ADVANCE BASE TELETYPE INSTALLATION *and* MAINTENANCE PRACTICES

NAVSHIPS 900,031

NAVY DEPARTMENT • BUREAU OF SHIPS

Washington, D. C., July 1944

SAFETY NOTICE

While the voltages used in teletype equipment are not in excess of 250 volts, they may be dangerous if contacted under certain conditions. For this reason, all safety precautions shall be observed—particularly when making line connections and tests inside the equipment.

BUREAU OF SHIPS,
NAVY DEPARTMENT,
Washington 25, D. C., 15 July 1944.

1. *Advance Base Teletypewriter Installation and Maintenance Practices* (Navships 900,031) has been prepared for use by Naval personnel engaged in installation and maintenance of teletypewriter equipment. Although particularly applicable to advance base installations this publication should prove useful to all interested personnel.

2. Much of the information contained in this publication has been obtained from material issued by American Telephone and Telegraph Co., the Teletype Corporation, North Electric Manufacturing Co., the Automatic Signal Corp., the Power Equipment Company, and the U. S. Army Signal Corps. The material has been rearranged in order to be specifically applicable to the Naval usage of the equipment.

3. It is hoped that field forces will submit corrections and additions or any information which will be helpful in improving subsequent editions.

4. Additional copies of this publication may be obtained from the Chief of the Bureau of Ships, (Code 993).

J. B. Dow,
Captain, U. S. N.

DESTRUCTION NOTICE

WHY To prevent the enemy from using or salvaging this equipment for his benefit.

WHEN When ordered by your commander, or when you are in immediate danger of capture.

HOW

1. *Smash or cut*—Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools, large rocks, track-laying vehicles, or explosives such at TNT, grenades, firearms, etc.
2. *Burn*—Use gasoline, kerosene, oil, flame-throwers, incendiary grenades, etc.
3. *Disposal*—Bury in slit trenches, fox-holes, other holes. Throw in streams. Scatter.
4. *Use Anything Immediately Available for Destruction of This Equipment.*

WHAT

1. *Smash*—Switchboards, front panels, relays, and all other parts.
   Rectifiers, vacuum tubes, meters, coils, and all other parts.
   Teletypewriter, frame, base, keyboard, typing unit, motor, and all other parts.
   Power units, engine, crankcase, carburetor, magneto windings, pulleys, shafts, and all other parts.
   Line control unit meter, relay and all parts.
   All chests, cords, and spare parts.
2. *Burn*—All remains. Use broken chests, manuals, oil and gasoline as fuel.

DESTROY EVERYTHING

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I. TELEGRAPH COMMUNICATION SYSTEMS

1. General. Telegraph systems can be divided into manual and teletypewriter systems and can be subdivided further into radio and wire circuits. This instruction book will be confined to wire circuit applications.

Since the only major difference between manual and teletypewriter systems is in the method of producing and receiving signals, an explanation of manual telegraph system fundamentals will apply to teletypewriter systems.

2. Manual Telegraph Systems. The simplest system for electrical communication between two points would be a series circuit from ground through a key at one station, to a single conductor line, then to a sounder, battery and ground at the other station. Opening and closing the key at one station would cause the sounder to operate and release at the other station thus providing, by the use of a predetermined code, communication in one direction.

Two sounders and two keys connected as shown in figure 1, with the normal condition of the circuit closed, will permit communication in either direction when either key is opened and closed. With both keys closed there is current flowing and the circuit is said to be in a *marking* condition. With either key open there is no current flowing and the circuit is said to be in a *spacing* condition.

Although many types of telegraph circuits have been designed they may all be grouped into three general classifications.

A. *One way* circuits which are capable of transmission in one direction only.

B. *Duplex* circuits which are capable of transmission in both directions simultaneously.

C. *Half-duplex* circuits which are capable of transmission in both directions but not simultaneously.

Telegraph circuits may be further subdivided by electrical characteristics into:

A. *Neutral* circuits in which there is a current flow in the line during the marking condition and no current flow in the line during the spacing condition.

B. *Polar* circuits in which there is a current flow in one direction through the line during the marking condition and current flow in the opposite direction through the line during the spacing condition.

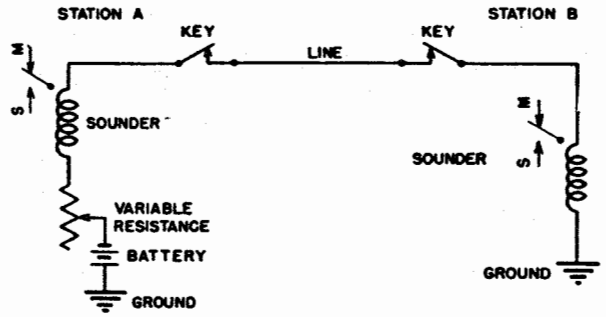
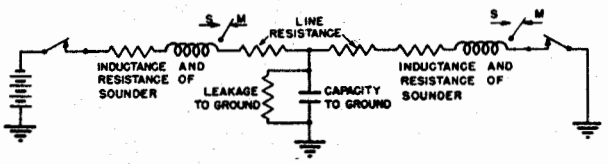


FIGURE 1.—*Simple manual telegraph circuit.*

The circuit illustrated in figure 1 can now be designated as a *neutral half-duplex* circuit. The number of stations connected to this system could be increased by inserting additional sounders and keys in series with the line. Under this condition a message sent by any station on the line would be received at all the stations.

3. Telegraph Signal Distortion. When a marking pulse is sent by a telegraph key the circuit changes instantaneously from an open to a closed condition at the beginning of the pulse and instantaneously from a closed to an open condition at the end of the pulse. This, in a non-reactive circuit, would produce instantaneous operation and release of the receiving sounder armature and perfect reproduction of

the transmitted signal. The actual telegraph circuit, however, cannot meet these conditions. The sounder winding introduces a certain



FIGRUE 2.—*Schematic representation of capacitance, inductance, and resistance in a simple telegraph circuit.*

amount of inductance and the line introduces a capacity to ground in the circuit. A schematic diagram representing this circuit is illustrated in figure 2.

Although closure of the telegraph key contact in a circuit is instantaneous (fig. 3A), a certain finite time interval is required for the current in the circuit to change from the steady state "spacing" (no current flow) to the steady state "marking" (maximum current flow) value. The interval *TC* on figure 3B (wave form exaggerated) may be called the *time constant* of this circuit. The value of the time constant for any particular circuit is mathematically related to the particular arrangement and amounts of capacitance, inductance and resistance contained in the circuit and will remain constant until any portion of the circuit make-up is changed. When the telegraph key is opened a similar time constant *TC1* (fig. 3B) will be required for the current in the circuit to change from the steady state marking to the steady state spacing condition.

By adjustment of the sounder armature spring tension the sounder can be made to operate at point *a* on current buildup and release at point *b* on current decay of figure 3B. Figure 3C represents the signal as received by the sounder armature. It is evident, by comparing figure 3C with figure 3A, that the signal has been

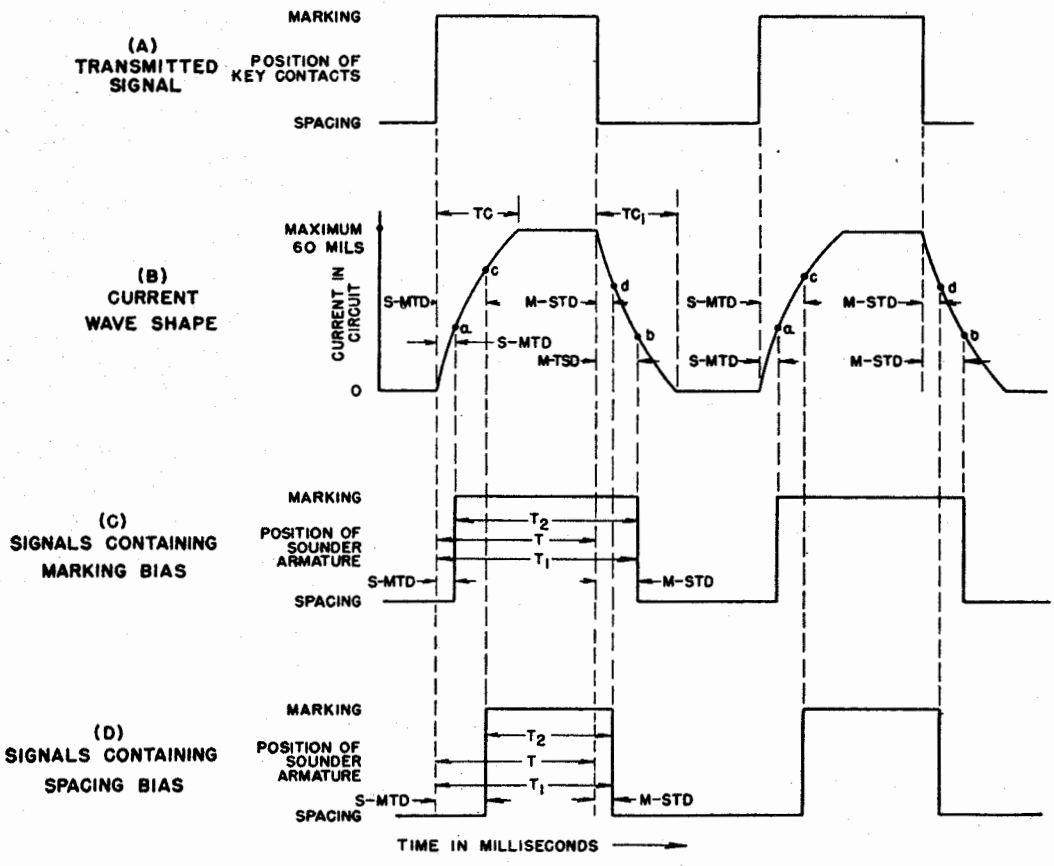


FIGURE 3.—*Diagram showing time relations of transmitted and received signals.*

distorted by having its marking period increased. This type of distortion is called *marking bias* and is measured in percent increase in length of the marking signal or milliseconds bias.

It is customary in general communication practice to refer to the *length* of a signal pulse, either marking or spacing, in milliseconds (thousandths of a second) and to any *difference in length* between the original and the received signal pulse as milliseconds *bias*.

The interval between closure of the key contact and operation of the sounder armature to the marking position is called a *space to mark transition* and is abbreviated *S-MTD*. The interval between opening of the key contact and release of the sounder armature to the spacing position is called a *mark to space transition* and is abbreviated *M-STD*. These time intervals are illustrated in figure 3B.

Further adjustment of the sounder armature spring tension can be made to cause the sounder armature to operate to a marking position at point *c* and release to a spacing position at point *d* (fig. 3B). Under these conditions the signal received will be as represented in figure 3D. This distortion is called *spacing bias* because the length of the spacing signal has been increased.

Any change in the magnitude of the time constants, TC and TC_1 in figure 3B, would immediately be reflected in a change of the bias of the received signal. Changes in magnitude of time constants are common in practical operation and will be produced by changes in line resistance caused by normal daily temperature variations or changes in leakage and capacity to ground caused by wet or dry weather.

Inspection of figures 3B and 3C will show that the total time from the operation of the key at the beginning of the signal to the release of the sounder at the end of the signal T minus the *S-MTD* is equal to the length of the received signal T_2 and T_1 minus the *M-STD* is equal to the length of the transmitted signal T. Writing these statements in equal form

$$T_1 - S\text{-}MTD = T_2 \quad (1)$$

$$T_1 - M\text{-}STD = T \quad (2)$$

Subtracting equation (2) from (1) we have

$$M\text{-}STD - S\text{-}MTD = T_2 - T \quad (3)$$

Since T_2 minus T is the difference in milliseconds between the length of the original signal as keyed and the effective length of the signal received by the sounder, we may say

$$\text{Milliseconds Bias} = M\text{-}STD - S\text{-}MTD \quad (4)$$

The same process of reasoning can be applied to figure 3B and 3D but in this case *S-MTD* will be larger than *M-STD* and the millisecond bias will be negative. A *positive* millisecond bias will always represent a *marking* bias and a *negative* millisecond bias will always represent a *spacing* bias.

Proper adjustment of the sounder armature spring tension can be made so that *M-STD* is equal to *S-MTD*. Under these conditions bias will be equal to zero and the sounder armature will accurately reproduce the transmitted signal. The received signal will be delayed several milliseconds by the *S-MTD* and *M-STD*, but since all successive signals are also delayed no signal distortion will result.

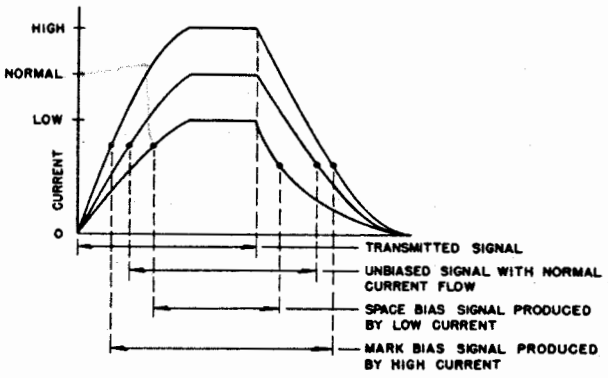


FIGURE 4.—*The effect of changes in steady state current.*

Figure 4 illustrates the effect on bias of an increase or decrease in steady state current. With any one armature spring tension adjustment of the sounder an increase in current flow will introduce a marking bias and a decrease in current flow will introduce a spacing bias.

4. Teletypewriter Circuits. Substitution of a teletypewriter unit for the sounder and key at each end of a telegraph circuit will produce a

simple teletypewriter circuit. This arrangement is illustrated in figure 5.

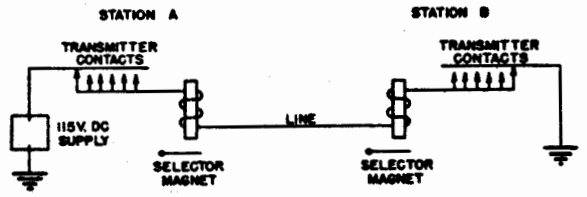


FIGURE 5.—*Simplified teletypewriter circuit.*

The transmitter contacts are actually a set of mechanically controlled keys which can produce a different sequential seven unit signal for any letter or function lever depressed. Each character consists of a 22 millisecond spacing signal functioning as a start pulse to release the receiving mechanism, five 22 millisecond intelligence pulses either marking or spacing and a 31 millisecond marking pulse used to stop the receiving mechanism. Figure 6 illustrates the signal generated by the transmitter contacts when the Y key lever is depressed.

The selector magnet of the receiving machine is arranged mechanically to release a trip latch when the start pulse is received thus allowing the selector cam sleeve to rotate through one revolution. During this revolution five swords are positioned by the operation or release of the selector magnet armature as determined by each intelligence pulse received. The time required to position each sword is approximately 20 percent of the time of one intelligence pulse or 4.4 milliseconds. The cams on the selector cam sleeve are so located that the time between each sword operation is fixed at 22 milliseconds. During 4.4 ms. of the first pulse the first sword will be positioned, during 4.4 ms. of the second pulse the second sword will be positioned, etc., until all five swords have been positioned. These swords control vanes, bell cranks and code bars to select and at the proper time print the selected character.

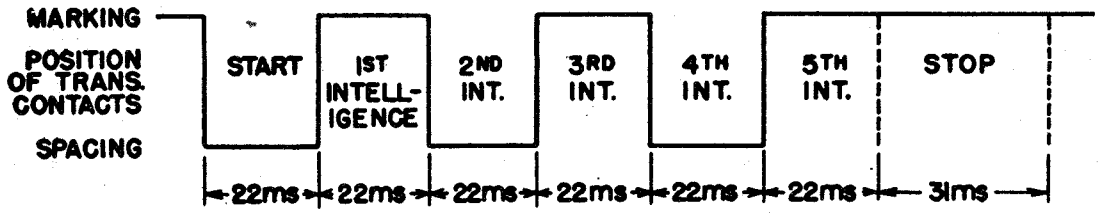
The receiving mechanism main shaft and its attached selector cam sleeve are geared to complete one revolution in one seventh less time than the transmitter cam shaft. When the selector magnet is released by the start pulse the selector cam sleeve starts to rotate and has completed its revolution and stopped before the transmitter cam shaft has completed its cycle. This self-synchronizing feature of the start-stop system confines the effect of any slight difference in motor speed adjustment of the sending and receiving machines to one character.

5. Orientation. The angular position of the first selector cam on the selector cam sleeve in its rest position, with respect to the first operating lever is controlled by the range finder. This is accomplished by controlling the position of the stop lever in the arc of rotation of the main shaft. With this arrangement, it is possible by shifting the range finder index arm to control the time interval between the release of the selector magnet on the start pulse and the time when the first sword is positioned on the first intelligence pulse. The time relation of the total intelligence pulse to the sword positioning periods is illustrated in figure 7. On a properly adjusted machine sending signals to itself, it should be possible to vary the range finder setting from 15 to 95 without misprints.

If the motor of a receiving machine operates at other than proper speed the time interval between sword positioning periods will be larger or smaller than 22 milliseconds. Under this condition, with the range finder properly set to locate the first sword positioning period in the center of the first intelligence pulse, it is evident that the fifth sword position may be controlled by the fourth intelligence or the stop pulse. By shifting the range finder index arm it is possible to adjust the machine to print properly, however the range will be seriously decreased.

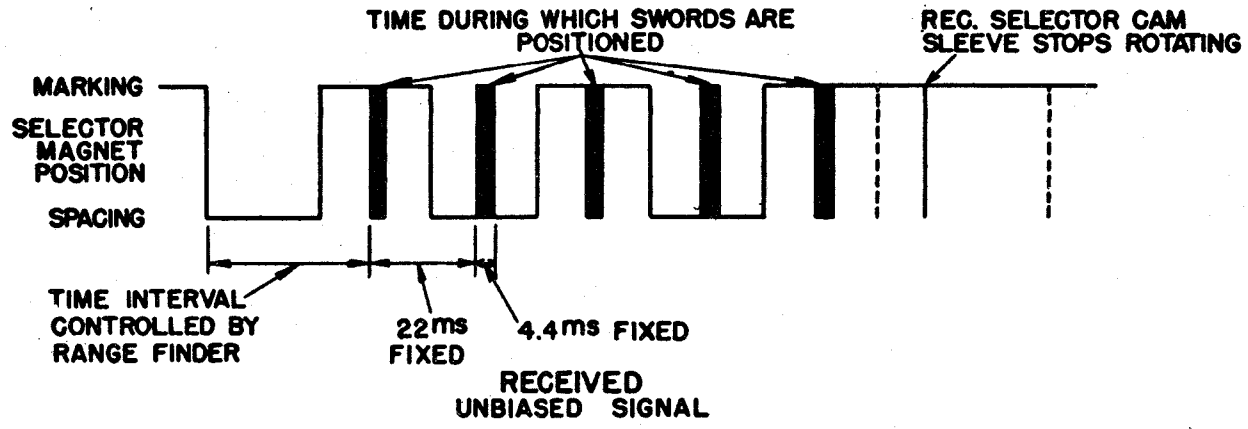
6. Distortion in Teletypewriter Systems. Distortion in teletypewriter circuits may be divided into three classes; bias, characteristic distortion and fortuitous distortion.

In a neutral telegraph circuit, *bias* as discussed in paragraph 3 is dependent on the electrical characteristics of the circuit and the adjustment of the receiving relay. The conditions required for a constant bias are that steady state currents both marking and spacing remain constant, relay adjustments do not change, and electrical constants such as capacity and leak-



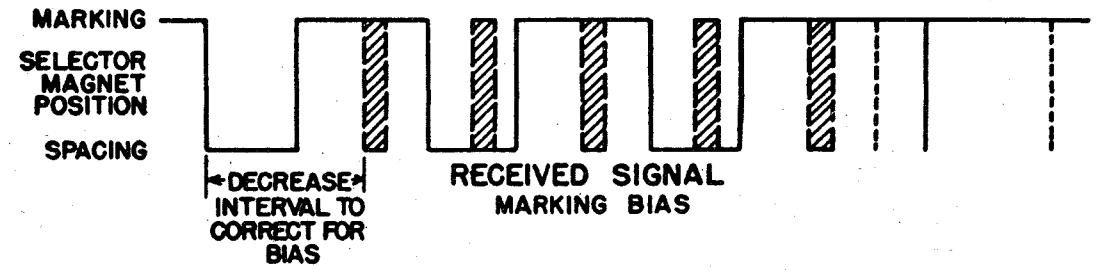
TRANSMITTED SIGNAL

FIGURE 6

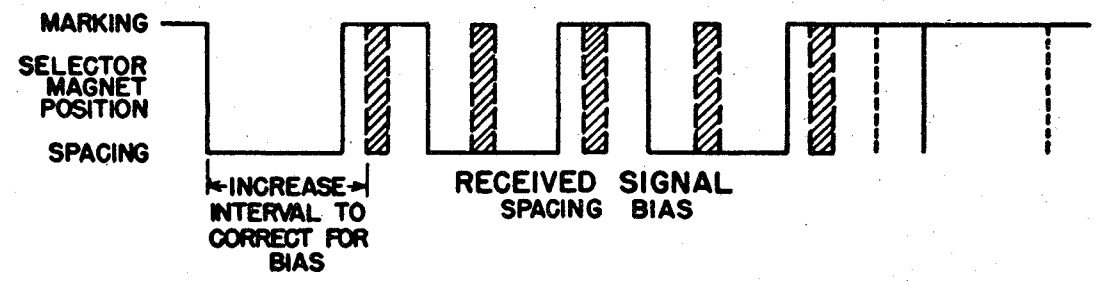


RECEIVED UNBIASED SIGNAL

FIGURE 7



SHIFT RANGE FINDER INDEX ARM TOWARD LOW END OF SCALE



SHIFT RANGE FINDER INDEX ARM TOWARD HIGH END OF SCALE

FIGURE 8

age to ground and line resistance remain constant. If any of these items varies it will be necessary to compensate by readjustment to maintain the same bias. The assumption is made for this type of bias that the length of the signal is sufficient for the line current to reach its steady state condition before the next transition takes place.

In an actual teletypewriter circuit the factors that produce bias are all present and a letter "Y" transmitted over the line might produce a signal as illustrated in figure 8. In this illustration the range finder setting is the same as in figure 7. Under these conditions a relatively small error in any one pulse might produce a misprint. When the machine is connected to a line a range should be taken by moving the range finder arm toward the low (0) end of the scale until the machine just misprints then toward the high (120) end of the scale until the machine again misprints. The sum of the two index arm scale readings should then be divided by two and the index arm set at this value. With the range finder set in this position the sword positioning periods will fall approximately in the middle of the biased pulses and thus provide the best operating margin. On a signal with marking bias the reading obtained on the high end of the scale with a properly adjusted machine will be less than 95 and on a signal with spacing bias the reading on the low end of the scale will be more than 15.

Characteristic distortion cannot be briefly defined, however its effects vary with both electrical constants and length of the individual signal pulse. The condition necessary to produce this distortion is that the length of a signal pulse either marking or spacing must be shorter than the time required for a complete transition from one steady state condition to the other with respect to current flow. This distortion will vary with the character being transmitted and the mechanical condition of the transmitting machine and is therefore not predictable. The only precaution to be taken against this distortion is to position the index arm in the center of the range as described in the preceding paragraph.

The form of distortion, caused by crossfire, power induction, momentary line wire troubles, BREAK key operation and the like, which interferes with received signals intermittently by various amounts, is known as *fortuitous distortion.* At times this effect may be large enough to produce complete failure of the circuit. Again the only precaution is to provide an optimum range adjustment.

7. The Line Relay. The armature tension spring on the selector magnet of a teletypewriter is not designed for bias adjustments. To provide the flexible adjustments which are requisite to efficient operation under field conditions of varying line electrical constants it is the general practice to use a line relay and operate the selector magnet from its contacts. The COQ–23403 Line Control Unit uses an adjustable armature retractile spring to provide a mechanically biased relay. The Western Electric 255–A Line Relay used in the M–15 Teletypewriter is a polar relay providing a fixed electrical bias. The operating winding of this relay is poled to operate the relay to the marking contact and the biasing winding is poled to operate the relay to the spacing contact. The addition of a variable resistor in the biasing winding circuit will permit adjustment of the bias of the relay. A simplified schematic of a teletypewriter network employing line relays is illustrated in figure 9.

8. Polar and Polarential Operation. Although these types of circuits are inherently more stable and capable of operation over longer distances and under more adverse conditions the equipment required is considerably larger and more difficult to maintain. For these reasons it is advantageous to use a neutral system at advance base installations where simplicity, portability and ease of maintenance are important factors.

Explanation of polar and polarential operation are beyond the scope of this text but information on these subjects is available in *Principles of Electricity Applied to Telephone and Telegraph Work* published by the American Telephone and Telegraph Company which is usually available in the reference libraries at Naval radio stations and teletype repair facilities.

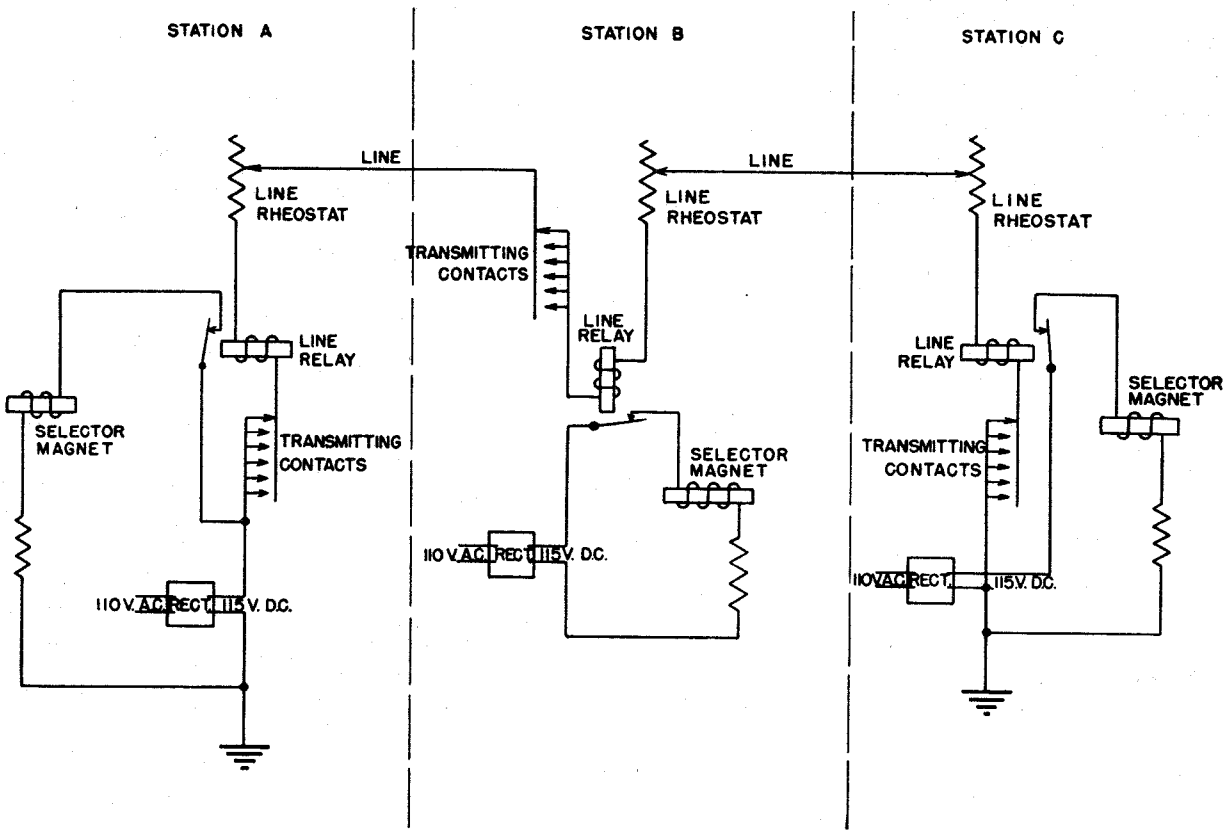


FIGURE 9.—*Simplified schematic series teletypewriter circuit.*

9. Telegraph Transmission Measurement. It is generally practicable to measure the total distortion of teletypewriter signals in the field. This information is valuable as a direct indication of the grade of transmission. Determination of the characteristic and fortuitous components of distortion separately is not generally possible, but during certain line-up procedures and in cases of transmission difficulty measurement of the bias provides a valuable tool.

Bias is a variable factor and generally may be minimized by the proper adjustment of relays and operating currents. It may be checked by applying a series of equal marks and spaces, known as *telegraph reversals*, at one end of the circuit and observing with a milliammeter the signals received at the other end. With unbiased signals the pointer of the meter will vibrate about zero when observing polar signals, and at about one-half the reading obtained with a steady marking signal in the case of d-c neutral circuits. Bias may also be checked by applying repeated teletypewriter space signals and observing the meter in a bias measuring circuit. Repeated space signals are employed for lining up the COQ–23403 Line Control Unit and BD–100 Switchboard.

The orientation range finder provided on teletypewriters may be used conveniently to give an indication of total distortion. For best results machines should be in good adjustment and care should be taken in making the observations. The finder and its scale are shown in figure 10. The scale is graduated in percent of a unit dot length (one intelligence pulse) and the range finder arm may be shifted over a range of 120 percent. Adjustment of this finder causes the selection points (fig. 7) to be shifted with respect to the beginning of the start pulse and when the shift is sufficiently great, errors will be made by the teletypewriter. The range over which the finder may be moved without errors in printing is reduced by any distortion of the incoming signals.

The determination of the limits of the orientation range involves adjusting the range finder to two extreme positions, one at the lower end of the scale and the other at the upper end. In each case observations are made of the typed record and a reading taken when about one error is typed per line of copy (1 error in 72 characters).

Representative orientation ranges on properly adjusted teletypewriters for different degrees of signal distortion are as follows:

	Points
Very little distortion	80
Moderate distortion	60–70
Average distortion	50
Large distortion	Less than 40

Representative orientation range limits with practically perfect signals and a teletypewriter in good condition are 15 and 95, as indicated

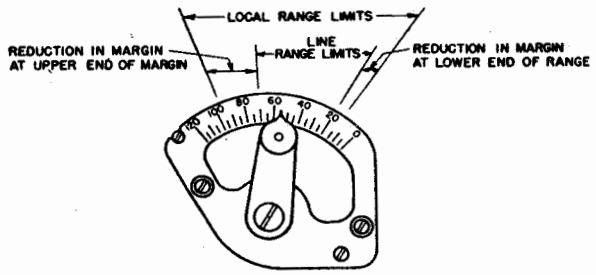


FIGURE 10.—*Teletypewriter orientation range finder.*

in figure 10. In this case, best operating results will be obtained when the finder arm of the receiving teletypewriter is set at the midpoint (55) of this range.

The orientation range may be obtained locally by using keyboard signals, and if the range is not less than about 70 percent (from about 20 to 90 on the scale) the machine may be assumed satisfactory. Special machines for sending practically undistorted teletypewriter characters, such as the Teletype Corp. Test Set DXD–4–DTS, if available, are more satisfactory for use in measuring orientation range limits. The difference between the range determined by local test, and the corresponding range obtained when receiving signals over a line, gives directly the reduction in margin due to signal distortion. This reduction, as illustrated in figure 10, is a direct measure of the total signal distortion. Signal bias affects one range limit more than the other; marking bias reduces the upper limit, spacing bias reduces the lower limit. Characteristic and fortuitous distortions cause reductions at both limits with miscellaneous signals.

Correct teletypewriter motor speed is important in maintaining the operating margins, and a check of speed should always be made before measuring ranges.

Tests may be made of the distortion tolerance of teletypewriters (or teletypewriters in combination with line circuits) by applying predistorted signals. Test Set DXD–4–DTS is arranged to supply miscellaneous teletypewriter signals having either marking or spacing bias adjustable from zero to about 40 percent. Well adjusted teletypewriters should type correctly when the signals from a test set are biased by as much as ±35 percent in a local test circuit. Line distortion in a teletypewriter circuit effectively reduces the tolerance of the receiving machine to predistorted signals. If this tolerance is reduced until maximum predistortion is ±15 percent the circuit corresponds to a telegraph coefficient of 15 and is at the lower limit for high grade service.

II. DISTRIBUTION SYSTEMS AND WIRING METHODS

10. Distribution. Teletypewriter networks may be arranged in many ways to provide for the requirements of each particular system. At advance base installations the most frequently used systems will be the series circuit and the connection of individual stations to a teletypewriter switchboard.

Teletypewriter machines may be connected in a series circuit as illustrated in figure 9. Although this is the simplest installation from the standpoint of equipment and wire requirements it has several disadvantages. Any one machine on the circuit can transmit to all other machines connected in the circuit, but cannot send to an individual machine. No matter how many machines have messages to transmit at one time only one message can be handled. A break in the wire line will cause all machines to be inoperative until the break has been repaired or the defective section has been isolated from the circuit.

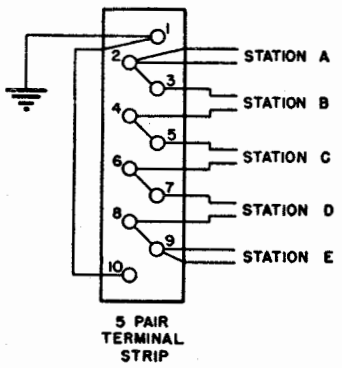


FIGURE 11.—*Test connecting block.*

NOTES

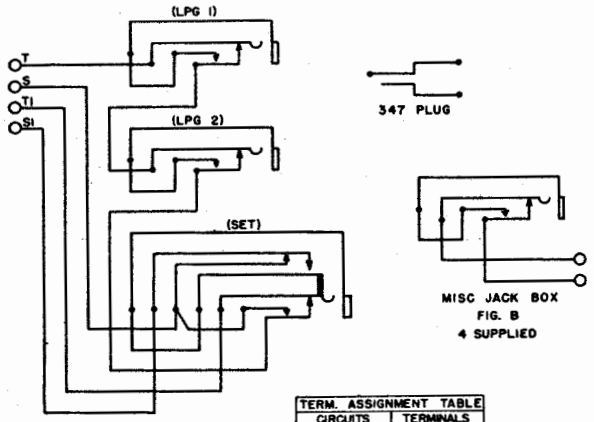
1. CONNECT CIRCUIT GROUND-RETURN. SUPPLY BATTERY AT STATION A AND GROUND AT STATION E OR VICE VERSA.
2. SHORT CIRCUIT AN OPEN LOOP BY PLACING A JUMPER BETWEEN AN ODD NUMBERED TERMINAL AND THE NEXT HIGHER EVEN NUMBERED TERMINAL.
3. TO CLEAR THE CIRCUIT WHEN A LOOP IS GROUNDED, SHORT CIRCUIT AS IN NOTE 2 AND ALSO REMOVE LOOP FROM TERMINALS.
4. IF PART OF LOOP IS LEFT OUT OF SERVICE LINE CURRENT AND RELAY BIAS READJUSTMENT MUST BE MADE.
5. IF TROUBLE LOCATES IN LOOP OR STATION SUPPLYING BATTERY ARRANGE FOR NEXT STATION ON LOOP TO SUPPLY BATTERY.

Teletypewriter machines may be wired individually to a central location. At this location the circuit may be arranged for series operation as illustrated in figure 11. Although this arrangement will normally require a greater amount of wire than an ordinary series loop it provides for efficient trouble testing and immediate isolation of any one machine the circuit of which has trouble. The terminal strip should be located at or near one of the stations on the circuit and this station should be connected to *B*, *C*, or *D* (fig. 11) while stations *A* and *E* should be those having the longest wire circuits.

A more elaborate equipment arrangement using a Western Electric Co. No. 63–C–1, or similar jack box (fig. 12) will provide for both short circuiting the terminals of any one station loop and completely disconnecting it from the circuit by inserting a No. 347 or similar dummy plug in the SET jack associated with the loop suspected of trouble. The LPG 1 and 2 jacks may be used to measure current flow or to patch in an additional station. The MISC. jacks are not used in this application of the equipment. Although these jack boxes are not generally available they may be obtained in limited quantities at some radio matériel pools. When more than four circuits are to be connected, two or more jack boxes can be used by connecting terminal 17 of the first jack box to terminal 1 of the second jack box and using terminals 18 and 19 of the first jack box and terminals 3 and 4 of the second jack box for two wire metallic circuits. The T1 and S1 terminals of any unused jack should be strapped together.

On installations where traffic load is heavy and it is desirable for stations to communicate without printing every message at all stations a BD–100 or similar switchboard should be installed. This system permits the connection of ten teletypewriter loops to each switchboard

unit and three such units can be connected in multiple and served by one operator and one operator's printer. Under normal conditions each loop will have one teletypewriter station connected to it but where wire saving considera-



TERM. ASSIGNMENT TABLE					
CIRCUITS		TERMINALS			
LOOP	MISC.	T	S	TI	SI
1		1	2	3	4
2		6	7	8	9
3		11	12	13	14
4		16	17	18	19
	1	5	10		
	2	15	20		
	3	21	22		
	4	23	24		

NOTES

1. CONNECT GROUND TO TERMINAL 1.
2. STRAP TERMINAL 1 TO 17, 2 TO 6, 7 TO 11, AND 12 TO 16.
3. CONNECT SINGLE CONDUCTOR, GROUND RETURN CIRCUITS TO TERMINALS 4 AND 18. SUPPLY BATTERY AT ONE OF THESE STATIONS.
4. CONNECT TWO WIRE CIRCUITS TO TERMINALS 8 AND 9 AND TERMINALS 13 AND 14.
5. IF PART OF CIRCUIT IS LEFT OUT OF SERVICE LINE CURRENT AND BIAS READJUSTMENTS MUST BE MADE.
6. IF STATION SUPPLYING BATTERY IS OUT OF SERVICE ARRANGE FOR BATTERY SUPPLY BY NEXT STATION IN CIRCUIT LINE UP.

FIGURE 12.—*Wiring a series circuit through a Western Electric 63–C–1 Jack Box for test purposes.*

tions are important two or more stations on the same wire route could be connected in series on one loop terminal. The switchboard is arranged to provide a visual signal to the operator when any station sends a break. The operator may connect his printer to any single loop, monitor on an established connection without interrupting it or connect three or more stations, including himself in a conference circuit. A conference circuit permits any station to type simultaneously to all other stations on the "hook-up." Any one conference circuit is limited to ten stations, but several smaller "hook-ups" may be established at the same time. Aside from the many traffic handling advantages the board has the added feature of confining station or loop trouble to the circuit on which the trouble is located without affecting operation of the other stations in the system.

11. Line Wire Installation. In general all teletypewriter and telegraph lines will be installed in accordance with existing practices covering the installation of telephone lines. Fifteen miles of No. 17 Telex two conductor cable is supplied with the Type C–17 Teletypewriter unit. This cable may be strung aerially or buried in the ground without further protection. If the cable is strung aerially by attachment to trees, poles or structures care should be taken to make fastenings in a location and manner which will protect wire from abrasion against the surface to which it is attached or against trees along the wire route. It is desirable, where possible, to bury Telex cable, thus effectively reducing the hazards of physical damage and the service interruptions caused by electrical storms. Experience has indicated that on teletype installations Telex cable will perform satisfactorily under water, providing tidal action is not present to cause abrasion.

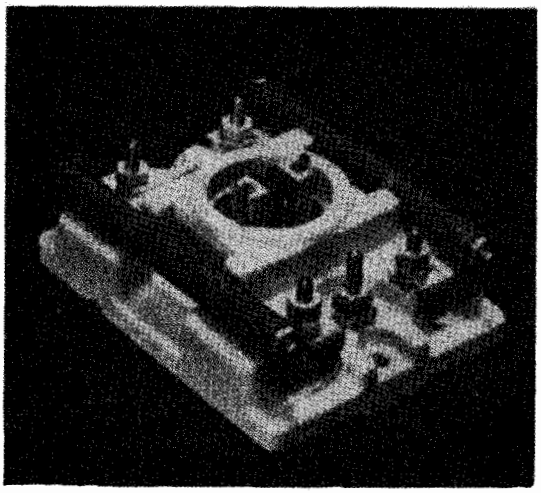


FIGURE 13.—*W. E. Co. 98A station protector.*

12. Protection. Both commercial and Navy experience have indicated that to minimize service interruptions teletypewriter lines must be adequately protected against current and voltage surges created by contact with power wires or lightning discharges. A Western Electric Co. No. 98–A (fig. 13) or similar station protector is satisfactory for this use.

Teletypewriter and telegraph circuits at advanced naval bases shall be considered exposed to these hazards, whenever the conductors serving the stations or equipment are subject to disturbances by lightning or to the possibility of direct or indirect contact with other circuits operating at more than 250 volts. All exposed lines shall be terminated in a station protector at each end of the line before connection to the station or equipment.

When exposed lines are fastened to wood or frame buildings insulated attachments should be used and line wires passing through walls to protectors should be placed in porcelain tubes.

13. Protector Installation. Station protectors should be mounted inside of buildings as close to the point of entry of the line wire as is consistent with the following requirements:

1. Readily accessible for the inspection and maintenance of the protector.
2. Not near inflammable material nor in a room where dust or gas of an explosive nature is present in the atmosphere.
3. Not subject to hazards created by power wires, moving machinery, piled equipment, etc.
4. Suitably protected from excessive moisture and the weather.

If the foregoing requirements cannot be met the protector may be mounted on the outside of the building. Under this condition the protector must be enclosed in a suitable weather-

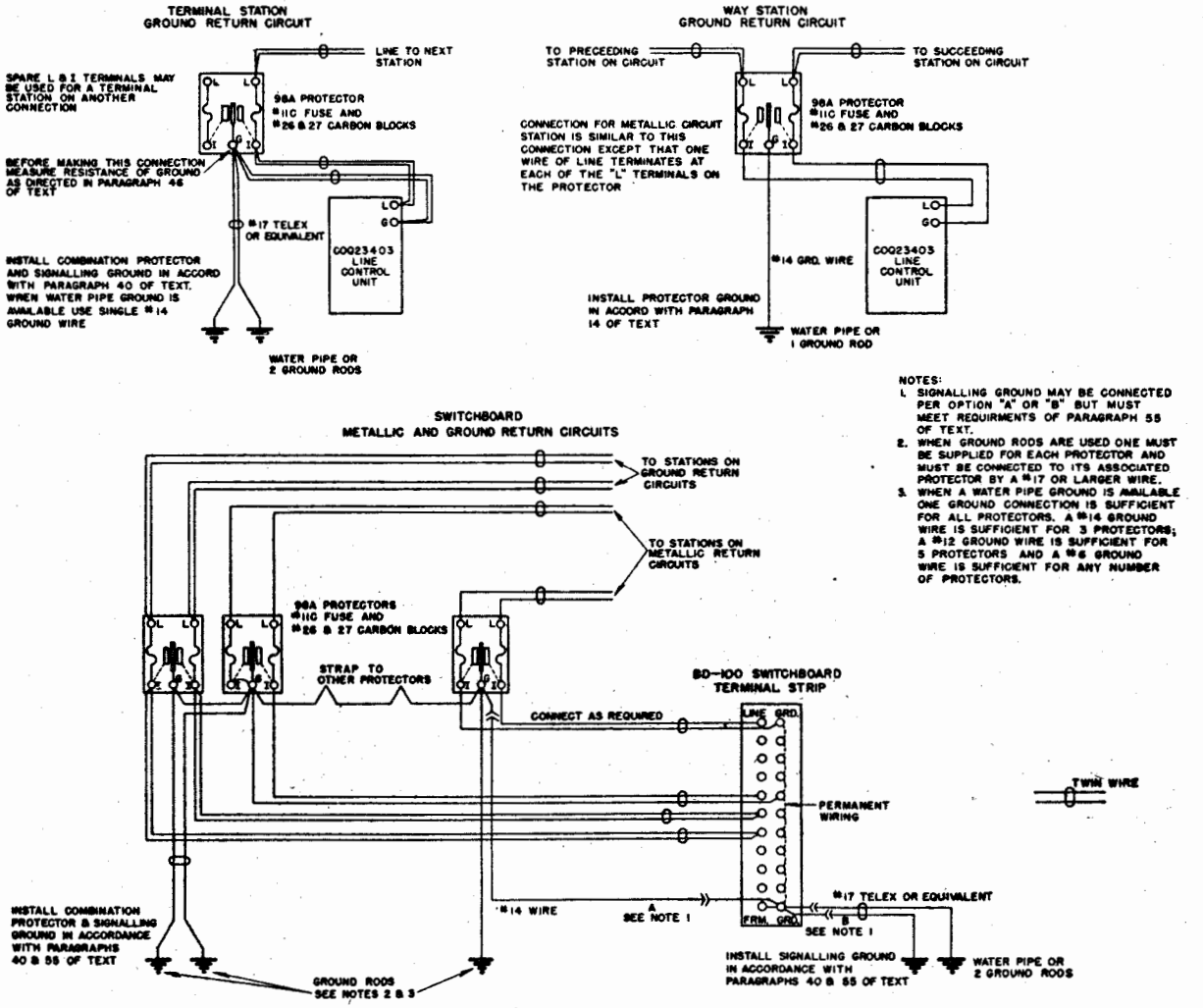


FIGURE 14.—*Installation and connection of protectors.*

proof metal housing such as the Western Electric Co. 93A Protector Mounting.

The fuses should be tagged to indicate the station to which the line wire is connected.

Protectors may be mounted on bulkheads or overhead with the fuses vertical to the deck when on a bulkhead. When a Western Electric Co. No. 58–AP Protector is used an asbestos mat should be placed between the protector and bulkhead. Fuses shall be positioned so that the slotted portion faces the porcelain mounting or asbestos mat.

Figure 14 illustrates the method of connecting station protection in teletypewriter systems.

14. Protector Ground. Each protector must have a connection to ground. When a water system in which at least part of the pipe is buried or a piped deep well is available it will be the best ground connection. Under the conditions to be met at many advance base installations it is not expected that such facilities will be available and driven ground rods must be used.

Ground rods should be driven deeply into the ground, preferably in a damp location. In order to obtain maximum protection for station equipment it is considered advisable to use one ground rod for each protector. No. 14 Telex ground wire or its equivalent should be used to connect each protector to its associated ground rod. At locations where there is a multiple installation of teletypewriter station protectors the ground posts of all protectors shall be strapped together with No. 14 wire.

When more than one ground rod is required all rods shall be separated by at least 1 foot. All ground rods shall be at least 6 feet from rods used for electric light, radio, lightning arrestors, lightning rods, or other equipment.

If the protector ground is to be used for signaling ground of the teletypewriter station or switchboard equipment, it should be installed in accordance with instructions covering the installation of that equipment in other sections of this manual.

15. Utilization of Telephone Circuits. At locations where telephone equipment employing metallic local battery talking circuits has been or will be installed, paralleling the route of proposed teletypewriter lines, it is possible to utilize the same wires for both means of communication. A two-wire metallic circuit arranged for the simultaneous transmission of one telephone and one teletypewriter message is said to be *simplexed.* Two two-wire metallic circuits arranged for the simultaneous transmission of three telephone or two telephone and one teletypewriter messages are said to be *phantomed.*

The Navy type CW–301224 (Army type C–161) Repeating Coil (fig. 15) is commonly used

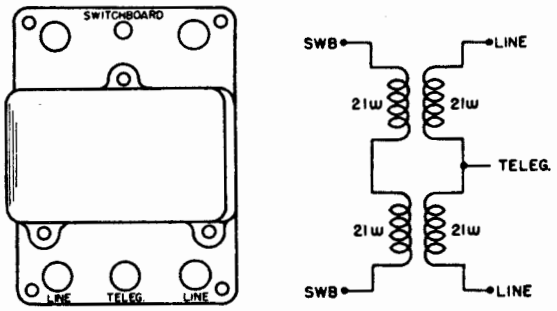


FIGURE 15.—*Type CW–301224 repeating coil.*

to construct simplex and phantom circuits. The coil is essentially a one-to-one ratio transformer with one of the windings center-tapped.

A *simplexed* circuit (fig. 16) is constructed by

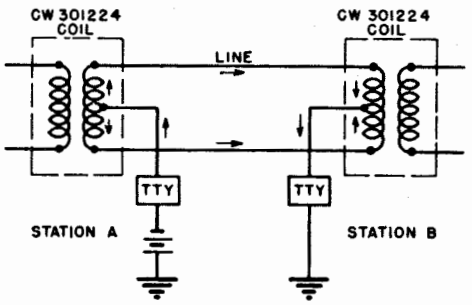


FIGURE 16.—*Simplex circuit.*

connecting the line terminals of two No. CW–301224 repeating coils together with a two-wire metallic circuit. Then two telephone instruments can be connected to the switchboard terminals of the coils to provide a talking circuit and two teletypewriters, wired for ground return operation, can be connected to the TELEG terminals to provide the teletypewriter circuit. Voice current produced at the telephone at Station *A* will pass through the switchboard side of the Station *A* coil and will be induced in the line side of that coil. This current passing through the line side of the coil at Station *B* will be induced into the switchboard side of that coil

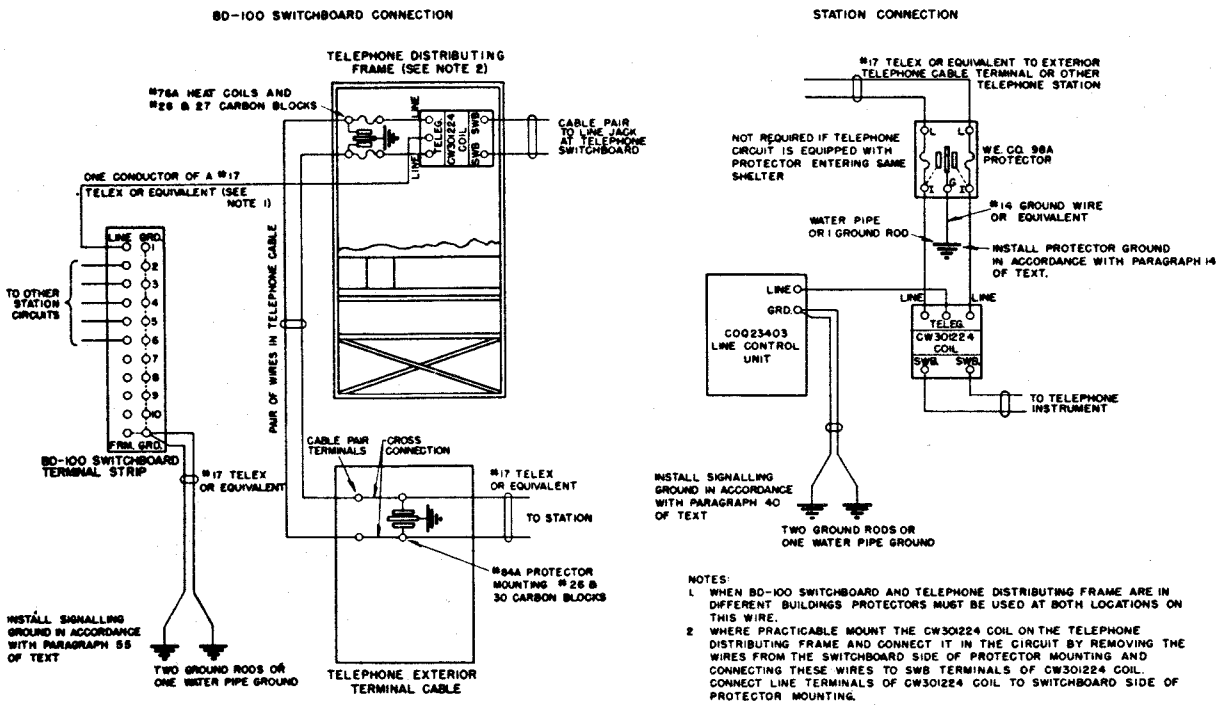


FIGURE 17.—*Installation and connection for simplexed circuits.*

and will operate. the telephone receiver at Station *B*. The arrows represent the current during any instant of a transition of a teletypewriter signal pulse from Station *A*. If the resistances of both sides of the metallic circuit are equal, this current will divide equally between the two halves of the Station *A* line coil. The magnetic fields produced by this current will be equal and opposite in polarity thus cancelling each other. Under this condition no current due to this signal will be induced in the switchboard side of the Station *A* coil and the telephone conversation will not be affected. The same reasoning will show that no interference in the telephone circuit will be produced by the teletypewriter signal at the Station *B* coil.

A teletypewriter circuit can be simplexed with a telephone line either where the terminating telephone and teletypewriter equipments are at the same location or a portion or all of a teletypewriter line may be simplexed to a part of a telephone line where their routes are parallel. Figure 17 illustrates a teletypewriter installation using simplexed lines.

A *phantom* circuit is constructed by connecting four No. CW-301224 repeating coils as illustrated in figure 18. In effect the arrangement is two simplex circuits used together to provide a metallic teletypewriter circuit. The explanation of operation of this circuit is the same as for a simplex circuit, however the application requires a little more care to prevent

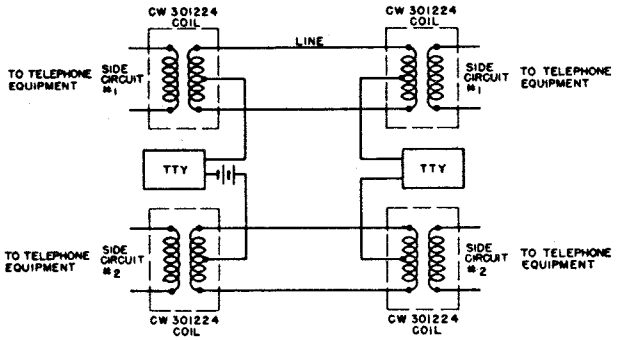


FIGURE 18.—*Phantom circuit.*

crosstalk and interference. In general the coils should be placed at or near the telephone equipments and the two 2-wire lines should follow the same route and have approximately the same electrical characteristics to reduce interference to a minimum. The phantom circuit should only be used in teletypewriter circuit applications when a metallic return circuit is definitelv required.

III. ADVANCE BASE TELETYPEWRITER EQUIPMENT

16. The C–17 Unit. This unit has been designed and assembled to furnish a readily installed complete teletypewriter system. The system will provide a high speed method of communication and when properly utilized will leave the telephone system free for short, important tactical orders and messages that must be handled expeditiously. Where traffic requires a more flexible system than can be obtained with a series network a teletypewriter switchboard is available. The C–17 unit comprises the following items of equipment:

- 6 Model 15 Typebar Page Printer.
- 6 XRT–115 Table.
- 6 REC–29 Rectifier.
- 6 COQ–23403 Line Control Unit.
- 1 BD–100 Switchboard.
- 1 RA–43–B Rectifier.
- 10 CW–301224 Repeating Coil.
- 6 Set spare parts and tools for M–15 Typebar Page Printer.
- 15 Miles of Telex two conductor cable.
- 1 Kit containing ground rods, ground clamps, BX cable, protectors and ground wire.
- 1 Kit containing oil, grease, grease guns, teletype paper, and ribbons.
- 1 Kit containing maintenance tools and test instruments.
- 2 NAVSHIPS 900,031—*Advance Base Teletype Installation and Maintenance Practices.*
- 12 Instruction Manual No. 22 for M–15 Typebar Page Printer containing Teletype Corporation Bulletins Nos. 120, 138, 144, 1044, 1077 and 1094; Specifications Nos. S–5017, S–5288, S–5386 and S–5402; and Wiring Drawings WD–2143A and 2146C.
- 12 War Department Technical Manual TM–11–359.
- 2 War Department Technical Manual TM–11–358.
- 2 War Department Technical Manual TM–11–954.

17. C–17 Station Equipment. Each of the six teletypewriter station units includes a M–15 Type Bar Page Printer arranged for transmitting and receiving messages, a XRT–115 metal table arranged for mounting the teletypewriter and associated rectifier, a REC–29 Rectifier and a COQ–23403 Line Control Unit. A detailed description of installation, maintenance and alignment of circuits is given in other sections of this instruction.

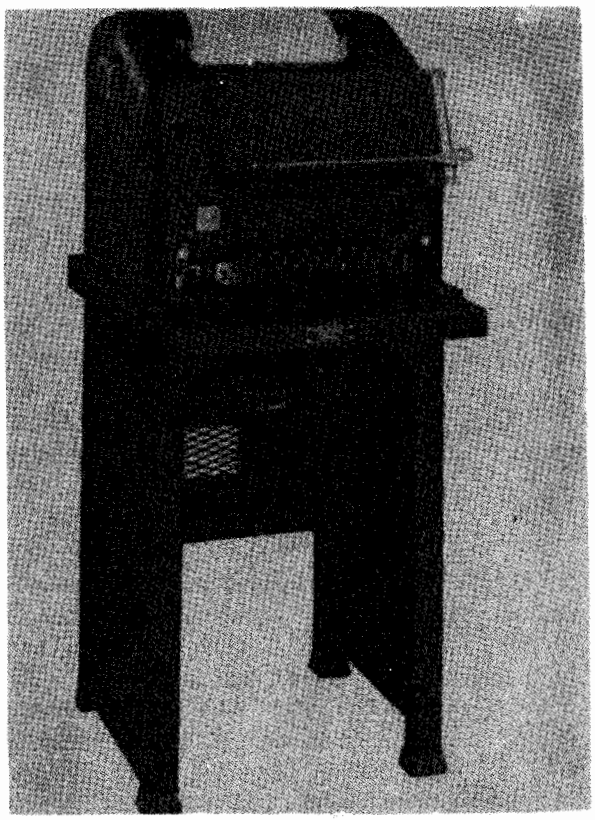
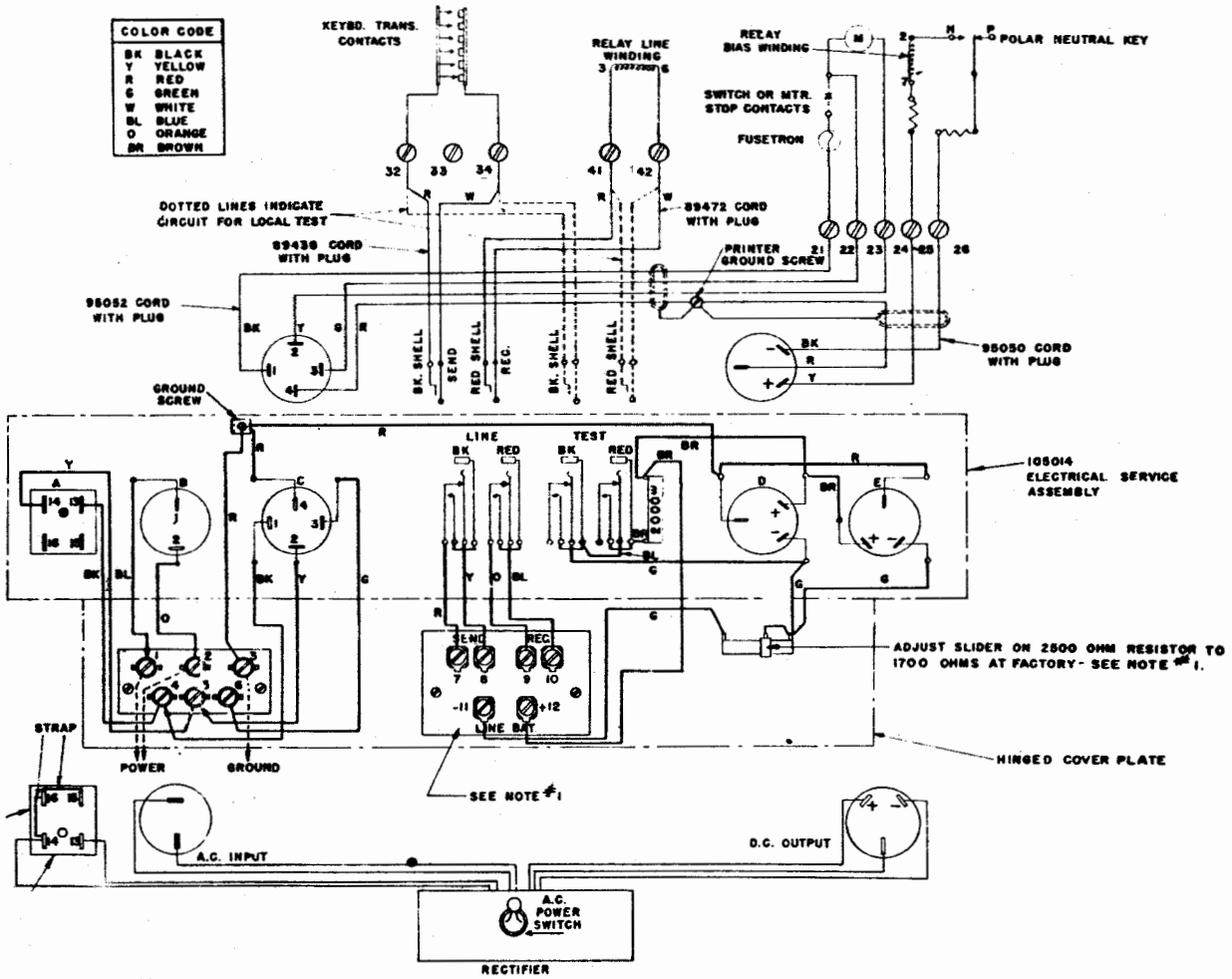


FIGURE 19.—*M–15 Teletypewriter and REC–29 Rectifier mounted on a XRT–115 Table.*

The *M–15 Type Bar Page Printer* (fig. 19) is a teletypewriter sending and receiving mechanism. When the keyboard is operated a copy of the message is made at both the transmitting and distant stations. Several machines may be connected in series on the same circuit and typing at one station will be recorded at all stations.

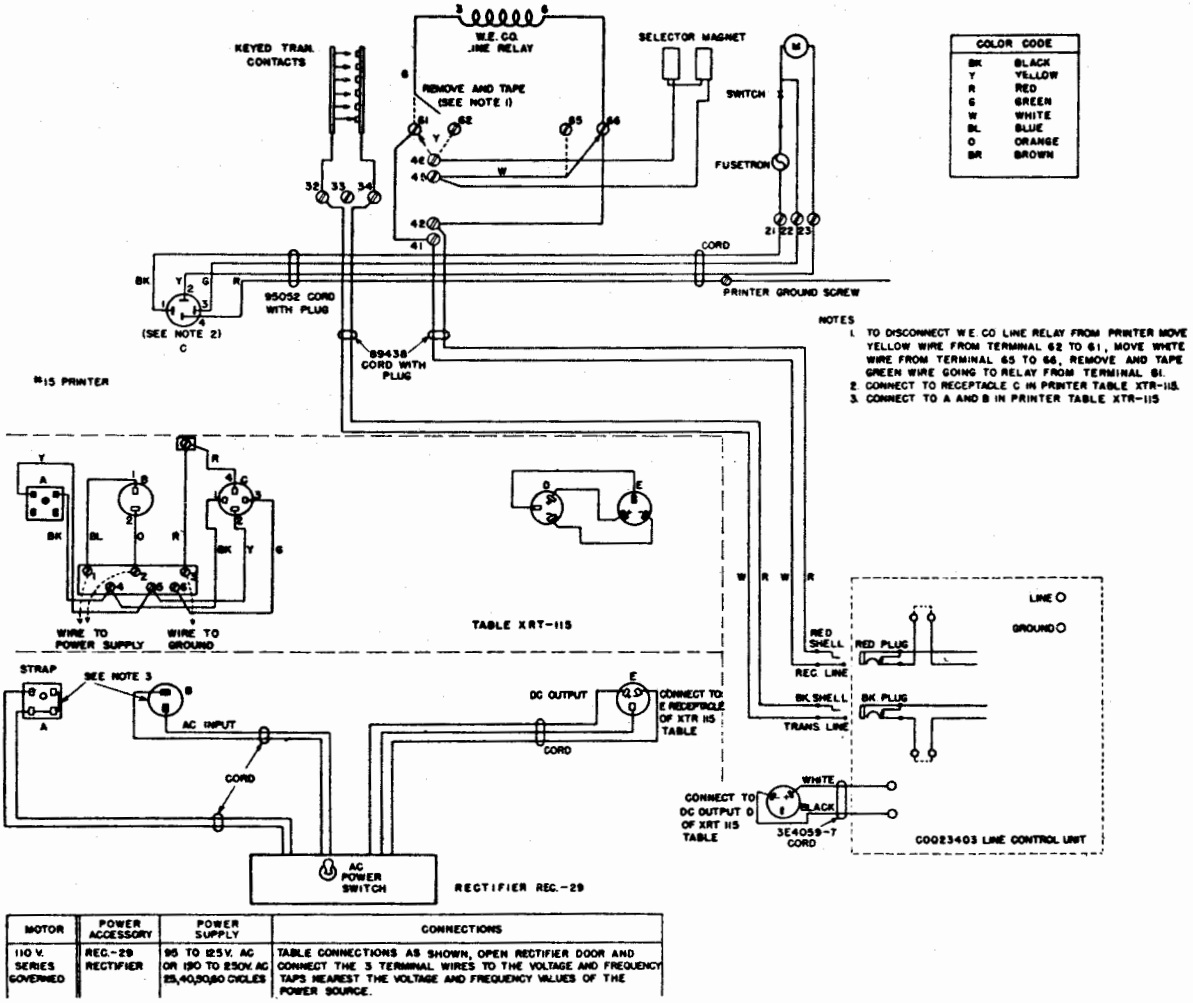
The unit is equipped with a W. E. Co. 255–A Line Relay. This relay is designed for use on high quality lines where line currents remain fixed and bias adjustments are relatively infrequent. These conditions can not be met on advanced base installations and the COQ–23403 Line Control Unit has been furnished to provide the necesary flexibility. Modifications necessary to remove the WE–255–A Relay from the circuit are detailed in the section on installation.

The *XRT–115 Table* is especially designed to support the teletypewriter, rectifier and the associated cords, receptacles and terminals. The teletypewriter is secured to the table top by clips, and a shelf built into the base provides mounting space for the rectifier without interference with the operator's leg room. An electrical service assembly mounted on the inside of the table provides terminals for a-c power supply and receptacles for the a-c and d-c power cords of the rectifier and printer as well as terminals and jacks for the line and test circuit. Figure 20 is the schematic drawing of the table, teletypewriter and rectifier using a WE–255–A Line Relay. Figure 21 shows the same equipment after modification in the field for use with the COQ–23403 Line Control Unit.



Note No. 1.—For single line operation, using rectifier as line battery source:
***Battery station.*—Connect line to terminals Nos. 7 and 10. Strap terminal Nos. 8 to 11 and terminal Nos. 9 to 12. With plugs inserted in line jacks, adjust slider on 2500 resistor to produce 0.060 ampere line current.**
***Nonbattery station.*—Connect line to terminals Nos. 7 and 10. Strap terminal Nos. 8 to 9.**

FIGURE 20 —*Station wiring using W. E. Co. 255–A Relay.*



MOTOR	POWER ACCESSORY	POWER SUPPLY	CONNECTIONS
110 V. SERIES GOVERNED	REC.-29 RECTIFIER	95 TO 125 V. AC OR 190 TO 250 V. AC 25,40,50,60 CYCLES	TABLE CONNECTIONS AS SHOWN, OPEN RECTIFIER DOOR AND CONNECT THE 3 TERMINAL WIRES TO THE VOLTAGE AND FREQUENCY TAPS NEAREST THE VOLTAGE AND FREQUENCY VALUES OF THE POWER SOURCE.

FIGURE 21.—*Connection for No. 15 Printer, Table XRT-115, REC-29, and COQ-23403 Line Control Unit.*

Rectifier REC-29 is designed to provide direct current suitable for signal line and local battery and to provide the proper a-c voltage for the operation of the teletypewriter series governed motor. The unit will operate on a-c power supplies varying from 95–125 and 190–250 volts at 25–60 cycles. It will deliver 110 volts alternating current sufficient for the operation of two series governed printer motors and 200 milliamperes of direct current at 120 volts. The rectifying unit is a selenium stack arranged for full wave operation.

Rectifier REC-10 was supplied at some of the older Navy station installations. The unit is designed to operate on a power supply of 105 to 125 volts at 50 to 60 cycles a. c. An output plug is furnished to provide 200 milliamperes at 120 volts d. c. The rectifying unit is a selenium stack arranged for full wave operation.

Line Control Unit COQ-23403 (figure 22) is a spring adjusted line relay unit arranged for

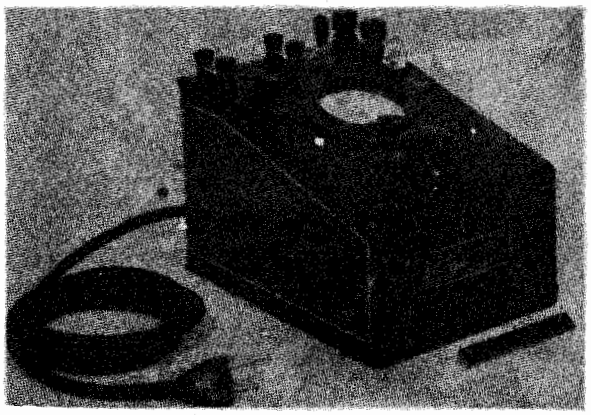


FIGURE 22.—*COQ-23403 (Army BE-77-A) Line Control Unit.*

neutral half-duplex operation. It is used to make the necessary connection between the teletypewriter line circuit and receiving mechanism. Means are provided for measuring and adjusting line current, measuring the voltage of the d-c power source and measuring and adjusting the bias of the signal reproduced by the contacts of the relay. Switch controls are supplied to operate with local or distant line battery supply and to operate the printer with or without the relay in the line circuit. Condensed instructions for use and a schematic wiring diagram are etched on panels attached to the sides of the unit.

18. Switchboard Equipment. Switchboard equipment is supplied with the C–17 unit for use when a series circuit will not handle the traffic load or meet flexibility requirements. The unit is designed to provide switching and signal repeating facilities for ten teletypewriter lines or loops operated on a neutral half-duplex basis. Provision is made for quickly connecting any station to another station or group of stations in the network, for monitoring, and for extending the facilities of the net through the use of additional switchboards. Three switchboards can be multipled to provide facilities for interconnecting thirty lines under the control of one operator. The unit consists of a BD–100 Switchboard and associated RA–43–B Rectifier. An operator's printer and table are obtained by using one of the six station equipments supplied in the C–17 unit. The COQ–23403 Line Control Unit and the REC–29 Rectifier normally required for this station are available for maintenance purposes. The BD–100 Switchboard as it appears when set up for use is illustrated in figure 23.

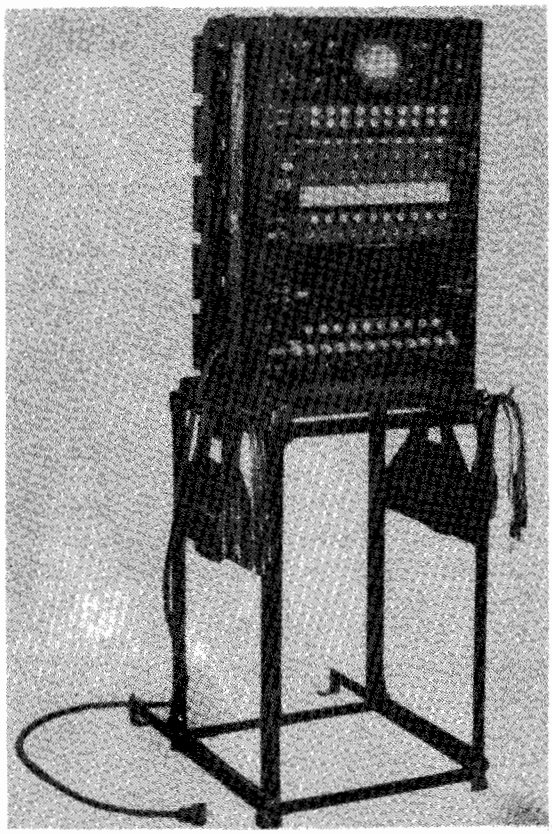


FIGURE 23.—*BD–100 Switchboard mounted on table.*

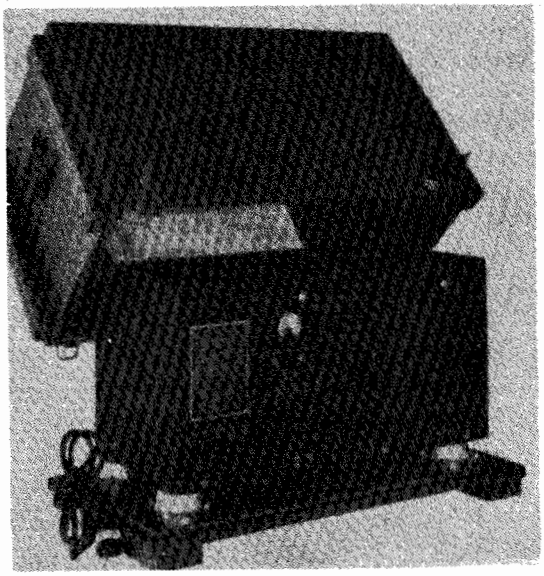


FIGURE 24.—*Rectifier RA–43–B.*

The BD–100 Switchboard is composed of two principal parts, the table and the switchboard itself. The table is an angleiron framework, with handles on two sides, used as a carrying case for the switchboard when the unit is assembled for transportation, and as a supporting stand for the switchboard when the unit is set up for use. The switchboard is of cabinet type protected during transportation by steel covers on the front and rear. Removing the front cover exposes line rheostats, milliammeter, line open and answering keys, signal lamps, line patching jacks, line current measuring keys, bias measuring jacks, line current switches, blown fuse indicators and fuses. Removing the rear cover exposes the ten jack-mounted repeating relay units.

Rectifier RA–43–B (figure 24) furnishes the switchboard with a maximum of 4.5 amperes of

direct current at 115 volts. This output is obtained from an a-c input within the ranges of 80–125, or 200–250 volts at 50 to 65 cycles. In addition the rectifier provides 115 volt a. c., sufficient for the motor of one operator's printer. The rectifying unit is composed of two grid controlled gas filled, vacuum tubes with a voltage regulating circuit capable of regulation within plus or minus five volts at rated inputs and at any load within rated outputs.

19. Other Station Equipment. At locations where a large volume of traffic must be handled other types of teletype gear have proven useful. The equipment described in this paragraph is designed to permit operation of a system on a semi-automatic basis in which a perforated tape is used to transmit signals to the line at the maximum speed of the equipment.

Model 15 Perforator Transmitter is arranged for use on the M–15 Teletypewriter in place of the standard direct keyboard. In addition to normal keyboard functions a tape punched in accordance with the five (5) unit code may be prepared. An end of line indicator or character counter is provided to indicate the need for carriage return key operation when the tape punching device is used without producing a monitoring copy. The Model 15 Perforator Transmitter and associated Model 15 Typebar Page Printer can be used to provide keyboard transmission directly to the line with either or both a monitoring copy and a perforated tape produced. It also can be used to perforate a tape without keyboard transmission directly to the line and with the receiving unit producing a copy of a message from another source.

The Transmitter Distributor is a motor driven device for transmitting five (5) unit code to a line under control of a previously punched tape. The machine provides a maximum line usage when a large volume of traffic must be handled. Interruptions to transmission which occur during manual operation directly to the line can be eliminated by preparation of the tape well in advance of transmission.

The Model 19 Teletypewriter is composed of a Model 15 Perforator Transmitter, a Model 15 Typebar Printer, a Transmitter Distributor, and the associated table and rectifier. This is the device generally used at stations where a large volume of traffic is to be handled by a tape system.

The Five Unit Tape Perforator is used to punch a five (5) unit code tape for subsequent use in a transmitter distributor. No typed record of the message punched is made by this perforator.

The Model 14 Non-typing Reperforator accepts signal pulses from a line and perforates the message on a tape for retransmission through a transmitter distributor. No typed record of the message is made by this reperforator.

The Model 14 Typing Reperforator accepts signal pulses from a line and perforates the message on a tape for retransmission through a transmitter distributor. The message is also typed along the tape. Chadless type tape must be used with this machine.

20. Army Tactical Equipment. The Signal Corps has procured tactical equipment to provide teletypewriter service similar to that available with the C–17 unit. In most cases this equipment is contained in permanent trunk type chests suitable for tactical applications requiring rapid handling with ease and safety of transportation. The various units of this equipment are being used at some naval advance bases and are therefore briefly described in this paragraph.

Army Telegraph Printer TG–7–B is a modified Model 15 Typebar Page Printer packaged in two chests. The WE–255–A Line Relay and associated mountings are not supplied. The Printer Motor is arranged for a-c or d-c operation.

Rectifier RA–87 is used with the Army type *TG–7–B* printer. The rectifier is designed to operate on an a-c power supply of 90 to 125

and 190 to 250 volts at 50 to 60 cycles. Two output receptacles are furnished to supply up to 400 milliamperes d. c. at 115 volts and three output receptacles are furnished to supply up to 4.35 amperes a. c. at 115 volts. The rectifying unit is a selenium stack arranged for full wave operation.

Power Unit PE–77–A is an engine driven generator designed to supply power for the teletypewriter unit TG–7–B when no a-c power is available. A 250 watt, 115 volt d-c generator is directly coupled to a single cylinder four cycle gasoline engine. The teletypewriter motor for use with this power supply must be designed for d-c operation.

Power Unit PE–75 is an engine driven alternator set used to supply 115 volt a-c power to operate the RA–43–B rectifier associated with BD–100 switchboard installations when this power is not available from some other source. The alternator is capable of producing 2500 watts of power. Securely mounted in a skid type base, it consists of a self-excited, self regulating a-c generator, pulley driven by a single cylinder, air cooled gasoline engine.

Army Telegraph Printer Set EE–97–A is a unit designed to furnish a complete sending and receiving teletypewriter station including a gasoline-driven power supply for use at locations where commercial a-c power might not be available. The unit is packaged in four permanent trunk type chests, two of which serve as printer table and operator's chair when the station is set up. The equipment supplied is:

1 TG–7–B Telegraph Printer (Modified Model 15 Typebar Page Printer).
1 BE–77–A Line Unit (same as COQ–23403 Line Control Unit).
1 RA–87 Rectifier Unit.
1 PE–77–A Power Unit.
2 GP–29 Ground Rods.
Quantity of paper, spare fuses, extension cords, and typewriter ribbons.

Army Telegraph Printer Set EE–98–A is similar to the EE–97 unit with the PE–77–A Power Unit omitted.

Army Telegraph Central Office Set TC–3 is a unit designed to provide complete teletypewriter switchboard service at a field location. The switchboard and gasoline-driven generator form their own shipping containers and the remaining equipment is packaged in five trunk type chests. The equipment supplied is as follows:

1 TG–7–B Telegraph Printer.
1 BD–100 Telegraph Switchboard.
1 RA–43–B Rectifier.
1 PE–75 Power Unit.
2 GP–29 Ground Rods.
Quantity of paper, ribbons, spare fuses and lamps, extension cords, patching cords and tools.

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IV. EQUIPMENT OPERATION

21. The Teletypewriter. The machine supplied in the C–17 unit is an M–15 Teletypewriter equipped for neutral or polar operation with a WE–255–A Line Relay. A simplified schematic drawing of the electrical circuit of this machine is illustrated in figure 25. Wiring

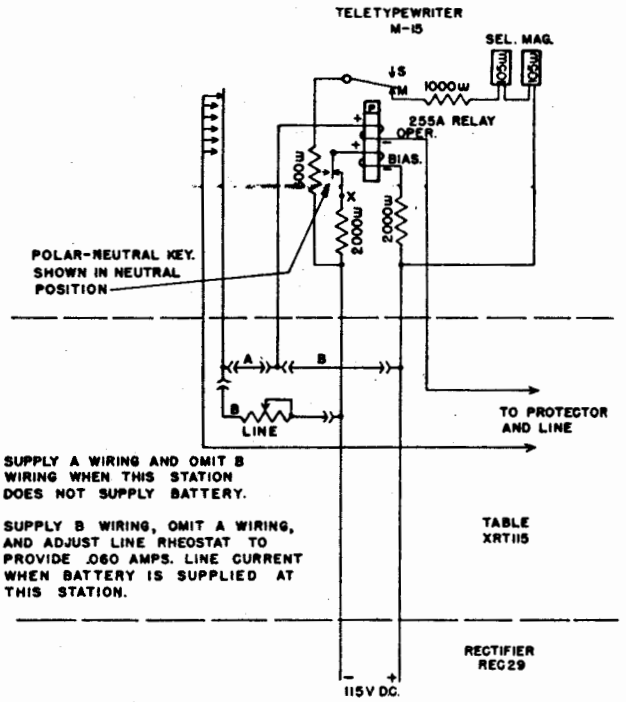


FIGURE 25.—*Simplified schematic circuit for M–15 Teletypewriter equipped with W. E. Co. 255A Relay.*

of the machine can be arranged either to supply battery to the line in series with a line rheostat or to have battery supplied by a distant station. The WE–255–A Polar Relay is permanently wired through two 2000 ohm resistors to provide a fixed biasing current in the biasing winding. Reference to figure 4 indicates the effect on signal bias at the selector magnet of this circuit if the line current varies in the operating winding of the WE–255–A Relay. Line current variation due to varying leakage to ground and to wide daily temperature variations on the lines will be the usual operating condition at advance base installations. With the above station arrangement no practical method of correcting circuit resistance for varying current flow or of compensating for signal bias is provided. It is intended that the COQ–23403 Line Control Unit described in the next paragraph be used at station installations. If the Line Control Unit is not available compensation for this signal bias can be obtained by insertion of a variable resistance at the point *X* (fig. 25) of the WE–255–A relay bias circuit.

22. The COQ–23403 Line Control Unit (Fig. 22). This unit is designed to provide a line relay which is readily adjustable for variations in line current and signal bias. Most of the components of the unit, including the single current Western Union 41–C Relay, are mounted within a sheet steel housing. Binding posts for line connection, binding posts and jacks for connection of teletypewriters, line fuse and blown fuse indicator, line rheostat, meter and meter key are mounted on the top cover of the line unit. A door in the front of the housing gives access to the line relay and a switch panel upon which relay and line current switches are located.

A schematic circuit of the Line Control Unit is illustrated in figure 26. The line current switch provides an easy method of controlling the location of the battery supply in any network and the relay switch provides a means of connecting the selector magnet directly in the line for emergency operation if a trouble develops in the relay. With complete failure of the local d-c supply, emergency operation may be accomplished by operating keys to distant current supply and relay out of circuit, providing 60 milliamperes of line current can be supplied by the distant station. The milliammeter is normally in the line and provides for rapid checking and adjustment of the line current.

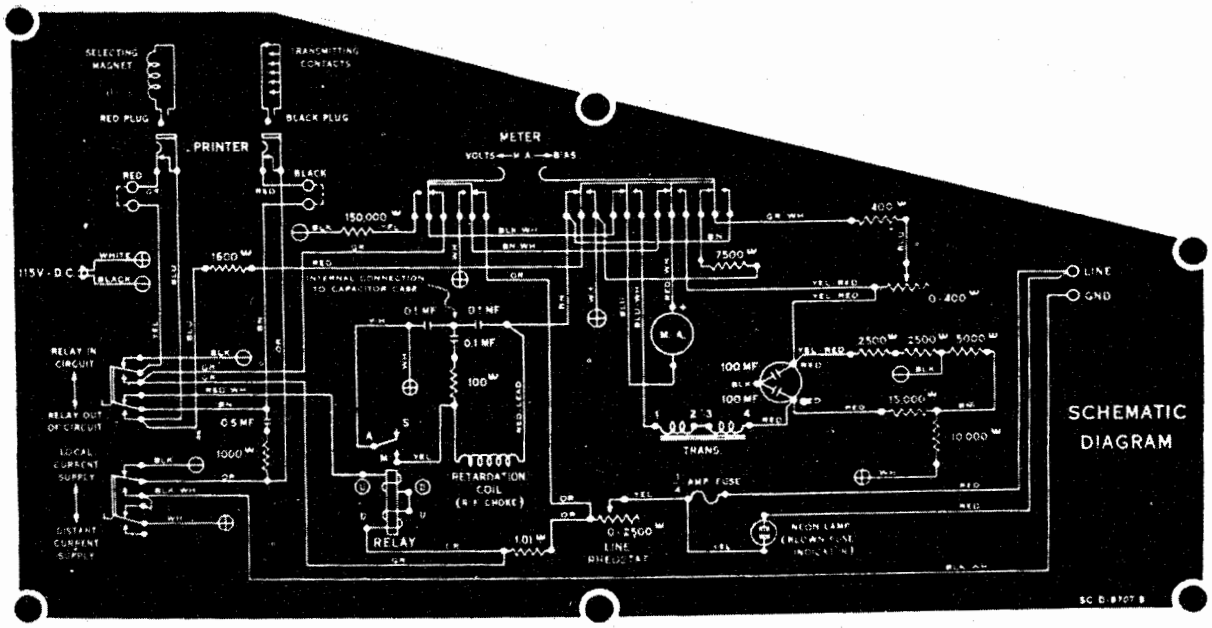


FIGURE 26.—*Left side panel of COQ–23403 Line Control Unit.*

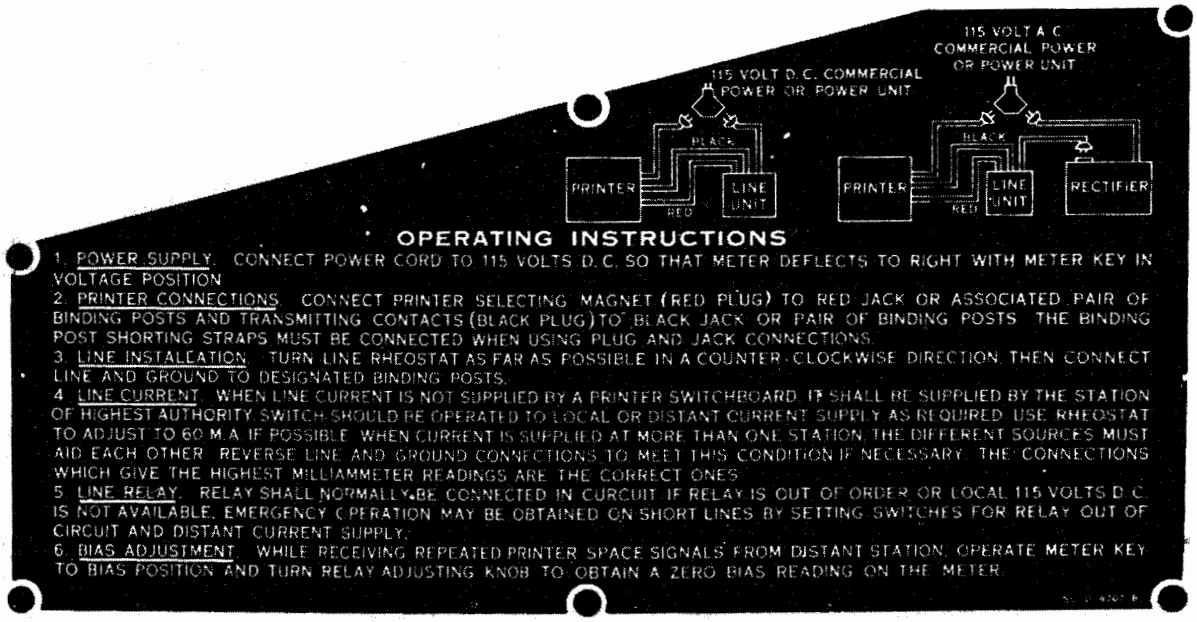


FIGURE 27.—*Right side of panel of COQ–23403 Line Control Unit.*

A METER key is provided to connect the milliammeter and a bias measuring circuit across the contacts of the WU–41–C Relay. With repeated spacing signals being transmitted on the line and the METER key in the BIAS position an indication is given of the bias distortion present in the signal being reproduced by the relay contacts. When an unbiased signal is being produced the meter needle will vibrate at the zero point and spacing or marking bias will be indicated by a meter reading to the left or right respectively. Adjustment of the biasing spring on the WU–41–C Relay can be made to compensate for the bias of the signal. Operation of the METER key to the VOLTS position will give a voltage reading of the d-c supply.

Condensed operating instructions (figure 27) are etched on a panel attached to the right side of the unit.

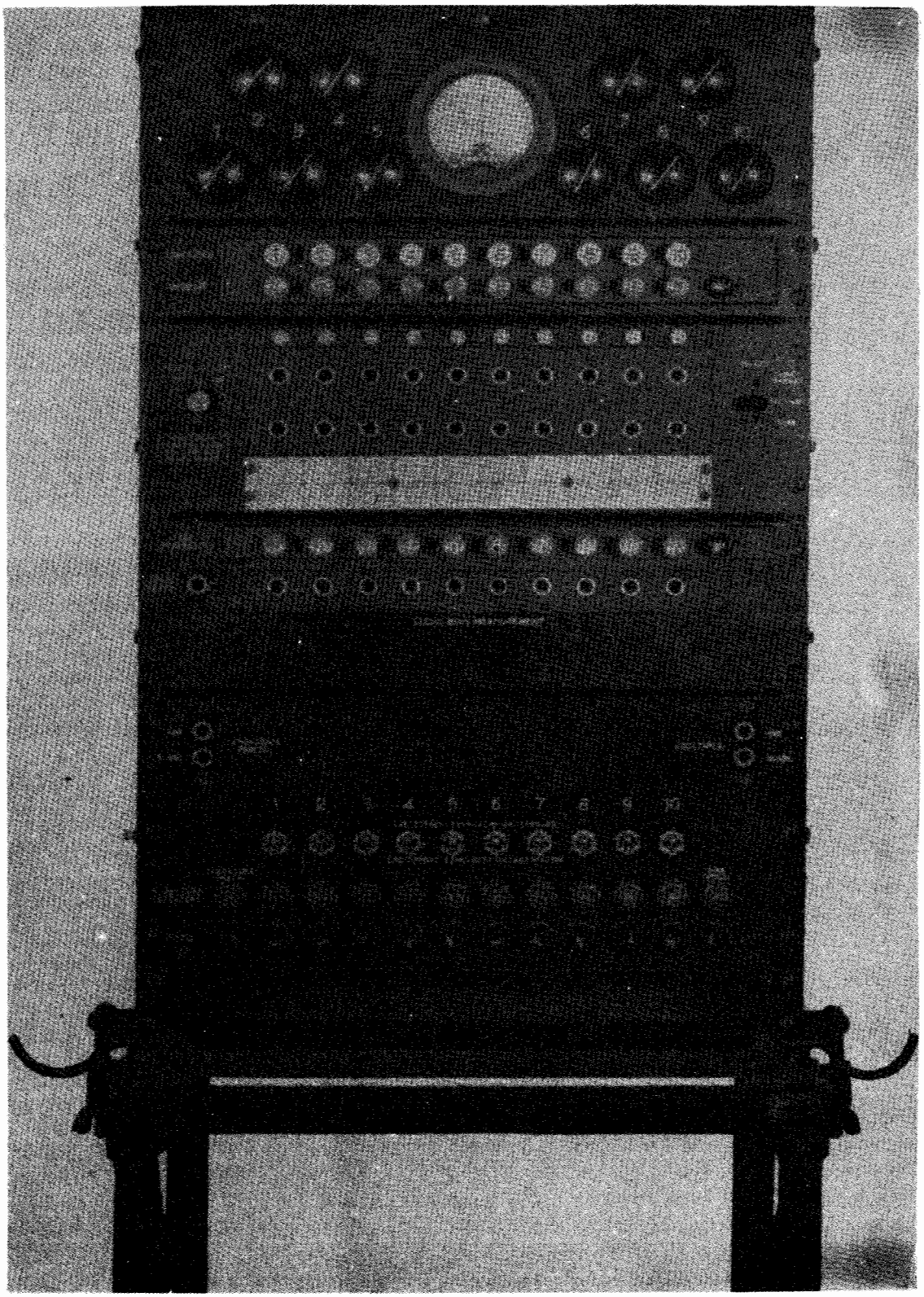


FIGURE 28.—*Face view of BD–100 Switchboard.*

23. The BD–100 Switchboard. The face of the switchboard is composed of panels on which are mounted the patching and control equipment. The items of equipment described in this paragraph may be identified on figure 28.

Each of the ten lines served by one switchboard has the following equipment mounted on the face of the switchboard:

(1) A *line rheostat* to control current flow in the line. With its knob rotated fully to the left (counter-clockwise) all of the resistance of the rheostat is cut into the line.

(2) A LINE OPEN key to extinguish the supervisory lamp when station equipment is not connected to the line or when a line in service becomes open in trouble. This is a locking key and can only be released by depressing the ANSWER key associated with the same line. The LINE OPEN key will not lock in its operated position when the associated ANSWER key is operated.

(3) An ANSWER key to connect the operator's teletypewriter to the line. This is a locking key and can only be released by depressing another ANSWER key or the ANSWER REL key.

(4) A *line supervisory lamp* to permit the station to signal the switchboard operator. This lamp will also indicate an open line and under this condition may be extinguished by depressing the LINE OPEN key.

(5) An UPPER AND LOWER PATCHING JACK to permit patching two or more stations together on a call or conference connection. When a connection is established by an operator the patching cord should be inserted first in the LOWER PATCHING JACK of the line to be called and then after a two or three second delay the other end of the patching cord should be inserted into the UPPER PATCHING JACK of the calling line. If a conference circuit is to be set up each of the called machines shall be patched successively in the same manner. This sequence is necessary to start the motor of the called machine. The LOWER PATCHING JACK may be patched to the BIAS METER JACK for measurement of the bias of the signal reproduced by the contacts of the Line Relay.

(6) A LINE CURRENT key to connect the milliammeter into the line for measurement of line current. This is a locking key and must be released by depressing another LINE CURRENT key or the LINE CURRENT REL key.

(7) A LOCAL BIAS MEASUREMENT jack to connect to the BIAS METER jack for measurement of the bias of the signal reproduced by the contacts of the Local Relay.

(8) A BATTERY SUPPLY switch to control the connection of line battery or ground to the line at the switchboard.

(9) A FUSE and BLOWN FUSE INDICATOR to protect the line equipment against excessive current flow. ***Caution: This is a one-quarter ampere fuse and will not protect the milliammeter.***

The following equipment on the face of the switchboard is common to all of the lines served:

(1) A MILLIAMMETER and a METER key to provide for measurement of battery supply voltage, line current or signal bias.

(2) A NIGHT ALARM key to provide, if desired, an audible signal when any *line supervisory lamp* is lighted.

(3) A BIAS METER jack to provide for connection of the *line* or *local* relay of any line to the bias measuring circuit.

(4) RED and BLACK OPERATOR'S PRINTER and MULTIPLE jacks to connect the operator's teletypewriter to the switchboard and to extend its circuits to the next switchboard in line when two or more boards are multipled.

(5) FUSES and BLOWN FUSE INDICATORS for the operator's printer and the bias circuit.

The terminals (fig. 29) for the connection of line wires, battery supply and ground are located on a panel behind a metal door on the left side of the switchboard.

Ten North Electric Co. BK–27–A Relay Units equipped with banana plugs are mounted in jacks at the rear of the board (fig. 30). Each unit contains a *line* and *local* relay to supply one of the ten lines served by the switchboard. The biasing springs of all relays are equipped with adjusting knobs accessible from the back of the switchboard. The jack mountings are on a hinged gate (fig. 29) which can be swung aside to provide access to the other equipment and wiring of the switchboard.

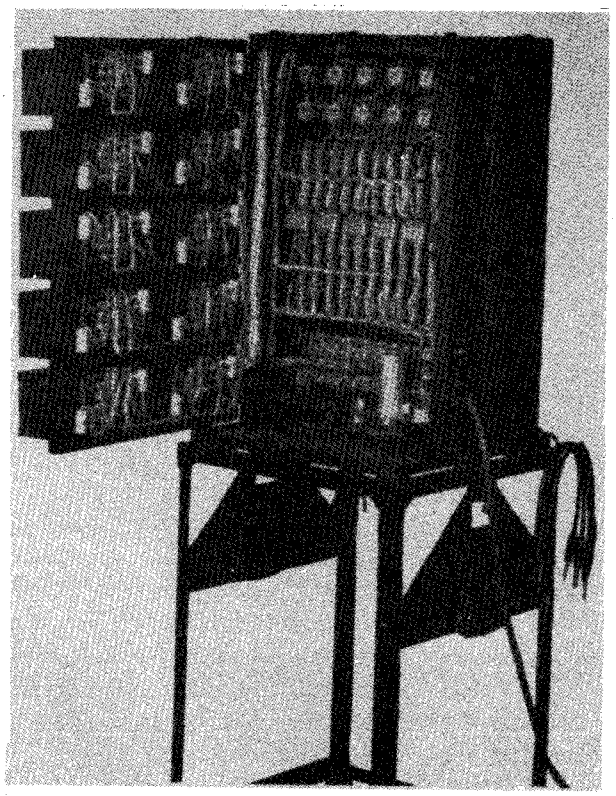


FIGURE 29.—*Interior and connecting panel of BD–100 Switchboard.*

24. The BD–100 Switchboard Circuit. Each of the line circuits in the switchboard is arranged to repeat teletypewriter signals into the circuits to which it is connected by patching cords. Figure 31 represents the connection of three stations to three of the line circuits of a switchboard. Battery for station 1 is supplied by the switchboard, for station 2 by the station and for station 3 by both the station and switchboard.

Station 1 desiring to originate a call will operate his BREAK key thus starting his teletypewriter motor and releasing the No. 1 line relay at the switchboard. The No. 1 *local* relay will remain operated under control of the make-before-break contact on the No. 1 *line* relay but the No. 1 *signal* relay will release and light the No. 1 *line supervisory lamp*. When station 1 releases his BREAK key the No. 1 *line* relay will reoperate.

The operator will answer the call by depressing the No. 1 ANSWER key operating the No. 1 *signal* relay and extinguishing the No. 1 *line supervisory lamp*. This key also connects battery through the windings of the No. 1 *local* relay and the OPR SEL MAG in parallel and both in series with the make contact of the No. 1 *line* relay, the OPR TR contacts and ground. When the operator transmits signals the No. 1 *local* relay and the OPR SEL MAG will operate and release in parallel under control of the OPR TR contacts, and the line relay at station 1 will operate and release under control of the No. 1 *local* relay make contact. The No. 1 *line* relay will remain operated under control of the make-before-break contact of the No. 1 *local* relay. When station 1 transmits signals to the operator its line relay and the No. 1 *line* relay will operate and release under control of the station 1 transmitting contacts and the OPR SEL MAG will operate and release under control of the make contact on the No. 1 *line* relay. The No. 1 *local* relay will remain operated under control of the make-before-break contact on the No. 1 *line* relay.

Assume that station 1 has asked the operator for a connection to station 2. The operator will

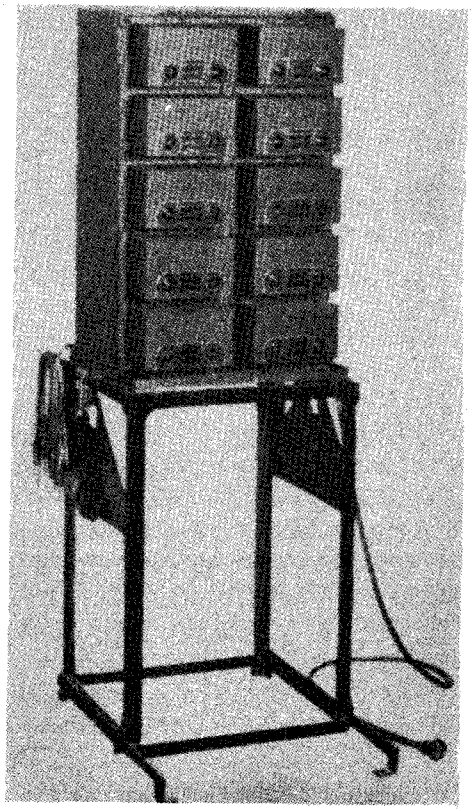


FIGURE 30.—*Line and local relays on the BD–100 Switchboard.*

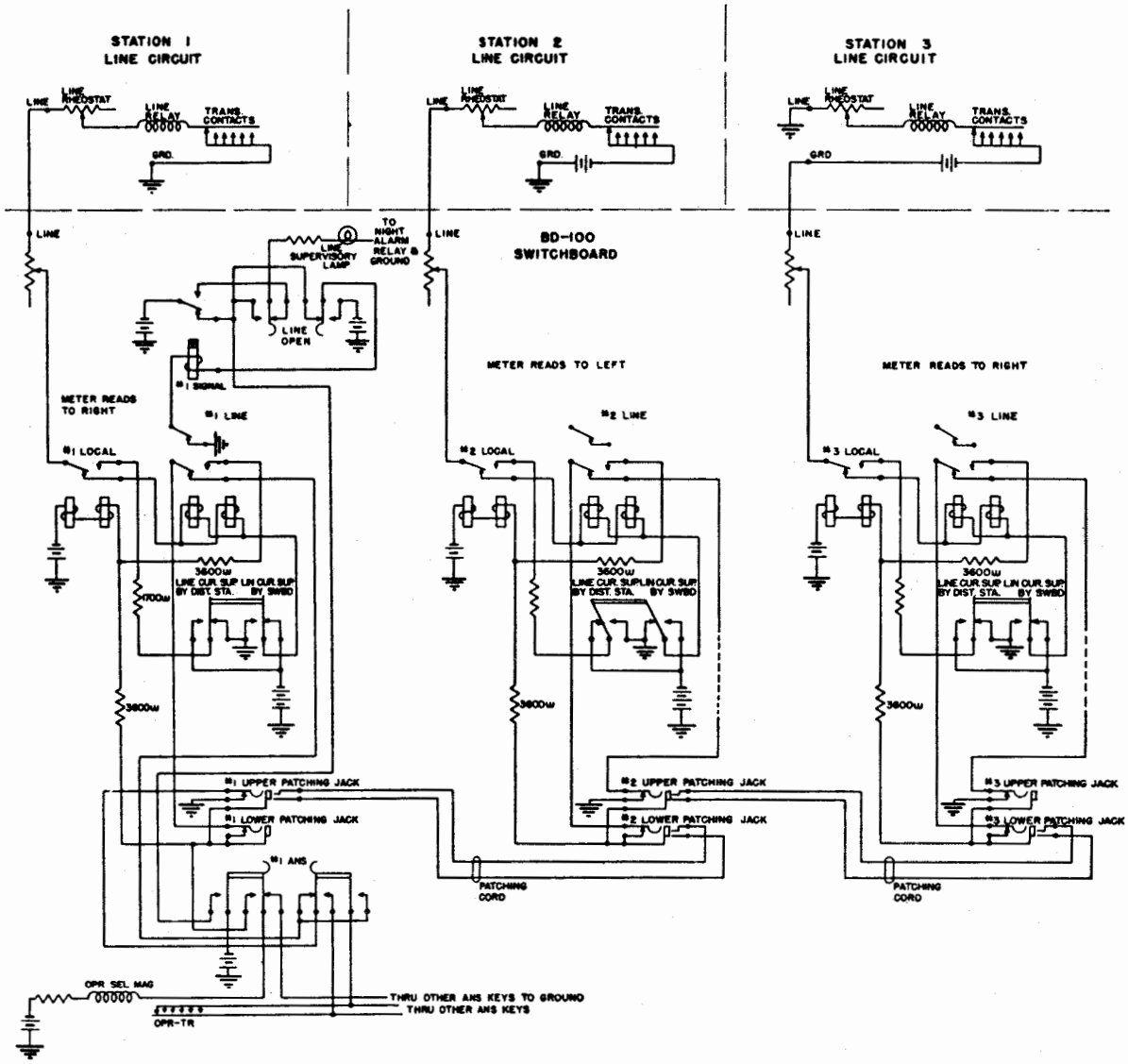
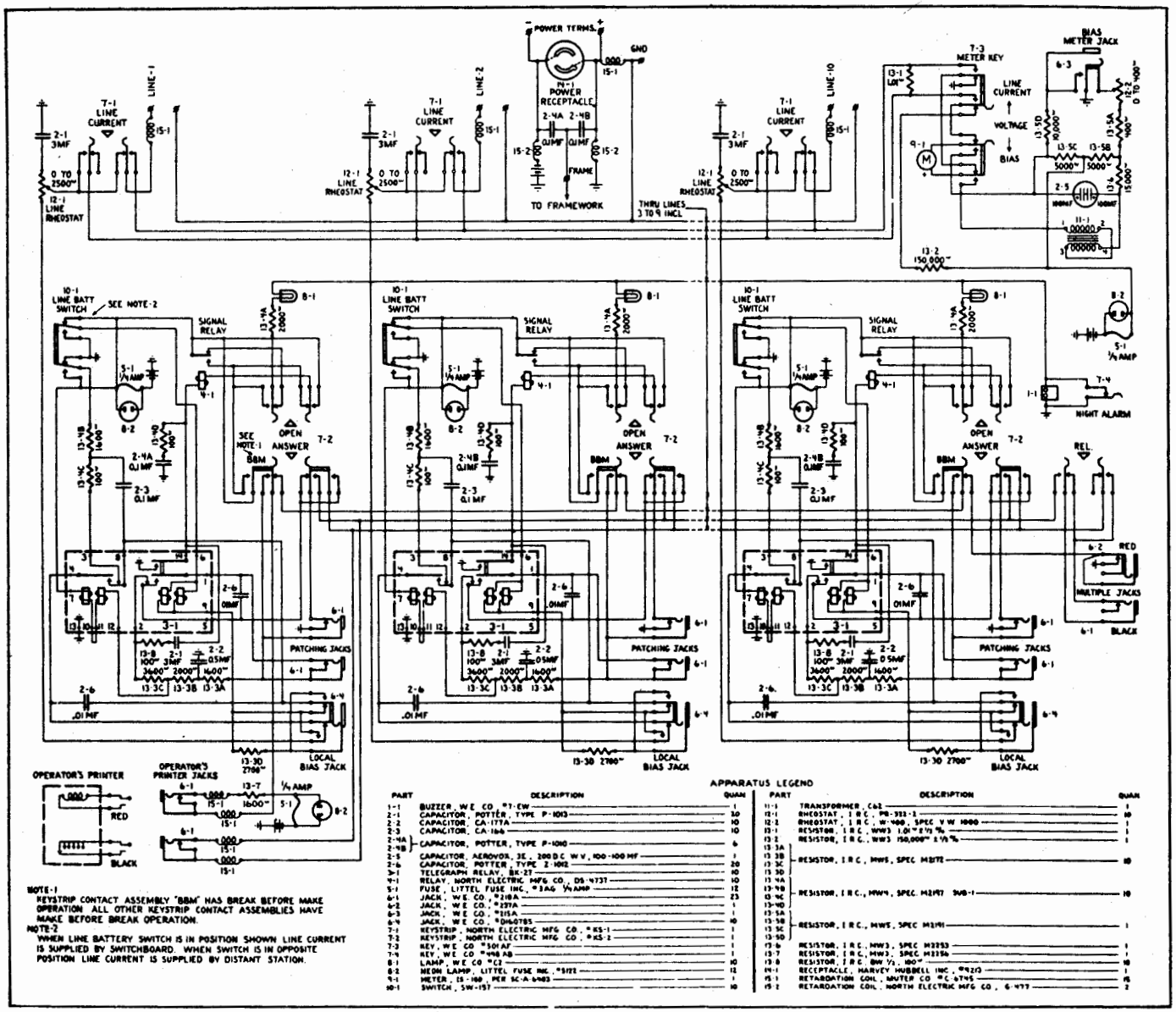


FIGURE 31.—*Simplified schematic of BD-100 Switchboard.*

plug one end of a patching cord into the No. 2 LOWER PATCHING JACK, wait three seconds and plug the other end of the cord into the No. 1 UPPER PATCHING JACK. The three second *break* necessary to start the teletypewriter motor at station 2 is supplied by the release of No. 2 *local* relay when the patching cord is plugged into the No. 2 LOWER PATCHING JACK. The No. 2 *line* relay is held operated under control of the make-before-break contact of the No. 2 *local* relay and when the patching cord is plugged into the No. 1 UPPER PATCHING JACK the No. 2 *local* relay will reoperate closing the line to station 2.

With station 1, station 2, and the operator all connected, battery at No. 1 *local* relay, No. 2 *local* relay and the OPR SEL MAG are all in parallel and this combination is in series with the make contact of No. 1 *line* relay, the OPR TR contacts, the tip of the patching cord, the make contact of No. 2 *line* relay and ground at the No. 2 UPPER PATCHING JACK. When the operator transmits, No. 1 *local* relay, No. 2 *local* relay and the OPR SEL MAG will operate and release under control of the OPR TR contacts and the station 1 and 2 line relays will operate and release under control of the No. 1 *local* and No. 2 *local* relays thus producing



PART	DESCRIPTION	QUAN
1-1	BUZZER, W E CO "7-EW	1
2-1	CAPACITOR, POTTER, TYPE P-1013	10
2-2	CAPACITOR, CA-177A	10
2-3	CAPACITOR, CA-166	10
2-4A, 2-4B	CAPACITOR, POTTER, TYPE P-1010	6
2-5	CAPACITOR, AEROVOX, JE, 300 D.C. W.V., 100-100 MF	1
2-6	CAPACITOR, POTTER, TYPE P-1012	20
3-1	TELEGRAPH RELAY, BK-27	10
4-1	RELAY, NORTH ELECTRIC MFG CO., DS-4737	10
5-1	FUSE, LITTEL FUSE INC., "3AG ¼ AMP	12
6-1	JACK, W E CO, "210A	23
6-2	JACK, W E CO, "237A	1
6-3	JACK, W E CO, "115A	1
6-4	JACK, W E CO, "D46785	10
7-1	KEYSTRIP, NORTH ELECTRIC MFG CO., "KS-1	1
7-2	KEYSTRIP, NORTH ELECTRIC MFG CO., "KS-2	1
7-3	KEY, W E CO "501AF	1
7-4	KEY, W E CO "498AB	1
8-1	LAMP, W E CO "12	10
8-2	NEON LAMP, LITTEL FUSE INC., "3122	12
9-1	METER, 15-160, PER SC-A 6903	1
10-1	SWITCH, SW-157	10

PART	DESCRIPTION	QUAN
11-1	TRANSFORMER, C62	1
12-1	RHEOSTAT, I R C, PR-323-1	10
12-2	RHEOSTAT, I R C, W-400, SPEC V W 1000	1
13-1	RESISTOR, I R C, WW3 1.04 "E"½ %	1
13-2	RESISTOR, I R C, WW3 150,000" 1½ %	1
13-3A		
13-3B	RESISTOR, I R C, MW5, SPEC M3172	10
13-4A		
13-4B		
13-4C	RESISTOR, I R C, MW4, SPEC M2197 SUB-1	10
13-4D		
13-5A		
13-5B	RESISTOR, I R C, MW5, SPEC M3191	1
13-5C		
13-5D		
13-6	RESISTOR, I R C, MW3, SPEC M3253	1
13-7	RESISTOR, I R C, MW3, SPEC M3256	1
13-8	RESISTOR, I R C, 8W ½, 100"	10
14-1	RECEPTACLE, HARVEY HUBBELL INC., "9210	1
15-1	RETARDATION COIL, SAUTER CO "C 6745	15
15-2	RETARDATION COIL, NORTH ELECTRIC MFG CO., 6-477	2

FIGURE 32.—*Switchboard BD-100, complete schematic diagram.*

copies of the message at all stations. Under this condition the No. 1 *line* and No. 2 *line* relays will remain operated under control of the make before break contacts on the No. 1 *local* and No. 2 *local* relays respectively.

Where station 1 transmits, its transmitting contacts will control the station 1 line relay and *No. 1 line* relay. The make contact of the *No. 1 line* relay in turn controls the operation and release of the *No. 2 local* relay and the OPR SEL MAG. The make contact of the *No. 2 local* relay controls the operation and release of the station 2 line relay and thus copy will be reproduced at all three stations. Under this condition the *No. 1 local* and the *No. 2 line* relays remain operated under control of the make before break contacts of the *No. 1 line* and the *No. 2 local* relays, respectively. A similar description will apply when station 2 is transmitting.

If station 1 had asked for a conference connection with station 2 and 3 the operator would have connected station 2 as just described and then connected station 3 in the same manner, by patching between the *No. 3 Lower Patching Jack* and the *No. 2 Upper Patching Jack*. It may be said that the *line* relay of the circuit associated with the transmitting station and the *local* relays of all the circuits associated with receiving stations will operate and release with the signals being transmitted and the *local* relay of the circuit associated with the transmitting station and the *line* relays of the circuits associated with the receiving stations will be held operated by make-before-break contacts on the other relay of a pair.

A slow release feature is incorporated in all of the *signal* relays to prevent their release when the *line* relays are following teletypewriter signals.

A schematic drawing of the complete circuit is illustrated in figure 32. Wiring drawings and a detailed description of circuit operation are contained in the War Department Technical Manual No. TM 11–358 packed with the equipment.

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V. SYSTEM DESIGN

25. Design Considerations. Considerable forethought should be given to the design and layout of an advance base teletypewriter system before actual installation is begun. The number of stations on the system, amount of traffic to be handled between the various stations, the equipment that will be available for the job, and even weather conditions should come under consideration before the circuits are actually installed. Some of these items and their relation to circuit design are covered in the following paragraphs.

26. Method of Connection. When definite information is available on station locations and the expected amount of traffic on the system can be estimated, a selection of the method of connection and equipment required can be made. The use of a teletypewriter switchboard offers several very important advantages over a series circuit arrangement aside from its ability to handle a great deal more traffic. A failure of one station line wire will not affect the operation of other stations and is immediately locatable in one particular wire line thus greatly reducing the time necessary to put that station back in service as well as protecting communications on the entire system Since the switchboard acts as a repeater each station may be at the maximum distance from the switchboard thus effectively doubling the distance between the most widely separated stations in the system. In selecting a switchboard, however, consideration must also be given to the necessity for supplying operating personnel for 24 hour coverage.

If unavailability or other considerations preclude the installation of a switchboard further consideration should be given to carrying all of the legs of a series circuit through a test connecting block or W. E. Co. 63–C–1 Jackbox as discussed in section II. This method of connection will greatly facilitate the testing and patching out of inoperative portions of the circuit. If this method is used however, care must be taken not to exceed resistance limitations. Where teletypewriter circuits parallel telephone circuits, either existing or proposed, savings in installation time and wire used can be effected by the utilization of CW–301224 Repeating Coils to provide simplex or phantom circuit operation.

27. Traffic Engineering. Information is given in this section which will assist in planning for the number of teletypewriter station sets, switchboards and connecting networks that will be required. Data are provided on the word (or 5-letter group) carrying capacity of trunk groups and the approximate number of teletypewriter switchboard positions that will be required for a predetermined volume of traffic. Available data from field experience in present theaters are reflected in the information contained herein. Engineering on the job will be more accurate than advance estimates.

The traffic handled by a teletypewriter switchboard probably will consist of traffic between stations connected to the same switchboard and outward and inward calls over trunks to distant similar swtichboards. The following table gives the approximate number of positions required for different amounts of total traffic per day.

TABLE I.—*Teletypewriter switchboard position requirements*

Average total calls per day	Approximate number positions required	Average number busy hour calls per operator
200	1	20. 0
485	2	24. 2
780	3	25. 9
1,040	4	26. 0
1,380	5	27. 6
1,690	6	28. 1
2,025	7	28. 9
2,380	8	29. 7

This data is based on the following assumptions:

(1) Each operator handles all types of calls.

(2) The distribution of traffic per 100 calls is 20 local to local calls, 40 incoming trunk calls and 40 outgoing trunk calls.

(3) Ten percent of the total avarage daily traffic is handléd in the busiest hour.

(4) Lower loads are used on the smaller boards to provide a reasonable grade of service during short traffic peaks.

(5) Every operator is able to reach every line and trunk.

(6) An operator is provided for each position during the busy hour.

The length of the message is not involved since the operator's time is concerned chiefly with setting up and taking down connections and only incidentally in monitoring. The table assumes ten percent of the total traffic per day as the amount of traffic handled in the busiest hour. If the busiest hour is assumed to be other than ten percent of the total traffic per day, multiply the total traffic per day by the ratio this percent is to ten and use the resulting figure as the total number of calls per day to obtain the number of positions required for this amount of traffic.

BD–100 Teletypewriter Switchboard Units are equipped for ten circuits per position, usable for either trunk or station loops. Connections are set up by means of patching cords. Three units of this switchboard are limited to a total of thirty circuits (trunks and loops). For example, if there are twenty local teletypewriter station loops, only ten trunks between switchboards can be installed. The number of connections that will be up at any one time is therefore variable, depending on the proportion of loops and trunks. These facts must be considered in the decision as to the number of units required at one location. The patching cords of which 10 are supplied with each position are 18 inches long. An accessory chest supplied with each position contains two additional 18-inch and ten 72-inch cords. If more than three positions are used in one line-up, connections are limited by the 72-inch cord length.

28. Trunk Group Engineering. It is expected at advance base installations that traffic will be handled on a direct keyboard transmission basis. The average speed of transmission for this type of traffic is assumed to be 30 words (5-letter groups) per minute. Table II provides data on the capacity of various trunk groups in calls or words per day. This data

TABLE II.—*Approximate trunk group requirements*

Number of trunks required in trunk group	Number of calls per trunk group per day									Number of words (5-letter groups) per trunk group per day [1]		
	7-minute holding time per message			10-minute holding time per message			12-minute holding time per message					
	Fast service	Medium service	Slow service	Fast service	Medium service	Slow service	Fast service	Medium service	Slow service	Fast service	Medium service	Slow service
1	10	50	90	10	40	60	10	30	50	750	7, 200	7, 200
2	50	90	170	40	90	130	30	70	100	5, 700	19, 800	27, 000
3	90	170	230	60	130	180	50	110	140	13, 000	33, 000	46, 000
4	130	230	350	90	180	250	70	150	190	20, 000	45, 000	60, 000
5	170	350	450	130	230	280	100	190	230	33, 000	60, 000	80, 000
6	230	450	500	170	280	350	140	230	280	40, 000	66, 000	92, 000
7	300	500	600	200	350	400	170	270	350	53, 000	92, 000	106, 000
8	400	600	650	250	400	500	210	350	400	66, 000	106, 000	132, 000
9	450	650	750	300	450	550	240	400	450	80, 000	120, 000	145, 000
10	500	750	800	350	500	600	270	450	500	92, 000	133, 000	165, 000
11	550	800		400	550		280	500		106, 000	143, 000	
12	600			450	600		350			120, 000	165, 000	
13	700			500			400			132, 000		
14	750			550			450			145, 000		
15	800			600			500			165, 000		

[1] These figures are based on 100 percent keyboard transmission at an average speed of 30 words per minute. If transmission from prepunched tapes is used 50 percent of the time multiply these figures by 1.5 and if transmission from prepunched tapes is used 100 percent of the time multiply these figures by 2.

will have its greatest application in large systems and when used for design purposes in advance base installation the information contained in the table should be carefully weighed against the information in the following paragraphs.

The assumption is made in this table that ten percent of the total traffic per day is handled in the busiest hour. If the busy hour traffic is assumed to be other than ten percent of the total traffic per day, multiply the total traffic per day by the ratio this percent is to ten and use the resulting figure as the total traffic per day to obtain from the table the number of trunks required.

The number of messages that can be transmitted over one circuit depends on the length of time the circuit is held for transmitting the average message. Data is given for the number of calls that can be handled per trunk group per day with average lengths of seven, ten and twelve minutes per call and for the number of words than can be handled per trunk group per day. Allowances are given for three different grades of service designated as fast service, which means few delayed calls because of "no circuit"; medium service, which means more delays; and slow service, with still more delays. This of course, is relative, but fast service contemplates that a high percentage of calls will be completed on the first attempt.

It should be remembered that all of the figures given in this table are based on a desire to complete calls between stations with a lack of delay similar to that available in commercial operation. A single trunk used continuously throughout a day at a thirty word per minute speed could under ideal conditions transmit 57,500 words, but the table allows only 750 words per day to supply practically undelayed traffic capabilities over one trunk. Of course in actual practice the maximum figure just stated can never be reached because of delay occasioned by maintenance, line-up, time used in establishing connections, etc. At advance base installations a compromise will have to be made between the amount of delay permissible in completing calls and the difficulties inherent in the establishment and maintenance of trunk line facilities.

29. Point to Point Service. When two or more stations are connected in a series circuit for intercommunication without the use of a switchboard the considerations for trunk design do not apply exactly. Under these conditions the circuit may approach but will never reach its maximum capability of 57,500 words per day, an average of 30 words per minute keyboard operation. It will be necessary in the design of this type of circuit to consider not only the total amount of traffic to be originated in a day but the frequency with which messages can be interrupted to permit transmission of messages of higher priority.

30. Circuit Engineering. In laying out circuits to meet service requirements, it is essential to know the limiting lengths of various types of sections. Furthermore, it is important to evaluate the transmission capabilities of each line section to permit the selection of proper facilities. The transmission capabilities of a line section are dependent on circuit length, type of line, construction and type of equipment, and can be readily evaluated by the use of transmission ratings or co-efficients. The use of coefficients will aid in the efficient employment of existing arrangements and in plans for new facilities.

31. Circuit Limits. The distances over which teletypewriter circuits can be satisfactorily operated are limited by different considerations for different types of circuits and operating conditions. Important factors are line leakage, line resistance, ground resistance, wave shape distortion and interference. A simple calculation involving line current, circuit resistance and voltage, although of some assistance in applying limiting values, is not sufficient to determine whether a circuit will be satisfactory since it neglects all other factors. These computations should however, be carried out as one phase of circuit design to insure a desirable line current value. The computations will not provide the actual limits which can be used as the circuit will be further limited by the distortion elements and a final circuit layout will be a compromise between current and distortion limits.

A teletypewriter circuit can be considered to be a series direct current arrangement and Ohm's Law computations will be applicable. All of the equipment included in the C–17 unit is designed to operate with an optimum line current of 60 milliamperes and the rectifiers for supplying this current are for operation at 115 volts. For design purposes each series circuit should have only one series battery supply although under actual operating conditions it may be permissible to use two 115 volt battery supplies at two different points on the circuit. The use of two batteries in series provides a line voltage of 230 volts which may be useful in overcoming the effects of line leakage. However the effect of line capacity increases with an increase in voltage and will probably cause an increase in signal distortion.

Maximum permissible line resistance to provide the optimum operating currents for the circuit can be calculated in the following manner:

Max. permissible resistance $R=E/I=115/.060$

$R=1917$ ohms

TABLE III.—*Constants of twin conductor wires*

Type of wire	Capacitance mf./mile		Resistance (ohms)			Maximum allowable tension (pounds) [1]
	Wet	Dry	Per loop mile	Per wire mile (1 conductor)	Per wire mile (2 conductors)	
Telex No. 17 2-conductor cable	0.17	0.15	58	29	14.5	[2] 110
Army type W50 outside twisted pair	.23	.07	26	13	6.5	150
Army type W108 parallel drop wire	.21	.13	180	90	45	160
Army type W108A parallel drop wire	.22	.13	230	115	57.5	140
Army type W110B field wire	.18	.07	186	93	46.5	120
Army type W130 assault wire	.19	.07	590	295	147.5	35
Army type W130A assault wire	.28	.09	590	295	147.5	35
Army type W143 field wire	.19	.19	35	17.5	8.8	90

[1] These figures are maximum allowable tension under normal conditions. Stringing tension of aerial wire should be lower than these values to allow for temperature changes, ice, etc.
[2] Minimum breaking strength.

For design purposes a maximum permissible resistance of 1900 ohms may be considered as one of the limiting factors in checking a proposed circuit layout.

Although the characteristics of teletypewriter circuits constructed with open wire facilities are generally better than those using cable twisted pair or twin conductor facilities it is expected that the former will not be used extensively at Naval advance base installations. Table III provides the constants for the more common types of twisted pair and twin conductor wire.

The internal line resistance of various units of C–17 equipment are shown in table IV.

TABLE IV.—*Resistance of teletypewriter line circuits*

Equipment	Total internal resistance ohms
M–15 teletypewriter with XRT–115 table:	
Using W. E. Co. 215–A line relay	85
Using W. E. Co. 255–A line relay	136
COQ–23403 line unit	220
BD–100 switchboard line circuit	76
CW–301224 repeating coil	10.5

When the line circuit of this equipment includes a variable resistor for controlling line current the tabulated values are based on the assumption that the resistor is set at its minimum value.

Sample calculations for the various methods of circuit connection are shown in figure 33.

At advance base installations a teletypewriter circuit can be considered satisfactory if there is an average of one character error in every 10 minutes of continuous use. This is the equivalent of one error in 3,700 operations. The maximum circuit limitations are based on this frequency of error and on the further assumptions that climatic conditions and maintenance practices will keep losses and distortions due to line leakage and capacity effects at an average value. Table V provides working limitations for the major circuit arrangements, that can be provided with a C–17 unit.

When any proposed circuit involves the connection of more than two teletypewriter stations or one teletypewriter station and a teletypewriter switchboard it will also be desirable to make a check of telegraph transmission coefficients.

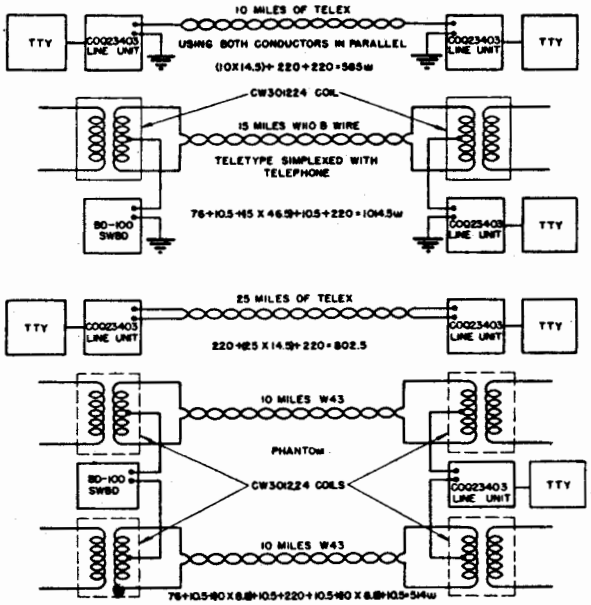


FIGURE 33.—*Sample line resistance calculations of a teletype circuit.*

32. Telegraph Transmission Coefficients. It has been found that, with either teletypewriter or Morse code reception, signals with a total distortion of less than ±35% are not likely to cause an error. Although a high degree of stability is desirable, it is not practicable to design telegraph circuits that will operate perfectly at all times. Any station-to-station connection which does not produce a long time average of more than one error in ten minutes (one character in 3700) will be considered high grade for military purposes, and in some cases layouts with a higher average of errors will be considered satisfactory. A circuit at the border line of these limits might operate with very few errors for a number of days and then have fairly frequent errors over a period of several minutes to several hours. If actual occurrence of errors interferes seriously with traffic, action should be taken to improve performance either by improvement in the transmission capabilities of the circuit or by the use of regenerative repeaters.

TABLE V.—*Circuit limitations*

Neutral D. C. telegraph line circuit between—		Limiting length of circuit miles
Equipment	Equipment	
COQ–23403 line control unit.	COQ–23403 line control unit.	[1] 35
COQ–23403 line control unit.	BD–100 switchboard	25
BD–100 switchboard	BD–100 switchboard	25
BD–100 switchboard	Army CF–2–A carrier telegraph terminal.	25
COQ–23403 line control unit.	Army CF–2–A carrier telegraph terminal.	25
COQ–23403 line control unit.	Army CF–2–B carrier telegraph terminal.	16
BD–100 switchboard	Army CF–2–B carrier telegraph terminal.	12
W. E. 215–A fixed bias line relay.	Any type equipment except UG terminal.	5
COQ–23403 line control unit.	Type UG carrier telegraph equipment.	¼
BD–100 switchboard	Type UG carrier telegraph equipment.	¼

[1] This limiting length is controlled by the unfavorable relation between resistance and capacitance with Telex wire or W–143 wire. Using W–110–B wire operating at 0.050 milliamperes of line current the circuit length can be extended to 40 miles.

NOTES

1. All limits are for a D. C. ground return circuit simplexed. The wire should have a resistance of 186 ohms per loop mile or less.
2. The limiting lengths are for average leakage and capacity conditions and should be reduced for extreme leakage and capacity value.
3. If the total loop resistance of a circuit exceeds 1,900 ohms but the circuit length does not exceed the mileage limitations of this table either the circuit length or circuit resistance must be reduced until the loop resistance is 1,900 ohms.

In a complete telegraph circuit the total distortion is made up of contributions from a considerable number of sources. Various types and lengths of telegraph transmission sections and local extension circuits differ in the amount of signal distortion which they cause. Furthermore, the performance of each part of a network varies from time to time because of changes in weather conditions, adjustments, etc. To evaluate or predict the transmission capabilities of a circuit is difficult, but a system of ratings called *transmission coefficients*, based on field and laboratory measurements, has been established. In the rating system (table VI) each part of a network is assigned a numerical coefficient in accordance with the quality of transmission which it provides—the lower the coefficient the higher the quality of the circuit.

TABLE VI.—*Coefficients for 60 word per minute teletypewriter network sections*

Type of network section	Telegraph coefficient
Carrier telegraph line section	2–4
D. C. neutral, polar, or polarential line section	5–7
Local extension from a carrier telegraph terminal to a COQ–23403 line unit on a neutral basis or to a telegraph repeater on a polar or polarential basis	5–7
Local extension for all other cases usually encountered	½–3

NOTES

1. Comparatively large values, possibly in excess of those given should be applied where any of the following conditions are extreme or several exist in combination:
   (A) Lines at or somewhat above mileage limitations of table V.
   (B) Lines seriously affected by moisture (continued rain, slush, or immersion).
   (C) Poor maintenance.
   (D) Excessive ground resistance, over about 200 ohms at a station or 20 ohms at a BD–100 switchboard.
   (E) Serious interference, such as that from powar systems, other communication circuits, static and ground potential differences.
2. The smaller values should be applied for favorable conditions, such as:
   (A) Short sections under good conditions, as in dry climates
   (B) Well maintained equipment and lines.
3. Intermediate values should be applied for average conditions.

It is desirable to predict the quality of transmission on all of the possible station-to-station connections in a proposed layout. Draw a layout diagram and assign to each section the proper transmission coefficient determined from table VI. The overall coefficient for any station-to-station connection will be the sum of the network section coefficients of the circuit connecting the two stations. This overall coefficient will provide a direct indication of the quality of service that may be expected; with an overall coefficient of 15 a frequency of error of one character in 3,700 can be expected; with an overall coefficient of 20 a frequency of error of one character in 500 can be expected. When the overall coefficient of any station-to-station connection exceeds the selected limit consideration should be given to improvement of the transmission capabilities of the circuit or to effectively breaking the circuit into two or more better circuits by the insertion of regenerative repeaters.

Calculation of the overall coefficient for a station-to-station connection whose circuit contains regenerative repeaters involves the calculation of an overall coefficient for each repeater section (regenerative repeater to regenerative repeater, or regenerative repeater to terminal station). Since each regenerative repeater reforms and retimes the received signals, the overall coefficient of the entire station-to-station connection will be somewhat higher than the highest one of the coefficients for the individual repeater sections making up the circuit. The error occurring in one section will be repeated by each successive regenerative repeater as an error so we might say that the total number of expected errors in the entire connection is equal to the sum of the errors of the regenerative sections. Thus two regenerative sections each having a coefficient of 15 would have an expected rate of error of 2 in 3,700 characters (1 error in 1,850 characters).

33. Telegraph Repeaters. When it is desired to work teletypewriter circuits over longer ranges than those specified in table V, it is necessary to use either open copper line construction or to provide additional equipment which will repeat the telegraph signals with a new battery supply for each section of line. Utilization of Army type TG–30 and TG–31 Non-regenerative Telegraph Repeaters operating on a polar or polarential basis upon a simplexed, ground-return circuit will permit total circuit lengths of 80 miles when Telex, W–110–B or W–143 wire is used. Utilization of these repeaters on large gauge open copper lines will permit circuit lengths of 400 miles.

When circuit lengths exceed limits specified above it will be necessary to provide regenerative repeaters. This equipment is designed to receive telegraph signals within maximum permissible distortion and reform and retransmit them as perfect signals. If further technical information is required on this subject reference should be made to War Department Technical Manual No. TM–11–486.

VI. STATION INSTALLATION

34. General. Since it is entirely possible that no other means of communication will exist when installing a teletypewriter station, a specific installation procedure will be necessary. Unless superseded by local instructions the procedures detailed in this Section should be followed.

The station or switchboard which normally supplies battery to the line will be designated *control* and other stations or switchboards will be designated *non-control*. Battery for stations connected to a switchboard will be supplied by the switchboard and battery for a series circuit not involving a switchboard can be supplied from either terminal. Battery for a trunk between switchboards can be supplied from either terminal. Where there is a choice between terminals equipped with WE–255–A Line Relays or COQ–23403 Line Control Units it will be most convenient to supply battery from the station equipped with a Line Control Unit.

35. Assembling the Equipment. Select a location which will provide maximum protection from the weather and ample room for operation and maintenance of the equipment. The back of the XRT–115 table should be at least 10 inches from the bulkhead to allow sufficient room to reload the machine with paper. Carefully unpack the teletypewriter base, keyboard, motor and typing unit. Assemble these parts in accordance with Teletype Corporation Specification S–5107. Serious damage may result from careless handling or inattention to proper procedures. The motor pinion should be lubricated with a thin film of grease before the typing unit is set in place. It is advisable, when the time interval between manufacture and installation has been long or there is an apparent lack of lubricant, to lubricate the machine in accordance with section X. If the COQ–23403 Line Control Unit is to be used, make the wiring modification explained in paragraph 44 before completely assembling the printer.

SAFETY PRACTICES ARE IMPORTANT. ALWAYS MEASURE THE VOLTAGE OF A POWER SUPPLY BEFORE MAKING ANY CONNECTION.

Open the hinged bottom on the electrical service assembly of the XRT–115 Table and connect the local a-c power supply to terminals 1 and 2. The "Tirex" cord furnished with the table may be used for this purpose. Connect terminal 3 of this assembly to ground through a separate wire.

With the rectifier power switch in the OFF position open the hinged door in the cover of the REC–29 Rectifier (Figure 34) and make the following connections. Connect the two flexible leads on the right hand side of the panel to the RECT CYCLES and MOTOR CYCLES terminals corresponding to the frequency of the available power supply. Connect the flexible lead on the left hand side of the panel to the A–C INPUT VOLTAGE terminal corresponding to the voltage of the available power supply. Place the rectifier on the deck underneath the table.

36. Station Set-Up, Without COQ–23403 Line Control Unit. Refer to figure 20 while making these connections. Strict adherence to the procedures of the following paragraphs is necessary to avoid damage to the equipment.

Plug the a-c power input cord of the rectifier into receptable B of the electrical service assembly on the XRT–115 Table (figure 35), and operate the power switch of the rectifier to the ON position. Adjust the d-c output of the rectifier with a 600 ohm resistor in series with a suitable milliammeter connected across the d-c output plug of the recti-

fier. Connect the flexible leads located near the top of the control panel to the RECTIFIER TAPS (L, M, H, and 1, 2, 3, 4, 5) which

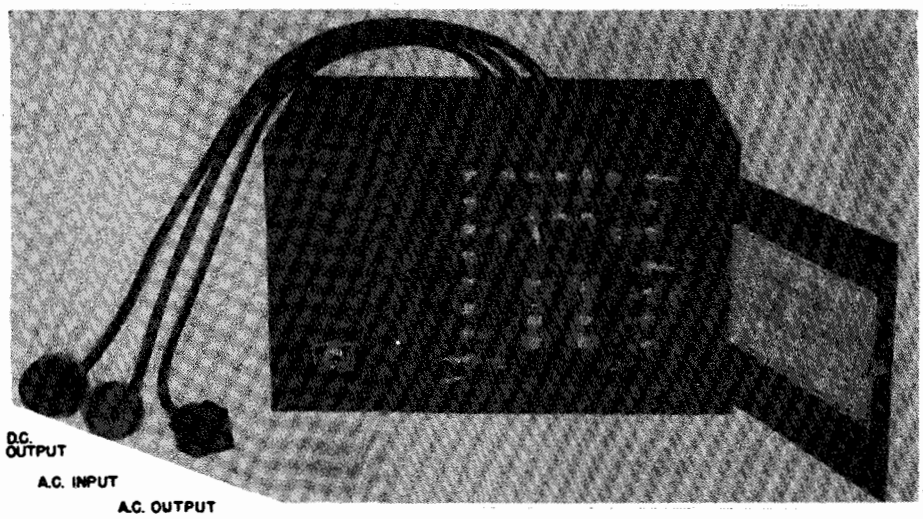


FIGURE 34.—*Rectifier REC–29—panel door open.*

cause the milliammeter to register a current flow nearest to but not less than 200 milliamperes. If the H and 5 terminals must be used to obtain this current value the power

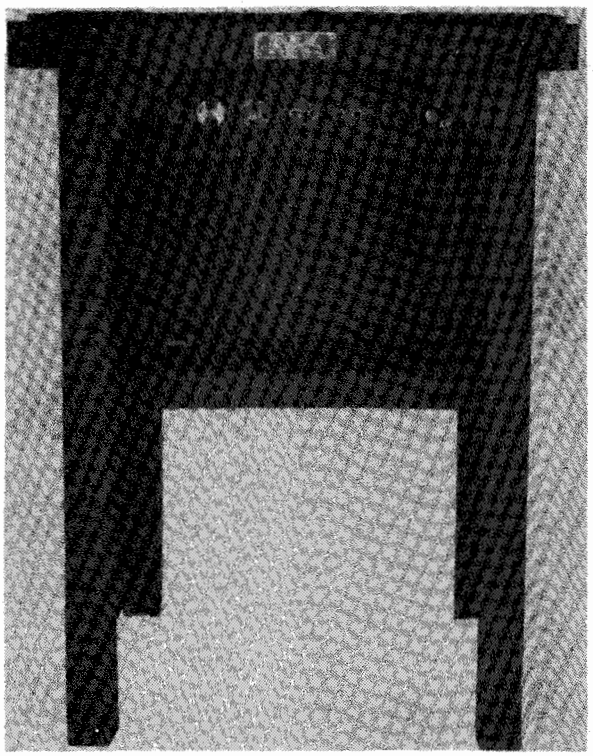


FIGURE 35.—*XRT–115 Table electrical service assembly.*

supply voltage should be rechecked with a voltmeter and the a-c INPUT VOLTAGE connection changed if necessary. If the H and 5 taps must still be used the rectifier should be considered unfit for use until repaired.

With the teletypewriter motor switch in the OFF position plug the a-c and d-c output cords of the rectifier into the A and E receptacles and plug the a-c and d-c cords of the teletypewriter into the C and D receptacles respectively of the electrical service assembly. (See fig. 38.)

37. Local Test, Without COQ–23403 Line Control Unit. To connect the teletypewriter for local test insert the red and black plugs of the LINE cords from the machine into the TEST RED and BLK jacks respectively of the electrical service assembly. Make the operations performance test as directed in paragraph 38.

38. Operations Performance Test. This series of tests is designed to completely check the operating features of the machine.

The sentence "THE QUICK BROWN FOX JUMPED OVER THE LAZY DOG'S BACK, 1234567890" contains all the letters of the alphabet and the ten most commonly used upper case characters. It is a check of all selection processes except LINE FEED, CAR RET and BLANK and should be memorized and used when a "test sentence" is specified.

1. *Motor.* Check that motor stop feature has not been operated. Operate the motor switch several times and observe motor response. If equipped with remote motor stop, check operation of this feature several times. Check speed of governed motor with tuning fork.

2. *Orientation and selection.* Check the range of the machine by printing the letters "R" and "Y" alternately while slowly moving the range-finder arm toward the lower end of the scale until errors in the printing occur. Note the position of the pointer. Check the upper limit of the range by moving the pointer toward the upper end of the scale until errors are printed. Secure the range finder arm at the midpoint of these two extremes. Print the "test sentence" to check the selection processes. The range under local test conditions with a well adjusted machine should be 80 points from 15 to 95.

3. *Figures and letters shift alignment.* Operate FIGS key, figure "2" key, LTRS key and W key in sequence for several operations. Note that the carriage shifts correctly, upper and lower edges of the letters and figures print uniformly and the characters line up evenly across the page.

4. *Line feed.* Position the line-feed lever in the single line position and operate LINE FEED key and some character key alternately. The characters should be printed in a straight line diagonally across the page in single space. Double line feed should be similarly checked.

5. *Spacing.* Depress "space bar" partially and see that carriage travels one space at a time. Depress space bar fully and note that machine repeats the spacing operation. Grasp type-bar carriage with both hands and check that there is practically no movement from side to side between spacing rack and spacing gear.

6. *Carriage-return.* With type-bar carriage at extreme right position operate CAR RET key. Carriage should return to extreme left position smoothly and quickly without hesitation, bouncing or jarring. Each line should begin directly beneath the previous line.

7. *Keyboard lock-out.* Operate BLANK key twice. Check that keyboard is now inoperable and SEND-REC key has moved to REC position. Move key to SEND position, depress character and BLANK key alternately until all characters have been operated. The keyboard should not lock-out during this sequence. The character key should be operated first to prevent locking out from the previous test.

8. *Ribbon reverse.* Observe ribbon as it approaches the end of spool and check for automatic ribbon reverse.

9. *Ribbon oscillation, feed and alignment.* Operate any character key and check that ribbon moves up in front of type pallet just before the pallet strikes the platen. Try this on both lower and upper-case characters. See that ribbon returns to position just below the level of the printed letter. Ribbon should feed laterally so that successively operated pallets do not strike the ribbon in the same place.

10. *Signal bell.* Operate FIGS key and then BELL key several times. Check that signal bell rings with desired loudness.

11. *Left margin.* Left edge of letter "M" should be printed 7/8 inch (plus or minus 1/16 in.) from the left edge of the platen, *not the paper edge.*

12. *Right margin.* Check that the machine will print lines of exactly 72 characters. The machine should begin to strike-over, or print in the same place when the 73rd character key is depressed.

13. *Margin bell.* Margin bell should operate immediately after 66th character has been printed.

39. Installation of Line. Install the teletypewriter line, protector and protector ground in accordance with section II of this publication. If the line is simplexed the protector ground will not be suitable for use as a signaling ground. If the line is arranged for ground return and the protector is used only for the teletypewriter circuit the protector ground may be used as a signaling ground However, if a water pipe ground is not available the signaling or combination signaling and protector ground must be installed in accordance with the special instructions of paragraph 40.

40. Signaling Ground A good ground is of the utmost importance in the successful opera-

tion of ground return teletypewriter circuits. A high resistance ground connection may introduce so much resistance into the line circuit that proper line current cannot be obtained. The resistance of such a ground is easily affected by changes in weather thus making frequent realignment of the circuit necessary.

Where water systems or their equivalent are not available, select the lowest and dampest site possible, preferably one near or in the bed of a stream, and install ground rods. Select a site with soil containing cinders, brine waste, mineral salts, clay or loam. Avoid sites with frozen ground or with soil containing greasy waste material, dry sand, gravel or rock. A good signaling ground at the end of 200 yards of wire is better than a poor ground ten feet from the station. At the site selected dig two holes six inches deep and one foot in diameter separated by at least 10 feet. Drive a ground rod into each hole until its top is three inches above the bottom of the hole. To prevent bending and whipping of the rod and subsequent enlargement of the hole, hit the rod squarely and not too hard. Clamp a separate wire to each rod and run them both back to the protector. A length of Telex two conductor cable may be used for this purpose with one of the conductors connected to each ground rod. Bury the exposed ends of the ground rods.

41. Testing Signaling Ground, Without COQ–23403 Line Control Unit. If there is any doubt that the ground is satisfactory the following measurement may be made. Using a multimeter determine whether any potential difference either a. c. or d. c. exists between the two wires from the ground rods. If no potential difference exists, measure the resistance between the two ground leads with the multimeter. If this resistance is less than 240 ohms the ground will be generally satisfactory for the operation of one teletypewriter station.

42. Unsatisfactory Grounds. If a satisfactory ground cannot be obtained by the aforementioned methods some of the following steps may prove helpful:

1. Drive more ground rods at least 10 feet from either of the first rods or in a different location. The use of more than 6 or 7 rods will not appreciably reduce the ground resistance.

2. Dig a hole about 6 feet deep, and drive a ground rod, or bury old kitchen ware, tin cans, coils of bare wire, etc. in the hole. Make a good electrical connection to the objects to be buried. Pack and wet the earth replaced in the hole.

3. Dig a hole about three feet in diameter and one foot deep around each rod. Mix a strong solution of salt and water, pour into the hole, and allow to soak in for half an hour. Replace excavated earth.

4. In frozen ground, use a rod long enough to reach below the frost line, or dig a hole below the frost line and drive the rod down from the bottom of the hole. Refill the hole immediately to prevent the ground freezing deeper around the rod.

5. When sap is running in the trees, a satisfactory emergency ground may be obtained from several large spikes driven into the base of a tree which has a large, deep root system.

6. On coral or similar formations a satisfactory ground may be obtained by digging a shallow excavation of relatively large area in the surface soil and burying a ground rod horizontally or burying a coil of bare copper wire which has been spread over the bottom of the hole. The replaced soil should be wet and tamped.

If none of these methods prove satisfactory it will probably be necessary to provide two wire metallic operation.

43. Line Connection, Without COQ–23403 Line Control Unit. Operate the teletypewriter motor switch and the rectifier power switch to the OFF position. If battery is to be supplied at this station strap terminal 8 to 11 and 9 to 12 on the electrical service assembly of the XRT–115 table. If battery is not to be supplied at this station strap terminal 8 to 9. Connect the line wires from the protector to terminals 7 and 10 of this terminal block.

Transfer the red plug from the TEST RED to the LINE RED jack. Connect a milliammeter across terminals 7 and 8 of the electrical service assembly. This milliammeter is most readily connected in this circuit by equipping it with a spare #89438 cord terminating in a black shelled plug and plugging into the LINE BLK jack. If this cord is not available the

meter may be wired to terminals 7 and 8 and a dummy bakelite plug inserted in the LINE BLK jack to open its short circuiting contacts. Operate the power switch of the rectifier to the ON position.

A deflection of the milliammeter connected in the line circuit will indicate that the other stations on the line are connected and line-up should be completed as explained in paragraph 51.

44. Station Setup, With COQ–23403 Line Control Unit. Reference shall be made to figure 21 while making these connections. Strict adherence to the procedures set up in the following paragraphs is necessary to avoid damage to the equipment.

For operation with the line control unit the WE–255–A Relay must be disconnected from the printer base circuit. The relay should be left in the printer base for possible future use of the teletypewriter on some other circuit where the line control unit is not used. At terminal 61 disconnect and tape the end of the green wire connecting to the WE–255–A Relay mounting. Move the yellow wire connected to terminal 62 onto terminal 61 and move the white wire connected to terminal 65 onto terminal 66. As an aid in maintenance operations, the machine should be marked in accordance with an acceptable local practice in the following manner:

> "Modified for use with COQ–23403 Line Control Unit or BD–100 Switchboard."

It is desirable to locate the line control unit on the right side of the table and at a height convenient for manipulation of the controls.

Plug the a-c power output, a-c power input, and d-c power output cords of the rectifier, the a-c power input cord of the teletypewriter and the d-c power input cord of the line control unit into the A, B, E, C, and D receptacles respectively of the electrical service assembly. Then turn the rectifier power switch to ON.

Operate the METER key on the Line Control Unit to the VOLTS position. Adjust the d-c output voltage of the rectifier by connecting the flexible leads located near the top of the control panel to the RECTIFIER TAPS (L, M, H, and 1, 2, 3, 4, 5) which cause the milliammeter needle to register nearest to the center red mark on the scale (115 volts). If the H and 5 terminals must be used to reach this adjustment the power supply voltage should be rechecked with an a-c voltmeter and the input tap connections changed if necessary. If the H and 5 taps must still be used the rectifier should be considered unfit for use until repaired. With correct polarity of the d-c supply the voltmeter should read to the right of zero.

45. Local Test, With COQ–23403 Line Control Unit. To connect the teletypewriter for local test turn the *line rheostat* of the line control unit as far as it will go in a counter-clockwise direction (IN position), and connect a short circuit across the LINE and GROUND terminals of the line control unit. Open the door in the front of the line control unit,

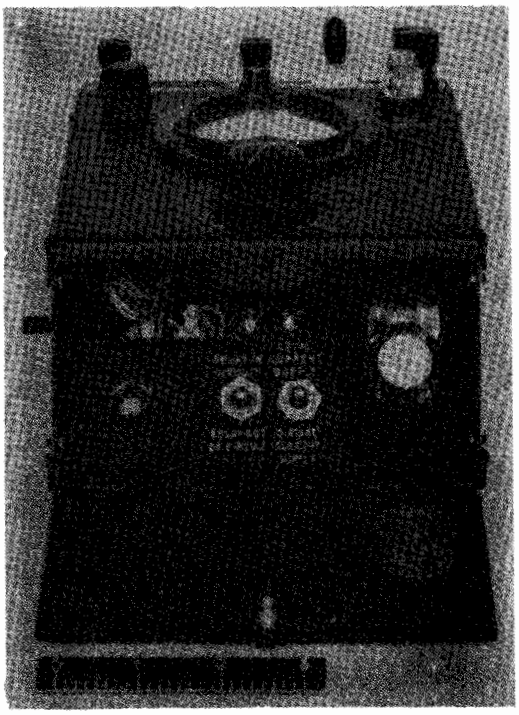


FIGURE 36.—*COQ–23403 Line Control Unit—Front door open.*

(Figure 36), and operate the switches to LOCAL CURRENT SUPPLY and RELAY IN CIRCUIT positions. Plug the red and black plugs of the teletypewriter line cords into the RED and BLACK jacks of the line control unit. Using the *line rheostat* adjust the line current to 60 milliamperes.

Recheck and if necessary readjust the voltage of the d-c rectifier output as explained in paragraph 44.

Operate the teletypewriter motor switch to the ON position and send repeated space signals. Operate the METER key of the Line Control Unit to the BIAS position and adjust the bias of the line relay by turning the adjusting knob on the front of the WU 41–C Relay until the milliammeter needle vibrates at zero.

***CAUTION:* Do not operate the METER key of the Line Relay Unit to the BIAS position unless repeated space signals are being transmitted.**

Make the operations performance test as directed in paragraph 38. The range obtainable on the orientation and selection test should approach 15 to 95 on the range finder index scale with the switch on the line control unit in either the RELAY IN CIRCUIT or RELAY OUT OF CIRCUIT position.

46. Installation of Line and Ground, With COQ–23403 Line Control Unit. Install and connect line and signal ground as described in paragraphs 39 and 40. The test of the ground should be made with the line control unit. Turn the teletypewriter motor switch to the OFF position. With the short circuiting wire connected between LINE and GROUND terminals of the line control unit and its switches in the LOCAL CURRENT SUPPLY and RELAY IN CIRCUIT positions, check that the meter indicates a 60 milliampere current. Remove the short circuit from the LINE and GND terminals and connect the two wires from the ground rods to these terminals. A current of more than 40 milliamperes measured on the meter of the line control unit indicates a satisfactory ground (less than 240 ohms) for signalling purposes. If the ground is unsatisfactory, proceed as explained in paragraph 42.

47. Line Connection, With COQ–23403 Line Control Unit. *Caution:* Strict adherence to the following methods of connecting the line are necessary to avoid damage to the Line Control Unit Meter. Turn the *line rheostat* of the line control unit in a counterclockwise direction to the IN position and operate the line current switch to the DISTANT CURRENT SUPPLY position. Connect the line and ground wires to the LINE and GND terminals respectively. If this is a *control* station, operate the line current switch to the LOCAL CURRENT SUPPLY position. A meter deflection will indicate that the other stations on the line are connected, and line-up as explained in paragraph 48 can be completed.

48. Station Alignment. At all *non-control* stations having COQ–23403 Line Control Units, the line and ground connections shall be reversed, if necessary, to keep current indications to the left of the zero point on the meter and the line rheostats shall be turned in a clockwise direction to the OUT position.

Operate all teletype motor switches at all stations to the ON position, as soon as there is sufficient current flow to prevent running *open*. If, at *non-control* stations having WE–255–A Relays, the line current exceeds 35 milliamperes and the machines run *open*, reverse the line and ground connections at terminals 7 and 10 of the electric service assembly.

When the milliammeter at the *control* station has remained at a maximum deflection for an appreciable time, the *line rheostat* at this station should be adjusted to provide a current flow of as near to .75 milliamperes as is possible. If all of the *non-control* stations on the line are equipped with WE–255–A Line Relays this adjustment should be 60 milliamperes. The *control* station should then send a ten second *break*.

The *non-control* station electrically most distant from the *control* station and equipped with a COQ–23403 Line Control Unit, shall adjust its *line rheostat* to provide a current of as near 60 milliamperes as is possible. At any stations on the circuit equipped with WE–255–A Relays, record the meter reading after the line current becomes steady, disconnect the milliammeter from the line circuit and shift the black plug from the TEST BLK to the LINE BLK jack. The most distant *non-control* station should wait a suitable time interval to allow the other stations on the circuit to measure line current, then transmit repeated space signals.

The *control* station should utilize the repeated space signals for adjusting line relay bias (COQ–23403 Line Control Unit or BD–100 Switchboard) and then should send a ten second *break* signal. The *non-control* station should

stop sending repeated space signals when this *break* is received.

Bias adjustment is accomplished at a station using a COQ–23403 Line Control Unit by operating the METER key to the BIAS position while repeated space signals are being received and adjusting spring tension of the WU–41C Relay until the meter needle vibrates at zero.

***Caution:* Do not operate the METER key of the Line Relay Unit to the BIAS position unless repeated space signals are being transmitted.**

The *control* station should send repeated space signals to permit measurement and adjustment of line relay bias at *non-control* stations equipped with COQ–23403 Line Control Units. Each *non-control* station in order electrically from the *control* station should, if necessary, adjust its line relay bias and then send a ten second *break*.

When the *control* station has received a *break* for each *non-control* station on the circuit, he will stop sending repeated space signals and transmit repeated RY signals. Each *non-control* station should receive several lines of this copy without error and measure the orientation range of the machine. In order of electrical distance from the *control*, each station should then send a ten second *break* signal and immediately follow the *break* by CAR-RET, LINE FEED, "Rcd OK, line current reads ____, installers initial," then CAR-RET, LINE FEED and one line of repeated RY's. The *control* station should continue to send repeated RY's to each station until the most distant station on the line has sent an "OK" and then take a range on the repeated RY signals from one of the *non-control* stations.

The range obtained at stations equipped with WE–255–A Line Relays should be at least 40 points. Any lower range indicates the need of a COQ–23403 Line Control Unit. As an emergency measure when the line control unit is not obtainable a Teletype Corp. set of parts No. 107152 or a 6000 ohm, 7 watt variable resistor may be connected in the biasing circuit of the WE–255–A Relay to provide a means of correcting for signal bias.

When the station has been completely installed, close the hinged bottom of the electrical service assembly and place the rectifier on the shelf of the table.

49. Line-Up Under Conditions of Line Leakage or Excessive Resistance. Inability to obtain a line current of sixty milliamperes at the *control* station indicates excessive line resistance for proper operation with one battery supply. Inability to obtain a line current of sixty milliamperes at the *non-control* station, after proper adjustment at the *control* station, indicates a line leakage condition.

When either of the above conditions is encountered and no other means of communication between the station locations is available, a line-up should be attempted with one battery supply even with improper current flow. This line-up should be carried at least to the point where communication is possible to permit passing of information between the stations.

If the difference between the line current readings at a *control* and *non-control* station is more than five milliamperes line leakage shall be considered excessive. When an indication of serious line leakage is present, the proper procedure is to eliminate the leakage condition as explained in paragraph 65. On an emergency basis it is probable that satisfactory operation of the circuit can be obtained by the use of two series aiding battery supplies in the loop.

The *control* station, on a determination of either type of trouble, shall notify the electrically most distant station that two battery supplies will be necessary and that he is adjusting his line rheostat to provide maximum resistance. The *non-control* station which is to supply the series aiding battery shall cut in all of his line resistance and then proceed to connect his station to supply series aiding battery. At a station equipped with a WE–255–A Relay, this shall be accomplished by removing the strap between terminals 8 and 9 of the electric service assembly and strapping terminals 8 to 11 and 9 to 12 on this assembly. At a station equipped with a COQ–23403 Line Control Unit, a series aiding battery may be connected by reversing the connections of the line and ground wires at the LINE and GND binding posts and operating the line current switch to the LOCAL CURRENT SUPPLY position. The line milliammeter under this condition will give an indication to the right of zero.

The line-up procedure detailed in paragraph 48 shall then be followed to complete the installation of the circuit.

VII. INSTALLATION OF THE BD-100 SWITCHBOARD

50. Choice of Location. In the usual case the location of the BD–100 Switchboard will be determined by the centralized position of the other communications equipment—radio, telephone, etc.—and the facilities made available for that equipment should be satisfactory for the BD–100 Switchboard. Should the occasion arise to establish the switchboard alone, several considerations should be kept in mind. A dry location under cover is essential. The operator will require light to operate the board, and for this reason consideration should be given to blackout security. A source of 110 volt, 50–65 cycle power capable of delivering about 500 watts is required for operation of one switchboard and should be conveniently available. Three switchboards in multiple will require about 1,000 watts.

51. Power Supply. It is expected that 60 cycle, 110 volt a-c will be available at most Navy shore installations. Ordinarily, therefore, the RA–43–B Rectifier will be used to furnish the necessary power for the BD–100 Switchboard. A source of alternating power, in conjunction with the RA–43–B Rectifier, should always be used in preference to a source of direct current power.

The teletypewriter motors supplied are usually not suitable for d-c operation and should be replaced with a proper type when d-c is used. In using a d-c power source it is very important that the grounded side of the switchboard be connected to the grounded side of the power system. Therefore, where the negative side of the power system is grounded the switchboard power leads must be reversed. This will mean that readings of voltage, current and marking bias at the switchboard meter will be to the left instead of to the right, and, at each station, current readings will be to the right, thus creating a degree of confusion during maintenance and alignment operations.

52. Setting Up the Equipment. During shipment the BD–100 Switchboard is contained within its own table (fig. 37). To set up the switchboard proceed as follows:

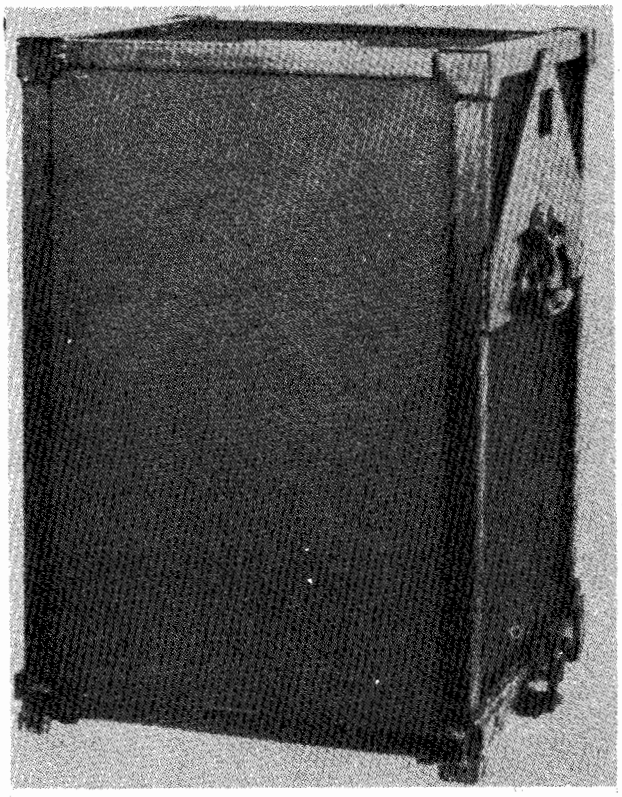


FIGURE 37.—*Switchboard BD–100 packed for transportation.*

Pull out the two horizontal foot extensions from the retainers along the bottom side braces of the table. Each foot extension is latched with a small circular button which springs into a hole in the side of the extension retainer. Push in this button until it disengages the hole. Grasp the back angle of the foot and pull it out until the bottom engages the second hole in the retainer. Loosen the two wing nuts on either side of the bottom of the switchboard

sufficiently to release the hooks which clamp the switchboard to the table. Lift the table up and off the switchboard and place it in the selected location. At least 30 inches of working space should be provided between bulkhead and the rear of the switchboard. Operation in the field has shown that there is a tendency of the foot extensions to be bent and warped out of shape if the switchboard is operated with them in the extended position. The added support and stability which might be expected from the feet in the extended position is short lived, so it is recommended that they be returned to the retracted position and the switchboard table be bolted to the deck. Bolt holes are provided in the foot extensions and these should be at the front of the switchboard. Place the switchboard squarely on the table. Engage the two eyebolts and hooks on the bottom of the switchboard with the tops of the square holes in the plates on the sides of the table. Tighten the wing nuts so that the switchboard is attached firmly to the table. Unhook the front and rear covers and remove them by pulling outward and lifting off the pins on the switchboard.

Assemble the operator's printer in accordance with the instructions of paragraph 35. The operator's printer should be located to the left of and at an angle to the switchboard so that the keyboard and the face of the switchboard are within convenient reach of the operator. The REC 29 Rectifier and the COQ–23403 Line Control Unit normally supplied with the station equipment are not required. Disconnect the WE–255–A Relay from the printer base as directed in paragraph 44. Plug the a-c and d-c cords of the teletypewriter into the C and D receptacles respectively of the electric service assembly.

To protect operating personnel from shock and to reduce the possibility of interference in radio and telephone circuits, a ground wire from a separate connection on the water-pipe ground or from a separate ground rod should be connected to the No. 3 terminal of the XRT–115 Table. Also place a wire between the No. 3 terminal of the table and a connection on the cover of the RA–43–B Rectifier.

Remove the RA–43–B Rectifier (Figure 38), from its case and place in a position convenient to the switchboard and printer. Open the cabinet door, remove packing from the tubes, check

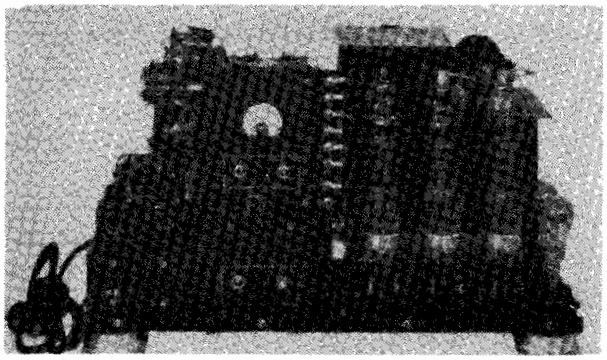


FIGURE 38.—*RA–43–B Rectifier cover removed.*

that a lead is connected to the 230 volt tap on the terminal strip at the right of the control panel.

Close the Rectifier door, plug the Rectifier into a 50 to 65 cycle a-c supply, operate the power switch and circuit breaker to the ON positions and the voltmeter switch to the a-c position. The meter will read voltages up to 300 volts under this condition but the scale reading must be multiplied by two. Record power supply voltage and turn power switch to OFF.

Connect the Rectifier internally for the power supply voltage in accordance with table VII.

TABLE VII.—*RA–43–B Rectifier connections*

Operation	Power supply voltage		
	80–100 volts	100–125 volts	200–250 volts
Remove wire from 230 terminal and connect to 115 terminal	Yes	Yes	No
Operate a-c voltage switch to 80–100 position	Yes	No	No
Operate a-c voltage switch to 100–125 position	No	Yes	Yes

***Caution:* Never operate rectifier with the a-c voltage switch in the "80–100" position when the line voltage is above 100.**

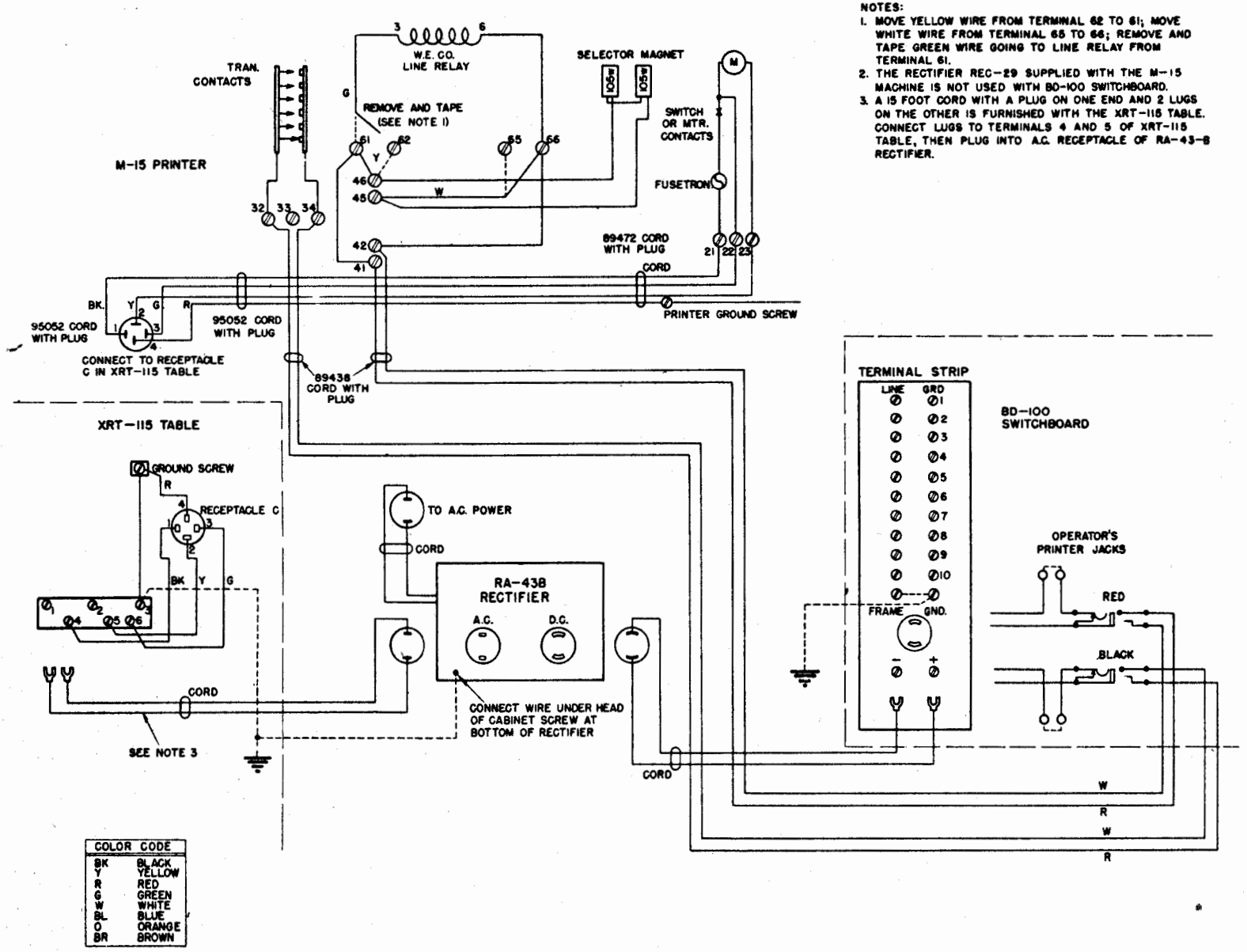


FIGURE 39.—*Equipment schematic BD-100 Switchboard.*

Operate the power switch and circuit breaker to the ON position, allow one or two minutes for the time delay switch to operate, then operate the voltmeter key to d-c and adjust the d-c output with the d-c VOLTAGE adjusting screw to 115 volts. The upper electrode of the neon tube should glow. If this is not the case remove tube and turn 180° in its socket. Readjustment of the d-c output voltage of the Rectifier will then be necessary. Operate the power switch to OFF.

53. Local Line-Up Procedure. (Refer to Figure 39.) After the equipment has been set into place it should be lined up for operation according to the following procedure. Turn all line rheostats to midposition (arrows pointing straight up), and remove all cords and plugs from switchboard jacks. Operate METER key to VOLTAGE position. Press all ANSWER buttons to restore LINE OPEN buttons, then press ANSWER REL button. Press LINE CURRENT REL button. Operate all line battery switches to up position (LINE CURRENT SUPPLIED BY SWITCHBOARD). It is important that local relays be adjusted for zero bias with line current switches operated to LINE CURRENT SUPPLIED BY SWITCHBOARD; an erroneous zero bias adjustment of the local relays will be obtained with the line battery switches operated to LINE CURRENT SUPPLIED BY DISTANT STATION. Turn the biasing knobs of all line relays to the extreme mark (clockwise) position, (Caution: Do not force knobs) then turn each back toward the spacing position (counterclockwise) one full turn. Check that teletypewriter motor switch is in OFF position.

Connect the (+) spade terminal (white wire) of the switchboard power cord to the (+) terminal of the switchboard and the (−) spade terminal (black wire) to the (−) terminal of the switchboard. Plug the switchboard power cord into the rectifier and operate rectifier POWER switch to ON. Allow one or two minutes for the rectifier to heat and check that all switchboard line lamps are lighted. Replace any lamps or fuses that are burned out. Check for meter indication to the right of zero (Note: exception for negative grounded power supply); if meter reads to left, turn off the power and check the d-c power connections at the switchboard. Make final d-c voltage adjustment to 115 volts. Operate all LINE OPEN keys; the signal lights should be extinguished by this operation.

Connect the spade terminals of the "Tirex" cord furnished with the XRT–115 Table, to terminals 4 and 5 of the electric service assembly. Plug this cord into the rectifier 115 VOLT AC PRINTER receptable or other 115 volt, 50 or 60 cycle a-c power source. Plug the red and black plugged line cords of the teletypewriter into the RED and BLK OPERATOR'S PRINTER jacks of the switchboard. To connect the operator's printer to multipled boards patch the RED and BLK OPERATOR'S PRINTER jacks of the second board to the RED and BLACK MULTIPLE jacks of the first board, and connect the d-c switchboard power cord of the second board into the convenience outlet on the first board.

Operate the operator's printer motor switch to ON then adjust the bias of the *local* relay of each line in the following manner: Patch the BIAS METER jack to the LOCAL BIAS MEASUREMENT jack. The *line* lamp should light. Operate ANSWER key: the *line* lamp should go out. Transmit repeated space signals from the operator's printer, operate the METER key to the BIAS position and adjust the bias of the *local* relay until a zero meter reading is obtained. Restore the METER key to the VOLTAGE position, release the space bar on the operator's printer, operate ANS REL key, operate LINE OPEN key and the *line* lamp should light. Remove the patch cord from the LOCAL BIAS MEASUREMENT jack thus extinguishing the *line* lamp.

***Caution:* Do not operate the METER key to the BIAS position unless repeated space signals are being transmitted.**

54. Local Test of Operator's Printer. The TEST jacks of the XRT–115 Table are inoperative at the operator's printer and special provision must be made to permit an operations performance test. The LINE and GND terminals of the No. 10 line should be short circuited and the line current adjusted to 60 milliamperes with the *line rheostat*. When the line is not

in use for actual testing the line current switch should be operated to LINE CURRENT SUPPLIED BY DISTANT STATION to prevent needless drain on the power source and unnecessary heating of the *line rheostat.* To make *the Operations Performance Test* operate the line current switch to LINE CURRENT SUPPLIED BY SWITCHBOARD, operate the ANSWER key of the test line and proceed with the test as explained in paragraph 38. When the test is completed operate the ANS REL key and restore the line current key to LINE CURRENT SUPPLIED BY DISTANT STATION. If less than the complement of ten lines is to be connected to the switchboard this test line should be left as just arranged and the designation strip should be marked "Test Line".

55. Signaling Ground. The importance of a good signaling ground has been discussed in the section on station installation and the statements made there apply with multiplied force since the switchboard serves ten lines, all of which may be ground return. The ground should be installed in accordance with instructions found in paragraph 40 and tested according to the following instructions.

If a single ground is used, such as a water pipe or any number of ground rods connected as one ground the resistance should be checked by the following methods. Connect the signalling ground to its terminal on the switchboard. Connect one ground return line and adjust the line current to 60 milliamperes. (Depress the LINE CURRENT key associated with the line and operate the METER key to LINE CURRENT to measure the current.) Connect a second ground return line and adjust the line current to 60 milliamperes. Again measure the line current in the first line. Observe the change of line current in the first line caused by the insertion and removal of one plug of a patch cord in the lower line jack of the second line. If the current decreases less than 1.5 milliamperes when the plug is removed from the second line, the ground is a good one and its resistance is less than 30 ohms. If the current change is more than 2.5 milliamperes, the ground is poorer, about 60 ohms, but will probably give satisfactory service. A current change of four milliamperes is just about the limit of operation (90 ohms ground), and under these conditions it will probably be difficult to maintain the line current and the relay bias adjustments. A decrease of 20 milliamperes indicates a ground resistance of about 600 ohms and is unusable except for a single ground return line.

If all the lines are already connected to the board, the measurement may be made without disconnecting any of the lines. To do so, connect all but two ground-return lines into a conference circuit and insert one end of a extra patch cord into the remaining lower *line* jack of the conference connection; this will open the circuit of all the lines in the conference network, effectively leaving in the switchboard circuit only the two lines to be tested. Open the circuit of the second line to be tested by inserting one plug from another patch cord in the lower line jack and proceed with the test just described.

Where two or more ground rods are used and separate leads are brought to the switchboard from two rods or groups of rods, their ground resistance may be measured before any station is connected. The following method may be used. Connect one ground lead to the switchboard ground terminal. Turn the line rheostat of an unused line circuit fully counter-clockwise and connect the other ground lead to the line terminal of the unused line. Place a short circuiting wire between this line terminal and the associated ground terminal. Adjust the line current through this short circuit to 60 milliamperes. Connect any line circuits in use into a conference circuit and insert one end of a patch cord into the remaining lower line jack to open the conference circuit. Observe the test line current and remove the short-circuiting wire. If the current decreases less than 3.5 milliamperes the ground is good and has a resistance of about 30 ohms or less. If the current decreases 6.5 milliamperes the ground resistance is about 60 ohms and is not an especially good one but will probably provide satisfactory operation. If the current decreases 12 milliamperes or more the ground resistance is greater than 120 ohms and is a poor ground. Having completed the test, replace the two ground leads on the switchboard ground terminal.

For methods of improving an unsatisfactory signalling ground consult paragraph 42.

56. Line-Up With Stations on D-C Wire Circuits. Before attempting a line-up, some prearranged system of signals and procedure should be agreed upon or ordered. The following plan is suggested and should be used unless otherwise ordered. This procedure will apply where teletypewriter stations or other BD–100 Switchboards are connected to the switchboard directly by wire lines (operating either ground-return or full metallic). For the method of lining-up circuits from carrier telegraph equipment to the switchboard see paragraph 57.

The BD–100 Switchboard will act as control for all station circuits connected to it. Either of the terminating switchboards may be designated as the control for interconnecting trunk circuits. Line battery is always furnished by the control point. The d-c power connections to BD–100 Switchboards and to COQ–23403 Line Control Units should always be poled so that voltage reads to the right of zero on the meter.

It is expressly undesirable to furnish series-aiding battery from two BD–100 Switchboards to an interconnecting trunk. To do so requires the reversal of the power connections at one of the switchboards. As can readily be seen, such a reversal of power will cause a reversal of current in all lines served by that switchboard. Moreover, if a station connected to that switchboard had been installed in accordance with these instructions and the line control unit power switch were accidentally operated to LOCAL CURRENT SUPPLY a bent switchboard meter needle might result. This danger, the maintenance confusion caused by the reversed line current and the possible increased distortion occasioned by the use of two line battery sources creates a very undesirable condition. It is impossible to furnish series-aiding battery from two points using the same primary source of d-c power.

Further instruction in this paragraph assumes that local line-up of the switchboard has been completed and that all keys have been left as last directed.

The general procedure of the line-up is to connect the line, adjust the line current, adjust the switchboard line relay bias and adjust the station line relay biases. The process is coordinated by means of *break* signals between the stations being lined up.

For lining-up a BD–100 which is a control for one or more stations on a line the following details will apply. At all *non-control* stations having COQ–23403 Line Control Units the line and ground connections should be reversed if necessary to keep current indication to the left of the zero point on the meter and the line rheostats should be turned in a clockwise direction to the OUT position. The line should be connected to the switchboard line terminal; the line lamp will light when the distant station is connected. During the time that connection of the line is being made at the terminal operate the line current switch to LINE CURRENT SUPPLIED BY DISTANT STATION. Depress LINE CURRENT key and operate METER key to LINE CURRENT position. When the METER has remained at a maximum deflection for an appreciable time adjust the *line rheostat* for line current as near 75 milliamperes as is possible, or, if no station on the line is equipped with a COQ–23403 Line Control Unit, adjust for a line current of 60 milliamperes. With the operator's printer motor switch ON, press ANSWER button and send a ten second *break* signal. The station most distant electrically from the Switchboard and equipped with a COQ–23403 Line Control Unit will then adjust its *line rheostat* to provide a current of as near 60 milliamperes as is possible and transmit repeated space signals to indicate that line current is adjusted.

The *line relay* at the Switchboard should be adjusted while receiving the repeated spaces. Patch from the BIAS METER jack to the LOWER PATCHING JACK and operate the METER key to BIAS. Adjust the proper *line relay* for a zero bias indication on the meter. Operate METER key to LINE CURRENT, remove bias meter end of patch cord, wait ten seconds and remove the line jack end of the cord. The ten second delay will transmit a *break* to the line.

Send repeated spaces from the operator's printer to permit measurement and adjustment of bias at stations equipped with COQ–23403 Line Control Units. Each station, in order of electrical distance from the switchboard, should

send a ten second *break* to indicate completion of the adjustment and readiness to complete the line-up.

When the switchboard has received a *break* for each station on the circuit, he should stop sending repeated space signals and transmit alternately the letters "R" and "Y". After receiving several lines of RY's correctly each station in order as above, should send a ten second *break* signal, CAR-RET, LINE FEED, the words "RCD OK, LINE CURRENT METER READS ____," then the installer's initials followed by CAR-RET, LINE FEED and one line of repeated RY's. The current and installer's initials should be made a part of the permanent record of the switchboard installation. The Switchboard should continue to send repeated RY's to each station until the most distant station has sent an OK.

In aligning a trunk between two BD–100 Switchboards a similar procedure will apply. The control (battery supplying) switchboard will proceed as is directed for the switchboard above, and the non-control switchboard will proceed as though it were a station in the above line-up.

57. Line-Up With Carrier Telegraph Terminal. The local line-up should be completed and all switches and keys left as last directed. Connect the line from the carrier equipment to the switchboard. The carrier attendant should have his *line rheostat* adjusted for all resistance *in*. At the switchboard, press LINE CURRENT button. Operate METER key to LINE CURRENT position. Adjust *line rheostat* for a current of 60 milliamperes. Send repeated space signals to allow the carrier attendant to adjust his relay for zero bias; await ten second *break* signal from the carrier attendant which will indicate that he has made his adjustment. Stop sending repeated spaces.

The carrier attendant should notify the switchboard operator as soon as the carrier terminals are lined-up. At that time the switchboard and the distant station should exchange repeated spaces and adjust their respective line relays.

VIII. LINE AND STATION EQUIPMENT MAINTENANCE

58. General. The maintenance of teletypewriter equipment is of two general classes: preventive and corrective. *Preventive maintenance* is a routine of systematic inspection, cleaning, lubrication and adjustment. It is an effort to locate and correct possible troubles before they have caused serious damage or failure of the equipment. *Corrective maintenance* is the process of restoring to operation that equipment which has failed.

Of the two types of maintenance, preventive is the more desirable. It is less costly in time, effort, money and material. Because it may be done at an opportune time and without undue rush or pressure it encourages more thorough work and materially reduces the loss of operating time. It should be the objective of each repair facility to keep corrective maintenance at a minimum by strict adherence to a routine schedule of preventive maintenance.

59. Personnel. Two classes of personnel will be directly associated with the operation and maintenance of teletypewriter system installations: *operating*, whose duties include the actual handling of messages, and *maintenance*, whose duties include all of the work necessary to maintain efficient functioning of the equipment. The training of these two types of personnel is distinctly different and to provide an efficient field organization a clear definition of the duties of each group is required. Qualified teletype technicians should perform all maintenance and repair work on the equipment.

Operating personnel should be instructed to perform the following duties daily:

1. Thoroughly dust the exterior of all equipment.

2. Check line current at each station equipped with a COQ–23403 Line Control Unit and on each line at a BD–100 Switchboard. Arrange, if necessary, with *control* station for readjustment.

3. Measure signal bias and correct bias adjustment of the line relay at each station equipped with a COQ–23403 Line Control Unit.

4. Measure signal bias and correct the bias adjustment of each working line at a BD–100 Switchboard.

5. Measure rectifier voltage at each station equipped with a COQ–23403 Line Control Unit or a BD–100 Switchboard and if out of limits refer to maintenance personnel for adjustment.

6. Replace burned out fuses. Repeated failure of fuses should be referred to the maintenance organization.

7. Replace burned out signal lamps at BD–100 Switchboards.

60. Records. Efficient maintenance of teletypewriter equipment will be aided considerably by a complete, up-to-date set of records. There is no prescribed form for these records and they may be varied to meet the individual situation. They may take the form of file cards, looseleaf binders or ledger books. The record should contain useful installation and maintenance data. The following is suggested as information which will be helpful to the maintenance man.

Installation data. Location of equipment, station call letters, type of equipment, details of the individual machine (such as remote motor control, use of line relay, receiving only, etc.), type of power supplied, type of signal line circuit, route of lines, location of battery source, date installed, hours of operation per day, most convenient maintenance time, phone number at the location of the equipment, and any other pertinent information which may be of value. If signal lines also are maintained by the organization it will be desirable to include pair and cable diagrams, location of cross-connection boxes, types of wire and cable used.

Maintenance history.—For routine inspections—date of inspection, whether partial or complete inspection, units inspected, parts replaced and reason for replacing, range of printer on local test, range of printer on signal line and initials of person making the inspection. For trouble visits—date, trouble reported, trouble found, corrective measures, range of machine on local test, range of machine on signal line and initials of repairman.

A valuable supplement to these records is an Inspection Chart large enough to list all the stations which are maintained by the organization and ruled with spaces for entering the schedule of inspection visits for each station. Such a chart placed in a conspicuous place on the bulkhead of a repair shop will serve as a convenient reminder of those machines which are in need of inspection. It is desirable to mark off the visits as they are made so that the status of any machine may be determined at a glance.

A monthly inspection of the maintenance records by the officer-in-charge of the facility will prove useful in establishing an indication of the effectiveness of the maintenance program and organization. Proportionately large numbers of corrective maintenance visits at a station should be analyzed to determine whether the preventive maintenance schedule is ineffective, whether some of the corrective maintenance visits could have been prevented by better analysis on the first visit or whether some special efforts should be initiated on the line or equipment involved. Each station requiring two or more corrective maintenance visits within a two week period should be brought to the attention of the officer-in-charge.

It will be found convenient for the repairman to carry a small notebook for entering in a rough fashion the required data on inspection or repair visits. This information should be transcribed to the permanent record immediately upon return from the visit.

61. Inspection Routines. Suggested maintenance schedules for the teletypewriter are based on operation throughout the 24 hours of a day. On this basis machines should be routined once every 10 days, once a month and once every six months. The semiannual routine will substitute for the monthly routine when it occurs and the monthly routine will substitute for every third ten day routine. Where the daily operating period is less than 24 hours the period of the shortest routine may be lengthened to provide for one routine every 250 operating hours, and the suggested monthly routine may occur after 750 operating hours. Every machine, regardless of usage, should be thoroughly routined semi-annually.

Where transportation and replacement equipment are available it is advantageous to perform the monthly and semi-annual routines at the repair shop. With proper scheduling the maintenance will provide a very useful back log of shopwork; moreover, parts, cleaning material and lubricants are always at hand.

Table VIII is offered as a guide to the maintenance items which should be performed on the M–15 Teletypewriter at each routine visit. It is not intended that this chart be considered inflexible but rather as a minimum operation which should be expanded or varied to suit the particular field requirements.

62. Disconnecting Machine From Line. At any standard station equipments including the BD–100 Switchboard the M–15 Teletypewriter can be removed from its associated line circuit without interruption to service on the other machines in the system. This is done by removing the red and black plugged transmitting and receiving cords from the RED and BLK jacks at the XRT–115 table, COQ–23403 Line Control Unit or BD–100 Switchboard. The necessary circuit closure is provided by short circuiting contacts on all of these jacks. Do not work on a machine at a station location without first removing the machine from the line as just explained. If battery for test purposes is required the machine may be connected for local test as explained in paragraph 63. Do not work on an Operator's Printer when the ANSWER key of any working line is depressed.

If it becomes necessary to work on the line circuit of an XRT–115 Table or on a COQ–23403 Line Control Unit other precautions will be necessary to prevent any appreciable service interruption.

Table VIII.—PREVENTIVE MAINTENANCE CHART, M–15 TELETYPEWRITER

10 DAYS OR 250 OPERATING HOURS

(See notes 1, 2, 3)

1. Lubricate the machine (see note 4).
2. Clean type pallets.
3. Polish transmitting contacts with burnisher.
4. Polish contacts and check adjustments of WE–225–A Relay when used.
5. Check and adjust speed or series governed motor.
6. Make operations performance test (see note 5).

MONTHLY

(See notes 1, 2, 3, and 6)

1. Remove dust and dirt from machines.
2. Clean type pallets.
3. Remove keyboard shaft. Clean oil ducts. Check bearings for excessive wear and sizing.
4. Remove main shaft. Check bearings and clutches for wear and sizing.
5. Check tightness of all nuts, bolts and screws.
6. Check gears and pinions for excessive wear.
7. Lubricate machine (see note 4).
8. Reassemble machine.
9. Polish transmitter contacts.
10. Polish contacts, clean pole faces and check adjustments of WE–255–A Relay when used.
11. Check and adjust speed of series governed motor.
12. Make operations performance test (see note 5).

SEMIANNUAL

(See notes 1, 2, 3 and 7)

1. Dismantle entire machine and subassemblies.
2. Discard all old felt washers and wicks.
3. Wash all parts in carbon-tetrachloride until clean. Allow parts to dry thoroughly.
4. Inspect for worn or damaged parts, paying special attention to the following:
   a. Nuts, bolts, or screws with damaged or burred threads, heads, or edges.
   b. Lock washers which have lost their spring or been squeezed flat.
   c. Ball bearings and their races for worn spots, cracks, or scores; Ball and race assemblies should be reasonably tight without binding or excessive end-play.
   d. Gears and pinions for worn teeth or feathered edges.
   e. Type-bar backstop for adjustment and for wear indicated by notches in the leather.
   f. Helical spring loops and spring posts for excessive wear. Check spring tension.
5. Disassemble motor unit and wash parts in carbon-tetrachloride. Carefully inspect ball bearings. Clean electrical contacts and commutator with OOO sandpaper (see note 4).
6. Reassemble machine using new felt washers and wicks. Lubricate the machine during reassembly. Make sure parts are free from carbon-tetrachloride (see note 4).
7. Polish transmitter contacts.
8. Polish contacts, clean pole faces and check adjustments of WE–255–A Relay or check adjustment of WU–41–C Relay.
9. Check selector armature spring adjustment.
10. Check and adjust speed of series governed motor.
11. Make operations performance test (see note 5).

NOTES

1. Notify other stations on circuit when station is to be out of service or restored to service.
2. Disconnect machine and line relay unit from line in accordance with paragraph 62 of test.
3. Make the following tests and adjustments on machine and line unit when either connecting a replacement machine or restoring routined machine to line.
   A. Connect machine to line, adjust line current and bias of COQ–23403 line control unit.
   B. Check range and orient machine.
   C. Send and receive test sentence with a distant station.
   D. Release machine to operator. Standby until operator is satisfied with performance of machine.
4. Lubricate machine in accordance with section X of the text.
5. Operations performance test is explained in paragraph 38 of the text.
6. Provide replacing teletypewriter and perform routine in shop when possible.
7. Provide replacing machine and line unit. Perform routine in shop.

At stations which do not supply battery to the line, a short circuit placed across the line or line and ground terminals at the station side of the protector will permit subsequent removal of the station equipment from the circuit. When the line circuit is simplexed to a telephone line and the CW–301224 Repeating Coil is between the station and protector, another method of short circuiting the station line or line and ground wires must be selected.

At stations supplying battery to the line it will be necessary to provide another source of line current. Generally the best method will be to use a spare REC–29 Rectifier and COQ–23403 Line Control Unit. The controls on the replacing equipment should be set in similar positions to those on the equipment to be replaced and change-over should be as rapid as possible to minimize interference. The line current should be adjusted to 60 milliamperes.

The WU–41–C Line Relay may be removed from a COQ–23403 Line Control Unit without interruption to service by operating the relay control switch to RELAY OUT OF CIRCUIT.

If any equipment is to be left off the line for an appreciable time, the line current should be readjusted.

Where the machine is operable the other stations or switchboard on the line should be notified that the station is being removed and the

approximate length of time that it will be out of service.

63. The Local Test Circuit. Almost every routine or trouble visit to a station will require an *Operations Performance Test* as described in paragraph 38. In most cases it will be possible to make this test without interference with the operation of other stations, except that during the test no messages can be originated or received at the subject station.

At stations equipped with the WE–255–A Relay the red and black plugs of the teletypewriter cords should be shifted from the LINE RED and BLK to the TEST RED and BLK jacks respectively. This will establish a 60 milliampere test circuit including the transmitting contacts, line winding of the WE–255–A Relay and 2000 ohms resistance in series with the d-c supply from the rectifier. An *Operations Performance Test* using this circuit will check the mechanical and electrical operation of the machine.

At stations equipped with a COQ–23403 Line Control Unit, the red and black plugs of the teletypewriter cords should be transferred from the RED and BLK jacks of the Line Control Unit to the TEST RED and BLK jacks of the XRT–115 Table. This will establish a 60 milliampere test circuit including the transmitting contacts, selector magnets and 2000 ohms resistance in series with d-c supply. An *Operations Performance Test* using this circuit will check the mechanical and electrical operation of the machine but will not check the ability of the Line Control Unit to repeat the signals from the line to the selector mechanism.

At BD–100 Switchboards the *Operations Performance Test* can be made by operating the line battery switch to LINE CURRENT SUPPLIED BY SWITCHBOARD and depressing the ANSWER key of the test line circuit established by paragraph 54 or if this line is not connected the ANSWER key of a working circuit not handling traffic can be used and the station operator on that circuit notified that a test is being made.

64. Maintenance of Other Station Equipment. As instruction books are furnished with each piece of equipment it is the intent of this manual to supplement but not repeat the various detailed procedures for adjustment and maintenance. For data not furnished in this manual, the repairman is referred to the manual or handbook covering the particular piece of equipment being repaired.

Station protectors. Experience at advanced bases has indicated that a good deal of trouble can be expected from lightning surges. Carbon block arrestors will ordinarily protect the station equipment, but repeated operation of the carbon blocks will build up a deposit or form dust which eventually will ground the line. Whenever a station is visited the carbon blocks should be inspected and lightly brushed to remove any accumulations of dust. If the blocks are pitted they should be replaced.

WE 255–A Relay. Maintenance of the WE–255–A Relay will consist of removing accumulated dust from the relay and cover, burnishing the relay contacts, removing magnetic particles from the armature and pole-piece screws and adjusting the relay to meet the various mechanical and electrical requirements specified in Teletype Corporation Bulletin No. 120. It should be remembered that the contact metal of the WE–255–A Relay is soft and filing or burnishing must be done sparingly, otherwise the life of the contacts will be materially shortened. The metal removed by burnishing—negligible as it may seem—may be great enough to create an internal bias in the relay; after burnishing always check all adjustments. The I–193A Test Set will be useful for accurate adjustment where it is necessary to maintain a large number of these relays.

COQ–23403 Line Control Unit. This unit seldom requires maintenance other than cleaning and dusting with an occasional check of the adjustments of the WU–41–C Relay. The tungsten carbide contacts on the relay do not pit under normal operating conditions and if they become badly worn or pitted the relay should be replaced. In an emergency, if pitting should occur, the relay may be disassembled and the contacts lightly dressed on a carborundum stone.

65. Line Maintenance. Under the best of operating conditions line trouble will account for the largest percentage of lost operating time on

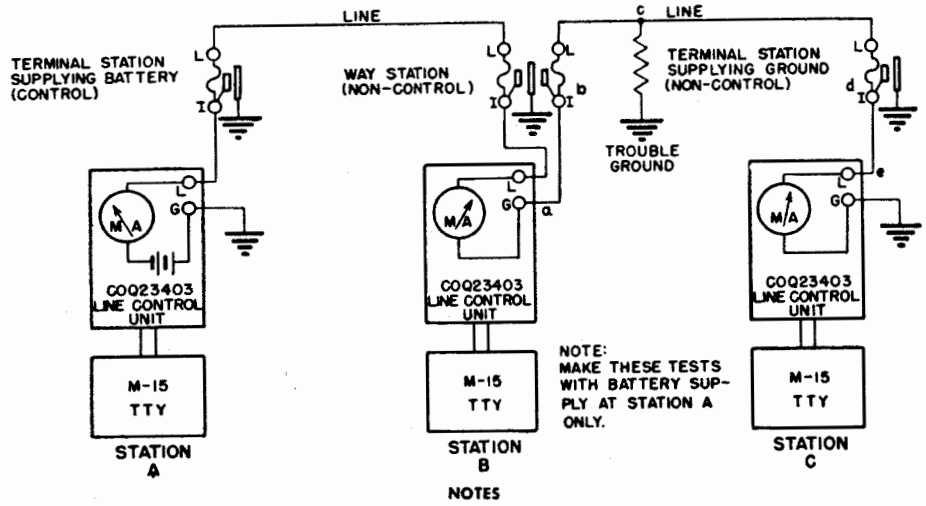
a teletypewriter circuit. However, care in the construction and maintenance of wire facilities will decrease lost operating time and trouble reports.

The most troublesome problem is generally one of abrasion. The insulation of wire fastened to trees without some protection may abrade through in about 30 days. The burying of Telex, where practicable, provides the best solution to most line maintenance problems, but the burying of Army field wire is not recommended. As an alternative, careful selection of a wire route and suspension of the wire at supports with drop wire clips or porcelain insulators will provide satisfactory protection against abrasion. Telex, when not subjected to abrasion caused by tidal action over coral, will perform satisfactorily under water.

Prompt clearing of potential ground troubles which in their early stages of development appear as line leakage, will effectively reduce out-of-service failures on circuits. These line leakage conditions can be recognized by a decrease in line current electrically beyond the point of trouble (fig. 40).

Periodic tests for line leakage have proved effective in reducing lost circuit time. Where a circuit may be removed from service for a short time the following test will indicate the amount of leakage. At the station supplying battery to the circuit insert a voltmeter in series with the line. The voltage reading observed when the break key at a distant station is operated will indicate the amount of line leakage. If there is no leakage the meter will read zero. If there is a solid ground on the line the meter will read the line battery voltage. Intermediate readings of the meter will indicate various degrees of line leakage.

66. Trouble Analysis. Methods of analyzing trouble will vary with both the personnel and the testing equipment available. The following paragraphs will suggest some methods for identifying the type and locating the more common troubles. Particular field conditions and the ingenuity of personnel will determine, in many cases, better ways of doing the job.



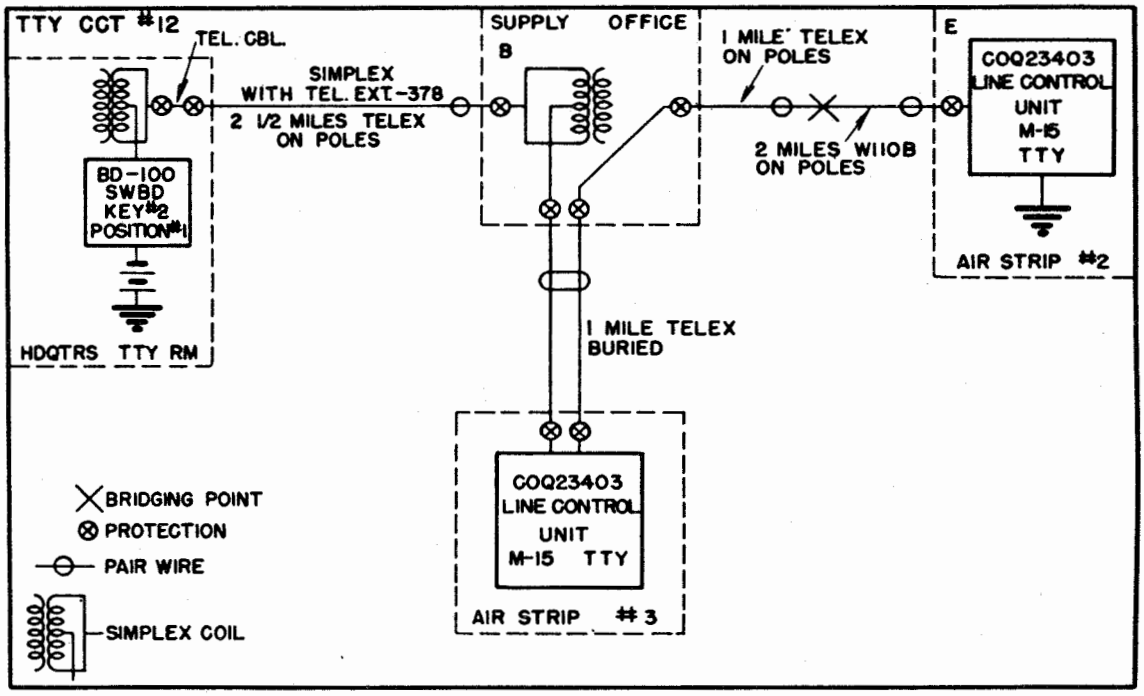
NOTES

1. ALL STATIONS BETWEEN THE BATTERY SUPPLY AND THE TROUBLE WILL RUN CLOSED. ALL STATIONS ELECTRICALLY BEYOND THE TROUBLE MAY OR MAY NOT RUN CLOSED DEPENDING ON THE RESISTANCE OF THE TROUBLE GROUND.
2. THE LINE CURRENT AT ALL STATIONS BETWEEN THE TROUBLE AND THE BATTERY SUPPLY MAY BE HIGHER THAN NORMAL. THE LINE CURRENT AT ALL STATIONS ELECTRICALLY BEYOND THE TROUBLE WILL BE LOWER THAN NORMAL.
3. A TROUBLE DISTRIBUTED OVER THE ENTIRE CIRCUIT WILL CAUSE A GRADUAL DECREASE IN LINE CURRENT ALONG THE CIRCUIT.
4. IF THE TROUBLE IS LOCATED BETWEEN TWO STATIONS AS INDICATED BY THE MILLIAMMETER READINGS HAVE THE OPERATORS AT BOTH STATIONS REMOVE THE PROTECTOR CARBONS TO DETERMINE WHETHER THE TROUBLE IS AT THE PROTECTORS.

FIGURE 40.—*Line leakage trouble in the ground return circuit.*

A prerequisite to a successful and rapid analysis of trouble is a knowledge of the circuit layout. Individual cards providing pertinent station layout information will be useful. These cards should be available to the repairman for use on the job. Figure 41 illustrates a suggested arrangement for a circuit layout card.

A preliminary analysis with the assistance of the operator will generally locate the trouble at



FRONT

TTY CCT #12		
LOC	REMARKS	NEAREST TELEPHONE
A	BATTERY SUPPLIED TO CIRCUIT, SIMPLEX COIL MOUNTED ON TEL. SWBD MAIN FRAME PROTECTORS AT MAIN FRAME AND CABLE TERMINAL. PR. #17 TEL. CABLE TERM. OUTSIDE WALL	EXT. 246
B	PROTECTORS & SIMPLEX COIL LOCATED ON NORTH WALL INSIDE SUPPLY OFFICE	
C	PROTECTORS ON EAST WALL COMMUNICATIONS SHACK WIRE BURIED ALONG CONNECTING ROAD	EXT. 135
D	BRIDGING TERMINAL PR. #6 LOCATED ON TREE, INTERSECTION ROADS X & Y	EXT. 274
E	PROTECTOR WEST WALL CONTROL SHACK	EXT. 175

REAR

FIGURE 41.—*Sample circuit layout card.*

or between stations. This analysis should be made before leaving the repair facility. When simplexed or phantomed circuits are used a check of the condition of the associated telephone line will often locate a trouble in a line or eliminate that portion of the circuit from consideration.

The remaining paragraphs in this section will be devoted to suggestions for the recognition and location of the more common troubles. Voltmeters, milliammeters, telephone test receivers, neon test lamps, ohmmeters, multimeters, Wheatstone bridge sets and buzzer sets will all be useful—but a thorough knowledge of the circuit is the best test tool.

67. Localization of Trouble. Reported troubles can generally be recognized as falling into either of two classes—those readily associated with the local equipment or those which may require further analysis to identify. The first class will include troubles such as failure to print a character, failure of a function, motor doesn't run, etc. The second class includes all other trouble which may interfere with circuit operation. A preliminary analysis carried out with the assistance of the operating personnel will generally localize this type to a particular line section or station.

When a machine is reported running open have the reporting operator check the line current at the milliammeter of the line control unit or switchboard. A normal line current generally indicates that the trouble is at the reporting station. If a WE–255–A Line Relay is in use at the reporting station have the operator set up a local test (par. 63). A machine running open on local test indicates that the trouble is at the reporting station.

If a positive indication of trouble is not obtained by the test of the preceding paragraph contact the operator of the station supplying battery to the line. If that station is running open, a battery supply trouble or an open line is indicated and may be localized as directed in figure 42. If the station supplying battery to the line is running closed have the operator check line current then attempt to establish teletype communication with the other stations on the circuit. When some of the machines on the circuit are running closed and some open, a ground, or a short circuit may be indicated. These troubles can be recognized and localized as explained in figures 43 and 44.

68. Localizing Trouble as Mechanical or Electrical. Troubles which have been localized to the station may be further localized into a particular part of the station equipment and into an electrical or mechanical trouble.

The LINE jacks and power supply at a station using a WE–255A line relay or the COQ–23403 Line Control Unit may be eliminated from the circuit by transferring the red and black plugs to the TEST RED and BLACK jacks of the electrical service assembly.

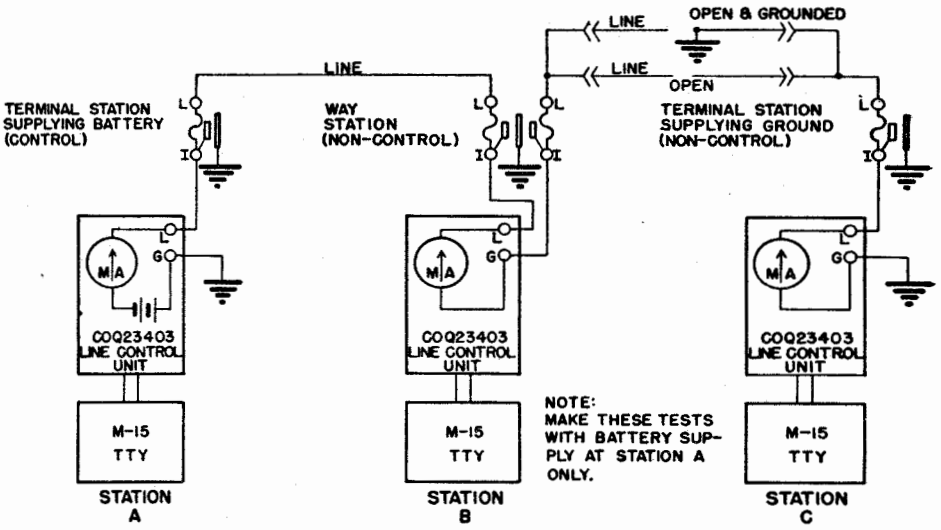
If the machine runs *open* on completion of the aforementioned test a simple check can be made to determine whether the trouble is electrical or mechanical. Hold the selector magnet armature operated. If the machine continues to run *open* the trouble is mechanical, if it runs *closed* and the armature returns to spacing when released the trouble is electrical.

69. Mechanical Trouble Analysis. Location of a mechanical trouble, not immediately apparent, can readily be determined by applying the *Operations Performance Test* described in paragraph 38. When the trouble has been localized to a particular function or unit, it is usually helpful to operate the motor switch to OFF and rotate the main shaft slowly by means of a handwheel (tool) or by manually rotating the motor, thus allowing observation of the operation of the machine or a particular function in "slow-motion." *Before making any readjustment always be reasonably certain that the particular adjustment is the cause of the trouble. Once a readjustment has been made the related adjustments must be checked.* It is bad practice to make adjustments from memory—better to refer to the *Teletype Manual.*

70. Electrical Trouble Analysis. An electrical trouble should be localized into one of the five electrical circuits of the machine, namely: Motor, Line, Relay Bias, Selector Magnet, or Selector Magnet Shunt. Having determined the circuit involved, make a methodical point to point check referring to wiring diagram WD2143A furnished in the *Teletype Manual.*

NOTES

1. ALL STATIONS ON THE CIRCUIT WILL RUN OPEN.
2. THE LINE CURRENT INDICATION ON THE METERS OF COQ23403 LINE CONTROL UNITS AND BD–100 SWITCHBOARDS WILL BE ZERO.
3. PRELIMINARY TESTS MAY BE MADE WITH THE ASSISTANCE OF THE STATION OPERATORS IN THE FOLLOWING MANNER AND ORDER.
   a. CHECK BATTERY SUPPLY AT STATION A. THE VOLTMETERS AT BD–100 SWITCHBOARDS AND COQ23403 LINE CONTROL UNITS MAY BE USED FOR THIS TEST. AT STATIONS USING A WE255A LINE RELAY HAVE THE OPERATOR CONNECT THE MACHINE FOR LOCAL TEST (PARAGRAPH 63 OF TEXT). IF THE MACHINE RUNS CLOSED UNDER THIS CONDITION THE BATTERY SUPPLY CAN BE ASSUMED CORRECT.
   b. MOMENTARILY GROUND THE I OR L TERMINALS OF THE PROTECTORS AT STATIONS A, B, AND OTHER WAY STATIONS, IN THAT ODER. WHENEVER THE MACHINES BETWEEN THE BATTERY SUPPLY AND THE TESTING POINT RUN CLOSED THE TROUBLE IS ELECTRICALLY BEYOND THE TEST POINT.

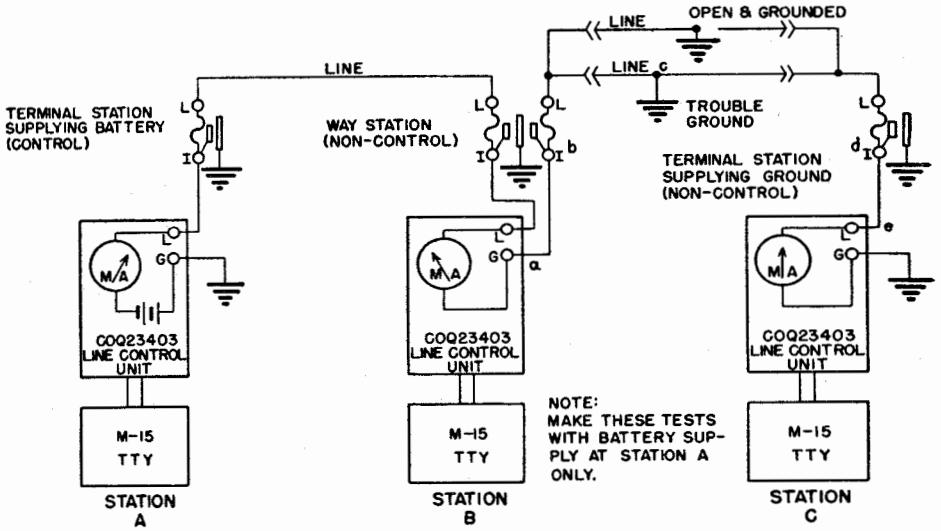


4. WHEN A TROUBLE HAS BEEN LOCATED BETWEEN TWO STATIONS HAVE THE OPERATORS CHECK OR REPLACE THE PROTECTOR FUSES.
5. THE REPAIRMAN MAY TEST FOR THE TROUBLE BY GROUNDING THE LINE THROUGH A VOLTMETER, AMMETER, TEST TELEPHONE RECEIVER OR NEON TEST LAMP. BETWEEN THE STATION SUPPLYING BATTERY AND THE TROUBLE AN INDITION OF CURRENT OR VOLTAGE WILL BE GIVEN BY THE TEST GEAR.

FIGURE 42.—*Open-circuit trouble on ground return circuit.*

NOTES

1. ALL STATIONS BETWEEN THE BATTERY SUPPLY AND THE TROUBLE WILL RUN CLOSED. ALL STATIONS ELECTRICALLY BEYOND THE TROUBLE WILL RUN OPEN.
2. THE LINE CURRENT MEASURED AT ALL STATIONS BETWEEN THE BATTERY SUPPLY AND THE TROUBLE MAY BE HIGHER THAN NORMAL. THE LINE CURENT READING AT ALL STATIONS ELECTRICALLY BEYOND THE TROUBLE WILL BE AT OR NEAR ZERO.
3. WHEN A TROUBLE REPORT INDICATES A STATION RUNNING OPEN CHECK THE CONDITION OF THE STATION SUPPLYING BATTERY TO THE LINE. IF THAT STATION IS RUNNING CLOSED REQUEST THE OPERATOR TO CONTACT THE OTHER STATIONS ON THE LINE. IF THE OPERATOR CAN CONTACT SOME STATIONS ON THE CIRCUIT AND NOT OTHERS THE TROUBE MAY BE LOCATED BETWEEN THE LAST STATION CONTACTED (RUNNING CLOSED) AND THE NEAREST STATION NOT CONTACTED (RUNNING OPEN).



4. WHEN A TROUBLE HAS BEEN LOCATED BETWEEN TWO STATIONS, HAVE THE OPERATOR AT THESE STATIONS ATTEMPT TO CLEAR THE GROUND TEMPORARILY BY REMOVING THE PROTECTOR CARBONS.
5. THE REPAIRMAN MAY TEST FOR TROUBLE BY CONNECTING A MILLIAMMETER, TEST RECEIVER OR NEON LAMP IN SERIES WITH THE LINE. BETWEEN THE BATTERY SUPPLY AND THE TROUBLE AN INDICATION OF CURRENT FLOW WILL BE GIVEN. ELECTRICALLY BEYOND THE TROUBLE LITTLE OR NO INDICATION OF CURRENT FLOW WILL BE GIVEN BY THE TEST GEAR.

FIGURE 43.—*Grounded-circuit trouble on ground return circuit.*

NOTES

1. IF THE TROUBLE IS NOT AT A TERMINAL STATION SUPPLYING BATTERY TO THE LINE THE STATION IN TROUBLE WILL RUN OPEN AND ALL OTHER STATIONS WILL RUN COSED.
2. IF THE TROUBLE IS AT THE TERMINAL STATION SUPPLYING BATTERY TO THE LINE THAT STATION WILL RUN CLOSED AND ALL OTHER STATIONS WILL RUN OPEN.
3. THE MILLIAMMETERS AT ALL STATIONS RUNNING OPEN WILL READ AT OR NEAR 0 AND THE MILLIAMMETERS AT ALL STATIONS RUNNING CLOSED WILL READ A HIGHER THAN NORMAL CURRENT.

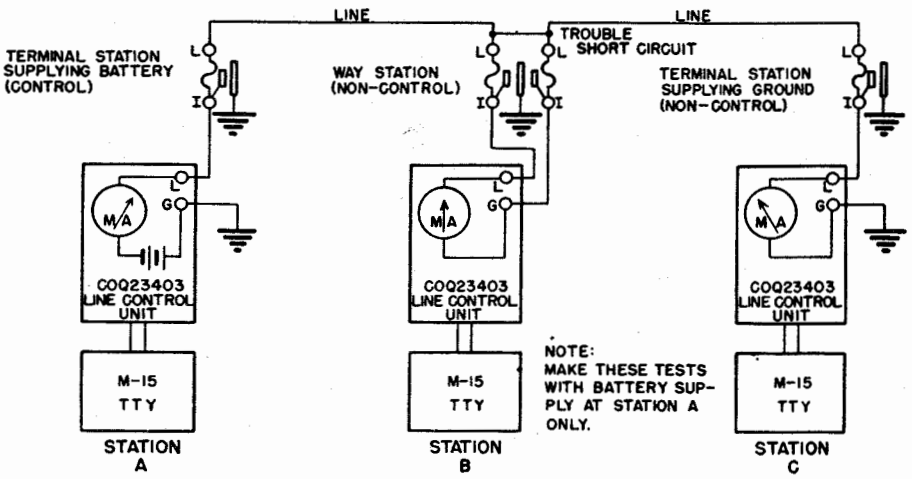


FIGURE 44.—*Short circuit in the ground return circuit.*

The following are suggestions for shooting trouble in each circuit with the machine connected for local test. The associated short schematics should prove helpful in making point to point checks. A neon test lamp and a multimeter will be extremely useful when attempting to locate electrical trouble. The location of the various base contacts referred to in the tests and drawings are shown in figure 45.

Motor Circuit (fig. 46). If the motor fails to start, check that it is receiving power. (Turning on the target lamp is a convenient power check.) If the machine has Remote Motor Stop, be sure it is in the unoperated position. Test for short or open, then make point to point check.

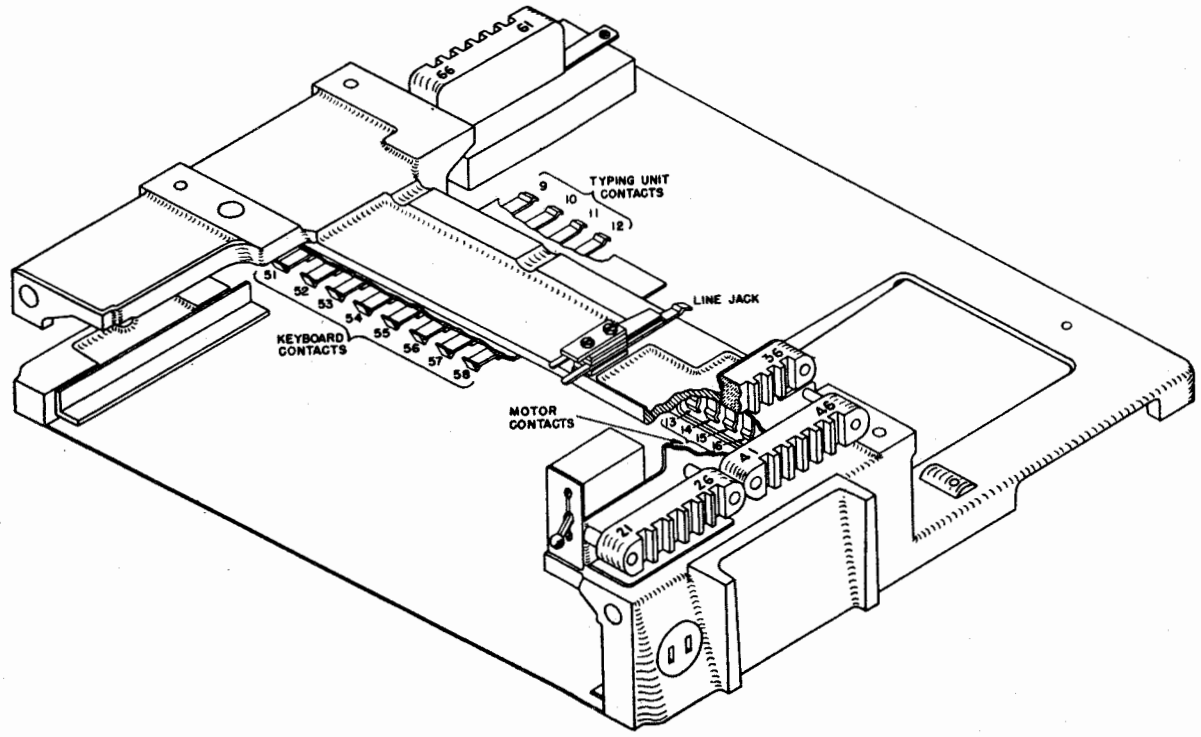


FIGURE 45.—*Terminal strip and base contact location, M–15 Teletypewriter.*

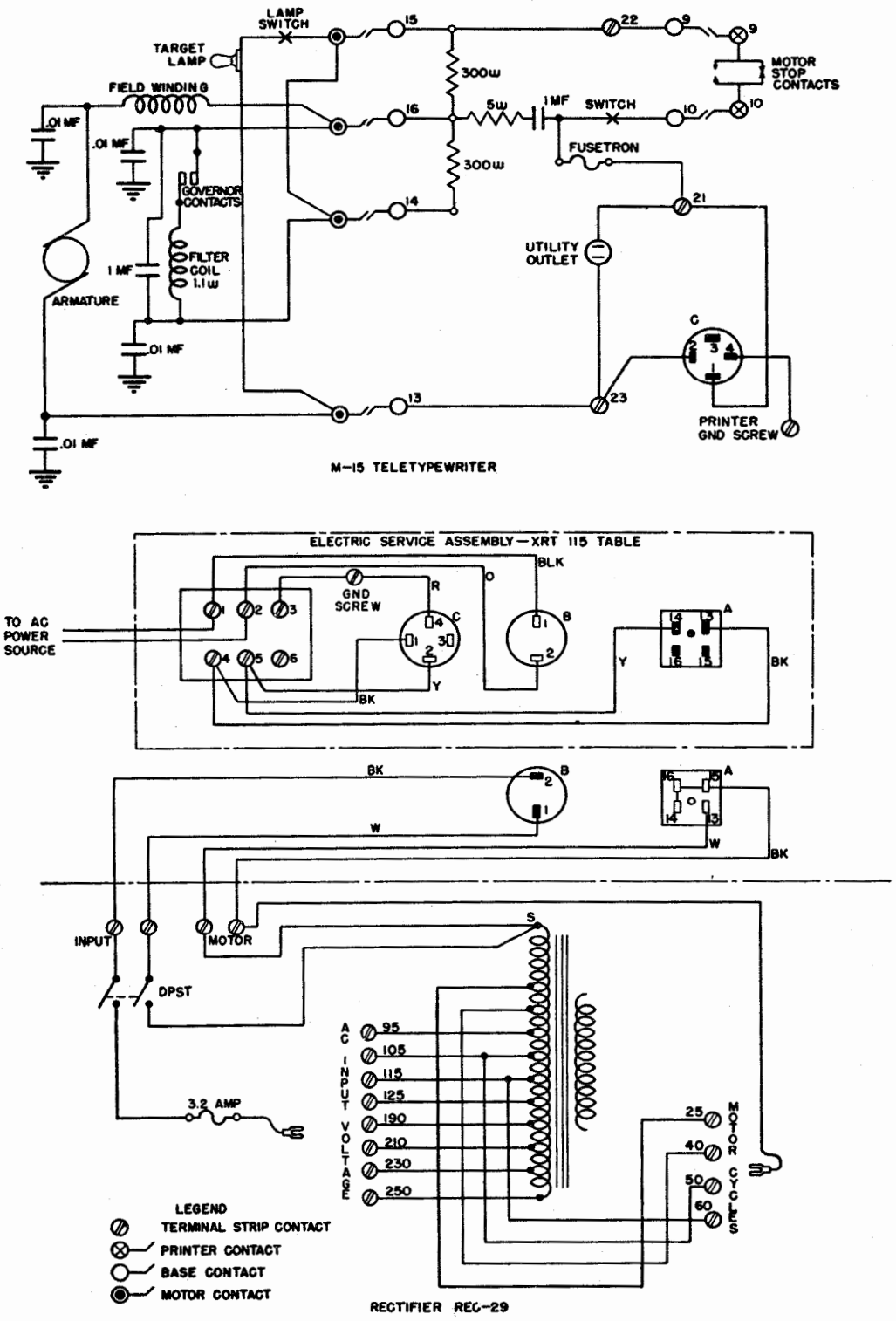


FIGURE 46.—*Motor circuit for series governed motor.*

Selector Magnet and Local Line Circuit. These circuits are closely interrelated, and a trouble in one circuit manifests itself in a manner which is common to both circuits. If the machine runs open, manually hold the selector armature in the marking position, switch off the motor and allow the machine to stop. In this position the selector magnet armature should be controlled electrically by the line relay and on local test both relay and armature should be marking. If, in this condition, the selector armature does not bind and is not held operated electrically to marking there is trouble in the selector magnet or local line circuit.

If the machine is using the WE–255–A Relay, remove the relay cover and check the relay armature. If the armature is on the marking contact the trouble is in the selector magnet circuit (fig. 47) and it should be checked for a short or open. If the armature is on the spacing contact the trouble is in the local line circuit (fig. 48) and a point to point check of that circuit should be made. Where no electrical trouble is found in either of these circuits a check of the Line Relay adjustments will usually reveal the trouble.

If the machine runs closed but cannot print, at a station using the WE–255–A Relay, watch the relay armature while typing on the key board. No movement of the armature indicates a local line circuit trouble (fig. 48); normal operation of the armature indicates a selector magnet circuit trouble (fig. 47).

In the case of a station using a COQ–23403

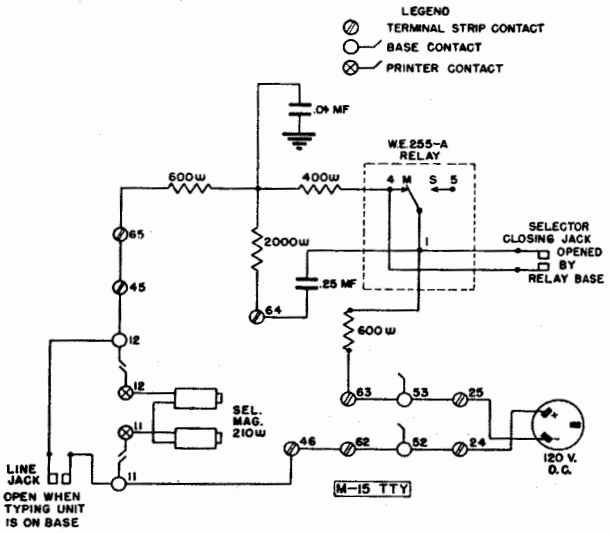


FIGURE 47.—*Selector magnet circuit using W. E. 255–A Relay.*

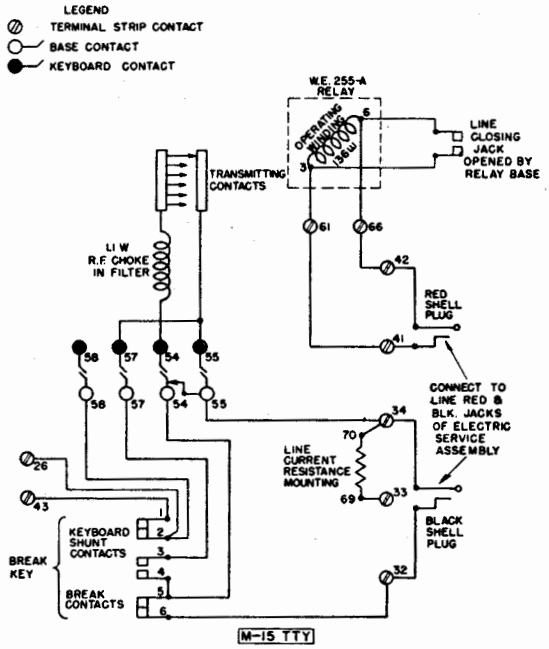


FIGURE 48.—*Line circuit using WE–255–A Relay.*

Line Control Unit, if the trouble has already been determined to be at the station and the machine is running open, segregation to one of the circuit components can readily be accomplished. The current and voltage indications obtained with the line control unit meter are the first testing tool. These indications usually have the following significance:

1. No voltage—d-c power failure.
2. No current, normal voltage—trouble in local line circuit.
3. Normal current, normal voltage—trouble in Selector Magnet circuit.

The trouble can be further isolated to either the teletypewriter or the line control unit in the following manner:

1. When the meter analysis indicates a local line circuit trouble (2 above) the black plugged cord should be removed from the line control unit. If the machine continues to run open the trouble is in the line control unit. If the machine runs

closed the trouble is in the transmitting contact circuit of the teletypewriter (fig. 49).

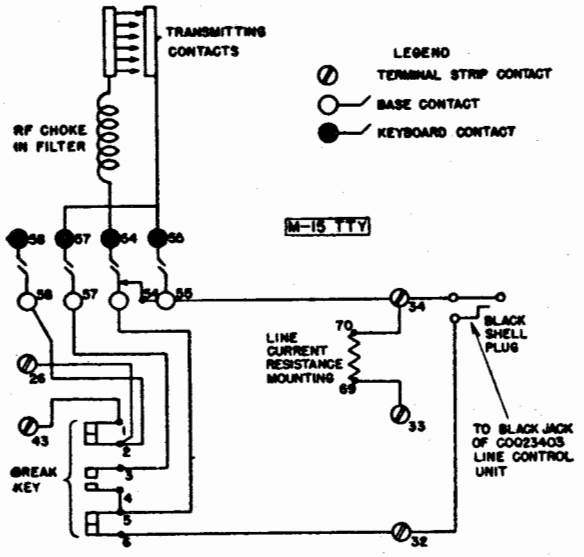


FIGURE 49.—*Transmitting contact circuit using COQ–23403 Line Control Unit.*

2. When the meter analysis indicates a selector magnet circuit trouble (3 above), transfer the red plugged cord from the RED jack of the line control unit to the TEST RED jack of the XRT–115 Table. If the machine continues to run open, the trouble is in the selector magnet circuit of the teletypewriter (Fig. 50). If the machine runs closed, the trouble is in the line control unit.

If the trouble has been determined to be in the line control unit, further analysis can be made.

1. When previous analysis has indicated a local line circuit trouble, operate the relay control switch to RELAY OUT OF CIRCUIT. If the machine runs *closed*, the trouble is in either the WU–41–C Relay winding or the relay control switch. Further analysis must be made by point-to-point check. If the machine continues to run *open* the trouble is in the *line rheostat* or other line circuit portions of the unit and must be analyzed by point-to-point check.

2. If previous analysis has indicated a selector magnet circuit trouble in the line control unit, reduce the tension on the armature spring of the WU–41–C Relay (turn adjusting knob in clockwise direction). If the teletypewriter runs closed before all of the tension has been removed, the need for a readjustment of the line relay is indicated. If the teletypewriter continues to run open after all of the tension has been removed, a line control unit circuit trouble or a relay trouble is indicated. Before removing the relay from the circuit operate the relay switch to RELAY OUT OF CIRCUIT.

If the station is equipped with a COQ–23403 Line Control Unit and the machine is running *closed* but cannot print, watch the ammeter while typing on the keyboard. Fluctuation of the meter needle indicates trouble in the Selector Magnet circuit (fig. 50) a constant meter reading indicates that the transmitting contact circuit (fig. 49) is shorted.

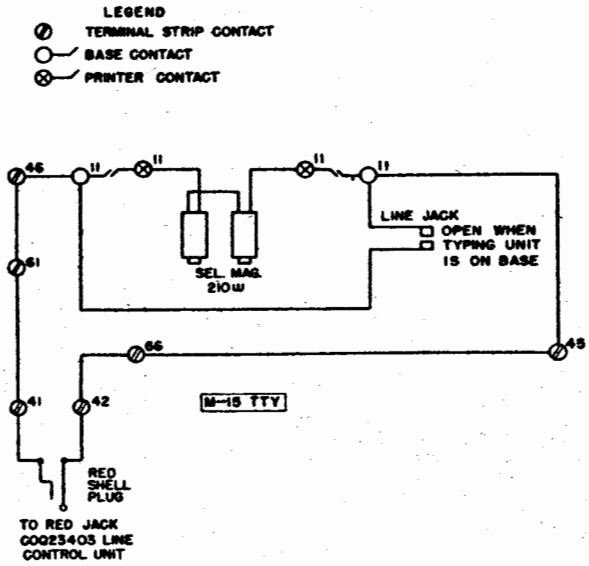


FIGURE 50.—*Selector magnet circuit using COQ–23403 Line Control Unit.*

WE–255–A Relay Bias Circuit (fig. 51). Check the WE–255–A Relay Armature. On local test with the line closed the relay should be on MARKING. Upon operation of the BREAK key, the relay armature should move to SPACING. Failure to move to SPACING may be due either to electrical or mechanical causes. If a spare relay is available place it in

the machine. If trouble persists, check the circuit with a multimeter or voltmeter. Voltmeter reading across the relay mounting terminals (2–7) with the relay removed should be 120 volts d-c.

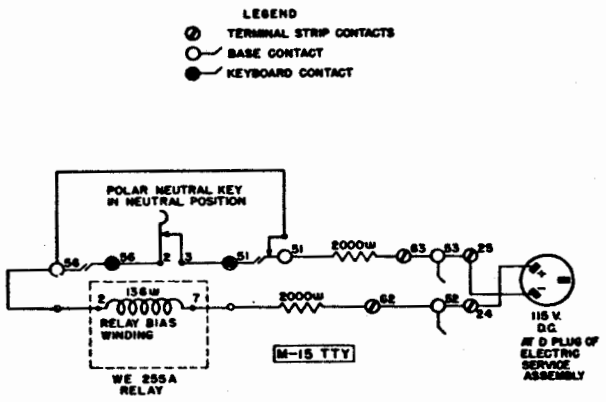


FIGURE 51.—*Bias circuit M–15 Teletypewriter using WE–255–A Relay.*

A common source of trouble in the bias circuit is the *push-pull, polar-neutral* key mounted at the front of the keyboard unit. This key may be operated to the *push* or *polar position* by someone unfamiliar with the machine, or it may be accidentally operated by the maintenance man when replacing the cover of the printer. This possibility should not be overlooked when searching for trouble.

WE–255–A Relay Selector Magnet Shunt Circuit (fig. 52). This circuit does not directly affect the operation of the machine since its only purpose is to keep the load on the rectifier constant whether the relay is on the marking or spacing contact. Trouble is located in this circuit only by a point to point check. On the semiannual routine this circuit should be checked for electrical continuity.

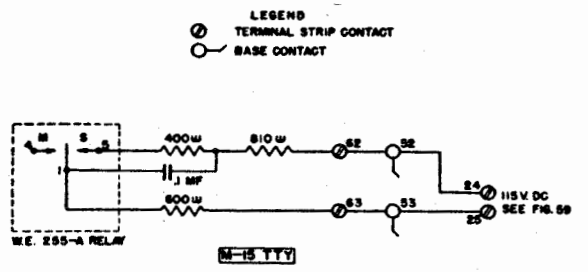


FIGURE 52.—*Selector magnet shunt circuit using WE–255–A Line Relay Used.*

71. Trouble-Shooters' Guide. The following list is intended as a useful guide to the newcomer and as a reference for the experienced hand. It does not list all the causes for any particular trouble but does cover the more likely ones.

(*a*) *Motor fails to start:*

1. Blown fuse in power sources.
2. Power plug out of socket.
3. Blown fuse in teletypewriter.
4. Open right hand motor-stop contact.
5. Open in motor circuit.
6. Motor-stop mechanism fails to release.
7. (Governed motor) Governor contacts dirty or not making contact.

NOTE.—If motor starts but speed cannot be regulated check governor contacts.

(*b*) *Machine runs open:*

1. Line circuit open.
2. Line current reversed.
3. Rectifier output fuse blown.
4. Magnet circuit open.
5. Line relay contacts dirty.
6. Selector trip-off out of adjustment.
7. Base and typing unit clips not making contact (terminals 11 and 12).
8. Main shaft clutch throw-out lever binding.

(*c*) *Machine runs closed—cannot print:*

1. Bias circuit reversed.
2. *Polar-neutral* key in *polar* position.
3. SEND-REC key in REC position.
4. Short in transmitting contacts.
5. Cross between (1–4) of WE–255A Line Relay.
6. Contacts of short-circuiting jack of table, line unit or jack board fail to open or are short-circuited.
7. Selector trip-off eccentric out of adjustment.
8. Selector armature binding on pivot screws.

(*d*) *Machine prints—has no range:*

1. Incorrect motor speed.
2. Range-finder indicator slipped below range setting.
3. Insufficient line current.
4. Insufficient or no bias current.
5. Line relay out of adjustment.

6. Line relay contacts dirty.
7. Armature link out of adjustment.
8. Armature bracket out of adjustment.
9. Armature locking wedge out of adjustment.
10. Armature stops out of adjustment.
11. Magnet bracket out of adjustment. (Too close or too wide.)
12. Bell crank or bell cranks out of adjustment.
13. Bind in selector vanes.
14. Bind in swords.
15. Bind in T levers.
16. Bind in code bars.
17. Printing-bail adjusting screw out of adjustment.
18. Clearance between function levers and vanes improper.
19. Selector-cam sleeve worn (tips of cam).
20. Selector-cam friction clutch tension.
21. Selector trip-off mechanism worn or binding.

(*e*) *Machine prints scrambled letters or occasional errors in transmitting or receiving:*

1. Check according to paragraphs (c) or (d).

(*f*) *Machine prints—does not shift or unshift, or letters and figures do not line up:*

1. Figures and letters stop screw.
2. Shift detent out of adjustment.
3. Shift stop post out of adjustment.
4. Platen unit pilot screws out of adjustment.
5. Shift link turnbuckle.
6. Figures or letters function levers.
7. Figures or letters function lever spring broken or missing.
8. Function bail blade broken or chipped.

(*g*) *Machine prints—does not line-feed properly:*

1. Single-double line-feed detent.
2. Pressure-roller release shaft arm operated.
3. Line-feed detent lever.
4. Line-feed link turnbuckle.
5. Line-feed check screw.
6. Line-feed check post stop screw.
7. Line-feed check lever.
8. Pressure-roller release cams adjustment.
9. Function bail blade broken or chipped.
10. Line-feed function-lever spring broken or missing.

(*h*) *Machine prints—fails to space properly:*

1. Spacing escapement pawls operating arm.
2. Spacing-shaft lower bearing bracket adjustment.
3. Spacing rack.
4. Lock-bar joint adjustment.
5. Carriage-return lock-bar latch.
6. Blocking of function-lever bail.
7. Left margin adjusting screw.
8. Right margin adjusting screw.
9. Spacing-lever stop bracket.
10. Space function-lever spring broken or missing.
11. Carriage guide screw binding.
12. Carriage support rollers binding.

(*i*) *Machine prints—fails to carriage-return correctly:*

1. Carriage-return draw-strap unhooked or broken.
2. Carriage-return drum spring broken, unhooked, or weak tension.
3. Spacing-shaft lower bracket bearing adjustment.
4. Spacing-racket adjustment.
5. Carriage-return latch-bar latch.
6. Carriage-return lock-bar latch eccentric screw.
7. Carriage-return shoulder stud screw.
8. Lock-bar slide joint adjustment.
9. Carriage-return operating-lever stop screw.
10. Carriage-return operating-lever spring broken or missing.
11. Carriage guide screws.
12. Carriage support rollers binding.
13. Function bail blade chipped or broken.
14. Carriage-return function-lever spring broken or missing.
15. Carriage-return reset bar spring broken or missing.

(*j*) *Machine cannot send:*

1. SEND-REC key in REC position.
2. Transmitting contacts shorted.
3. Keyboard incorrectly inserted in base.
4. Transmitting-shaft gear not engaging main-shaft gear.
5. Transmitting shaft binds.
6. Universal bar binds.
7. Trip-off pawl spring broken or missing.
8. Trip-off adjustments of keyboard.

(*k*) *Machine runs and prints correctly—ribbon does not reverse:*

1. Reversing eyelets missing from ribbon.
2. Ribbon-reverse shafts.
3. Ribbon-reverse shafts collars.
4. Ribbon-reverse shaft link.
5. Ribbon-reverse pawl springs (broken or missing).

(*l*) *Machine operates correctly—ribbon does not oscillate or remains motionless.*

1. Ribbon-feed shaft bearing plates.
2. Ribbon-feed shaft detent spring.
3. Vertical ribbon-feed shafts.
4. Ribbon-spool brackets.
5. Ribbon-spool shaft spur gears.
6. Vertical ribbon-feed shaft spring tension.
7. Ribbon-spool cups.
8. Vertical ribbon-feed shaft.
9. Ribbon-lock-out bar for operated position.
10. Ribbon-shift lever bracket.
11. Lock-out bar and ribbon-oscillator levers not in respective slots.
12. Ribbon-oscillator lever adjustment.
13. Ribbon lock-out bar adjustment.

(*m*) *Machine runs—letter "S" prints but signal bell does not operate:*

1. Sixth vane.
2. Bell function-lever spring missing or broken.
3. Function-bail blade chipped or broken.
4. Signal-bell hammer spring broken or missing.
5. Signal-bell latch-bar latch.
6. Signal-bell hammer back-stop.
7. Signal-bell operating lever spring.

(*n*) *Machine runs—signal bell operates but letter "S" does not print:*

1. Sixth vane.
2. Signal-bell latch-bar latch.
3. Function-lever bail blocking plate.
4. Signal-bell reset bar spring broken or missing.

(*o*) *Machine runs—left margin uneven or letters not properly spaced:*

1. Right margin-adjusting screw.
2. Dashpot vent screw.
3. Spacing rack.
4. Dashpot-lever spring broken or missing.
5. Carriage-return lock-bar latch.

(*p*) *Machine runs—more or less than 72 characters per line:*

1. Left margin screw.
2. Right margin screw.
3. Spacing-stop lever bracket.

(*q*) *Machine runs—margin bell does not operate on 66th character:*

1. Margin-bell cam.
2. Margin-bell hammer.
3. Margin-bell hammer spring broken or missing.
4. Margin-bell pawl spring broken or missing.

(*r*) *Machine runs and prints correctly—remote motor stop does not operate:*

1. Sixth vane.
2. Motor-stop lever bracket.
3. Motor-stop lever eccentric.
4. Motor-stop lever backstop screw.
5. Motor-stop pawl backstop.
6. Motor-stop release lever.
7. Motor-stop pawl spring broken or missing.
8. Motor-stop lever spring broken or missing.
9. Motor-stop contact lever spring broken or missing.
10. Motor-stop backstop screw adjustment.
11. Motor-stop left and right contacts.
12. Motor-stop function-lever spring broken or missing.
13. Function-bail blade chipped or broken.

IX. MAINTENANCE OF BD-100 SWITCHBOARD

72. General. Maintenance of the BD–100 Switchboard is generally confined to occasional bias adjustment of the repeater relays (par. 56). This work, as well as the replacement of burned out lamps and fuses, may be done by the operating personnel. However, any electrical troubles, and the adjustment of relay contacts, keystrips and keys should be handled only by qualified maintenance personnel. The equipment should always be handled carefully, the specified voltage and current values should be adhered to closely and attention should be given to installation of lines and grounds. *A high percentage of communication failure is caused by faulty lines and grounds.*

73. Repeater Relay BK–27–A. This unit consists of two individual relays, local and line, mounted on a common base and enclosed in a metal cover. The unit is equipped for plug and jack mounting to permit rapid replacement. A relay which in operation cannot be adjusted to meet a specific line condition or fails otherwise to function properly should be replaced with a known good relay. If the circuit will then function properly the replaced relay should be readjusted. War Department Technical Manual TM 11–358 provides a method of adjustment but has been superseded by the method explained in this paragraph. Adjustment of the relay at a repair facility is preferable.

Never use a file or a contact burnisher on the relay contacts. The contact material is hard enough to scrape particles from these tools. Such particles may cause relay trouble. If excessive contact pitting exists, remove the contact screws and contact springs and dress the contact points on a carborundum stone.

To completely readjust the relay refer to figure 53 and proceed as follows: Note—*All adjustments must hold after the locking nuts are secured. After completing each adjustment check the related adjustments.*

A. Remove the cover by removing the four corner screws from the back of the unit, then pressing on the two adjusting knobs until the cover slides off.

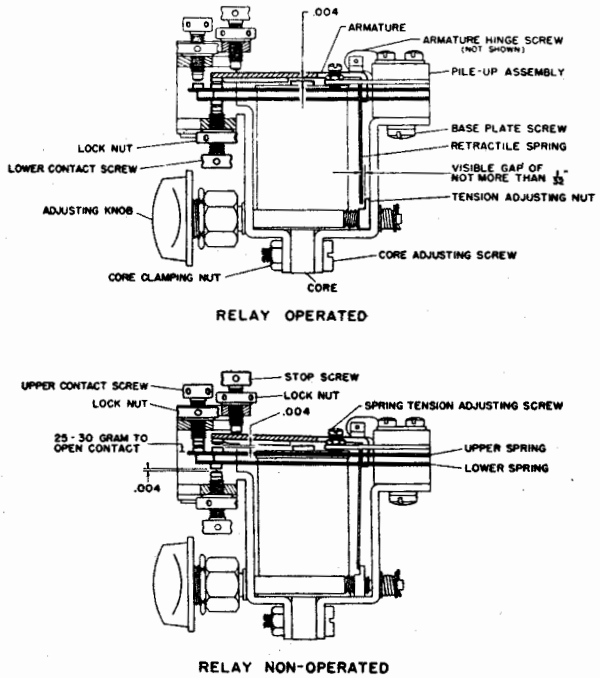


FIGURE 53.—*Relay BK–27–A adjustment drawing.*

B. Rotate the adjusting knob to the extreme marking (clockwise) position. Remove the armature hinge screws, being careful not to lose the ball-bearings seated at the tips of the screws. Clean the ball-bearings and their seats with a small amount of carbon tetrachloride. A toothpick will prove useful for cleaning the bearing seats. Replace the bearings, armature hinge screws, and lock nuts. The armature, after adjustment, should be centered and able to move freely with little or no side play.

C. All contact points should be in line. Adjust by loosening the contact pile-up assembly base plate screws and shifting the contact pile-up assembly base plate.

D. The armature, when held lightly against the core faces, should be parallel and flat on the core faces and the armature retractile spring should just touch the tension adjusting nut. To adjust:

1. Back all contact screws out of the way.
2. Adjust the armature by turning the core adjusting eccentric screws.
3. Adjust the armature retractile spring by bending.

E. With the relay armature held in its operated position the air gap between the armature and the core faces should be 0.004 inch. Adjust with the lower contact screw.

F. The auxiliary make contact gap should be 0.004 inch. The main make contact gap should be 0.004 inch. The break contact gap will not require adjustment. To adjust:

1. Turn the relay adjusting knob to the extreme spacing (counter-clockwise) position.
2. With the relay in its nonoperated position, adjust the upper contact screw until the auxiliary make contact gap (between the lower contact screw and the lower spring) is 0.004 inch.
3. Adjust the stop screw until the main make contact gap (between the armature and the upper contact spring) is 0.004 inch. The break contact gap is fixed by adjustment of the auxiliary and main make contact gaps.

G. With the relay nonoperated, the spring tension against the upper contact screw should be 0.9 to 1.1 ounces (25 to 30 grams), measured at the extreme end of the upper spring. Adjust this spring tension by the spring tension screw located on the pile-up assembly.

H. Tighten all screws, lock-nuts, mounting screws and nuts securely and recheck all adjustments.

74. Signal Relays (fig. 54) Readjust the signal relays only when absolutely necessary. Check adjustments carefully before changing them.

A. Set the armature travel to 0.045 inch (plus or minus 0.002 inch) measured from the residual rivet under the insulated stud to the top of the frame. To adjust, bend the armature slightly toward or away from the core.

B. Set the break contact so that both points are broken when the armature has traveled 0.015 inch (plus or minus 0.003 inch).

C. Set the make contact so that both points are made when the armature has traveled 0.025 inch (plus or minus 0.003 inch).

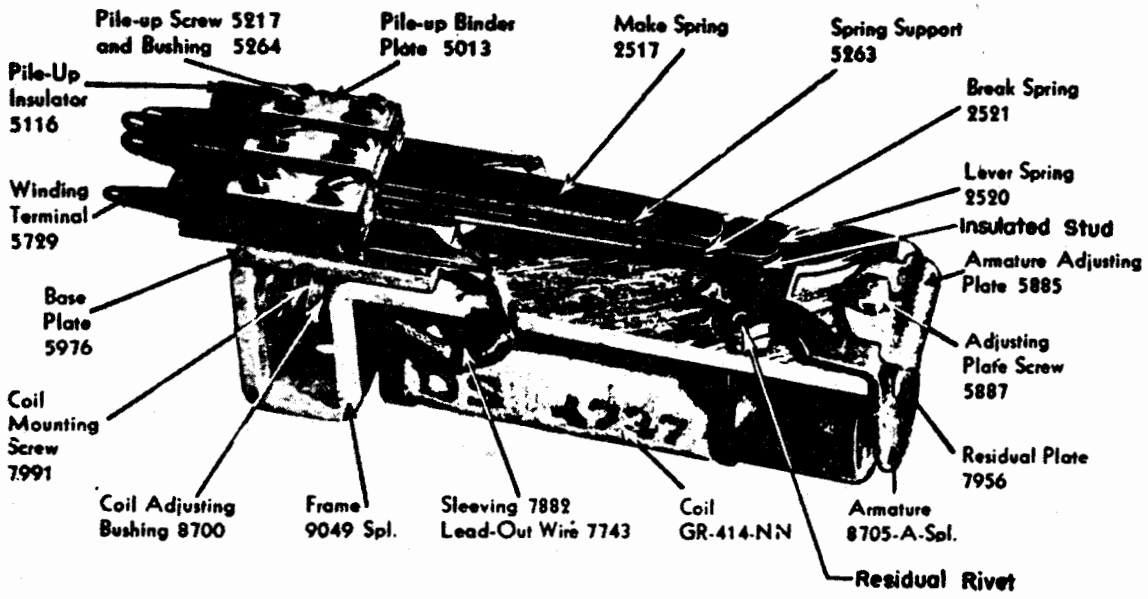


FIGURE 54.—*Signal relay BD-100 Switchboard.*

D. Adjust the tension of the lever spring to exert a pressure of 0.1 to 1.3 ounces on the insulated stud. This tension should be measured at the extreme end of the spring, with the break spring tension removed.

E. Test the relay in the switchboard by depressing the ANSWER key associated with the circuit in which the relay is operating. Have repeated *blank* signals sent from the distant printer. The armature should show no tendency to fall back to the spacing contact during these signals, each of which is the equivalent of a spacing signal 132 milliseconds in length.

75. Keystrips. The keystrips seldom require adjustment but when trouble is suspected the following requirements should be checked before attempting to readjust the keys. Use a flat-nose pliers or similar tool to make adjustments.

A. Line Current Keys:

1. Transfer contacts must make before break.
2. All contacts to have a minimum follow of 0.015 inch—that is, the moving contact should push the stationary contact a distance of at least 0.015 inch after making contact with it.
3. Make contacts of make-before-break combinations to make at least 0.015 inch before break contacts break.
4. Lever springs to rest on cam with a minimum pressure of 0.2 ounce (6 grams).

B. Line Open and Answer Keys:

1. Transfer contacts on left side of bottom row (blue) keys to break before make. All other transfer contacts including REL key contacts to make before break.
2. All contacts to have a minimum follow of 0.015 inch.
3. Break contacts of break-before-make combinations to break at least 0.015 inch before make contacts make.
4. Make contacts of make-before-break combinations to make at least 0.015 inch before break contacts break.
5. Lever springs to rest against cam with a minimum pressure of 0.2 ounce.

X. LUBRICATION AND CLEANING

76. General. The most important factor in maintenance of station equipment is proper lubrication and cleaning of the machine. Lubrication does not mean drenching the teletypewriter with oil or swabbing it with grease. Too much lubricant will in a short time, collect dust and grit and oilsoak the wiring. A machine in this condition will be subjected to excessive wear and deterioration of insulation. Such machines are a source of constant trouble as well as a fire hazard.

Always clean a teletypewriter before lubricating it. During the cleaning process the power should be disconnected except as otherwise stated. Old grease and dirt should be removed from around points where grease lubrication is specified with a KS–6320 orange stick or a piece of fiber. Avoid wiping old grease or dirt into wearing surfaces, as this makes it difficult or impossible for fresh lubricant to work its way in. Avoid disturbing the springs or adjustments. Troubles frequently develop as a result of careless cleaning or inspection.

A clean dry piece of cheesecloth should be used for cleaning. It may be wrapped around a screwdriver or orange stick to reach points not readily accessible. Always complete the cleaning of the machine before starting lubrication.

77. Cleaning of Type. Insert a doubled piece of cheese-cloth between the type bars and the backstop to catch the dirt and excess cleaning fluid. Clean the type thoroughly with a piece of cheese-cloth moistened with carbon tetrachloride. Use the cleaning fluid sparingly to avoid getting it on other parts of the machine. Then brush the type with a dry typewriter brush.

78. Cleaning of Selecting Mechanism. The code bar bearings, T lever pivots and the sword and selector lever assembly between the separator plates should be cleaned without disassembling. Pour over each assembly about a teaspoonful of carbon tetrachloride. Hold a rag underneath the mechanism during the cleaning process to catch the drippings. The cap of the carbon tetrachloride can usually is a convenient measure for the cleaning fluid.

79. Cleaning of Key Caps. Clean the key caps with a cloth slightly moistened with water. (Do not use carbon tetrachloride on rubber caps.)

80. Transmitting Contacts. The transmitting contacts should not be cleaned or filed unless there is definite evidence of keyboard trouble. To clean the contacts use a clean contact burnisher. If it becomes necessary to use a file, use only a few light strokes as the contact metal is very soft. After filing, wipe out the space between the springs with a piece of cheesecloth wrapped around a thin flat tool or piece of fiber, and burnish the contacts with a clean burnisher. If cleaning, filing, or burnishing is done a check of the adjustments *must* be made.

81. Motor-Stop Contacts. Clean with cheesecloth dampened with carbon tetrachloride then burnish the contacts.

82. Series Type Motors. (*1*) *Brushes:*

(a) In removing the brushes, note or mark the position so that the brush may be replaced in the same holder and with the same side upper-most. If the brush has a number stamped on the carbon, this may be used as a guide.

(b) There should be at least $\frac{5}{16}$ inch of brush material remaining. The surface bearing on the commutator should constitute a considerable portion of the brush face, and the contacting surface should extend across at least three-fourths of the long dimension of the brush face. If these requirements are not met, substitute a brush which has been properly surfaced as described in the next paragraph.

(c) A suggested method of shaping the brush face to the proper curvature is as follows:

1. Wrap a piece of No. 0000 sandpaper around a sector of the armature under the brush holder.
2. Place the brush in the holder with the numbered or marked side up, bearing against the sandpaper under the normal pressure of the brush spring.
3. Turn the armature (around which the sandpaper is wrapped) back and forth by hand until the brush surface has the proper curvature. The last turning of the armature should be in the normal direction of rotation.
4. Remove the brush and bevel the edges slightly with sandpaper.
5. Wipe off the brush with a piece of cheesecloth slightly moistened with carbon tetrachloride.
6. See that the pigtail inside of the brush spring is intact, free from kinks, and will allow the brush spring to extend properly.
7. Clean out the brush holder with cheesecloth moistened with carbon tetrachloride and wrapped around a screwdriver blade or KS–6320 orange stick.
8. The brush should be reinserted in the same brush holder and with the same side uppermost.
9. See that the brush moves freely in the brush holder. Check the pressure of the brush springs.

(2) *Commutator:*

(a) A smooth, even, chocolate brown coating of oxide on the commutator is a desirable condition, and the commutator should not be disturbed unless there is excessive sparking at the brushes.

(b) If there is excessive sparking, clean the commutator with cheesecloth moistened with carbon tetrachloride, turning the shaft over by hand with the brushes out.

(c) If there is still excessive sparking, remove the armature from the motor and check the segments for bad burns which will indicate a possible open winding. In the absence of burns, clean the commutator lightly with No. 0000 sandpaper. To do this, wrap a piece of sandpaper around the commutator and rotate the armature, holding the sandpaper lightly by hand. Do not attempt to remove any grooves or pits. If the commutator is grooved or pitted, arrange to change the motor. Blow out the cuttings and sand particles. Wipe the commutator with a piece of cheesecloth dampened with carbon tetrachloride. Drench the ball races and ball retainers with carbon tetrachloride and when dry apply a liberal coating of grease to the balls. If the operation of the motor is not satisfactory after conditioning the brushes and commutator replace the motor.

(d) Avoid touching the commutator surface after cleaning as grease and perspiration from the hands can cause commutator troubles.

(3) *Governors:*

(a) Brushes, Slip Rings, and Contact Disks:

1. Slip rings and contact disks may be cleaned with a piece of cheesecloth dampened with carbon tetrachloride. A smooth, even coating of oxide is a desirable condition, and should not be disturbed unless there is excessive sparking at the brushes.
2. Remove pits or burned spots from slip rings or contact disks with No. 0000 sandpaper held against the ring or disk with motor running at normal speed. A piece of cheescloth should be held with the sandpaper in such a way as to immediately wipe off the cuttings and particles.
3. There should be at least $\frac{3}{16}$ inch of brush material remaining for the slip-ring type, $\frac{3}{32}$ inch for the end-ring type.
4. To resurface brushes used with the slip-ring type of governor, hold a piece of No. 0000 sandpaper around a segment of the governor and rotate the governor back and forth. The last turn of the governor should be in the normal direction of rotation. Clean the brushes with a piece of cheesecloth dampened with carbon tetrachloride and see that they move freely in the brush holders.
5. Avoid touching the surface of slip rings or disks after cleaning as grease and perspiration from the hands can cause trouble.

83. Lubrication. The machine is ready for lubrication when it has been thoroughly cleaned and all cleaning fluid has been removed from

the parts. The lubrication should be in accordance with the following general instructions and at the particular points specified in the Teletype Corporation bulletin on adjustments and Teletype Corporation Specification S–5288 on lubrication. Apply an amount of lubricant just sufficient for each purpose. Wiping off excess oil or grease tends to work dirt and grit into bearing surfaces.

The Teletype Corporation specifies the use of KS7470 oil and KS7471 grease in the lubrication procedures. These materials will be generally available at teletype repair facilities. Lack of these, however, should in no way interfere with routine maintenance procedures. Any good grade of medium cup grease and a good quality SAE No. 10 non-paraffin base automobile crankcase oil will be satisfactory as substitute lubricants. Typewriter oil or "3 in 1" do not have sufficient body for teletype requirements and should never be used.

The Teletype Corporation instructions specify three types of lubrications: i. e., oil, grease, and oil-grease-oil. The term *oil-grease-oil* may be confusing but simply means to apply, oil, then grease, then oil, in that order to the specified location on a part.

An oil can having a spout at least three inches long and with the tip curved will be most useful for applying oil. Grease should be applied with a No. 88975 (KS–8319) grease gun, or, where that is not available by a tooth pick, screw driver blade or similar instrument.

When lubricating small parts apply only a single drop of oil. Two or three drops of oil should be sufficient at any point. Oil cups should be filled completely without overflowing. One stroke of a grease gun plunger should supply sufficient grease for any point. New felt washers and wicks should be thoroughly saturated in oil, then squeezed by hand to remove oil.

After the machine has been completely lubricated the selector magnet armature, the selector magnet core and the armature front and back stops should be cleaned. Draw a good grade of bond paper between the adjacent surfaces while they are held firmly together.

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