connected together and the X jack is connected to the retardation coil for holding purposes. The operation of the SLV key disconnects the DIAL jack sleeve from the X jack sleeve and connects it to the MEAS jack sleeve.

2.08 The 5 db-10 db key is provided for extending the range of the db meter by switching 5 and 10 db pads out of the circuit. When this key is normal, the 10 db pad is in the circuit and the black scale is read directly for loss measurements. When the 5 db key is operated, the 10 db pad is replaced by a 5 db pad and meter readings made under these conditions should have 5 db added to the readings on the black scale. When the 10 db key is operated both pads are removed from the circuit and 10 db should be added to all black scale meter readings. With the key in this (10 db) position, the single line to the left of the scale graduations mentioned in paragraph 2.04 indicates a loss of 25 db. As described previously, the red scale is for use in making gain measurements with a suitable pad circuit. For such measurements the 5 db-10 db key of the set should remain normal and the gain range will then depend on the size of the external pads and the reading of the red scale.

2.09 The circuit of the 12A set in normal measuring condition is shown in schematic form in Fig. 10. For this condition, input connections are made to the MEAS jacks which are in turn led through key contacts to a retardation coil.

2.10 This retardation coil acts as a bridge to give a d-c path for holding the connection established to the test line when required. The coil and a condenser make up a filter circuit for attenuating the lower frequencies so that low frequency noise will not interfere with transmission measurements at low levels. The transformer serves to match the impedance of the meter circuit to that of a 600 ohm line.

2.11 The circuit label in the cover of the carrying case shows the detailed arrangements of the jacks and keys.

2.12 The apparatus in the 12A set can be made accessible for maintenance purposes by removing the four corner screws from the top panel and lifting the entire assembled unit from the box.

3. TRANSMISSION PERFORMANCE

3.01 The accuracy of the 12A set for 1000 cycle measurements in the 0 to 5 db portion of the black scale immediately after calibration is ± 0.2 db at normal room temperatures. Under the same conditions, the accuracy for the 5 to 10 db part of this scale is ± 0.5 db but, as pointed out in paragraph 4.03, the use of this measuring range can be avoided for losses of 15 db or less by proper use of the pad key. When the set is calibrated at a temperature in the range between 40° and 90° F., and measurements are made in the 0-5 db portion of the black scale at any other temperature in this range without recalibration additional error due to this cause will result. This additional error will be within the limits of ± 0.2 db. At temperatures beyond this range, the additional error becomes increasingly greater and in extreme cases may amount to more than 1 db. This is beyond the compensating ability of the adjusting dial rheostat resistance. The set, therefore, should not be used under temperature conditions for which it can not be calibrated, and after exposure to very high or low temperatures should be allowed to return to approximately the calibrating temperature before use. The temperature of the copper-oxide rectifier changes slowly, and the time allowed should depend on the temperature differences involved. In extreme cases time allowances up to about an hour may be necessary.

3.02 At the temperature of calibration of the meter the 25 db mark is accurate to about ± 1 db, and readings between 20 and 25 can only be estimated.

3.03 This measuring set has a practically flat receiving characteristic in the frequency range from 700 to 4000 cycles, the maximum deviation being about 0.2 db. In the range below 700 cycles, due to the action of the low frequency filter the characteristic falls off, the loss at 350 cycles being about 1 db below the 1000 cycle loss. At 60 cycles, the loss is about 25 db below the 1000 cycle loss. In the range above 4000 cycles due to the capacitance of the rectifier the characteristic also falls off so that at 10,000 cycles it is about 1 db below the 1000 cycle loss. Where desired the error at these and other frequencies may be determined and a calibration curve plotted for future reference.

3.04 The input impedance of the 12A set at 1000 cycles is close to 600 ohms. While it varies with frequency the deviation is usually unimportant.

4. OPERATING FEATURES

4.01 The 12A set should be in an approximately horizontal position when measurements are made.

4.02 As stated in paragraph 2.05, connections to external circuits are made by means of

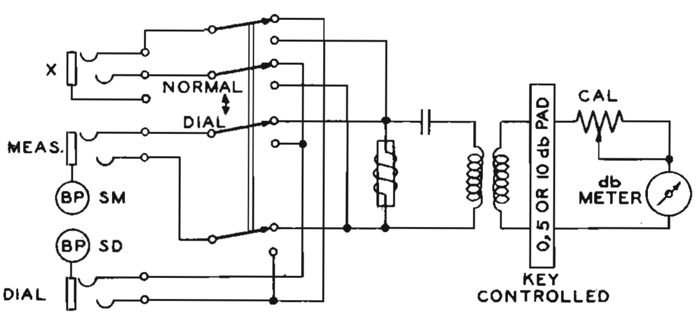


Fig. 10 - Schematic of 12A Set Circuit
Normal Measuring Condition.

the jacks in the measuring set. In order to provide for connecting to the various types of switchboards, test boards and PBXs, etc., four different types of jacks are furnished; those for use with 109, 110, and 241 plugs and a jack for use in step-by-step switch rooms.

4.03 The 5 db-10 db pad key is provided for increasing the measuring range of the set, and for shifting the meter pointer to the more accurate part of the scale when the measured loss is between 5 db and 15 db. Thus, if the loss in a particular loop or trunk is about 8 db, a more accurate reading can be obtained by operating the 5 db key and causing the meter to read about 3 db. Or, if an initial reading of about 11 db is obtained, this can be changed to about 1 db by operating the 10 db key.

4.04 When this set is used for measuring transmission gains on circuits a series of pads which can be used in 5 db steps should be provided to be inserted in the measuring circuit ahead of the measuring set. If repeater gains are being measured the pads should be connected between the 1 MW source of testing power and the input of the repeaters.

4.05 The 12A set is calibrated by connecting it to a 1000 cycle source of 1 MW testing power and adjusting the CAL resistance with a screw-driver until the meter reads 0 on the black scale. As mentioned previously this should be at approximately the temperature to which the set is to be exposed during measurement.

4.06 In general, transmission loss can be measured by connecting the circuit involved to the MEAS jacks of the 12A set and to a source of testing power. If hand sets or other testing facilities are required to establish a connection to the testing power they are connected to the DIAL jacks and the DIAL key is operated. After the connection is established 1000 cycle test tone can be heard on the circuit and the DIAL-SLV key should be restored, thus connecting the testing power to the meter circuit. With the 5 db-10 db pad key normal the meter reads directly the loss between the source of testing power and the 12A set. If the measured loss is less than 15 db the meter reading can be kept in the 0-5 db range by means of the 5 db or 10 db pad key. When the pad key is operated this loss is obtained by adding the operated pad key designation to the meter reading.

4.07 When testing a PBX cord circuit using 1 MW testing power supplied over a trunk from the central office, the X jack is patched to the trunk jack, the cord circuit patched to the DIAL and MEAS jacks and ground supplied at the SM binding post. Then, with the DIAL key operated, the measured loss is that of the PBX trunk. With this key restored to normal the measured loss is that of the trunk plus that of the PBX cord circuit in the trunk to extension transmission condition. With the SLV key operated, the measured loss is that of the trunk plus that of the extension to extension transmission condition of the cord circuit. With the DIAL key operated, the trunk connection to the 1 MW testing power is held while changing cords.

SECTION VI - J94020A TRANSMISSION MEASURING SET

1. GENERAL

1.01 This section describes the J94020A transmission measuring set which is a portable receiving set for measuring transmission losses from 0-25 db in the 300 to 4000 cycle frequency range. An external source of testing power is required for calibrating and for measuring.

1.02 The set contains an amplifier which normally operates from a power source of 60 cycles and 105-125 volts. Connection is made by means of a detachable plug-ended rubber insulated cord supplied with the set. When 60 cycle power is not available it can be made to operate from dry cells or regular office batteries in accordance with instructions given in Fig. 14.

2. EQUIPMENT AND CIRCUIT FEATURES

2.01 The receiving set is assembled in a size "C" test set casing, the approximate dimensions of which including the cover are 14-3/4" x 10" x 9". It is equipped with a leather carrying handle and weighs 37 pounts. The meter and the adjustable features of the set, consisting of two keys and two potentiometers, are mounted on the surface panel as shown in Fig. 11.

2.02 A cover is provided to protect the surface equipment when not in use. Two vacuum tubes, one an amplifier, and the other a rectifier, are located beneath tube guards. These tubes need not be removed during normal handling of the set. A meter having a 10 db scale range indicates measured losses directly in db. The scale is calibrated in .2 db steps between 0 and 5 db and in .5 db steps from 5 to 10 db.

2.03 The lever type keys control the connection of the measuring jacks to the dialing jacks when required for setting up connections in a dial office, the removal of the 5 db and the 10 db pads from the circuit to extend the measuring range of the set to 25 db and the insertion of a 5 db pad when required for calibrating the set. The potentiometers are adjusted by means of a screw-driver when the calibration of the set is required. The potentiometer designated SCALE ADJ adjusts the characteristic of a copper oxide rectifier to match the meter scale and the one designated CAL compensates for changes in the amplifier gain or rectifier sensitivity.

2.04 The external connections for power supply and for testing are made at the jack panel as shown in Fig. 12.

2.05 Two groups of jacks are provided for making the test connections to the set. One group

Fig. 11 - Transmission Measuring Set - Cover Removed.

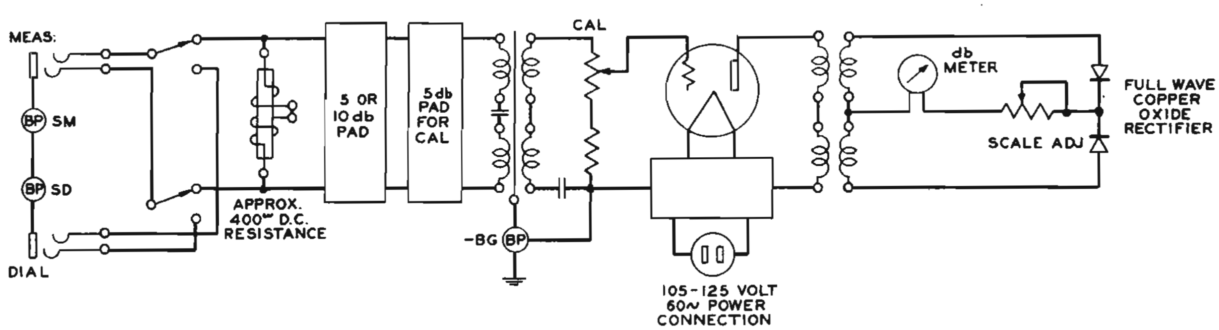


Fig. 12 - Schematic Diagram of J94020A Transmission Measuring Set.

of jacks designated MEAS provides for connecting the set to the circuit being measured; the other group designated DIAL provides for connecting a dialing set when required for controlling or establishing connections. The designations indicate the type of plug which may be used with them. The SD and SM binding posts are in the sleeve circuit and are normally strapped. They permit setting up multiple sleeve circuit connections where required. The -BG binding post should be connected to an office frame ground. The other binding posts are required only when the set is arranged for dry cell or office battery operation.

2.06 The circuit of the measuring set is shown in schematic form in Fig. 13.

2.07 The principal features of the input circuit are jack terminations, a key for connecting the DIAL jacks to the MEAS jacks, a retardation coil for holding a circuit connection when necessary, and a series of pads adjustable in 5 db steps by means of keys to control the calibrating and the testing range. A single stage amplifier supplied from 60 cycle power increases the sensitivity of the set for measuring losses to 25 db and is adjustable by means of a potentiometer over about a 10 db range for pur-

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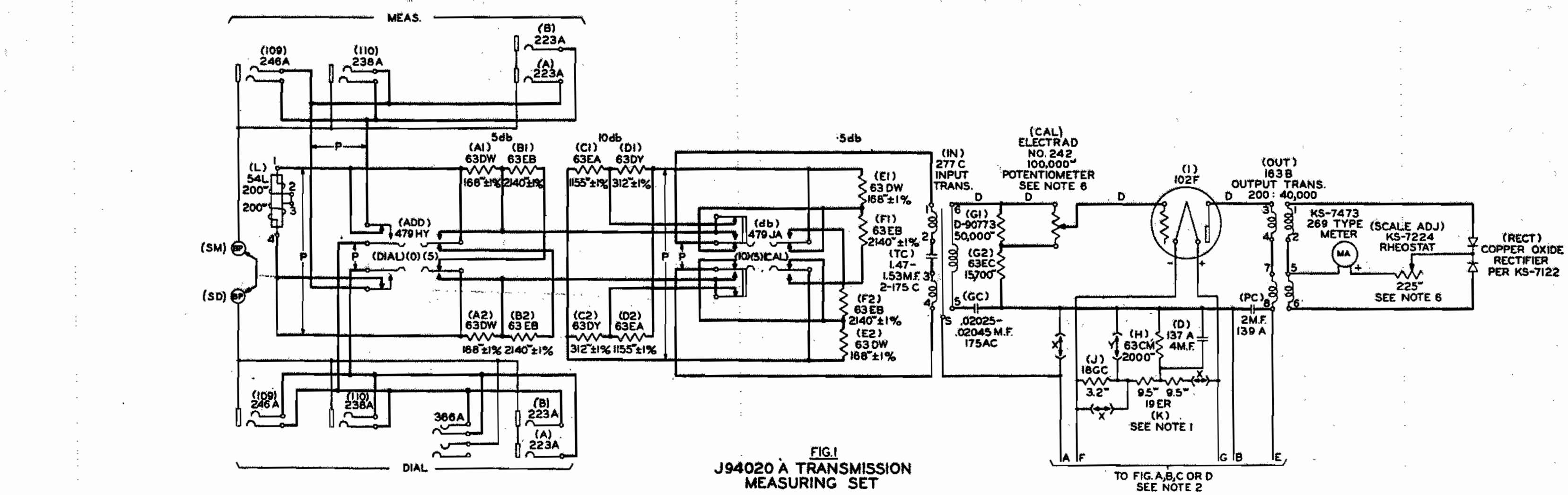

FIG. 1

J94020 A TRANSMISSION MEASURING SET

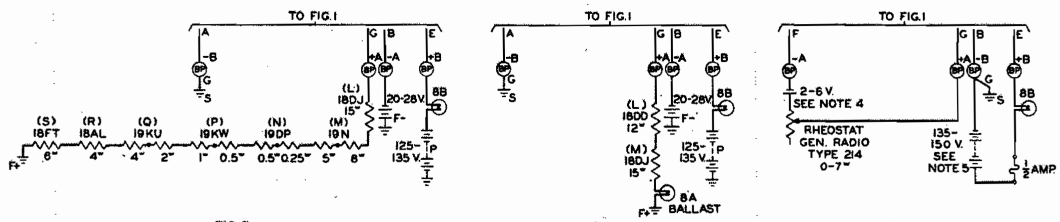

FIG. D

FIG. C

FIG. B

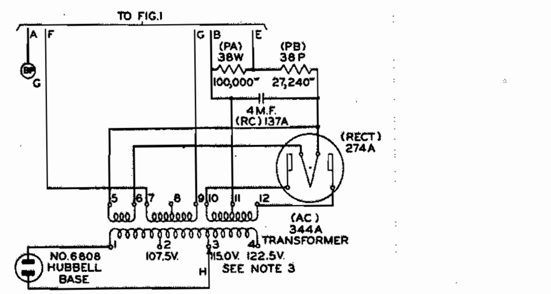

FIG. A

NOTES:

1. USE "X" WIRING WHEN FIG. A OR B IS USED AND "Y" WHEN FIG. C OR D IS USED.

2. USE FIG. A WHEN CIRCUIT IS TO BE OPERATED BY 110 VOLT 60 CYCLE A.C.; FIG. B WHEN CIRCUIT IS TO BE OPERATED BY DRY CELL BATTERIES; FIG. C WHEN NON-REGULATED BATTERY IS USED; FIG. D WHEN REGULATED BATTERY IS TO BE USED

3. LEAD H SHOULD BE CONNECTED TO TERMINAL ON PRIMARY WHICH IS NEAREST A.C. SUPPLY VOLTAGE. THE A.C. VOLTAGE SHOULD NOT VARY MORE THAN ±7.5 V. FROM VOLTAGE SPECIFIED FOR THE TERMINAL TO WHICH LEAD H IS CONNECTED.

4. DRY CELLS PER KS-6542 OR THEIR EQUIVALENT OR A STORAGE BATTERY MAY BE USED TO SUPPLY FILAMENT CURRENT.

5. (A) PROVIDE 3 DRY BATTERIES PER KS-6948 OR THEIR EQUIVALENT TO SUPPLY PLATE VOLTAGE.
   (B) IF SUFFICIENT SENSITIVITY CAN NOT BE OBTAINED WITH 3 DRY BATTERIES PER KS-6948 OR THEIR EQUIVALENT IT WILL BE NECESSARY TO INCREASE THE PLATE VOLTAGE BY ADDING ANOTHER DRY BATTERY OR BY REPLACING THE TUBE WITH ONE WHICH WILL INCREASE THE SENSITIVITY.

6. THE POTENTIOMETER AND RHEOSTAT SHOULD BE CONNECTED IN THE CIRCUIT SUCH THAT TURNING THEIR SHAFTS IN A CLOCKWISE DIRECTION WILL CAUSE THE POINTER ON THE db METER TO MOVE IN A CLOCKWISE DIRECTION.

7. THE STRAP BETWEEN BINDING POSTS (SM) AND (SD) SHALL BE REMOVED ONLY WHEN REQUIRED FOR SPECIAL TEST CONDITIONS.

FOR REFERENCE SEE:
SD-91016-01: SCHEMATIC

J94020A TRANSMISSION MEASURING SET

CIRCUIT LABEL

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Fig. 13 - J94020A Transmission Measuring Set - Circuit Label.

poses of calibration. A full wave copper oxide rectifier changes the amplified received testing current to direct current to actuate the db meter. A scale adjusting rheostat described above is provided. A condenser is provided in series with the input transformer to prevent the flow of direct current in this circuit. The input transformer and the condensers in the low and the high sides form a high pass filter to cut off at about 300 cycles.

2.08 The circuit label in the cover of the carrying case shows the detailed arrangement of the jacks, the keys which control the loss pads in the input circuit and the amplifier circuit.

2.09 As shown in Fig. 14, three loss pads of the lattice type are provided, two of 5 db and one of 10 db, of which the 10 and one of the 5 db pads are connected in the circuit when the keys are normal. These are removed, respectively, by the operation of the 10 key and the 5 key. The operation of the CAL key connects an additional 5 db loss pad in the circuit for calibrating which produces a midscale reading when 1 milliwatt is supplied to the measuring circuit.

2.10 The loss ranges, the meter scale reading and the respective key positions are given in the following table:

Loss Range db	Scale Reading	5 Key	10 Key
25-15	10-0	5	10
15-10	5-0	0	10
10-5	5-0	5	0
5-0	5-0	0	0
CAL	5	0	CAL
CAL	0	5	CAL

The positions of the keys are designated with the amount to be added to the meter scale readings to obtain the measured loss in db. When calibrating the set, the amount indicated by the scale and the key are not to be added.

2.11 When 60 cycle power is not available, the set must be changed to operate from dry cells or regular office batteries. One arrangement includes a 6 volt storage battery or dry cells for filament supply and three 45 volt dry cells for plate voltage supply. A filament rheostat will be required to adjust the filament supply voltage. Another arrangement makes use of the usual repeater plate and filament supply when available. The required external connections and the internal wiring changes for either arrangement are made to the binding posts of the set as indicated on the circuit Fig. 13.

3. TRANSMISSION PERFORMANCE

3.01 The set has been designed for use in offices where the standard testing power of 1 milliwatt is available, in which case it may be calibrated as often as desired. Immediately after calibration its accuracy for the frequency used in calibrating is ± .2 db for the 0-5 range of the meter scale and ± .5 db for the remainder. After the set has been in use for an hour and temperature saturation has been reached the calibration remains constant to within a few tenths db.

3.02 The frequency characteristic of the set is approximately flat from 300 to 4000 cycles so that when calibrated at 1000 cycles the additional error when measuring with frequencies in this range should not exceed ± .5 db. When calibrated at each measuring frequency, this error is eliminated.

3.03 The impedance of the input circuit is approximately 600 ohms for all positions of the keys except "DIAL". For this position the impedance termination supplied to the line under test is dependent on the circuit connected to the dial jacks. Bridged across the input to the measuring circuit is a retardation coil which provides for "holding" a circuit when required.

4. OPERATING FEATURES

4.01 The set should be operated in a horizontal position. Connect the -BG binding post to a building or frame ground and make the connections to the 60 cycle power supply by means of the extension cord.

4.02 The calibration of the set should be checked and readjustments made if necessary as follows:

(a) Connect a 1 milliwatt source of testing power to the MEAS jacks, using a cord and plug inserted in the jack with a corresponding number designation.

(b) With both keys normal on the set, operate the CAL key.

(c) Adjust the CAL rheostat until a reading of 5 db is indicated on the meter.

(d) Operate the 5 key and adjust the SCALE ADJ rheostat until the meter indicates 0 db. (A slight overadjustment will reduce the number of repetitions of this correction.)

(e) Repeat (b), (c), and (d) until the meter indication is correct at both points without further adjustment of either dial.

(f) Restore the keys to normal and remove the connection to the local source of testing power.

4.03 A circuit can be measured as follows:

(a) With all keys normal on the set, operate the key to DIAL. This connects the DIAL jacks to the MEAS jacks so that a dial or telephone set can be used in obtaining connections over the test line.

(b) Obtain the connection to the source of testing power over the circuit to be tested in accordance with sections VI and VII, using the MEAS jacks which correspond to the type of plug on the test cord.

(c) Operate the 5 key or the 10 key as required to obtain a meter scale reading between 0 and 5 db, if possible. The key designation added to the meter scale reading is the measured loss of the circuit.

(d) Remove the cord and plug from the circuit to release the connection.

5. MAINTENANCE

5.01 The set shall be equipped with vacuum tubes known to be in good condition. Under normal operation the vacuum tubes should remain in good condition approximately 25,000 hours of actual operation.

5.02 The slide wire rheostat and potentiometer shall be cleaned, when necessary by applying a thin coating of unmedicated vaseline and then wiping it off with a clean, dry, lintless cloth. KS-2423 cloth is recommended.

5.03 The keys shall make reliable contact and have perceptible contact follow.

SECTION VII - LOSS MEASURING EQUIPMENT

1. GENERAL

1.01 This section describes a measuring system for making 1000 cycle loss measurements of a line from station to station, a circuit within a station or an individual piece of apparatus. Measurements of transmission loss caused by the circuit under test are made by supplying the standard testing power of 1 milliwatt at 1000 cycles to one end of the circuit and measuring the received power at the other. The measurement of the received power is made directly in db.

1.02 The sending power for this system is supplied by a 1000 cycle machine per KS-5472 or a J94002A sending panel described under sections II and III. For measuring the received power the 9A, 12A, or J94020A transmission measuring sets described in sections IV, V, and VI may be used. The 12A and J94020A measuring sets are equipped with several jacks and a key which provide means for connecting the measuring set to the circuit to be tested and also to the test or traffic facilities which may be needed for establishing the connection to the testing power. The 9A transmission measuring set is equipped with two binding posts which provide the only means for making connection to the set.

1.03 The description of the manner of making transmission measurements in this section assumes the use of the J94020A measuring set where losses from 0 to 25 db are to be measured, the 12A for losses from 0-20 db, and the 9A for losses in the 0 to 10 db range. It assumes that where the J94020A set is used, 105-125 volts 60 cycle power is available, or that dry cells or office battery will be used as described in section VI. The use of the KS-5472 1000 cycle machine or the J94002A sending panel for supplying the testing power is assumed, and where used 105-125 volts 60 cycle power is available.

2. TESTING ARRANGEMENTS

2.01 Jacks, cords, clips, etc. should be used as needed to make the connections between the testing equipment and the circuit or piece of apparatus under test.

TESTING LINES

2.02 Over-all measurements can be made from the dispatcher's station to the last station on the line, with all bridges and tie lines connected as shown in Fig. 14. A test can be made from the dispatcher's station to a test station or from test station to test station with intermediate way stations connected but with distant lines and branches disconnected as shown in Fig. 15. The same section of the line can be tested with all bridging way stations disconnected as shown in Fig. 16.

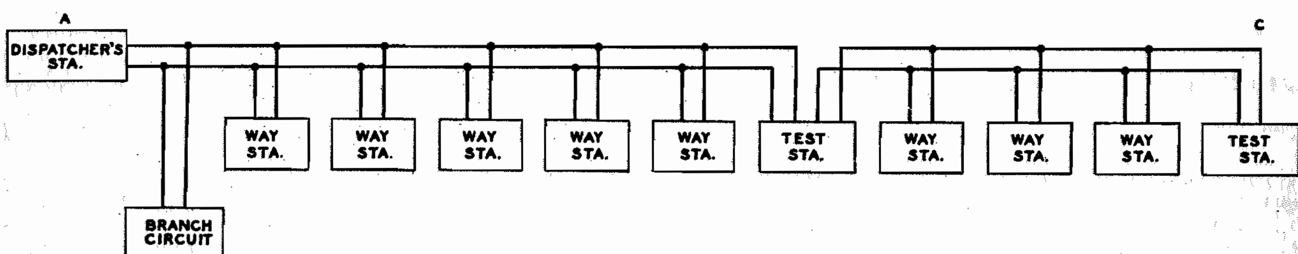

Fig. 14 - Test between A and C in either Direction. All Way Stations and Branch Circuit Connected.

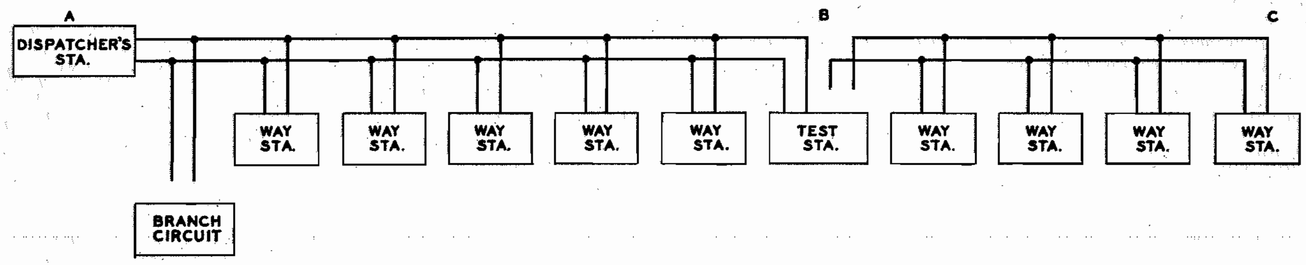

Fig. 15 - Test between A and B in either Direction. All Way Stations Connected and Branch Circuit Disconnected.

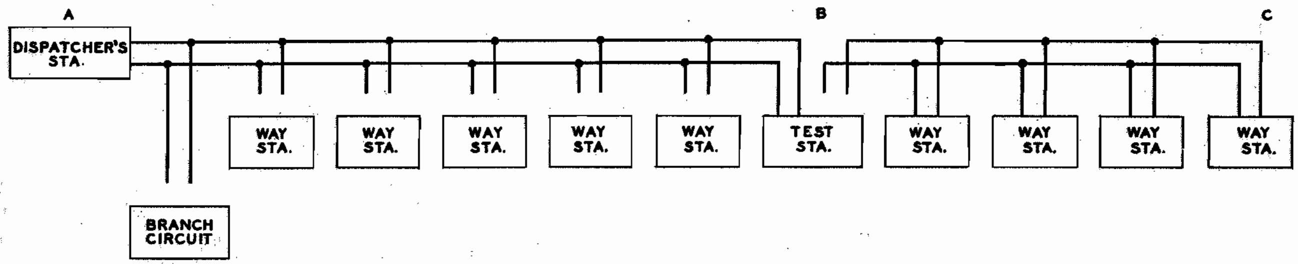

Fig. 16 - Test between A and B in either Direction. Way Stations Connected but Line from B to C Disconnected at B and Branch Circuits Disconnected.

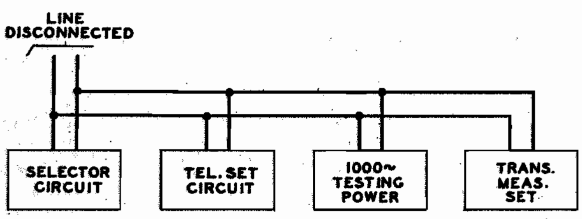

Fig. 17 - Test of Bridging Loss of Station Equipment.

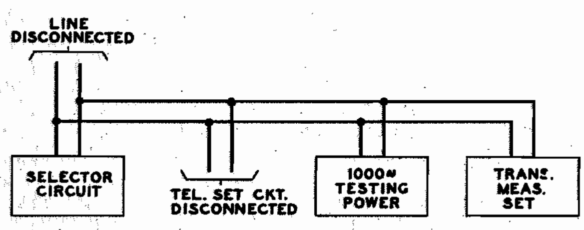

Fig. 18 - Test of Bridging Loss of Selector Equipment.

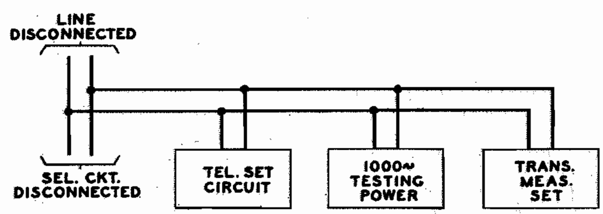

Fig. 19 - Test of Bridging Loss of Telephone Set Circuit.

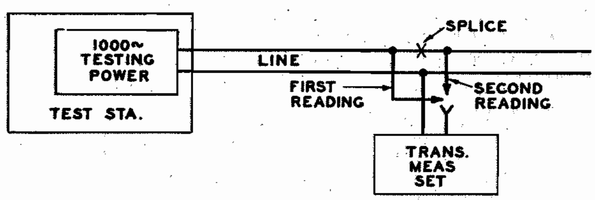

Fig. 20 - Test of Splice at a Pole Arm.

TESTING STATION CIRCUITS

2.03 If it is convenient to use both the sending source and transmission measuring set at the station, the bridging loss of the station equipment can be measured by disconnecting the line and connecting the measuring equipment as shown in Fig. 17. The selector circuit and the telephone circuit can be tested individually in the same manner as shown in Figs. 18 and 19.

2.04 If it is not convenient to have the machine or sending panel at a way station a straightaway method may be used. The source of testing power may be delivered into the line at the nearest test station or dispatcher's station and measurements taken at the way station of the bridging loss of the line with and without the station equipment pertaining to that office. The difference in these two readings will be the bridging loss of the station equipment if the impedance of the line is 600 ohms in both directions. In this same manner measurement of either the telephone set circuit or the selector circuit may be made. In order to accommodate the range of the transmission measuring set it may be necessary to disconnect other way stations or branch circuits during the test. This is particularly true if the 9A set is used, the range being limited to 0-10 db, while the bridging and transmission loss from the dispatcher's station to a way station with all stations and branch circuits bridged on may be greater than 10 db.

TESTING A SPLICE AT A POLE ARM

2.05 The same straightaway method may be used in measuring the loss of a bad wire splice. Splices of less than 0.1 db loss (about 14 ohms resistance) are not easily detected with this system. The method of performing this test is shown in Fig. 20.

TESTING CONTACT OF KEY, JACK, RELAY, ETC.

2.06 The same limitations apply as in testing a splice. The loop method shown in Fig. 19 can be employed or the measurement can be made directly as in Fig. 20. Manipulation of key handles, plugs, etc. will usually determine the existance of bad contacts or spring adjustments.

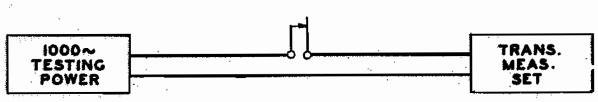

Fig. 21 - Test of Contact of Key, etc.

TESTING INDUCTION COILS, REPEATING COILS OR TRANSFORMERS

2.07 Disconnect the coil from the circuit and make connections to testing equipment as shown in Fig. 22.

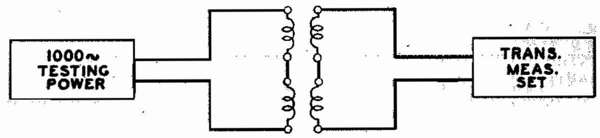

Fig. 22 - Test of Induction Coil.

TESTING RESISTANCES, RELAYS, ETC.

2.08 Make the connections to the transmission measuring set the same (with the exception of condensers) as is used in its regular circuit. For example, series connected apparatus is tested in series and shunt connected apparatus in shunt. Condensers having a capacity of 0.25 MF or more regardless of their connection in the respective transmission circuits can be tested in shunt as shown in Fig. 23. Condensers having a smaller capacity can be tested in series in order to obtain greater discrimination as shown in Fig. 24.

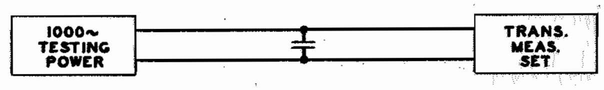

Fig. 23 - Test of Condenser of 0.25 MF or More.

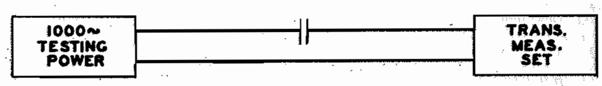

Fig. 24 - Test of Condenser of Less than 0.25 MF.

SECTION VIII - GAIN MEASURING EQUIPMENT

1. GENERAL

1.01 This section describes a measuring system for making 1000 cycle gain measurements of 0-50 db using a source of testing power such as the KS-5472 machine or J94002A sending panel, a sending pad circuit, and a receiving set normally limited to transmission loss measurements such as the 9A, 12A, or the J94020A transmission measuring set.

2. SOURCE OF TESTING POWER

2.01 Any source of testing power at 1000 cycles, adjusted to supply 1 milliwatt into 600 ohms, is suitable for use with this system.

3. SENDING PAD CIRCUIT

3.01 The sending pad circuit shown in Fig. 25 consists of jacks and key controlled pads which may be operated singly or in combinations to give losses in 5 db steps. This circuit in conjunction with a source of testing power, makes available sending power of 1 milliwatt or of 5 to 50 db below 1 milliwatt in steps of 5 db. The 20 db pad need not be provided for offices equipped only with telephone repeaters having gain of 20 db or less, such as the Western Electric 2 wire repeater.

4. TRANSMISSION RECEIVING SET

4.01 Any transmission measuring set calibrated in db with respect to a reference power

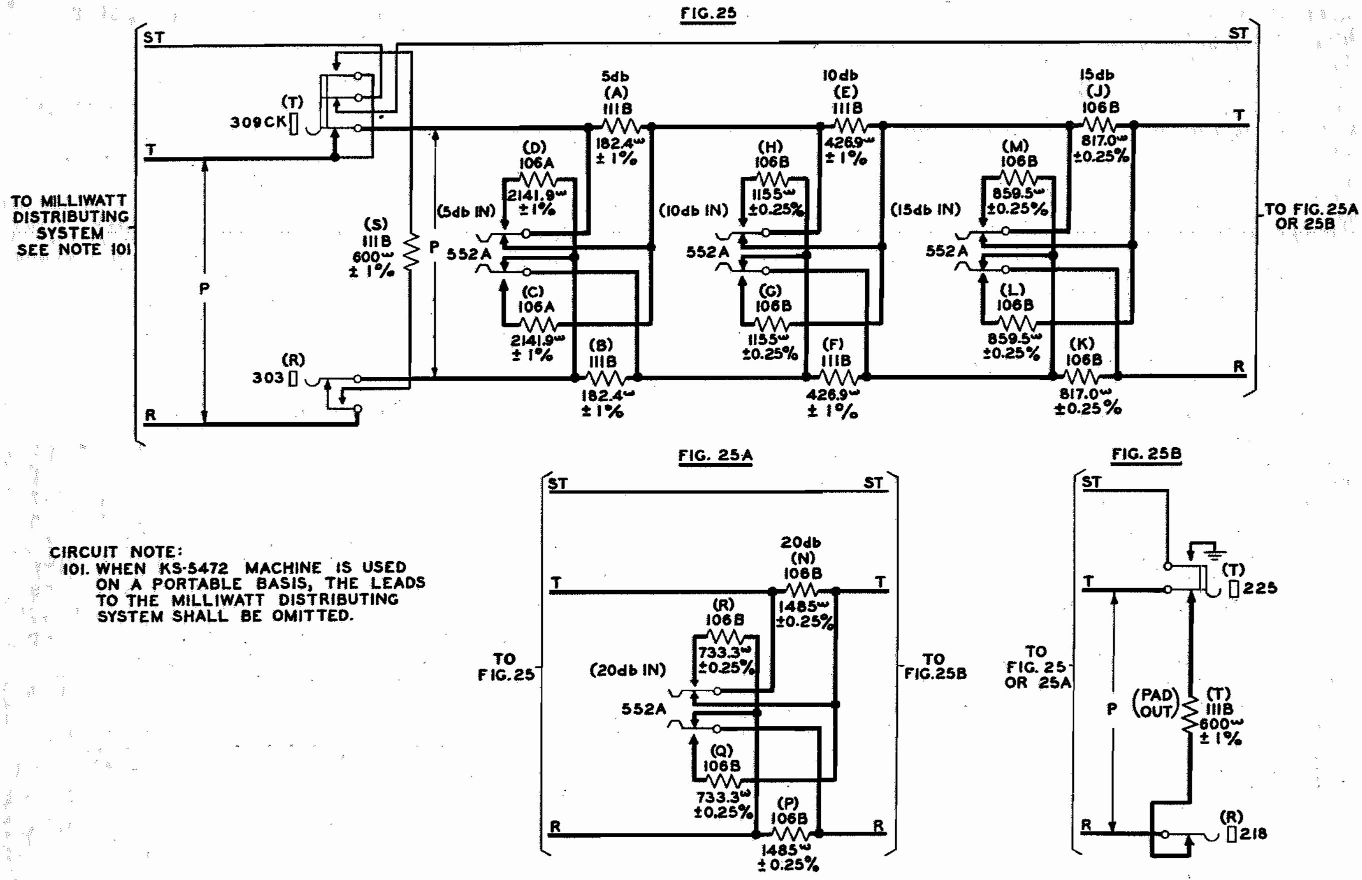

Fig. 25 - Sending Pad Circuit.

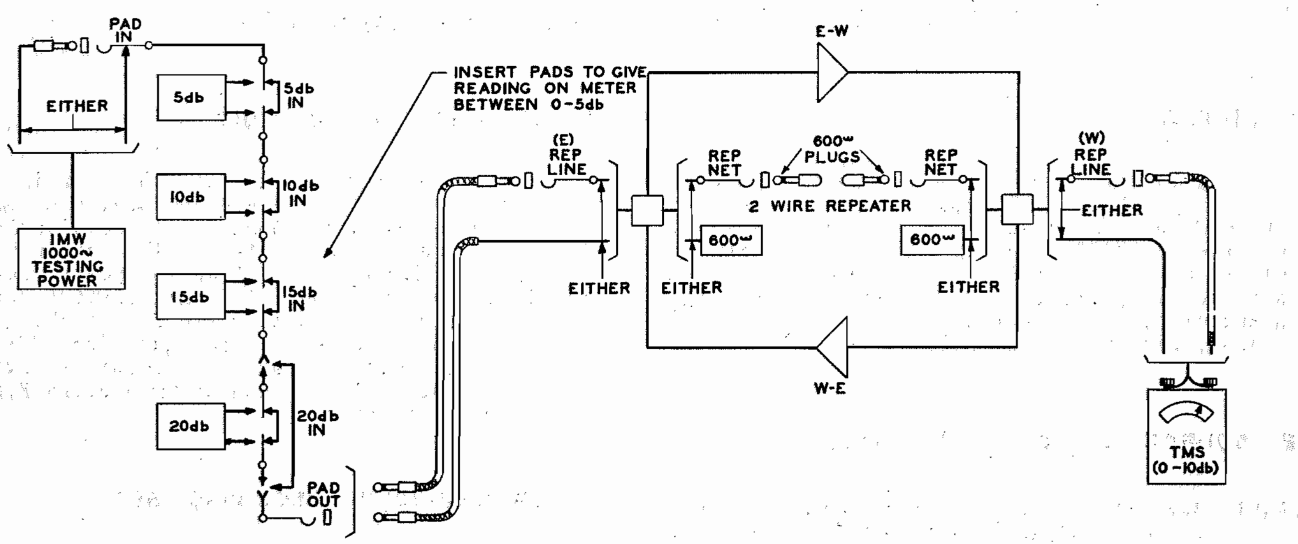

Fig. 26 - Gain Measurement of One Side of a 2 Wire Repeater.

of 1 milliwatt in a 600 ohm circuit, is suitable for use with this system.

5. OPERATION

5.01 Fig. 26 shows a simple diagram of the application of this system to the gain measurement of one side of a 2 wire repeater. To measure the other direction of transmission the sending and receiving connections to the repeater are interchanged.

5.02 The gain of the repeater or amplifier is determined by subtracting the meter reading from the designated level of the sending power. For example, if the meter reads 2 db and the sending power is -10 db the gain is 8 db.

Bell Telephone Laboratories, Inc.