CHAPTER 19

CENTRAL OFFICE TEST FACILITIES

19.1 INTRODUCTION

Test facilities, such as testboards and test desks, are used to facilitate the location of troubles on toll and local circuits and to expedite the restoration of the service that has been interrupted. Before investigating the more common types of testboards and test desks used today, it would be helpful to examine the basic methods of measurements used in direct-current and alternating-current test circuits.

19.2 MEASUREMENTS IN D.C. CIRCUITS

A. INSULATION RESISTANCE

Measurements of faulty insulation is accomplished by connecting a voltmeter and battery in series with the wires under test. See Figure 19-1.

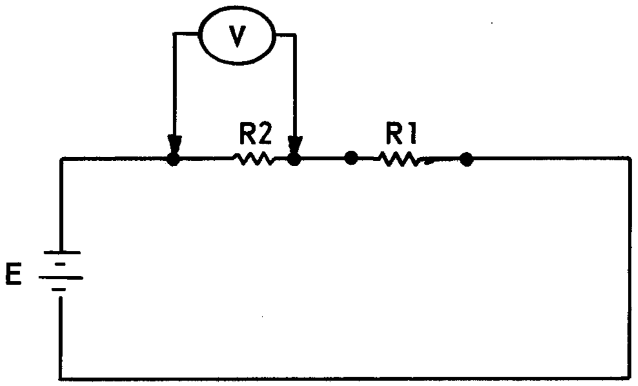

Figure 19-1 Insulation Measurement

Voltmeter V reads the drop across its own internal resistance, R2. The voltmeters used for measuring insulation are especially designed to have abnormally high internal resistances; the ones used in the standard testboard testing circuits have a resistance of 100,000 ohms. The resistance of the fault, R1, may be found by determining the voltage drop (V) across the known resistance (R_2).

B. WHEATSTONE BRIDGE

The Wheatstone Bridge is an invaluable instrument in locating the four common types of line faults encountered in the open wire and cable plant. These faults are essentially crosses, grounds, opens and resistance unbalance.

Figure 19-2 illustrates the conventional type of Wheatstone Bridge. It consists of a network of resistors with a galvanometer connected between one set of diagonally opposite corners and a battery between the other set of diagonally opposite corners.

If the resistance of the A arm is assumed to be equal to that of the B arm and the total resistance consisting of the A and X arms is assumed to be greater than the total resistance consisting of the B and R arms, more current will flow through the resistances B and R than through the resistances A and X. Consequently, the voltage drop across B will be larger than that across A, and the junction between resistances A and X will be at a higher potential than that between resistances B and R. The net result will be that an unbalance current will flow downward through the galvanometer.

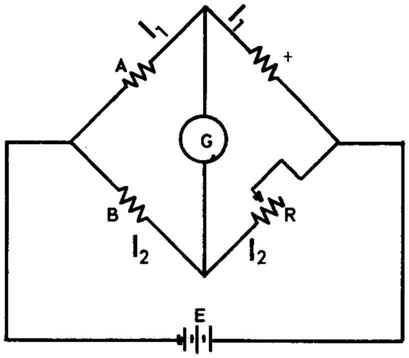

Figure 19-2 Basic Wheatstone Bridge Circuit

If the resistance of the R arm of the bridge is varied until the current flowing through the resistances B and R is equal to that flowing through the resistances A and X, the voltage drop across B will be equal to that across A. Since the junction between resistances A and X then will be at the same potential as the junction between resistances B and R, no current will flow through the galvanometer. Under this condition the bridge is said to be balanced. This is also the condition of the bridge at the completion of measurements made on cable or open wire conductors. When the bridge is balanced and the resistance of the three arms of the bridge are known, the resistance of the fourth arm may be calculated.

Wheatstone bridges are usually constructed so that the resistance in the A and B arms can be varied to suit the needs of a particular test. The A and B arms are commonly called ratio arms since by changing the ratio A/B the range of resistances which can be measured is materially increased. Mathematically, the unknown resistance X is found by multiplying the ratio A/B by R.

C. SIMPLE LOOP TEST

To make simple loop tests, the circuit shown in Figure 19-3 is employed. In this circuit, the X (unknown resistance) arm of the bridge shown in Figure 19-2 is replaced by a pair of wires which have been looped or connected together at the distant office. When the bridge is balanced, no current flows through the galvanometer and the loop resistance (L) is found by multiplying the ratio A/B by R. If the ratio arms A and B are made equal, then A/B becomes equal to one, and L is equal to R.

Measurements of the loop resistance of open wire or cable pairs thus can be made by short-circuiting the two wires of a pair at the distant office and measuring the resistance of the wires by means of the bridge at the home office.

D. VARLEY LOOP MEASUREMENTS

A Varley loop measurement is a special type of loop resistance measurement which is used for locating troubles such as grounds and crosses. A line fault location by the Varley loop method requires the use of one good wire in addition to the faulty wire. It consists essentially of the determination of the loop resistance of the conductors between the fault and the distant office.

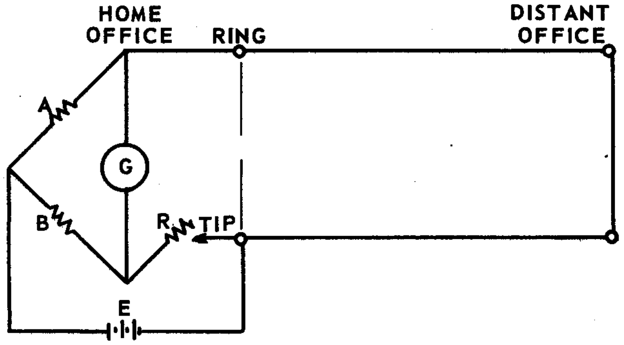

Figure 19-3 Circuit for Simple Loop Test

Figures 19-4 and 19-5 are schematics showing the equivalent bridge circuits for making grounded and metallic Varley measurements, respectively. A grounded Varley measurement, shown in Figure 19-4, is one in which the return path from the fault to the battery is through ground. A metallic Varley measurement, shown in Figure 19-5, is one in which the return path is through a wire. The magnitude of the resistance in the return path does not affect the bridge balance; however, it does affect the bridge sensitivity and, therefore, the accuracy of the measurement.

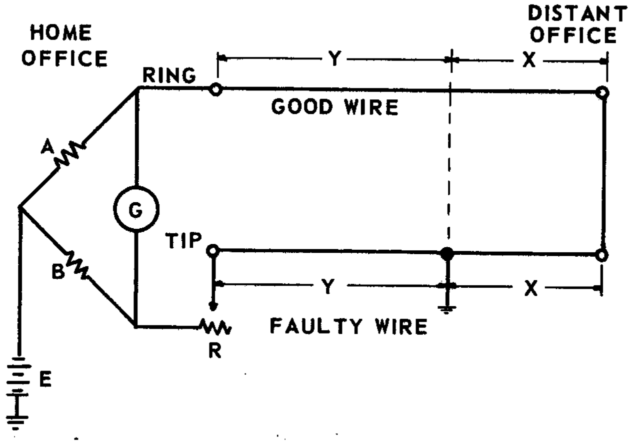

Figure 19-4 Schematic Circuit for Grounded Varley Measurement

In both figures, assume the values of the Wheatstone Bridge ratio arms A and B to be equal, the good and faulty wires to have equal conductor resistance, Y to be the resistance of one wire from the home office to the fault, and X to be the resistance of that wire from the fault to the distant office. Since the ratio A/B is equal to one, it is easily shown that

$$R = 2X = V$$

The balancing resistance, R, is equal to the loop resistance from the fault to the distant office, and is known as the Varley measurement or V.

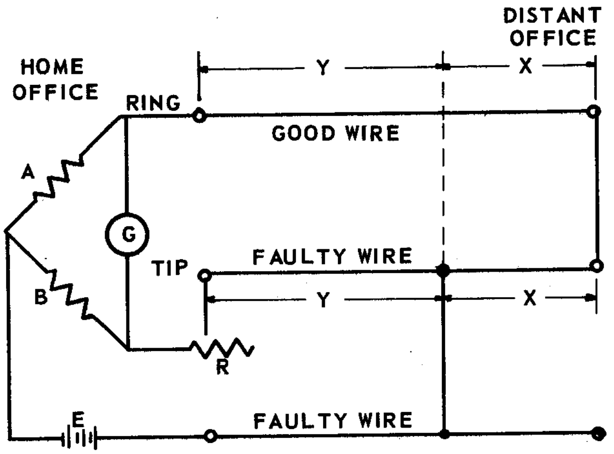

Figure 19-5 Schematic Circuit for Metallic Varley Measurement

E. MURRAY LOOP TEST

The theory of the Murray loop test is similar to that of the Varley. But instead of setting the arms A and B to have equal values and using the adjustable balancing resistance R to compensate for the difference in wire resistance between the good wire connection and the defective wire connection, the arm B is eliminated altogether and the variable resistance arm is connected in its place as shown in Figure 19-6. In this arrangement, the ratio of the reading R to the setting of the arm A, is equal to the ratio of the resistance of the defective wire from the home office to ground to the resistance of this same wire from ground, to the distant office plus the resistance of the good wire, or expressed mathematically.

$$\frac{R}{A} = \frac{X - Y}{X + Y}$$

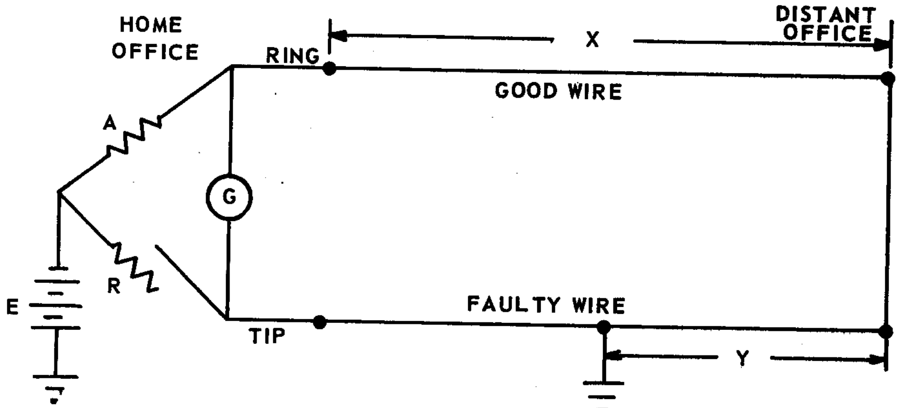

Figure 19-6 Schematic Circuit for Murray Test

The advantage of the Murray test in locating a fault is that the test does not require the use of a third wire (good wire) as would be necessary in the Varley method. Except in certain special conditions involving rural lines or one pair service cables, the Murray test is rarely used in telephone practice for locating grounds or crosses. The Murray type connection is commonly used, however, for locating opens. But since the wires here are open, it is obvious that no ordinary direct current measurement can be made. Instead, a low frequency alternating current is generated by means of an interrupter which reverses the battery voltage several times a second and simultaneously reverses the polarity of the galvanometer connections. The bridge, when balanced, then compares the capacitance of the good wire to its far end with that of the defective wire to the point where it is open.

19.3 MEASUREMENTS IN A.C. CIRCUITS

A. IMPEDANCE MEASUREMENTS

It is important to match impedances at junction points of communication circuits in order to eliminate unnecessary transmission losses or other undesirable effects. This makes it necessary, for practical maintenance purposes, to have available a device which can measure impedances accurately.

Figure 19-7 indicates the principle of a simple bridge circuit widely used in the telephone plant for measuring impedances in the voice-frequency range between 100 and 3000 Hertz. As shown, the unknown impedance is connected in one arm of the bridge and the balancing arm consists of a variable resistor and a variable inductor in series. Arms R_a and R_b are resistors of equal value. Measuring current is supplied from a variable oscillator capable of delivering satisfactory waveshape and output through the range of voice frequencies for which the bridge is designed. The values of R and L, when adjusted so that no current is in the telephone receiver, will be equal to the corresponding values of the unknown impedance. The circuit as shown in the diagram could measure only an inductive impedance. The practical circuit, however, is arranged so that the variable inductor may be switched into the other arm of the bridge in series with the unknown impedance. When the bridge is balanced in this condition, the inductometer in effect gives a measure of negative inductance, which is equivalent to capacitance. The variable units are actually calibrated to read resistance in ohms and inductance in millihenries, but the readings may readily be converted into reactance and impedance values by the application of basic a-c equations.

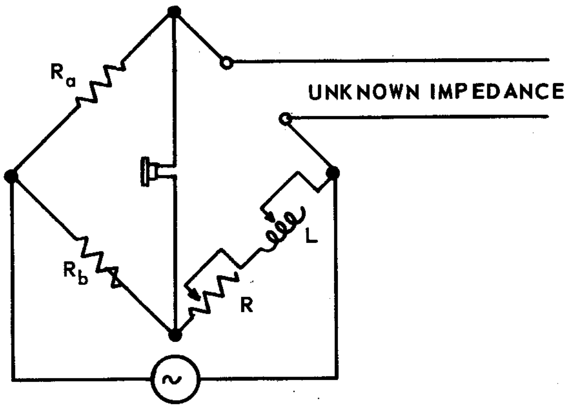

Figure 19-7 Simple Impedance Bridge

Other bridge designs, operating on a basically similar principle, are used for impedance measurements at higher frequencies. One of these, which is satisfactory for measurements between 1800 and 35,000 Hertz, is shown schematically in Figure 19-8. The bridge here is the familiar hybrid coil. When the unknown impedance connected to the "line" side of the coil is matched by the adjustable impedance connected to the "net" side of the coil, voltage applied to the series winding from an oscillator will produce no current in the bridge connection to the amplifier-detector. It will be noted that the reactance adjustment in this circuit is made by means of a variable capacitor rather than an inductometer. If the reactance of the unknown impedance is inductive, the variable capacitor is transferred by an appropriate switch to the line side of the coil in series with the unknown impedance.

Another bridge, designed for making measurements between 1 and 100 KHz, is shown in Figure 19-9 in a simplified schematic. This bridge differs from the usual circuit in that the ratio arms are four pairs of equal resistances, and the variable and unknown impedances are connected between mid-points of opposite pairs. The impedance is measured when the bridge is balanced in terms of resistance and capacitance in parallel rather than in series, and switches are provided to transfer the variable elements to the opposite side of the bridge if this should be necessary to secure balance.

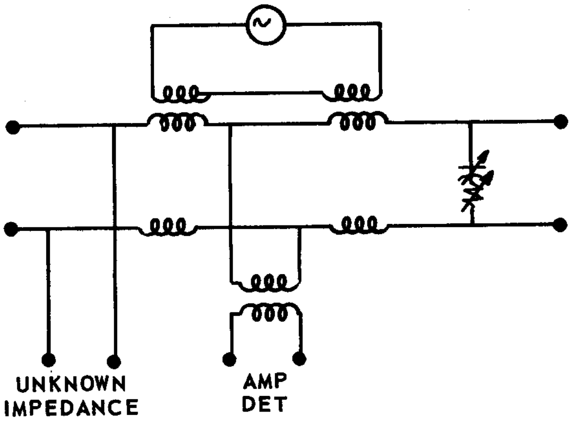

Figure 19-8 Hybrid-Type Impedance Bridge

One of the major uses of the impedance bridge in practical communications work is the location of impedance irregularities in long wire circuits. The impedance of a long line that is free from irregularities and terminated in its characteristic impedance, when measured over a wide band of frequencies, will appear as a smooth curve over the measured frequency range. If, however, there is an impedance irregularity along the line, such as might be caused by a defective or improperly located loading coil, some part of the energy applied to the line at the sending end will be reflected back from the point of irregularity. The reflected wave will add to or subtract from the initial applied wave, depending on its phase relationship when it reaches the sending end. The sending end impedance will be affected accordingly. The phase of the reflected wave with respect to the initial wave of course depends on the time it takes to travel from the irregularity to the sending end or, since the velocity of propagation is a constant for a particular type of facility, on the distance from the irregularity to the sending end.

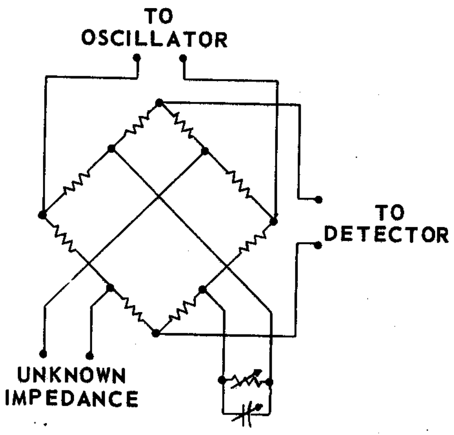

Figure 19-9 Simple Impedance Bridge

B. TRANSMISSION MEASUREMENTS

Most widely used, of the many types of measurements required in communications work, are those known as transmission measurements. These are measurements of the ratio of the power at the receiving end of a transmission line to the power applied to the transmitting end; this indicates the loss or gain of a circuit in terms of decibels or comparable logarithmic units. Two basic methods of making transmission measurements are commonly employed. The first is a direct method in which a known amount of power (generally 1 milliwatt) is applied to the sending end of the circuit under test and the power at the receiving end is measured by a direct-reading meter in terms of db or dbm. This is obviously the simpler method and is used wherever practicable. In situations where it is not feasible to supply a known fixed power at the sending end of the circuit, a comparison method is used in which the loss or gain of the circuit under test is measured by comparing it with a known, calibrated loss or gain.

For routine checking of telephone circuits, transmission measurements are usually made at a single frequency of 1000 Hertz and, in most cases, the direct method of measurement is employed. Fixed testing power of 1 milliwatt is supplied at the sending terminals from a 1000-Hertz source of power, which consists of a small magneto-generator. At the receiving end, the power is amplified, rectified by copper-oxide varistors, and supplied to a d-c meter reading directly in db or dbm. The detailed circuit arrangement is shown in Figure 19-10. Where measurements at frequencies other than 1000 Hertz are required, the same receiving circuit may be used, but the sending power is furnished by an appropriate variable oscillator. To insure that the test power is at 1 milliwatt, the oscillator output is calibrated against a fixed 1000-Hertz generator output for each series of measurements at other frequencies.

In situations where a fixed known testing power source is not available, as would ordinarily be true in the case of portable transmission measuring sets, the comparison method mentioned above may be employed. The general principle of this type is illustrated in Figure 19-11. The set is first calibrated by connecting a voltage to a fixed artificial line which causes a definite known loss. The entering current, after passing through this line, is amplified and rectified and passed through a potentiometer to a d-c meter. The value of the applied voltage is then adjusted to such a value as to give any desired deflection of the meter, usually at mid-scale. After calibrating, connections are changed so that the same voltage is applied to a variable artificial line in series with the circuit whose equivalent is to be determined. By cutting out sections of the artifical line, the total loss in the circuit is made the same as that in the calibrating circuit, so that the d-c meter gives the same deflection in both cases. The dials are arranged to read the loss in the unknown circuit directly.

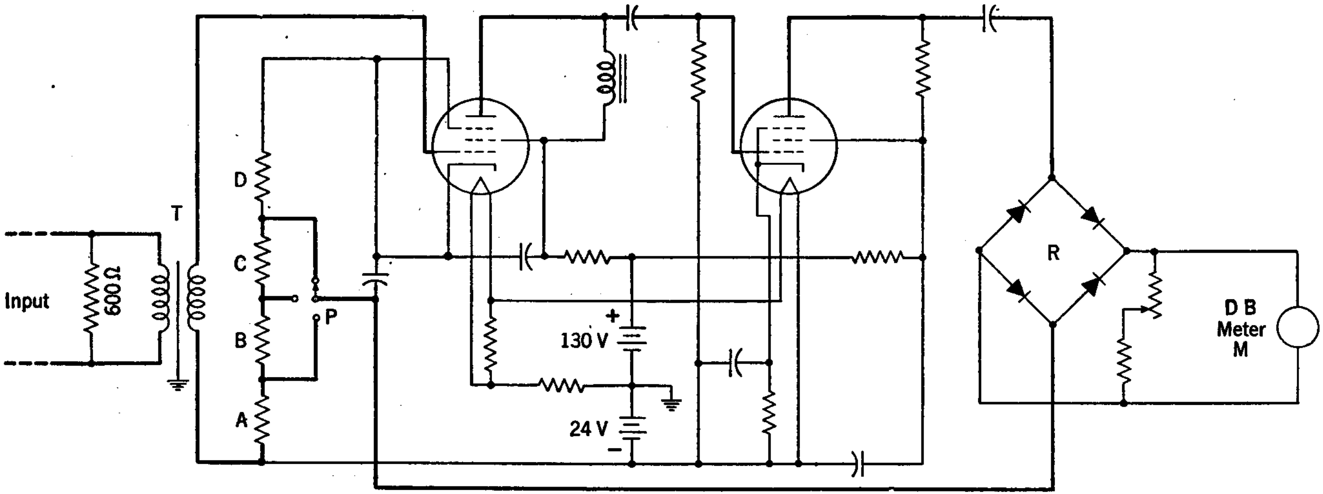

Figure 19-10 Direct Reading Transmission Measuring Set with Amplifier

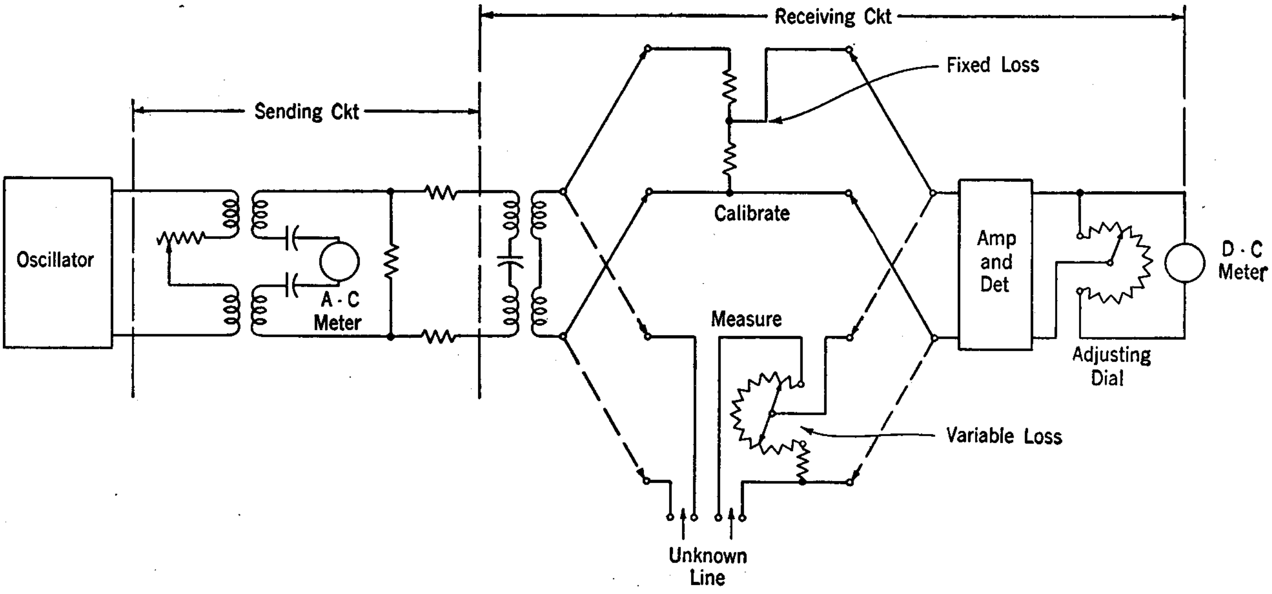

Figure 19-11 Principle of Transmission Measuring Set

For transmission measurements at higher frequencies up to 350 KHz, both comparison type and direct-reading sets are extensively used in the telephone plant. The principles involved are not essentially different from those already discussed for measurements at voice-frequencies, although the measuring sets themselves are necessarily somewhat more elaborate in design. The comparison type sets generally employ thermocouple detectors to drive a direct-reading meter. The receiving circuits of the direct-reading sets are essentially super-heterodyne detectors, the outputs of which are fed to d-c milli- or microammeters reading directly in dbm. Appropriate types of variable oscillators must be employed with each measuring set.

C. NOISE MEASUREMENTS

Voltages within the voice-frequency range, induced in a telephone circuit by electric power circuits, are manifested to a listener on the telephone circuit as noise. In many cases, crosstalk currents may also appear merely as noise. This is particularly true in the case of cable circuits where any crosstalk heard is likely to come simultaneously from a considerable number of other circuits, and appears to the listener on the disturbed circuit as a special form of noise, called "babble." In other words, it is just an unintelligible conglomeration of speech sounds coming from a large number of sources.

The disturbing effect of noise to a listener depends first, of course, upon its volume. It also depends upon the frequency of the noise currents. Figure 19-12 shows the results of tests that have been made to determine the relative disturbing effects of various noise frequencies. It will be noted that the disturbing effect peaks up rather sharply in the neighborhood of 1100 cycles. Where noise is of appreciable volume - particularly in the more sensitive frequency range - it is naturally annoying to the telephone user and may seriously reduce the intelligibility of conversation. It is accordingly necessary to keep the noise in working telephone circuits below those limits where its interfering effect on conversation will be important.

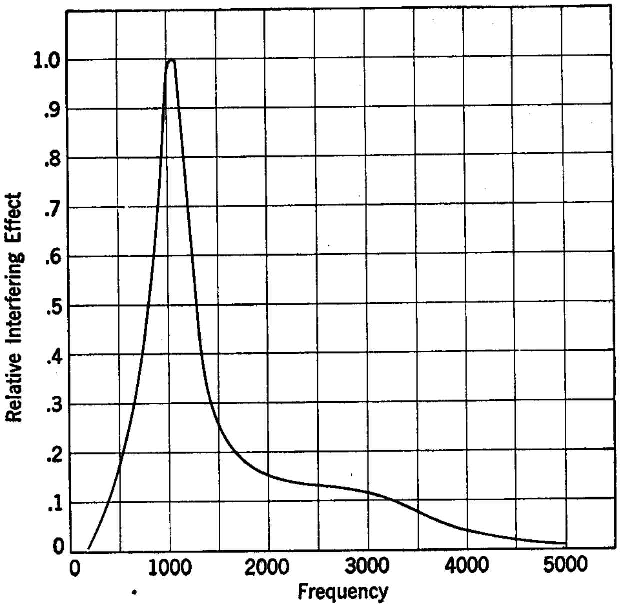

Figure 19-12 Relative Interfering Effect of Noise at Different Frequencies

Noise measurements differ from transmission loss measurements in that the received current which is introduced into the measuring circuit is much smaller and necessitates the use of a more sensitive amplifier. Since no sending power is employed and since no unusual terminations are required at the distant end of the circuit being tested, noise and crosstalk volume measurements can be made on a bridging basis with normal circuit terminations during the momentarily idle periods while the circuits are in service.

The ideal objective of the various methods for counteracting crosstalk and noise induction in telephone circuits is to eliminate their effects altogether. In practice this ideal is rarely attained. But certain practical limits are established, and every reasonable effort is made to keep the crosstalk and noise below these limits. In designing and maintaining circuits, therefore, it is desirable to be able to make definite quantitative measurements of both crosstalk and noise. As in any other kind of measurement, this requires the establishment of definite units.

The measure of either crosstalk or noise that would be of major significance is the extent of the interference or annoyance to which a listener on a disturbed circuit is subjected. Since such a measure is obviously affected by numerous subjective factors, it is clear that completely objective quantitative measurements of crosstalk and noise effects are practically impossible. It is possible, however, to make precise quantitative measurements of the crosstalk coupling between a given sending point on a disturbed circuit and a given receiving point. Essentially this is simply the measurement of the transmission loss between the two points, and like any other transmission measurement it may be made at one or more frequencies as desired. Such a measurement gives a value of what is known as "crosstalk coupling loss" in db. A more commonly used measure of crosstalk coupling employs a unit designated dbx, which expresses the coupling in db above "reference coupling." Reference coupling is equivalent, broadly speaking, to a crosstalk coupling loss of 90 db, and is formally defined as "the coupling which would be required to give a reading of zero dba on a 2-type noise measuring set connected to the disturbed circuit when a test tone of 90 dba (using the same weighting as that used on the disturbed circuit) is impressed on the disturbing circuit."

Another unit sometimes used for measuring crosstalk coupling is the "crosstalk unit," abbreviated CU. The number of crosstalk units representing any given coupling is 10^6 times the ratio of the current or voltage in the disturbed circuit to the current or voltage in the disturbing circuit at the two points under consideration; or, if the circuit impedances are not the same, 10^6 times the square root of the power ratio. The relationships between the three measures of crosstalk coupling are shown graphically in Figure 19-13.

For measuring noise, a basic reference point has been selected, which is equal to 10^{-12} watts of 1000-Hertz power. This corresponds to 90 db below 1 milliwatt (-90 dbm). Noise may then be measured in terms of number of decibels above this reference point. However, the interfering effect of noise on a listener varies with both the level and the frequency; and the relative importance of the components of noise at the different frequencies must be taken into consideration in determining the total amount of interference.

The interfering effect also varies according to the sensitivity of the receiving device that converts the noise currents into audible sound. For these reasons, in measuring noise, it is desirable to employ "weighting networks" which act to integrate the noise power over the voice-frequency range by giving each small band of frequencies a weighting proportional to its contribution to the total interfering effect.* Different weighting networks may be used with different receiving devices. Even so, equal values of db reading will not necessarily indicate equal interfering effects without some adjustment of the calibration constants. In practice, an adjusted unit designed dba is employed, which measures the acoustic interfering effect of the frequency-weighted noise energy. Equal values of dba measured across any receiving device, with proper weighting used, should indicate approximately equal interfering effects.

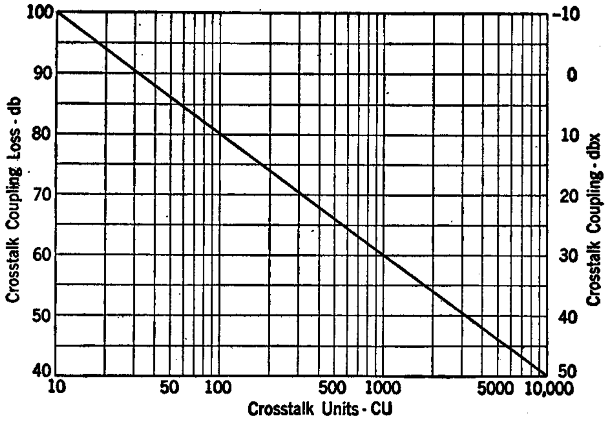

Figure 19-13 Relations Between Crosstalk Measuring Units

19.4 TOLL TESTBOARDS

A. GENERAL

Many of the toll testboards and much of the testing equipment still in use are considered obsolete and will not be described here. When engineering effort is to be expended on these obsolete items, considerable research and careful engineering is required on the part of the engineer. We will therefore consider only the more common units which are currently in general use.

B. TOLL TESTBOARD CLASSIFICATIONS

Toll testboards fall into three principle categories:

1. Primary testboards
2. Secondary testboards
3. Telegraph testboards

Primary testboard positions are used to terminate the toll line cable and open wire pairs. The primary jacks permit ready access to the line conductors to facilitate testing them and determining the type and location of any existing trouble. These jacks also permit patching on a temporary basis defective cable pairs or toll terminating equipment.

Secondary testboard positions provide an appearance of the circuit on the drop side of cable equipment or a complete appearance of open wire lines (in toll test stations equipped with both a primary and secondary testboard). Facilities are provided for monitoring, talking and signaling on circuits as desired and for patching or making operating tests on drop circuits and ringer equipment. In some cases, such as the No. 18-B type of testboard, "test and out of service" jacks are provided as an exact multiple of the toll line multiple in the toll switchboard.

The third category, telegraph testboards, service both line and subscriber telegraph circuits.

A simplified diagram giving the relationship of the primary and secondary positions of toll testboards is shown in Figure 19-14.

C. NO. 17 TOLL TESTBOARDS

The No. 17B toll testboard has been developed to replace both the multiple and nonmultiple No. 8 test and control board. From a functional point of view the No. 17B toll testboard is the same as the No. 8 test and control board, in that it continues the direct reporting of intertoll trunk (toll line) troubles by the operator to the test board attendant and provides overall toll circuit testing features.

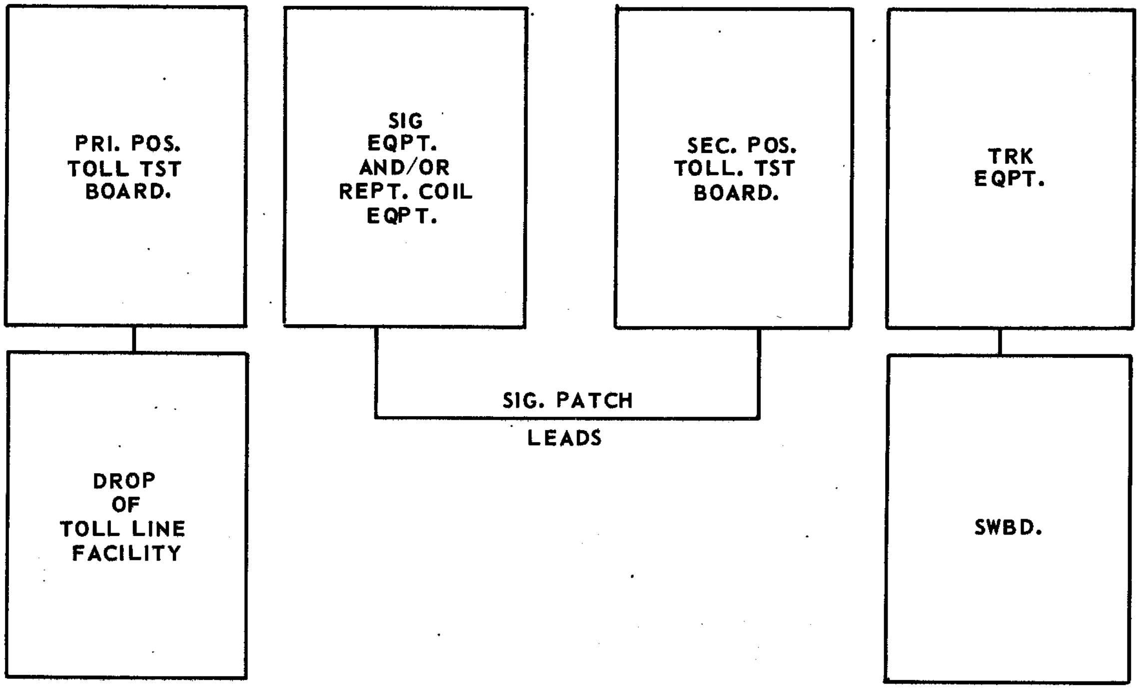

Figure 19-14 Relationship of Primary and Secondary Positions of Toll Testboard

The No. 17B toll testboard is designed for use in a No. 5 crossbar office, a crossbar tandem office at toll switching points, and is associated with switchboards such as No. 1, 3 type, or No. 11, for facilitating the location of troubles on toll circuits and to expedite the restoration of service when it has been interrupted. The testboard consists of a lower unit housing testing equipment and a jack field in which appears the intertoll trunks and community dial office trunks. In some cases patching jacks are provided.

The equipment consists of facilities for monitoring and talking on a trunk, for making 1000 Hertz transmission measurements, noise measurements, signaling, timed ringing and miscellaneous other tests. The lower unit consists generally of the keyshelf and associated cord and test circuit.

Intertoll dialing (ITD) and community dial trunks and miscellaneous test circuits are on standard jack field frameworks. Patching jacks are provided on a four-jack basis per ringdown intertoll trunk. Patching jacks are not provided for intertoll dial trunks.

The No. 17C toll testboard is a variation of the No. 17 type testboard which is designed specifically to operate with the four-wire intertoll trunks of the No. 4 crossbar toll switching systems. It is used for making over-all tests of the toll circuits. Supplementary jack bays are used for patching.

D. NO. 18B TOLL TESTBOARD

The No. 18B toll testboard is used to facilitate the location of troubles on toll circuits and to expedite the restoration of service that has been interrupted. It permits over-all testing of toll circuits and serves the purpose of a primary board, combined board, and decentralized toll, Dial System A, or crossbar tandem testboard, by providing all of the jack appearances and testing equipment usually required for the testing, patching, and maintenance of intertoll trunks and their associated office equipment. A view of this testboard is shown in Figure 19-15.

The testboard is primarily designed to be associated with switchboards, such as No. 3, 3C, 3CF, 3CL, or 11 (sleeve supervision), but may also be used with crossbar tandem offices and decentralized toll switchboards. The testboard secondary cords may be modified with an auxiliary secondary cord circuit so that the testboard may be associated with No. 1 and 2 toll switchboards or 9C, 10 and 12 toll positions in manual offices or connecting company offices. The auxiliary secondary cord converts the 48-volt ringing signal from the position circuit to 20-Hertz ringing and converts the supervisory signal in the connecting circuit to sleeve supervision required in the testboard.

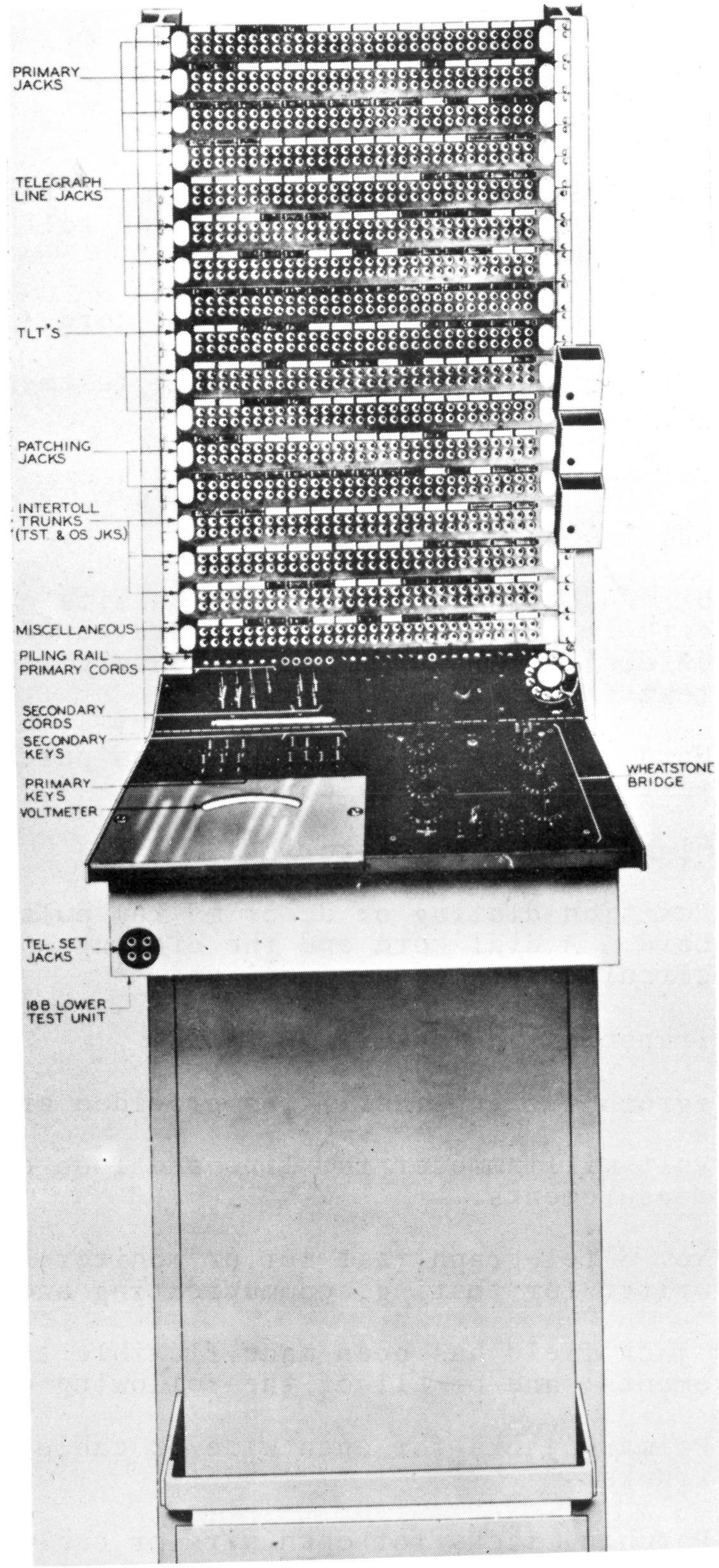

Figure 19-15 18B Toll Testboard

Primary testboard arrangement permits testing and maintenance of outside plant facilities on toll lines. Primary testing facilities provided are:

1. Single plug and twin plug test cord.
2. Talking and ringing to outside testmen or telegraph subscriber.
3. Voltmeter testing.
4. Wheatstone Bridge testing.

Combined testboard arrangement permits over-all testing of intertoll trunks and their associated office equipment by providing both primary and secondary test facilities. Secondary test facilities provide:

1. Cord circuits which may serve as patching, holding, testing, or talking cords.
2. High impedance monitoring.
3. Position dialing or dc or mf key pulsing on either cord. A dial cord and the dialing and supervisory circuit may also be furnished.
4. Transmission measuring.

Telegraph testing facilities provided are:

1. Volt-milliammeter for line and loop current measurements.
2. No. 3 telegraph test set or monitoring teletypewriter for testing, communicating and monitoring.

The jack field has been made flexible to meet various job requirements; and/or all of the following may be included:

1. Primary jacks for open wire or cable intertoll trunks.
2. Patching jacks for open wire or cable intertoll trunks.

3. Test and out-of-service jacks for intertoll trunks and community dial office trunk circuits.

4. Patching, monitoring and signal test jacks for full period talking in long line circuits.

5. Incoming and outgoing 2-way and test trunk circuits.

6. Telegraph line jacks.

7. Telegraph loop terminal jacks.

8. Miscellaneous test and out-of-service jacks.

E. NO. 19A TOLL TESTBOARD

The No. 19A toll testboard is used in No. 5 Crossbar (4 wire) toll offices for making over-all tests of the toll circuits. This testboard consists of a lower unit which houses testing and control equipment, and a jack field in which an appearance of the intertoll trunks (test jacks, patch jacks) and miscellaneous other trunks appear.

In line with the general design of the No. 5 Crossbar (4 wire) toll switching system, the circuits in this board are arranged on a 4-wire basis necessitating the use of twin jacks in the jack field and twin plugs on the cords which connect to these jacks.

The testing facilities available provide for monitoring and talking on a trunk and for making 1000 Hertz and multi-frequency transmission measurements, signaling, and miscellaneous other tests enabling the testman to diagnose the trouble which exists on a circuit, so that he may notify the proper maintenance group of the nature of the trouble.

F. NO. 9 TELEGRAPH TESTBOARD

The No. 9 telegraph testboard employs relay rack bays for mounting the jacks and testing equipment required for maintaining telegraph service. The telegraph testboard is divided into two major types as follows:

1. Telegraph Line Bays: The line bays contain generally only those jack circuits which stand between the interoffice lines or trunks and the equipment

in the telegraph office. A telegraph line bay contains a writing shelf or a test lower unit which contains cord-ended testing equipment. A jack field mounted in the upper part of the bay contains carrier and dc telegraph line jacks, interposition trunks, and miscellaneous jacks. The upper unit equipment also includes an apparatus panel, miscellaneous mounting plates, and, when so desired, terminal strips for the jack circuits.

2. Telegraph Loop Terminal Bays: The terminal bays are intended primarily for the administration of private-line telegraph service and contain jack circuits for patching and testing subscriber loops as well as directly associated equipment.

   A telegraph loop terminal bay contains either a test lower unit similar to that at a line bay or a shelf for mounting a teletypewriter. Above these is a jack field, consisting of various arrangements of 3, 4, 5, 6, 7, or 8 jack TLT circuits as well as interposition trunks and miscellaneous jacks. Above the jack field are telegraph relays and sounder and relays associated with the telegraph loop terminals. These relays operate under control of manual telegraph subscribers over their loops and are used to call in an attendant.

   In addition to the normal functions of the TLT positions, those particular positions in which the telegraph repeaters, assigned to teletypewriter switchboard ringdown, intertoll trunks, and automatic signaling trunks are terminated, are equipped with additional testing facilities. As these facilities test the teletypewriter switchboard circuits, they vary in design according to the type of switchboard.

The test lower unit equipment provides for the following:

1. Current and bias measurements in telegraph lines and loops.

2. Voltmeter tests to check continuity, voltages, polarities, loop leakage, and busy conditions on trunks.

3. Operating tests, that is, monitoring and communication with telegraph key and sounder or with teletypewriter.
4. Telephone communication with teletypewriter subscribers and with attendants in a distant office.
5. Telegraph communication with attendants in a distant office.
6. Teletypewriter orientation range scale measurements on associated teletypewriter.

Testing equipment not located in the testboard bays, but terminating there, provides facilities for making the following tests:

1. Hit indication on lines.
2. Transmission measuring.
3. Stability testing.
4. Loop current indicating.

To permit making transmission tests, sources of teletypewriter signals, biased and unbiased, and reversals signals, etc., are provided.

Means are also available whereby a testboard attendant at the line positions can associate a meter at the loop pad bay with any 130-volt subscriber loop arranged for inverse neutral operation in order to observe the current flowing in the loop. The attendant at the loop pad bay may then observe, and by means of the associated loop pad potentiometer, adjust the current to the proper value.

Several applications of jacks in the line bays and telegraph loop terminal bays are shown in Figure 19-16.

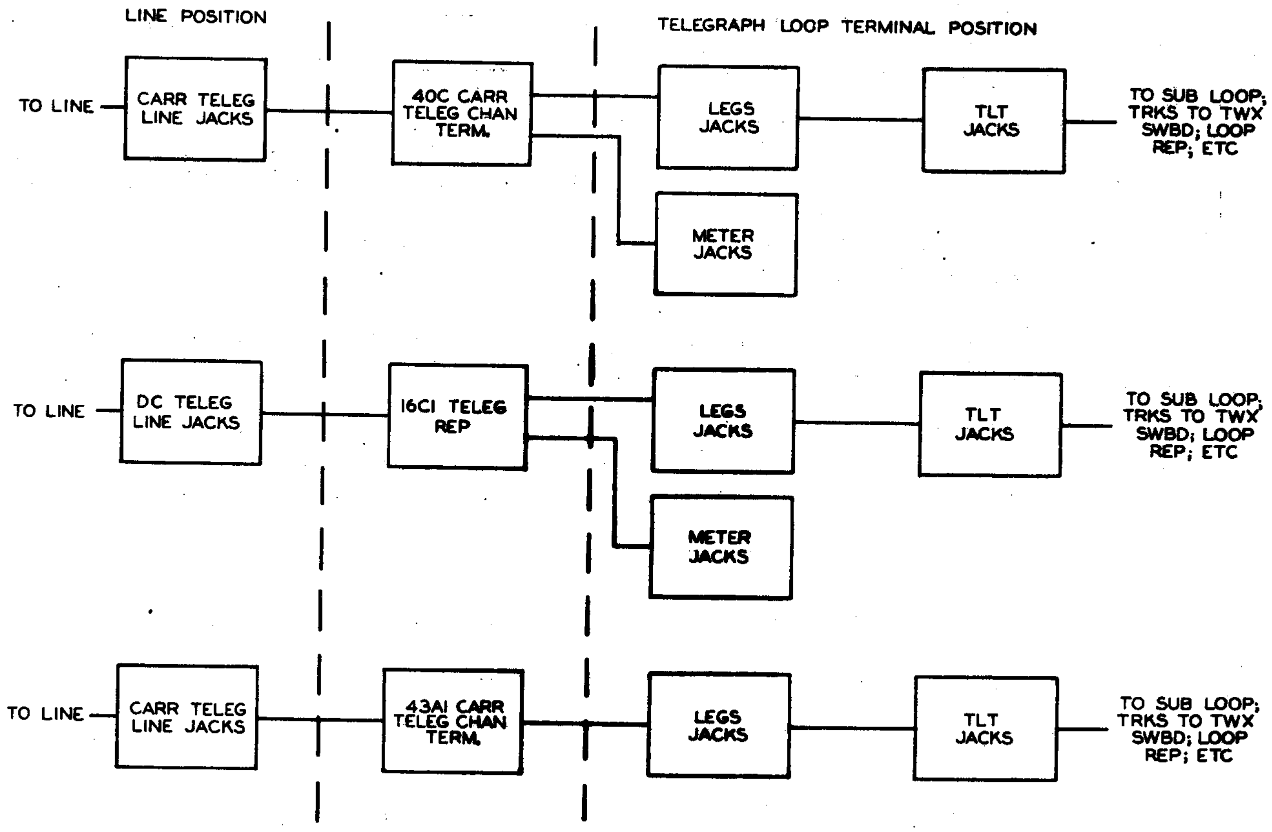

Figure 19-16 Typical Uses of Jack Circuits at Telegraph Testboard

19.5 LOCAL TESTING

A. GENERAL

Local testing facilities are furnished for the maintenance of all types of central offices, as well as the associated outside plant equipment. The testing methods used will vary in technique, from manually controlled tests to automatically controlled tests, depending upon the type and vintage of equipment being tested.

While the names of frames, cabinets and desks used for local testing would make a rather long list, only three types have been selected for discussion in this chapter. These three types of test facilities use nearly all of the techniques that would be found in a completed study of the local testing field. The testing facilities covered herein are the No. 14 local test desk, the master test frame (No. 5 crossbar), and the line insulation test frame.

B. NO. 14 LOCAL TEST DESK

The No. 14 local test desk is designed as a universal desk for use in all systems, manual, panel, step-by-step, and crossbar. The No. 14 local test desk is also universal in that it can be used on either a local or centralized basis, predominantly for outside of plant equipment. Also one test center can be arranged to serve any combination of offices.

The physical appearance of a local test desk is similar to a switchboard in that each position has a key and plug shelf, writing space and face equipment with 10-1/4 inch panels. See Figure 19-17. A number of positions may be located side by side forming a line-up.

The local test center, test desk, repair service desk and desks for supervision, are usually located in the same building, but in a separate room from the switching equipment. Local test centers may be furnished on a one per building basis; however, in metropolitan areas where the local office buildings are close together, the test centers may be furnished on a centralized basis. In centralized testing the local test center serves the building it is located in as well as a number of nearby buildings, with resultant savings in space, equipment and personnel.

The various tests are made under control of keys in the keyshelf. The connection to the line under test is obtained by single ended cords that are plugged into test trunks located in the face equipment. The cords are for the primary test circuit, secondary test circuit, and WHEATSTONE BRIDGE test circuit. An overlap exists between the test functions of the primary and secondary test circuits; each will perform some tests not performed by the other circuit as well as some of the same tests. The type of functions common to both test circuits are means of establishing connections to subscribers' lines, talking, monitoring, and ringing. By operation of the reverse key, the association of the primary and secondary cords to the primary and secondary test circuits can be reversed, except for the howler which is only associated with the secondary test cord.

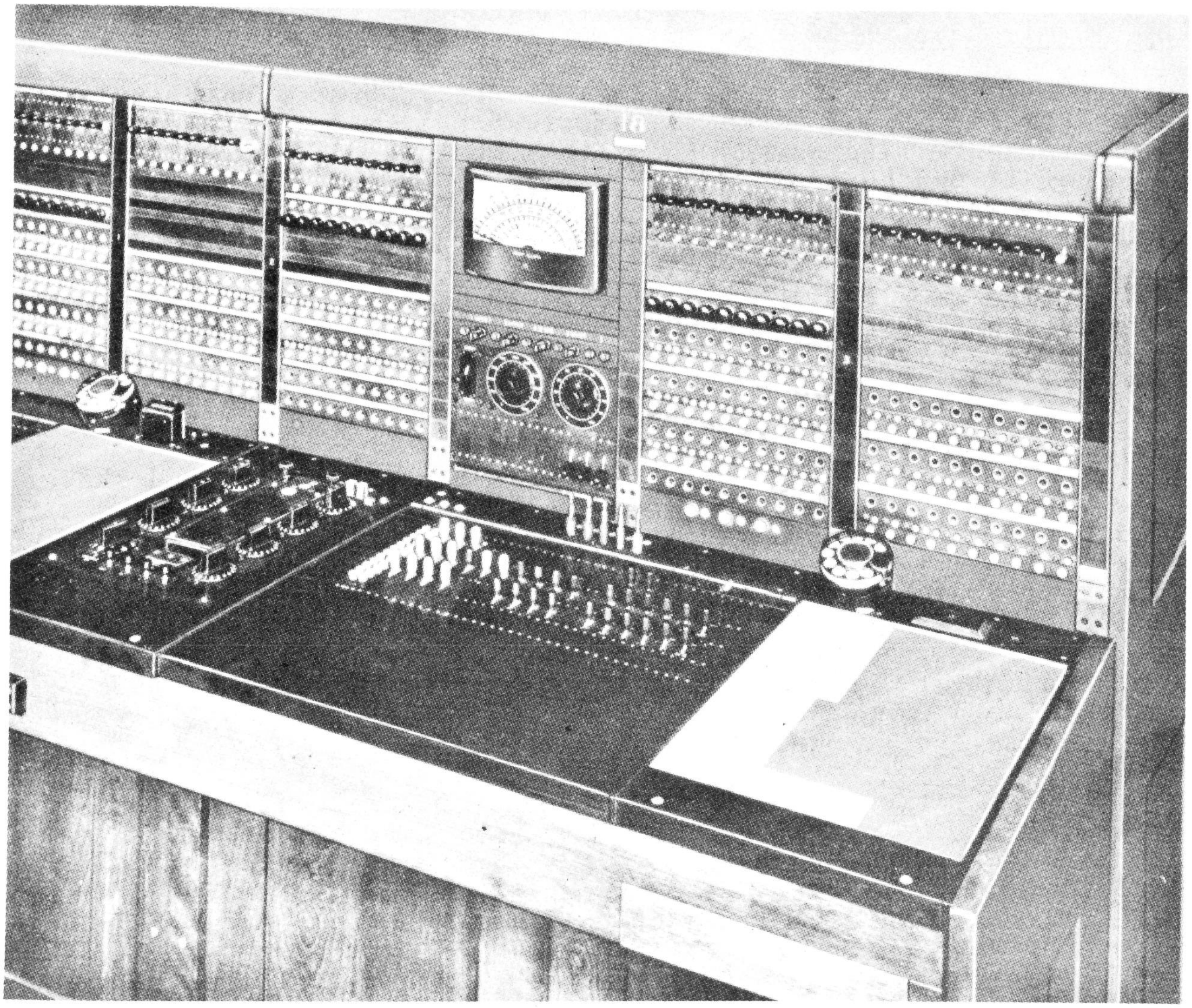

Figure 19-17 No. 14 Local Test Desk Test Position

The test trunks, which appear in the face equipment, test trunks to the MDF, in and out test trunks, intermittent trouble, wheatstone bridge test trunks, etc., terminate on distributing frames. The personnel working at the local test desk instruct the maintenance personnel what cross-connections are to be set up between test trunks and other lines or trunks. Communication between the testman and the local distributing frame is by a loudspeaker system. Call circuits and talking trunks are furnished for communication with other maintenance locations and operators at switchboards or toll testboards. The keys for controlling these talking connections are located in the top of the face equipment and multipled through the line-up but not necessarily on a position basis. The test center may also serve alarm receiving equipment and a teletypewriter for recording details of line failure from the line insulation test frame.

C. MASTER TEST FRAME

The testing facilities for mechanical switching offices have undergone evolutionary development to keep pace with the development of the switching systems. The present day facilities incorporate a considerable degree of automatic as well as manual testing techniques. For purposes of illustration in the text the master test frame of the No. 5 crossbar office will be discussed. This test frame incorporates procedures and techniques common to test frames of other switching systems, such as trouble indicator, trouble recorder, and sender test frames.

Practically all of the maintenance facilities in a No. 5 crossbar office are concentrated in several bays of equipment, known as the master test frame. This frame, together with other maintenance facilities, is located in a part of the office called the maintenance center. This center is usually located near the major common control frames, such as markers, senders and registers, to facilitate cabling and maintenance.

The principle maintenance functions performed by the master test frame are:

1. Automatically records, on punched cards, troubles encountered on service calls and equipment used on test calls.

2. Tests nearly all of the major circuits in the office.

3. Automatically monitors the pulsing performance of registers and senders during service and test calls.

4. Acts as a central control and observation point for the office.

The equipment of the master test frame consists primarily of a trouble recorder on automatic monitor, a master test circuit, and a jack bay for outgoing trunks. During unattended periods the alarms may be extended to a distant office.

D. LINE INSULATION TEST FRAME

The line insulation test equipment is arranged to operate on an automatic basis to disclose defects in cable, cable terminals, drop wire, and inside wire which may eventually affect subscriber service. The tests are controlled either by the local maintenance force or by remote control from a local test center. The test control circuit connects the test circuit successively to the subscriber lines skipping busy lines and other lines which may produce false indications or cause service interference. The test equipment stops automatically upon completion of the test cycle or when the traffic load in the office requires the use of the equipment temporarily assigned for line insulation testing. When the test control equipment locates a line that fails to meet the test condition, a record is made of the line and the test condition under which the line failed. Line locations are successively generated in the test control circuit for connecting the test circuit to the line. Any line that is found busy as well as lines assigned to toll trunks, dial PBX, test lines or other uses which would give a false trouble indication or service interference are skipped by the line insulation test control circuit. The speed of testing is approximately 12,000 lines per hour. The line insulation test frame can be started by operating keys at the test frame or from the local test desk through the test trunk and selector circuit. Access to the line link frames of crossbar offices is obtained through one of the marker multiples and the no test connector. Access to the lines of step-by-step offices is obtained through the test distributor and test connector.

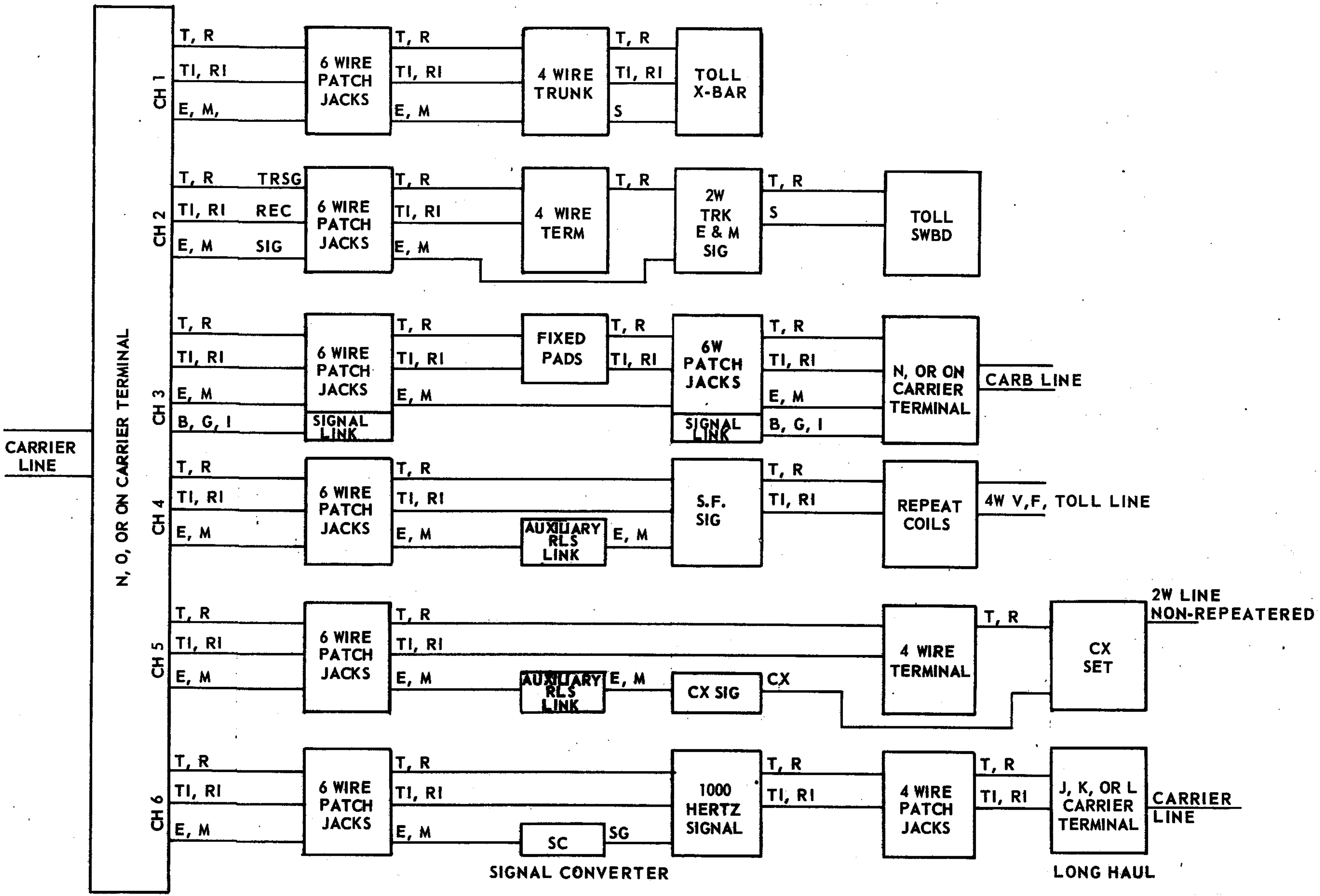

Figure 19-18 Connections at a Six-Wire Voice Frequency Patch Bay

19.6 VOICE FREQUENCY PATCHING BAYS

The voice frequency (V.F.) side of the various short-haul carrier systems may connect through six-wire voice frequency patch jacks to the assigned V.F. facilities. At the six-wire (6W) patch jacks, access to the carrier channel equipment and the V.F. equipment, or the segregation of the two equipments, may be made. The six-wire voice frequency patch bay provides a centralized monitoring, level measuring, signal testing, and patching position for the carrier system.

Figure 19-18 shows a block schematic of the connections of various types of V.F. equipment through 6W patch jacks to a carrier system. The connections as shown, illustrates the variation of facility assignment to a carrier system and does not represent a typical assignment. Channel 1 provides a line circuit for a trunk connecting to a toll crossbar switching system. Channel 2 provides a line circuit for a trunk connecting to a toll switchboard. Channel 3 shows a through connection from one carrier system to Channel 1 of another carrier system. Fixed pads, which are part of the six-wire patch bay equipment, are used to adjust the output level of one carrier system to the input level of the other carrier system. Signal link jacks and lamps, and a turn-over in the cross connection of E and M leads, are necessary to connect the signaling leads of one system to the signaling leads of the other system. Channel 4 is connected through to a 4W toll line, which is arranged for single-frequency signaling at the distant end. The toll terminal equipment necessary to connect to the carrier system is also indicated. Channel 5 is a similar arrangement that connects to a 2W V.F. line, which is arranged for composite signaling at the distant end. Channel 6 is a through connection to a carrier system which does not have built-in signaling. Toll terminal signaling equipment is provided on the J, K, and L carrier system.

Four-wire terminating sets or hybrids are provided in the channel units of the short-haul carrier systems. When the carrier system is connected through 6W patch jacks, the terminating sets or hybrids are not used.

The 6W patch bay monitoring and test equipment is shown in Figure 19-19. A voice frequency amplifier and telephone set are provided for monitoring and talking on carrier channels and for use with order wires and local trunks that are provided at the 6W patch bay. A common transmission and noise measuring system is provided per line-up or group of bays and a 1000 Hertz, one milliwatt, signal is provided as a standard level test signal. A Transmission Measuring Set (T.M.S.) circuit that contains position control relays, an amplifier-rectifier, and a projection type DB meter is used to measure a change in level of the MW signal after it has been transmitted through either the carrier facility or the V.F. facility. A patch to DEM OUT (Demodulator Out) and MOD IN (Modulator In) jacks disconnects the carrier channel from the V.F. facility and provides a test connection to the carrier channel. A patch to EQ OUT (Equalizer Out) and EQ IN (Equalizer In) jacks disconnects the V.F. facility from the carrier facility and provides a test connection to the V.F. facility. An auxiliary T.M.S. meter, under the control of a key, may be provided at the location of the carrier equipment. With it, levels adjustments may be made on the carrier equipment while the results are observed on the meter. Additional patch and test jacks, for program equipment assigned to carrier channels, may be provided at the 6W patch bay. These jacks are cross connected to the two-wire V.F. program equipment so that level measurements may be at this point. Reversing of the program equipment may be controlled by a test jack at the 6W patch bay. Testing of the channel or V.F. signaling circuits, and spare signaling circuits terminated on jacks at the 6W patch bays, is accomplished by the use of portable signal test sets. Signal test battery supplies are provided at the bays.

Although the foregoing deals with the 6 wire Voice Frequency Patch Bay other patching bays exist such as the 4 wire V.F. Patch Bay, which is similar but doesn't use the E & M lead (signaling) jacks. High-frequency patch bays are used at intermediate or end points in carrier systems as the voice-frequency is only modulated in steps up to the line frequency.

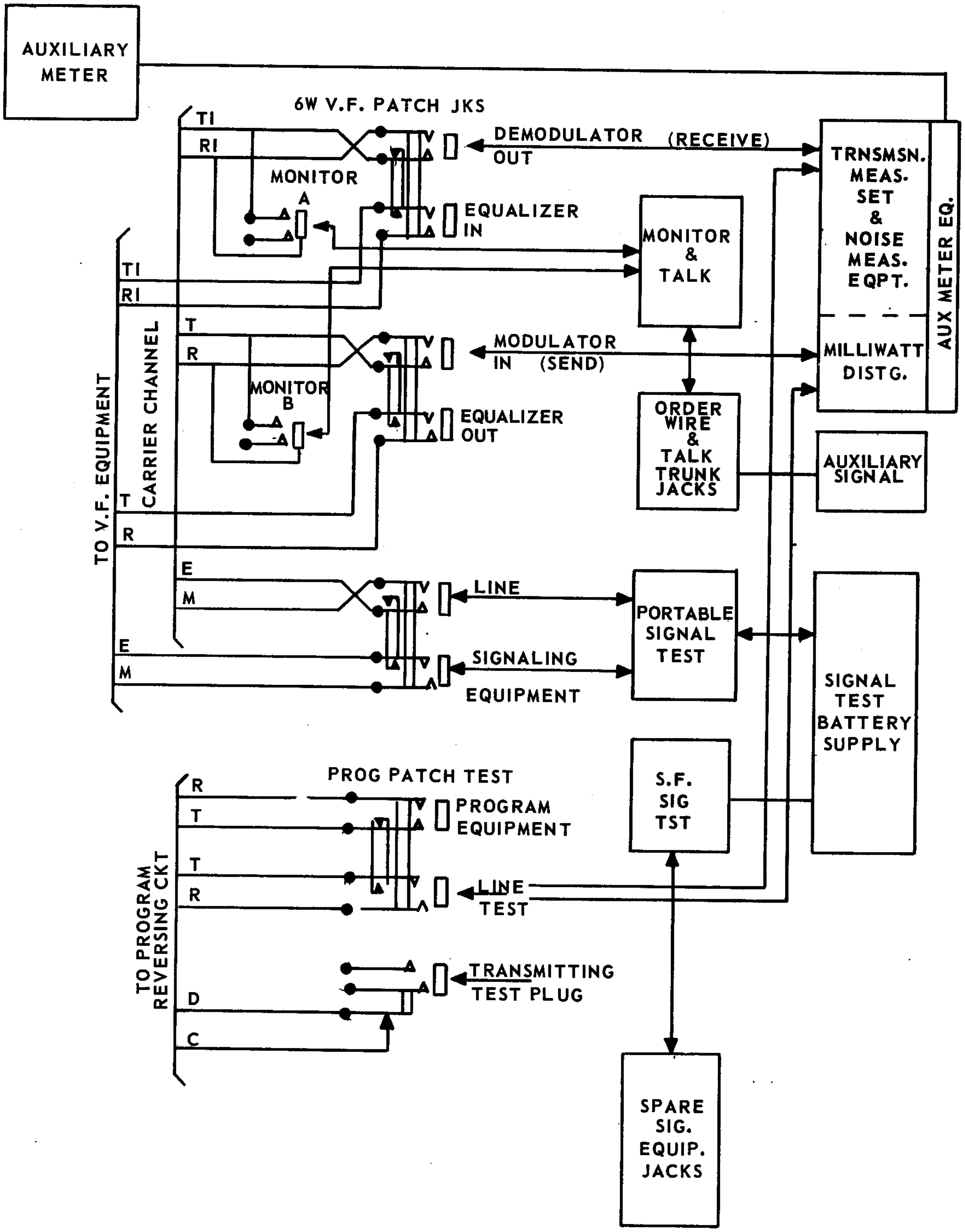

Figure 19-19 Test Equipment at a 6 Wire Voice Frequency Patch Bay