INSTALLATION • OPERATION • MAINTENANCE

# INSTRUCTIONS

# TYPE HKB RELAY, CARRIER CONTROL UNIT (TYPE JY) AND TEST EQUIPMENT



## APPLICATION

The type HKB relay is a high speed carrier relay used in conjunction with power line carrier equipment to provide complete phase and ground fault protection of a transmission line section. Simultaneous tripping of the relays at each line terminal is obtained in three cycles or less for all internal faults within the limits of the relay settings. The relay operates on line current only, and no source of a-c line potential is required. Consequently, the relays will not trip during a system swing or out-of-step conditions. The carrier equipment operates directly from the station battery.

## PRINCIPLE OF OPERATION

The HKB carrier relaying system compares the phase positions of the currents at the ends of a line-section over a carrier channel to determine whether an internal or external fault exists. The three-phase line currents energize a sequence network which gives a single-phase output voltage proportional to a combination of sequence components of the line current. During a fault, this single-phase voltage controls an electronic circuit which allows the transmission of carrier on alternate half-cycles of the power-frequency current. Carrier is transmitted from both line terminals in this manner, and is received at the opposite ends where it is compared with the phase position of the local sequence network output. This comparison takes place in the grid circuit of a vacuum tube. The polarities of the voltages to be compared are such that for an internal fault, plate current flows on alternate power-frequency half-cycles. A relay connected in the plate circuit of the vacuum tube operates under this condition to complete the trip circuit. During an external fault, the change in direction of current flow causes the plate current to be continuously blocked, and the plate circuit relay does not operate.

Since this relaying system operates only during a fault, the carrier channel is available at all other times for the transmission of other functions.

## PART I — TYPE HKB RELAY

**CAUTION** Before putting relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

## CONSTRUCTION

The relay consists of a combination positive, negative and zero sequence network, a saturating auxiliary transformer, two Rectox units, two polar relay units, a telephone-type relay, a neon lamp, contactor switch and operation indicator all mounted in a Type M-20 Flexitest Case.

When the standard projection case is supplied, the sequence network, tap plates, and saturating auxiliary transformer are mounted in a box which can be located on the rear of the switchboard panel in any convenient position. The remainder of the relay elements are mounted in the relay case proper. The taps and terminal numbers of the relay in the standard case and the external box correspond to those in the type FT case. (See Figures 1,

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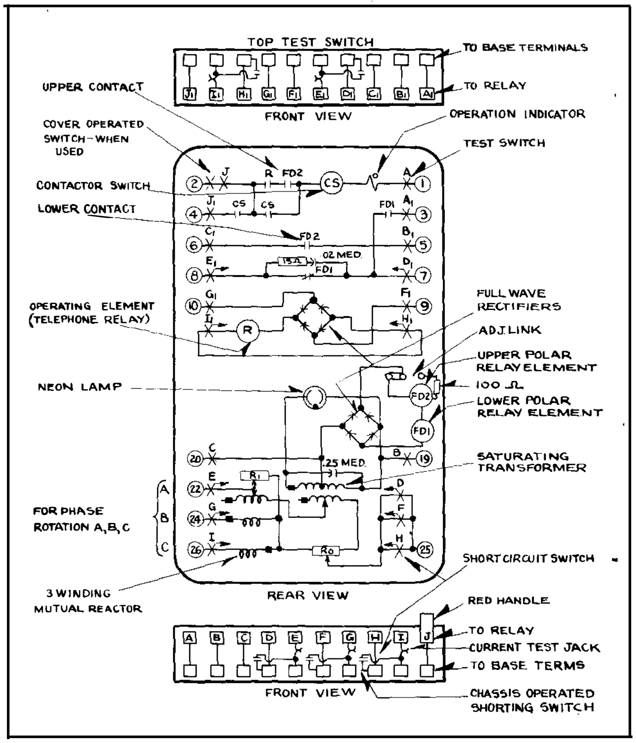



**Fig. 1—Internal Schematic Of The Type HKB Carrier Relay In The Type FT Case.**

2, and 3). Terminals 18, 19 and 20 of the external box are to be connected to the corresponding terminals of the relay in the standard case. Otherwise, all external connections for the relay in the standard projection case or in the type FT case are made to the same terminals.

Sequence Network

The currents from the current transformer secondaries are passed thru a network consisting of a three-winding iron-core reactor and two resistors. The zero-sequence resistor, $R_0$, consists of three resistor tubes tapped to obtain settings for various ground fault conditions. The other resistor $R_1$ is a formed single wire mounted on the rear of the relay sub-base. The output of this network provides a voltage across the primary of the saturating transformer.

The lower tap block provides for adjustment of the relative amounts of the positive, negative and zero sequence components of current in the network output. Thus, a single relay

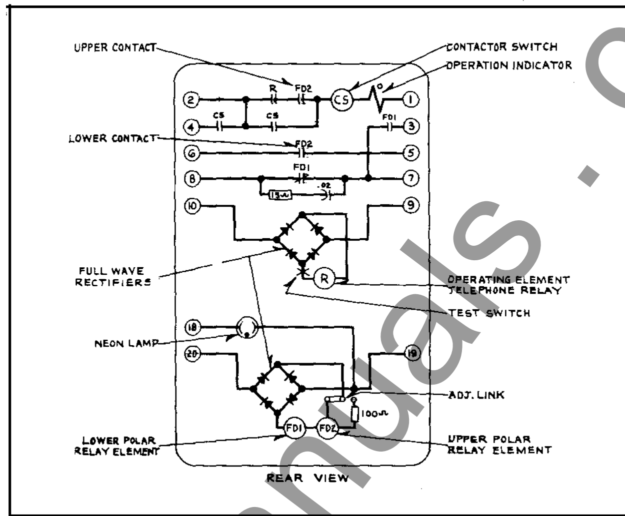



**Fig. 2—Internal Schematic Of The Type HKB Carrier Relay In The Standard Projection Case.**

element energized from the network can be used as a fault detector for all types of faults.

Saturating Auxiliary Transformer

The voltage from the network is fed into the tapped primary (upper tap plate) of a small saturating transformer. This transformer and a neon lamp connected across its secondary are used to limit the voltage impressed on the fault detectors (polar relay elements) and the carrier Control Unit, thus providing a small range of voltage for a large variation of maximum to minimum fault currents. This provides high operating energy for light faults, and limits the operating energy for heavy faults to a reasonable value.

The upper tap plate changes the output of the saturating transformer, and is marked in amperes required to pick up the lower fault detector element. For further discussion, see section entitled, "Settings".

Rectox Units

The secondary of the saturating transformer feeds a bridge-connected Rectox Unit, the output of which energizes the polar fault detector elements. A second Rectox, energized from the output of the Control Unit, supplies a d-c voltage to the telephone relay element which operates only for an internal fault. The use

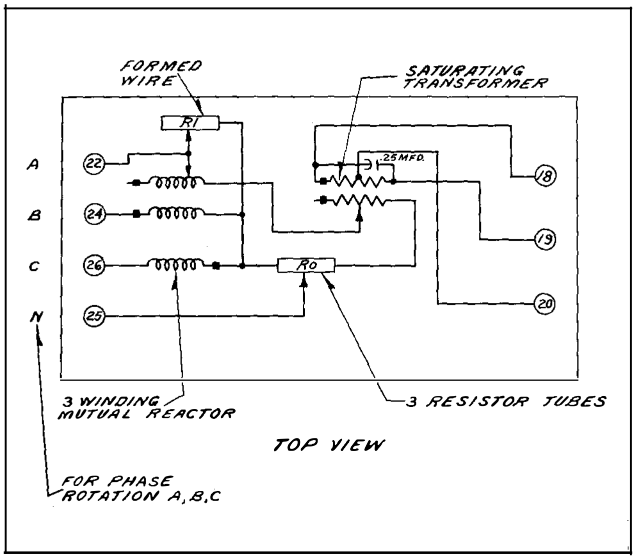



**Fig. 3—Internal Schematic Of The Sequence Network Used With The Type HKB Relay In The Standard Projection Case.**

of sensitive polar relay keeps down the energy required from the current transformers.

Polar-Type Relays

These elements consist of a rectangular shaped magnetic frame, an electromagnet, a permanent magnet, and an armature with a set of contacts. The poles of the permanent magnet clamp directly to each side of the magnetic frame. Flux from the permanent magnet divides into two paths, one path across the air gap at the front of the element in which the armature is located, the other across two gaps at the base of the frame. Two adjustable screw type shunts which require no locking screws are located across the rear air gaps. These change the reluctance of the magnetic path so as to force some of the flux thru the moving armature which is fastened to the leaf spring and attached to the frame midway between the two rear air gaps. Flux in the armature polarizes it and creates a magnetic bias causing it to move toward one or the other of the poles, depending upon the adjustment of the magnetic shunt screws.

A coil is placed around the armature and within the magnetic frame. The current which flows in the coil produces a magnetic field which opposes the permanent magnet field and acts to move the armature in the contact-closing direction.

Contactor Switch

The d-c contactor switch in the relay is a small solenoid type switch. A cylindrical plunger with a silver disc mounted on its lower end moves in the core of the solenoid. As the plunger travels upward, the disc bridges three silver stationary contacts. The coil is in series with the main contacts of the relay and with the trip coil of the breaker. When the relay contacts close, the coil becomes energized and closes the switch contacts. This shunts the main relay contacts thereby relieving them of the duty of carrying tripping current. These contacts remain closed until the trip circuit is opened by the auxiliary switch on the breaker. The contactor switch is equipped with a third point which is connected to a terminal on the relay to operate a bell alarm.

Operation Indicator

The operation indicator is a small solenoid coil connected in the trip circuit. When the coil is energized, a spring-restrained armature releases the white target which falls by gravity to indicate completion of the trip circuit. The indicator is reset from outside of the case by a push rod.

## RELAYS IN TYPE FT CASE

The type FT cases are dust-proof enclosures combining relay elements and knife-blade test switches in the same case. This combination provides a compact flexible assembly easy to maintain, inspect, test and adjust. There are six case sizes, designated as S10, S20, M10, M20, L10, L20. S refers to the small; M the medium; and L, the large size chassis frame. The numbers refer to the possible number of test switch positions 10 or 20.

To remove the chassis, first remove the cover which exposes the relay elements and test switches for inspection and testing Next open the elongated red handle switches.

These should always be opened first before any of the black handle switches or the cam action latches. This opens the trip circuit to prevent accidental trip out. Then open all the remaining switches. With all the switches fully opened, grasp the two cam action latch arms and pull outward. Using the latch arms as handles, pull the chassis out of the case. The chassis can be set on a test bench in a normal upright position as well as on its top, back or sides for easy inspection, maintenance and test.

After removing the chassis a duplicate chassis may be inserted in the case or the blade portion of the switches can be closed and the cover put in place without the chassis. The chassis operated shorting switch located behind the current test switch prevents open circuiting the current transformers when the current type test switches are closed.

When the chassis is to be put back in the case, the above procedure is to be followed in the reversed order. The elongated red handle switch should not be closed until after the chassis has been latched in place and all of the black handle switches closed.

The electrical circuits are as follows: Each terminal in the base connects thru a test switch to the relay elements in the chassis as shown on the internal schematic diagrams. The relay terminal is identified by numbers marked on both the inside and outside of the base. The test switch positions are identified by letters marked on the top and bottom surface of the moulded blocks. These letters can be seen when the chassis is removed from the case.

The potential and control circuits thru the relay are disconnected from the external circuit by opening the associated test switches. Opening the current test switch short-circuits the current transformer secondary and disconnects one side of the relay coil but leaves the other side of the coil connected to the external circuit thru the current test jack jaws. This circuit can be isolated by inserting the current test plug (without external connections), by inserting the ten circuit test plug, or by inserting a piece of insulating material approximately 1/32" thick into the current test jack jaws. Both switches of the current test switch pair must be open when using the current test plug or insulating material in this manner to short-circuit the current transformer secondary.

A cover operated switch can be supplied with its contacts wired in series with the trip circuit. This switch opens the trip circuit when the cover is removed. This switch can be added to the existing type FT cases at any time.

The relays can be tested in service, in the case but with the external circuits isolated or out of the case as follows:

For testing in service the ammeter test plug connected to suitable instruments, can be inserted in the current test jaws after opening the knife-blade switch to check the current thru the relay.

Voltages between the potential circuits can be measured conveniently by clamping #2 clip leads on the projecting clip lead lug on the contact jaw.

For testing in the case the ten circuit test plug can be inserted in the contact jaws, with all blades in the full open position. This connects the relay elements to a set of binding posts and completely isolates the relay circuits from the external connections by means of an insulating barrier on the plug. The plug is inserted in the bottom test jaws with the binding posts up and in the top test switch jaws with the binding posts down.

The external test circuits may be made to the relay elements by #2 test clip leads instead of the test plug. When connecting an external test circuit to the current elements using clip leads, care should be taken to see that the current test jack jaws are open so that the relay is completely isolated from the external circuits. Suggested means for isolating this circuit are outlined above.

For testing out of the case relay elements may be tested by using the ten circuit test plug or by #2 test clip leads as described above. The factory calibration is made with the chassis in the case and removing the chassis from the case will change the calibration values of some relays by a small percentage. It is recommended that the relay be checked in position as a final check on calibration.

## CHARACTERISTICS

The overall operating characteristic of the HKB relay and carrier equipment is shown in Figure 4. This shows the current in the operating relay element (telephone-type relay) plotted against the phase angle difference between the fault currents at opposite ends of the line. As indicated, the operating element will trip when the phase angle departs approximately 60° from the in-phase, or through fault condition. As the electronic control circuits operate under a saturated condition, the shape of this curve will not change materially over a wide range of fault currents.

The sequence network in the relay is arranged for several possible combinations of sequence components. For most applications, the output of the network will contain the positive, negative and zero sequence components of the line current. In this case, the taps on the upper tap plate indicate the balanced threephase amperes which will pick up the lower or carrier start fault detector (FD1). The upper polar element (FD2), which supervises operation of the telephone-type relay, is adjusted to pick up at a current 25 percent above tap value. The taps available are 3, 4, 5, 6, 7, 8, and 10. These taps are on the primary of the saturating transformer. For phase-to-phase faults AB and CA, enough negative sequence current has been introduced to allow the fault detector FD1 to pick up at 86% of the tap setting. For BC faults, the fault detector will pick up at approximately 50% of the tap setting. This difference in pick-up current for different phase-to-phase faults is fundamental; and occurs because of the angles at which the positive and negative sequence

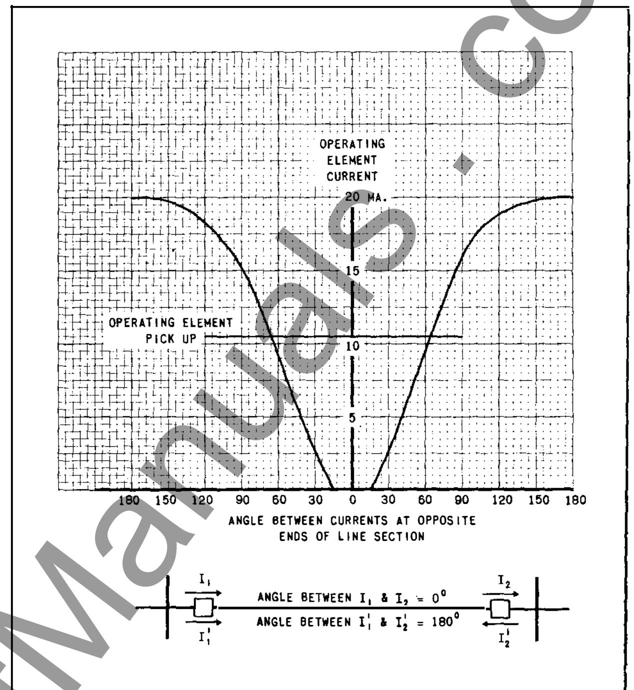



**Fig. 4—Typical Overall Operating Characteristics Of The Type HKB Carrier System.**

components of current add together.

With the sequence network arranged for positive, negative and zero sequence output, there are some applications where the maximum load current and minimum fault current are too close together to set the relay to pick up under minimum fault current, yet not operate under load. For these cases, a tap is available which cuts the three phase sensitivity in half, while the phase-to-phase setting is substantially unchanged. The relay then trips at 90% of tap value for AB and CA faults, and at twice tap value for three-phase faults. The setting for BC faults is 65 percent of tap value. In some cases, it may be desirable to eliminate response to positive sequence current entirely, and operate the relay on negative-plus-zero sequence current. A tap is available to operate in this manner. The fault detector picks up at 95% of tap value for all phase-to-phase faults, but is unaffected by balanced load current or three-phase faults.

For ground faults, separate taps are available for adjustment of the ground fault sensitivity to about 1/4 or 1/8 of the upper tap plate setting. See Table II. For example, if the upper tap plate is set at tap 4, the fault detector (FD1) pick-up current for ground faults can be either 1 or 1/2 ampere. In special applications, it may be desirable to eliminate response to zero sequence current. The relay is provided with a tap to allow such operation.

## SETTINGS

The HKB relay has separate tap plates for adjustment of the phase and ground fault sensitivities and the sequence components included in the network output. The range of the available taps is sufficient to cover a wide range of application. The method of determining the correct taps for a given installation is discussed in the following paragraph.

In all cases, the similar fault detectors on the relays at both terminals of a line section must be set to pick up at the same value of line current. This is necessary for correct blocking during faults external to the protected line section.

### Sequence Combination Taps

The two halves of the lower tap plate are for connecting the sequence network to provide any of the combinations described in the previous section. The left half of the tap plate changes the tap on the third winding of the mutual reactor and thus changes the relative amounts of positive and negative sequence sensitivity. Operation of the relay with the various taps is given in the table below.

TABLE I

| Comb. | Sequence Components In Network Output | Taps on Lower Top Block | | Fault Detector FD1 Pick Up △ | |
|---|---|---|---|---|---|
| | | Left Half | Right Half | 3Ø Fault | Ø - Ø Fault |
| 1 | Pos. Neg., Zero | C | G or H* | Tap Value | 86% Tap Value (53% on BC Fault) |
| 2 | Pos., Neg., Zero | B | G or H | 2x Tap Value | 90% Tap Value (65% on BC Fault) |
| 3 | Neg., Zero | A | G or H | -- | Tap Value |

* Taps F, G and H are zero-sequence taps for adjusting ground fault sensitivity. See section on zero-sequence current tap.

△ Fault detector FD2 is set to pick up at 125% of FD1 for a two-terminal line, or 250% of FD1 for a three-terminal line.

### Positive-Sequence Current Tap and FD2 Tap

The upper tap plate has values of 3, 4, 5, 6, 7, 8, and 10. As mentioned before, these numbers represent the three-phase, fault detector FD1 pickup currents, when the relay is connected for positive, negative and zero sequence output. The fault detector FD2 closes its contact to allow tripping at current value 25 percent above the fault detector FD1 setting. This 25 percent difference is necessary to insure that the carrier start fault detectors (FD1) at both ends of a transmission line section pick up to start carrier on an external fault before operating energy is applied through FD2.

For a three-terminal line, the tap link on FD1 panel is connected to the right hand tap which allows FD2 to pick up at 250% of FD1 setting. This is necessary to allow proper blocking on three-terminal lines when approximately equal currents are fed in two terminals, and their sum flows out the third terminal of the line. For two-terminal lines, the link is connected to the left hand tap, and operation is as described in the previous paragraph.

The taps on the upper and lower tap plates should be selected to assure operation on minimum internal line-to-line faults, and yet not operate on normal load current, particularly if the carrier channel is to be used for auxiliary functions. The dropout current of the fault detector is 75 percent of the pick-up current, and this factor must also be considered in selecting the positive-sequence current tap and sequence component combination. The margin between load current and fault detector pick up should be sufficient to allow the fault detector to drop out after an external fault, when load current continues to flow.

### Zero-Sequence Current Tap

The right half of the lower tap plate is for adjusting the ground fault response of the relay. Taps G and H give ground fault sensitivities as listed in Table II. Tap F is used applications where increased sensitivity to ground faults is not required. When this tap is used, the voltage output of the network due to zero-sequence current is eliminated.

TABLE II

| Comb. | Lower Left Tap | Ground Fault Pickup Percent of Upper Tap Setting | |
|---|---|---|---|
| | | Tap G | Tap H |
| 1 | C | 25% | 12% |
| 2 | B | 20 | 10 |
| 3 | A | 20 | 10 |

Examples of Relay Settings

CASE I

Assume a two-terminal line with current transformers rated 400/5 at both terminals. Also assume that full load current is 300 amperes, and that on minimum internal phase-to-phase faults 2000 amperes is fed in from one end and 600 amperes from the other end. Further assume that on minimum internal ground faults, 400 amperes is fed in from one end, and 100 amperes from the other end.

Positive Sequence Current Tap

Secondary Values:

$$\text{Load Current} = 300 \times \frac{5}{400} = 3.75 \text{ amperes} \quad (1)$$

Minimum Phase-To-Phase Fault Currents:

$$600 \times \frac{5}{400} = 7.5 \text{ amperes} \quad (2)$$

Fault detector FDI setting (three phase) must be at least:

$$\frac{3.75}{0.75} = 5 \text{ amperes (0.75 is dropout ratio of fault detector)} \quad (3)$$

so that the fault detector will reset on load current.

In order to complete the trip circuit on a 7.5 ampere phase-to-phase fault, the fault detector FD1 setting (three-phase) must be not more than:

$$7.5 \times \frac{1}{0.866} \times \frac{1}{1.25} = 6.98 \text{ amperes} \quad (4)$$

$$\left(1.25 = \frac{\text{FD2 pick up}}{\text{FD 1 pick up}}\right)$$

Sequence Combination Tap

From a comparison of (3) and (4) above, it is evident that the fault detector can be set to trip under minimum phase fault condition yet not operate under maximum load. In this case, tap C on the lower left tap block would be used (see Table 1, Comb 1) as there is sufficient difference between maximum load and minimum fault to use the full three-phase sensitivity. Current tap 6 would be used.

Zero Sequence Tap

Secondary Value:

$$100 \times \frac{5}{400} = 1.25 \text{ amperes minimum ground fault current.}$$

With the upper tap 6 and sequence tap C in use, the fault detector FD1 pickup currents for ground faults are as follows:

Lower right tap G-1/4 x 6 = 1.5 amp.
Minimum trip = 1.25 x 1.5 = 1.88 amp.
Lower right tap H-1/8 x 6 = 0.75 amp.
Minimum trip = 1.25 x 0.75 = 0.94 amp.

From the above, tap H would be used to trip the minimum ground fault of 1.25 amperes.

Case II

Assume the same fault currents as in Case I, but a maximum load current of 500 amperes. In this example, with the same sequence combination as in Case I, the fault detectors cannot be set to trip on the minimum internal three-phase fault, yet remain inoperative on load current. (Compare (5) and (6) below). However, by connecting the network per Combination 2 on Table I, the relay can be set to trip on minimum phase-to-phase fault, although it will have only half the sensitivity to three-phase faults. This will allow operation at maximum load without picking up the fault detector, and provide high speed relaying of all except light three-phase faults.

In order to complete the trip circuit on a 7.5 ampere phase-to-phase fault, the fault detector tap must now be not more than:

$$7.5 \times \frac{1}{1.25} \times \frac{1}{0.9} = 6.6 \qquad (5)$$

To be sure the fault detector FD1 will reset after a fault, the minimum tap setting is determined as follows:

$$\text{Load Current} = 500 \times \frac{5}{400} = 6.25 \text{ amps} \qquad (6)$$

$$\frac{6.25}{0.75} = 8.33 \qquad (7)$$

Since the fault detector pickup current for three-phase faults is twice tap value, half the above value (Eq. 7) should be used in determining the minimum three-phase tap.

$$\frac{8.33}{2} = 4.17 \qquad (8)$$

From a comparison of (5) and (8) above, tap 5 or 6 could be used.

With the three-phase tap 5 in use, the fault detector pickup current for ground faults will be as follows:

Tap G-1/5 x 5 = 1.0 a.
Minimum trip = 1.0 x 1.25 a. = 1.25 amp.

Tap H-1/10 x 5 = 0.5 a.
Minimum trip = 1.25 x 0.5 a. = 0.63 amp.

Therefore, tap H would be used to trip the minimum ground fault of 1.25 ampere with a margin of safety.

## INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration and heat. Mount the relay vertically by means of the two mounting studs for the type FT projection case or by means of the four mounting holes on the flange for the semi-flush type FT case. Either of the studs or the mounting screws may be utilized for grounding the relay. The electrical connections may be made direct to the terminals by means of screws for steel panel mounting or to terminal studs furnished with the relay for ebony-asbestos or slate panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the studs and then turning the proper nut with a wrench.

External Resistor

A resistor is required in the carrier start fault detector circuit, as shown in Fig. 12 connected between HKB relay terminal 8 and battery positive. Its function is to avoid short circuiting the station battery through the normally-closed contact of the carrier start fault detector FD1.

The values of this resistor are tabulated below.

| Style No. | D.C. Supply | Ohms | Outline & Drilling |
|---|---|---|---|
| 1337179 | 125 volts | 250 | Fig. 5a |
| 1337181 | 250 volts | 625 | Fig. 5b |

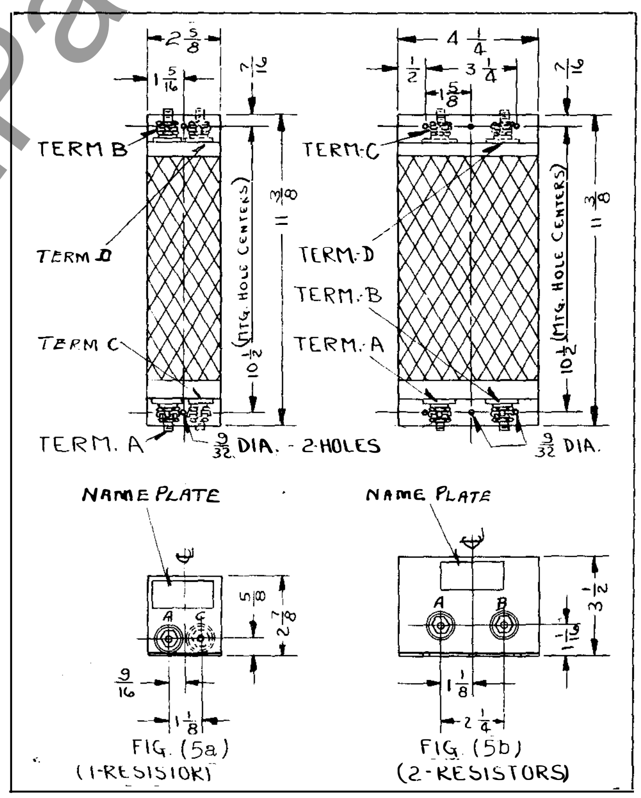



**Fig. 5—Outline And Drilling Plan For The External Resistor Used In The HKB Relay Control Circuit. For Reference Only.**

This resistor can be mounted on the rear of the switchboard in any convenient location.

## ADJUSTMENTS AND MAINTENANCE

### CAUTION

1. Make sure that the neon lamp is in place whenever relay operation is being checked. This is necessary to limit the voltage peaks in the filter output at high currents so as to prevent damage to the Rectox Units.

2. When changing taps under load, the spare tap screw should be inserted before removing the other tap screw.

3. All contacts should be periodically cleaned with a fine file. S#1002110 file is recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

4. The proper adjustments to insure correct operation of this relay have been made at the factory and should not be disturbed after receipt by the customer. If the adjustments have been changed, the relay taken apart for repairs, or if it is desired to check the adjustments at regular maintenance periods, the instructions below should be followed.

Sequence Network

There are no adjustments to make in the network.

The following mechanical adjustments are given as a guide, and some deviation from them may be necessary to obtain proper electrical calibration.

FAULT DETECTORS-GENERAL

The sensitivity of the polar elements is adjusted by means of two magnetic, screw-type shunts at the rear of the element. These shunt screws are held in proper adjustment by a flat strip spring across the back of the element frame, so no locking screws are required. Looking at the relay front view, turning out the right-hand shunt decreases the amount of current required to close the right-hand contact. Conversely, drawing out the left-hand shunt increases the amount of current required to trip the relay. In general, the farther out the shunt screws are turned, the greater the toggle action will be, and as a result, the dropout current will be lower. In adjusting the polar elements, be sure that a definite toggle action is obtained, rather than a gradual movement of the armature from the back (left-hand, front view) to the front (right-hand, front view) contact as the current is increased.

During calibration, connect a 10,000 ohm resistor across terminals 19 and 20 or switch jaws B and C. (For the special relay wired per 18-D-5121, use terminals 3 and 22 or switchjaws A1 and E.) Connect the panel link to the left-hand terminal. Set the relay taps on 5, C, and H.

A. Lower Polar Element (FD-1) - Adjust the contact screws to obtain an .050" contact gap such that the armature motion between the left and right hand contacts is in the central part of the air gap between the pole faces. Tighten the contact locking nuts. Approximate adjustments of the two magnetic shunt screws are as follows:

Screw both shunt screws all the way in. Then back out both screws six turns. Pass 4.33 amperes, 60 cycles, in phase A and out phase B. Screw in the left hand shunt until the armature moves to the right. If the armature moves to the right at less than 4.33 amperes, screw out the left-hand shunt until proper armature action is obtained.

Reduce the current until the armature resets to the left. This should happen at not less than 75% of the pickup value, or 3.25 amperes. If the armature resets at less than this value, it will be necessary to advance the right hand shunt to obtain a dropout of 75% or greater. This in turn will require a slight readjustment of the left hand shunt. Recheck the pickup and dropout points several times, and make any minor "trimming" adjustments of the shunt screws that may be necessary to obtain correct calibration. If the above procedure does not give a sufficiently high dropout, a small amount of further adjustment can be obtained by advancing the right-hand contact screw a fraction of a turn. As finally adjusted, the contact gap should be at least .030", and the action of the armature should be snappy at the pickup and dropout points.

B. Upper Polar Element (FD-2) - Adjust the contact screws to obtain an .050" contact gap such that the armature motion between contacts is in the central portion of the air gap between the pole faces. Tighten the locking nuts.

Follow the same adjustment procedure as for FD1, except for a pickup current of 5.41 amperes, and a dropout current of at least 75% of pickup, or 4.06 amperes. Just above the pickup current, there will be a slight amount of contact vibration. Make a final adjustment of the two right-hand contact screws to obtain equal vibration of both contacts as indicated by a neon lamp connected in the contact circuit.

Operating Element (Telephone Type Relay)

Adjust the contact gap to 0.045". This is done by bending down the armature contact-lever stop on the relay frame. Now with the armature in the operated position, adjust the armature residual gap to 0.010" by means of the adjustable set screw. This gap should be measured just below the armature set screw. For those relays with a fixed residual spacer, the gap is about 0.008". Check to see that there is a contact follow of a few thousandths of an inch after the contact closes.

Connect a d-c milliammeter (0-25 ma.) across test switchjaws H1 and I1 (relay out of case). Connect a source of variable a-c voltage (0 to 10 volts, 60 cycles) across switchjaws F1 and G1. The relay should pick up at 10 to 12 ma. direct current in the coil circuit with sine wave voltage applied to the a-c side of the bridge rectifier. The dropout current will be 4 to 7 ma. The contact spring tension can be changed, if necessary, to obtain these values.

For the relay in the standard case, apply a-c voltage across terminals 9 and 10 and insert a test plug connected to a d-c milliammeter in the single test switch jack of the relay. If clip leads are used, it will be necessary to slip a strip of insulating material such as fiber into the test switch jack after opening the switch blade to obtain a reading.

Contactor Switch

Adjust the stationary core of the switch for a clearance between the stationary core when the switch is picked up. This can be most conveniently done by turning the relay upside-down. Screw up the core screw until the moving core starts rotating. Now, back off the core screw until the moving core stops rotating. This indicates the point where the play in the moving contact assembly is taken up, and where the moving core just separates from the stationary core screw. Back off the stationary core screw one turn beyond this point and lock in place. This prevents the moving core from striking and sticking to the stationary core because of residual magnetism. Adjust the contact clearance for 3/32 inch by means of the two small nuts on either side of the Micarta disc. The switch should pick up at 2 amperes d-c. Test for sticking after 30 amperes d-c have been passed thru the coil. The coil resistance is approximately 0.25 ohm.

Operation Indicator

Adjust the indicator to operate at 1.0 ampere d-c gradually applied by loosening the two screws on the under side of the assembly, and moving the bracket forward or backward. If the two helical springs which reset the armature are replaced by new springs, they should be weakened slightly by stretching to obtain the 1 ampere calibration. The coil resistance is approximately 0.16 ohms.

## RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When

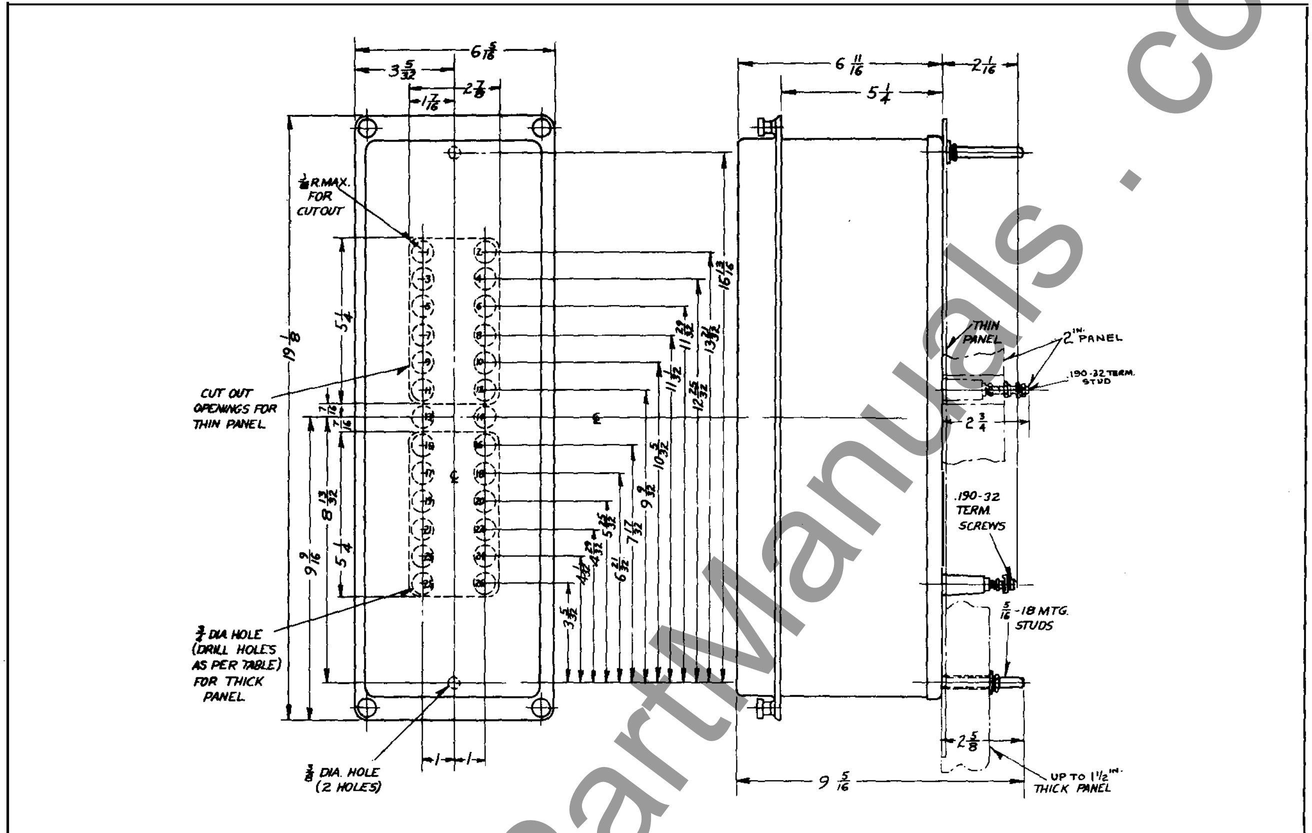



**Fig. 6—Outline And Drilling Plan For The M-20 Projection Type FT Flexitest Case. See The Internal Schematic For The Terminals Supplied. For Reference Only.**

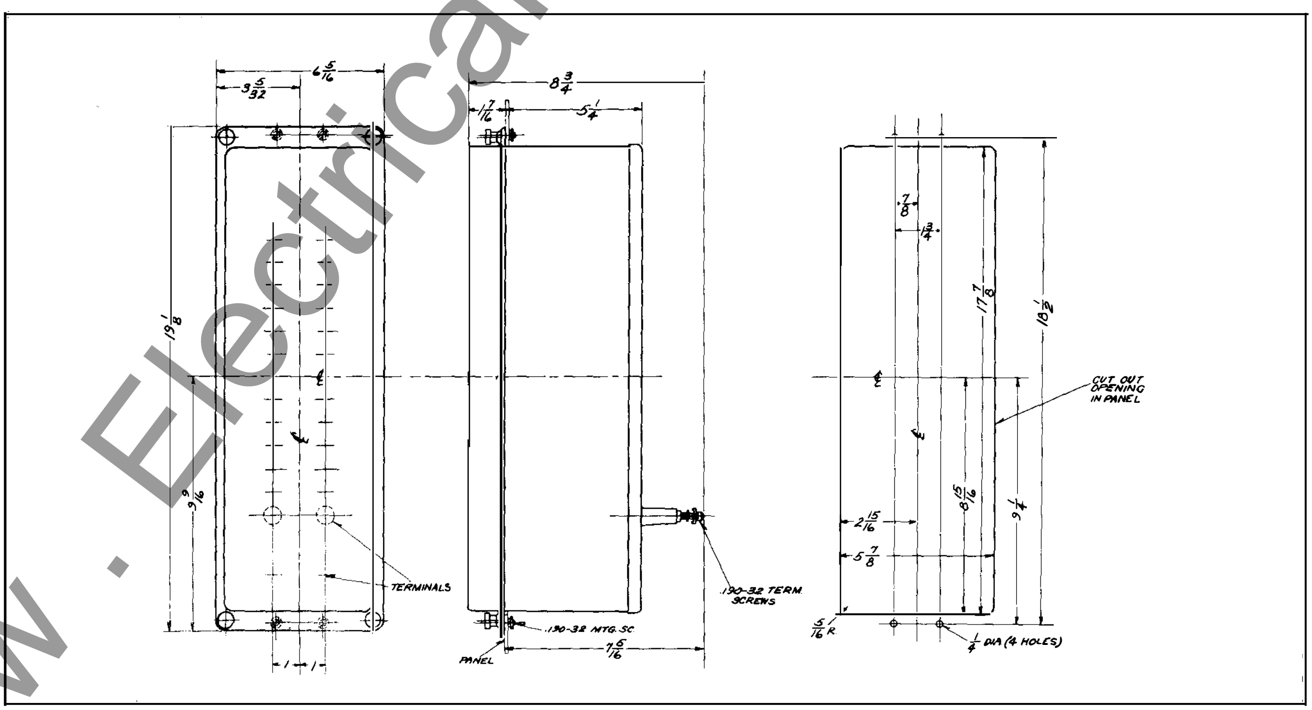



**Fig. 7—Outline And Drilling Plan For The M-20 Semi-Flush Type FT Flexitest Case. For Reference Only.**

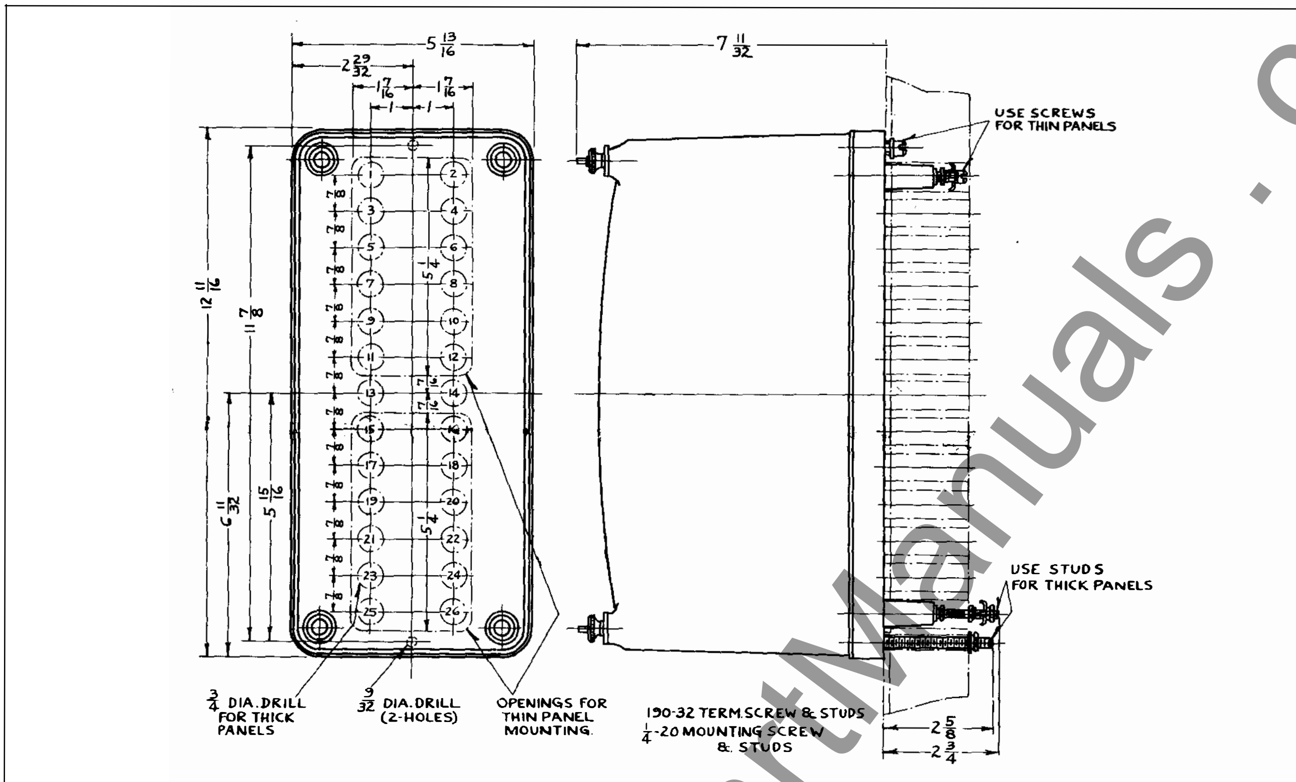



Fig. 8—Outline And Drilling Plan For The Standard Projection Case. See The Internal Schematic For The Terminals Supplied. For Reference Only.

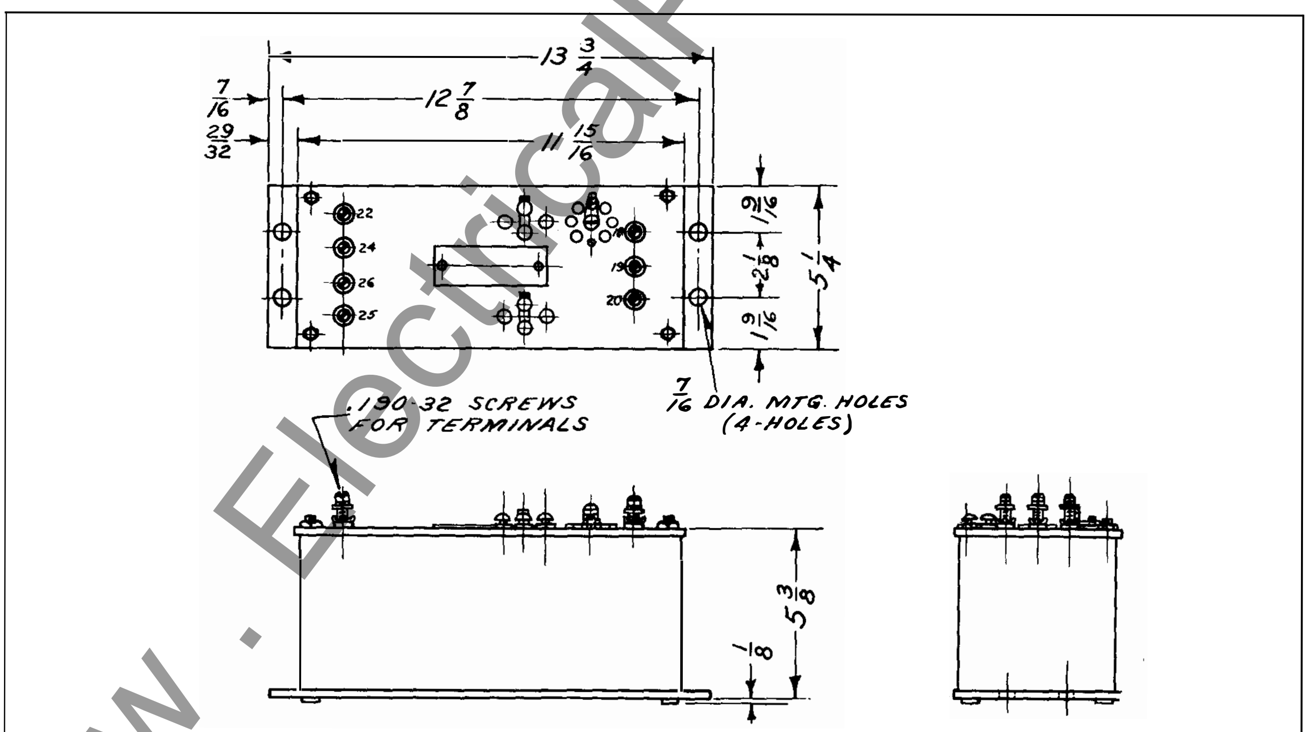



Fig. 9—Outline And Drilling Plan For The Sequence Filter Used With The Type HKB Relay In The Standard Case. For Reference Only.

ordering parts, always give the complete name-plate data.

## ENERGY REQUIREMENTS

Burdens measured at a abalanced three-phase current of five amperes.

| Relay Taps | Phase A VA | Phase A Angle | Phase B VA | Phase B Angle | Phase C VA | Phase C Angle |
|---|---|---|---|---|---|---|
| A-F-3 | 2.4 | 5° | 0.6 | 0° | 2.5 | 50° |
| A-H-10 | 3.25 | 0° | 0.8 | 100° | 1.28 | 55° |
| B-F-3 | 2.3 | 0° | 0.63 | 0° | 2.45 | 55° |
| B-H-10 | 4.95 | 0° | 2.35 | 90° | 0.3 | 60° |
| C-F-3 | 2.32 | 0° | 0.78 | 0° | 2.36 | 50° |
| C-H-10 | 6.35 | 342° | 3.83 | 80° | 1.98 | 185° |

Burdens measured at a single-phase to neutral current of five amperes.

| Relay Taps | Phase A VA | Phase A Angle | Phase B VA | Phase B Angle | Phase C VA | Phase C Angle |
|---|---|---|---|---|---|---|
| A-F-3 | 2.47 | 0° | 2.1 | 10° | 1.97 | 20° |
| A-H-10 | 7.3 | 60° | 12.5 | 53° | 6.7 | 26° |
| B-F-3 | 2.45 | 0° | 2.09 | 15° | 2.07 | 10° |
| B-H-10 | 16.8 | 55° | 22.0 | 50° | 12.3 | 38° |
| C-F-3 | 2.49 | 0° | 1.99 | 15° | 2.11 | 15° |
| C-H-10 | 31.2 | 41° | 36.0 | 38° | 23.6 | 35° |

The angles above are the degrees by which the current lags its respective voltage.

# PART II-TYPE HKB CONTROL UNIT (JY)

**CAUTION** When adjusting this equipment, allow the tube heaters to warm up for at least 30 seconds before applying plate voltage (by operating the relay fault detector). This precaution is necessary to prevent damage to the type 2050 thyratrons.

## CONSTRUCTION

The HKB Control Unit consists of an electronic trigger circuit employing two thryatrons; a rectifier-doubler vacuum tube for the received carrier and a vacuum "relay" tube which compares the phase positions of the local and distant line currents.

The general appearance and construction of the Type HKB Control Unit is shown by the outline drawing, Figure 11. The entire equipment, with the exception of the accessories, is mounted on a standard 3/16" thick aluminum panel 19" wide and 8-23/32" high with standard notching. The front of the panel is black wrinkle finished, and the rear is Nasat. The tubes protrude through the front panel for convenient installation and replacement.

Jacks are provided on the front of the panel for current metering as follows:

| | |
|---|---|
| J1(top jack) | Heater current |
| J2(center jack) | Relay tube mission current |
| J3(bottom jack) | Rectifier-doubler output current. |

## INSTALLATION

When used with the Type JY Transmitter and Receiver, the HKB Control Unit is mounted in the same cabinet with these panels and immediately beneath the Receiver panel. The instruction Book for the complete assembly of which this unit is a part should be referred to for additional mounting instructions.

Upon delivery, the unit should be very carefully checked for damaged parts. Particular attention should be given to any parts which may have become loose in shipment, or wires which may have broken because of vibration. Each HKB Control Unit is supplied with an accessory group of components for adapting it for operation from 125 volts d-c or 250 volts d-c. These components should be checked for damage and to see that none are missing, and checked against the order or requisition and the parts list in this book. Any shortage should be immediately reported to the transportation company and to the nearest district office of the manufacturer.

The necessary connections from the JY (cabinet) assembly terminal blocks to the switchboard, relays, etc,, should be made in suitable conduit. Number 12 gauge wire is recommended for these connections. The connection diagrams in the instruction book for the complete assembly should be followed. Be sure to ground terminal #1 on the HKB Unit and also cabinet terminal #1.

CIRCUIT ADJUSTMENT- GENERAL

Do not insert the tubes into the HKB Control Unit until the following paragraphs dealing with circuit adjustments have been read.

The HKB Control Unit is designed to use the same tubes for either 125 volt or 250 volt operation. When used on 250 volts d-c, the proper value of plate voltage for the Type 25L6 Relay Tube is obtained from a connection at the positive end of the transmitter tube heaters.

Short out the JY transmitter amplifier cathode resistor with the jumpere supplied on the resistor. This connection is for the normal transmitter operating condition.

In order to obtain bias voltage for both the HKB Control Unit and the assosiated carrier transmitter, the entire d-c current drain of both units is caused to flow though a combination of resistors in the Control Unit. In this way, adjustable bias for the type 2050 thyratrons and fixed bias of two different values, for the power amplifier tubes of the transmitter is obtained. Because the adjustment procedure will follow the tabulations shown on Table I and II as closely as possible, it is important to become thoroughly familiar with the tables. Five columns are included in these tables. The first column indicates the quantity to be checked. The second column indicates the minimum value permissible. The third column indicates the normal value. The fourth column indicates the maximum value permissible. The fifth column should be filled in at the time of installation, to indicate the actual value which was obtained. The last column is of great importance and should be filled in as soon as the HKB Control Unit is installed. All quantities must be brought within the minimum and maximum value specified before the equipment can be considered to be in satisfactory operating condition. A copy of these values should be kept with the equipment for checking purposes. All letters of inquiry to the manufacturer regarding the operation of this unit should be accompanied by a list of actual values of the eight quantities tabulated on Table I or II.

The maximum and minimum limits of the values in the table do not all correspond to the same percentage. In the case of the power supply or battery voltage, the limits given are the maximum and minimum at which the unit can be properly adjusted to operate; and these limits include the maximum variation in power supply voltage. For instance, the HKB unit with 125 volt accessories can be adjusted to function properly on any battery which never exceeds 150 volts or drops below 100 volts. But once the normal voltage is established and adjustments are made for operation on that voltage, it should not be permitted to fluctuate normally more than plus or minus five percent.

The Unit has been designed to use either glass or metal tubes of types 25L6 and 25Z6, and the adjustment data is the same for either.

CIRCUIT ADJUSTMENTS - 125 VOLT EQUIPMENT

The numbers at the beginning of the following paragraphs correspond to the line number in the Adjustment Data Tables.

1. The first line in the Adjustment Data Table is the power supply or battery voltage, which is to be measured at the cabinet terminals before any of the equipment is turned on. The actual value of this voltage at the time of installation should be entered on the line in the fifth column of the data table. If it is not within the limits of 100 to 150 volts d-c, do not proceed.

2. Adjustment of the HKB Control Unit tube heater current is now to be carried out. Since the bias resistor (combination of R8, R9, R10, R11 and R5) is common to the heater circuits of both the carrier transmitter-receiver and the HKB Control Unit, adjustment of heater current of one unit will affect that of the other. In order to avoid difficulty, the bias resistor mentioned is to be temporarily shorted out during the adjustment of heater current for both the transmitter-receiver and the HKB Control Unit. BEFORE PROCEEDING,

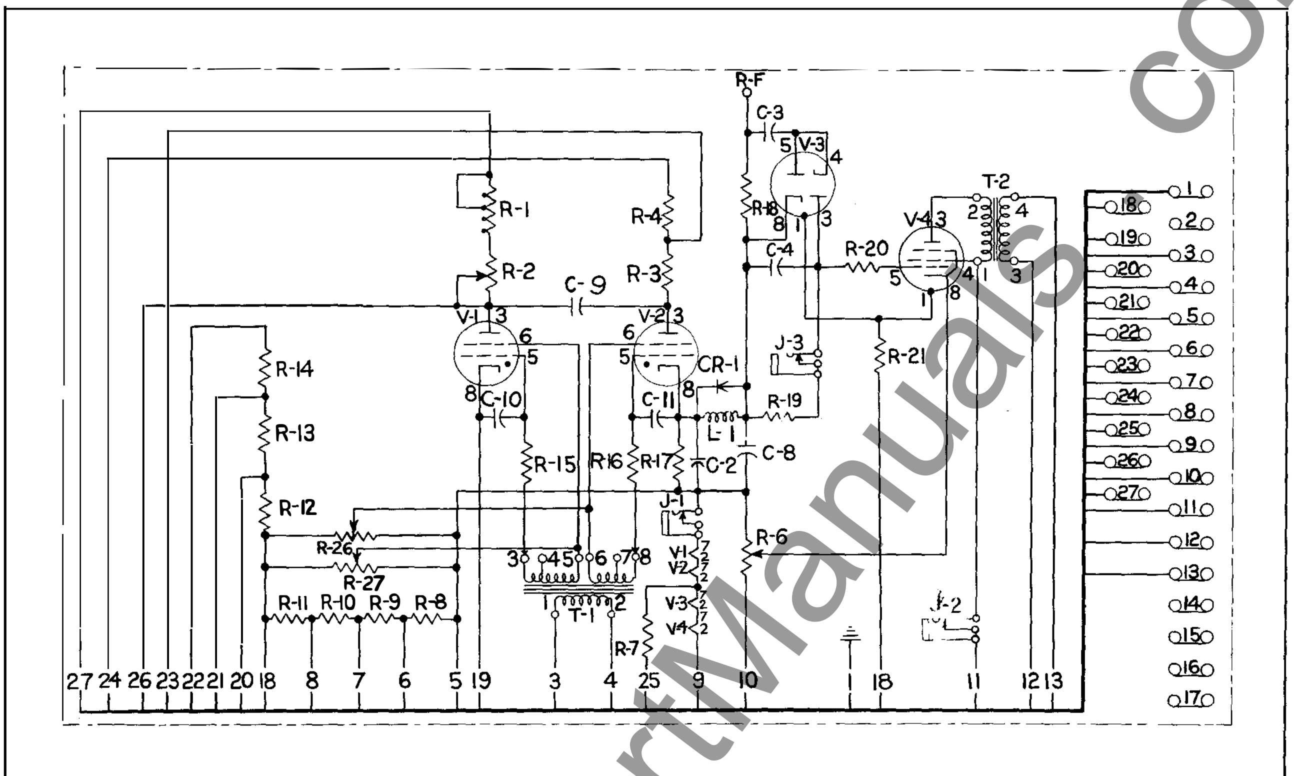



Fig. 10—Internal Schematic Of The Type HKB Control Unit For Type JY Carrier.

REFER TO THE INSTRUCTION BOOK FOR THE ASSEMBLY OF WHICH THIS UNIT IS A PART AND CARRY OUT THE DIRECTIONS THEREIN FOR INSERTING MAXIMUM RESISTANCE INTO THE TRANSMITTER-RECEIVER HEATER CIRCUIT. Connect a jumper wire across terminals #5 and #18 of the HKB Control Unit. The adjusting clip on resistor R6 is to be set roughly in the center of the resistor. The adjusting clips on the two adjustable resistors R23 and R24, which are external heater series resistors mounted on a separate panel, are to be set so as to short out the least possible amount of these resistors. Open the transmitter amplifier cathode return circuit by inserting an open circuit plug in transmitter jack 8. The tubes are now to be inserted into the HKB assembly of which the HKB unit is a part. Plug a d-c ammeter of 1 ampere range into jack J1 and adjust the shorting clips of external resistors R23 and R24 to obtain the correct heater current as given in line #2 of the table. It is desirable to keep the amount shorted out of each of these two resistors about equal so as to distribute the heat produced equally between them. When the power is first applied, the tube heater current will be above normal due to the low resistance of the cold heater elements. Consequently, power should be applied for at least two minutes before readings are taken. After the heater current of the HKB Control Unit and the heater current of the transmitter-receiver have each been adjusted, remove the jumper wire from terminals #5 and #18 of the HKB Unit. (Close the transmitter amplifier cathode circuit.)

3. After the adjustments on the transmitter have been completed and the transmitter is in normal operation measure again the heater current of the HKB Unit as Jack J1. If not within the limits of line #3 in the Data Table, make such slight changes to the setting of the external resistors R23 and R24 as may be required to correct it. (A similar operation should be carried out on the transmitter-receiver.)

TABLE I

ADJUSTMENT FOR HKB CONTROL UNIT ON 125 VOLTS

See text of Instruction book for discussion of the following table. Numbers preceeding data refer to test paragraph numbers.

| | Quantity | Min. | Normal | Max. | Actual |
|---|---|---|---|---|---|
| 1. | Power Supply Volts | 100. | 125. | 150. | |
| 2. | Heater Amperes, Preliminary Adjustment # | .59 | .62 | .65 | |
| 3. | Heater Amperes, Final Adjustment + | .54 | .56 | .58 | |
| 4. | Current at Jack J2, Milliamperes | .0 | .0 | .10 | |
| | Rectifier-doubler Output Milliamperes at J3* | .0 | .05 | .10 | |
| 5. | Total Bias Volts | 11. | 14. | 17. | |
| 6. | Master Oscillator Plate Volts---------------- | 25. | 30. | 36. | |
| 7. | Thyratron Grid Bias Volts | 4.0 | 5.0 | 6.0 | |
| 8. | Relay Tube Grid Bias Volts | 20. | 26. | 32. | |
| | HKB Relay Operating Element Current, Ma. | 18. | 20. | 22. | |

# - The total tube heater current of the associated transmitter should be adjusted to this value also.

+ - The final value of the tube heater current of the transmitter should be within these limits for the total, and half of these values for each branch.

* - With no carrier being received.

TABLE II

ADJUSTMENT DATA FOR HKB CONTROL UNIT ON 250 VOLTS

See text of instruction book for discussion of the following table. Numbers preceeding data refer to test paragraph numbers.

| | Quantity | Min. | Normal | Max. | Actual |
|---|---|---|---|---|---|
| 1. | Power Supply Volts | 200. | 250. | 300. | |
| 2. | Tube Heater Amperes - Control Unit | .54 | .56 | .58 | |
| | " " " - Transmitter | .81 | .85 | .89 | |
| 3. | Plate Circuit Supply Volts | 95. | 135. | 165. | |
| 4. | Current at Jack J2, Milliamperes | .0 | .0 | 0.1 | |
| | Rectifier-doubler Output Milliamperes at J3* | .0 | .05 | 0.1 | |
| 5. | Total Bias Volts | 17. | 22. | 28. | |
| 6. | Master Oscillator Plate Volts----------------- | 60. | 65. | 73. | |
| 7. | Thyratron Grid Bias Volts | 5.0 | 6.0 | 7.0 | |
| 8. | Relay Tube Grid Bias Volts | 20. | 26. | 32. | |
| | HKB Relay Operating Element Current, Ma. | 18. | 20. | 22. | |

* - With no carrier being received.

4. After the above adjustments are completed, measure at the other two metering jacks, J2 and J3, to see that no current is flowing. Under the conditions of the bias resistor R6 being set near the center, the Relay tube, V4, is biased well beyond plate current cut-off, so that the current at jack J2 should be well below the limit of .1 milliampere. Under the condition of no r-f signal received, the current at jack J3 should be well below the limit of .1 ma. Any excessive current flow should be investigated and the fault cleared before proceeding with the tests. (make final check with 1.5 milliampere range of meter.)

5. Measure the d-c bias voltage between terminals #5 and #18.

6. This adjustment is for the purpose of obtaining the correct Master Oscillator plate voltage for the transmitter. The transmitter must be completely adjusted and in a state of normal operation (ready to be controlled by the HKB Unit). In making this adjustment it is necessary to have $V_1$ thyratron continuously ignited. For Control Unit S#867954A, a single resistor R5 is in place of resistors R26 and R27. Remove the lead from the R5 tap nearer the panel and connect this lead to terminal #19 of the Control Unit. For Control Unit S#1471841, remove the lead from the R27 tap and connect to terminal #19. Now turn on the equipment and allow the thyratrons to heat up for one minute. Block open the back contact of the HKB lower fault detector. Thyratron V1 will fire and remain conducting. Connect a d-c voltmeter of at least 1000 ohm-per-volt resistance between terminal #5 and terminal #19. Adjust $R_1$ and R2 to obtain the required voltage as given in Table I or II. The transmitter should now be sending out carrier at its full output power. Restore all connections to normal.

7. The object of the following adjustment is to set the firing point of the thyratrons V1 and V2 to the proper value by adjusting their grid bias. Two resistors, R26 and R27, are provided for separate adjustment of V1 and V2 grid bias in Control Unit S31471841 Control Unit S#867954A has a single resistor with two sliders (R5) for adjustment of V1 and V2 grid bias. The bias can be measured between each slider and terminal #5.

The negative grid bias on thyratron V1 should be set to zero volts. For either control unit style 867954-A or 1471841, remove the lead from the slider (on R5 or R27) which supplies bias to V1 thyratron and connect it to the positive end terminal of that resistor (check with a d.c. voltmeter).

Set the negative grid bias on thyratron V2 to -5 volts for 125-volt carrier sets, or to -6 volts for 250-volt sets by adjustment of the slider on resistor R5 or R26. The bias voltage can be measured from the slider (-) to the positive end terminal (+) of R26.

With the above bias values, carrier will be transmitted for somewhat more than one-half cycle (at 60 cycles) at low values of fault current. This may be seen when viewing the signal across the coaxial cable on an oscilloscope.

8. The following adjustment covers the setting of the relay tube (V4) grid bias. Plug a d-c milliammeter (0-25 ma.) into the current jack on test switch I1 (top of relay, second from left end) of the HKB relay to measure the operating element coil current. Pass a current in phase A and out phase B of the relay sufficient to pick up both FD1 and FD2 fault detectors. With relay taps 4, C, and H, 5 amperes should be sufficient. The current from the test transformer can be used if desired. Reduce the grid bias on the relay tube V4 by adjusting the slider on resistor R6 until the d-c milliammeter in relay jack I1 reads 20 ma.

The relay tube grid bias is measured between the slider of R6 and terminal #5 of the control unit. A voltmeter of at least 1000 ohms-per-volt resistance should be used. Carrier from the distant line terminal must not be transmitted, during this adjustment. All test circuits and instruments may now be removed, and the relay test switches returned to normal.

CIRCUIT ADJUSTMENTS - 250 VOLT EQUIPMENT

1. The first line in the Adjustment Data Table is the power supply or battery voltage, which is to be measured at the cabinet terminals before any of the equipment is turned on. The actual value of this voltage at the time of installation should be entered on the line in the fifth column of the data table. If it is not within the limits of 200 to 300 volts d-c, do not proceed.

2. Adjustment of the HKB Control Unit tube heater current will be accomplished along with the adjustment of the transmitter heater current, because all the heaters of the assembly are connected in series. The necessary external heater series resistors are a part of the accessories for the assembly of which this Unit is a part; and the instructions for their adjustments are to be found in the instruction book for the complete assembly. After the adjustment is completed record the value of current as measured at jack J1. The heater currents of the Control Unit and the transmitter should be within the limits tabulated on Table II.

External accessory resistor R25 is connected in shunt to the HKB tube heaters. By bypassing .3 ampere, it enables their operation in series with the tube heaters of the transmitter, which draw .9 ampere. Resistor R25 is adjusted at the factory to 208 ohms plus or minus 1 percent and should not be changed from the above value.

3. The plate circuit supply voltage is to be measured between terminal #5 and terminal #10.

4. After the above adjustments are completed, measure at the other two metering jacks, J2 and J3, to see that no current is flowing. Under the condition of the bias resistor R6 being set near the center, the Relay Tube, V4, is biased well beyond plate current cut-off, so that the current at jack J2 should be well below the limit of .1 milliampere. Under the condition of no r-f signal received, the current at jack J3 should be well below the limit of .1 ma. Any excessive current flow should be investigated and the fault cleared before proceeding with the tests. (Make final check with 1 milliampere range of meter.)

5. Measure the d-c bias voltage between terminals #5 and #18.

6. Oscillator Plate Voltage. Adjustments are exactly the same as for 125 volt equipment. See paragraph 6 of previous section. Refer to values on Table II.

7. Thyratron Grid Bias Volts. Adjustments are exactly the same as for 125-volt equipment. See paragraph 7 of previous section. Refer to values on Table II.

8. Relay Tube Grid Bias Volts. Adjustments are exactly the same as for 125-volt equipment. See paragraph 8 of previous section. Refer to values on Table II.

## OVERALL TEST OF COMPLETE INSTALLATION

After the complete equipment has been installed and adjusted, the following tests can be made which will provide an overall check on the relay and carrier equipment. The phase rotation of the three-phase currents can be checked by measuring the a-c voltage across relay terminals 19 and 20 or test switches B and C with a high resistance a-c voltmeter of at least 1000 ohms per volt. The reading obtained should be approximately 0.9 volts per ampere of balanced three-phase load current (secondary value) with relay taps 4, C and H.

This test requires that a balanced three-phase load current of at least 1.0 ampere (secondary) be flowing through the line-section protected by the HKB relays. At both terminals of the protected line-section, remove the HKB relay cover and open the trip circuit by pulling the test switch blade with the long red handle. Put the tap screw on the upper tap plate in the 4 tap, and on the lower one in the C and H taps. Be sure to insert the spare tap screw before removing the connected one. Now open test switches D and E on the relay at one end of the line section (station A) and insert a current test plug or strip of insulating material into the test jack on switch E to open the circuit through that switch. The above operation shorts the phase A to neutral circuit ahead of the sequence filter and disconnects the phase A lead from the filter. This causes the phase B and C currents to return to the current transformers through the zero-sequence resistor in the filter, thus simulating a phase A-to-ground fault fed from one end of the line only. As a result, both the fault detector and operating element at Station A should close their contacts. Completion of the trip circuit can be checked by connecting a small lamp (not over 10 watts) across the terminals of test switch J.

Now perform the above operations at the opposite end of the line-section (station B) without resetting the switches at Staion A. This simulates a phase-to ground fault external to the protected line-section. The fault detector, but not the operating element at B should pick up, and the operating element at A should reset. Restore test switches D and E at Station A to normal (closed). The line conditions now represent a phase-to-ground fault fed from Station B only. The fault detector at A should reset and the operating element at B should pick up. Restore test switches D and E at Station B to normal, and both elements of the relay at Station B should reset. For the relay in the standard case, the above test can be performed using suitable external test switches.

The above tests have checked phase rotation, the polarity of the sequence filter output, the interconnections between the relay and the carrier set and the Phase A current connections to the relay at both stations. Phase B and C can be similarly checked by opening test switches F and G for phase B, and switches H and I for phase C. The same procedure described for Phase A is then followed.

If all the tests have been completed with satisfactory results, the test switches at both line terminals should be closed (close the trip circuit test switch last) and the relay cover replaced. The equipment is now ready to protect the line-section to which it is connected.

## MAINTENANCE

Since the Control Unit has no front-of-panel controls, it requires no attention except maintenance as described in the following paragraphs. The unit cannot be taken out of service without taking the entire assembly out of service.

Every three months an overall inspection should be made to see that no excessive corrosion has developed due to fumes or condensation of moisture. Any accumulated dust and dirt should be cleaned out, as often as once a month in some localities.

### Tubes

At the end of each year of operation, the tubes should be removed from their sockets, and their contacts inspected for possible dirt or corrosion. If there is any discoloration, it may be removed by the use of very fine sandpaper. In order to assure maximum tube life, it is very important that the resistance of the contacts be kept to an absolute minimum. If necessary, this cleaning operation should be performed more frequently than indicated above.

### Resistors

The resistors are operated well within there ratings, and should not fail during the life of the unit. In the accessory equipment, the ferrule resistors should be removed from their clips at the end of each year's operation, and the ferrules and clips cleaned of corrosion with crocus cloth or very fine sandpaper. In a corrisive atmosphere a film of vaseline will reduce trouble.

### TYPE JY HKB CONTROL UNIT COMPONENT PARTS

125/250 volts d-c
Style: 1471841A

Electrical Parts per Component Parts List (Dwg. 7614215), except resistors R23, R24, and R25 and tubes. Style: 1471840-A- as above, but with tubes.

COMPONENT PARTS

| SYMBOL | NUMBER REQUIRED | NAME | RATING |
|---|---|---|---|
| | | CAPACITORS | |
| C1* | 1 | Thyratron Plate to Plate | .05 Mfd., 600 V. d-c |
| C2 | 1 | Thyratron Output | .05 Mfd., 600 V. d-c |
| C3 | 1 | Rectifier Doubler Input | .0056 Mfd., 600 V. d-c |
| C4 | 1 | Rectifier Doubler Output | .0056 Mfd., 600 V. d-c |
| C5* | 1 | Transformer By-Pass | .0039 Mfd., 500 V. d-c |
| C6* | 1 | Thyratron Grid By-Pass | 22 MMF., 500 V. d-c |
| C7* | 1 | Thyratron Grid By-Pass | 22 MMF., 500 V. d-c |
| C8# | 1 | Delay Filter | .1 Mfd., 600 V. d-c |
| C9# | 1 | Thyratron Plate to Plate | .25 Mfd. ± 20% 600 V. d-c |
| C10# | 1 | Thyratron Grid By-Pass | .0022 Mfd. ± 10% 500 V. d-c |
| C11# | 1 | Thyratron Grid By-Pass | .0022 Mfd. ± 10% 500 V. d-c |
| | | METER JACKS | |
| J1 | 1 | Tube Heaters | Wester Electric 232A |
| J2 | 1 | Relay Tube Plate & Screen | or |
| J3 | 1 | Rectifier Doubler Output | Cook Electric JK-24 |
| | | REACTORS | |
| L1* | 1 | Carrier Start Circuit | 7 henries, 25 ma. d-c, 440 ohms d-c resistance |
| L1# | 1 | Delay Filter | S#1336643, 10 hy, 7000Ω d-c. resistance |
| | | RESISTORS | |
| R1 | 1 | Carrier Start Thyratron Plate | 16,000 ohms, 22 watt, tapped |
| R2 | 1 | Carrier Start Thyratron Plate | 2,000 ohms, 21 watt, adjustable (1 band). |
| R3 | 1 | Relay Thyratron Plate | 2,000 ohms, 21 watt. |
| R4 | 1 | Relay Thyratron Plate | 8,000 ohms, 12 watt. |
| R5* | 1 | Thyratron Bias | 50 ohms, 22 watt, adjustable (1 band). |
| R6 | 1 | Relay Tube Bias | 2,000 ohms, 22 watt, adjustable (1 band). |
| R7 | 1 | Heater Shunt | 160 ohms, 45 watt. |
| R8 | 1 | Amplifier Bias | 6.3 ohms, 45 watt. |
| R9 | 1 | Amplifier Bias | 10 ohms, 45 watt. |
| R10 | 1 | Amplifier Bias | 2.5 ohms, 21 watt. |
| R11 | 1 | Amplifier Bias | 4 ohms, 45 watt. |
| R12 | 1 | Bias Restoring | 5,600 ohms, 1 watt. |
| R13 | 1 | Bias Restoring | 0.11 megohms, 1 watt. |
| R14 | 1 | Bias Restoring | 91,000 ohms, 1 watt. |
| R15 | 1 | Thyratron Grid | 0.1 megohm, 1 watt. |
| R16 | 1 | Thyratron Grid | 0.1 megohm. 1 watt. |
| R17 | 1 | Thyratron Cathode | 2,400 ohms, 1 watt. |
| R18 | 1 | Rectifier Doubler Input | 2,000 ohms, 1 watt. |
| R19 | 1 | Rectifier Doubler Output | 51,000 ohms, 1 watt. |
| R20 | 1 | Relay Tube Grid | 51,000 ohms, 1 watt. |
| R21 | 1 | Tube Shell Grounding | 0.27 megohms, 1 watt. |
| R22* | 1 | Reactor Shunt | 5,100 ohms, 1 watt. |
| R23 | 1 | Heater Series | 63 ohms, wire wound, adjustable (1 band). |
| R24 | 1 | Heater Series | 63 ohms, wire wound, adjustable (1 band). |
| R25 | 1 | Heater Shunt | 250 ohms, wire wound, adjustable (2 bands). |
| R26# | 1 | Thyratron Bias | 100 ohms, 22 watt, adjustable (1 band). |
| R27# | 1 | Thyratron Bias | 100 ohms, 22 watt, adjustable (1 band). |
| CR-1# | 1 | Rectox | S#1194744 |
| | | TRANSFORMERS | |
| T1 | 1 | Thyratron Input | 1/4 ratio tapped secondary, L426682 |
| T2 | 1 | Relay Tube Output | 2500/500 ohms Impedance Ratio, L426549 |
| T3* | 1 | Receiver-Audio | 2500/500 ohms Impedance Ratio, L426549 |
| | | TUBES | |
| V1 | 1 | Carrier Start Thyratron-Gas | Type 2050 |
| V2 | 1 | Relay Thyratron-Gas | Type 2050 |
| V3 | 1 | Rectifier Doubler-Vacuum | Type 25Z6 |
| V4 | 1 | Relay Tube-Vacuum | Type 25L6 |
| | | TUBE SOCKETS | |
| X1-X4 | 4 | Octal Tube Socket | S#1473459 (From Dwg. T7614215-14). |

*In Control Unit S#867954A only.
#In Control Unit S#1471841 only.

ORDERING INFORMATION

The Westinghouse Electric Corporation is prepared to supply any of the listed parts for servicing this unit. Orders should specify that they are for the Type JY, HKB Control Unit, and mention the unit style number and circuit symbol where it is given. All orders must specify the rating as well.

ACCESSORY GROUP COMPONENTS

Note: Item 1 or 2 will be supplied with the HKB Control Unit for the appropriate application. Tubes are included with the Control Unit.

1. Accessory Group for 125 volts.
   Style: 867955
   Electrical Parts - Resistors R23 & R24
   Mounting panel for R23 and R24.

2. Accessory Group for 250 volts (less external heater series resistor).
   Style: 867956
   Electrical Parts - Resistor R25
   Mounting panel for R25.

# PART III — TYPE HKB TEST FACILITIES

## APPLICATION

The type HKB test facilities provide a simple manually operated test procedure that will check the combined relay and carrier equipment. The test can be performed without the aid of instruments. The results given assurance that all equipment is in normal operating condition without resorting to more elaborate test procedures.

## CONSTRUCTION

Test Switch

The type W test switch is provided with eight pairs of contacts, two pairs of which

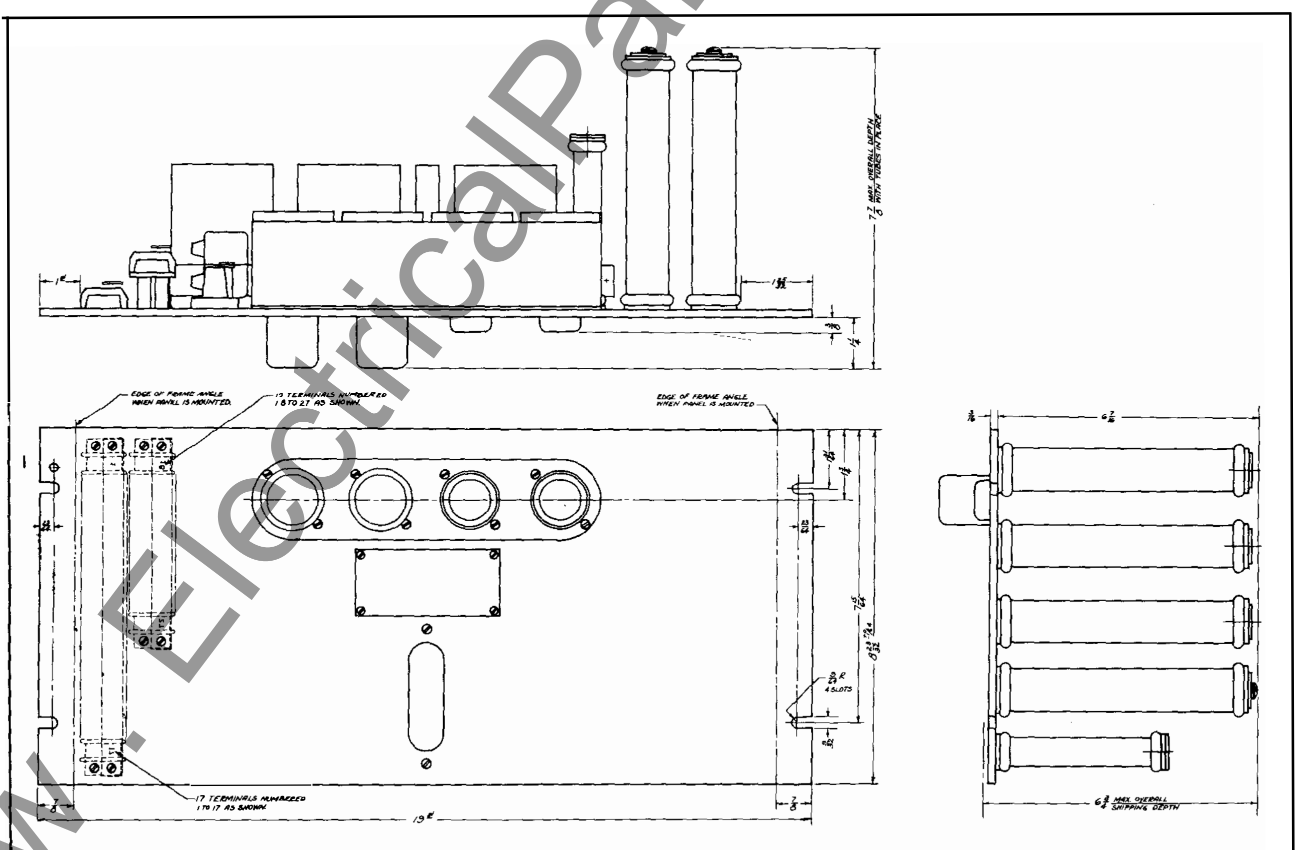


Fig. 11—Outline And Mounting Plan Of The Type HKB Control Unit For Type JY Carrier. For Reference Only.

are closed in the "carrier on" position. The contact arrangement is shown in Fig. 12, and the outline and drilling plan in Fig. 15. These contacts are used to complete the HKB trip circuit and the alarm circuit is indicated in Fig. 12 by contacts 1, 2, and 7, 8. In the "carrier off" position the HKB trip circuit is opened through contacts 1 and 2, but the alarm circuit remains closed. Two test positions to the right of the "carrier off" positions are provided. When the switch is moved to either of these positions, the relay trip and alarm circuits are interrupted and a red alarm light is turned on by switch contact 3 and 4. Moving the switch to the TEST 1 position will connect the output of the auxiliary test transformer directly to the HKB terminals number 25 and 26, through the type W contacts number 9 and 10, 11 and 12. Moving the switch to the TEST 2 position will connect the test transformer with a reversed polarity to the HKB relay through switch contacts 13, 14 and 15, 16.

Auxiliary Test Transformer

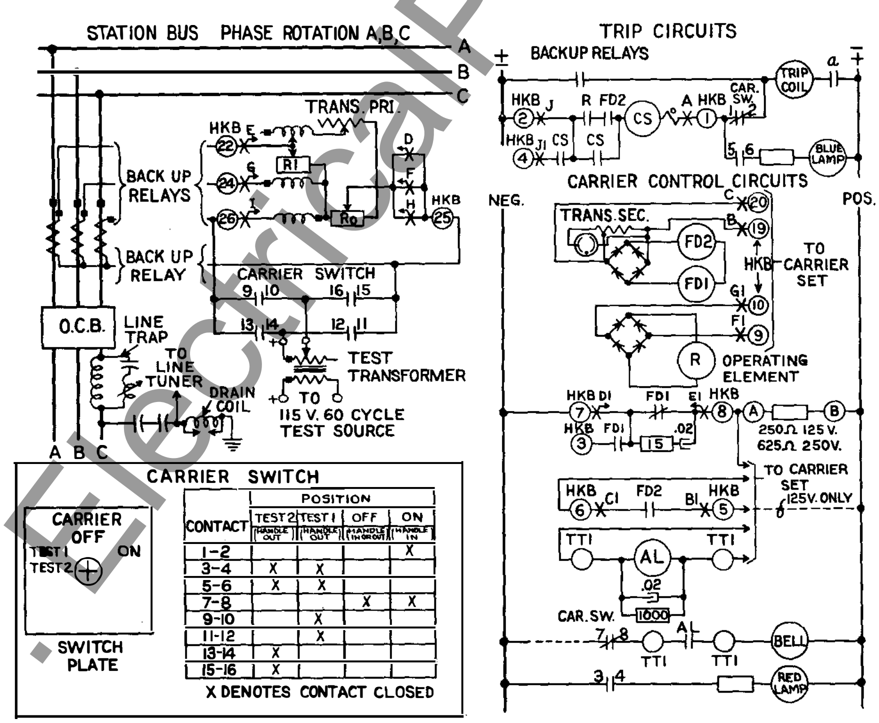
The auxiliary test transformer is designed to operate from a 115 volt, 60 cycle power source. Four secondary taps numbered 1, 2, 3, and 4 are provided to vary the magnitude of the test current. The tap numbers equal the current in amperes that will be passed through the relay when ground tap H is used. If the relay is connected to use ground tap G, approximately two times the transformer tap value (2,4,6, or 8 amperes) will be passed through the relay. The outline and drilling plan of the transformer is shown in Fig. 13.

Indicating Lamps

The red and blue indicating lamps are standard rectangular Minalites. Outline and drilling dimensions are given in Fig. 15.

## ADJUSTMENT

Choose a transformer tap that will provide




| CONTACT | TEST 2 (HANDLE OUT) | TEST 1 (HANDLE OUT) | OFF (HANDLE IN OR OUT) | ON (HANDLE IN) |
|---|---|---|---|---|
| 1-2 | | | | X |
| 3-4 | X | X | | |
| 5-6 | X | X | | |
| 7-8 | | | X | X |
| 9-10 | | X | | |
| 11-12 | | X | | |
| 13-14 | X | | | |
| 15-16 | X | | | |

Fig. 12—Schematic Connections Of Type HKB Relay And Test Facilities.

approximately two times the phase-to-ground current setting of the HKB relay as previously determined.

## OPERATION

A multi-contact switch is provided at each line terminal which serves the dual functions of a carrier on-off switch and a test switch. This switch is arranged to apply a single phase current to the HKB relay to simulated internal and through fault conditions. Relay operation is noted by observing a blue indicating lamp connected in the HKB relay trip circuit. During the test the HKB trip circuit to the line breaker is opened and a red warning light is energized through auxiliary contacts on the test switch.

Use of the auxiliary test equipment is to be limited to provide a simplified test after the initial installation tests have been performed as described in part II of this instruction leaflet.

The test apparatus is to be connected as shown in Fig. 12 with the auxiliary test transformers energized from 115 volt, 60 cycle power sources at each line terminal that are in phase with each other. The following operation procedure assumes that the same polarity is used in connecting the test transformer at each line terminal.

1. Turn the carrier test switch at both line terminals to CARRIER OFF.

2. Turn the carrier test switch to TEST 1 at line terminal #1. The local relay should operate to transmit half cycle impulses of carrier, and trip. Tripping will be indicated by the blue light.

3. Turn the HKB test switch at the remote line terminal #2 to TEST 1. This will simulate an internal fault fed from both line terminals. The relay at line terminal #2 will trip, and the relay at line terminal #1 will remain tripped. Tripping will be indicated by the blue lights at each line terminal. Carrier will be transmitted in half cycle impulses simultaneously from each end of the line.

4. Reset the HKB test switch at line terminal #1. The relay at terminal #1 will reset and turn off the blue light. The relay at terminal #2 will hold its trip contact closed, lighting the blue light.

5. Turn the HKB test switch at line terminal #1 to TEST 2. This condition will simulate an external fault. The trip contacts of both relay, will be held open and the blue light will be extinguished.

6. Reset the test switches at both line terminals to CARRIER OFF before returning to CARRIER ON for normal service. Push in handle to turn in ON position.

This completes the test procedure.

Component Style Numbers

| | |
|---|---|
| Test Transformer | S#1338284 |
| Type W Test Switch | S#1584284 for 1/8" panel mounting. |
| Type W Test Switch | S#1584285 for 1-1/2" panel mounting. |

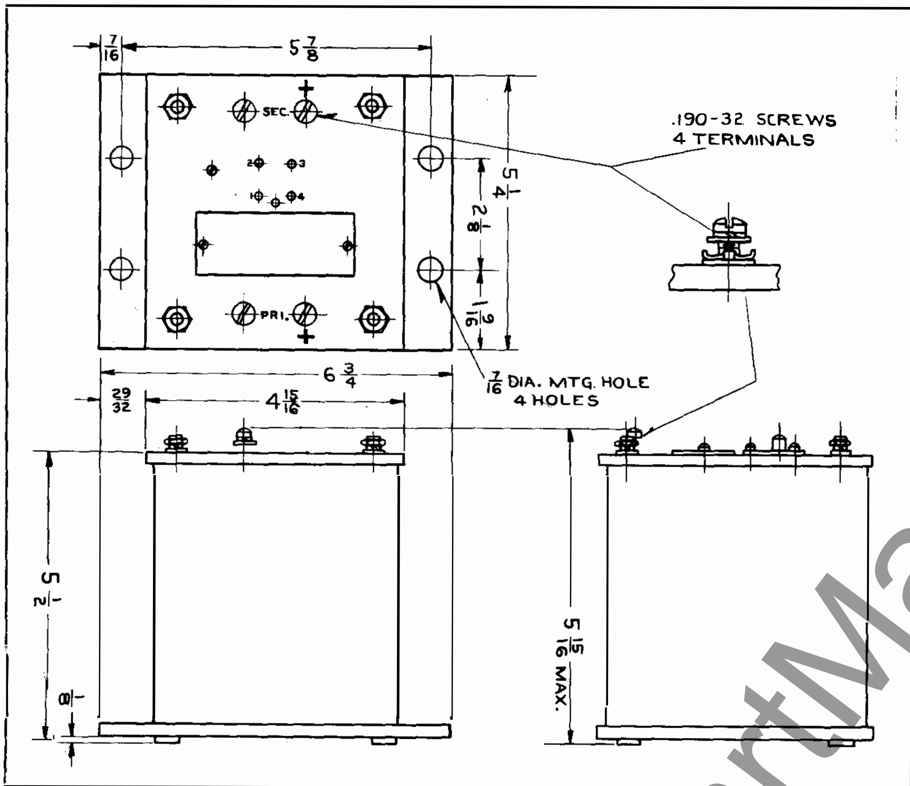



Fig. 13—Outline And Drilling Plan Of The Type HKB Test Transformer. For Reference Only.

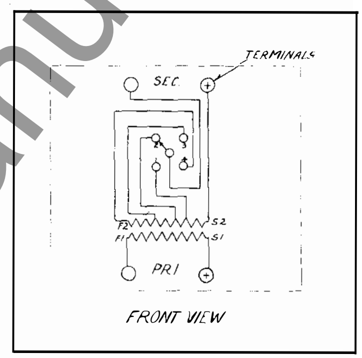



Fig. 14—Internal Schematic Of The Type HKB Test Transformer.

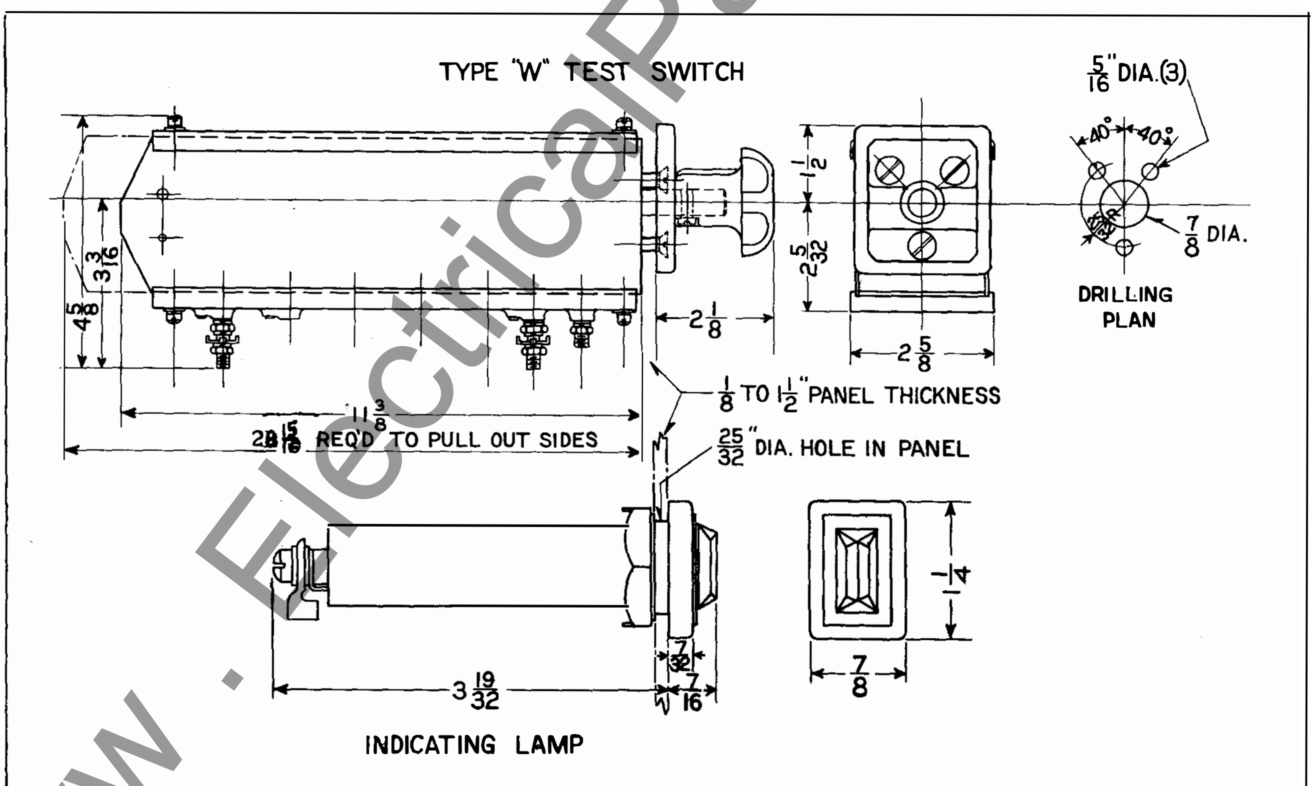



Fig. 15—Outline And Drilling Plan Of The Type W Test Switch And Indicating Lamps Which Are Part Of The Type HKB Test Facilities. For Reference Only.

INSTALLATION • OPERATION • MAINTENANCE

# INSTRUCTIONS

## TYPE HKB RELAY, CARRIER CONTROL UNIT AND TEST EQUIPMENT

## APPLICATION

The type HKB relay is a high speed carrier relay used in conjunction with power lines carrier equipment to provide complete phase and ground fault protection of a transmission line section. Simultaneous tripping of the relays at each line terminal is obtained in three cycles or less for all internal faults within the limits of the relay settings. The relay operates on line current only, and no source of a-c line potential is required. Consequently, the relays will not trip during a system swing or out-of-step condition. The carrier equipment operates directly from the station battery.

## PRINCIPLE OF OPERATION

The HKB carrier relaying system compares the phase positions of the currents at the ends of a line-section over a carrier channel to determine whether an internal or external fault exists. The three-phase line currents energize a sequence filter which gives a single-phase output voltage proportional to a combination of sequence components of the line current. During a fault, this single-pnase voltage controls an electronic circuit which allows the transmission of carrier on alternate half-cycles of the power-frequency current. Carrier is transmitted from both line terminals in this manner, and is received at the opposite ends where it is compared with the phase position of the local sequence filter output. This comparison takes place in the grid circuit of a vacuum tube. The polarities of the voltages to be compared are such that for an internal fault, plate current flows on alternate power-frequency half-cycles. A relay connected in the plate circuit of the vacuum tube operates under this condition to complete the trip circuit. During an external fault, the change in direction of current flow causes the plate current to be continuously blocked, and the plate circuit relay does not operate.

Since this relaying system operates only during a fault, the carrier channel is available at all other times for the transmission of other functions.

## PART I – TYPE HKB RELAY

**CAUTION** Before putting relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

## CONSTRUCTION

The relay consists of a combination positive, negative and zero sequence filter, a saturating auxiliary transformer, two Rectox units, two polar relay units, a telephone-type relay, a neon lamp, contactor switch and operation indicator all mounted in a Type M-20 Flexitest Case.

When the standard projection case is supplied, the sequence filter, tap plates, and saturating auxiliary transformer are mounted in a box which can be located on the rear of the switchboard panel in any convenient position. The remainder of the relay elements are mounted in the relay case proper. The taps and terminal numbers of the relay in the standard case and the external box correspond to those in the type FT case. (See Figures 1,

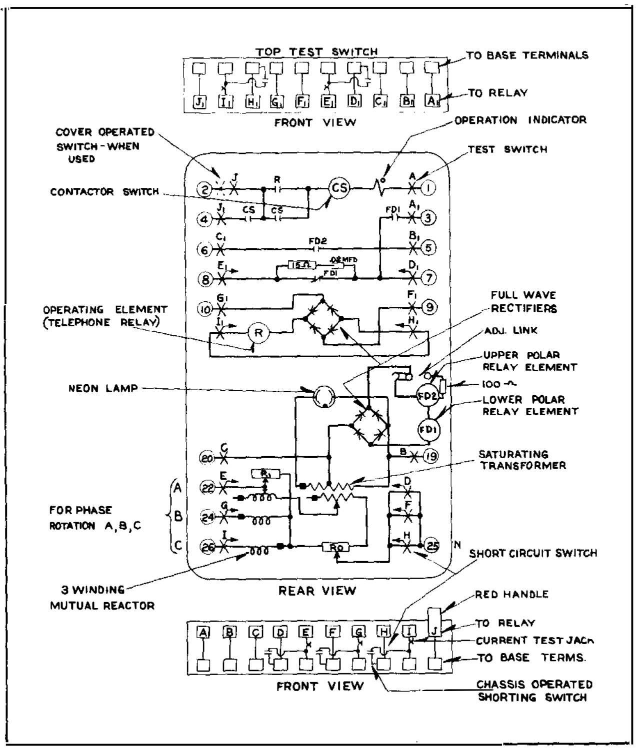



**Fig. 1—Internal Schematic Of The Type HKB Carrier Relay In The Type FT Case.**

2, and 3). Terminals 18, 19 and 20 of the external box are to be connected to the corresponding terminals of the relay in the standard case. Otherwise, all external connections for the relay in the standard projection case or in the type FT case are made to the same terminals.

Sequence Filter

The currents from the current transformer secondaries are passed thru a filter consisting of a three-winding iron-core reactor and two resistors. The zero-sequence resistor, $R_0$, consists of three resistor tubes tapped to obtain settings for various ground fault conditions. The other resistor $R_1$ is a formed single wire mounted on the rear of the relay sub-base. The output of this filter provides a voltage across the primary of the saturating transformer.

The lower tap block provides for adjustment of the relative amounts of the positive, negative and zero sequence components of current in the filter output. Thus a single relay element energized from the filter can be used

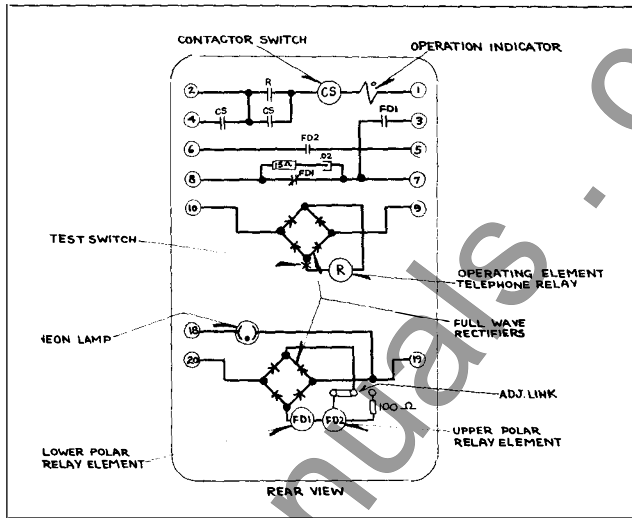



**Fig. 2—Internal Schematic Of The Type HKB Carrier Relay In The Standard Projection Case.**

as a fault detector for all types of faults.

Saturating Auxiliary Transformer

The voltage from the filter is fed into the tapped primary (upper tap plate) of a small saturating transformer. This transformer and a neon lamp connected across its secondary are used to limit the voltage impressed on the fault detectors (polar relay elements) and the carrier Control Unit, thus providing a small range of voltage for a large variation of maximum to minimum fault currents. This provides high operating energy for light faults, and limits the operating energy for heavy faults to a reasonable value.

The upper tap plate changes the output of the saturating transformer, and is marked in amperes required to pick up the lower fault detector element. For further discussion, see section entitled, "Settings".

Rectox Units

The secondary of the saturating transformer feeds a bridge-connected Rectox unit, the output of which energizes the polar fault detector elements. A second Rectox, energized from the output of the Control Unit, supplies a d-c voltage to the telephone relay element which operates only for an internal fault. The use of sensitive polar relay keeps down the energy

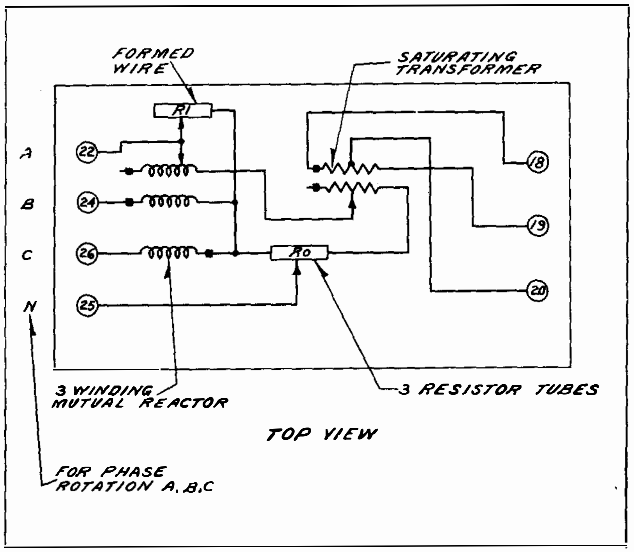



**Fig. 3—Internal Schematic Of The Sequence Filter Used With The Type HKB Relay In The Standard Projection Case.**

required from the current transformers.

Polar-Type Relays

These elements consist of a rectangular shaped magnetic frame, an electromagnet, a permanent magnet, and an armature with a set of contacts. The poles of the permanent magnet clamp directly to each side of the magnetic frame. Flux from the permanent magnet divides into two paths, one path across the air gap at the front of the element in which the armature is located, the other across two gaps at the base of the frame. Two adjustable shunts are located across the rear air gaps. These change the reluctance of the magnetic path so as to force some of the flux thru the moving armature which is fastened to the leaf spring and attached to the frame midway between the two rear air gaps. Flux in the armature polarizes it and creates a magnetic bias causing it to move toward one or the other of the poles, depending upon the adjustment of the magnetic shunts.

A coil is placed around the armature and within the magnetic frame. The current which flows in the coil produces a magnetic field which opposes the permanent magnet field and acts to move the armature in the contact-closing direction.

Contactor Switch

The d-c contactor switch in the relay is a small solenoid type switch. A cylindrical plunger with a silver disc mounted on its lower end moves in the core of the solenoid. As the plunger travels upward, the disc bridges three silver stationary contacts. The coil is in series with the main contacts of the relay and with the trip coil of the breaker. When the relay contacts close, the coil becomes energized and closes the switch contacts. This shunts the main relay contacts thereby relieving them of the duty of carrying tripping current. These contacts remain closed until the trip circuit is opened by the auxiliary switch on the breaker. The contactor switch is equipped with a third point which is connected to a terminal on the relay to operate a bell alarm.

Operation Indicator

The operation indicator is a small solenoid coil connected in the trip circuit. When the coil is energized, a spring-restrained armature releases the white target which falls by gravity to indicate completion of the trip circuit. The indicator is reset from outside of the case by a push rod.

Flexitest Relay Case

The type FT cases are dust-proof enclosures combining relay elements and knife-blade test switches in the same case. This combination provides a compact flexible assembly easy to maintain, inspect, test and adjust. There are three main units of the type FT case: the case, cover, and chassis. The case is an all welded steel housing containing the hinge half of the knife-blade test switches and the terminals for external connections. The cover is a drawn steel frame with a clear window which fits over the front of the case with the switches closed. The chassis is a frame that supports the relay elements and the contact jaw half of the test switches. This slides in and out of the case. The electrical connections between the base and chassis are completed through the closed knife-blades.

ng Chassis

remove the chassis, first remove the by unscrewing the captive nuts at the s. There are two cover nuts on the S ase and four on the L and M size cases. exposes the relay elements and all the switches for inspection and test. The step is to open the test switches. open the elongated red handle switches before any of the black handle switches cam action latches. This opens the circuit to prevent accidental trip out. open all the remaining switches. The of opening the remaining switches is not ant. In opening the test switches they l be moved all the way back against the . With all the switches fully opened, the two cam action latch arms and pull rd. This releases the chassis from the Using the latch arms as handles, pull hassis out of the case. The chassis can et on a test bench in a normal upright ion as well as on its top. back or sides, asy inspection, maintenance and test.

er removing the chassis a duplicate is may be inserted in the case or the portion of the switches can be closed the cover put in place without the is. The chassis operated shorting switch ed behind the current test switch nts open circuiting the current trans-rs when the current type test switches losed.

n the chassis is to be put back in the the above procedure is to be followed in eversed order. The elongated red handle h should not be closed until after the is has been latched in place and all of lack handle switches closed.

rical Circuits

h terminal in the base connects thru a switch to the relay elements in the is as shown on the internal schematic ams. The relay terminal is identified by rs marked on both the inside and outside e base. The test switch positions are ified by letters marked on the top and bottom surface of the moulded blocks. These letters can be seen when the chassis is removed from the case.

The potential and control circuits thru the relay are disconnected from the external circuit by opening the associated test switches. Opening the current test switch short circuits the current transformer secondary and disconnects one side of the relay coil but leaves the other side of the coil connected to the external circuit thru the current test jack jaws. This circuit can be isolated by inserting the current test plug (without external connections), by inserting the ten circuit test plug, or by inserting a piece of insulating material approximately 1/32" thick into the current test jack jaws. Both switches of the current test switch pair must be open when using the current test plug or insulating material in this manner to short-circuit the current transformer secondary.

A cover operated switch can be supplied with its contacts wired in series with the trip circuit. This switch opens the trip circuit when the cover is removed. This switch can be added to the existing type FT case at any time.

Testing

The relay can be tested in service, in the case but with the external circuits isolated or out of the case as follows:

Testing In Service

The ammeter test plug can be inserted in the current test jaws after opening the knife-blade switch to check the current thru the relay. This plug consists of two conducting strips separated by an insulating strip. The ammeter is connected to these strips by terminal screws and the leads are carried out thru holes in the back of the insulated handle.

Voltages between the potential circuits can be measured conveniently by clamping #2 clip leads on the projecting clip lead lug on the contact jaw.

Testing In Case

With all blades in the full open position, the ten circuit test plug can be inserted in the contact jaws. This connects the relay elements to a set of binding posts and completely isolates the relay circuits from the external connections by means of an insulating barrier on the plug. The external test circuits are connected to these binding posts. The plug is inserted in the bottom test jaws with the binding posts up and in the top test switch jaws with the binding posts down.

The external test circuits may be made to the relay elements by #2 test clip leads instead of the test plug. When connecting an external test circuit to the current elements using clip leads, care should be taken to see that the current test jack jaws are open so that the relay is completely isolated from the external circuits. Suggested means for isolating this circuit are outlined above, under "Electrical Circuits".

Testing Out Of Case

With the chassis removed from the base relay elements may be tested by using the ten circuit test plug or by #2 test clip leads as described above. The factory calibration is made with the chassis in the case and removing the chassis from the case will change the calibration values by a small percentage. It is recommended that the relay be checked in position as a final check on calibration.

## CHARACTERISTICS

The overall operating characteristic of the HKB relay and carrier equipment is shown in Figure 4. This shows the current in the operating relay element (telephone-type relay) plotted against the phase angle difference between the fault currents at opposite ends of the line. As indicated, the operating element will trip when the phase angle departs approximately 45° from the in-phase, or through fault condition. As the electronic control circuits operate under a saturated condition, the shape of this curve will not change materially over a wide range of fault currents.

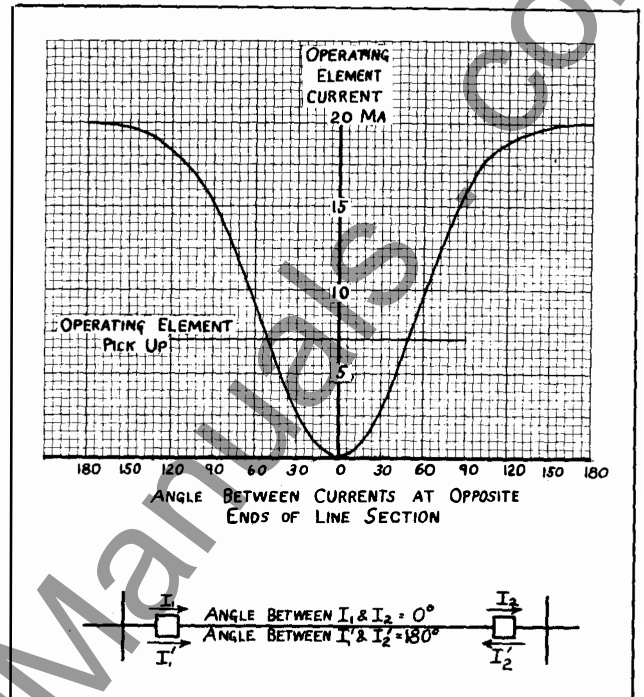



**Fig. 4—Typical Overall Operating Characteristics Of The Type HKB Carrier System.**

The sequence filter in the relay is arranged for several possible combinations of sequence components. For most applications, the output of the filter will contain the positive, negative and zero sequence components of the line current. In this case, the taps on the upper tap plate indicate the balanced three-phase amperes which will pick up the lower or carrier start fault detector (FD1). The upper polar element (FD2), which supervises operation of the telephone-type relay, is adjusted to pick up at a current 25 percent above tap value. The taps available are 3,4,5,6,7,8, and 10. These taps are on the primary of the saturating transformer. For phase-to-phase faults AB and CA, enough negative sequence current has been introduced to allow the fault detector FD1 to pick up at 86% of the tap setting. For BC faults, the fault detector will pick up at approximately 50% of the tap setting. This difference in pick up current for different phase-to-phase faults is fundamental; and occurs because of the angles at which the positive and negative sequence components of current add together.

With the sequence filter arranged for positive, negative and zero sequence output, there are some applications where the maximum load current and minimum fault current are too close together to set the relay to pick up under minimum fault current, yet not operate under load. For these cases, a tap is available which cuts the three phase sensitivity in half, while the phase-to-phase setting is substantially unchanged. The relay then trips at 90% of tap value for AB and CA faults, and at twice tap value for three-phase faults. The setting for BC faults is 65 percent of tap value. In some cases, it may be desirable to eliminate response to positive sequence current entirely, and operate the relay on negative-plus-zero sequence current. A tap is available to operate in this manner. The fault detector picks up at 95% of tap value for all phase-to-phase faults, but is unaffected by balanced load current or three-phase faults.

For ground faults, separate taps are available for adjustment of the ground fault sensitivity to about 1/4 or 1/8 of the upper tap plate setting. See Table II. For example, if the upper tap plate is set at tap 4, the fault detector (FD1) pick-up current for ground faults can be either 1 or 1/2 ampere. In special applications, it may be desirable to eliminate response to zero sequence current. The relay is provided with a tap to allow such operation.

## SETTINGS

The HKB relay has separate tap plates for adjustment of the phase and ground fault sensitivities and the sequence components included in the filter output. The range of the available taps is sufficient to cover a wide range of application. The method of determining the correct taps for a given installation is discussed in the following paragraph.

In all cases, the similar fault detectors on the relays at both terminals of a line section must be set to pick up at the same value of line current. This is necessary for correct blocking during faults external to the protected line section.

Sequence Combination Taps

The two halves of the lower tap plate are for connecting the sequence filter to provide any of the combinations described in the previous section. The left half of the tap plate changes the tap on the third winding of the mutual reactor and thus changes the relative amounts of positive and negative sequence sensitivity. Operation of the relay with the various taps is given in the table below.

TABLE I

| Comb. | Sequence Components In Filter Output | Taps on Lower Tap Block | | Fault Detector FD1 Pick Up △ | |
|---|---|---|---|---|---|
| | | Left Half | Right Half | 3Ø Fault | Ø - Ø Fault |
| 1 | Pos. Neg., Zero | C | G or H* | Tap Value | 86% Tap Value (53% on BC Fault) |
| 2 | Pos., Neg., Zero | B | G or H | 2x Tap Value | 90% Tap Value (65% on BC Fault) |
| 3 | Neg., Zero | A | G or H | | 95% Tap Value |

* Taps F, G and H are zero-sequence taps for adjusting ground fault sensitivity. See section on zero-sequence current tap.

△ Fault detector FD2 is set to pick up at 125% of FD1 for a two-terminal line, or 250% of FD1 for a three-terminal line.

Positive-Sequence Current Tap and FD2 Tap

The upper tap plate has values of 3,4,5,6,7, 8, and 10. As mentioned before, these numbers represent the three-phase, fault detector FD1 pickup currents, when the relay is connected for positive, negative and zero sequence output. The fault detector FD2 closes its contact to allow tripping at current value 25 percent above the fault detector FD1 setting. This 25 percent difference is necessary to insure that the carrier start fault detectors (FD1) at both ends of a transmission line section pick up to start carrier on an external fault before operating energy is applied through FD2.

For a three-terminal line, the tap link on FD1 panel is connected to the right hand tap which allows FD2 to pick up at 250% of FD1 setting. This is necessary to allow proper blocking on three-terminal lines when approximately equal currents are fed in two terminals, and their sum flows out the third terminal of the line. For two-terminal lines, the link is connected to the left hand tap, and operation is as described in the previous paragraph.

The taps on the upper and lower tap plates should be selected to assure operation on minimum internal line-to-line faults, and yet not operate on normal load current, particularly if the carrier channel is to be used for auxiliary function. The dropout current of the fault detector is 75 percent of the pick up current, and this factor must also be considered in selecting the positive-sequence current tap and sequence component combination. The margin between load current and fault detector pick up should be sufficient to allow the fault detector to drop out after an external fault, when load current continues to flow.

Zero-Sequence Current Tap

The right half of the lower tap plate is for adjusting the ground fault response of the relay. Taps G and H give ground fault sensitivities as listed in Table II. Tap F is used applications where increased sensitivity to ground faults is not required. When this tap is used, the voltage output of the filter due to zero-sequence current is eliminated.

Table II

| Comb. | Lower Left Tap | Ground Fault Pickup Percent of Upper Tap Setting | |
|---|---|---|---|
| | | Tap G | Tap H |
| 1 | C | 25% | 12% |
| 2 | B | 20 | 10 |
| 3 | A | 20 | 10 |

Examples of Relay Settings

CASE I

Assume a two-terminal line with current transformers rated 400/5 at both terminals. Also assume that full load current is 300 amperes, and that on minimum internal phase-to-phase faults 2000 amperes is fed in from one end and 600 amperes from the other end. Further assume that on minimum internal ground faults, 400 amperes is fed in from one end, and 100 amperes from the other end.

Positive Sequence Current Tap

Secondary Values:

Load Current $= 300 \times \frac{5}{400} = 3.75$ amperes (1)

Minimum Phase-To-Phase Fault Current:

$600 \times \frac{5}{400} = 7.5$ amperes (2)

Fault detector FD1 setting (three phase) must be at least:

$\frac{3.75}{0.75} = 5$ amperes (0.75 is dropout ratio of fault detector) (3)

so that the fault detector will reset on load current.

In order to complete the trip circuit on a 7.5 ampere phase-to-phase fault, the fault detector FD1 setting (three-phase) must be not more than:

$7.5 \times \frac{1}{0.866} \times \frac{1}{1.25} = 6.98$ amperes (4)

$1.25 = \frac{\text{FD2 pick up}}{\text{FD1 pick up}}$

Sequence Combination Tap

From a comparison of (3) and (4) above, it is evident that the fault detector can be set to trip under minimum phase fault condition, yet not operate under maximum load. In this case, tap C on the lower left tap block would be used (see Table 1, Comb. 1) as there is sufficient difference between maximum load and minimum fault to use the full three-phase sensitivity. Current tap 6 would be used.

Zero Sequence Tap

Secondary Value:

$100 \times \frac{5}{400} = 1.25$ amperes minimum ground fault current

With the upper tap 6 and sequence tap C in use, the fault detector FD1 pickup currents for ground faults are as follows:

Lower right tap G-1/4 x 6 = 1.5 amp.
Minimum trip = 1.25 x 1.5 = 1.88 amp.
Lower right tap H-1/8 x 6 = 0.75 amp.
Minimum trip = 1.25 x 0.75 = 0.94 amp.

From the above, tap H would be used to

trip the minimum ground fault of 1.25 amperes.

CASE II

Assume the same fault currents as in Case I, but a maximum load current of 500 amperes. In this example, with the same sequence combination as in Case I, the fault detectors cannot be set to trip on the minimum internal three-phase fault, yet remain inoperative on load current. (Compare (5) and (6) below). However, by connecting the filter per Combination 2 on Table I, the relay can be set to trip on minimum phase-to-phase fault, although it will have only half the sensitivity to three-phase faults. This will allow operation at maximum load without picking up the fault detector, and provide high speed relaying of all except light three-phase faults.

In order to complete the trip circuit on a 7.5 ampere phase-to-phase fault, the fault detector tap must now be not more than:

$$7.5 \times \frac{1}{1.25} \times \frac{1}{0.9} = 6.6 \qquad (5)$$

To be sure the fault detector FD1 will reset after a fault, the minimum tap setting is determined as follows:

$$\text{Load Current} = 500 \times \frac{5}{400} = 6.25 \text{ amps} \qquad (6)$$

$$\frac{6.25}{0.75} = 8.33 \qquad (7)$$

Since the fault detector pickup current for three-phase faults is twice tap value, half the above value (Eq. 7) should be used in determining the minimum three-phase tap.

$$\frac{8.33}{2} = 4.17 \qquad (8)$$

From a comparison of (5) and (8) above, tap 5 or 6 could be used.

With the three-phase tap 5 in use, the fault detector pickup current for ground faults will be as follows:

Tap G-1/5 x 5 =1.0 a.
Minimum trip = 1.0 x 1.25 a. = 1.25 amp.

Tap H-1/10 x 5 = 0.5 a.
Minimum trip = 1.25 x 0.5 a. = 0.63 amp.

Therefore, tap H would be used to trip the minimum ground fault of 1.25 ampere with a margin of safety.

# INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration and heat. Mount the relay vertically by means of the two mounting studs for the type FT projection case or by means of the four mounting holes on the flange for the semi-flush type FT case. Either of the studs or the mounting screws may be utilized for grounding the relay. The electrical connections may be made direct to the terminals by means of screws for steel panel mounting or to terminal studs furnished with the relay for ebony-asbestos or slate panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the studs and then turning the proper nut with a wrench.

External Resistor

A resistor is required in the carrier start fault detector circuit, as shown in Fig. 12 connected between HKB relay terminal 8 and

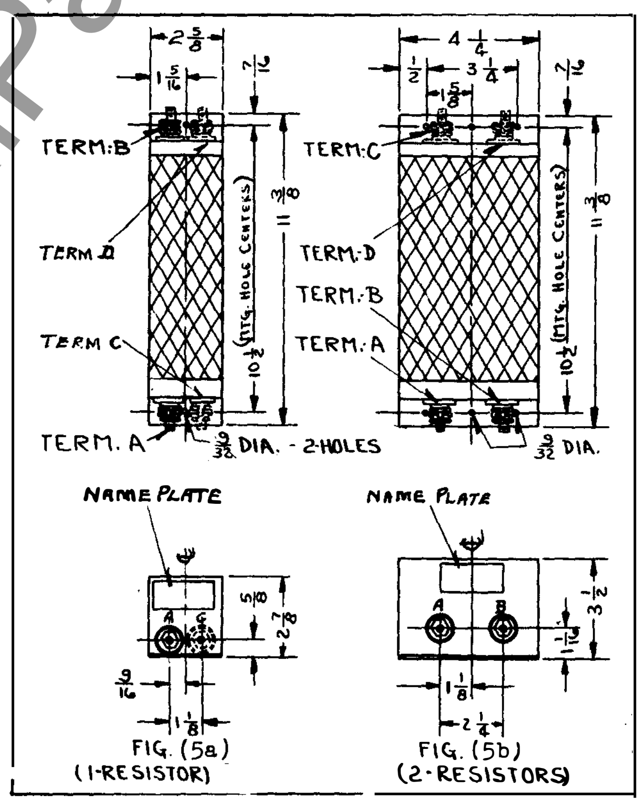



**Fig. 5—Outline And Drilling Plan For The External Resistor Used In The HKB Relay Control Circuit. For Reference Only.**

battery positive. Its function is to avoid short circuiting the station battery through the normally-closed contact of the carrier start fault detector FD1.

The values of this resistor are tabulated below.

| Style No. | D.C. Supply | Ohms | Outline & Drilling |
|---|---|---|---|
| 1337179 | 125 volts | 250 | Fig. 5a |
| 1337181 | 250 volts | 625 | Fig. 5b |

This resistor can be mounted on the rear of the switchboard in any convenient location.

## ADJUSTMENTS AND MAINTENANCE

**CAUTION**

1. Make sure that the neon lamp is in place whenever relay operation is being checked. This is necessary to limit the voltage peaks in the filter output at high currents so as to prevent damage to the Rectox Units.

2. When changing taps under load, the spare tap screw should be inserted before removing the other tap screw.

3. All contacts should be periodically cleaned with a fine file. S#1002110 file is recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

4. The proper adjustments to insure correct operation of this relay have been made at the factory and should not be disturbed after receipt by the customer. If the adjustments have been changed, the relay taken apart for repairs, or if it is desired to check the adjustments at regular maintenance periods, the instructions below should be followed.

Sequence Filter

There are no adjustments to make in the filter.

The following mechanical adjustments are given as a guide, and some deviation from them may be necessary to obtain proper electrical calibration.

Fault Detector FD1 (Lower Polarized Relay Element)

Back off contact screws so that they do not make contact. Screw magnetic shunts into the all out position. The armature should remain against whichever side it is pushed with this adjustment.

Contact Adjustment

Push the armature to the right. Adjust the right-hand contact until it barely makes a light circuit. A flickering light is permissible. Give the contact screw 2/3 turn to obtain the proper follow. Lock in position by tightening the nut on the contact screw.

Now push the armature to the left. Adjust the left hand contact until it barely makes a light circuit, then give the contact screw an additional 2/3 turn to obtain the proper contact follow. Lock in position.

Calibration

During calibration, connect a 10,000 ohm resistor across terminals 19 and 20 or switch jaws B and C to simulate the load of the transformer in the Control Unit. Approximate adjustments are as follows: Screw in the right hand magnetic shunt until the top air gap is shunted. With the upper tap on 4, and the lower taps on C and H, pass 3.46 amperes, 60 cycles in phase A and out phase B, and screw in the left hand shunt until the armature closes the right hand contact. Reduce the current until the armature resets; this should happen at not less than 75% of the pick up value. Lock the shunts in position and recheck the calibration several times. The action of the armature should be snappy. It may be necessary to increase the contact follow to obtain the required dropout. As finally adjusted, the contact gap must be at least .016 inch.

Fault Detector FD2 (Upper Polarized Relay Element)

Contact Adjustment

Adjust the single contact the same as the right hand contact on the lower polar element.

Calibration

Connect the 10,000 ohm resistor across relay terminals 19 and 20 or switch jaws B and C. Set the relay taps on 4, C and H as before. Screw in the right hand shunt until the top air gap is shunted. Pass 4.33 amperes in phase A and out phase B, and screw in the left hand shunt until the armature closes its contact. Reduce the current until the armature resets; this should happen at not less than 75% of the pick up value. Lock the shunts in position and recheck the calibration several times. The action of the armature should be snappy. It may be necessary to increase the follow on the contact to obtain the required dropout. As finally adjusted, the contact gap must be at least .016 inch.

Operating Element (Telephone Type Relay)

Check contact adjustment to see that stationary contact is deflected 5 to 10 mils after contact closes.

Calibration

Connect a d-c milliammeter (0-25 ma) across test switch jaws H1 and I1 (relay out of case). Connect a source of variable a-c voltage (0 to 10 volts) between terminals 9 and 10 (or switch jaws F1 and G1). The element is to be adjusted for 7.5 to 8.5 ma. d-c pick up and 3 to 5 ma. dropout. The contact spring tension and the armature set screw can be adjusted to obtain these values.

For the relay in the standard case, apply the a-c voltage across terminals 9 and 10 and insert a test plug connected to a d-c milliammeter in the single test switch jack of the relay. If clip leads are used, it will be necessary to slip a strip of insulating material such as fiber into the test switch jack after opening the switch blade to obtain a reading.

Contactor Switch

Adjust the stationary core of the switch for a clearance between the stationary core when the switch is picked up. This can be most conveniently done by turning the relay upside-down. Screw up the core screw until the moving core starts rotating. Now, back off the core screw until the moving core stops rotating. This indicates the point where the play in the moving contact assembly is taken up, and where the moving core just separates from the stationary core screw. Back off the stationary core screw one turn beyond this point and lock in place. This prevents the moving core from striking and sticking to the stationary core because of residual magnetism. Adjust the contact clearance for 3/32 inch by means of the two small nuts on either side of the Micarta disc. The switch should pick up at 2 amperes d-c. Test for sticking after 30 amperes d-c have been passed thru the coil. The coil resistance is approximately 0.25 ohm.

Operation Indicator

Adjust the indicator to operate at 1.0 ampere d-c gradually applied by loosening the two screws on the under side of the assembly, and moving the bracket forward or backward. If the two helical springs which reset the armature are replaced by new springs, they should be weakened slightly by stretching to obtain the 1 ampere calibration. The coil resistance is approximately 0.16 ohm.

## RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

## ENERGY REQUIREMENTS

Burdens measured at a balanced three-phase current of five amperes.

| Relay Taps | Phase A VA | Phase A Angle | Phase B VA | Phase B Angle | Phase C VA | Phase C Angle |
|---|---|---|---|---|---|---|
| A-F-3 | 2.4 | 5° | 0.6 | 0° | 2.5 | 50° |
| A-H-10 | 3.25 | 0° | 0.8 | 100° | 1.28 | 55° |
| B-F-3 | 2.3 | 0° | 0.63 | 0° | 2.45 | 55° |
| B-H-10 | 4.95 | 0° | 2.35 | 90° | 0.3 | 60° |
| C-F-3 | 2.32 | 0° | 0.78 | 0° | 2.36 | 50° |
| C-H-10 | 6.35 | 342° | 3.83 | 80° | 1.98 | 185° |

Burdens measured at a single-phase to neutral current of five amperes.

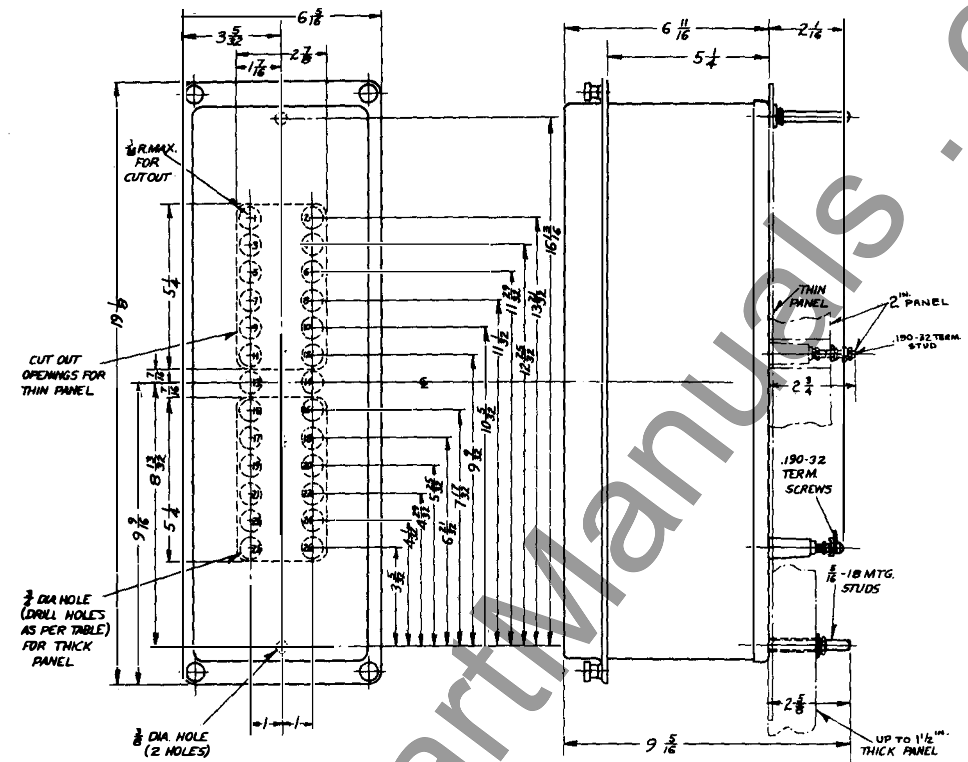



Fig. 6—Outline And Drilling Plan For The M-20 Projection Type FT Flexitest Case. See The Internal Schematic For The Terminals Supplied. For Reference Only.

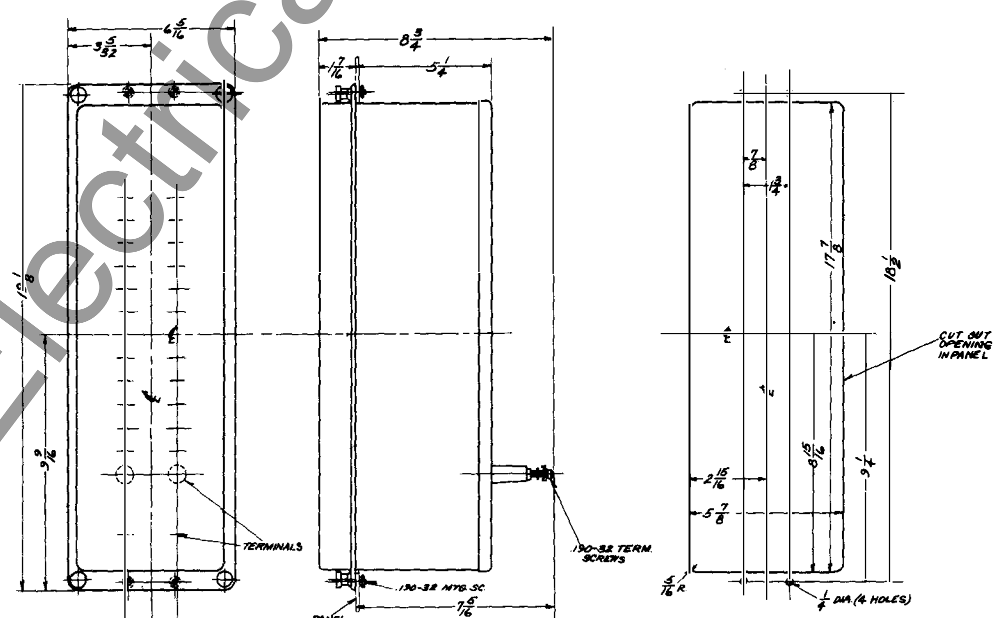



Fig. 7—Outline And Drilling Plan For The M-20 Semi-Flush Type FT Flexitest Case. For Reference Only.

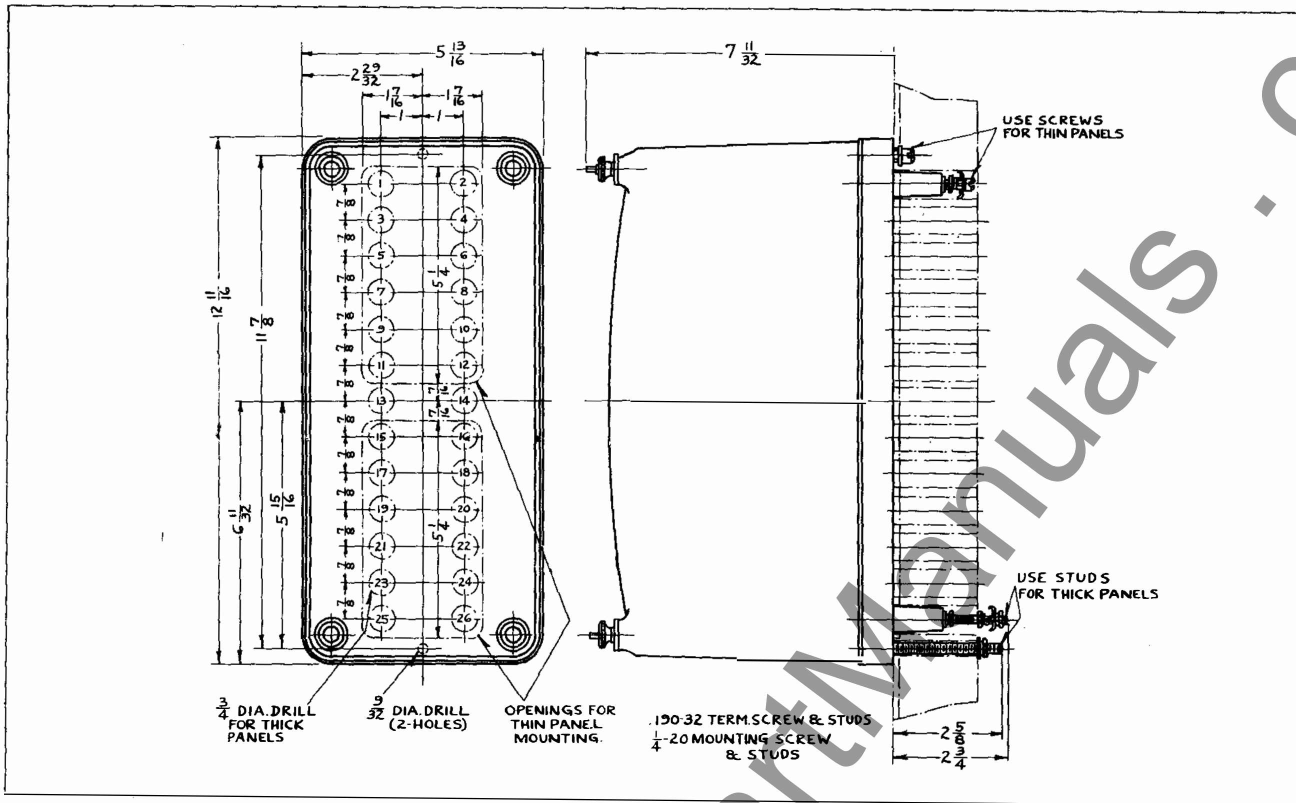



**Fig. 8—Outline And Drilling Plan For The Standard Projection Case. See The Internal Schematic For The Terminals Supplied. For Reference Only.**

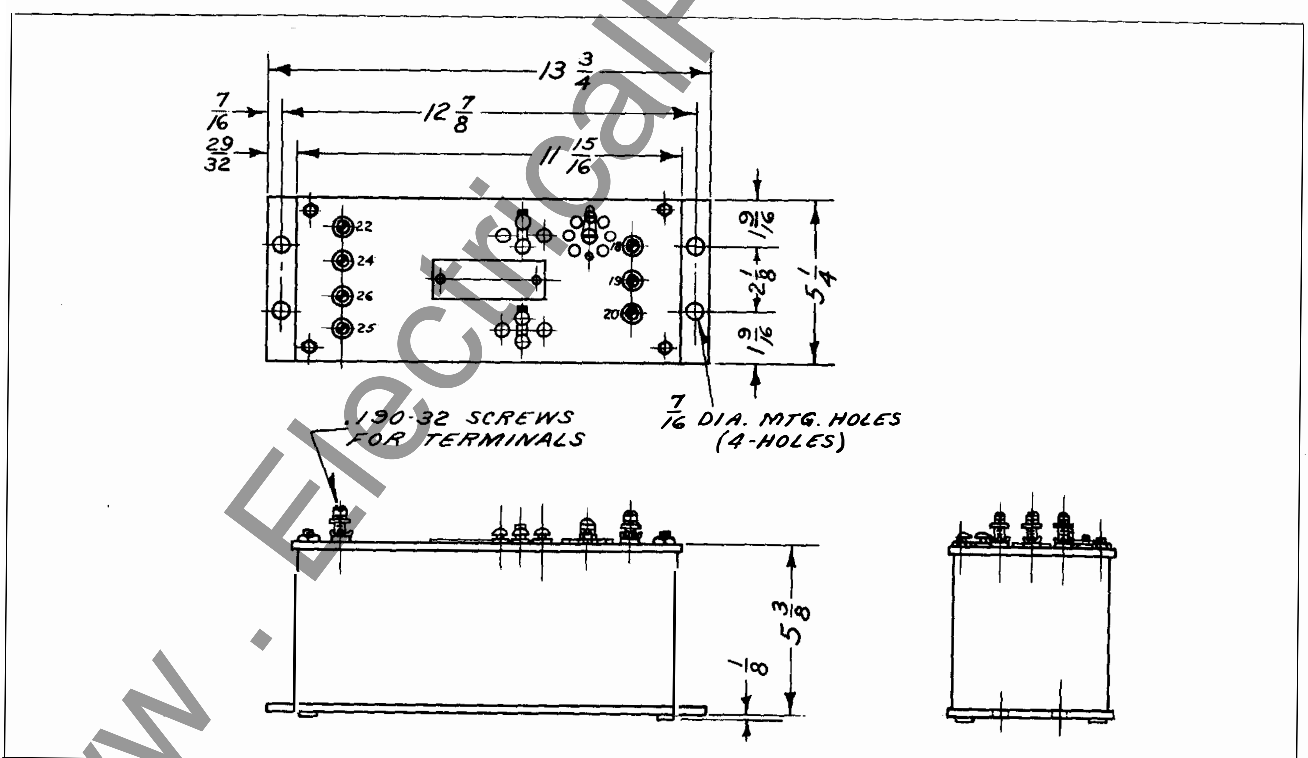



**Fig. 9—Outline And Drilling Plan For The Sequence Filter Used With The Type HKB Relay In The Standard Case. For Reference Only.**

| Relay Taps | Phase A VA | Phase A Angle | Phase B VA | Phase B Angle | Phase C VA | Phase C Angle |
|---|---|---|---|---|---|---|
| A-F-3 | 2.47 | 0° | 2.1 | 10° | 1.97 | 20° |
| A-H-10 | 7.3 | 60° | 12.5 | 53° | 6.7 | 26° |
| B-F-3 | 2.45 | 0° | 2.09 | 15° | 2.07 | 10° |
| B-H-10 | 16.8 | 55° | 22.0 | 50° | 12.3 | 38° |
| C-F-3 | 2.49 | 0° | 1.99 | 15° | 2.11 | 15° |
| C-H-10 | 31.2 | 41° | 36.0 | 38° | 23.6 | 35° |

The angles above are the degrees by which the current lags its respective voltage.

## PART II – TYPE HKB CONTROL UNIT

**CAUTION** When adjusting this equipment, allow the tube heaters to warm up for at least 30 seconds before applying plate voltage (by operating the relay fault detector). This precaution is necessary to prevent damage to the Type 2050 thyratrons.

### CONSTRUCTION

The HKB Control Unit consists of an electronic trigger circuit employing two thyratrons; a rectifier-doubler vacuum tube for the received carrier and a vacuum "relay" tube which compares the phase positions of the local and distant line currents.

The general appearance and construction of the Type HKB Control Unit is shown by the outline drawing, Figure 11. The entire equipment, with the exception of the accessories, is mounted on a standard 3/16" thick aluminum panel 19" wide and 8-23/32" high with standard notching. The front of the panel is black wrinkle finished, and the rear is Nasat. The tubes protrude through the front panel for convenient installation and replacement.

Jacks are provided on the front of the panel for current metering as follows:

J1(top jack) Heater current
J2(center jack) Relay tube emission current
J3(bottom jack) Rectifier-doubler output current

### INSTALLATION

When used with the Type JY Transmitter and Receiver, the HKB Control Unit is mounted in the same cabinet with these panels and immediately beneath the Receiver panel. The Instruction Book for the complete assembly of which this unit is a part should be referred to for additional mounting instructions.

Upon delivery, the unit should be very carefully checked for damaged parts. Particular attention should be given to any parts which may have become loose in shipment, or wires which may have broken because of vibration. Each HKB Control Unit is supplied with an accessory group of components for adapting it for operation from 125 volts d-c or 250 volts d-c. These components should be checked for damage and to see that none are missing, and checked against the order or requisition and the parts list in this book as well as the instruction sheet furnished with each accessory package. Any shortage should be immediately reported to the transportation company and to the nearest district office of the manufacturer. The dummy resistor plug furnished with the HKB accessories is for use in the JY Transmitter amplifier cathode circuit. Remove the resistor regularly furnished with the JY Transmitter and replace with this dummy plug.

The necessary connections from the JY (cabinet) assembly terminal blocks to the switchboard, relays, etc., should be made in suitable conduit. Number 12 gauge wire is recommended for these connections. The connection diagrams in the instruction book for the complete assembly should be followed. Be sure to ground terminal #1 on the HKB Unit and also cabinet terminal #1.

CIRCUIT ADJUSTMENT - GENERAL

Do not insert the tubes into the HKB Control Unit until the following paragraphs dealing with circuit adjustments have been read.

The HKB Control Unit is designed to use the same tubes for either 125 volt or 250 volt operation. When used on 250 volts d-c, the proper value of plate voltage for the Type 25L6 Relay Tube is obtained from a connection at the positive end of the transmitter tube heaters.

In order to obtain bias voltage for both the

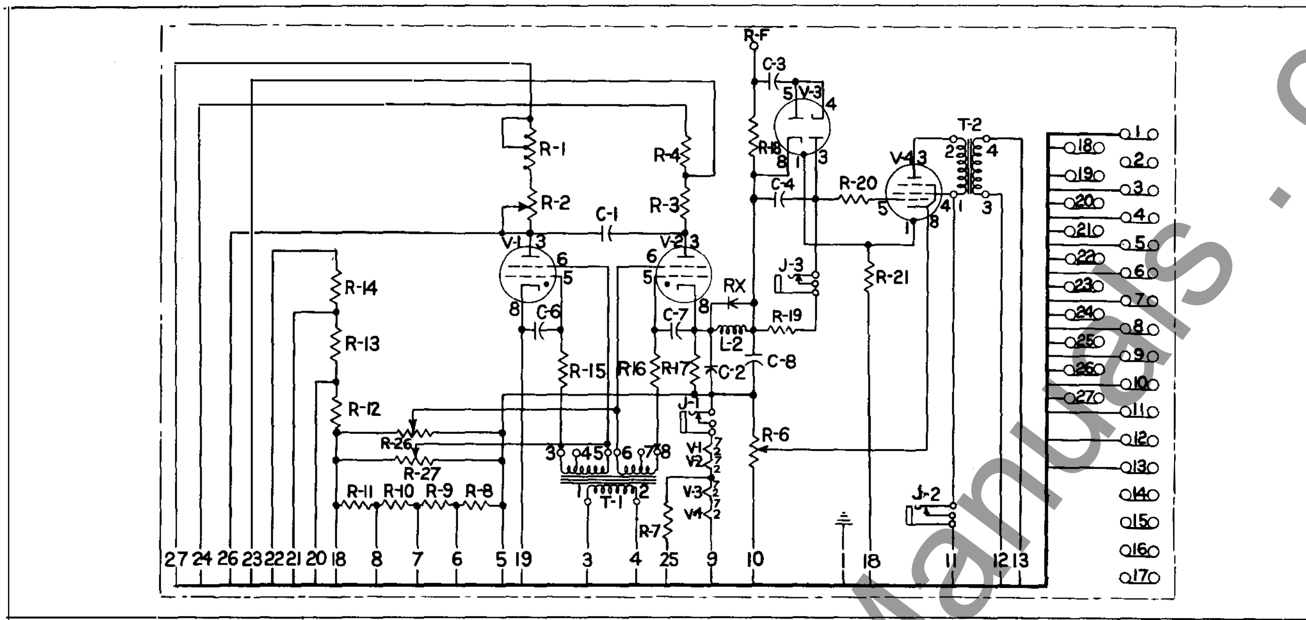



Fig. 10—Internal Schematic Of The Type HKB Control Unit.

HKB Control Unit and the associated carrier transmitter, the entire d-c current drain of both units is caused to flow through a combination of resistors in the Control Unit. In this way, adjustable bias for the Type 2050 thyratrons and fixed bias of two different values, for the power amplifier tubes of the transmitter is obtained. Because the adjustment procedure will follow the tabulations shown on Tables I and II as closely as possible, it is important to become thoroughly familiar with the tables. Five columns are included in these tables. The first column indicates the quantity to be checked. The second column indicates the minimum value permissible. The third column indicates the normal value. The fourth column indicates the maximum value permissible. The fifth column should be filled in at the time of installation, to indicate the actual value which was obtained. The last column is of great importance and should be filled in as soon as the HKB Control Unit is installed. All quantities must be brought within the minimum and maximum value specified before the equipment can be considered to be in satisfactory operating condition. A copy of these values should be kept with the equipment for checking purposes. All letters of inquiry to the manufacturer regarding the operation of this unit should be accompanied by a list of actual values of the eight quantities tabulated on Table I or II.

The maximum and minimum limits of the values in the table do not all correspond to the same percentage. In the case of the power supply or battery voltage, the limits given are the maximum and minimum at which the unit can be properly adjusted to operate; and these limits include the maximum variation in power supply voltage. For instance, the HKB unit with 125 volt accessories can be adjusted to function properly on any battery which never exceeds 150 volts or drops below 100 volts. But once the normal voltage is established and adjustments are made for operation on that voltage, it should not be permitted to fluctuate normally more than plus or minus five percent.

The Unit has been designed to use either glass or metal tubes of types 25L6 and 25Z6, and the adjustment data is the same for either.

CIRCUIT ADJUSTMENTS - 125 VOLT EQUIPMENT

The numbers at the beginning of the following paragraphs correspond to the line numbers in the Adjustment Data Tables.

1. The first line in the Adjustment Data Table is the power supply or battery voltage, which is to be measured at the cabinet terminals before any of the equipment is turned on. The actual value of this voltage at the time of installation should be entered on the line in the fifth column of the data table. If it is not within the limits of 100 to 150 volts d-c, do not proceed.

2. Adjustment of the HKB Control Unit tube heater current is now to be carried out. Since the bias resistor (combination of R8, R9, R10, R11 and R5) is common to the heater circuits of both the carrier transmitter-receiver and the HKB Control Unit, adjustment of heater current of the one unit will affect that of the other. In order to avoid difficulty, the bias resistor mentioned is to be temporarily shorted out during the adjustment of heater current for both the transmitter-receiver and the HKB Control Unit. BEFORE PROCEEDING, REFER TO THE INSTRUCTION BOOK FOR THE ASSEMBLY OF WHICH THIS UNIT IS A PART AND CARRY OUT THE DIRECTIONS THEREIN FOR INSERTING MAXIMUM RESISTANCE INTO THE TRANSMITTER-RECEIVER HEATER CIRCUIT. Connect a jumper wire across terminals #5 and #18 of the HKB Control Unit. The adjusting clip on resistor R6 is to be set roughly in the center of the resistor. The adjusting clips on the two adjustable resistors R23 and R24, which are external heater series resistors mounted on a separate panel, are to be set so as to short out the least possible amount of these resistors. Remove the dummy resistor plug from its clips in the transmitter amplifier cathode return circuit. The tubes are now to be inserted into the HKB assembly of which the HKB Unit is a part. Plug a d-c ammeter of 1 ampere range into jack J1 and adjust the shorting clips of external resistors R23 and R24 to obtain the correct heater current as given in line #2 of the table. It is desirable to keep the amount shorted out of each of these two resistors about equal so as to distribute the heat produced equally between them. When the power is first applied, the tube heater current will be above normal due to the low resistance of the cold heater elements. Consequently power should be applied for at least two minutes before readings are taken. After the heater current of the HKB Control Unit and the heater current of the transmitter-receiver have each been adjusted, remove the jumper wire from terminals #5 and #18 of the HKB Unit. Replace the dummy resistor plug in its clips in the transmitter.

3. After the adjustments on the transmitter have been completed and the transmitter is in normal operation measure again the heater current of the HKB Unit at Jack J1. If not within the limits of line #3 in the Data Table, make such slight changes to the setting of the external resistors R23 and R24 as may be required to correct it. (A similar operation should be carried out on the transmitter-receiver.)

4. After the above adjustments are completed, measure at the other two metering jacks. J2 and J3, to see that no current is flowing. Under the condition of the bias resistor R6 being set near the center, the Relay Tube, V4, is biased well beyond plate current cut-off, so that the current at jack J2 should be well below the limit of .1 milliampere. Under the condition of no r-f signal received, the current at jack J3 should be well below the limit of .1 ma. Any excessive current flow should be investigated and the fault cleared before proceeding with the tests. (Make final check with 1.5 milliampere range of meter.)

5. Measure the d-c bias voltage between terminals #5 and #18.

6. This adjustment is for the purpose of obtaining the correct Master Oscillator plate voltage for the transmitter. The transmitter must be completely adjusted and in a state of normal operation (ready to be controlled by the HKB Unit). In making this adjustment it is necessary to have $V_1$ thyratron continuously ignited. For Control Unit S#867954A, a single resistor R5 is in place of resistors R26 and R27. Remove the lead from the R5 tap nearer the panel and connect this lead to terminal #19 of the Control Unit. For Control Unit S#1471841, remove the lead from the R27 tap

TABLE I

ADJUSTMENT FOR HKB CONTROL UNIT ON 125 VOLTS

See text of Instruction book for discussion of the following table. Numbers preceeding data refer to test paragraph numbers.

| | Quantity | Min. | Normal | Max. | Actual |
|---|---|---|---|---|---|
| 1. | Power Supply Volts | 100 | 125 | 150 | |
| 2. | Heater Amperes, Preliminary Adjustment # | .59 | .62 | .65 | |
| 3. | Heater Amperes, Final Adjustment + | .54 | .56 | .58 | |
| 4. | Current at jack J2, Milliamperes | 0 | 0 | .10 | |
| | Rectifier-doubler Output Milliamperes at J3 * | 0 | .05 | .10 | |
| 5. | Total Bias Volts | 11 | 14 | 17 | |
| 6. | Master Oscillator Plate Volts---------------------See transmitter instruction book. | | | | |
| 7. | Thyratron Grid Bias Volts | 4.0 | 6.0 | 10.0 | |
| 8. | Relay Tube Grid Bias Volts | 20 | 26 | 32 | |
| | HKB Relay Operating Element Current, Ma. | 18 | 20 | 22 | |

\# - The total tube heater current of the associated transmitter should be adjusted to this value also.

\+ - The final value of the tube heater current of the transmitter should be within these limits for the total, and half of these values for each branch.

* - With no carrier being received.

TABLE II

ADJUSTMENT DATA FOR HKB CONTROL UNIT ON 250 VOLTS

See text of instruction book for discussion of the following table. Numbers preceeding data refer to text paragraph numbers.

| | Quantity | Min. | Normal | Max. | Actual |
|---|---|---|---|---|---|
| 1. | Power Supply Volts | 200 | 250 | 300 | |
| 2. | Tube Heater Amperes - Control Unit | .54 | .56 | .58 | |
| | " " " - Transmitter | .81 | .85 | .89 | |
| 3. | Plate Circuit Supply Volts | 95 | 135 | 165 | |
| 4. | Current at jack J2, Milliamperes | 0 | 0 | 0.1 | |
| | Rectifier-doubler Output Milliamperes at J3 * | 0 | .05 | 0.1 | |
| 5. | Total Bias Volts | 17 | 22 | 28 | |
| 6. | Master Oscillator Plate Volts--------------------See transmitter instruction book. | | | | |
| 7. | Thyratron Grid Bias Volts | 4.0 | 7.0 | 12.0 | |
| 8. | Relay Tube Grid Bias Volts | 20 | 26 | 32 | |
| | HKB Relay Operating Element Current, Ma. | 18 | 20 | 22 | |

* - With no carrier being received.

and connect to terminal #19. Now turn on the equipment and allow the thyratrons to heat up for one minute. Block open the back contact of the HKB lower fault detector. Thyratron V1 will fire and remain conducting. Connect a d-c voltmeter of at least 1000 ohm-per-volt resistance between terminal #5 and terminal #19. Adjust R1 and R2 to obtain the required voltage as given in the Table in the Transmitter Instruction Book. The transmitter should now be sending out carrier at its full output power. Restore all connections to normal.

7. The object of the following adjustment is to set the firing point of the thyratrons V1 and V2 to the proper value by adjusting their grid bias. Two resistors, R26 and R27, are provided for separate adjustment of V1 and V2 grid bias in Control Unit S#1471841. Control Unit S#867954A has a single resistor with two sliders (R5) for adjustment of V1 and V2 grid bias. The bias can be measured between each slider and terminal #5.

In making this adjustment, it is necessary to apply a simulated fault to the HKB relay and associated carrier set. If the current circuits of the relay are not connected to the line current transformers, a single-phase 60 cycle current from a variable test source can be applied to the HKB relay terminals 24 and 25, simulating a single-phase-to-ground fault. If the relay current circuits are connected to the line, open test switches D, E. F, G H, I and J. Test switch J opens the trip circuit. This switch should be opened first and left open during all adjustments. The current circuits to the relay have been shorted by opening switches D, F, and H, but the relay is still connected to the current transformers through the test jacks on switches E, G and I. These circuits are opened by inserting current test plugs or strips of insulation into the test jacks on switches E, G and I. The relay is now entirely disconnected from the current transformers, and the single phase test source can be connected between switch jaws F and G.

Put the upper tap screw in tap 4 and the lower tap screws in the C and H taps. This sets the pickup current of the relay fault detector at 0.5 ampere for a single-phase-to-ground fault. Adjust the sliders on R5 or R26 and R27 for maximum grid bias on the thyratrons (sliders away from the panel). Block open the normally closed contact on the carrier start fault detector (lower polar element). Insert a milliammeter in jack J1 of the carrier transmitter to read oscillator cathode current. Apply the single-phase test current to the relay and increase it to 0.3 amperes. Now gradually reduce the bias on thyratron V1 by moving R5 slider #1 (the one nearer the panel) or the slider on R27 toward the panel. A point will be reached where V1 fires to start carrier. This will be indicated by reading on the d-c milliammeter in transmitter Jack J1. Tighten the slider at this point. Check this setting by reducing the test current to zero and momentarily removing the blocking in the FD1 back contact to extinguish V1. Increase the test current until V1 fires. This should occur at 0.3 ampere ± 10%.

With V1 fired and the test current set at 0.3 ampere, gradually reduce the bias on thyratron V2 by moving R5 slider #2 (the one further from the panel) or the slider on R26 toward the panel. A point will be reached where V2 fires and triggering will then take place with thyratrons V1 and V2 firing on alternate half cycles of the applied test current. Triggering will be indicated by a reduction in the milliammeter reading at transmitter jack J1 to 50 or 60% of its initial value. Tighten the slider at this point. Check the setting by reducing the test current to zero and momentarily removing the blocking in the FD1 back contact to extinguish V1 or V2 (either may remain fired). Increase the test current until triggering begins. This should occur at 0.3 ampere ± 10%.

Note: Taps are provided on the secondary of transformer T1 to compensate for variation in tubes. The lead shown connected to transformer T1 terminal #3 may be connected to terminal #4, and similarly for terminal #7 and #8.

8. The following adjustment covers the setting of the relay tube (V4) grid bias.

With the test current circuit applied to the relay (described in paragraph 7), increase the a-c current until the neon lamp in the HKB relay lights. Plug a d-c milliammeter into the current jack on test switch I1 on the relay to measure the operating element coil current. Reduce the grid bias on the relay tube by adjusting the slider on resistor R6 until the operating element coil current is 20 milliamperes. The relay tube grid bias is measured between the slider on R6 and terminal #5 of the Control Unit. A voltmeter of at least 1000 ohms-per-volt resistance should be used. Carrier from the distant line terminal should not be transmitted during this adjustment. When the relay tube grid bias is adjusted as described, the overall characteristic of the HKB relaying system is shown in Figure 2. All test circuits and meters may now be removed, and the relay test switches returned to normal. The switch with the red handle should be closed last as this connects the relay to the breaker trip circuit.

CIRCUIT ADJUSTMENTS - 250 VOLT EQUIPMENT

1. The first line in the Adjustment Data Table is the power supply or battery voltage, which is to be measured at the cabinet terminals before any of the equipment is turned on. The actual value of this voltage at the time of installation should be entered on the line in the fifth column of the data table. If it is not within the limits of 200 to 300 volts d-c, do not proceed.

2. Adjustment of the HKB Control Unit tube heater current will be accomplished along with the adjustment of the transmitter heater current, because all the heaters of the assembly are connected in series. The necessary external heater series resistors are a part of the accessories for the assembly of which this Unit is a part; and the instructions for their adjustments are to be found in the instruction book for the complete assembly. After the adjustment is completed record the value of current as measured at jack J1. The heater currents of the Control Unit and the transmitter should be within the limits tabulated on Table II.

External accessory resistor R25 is connected in shunt to the HKB tube heaters. By bypassing .3 ampere, it enables their operation in series with the tube heaters of the transmitter, which draw .9 ampere. Resistor R25 is adjusted at the factory to 208 ohms plus or minus 1 percent and should not be changed from the above value.

3. The plate circuit supply voltage is to be measured between terminal #5 and terminal #10.

4. After the above adjustments are completed, measure at the other two metering jacks, J2 and J3, to see that no current is flowing. Under the condition of the bias resistor R6 being set near the center, the Relay Tube, V4, is biased well beyond plate current cut-off, so that the current at jack J2 should be well below the limit of .1 milliampere. Under the condition of no r-f signal received, the current at jack J3 should be well below the limit of .1 ma. Any excessive current flow should be investigated and the fault cleared before proceeding with the tests. (Make final check with 1 milliampere range of meter).

5. Measure the d-c bias voltage between terminals #5 and #18.

6. Oscillator Plate Voltage. Adjustments are exactly the same as for 125 volt equipment. See paragraph 6 of previous section. Refer to values on Table II.

7. Thyratron Grid Bias Volts. Adjustments are exactly the same as for 125-volt equipment. See paragraph 7 of previous section. Refer to values on Table II.

8. Relay Tube Grid Bias Volts. Adjustments are exactly the same as for 125-volt equipment. See paragraph 8 of previous section. Refer to values on Table II.

## OVERALL TEST OF COMPLETE INSTALLATION

After the complete equipment has been installed and adjusted, the following tests can be made which will provide an overall check on the relay and carrier equipment. The phase rotation of the three-phase currents can be checked by measuring the a-c voltage across relay terminals 19 and 20 or test switches B and C with a high resistance a-c voltmeter of at least 1000 ohms per volt. The reading obtained should be approximately 0.9 volts per ampere of balanced three-phase load current (secondary value) with relay taps 4, C and H.

This test requires that a balanced three-phase load current of at least 1.0 ampere (secondary) be flowing through the line-section protected by the HKB relays. At both terminals of the protected line-section, remove the HKB relay cover and open the trip circuit by pulling the test switch blade with the long red handle. Put the tap screw on the upper tap plate in the 4 tap, and on the lower one in the C and H taps. Be sure to insert the spare tap screw before removing the connected one. Now open test switches D and E on the relay at one end of the line section (Station A) and insert a current test plug or strip of insulating material into the test jack on switch E to open the circuit through that switch. The above operation shorts the phase A to neutral circuit ahead of the sequence filter and disconnects the phase A lead from the filter. This causes the phase B and C currents to return to the current transformers through the zero-sequence resistor in the filter, thus simulating a phase A-to-ground fault fed from one end of the line only. As a result, both the fault detector and operating element at Station A should close their contacts. Completion of the trip circuit can be checked by connecting a small lamp (not over 10 watts) across the terminals of test switch J.

Now perform the above operations at the opposite end of the line-section (Station B) without resetting the switches at Station A. This simulates a phase-to-ground fault external to the protected line-section. The fault detector, but not the operating element at B should pick up, and the operating element at A should reset. Restore test switches D and E at Station A to normal (closed). The line conditions now represent a phase-to-ground fault fed from Station B only. The fault detector At A should reset and the operating element at B should pick up. Restore test switches D and E at Station B to normal, and both elements of the relay in the standard case, the above test can be performed using suitable external test switches.

The above tests have checked phase rotation, the polarity of the sequence filter output, the interconnections between the relay and the carrier set and the Phase A current connections to the relay at both stations. Phase B and C can be similarly checked by opening test switches F and G for phase B, and switches H and I for phase C. The same procedure described for Phase A is then followed.

If all the tests have been completed with satisfactory results, the test switches at both line terminals should be closed (close the trip circuit test switch last) and the relay cover replaced. The equipment is now ready to protect the line-section to which it is connected.

## MAINTENANCE

Since the Control Unit has no front-of-panel controls, it requires no attention except maintenance as described in the following paragraphs. The unit cannot be taken out of service without taking the entire assembly out of service.

Every three months an overall inspection should be made to see that no excessive corrosion has developed due to fumes or condensation of moisture. Any accumulated dust and dirt should be cleaned out, as often as once a month in some localities.

Tubes

At the end of each year of operation, the tubes should be removed from their sockets, and their contacts inspected for possible dirt or corrosion. If there is any discoloration, it may be removed by the use of very fine sandpaper. In order to assure maximum tube life, it is very important that the resistance of the contacts be kept to an absolute minimum. If necessary, this cleaning operation should be performed more frequently than indicated above.

Resistors

The resistors are operated well within their ratings, and should not fail during the life of the unit. In the accessory equipment, the ferrule resistors should be removed from their clips at the end of each year's operation, and the ferrules and clips cleaned of corrosion with crocus cloth or very fine sandpaper. In a corrosive atmosphere a film of vaseline will reduce trouble.

TYPE JY HKB CONTROL UNIT COMPONENT PARTS

125/250 volts d-c
Style: 1471841**A**

Electrical Parts per Component Parts List (**Dwg**. 7615216), except resistors R23, R24, and R25 and tubes. **Style: 1471840-A-** as above, but with tubes.

ORDERING INFORMATION

The Westinghouse Electric Corporation is prepared to supply any of the listed parts for servicing this unit. Orders should specify that they are for the Type JY, HKB Control Unit, and mention the unit style number and circuit symbol where it is given. All orders must specify the rating as well.

ACCESSORY GROUP COMPONENTS

Note: Item 1 or 2 will be supplied with the HKB Control Unit for the appropriate application. Tubes are included with the Control Unit.

1. Accessory Group for 125 volts.
   Style: 867955
   Electrical Parts - Resistors R23 & R24.
   Mounting panel for R23 & R24.
   Dummy resistor for JY Transmitter.

2. Accessory Group for 250 volts (less external heater series resistor).
   Style: 867956
   Electrical Parts - Resistor R25
   Mounting panel for R25
   Dummy resistor for **JY** transmitter.

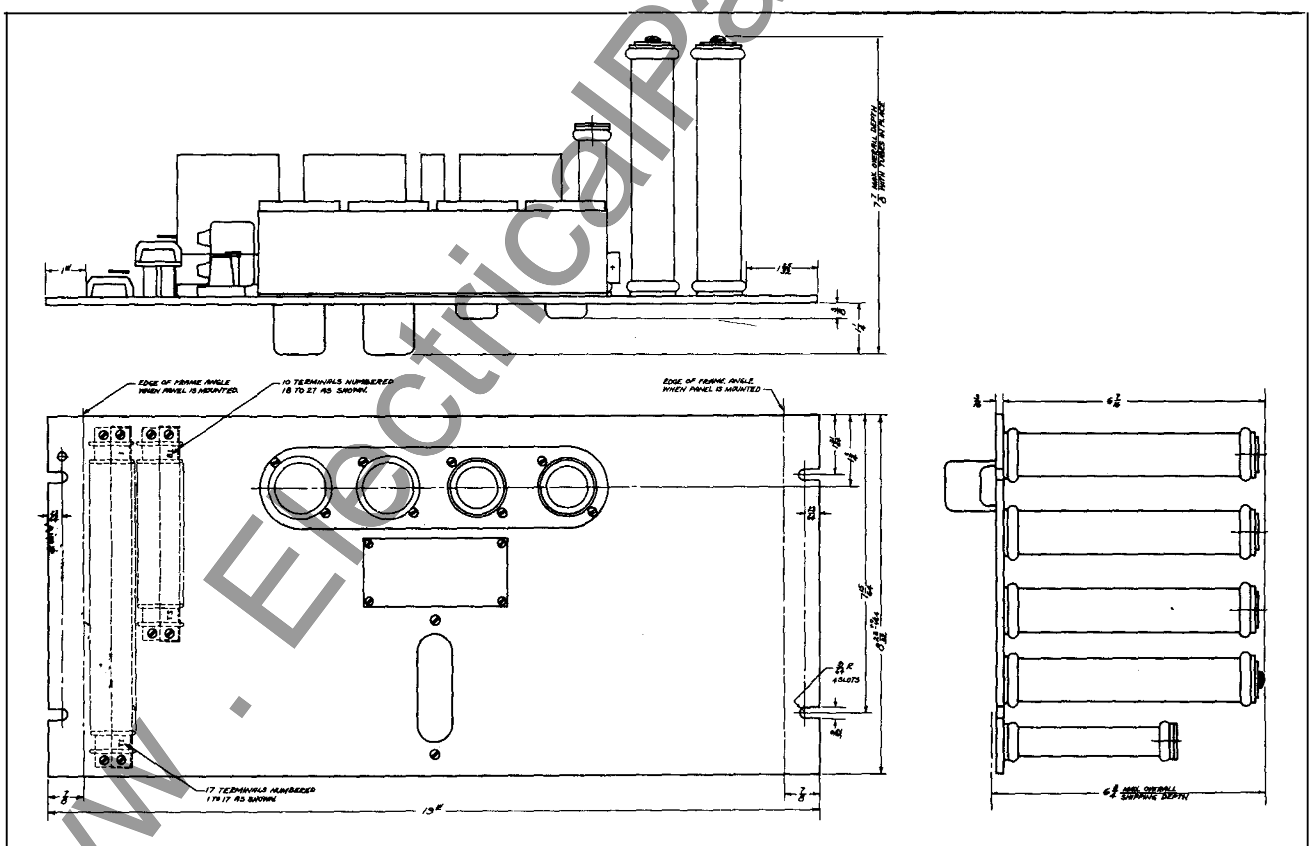



**Fig. 11—Outline And Mounting Plan Of The Type HKB Control Unit. For Reference Only.**

## COMPONENT PARTS

| SYMBOL | NUMBER REQUIRED | NAME | RATING |
|---|---|---|---|
| | | **CAPACITORS** | |
| C1 | 1 | Thyratron Plate to Plate | .25 Mfd., 600 V. d-c |
| C2 | 1 | Thyratron Output | .05 Mfd., 600 V. d-c |
| C3 | 1 | Rectifier Doubler Input | .0051 Mfd., 600 V. d-c |
| C4 | 1 | Rectifier Doubler Output | .0051 Mfd., 600 V. d-c |
| C5 * | 1 | Transformer By-Pass | .003 Mfd., 500 V. d-c |
| C6 | 1 | Thyratron Grid By-Pass | .002 Mfd., 500 V. d-c |
| C7 | 1 | Thyratron Grid By-Pass | .002 Mfd., 500 V. d-c |
| C8 | 1 | Delay Filter | .1 Mfd., 600 V. d-c |
| | | **METER JACKS** | |
| J1 | 1 | Tube Heaters | Western Electric 232A |
| J2 | 1 | Relay Tube Plate & Screen | or |
| J3 | 1 | Rectifier Doubler Output | Cook Electric JK-24 |
| | | **REACTORS** | |
| L1 * | 1 | Carrier Start Circuit | 7 henries, 25 ma. d-c, 440 ohms d-c resistance |
| L2 | 1 | Delay Filter | S#1336643, 10 hy, 7000 Ω d-c resistance. |
| | | **RESISTORS** | |
| R1 | 1 | Carrier Start Thyratron Plate | 16,000 ohms, 22 watt, tapped. |
| R2 | 1 | Carrier Start Thyratron Plate | 2,000 ohms, 12 watt, adjustable (1 band). |
| R3 | 1 | Relay Thyratron Plate | 2,000 ohms, 12 watt. |
| R4 | 1 | Relay Thyratron Plate | 8,000 ohms. 12 watt. |
| R5 * | 1 | Thyratron Bias | 50 ohms, 22 watt, adjustable (1 band). |
| R6 | 1 | Relay Tube Bias | 2,000 ohms, 22 watt, adjustable (1 band). |
| R7 | 1 | Heater Shunt | 160 ohms, 22 watt. |
| R8 | 1 | Amplifier Bias | 6.3 ohms, 22 watt. |
| R9 | 1 | Amplifier Bias | 10 ohms, 22 watt. |
| R10 | 1 | Amplifier Bias | 2.5 ohms, 12 watt. |
| R11 | 1 | Amplifier Bias | 4 ohms, 22 watt |
| R12 | 1 | Bias Restoring | 5,600 ohms, 1 watt. |
| R13 | 1 | Bias Restoring | 0.11 megohms, 1 watt. |
| R14 | 1 | Bias Restoring | 91,000 ohms, 1 watt. |
| R15 | 1 | Thyratron Grid | 0.1 megohm, 1 watt. |
| R16 | 1 | Thyratron Grid | 0.1 megohm, 1 watt. |
| R17 | 1 | Thyratron Cathode | 2,400 ohms, 1 watt. |
| R18 | 1 | Rectifier Doubler Input | 2,000 ohms, 1 watt. |
| R19 | 1 | Rectifier Doubler Output | 51,000 ohms, 1 watt. |
| R20 | 1 | Relay Tube Grid | 51,000 ohms, 1 watt. |
| R21 | 1 | Tube Shell Grounding | 0.27 megohms, 1 watt. |
| R22 * | 1 | Reactor Shunt | 5,100 ohms, 1 watt. |
| R23 | 1 | Heater Series | 63 ohms, wire wound, adjustable (1 band). |
| R24 | 1 | Heater Series | 63 ohms, wire wound, adjustable (1 band). |
| R25 | 1 | Heater Shunt | 250 ohms, wire wound, adjustable (2 bands). |
| R26# | 1 | Thyratron Bias | 100 ohms, 22 watt, adjustable (1 band). |
| R27# | 1 | Thyratron Bias | 100 ohms, 22 watt, adjustable (1 band). |
| Rx | 1 | Rectox | S#1360902 |
| | | **TRANSFORMERS** | |
| T1 | 1 | Thyratron Input | 1/4 ratio topped secondary. |
| T2 | 1 | Relay Tube Output | 2500/500 ohms Impedance Ratio. |
| T3 * | 1 | Receiver-Audio | 2500/500 ohms Impedance Ratio. |
| | | **TUBES** | |
| V1 | 1 | Carrier Start Thyratron-Gas | Type 2050 |
| V2 | 1 | Relay Thyratron-Gas | Type 2050 |
| V3 | 1 | Rectifier Doubler-Vacuum | Type 25Z6 |
| V4 | 1 | Relay Tube-Vacuum | Type 25L6 |
| | | **TUBE SOCKETS** | |
| X1-X4 | 4 | Octal Ceramic Tube Socket | Amphenol Type MIP8T (From Dwg. T7614215-1) |

*In Control Unit S#867954A only.
#In Control Unit S#1471841 only.

## PART III – TYPE HKB TEST FACILITIES

### APPLICATION

The type HKB test facilities provide a simple manually operated test procedure that will check the combined relay and carrier equipment. The test can be performed without the aid of instruments. The results give assurance that all equipment is in normal operating condition without resorting to more elaborate test procedures.

### CONSTRUCTION

Test Switch

The type W test switch is provided with eight pairs of contacts, two pairs of which are closed in the "carrier on" position. The contact arrangement is shown in Fig. 12, and the outline and drilling plan in Fig. 15. These contacts are used to complete the HKB trip circuit and the alarm circuit as indicated in Fig. 12 by contacts 1, 2, and 7, 8. In the "carrier off" position the HKB trip circuit is opened through contacts 1 and 2, but the alarm circuit remains closed. Two test positions to the right of the "carrier off" positions are provided. When the switch is moved to either of these positions, the relay trip and alarm circuits are interrupted and a red alarm light is turned on by switch contact 3 and 4. Moving the switch to the TEST 1 position will connect the output of the auxiliary test transformer directly to the HKB terminals number 25 and 26, through the type W contacts number 9 and 10, and 11 and 12. Moving the switch to the TEST 2 position will connect the test transformer with a reversed polarity to the HKB relay through switch contacts 13, 14 and 15, 16.

Auxiliary Test Transformer

The auxiliary test transformer is designed to operate from a 115 volt, 60 cycle power source. Four secondary taps numbered 1, 2, 3 and 4 are provided to vary the magnitude of the test current. The tap numbers equal the current in amperes that will be passed through the relay when ground tap H is used. If the relay is connected to use ground tap G, approximately two times the transformer tap value (2, 4, 6 or 8 amperes) will be passed through the relay. The outline and drilling plan of the transformer is shown in Fig. 13.

Indicating Lamps

The red and blue indicating lamps are standard rectangular Minalites. Outline and drilling dimensions are given in Fig. 15.

### ADJUSTMENT

Choose a transformer tap that will provide approximately two times the phase-to-ground current setting of the HKB relay as previously determined.

### OPERATION

A multi-contact switch is provided at each line terminal which serves the dual functions of a carrier on-off switch and a test switch. This switch is arranged to apply a single phase current to the HKB relay to simulate internal and through fault conditions. Relay operation is noted by observing a blue indicating lamp connected in the HKB relay trip circuit. During the test the HKB trip circuit to the line breaker is opened and a red warning light is energized through auxiliary contacts on the test switch.

Use of the auxiliary test equipment is to be limited to provide a simplified test after the initial installation tests have been performed as described in part II of this instruction leaflet.

The test apparatus is to be connected as shown in Fig. 12 with the auxiliary test transformers energized from 115 volt, 60 cycle power sources at each line terminal that are in phase with each other. The following operation procedure assumes that the same polarity is used in connecting the test transformer at each line terminal.

1. Turn the carrier test switch at both line terminals to CARRIER OFF.

2. Turn the carrier test switch to TEST 1 at line terminal #1. The local relay should operate to transmit half cycle impulses of carrier, and trip. Tripping will be indicated by the blue light.

3. Turn the HKB test switch at the remote line terminal #2 to TEST 1. This will simulate an internal fault fed from both line terminals. The relay at line terminal #2 will trip, and the relay at line terminal #1 will remain tripped. Tripping will be indicated by the blue lights at each line terminal. Carrier will be transmitted in half cycle impulses simultaneously from each end of the line.

4. Reset the HKB test switch at line terminal #1. The relay at terminal #1 will reset and turn off the blue light. The relay at terminal #2 will hold its trip contact closed, lighting the blue light.

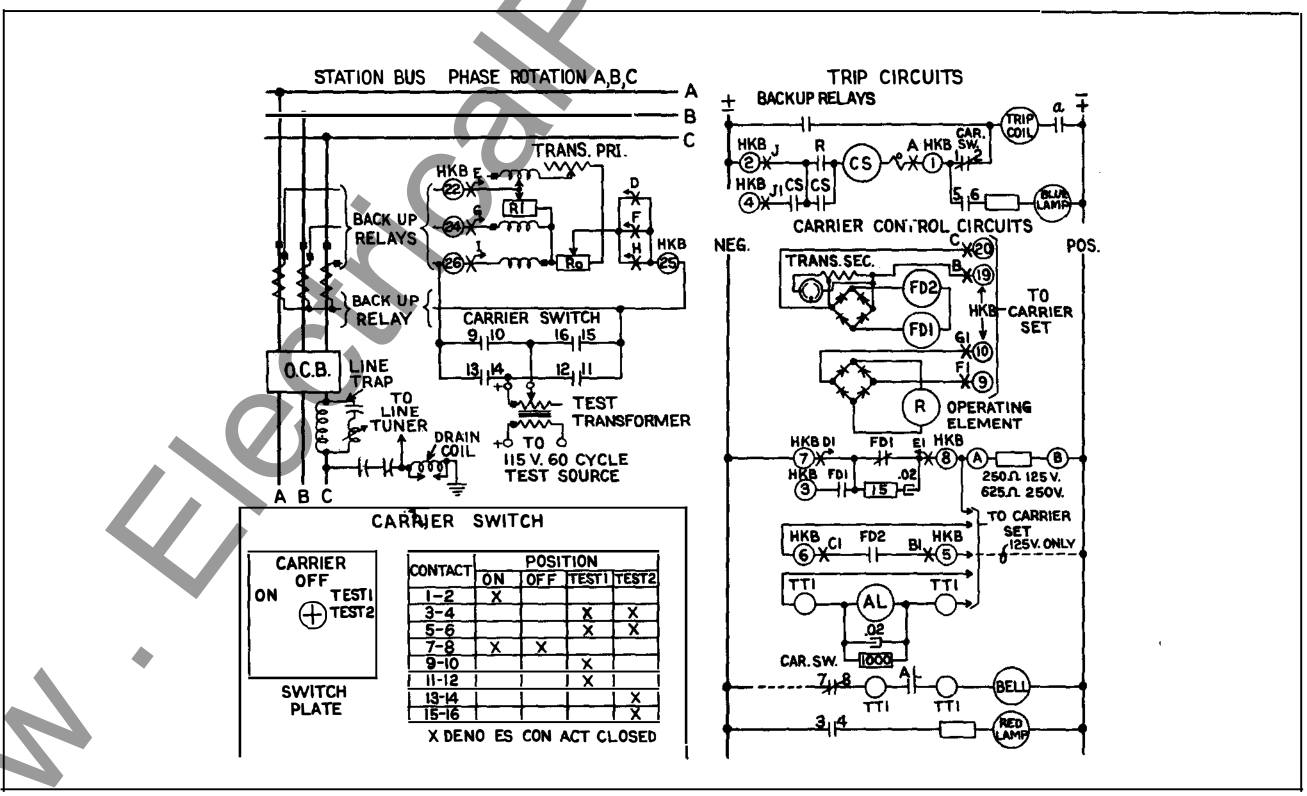
5. Turn the HKB test switch at line terminal #1 to TEST 2. This condition will simulate an external fault. The trip contacts of both relays will be held open and the blue light will be extinguished.

6. Reset the test switches at both line terminals to CARRIER OFF before returning to CARRIER ON for normal service.

This completes the test procedure.

Component Style Numbers

| | | |
|---|---|---|
| Test Transformer | S#1338284 | |
| Type W Test Switch | S#1446447 | for 1/8" panel mounting. |
| Type W Test Switch | S#1446448 | for 1-1/2" panel mounting. |




| CONTACT | ON | OFF | TEST1 | TEST2 |
|---|---|---|---|---|
| 1-2 | X | | | |
| 3-4 | | | X | X |
| 5-6 | | | X | X |
| 7-8 | X | X | | |
| 9-10 | | | X | |
| 11-12 | | | X | |
| 13-14 | | | | X |
| 15-16 | | | | X |

Fig. 12—Schematic Connections Of Type HKB Relay And Test Facilities.

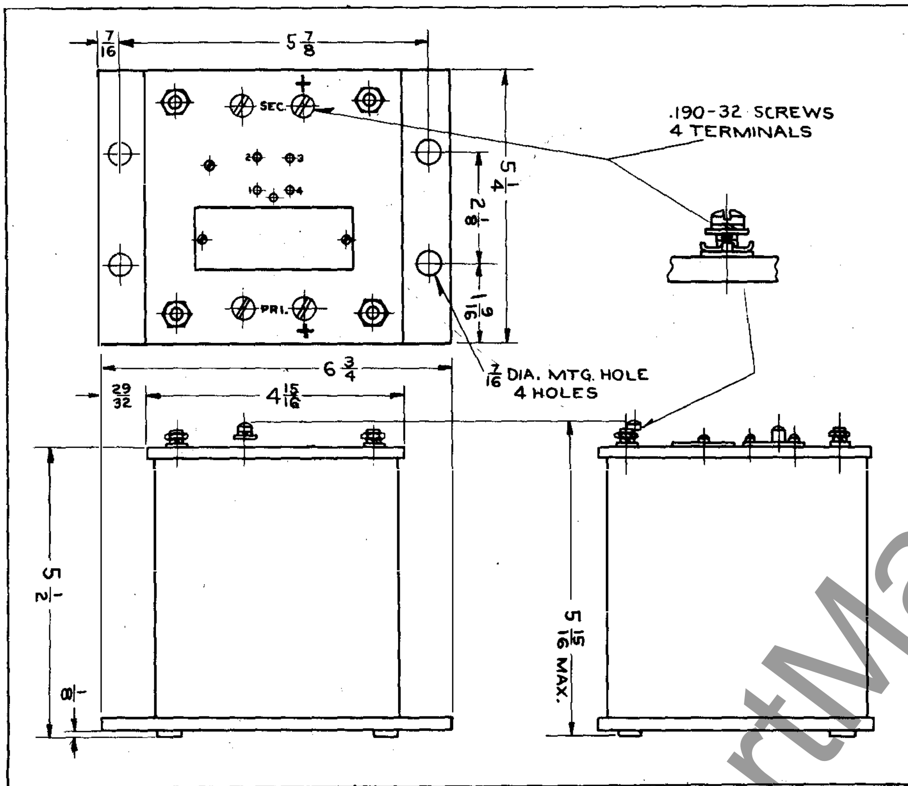



Fig. 13—Outline And Drilling Plan Of The Type HKB Test Transformer. For Reference Only.

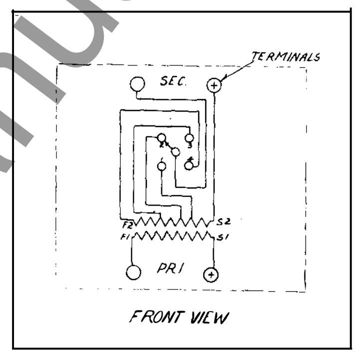



Fig. 14—Internal Schematic Of The Type HKB Test Transformer.

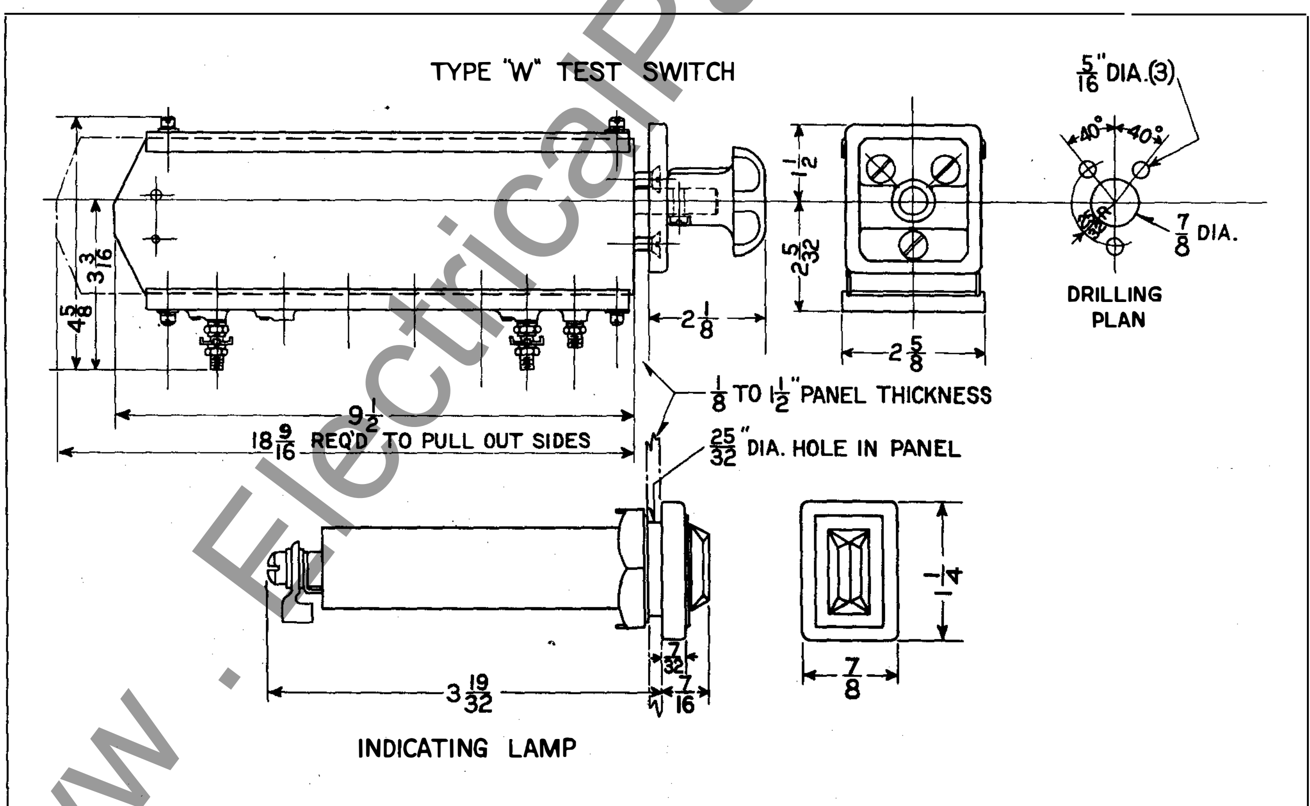



Fig. 15—Outline And Drilling Plan Of The Type W Test Switch And Indicating Lamps Which Are Part Of The Type HKB Test Facilities. For Reference Only.

**WESTINGHOUSE ELECTRIC CORPORATION**
**METER DIVISION** **NEWARK, N.J.**
Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

# INSTRUCTIONS

# TYPE HKB RELAY, CARRIER CONTROL UNIT AND TEST EQUIPMENT

Superseded by I.L. 41-650D Dec. 1948

## APPLICATION

The type HKB relay is a high speed carrier relay used in conjunction with power lines carrier equipment to provide complete phase and ground fault protection of a transmission line section. Simultaneous tripping of the relays at each line terminal is obtained in three cycles or less for all internal faults within the limits of the relay settings. The relay operates on line current only, and no source of a-c line potential is required. Consequently, the relays will not trip during a system swing or out-of-step condition. The carrier equipment operates directly from the station battery.

## PRINCIPLE OF OPERATION

The HKB carrier relaying system compares the phase positions of the currents at the ends of a line-section over a carrier channel to determine whether an internal or external fault exists. The three-phase line currents energize a sequence filter which gives a single-phase output voltage proportional to a combination of sequence components of the line current. During a fault, this single-pnase voltage controls an electronic circuit which allows the transmission of carrier on alternate half-cycles of the power-frequency current. Carrier is transmitted from both line terminals in this manner, and is received at the opposite ends where it is compared with the phase position of the local sequence filter output. This comparison takes place in the grid circuit of a vacuum tube. The polarities of the voltages to be compared are such that for an internal fault, plate current flows on alternate power-frequency half-cycles. A relay connected in the plate circuit of the vacuum tube operates under this condition to complete the trip circuit. During an external fault, the change in direction of current flow causes the plate current to be continuously blocked, and the plate circuit relay does not operate.

Since this relaying system operates only during a fault, the carrier channel is available at all other times for the transmission of other functions.

## PART I – TYPE HKB RELAY

**CAUTION** Before putting relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

## CONSTRUCTION

The relay consists of a combination positive, negative and zero sequence filter, a saturating auxiliary transformer, two Rectox units, two polar relay units, a telephone-type relay, a neon lamp, contactor switch and operation indicator all mounted in a Type M-20 Flexitest Case.

When the standard projection case is supplied, the sequence filter, top plates, and saturating auxiliary transformer are mounted in a box which can be located on the rear of the switchboard panel in any convenient position. The remainder of the relay elements are mounted in the relay case proper. The taps and terminal numbers of the relay in the standard case and the external box correspond to those in the type FT case. (See Figures 1,

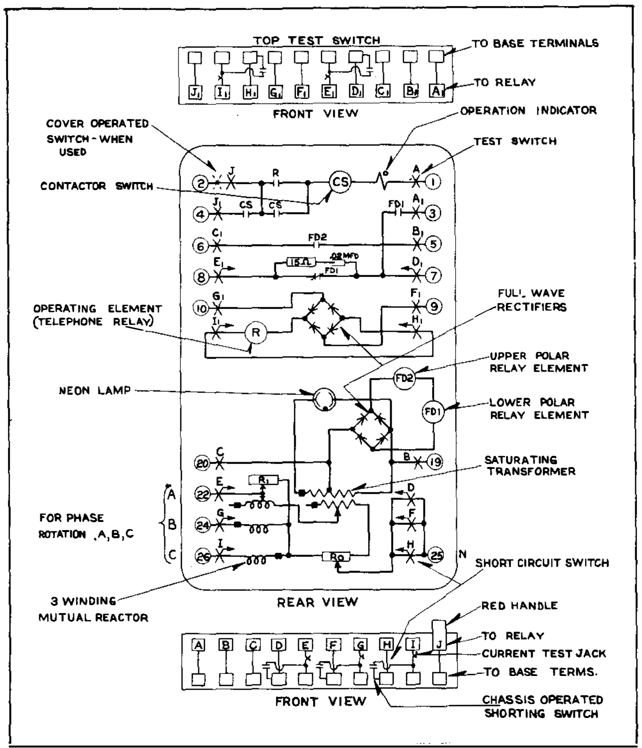



**Fig. 1—Internal Schematic Of The Type HKB Carrier Relay In The Type FT Case.**

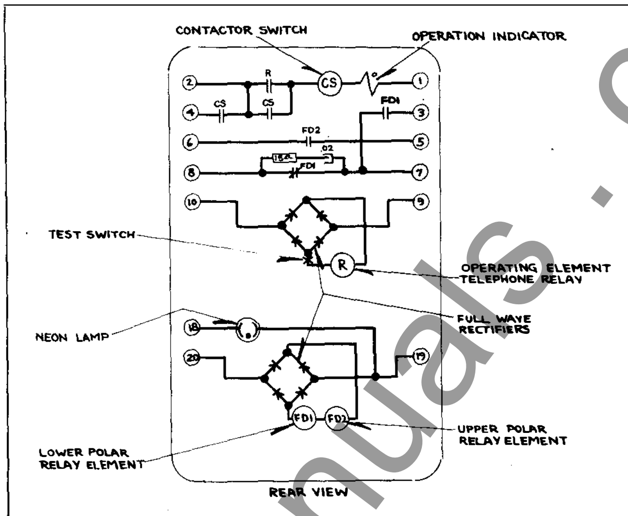



**Fig. 2—Internal Schematic Of The Type HKB Carrier Relay In The Standard Projection Case.**

2, and 3). Terminals 18, 19 and 20 of the external box are to be connected to the corresponding terminals of the relay in the standard case. Otherwise, all external connections for the relay in the standard projection case or in the type FT case are made to the same terminals.

Sequence Filter

The currents from the current transformer secondaries are passed thru a filter consisting of a three-winding iron-core reactor and two resistors. The zero-sequence resistor, $R_O$, consists of three resistor tubes tapped to obtain settings for various ground fault conditions. The other resistor $R_1$ is a formed single wire mounted on the rear of the relay sub-base. The output of this filter provides a voltage across the primary of the saturating transformer.

The lower tap block provides for adjustment of the relative amounts of the positive, negative and zero sequence components of current in the filter output. Thus a single relay element energized from the filter can be used as a fault detector for all types of faults.

Saturating Auxiliary Transformer

The voltage from the filter is fed into the tapped primary (upper tap plate) of a small saturating transformer. This transformer and a neon lamp connected across its secondary are used to limit the voltage impressed on the fault detectors (polar relay elements) and the carrier Control Unit, thus providing a small range of voltage for a large variation of maximum to minimum fault currents. This provides high operating energy for light faults, and limits the operating energy for heavy faults to a reasonable value.

The upper tap plate changes the output of the saturating transformer, and is marked in amperes required to pick up the lower fault detector element. For further discussion, see section entitled, "Settings".

Rectox Units

The secondary of the saturating transformer feeds a bridge-connected Rectox unit, the output of which energizes the polar fault detector elements. A second Rectox, energized from the output of the Control Unit, supplies a d-c voltage to the telephone relay element which operates only for an internal fault. The use of sensitive polar relay keeps down the energy

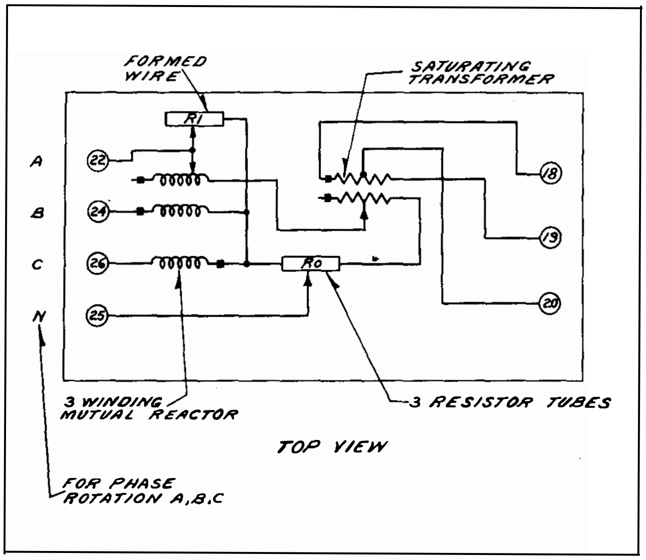



**Fig. 3—Internal Schematic Of The Sequence Filter Used With The Type HKB Relay In The Standard Projection Case.**

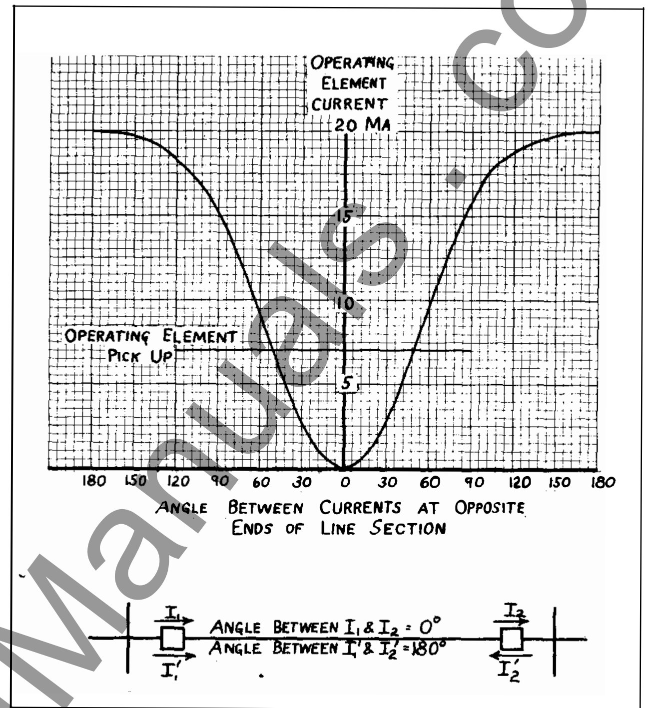



**Fig. 4—Typical Overall Operating Characteristics Of The Type HKB Carrier System.**

required from the current transformers.

Polar-Type Relays

These elements consist of a rectangular shaped magnetic frame, an electromagnet, a permanent magnet, and an armature with a set of contacts. The poles of the permanent magnet clamp directly to each side of the magnetic frame. Flux from the permanent magnet divides into two paths, one path across the air gap at the front of the element in which the armature is located, the other across two gaps at the base of the frame. Two adjustable shunts are located across the rear air gaps. These change the reluctance of the magnetic path so as to force some of the flux thru the moving armature which is fastened to the leaf spring and attached to the frame midway between the two rear air gaps. Flux in the armature polarizes it and creates a magnetic bias causing it to move toward one or the other of the poles, depending upon the adjustment of the magnetic shunts.

A coil is placed around the armature and within the magnetic frame. The current which flows in the coil produces a magnetic field which opposes the permanent magnet field and acts to move the armature in the contact-closing direction.

Contactor Switch

The d-c contactor switch in the relay is a small solenoid type switch. A cylindrical plunger with a silver disc mounted on its lower end moves in the core of the solenoid. As the plunger travels upward, the disc bridges three silver stationary contacts. The coil is in series with the main contacts of the relay and with the trip coil of the breaker. When the relay contacts close, the coil becomes energized and closes the switch contacts. This shunts the main relay contacts thereby relieving them of the duty of carrying tripping current. These contacts remain closed until the trip circuit is opened by the auxiliary switch on the breaker. The contactor switch is equipped with a third point which is connected to a terminal on the relay to operate a bell alarm.

Operation Indicator

The operation indicator is a small solenoid which the positive and negative sequence components of current add together.

With the sequence filter arranged for positive, negative and zero sequence output, there are some applications where the maximum load current and minimum fault current are too close together to set the relay to pick up under minimum fault current, yet not operate under load. For these cases, a tap is available which cuts the three phase sensitivity in half, while the phase-to-phase setting is substantially unchanged. The relay then trips at tap value for AB and CA faults, and at twice tap value for three-phase faults. The setting for BC faults is 70 percent of tap value. In some cases, it may be desirable to eliminate response to positive sequence current entirely, and operate the relay on negative-plus-zero sequence current. A tap is available to operate in this manner. The fault detector picks up at tap value for all phase-to-phase faults, but is unaffected by balance load current or three-phase faults.

For ground faults, separate taps are available for adjustment of the ground fault sensitivity to 1/4 or 1/8 of the upper tap plate setting. For example, if the upper tap plate is set at tap 4, the fault detector (FD1) pick-up current for ground faults can be either 1 or 1/2 ampere. In special applications, it may be desirable to eliminate response to zero sequence current. The relay is provided with a tap to allow such operation.

## SETTINGS

The HKB relay has separate tap plates for adjustment of the phase and ground fault sensitivities and the sequence components included in the filter output. The range of the available taps is sufficient to cover a wide range of application. The method of determining the correct taps for a given installation is discussed in the following paragraph.

In all cases, the similar fault detectors on the relays at both terminals of a line section must be set to pick up at the same value of line current. This is necessary for correct blocking during faults external to the protected line section.

### Sequence Combination Taps

The two halves of the lower tap plate are for connecting the sequence filter to provide any of the combinations described in the previous section. The left half of the tap plate changes the tap on the third winding of the mutual reactor and thus changes the relative amounts of positive and negative sequence sensitivity. Operation of the relay with the various taps is given in the table below.

TABLE I

| Comb. | Sequence Components In Filter Output | Taps on Lower Tap Block | | Fault Detector FD1 Pick Up △ | |
|---|---|---|---|---|---|
| | | Left Half | Right Half | 3Ø Fault | Ø - Ø Fault |
| 1 | Pos., Neg., Zero | C | G or H* | Tap Value | 86% Tap Value (50% on BC Fault) |
| 2 | Pos., Neg., Zero | B | G or H | 2x Tap Value | Tap Value (70% on BC Fault) |
| 3 | Neg., Zero | A | G or H | -- | Tap Value |

* Taps F, G and H are zero-sequence taps for adjusting ground fault sensitivity. See section on zero-sequence current tap.

△ Fault detector FD2 is set to pick up at 125% of FD1.

### Positive-Sequence Current Tap

The upper tap plate has values of 3,4,5,6,7, 8, and 10. As mentioned before, these numbers represent the three-phase, fault detector FD1 pickup currents, when the relay is connected for positive, negative and zero sequence output. The fault detector FD2 closes its contact to allow tripping at current value 25 percent above the fault detector FD1 setting. This 25 percent difference is necessary to insure that the carrier start fault detectors (FD1) at both ends of a transmission line section pick up to start carrier on an external fault before operating energy is applied through FD2.

The taps on the upper and lower tap plates should be selected to assure operation on minimum internal line-to-line faults, and yet not operate on normal load current, particularly if the carrier channel is to be used for auxiliary function. The dropout current of the fault detector is 75 percent of the pick up current, and this factor must also be considered in selecting the positive-sequence current tap and sequence component combination. The margin between load current and fault detector pick up should be sufficient to allow the fault detector to drop out after an external fault, when load current continues to flow.

Zero-Sequence Current Tap

The right half of the lower tap plate is for adjusting the ground fault response of the relay. Taps G and H give ground fault sensitivities equal to 1/4 and 1/8 of the upper tap plate setting, respectively. Tap F is used in applications where increased sensitivity to ground faults is not required. When this tap is used, the voltage output of the filter due to zero-sequence current is eliminated.

Examples of Relay Settings

CASE I

Assume a two-terminal line with current transformers rated 400/5 at both terminals. Also assume that full load current is 300 amperes, and that on minimum internal phase-to-phase faults 2000 amperes is fed in from one end and 600 amperes from the other end.

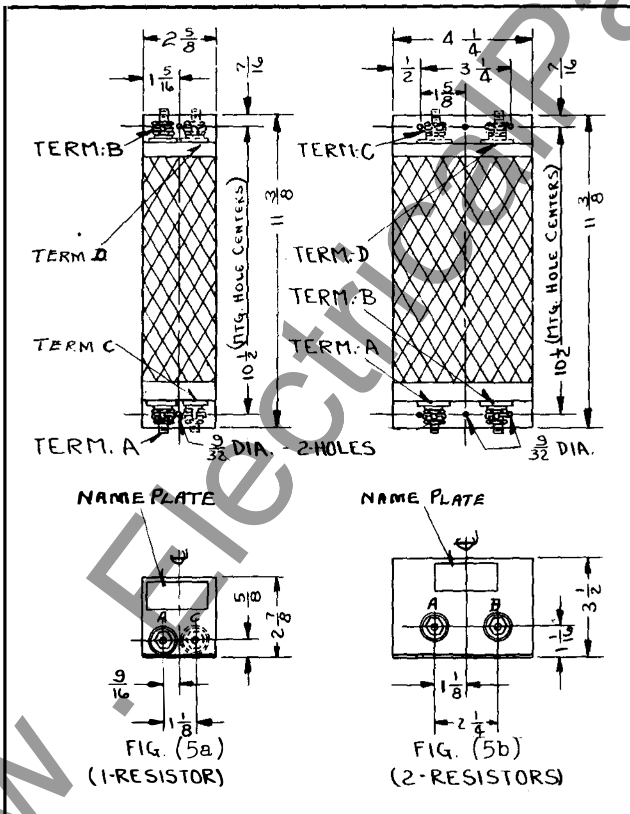



**Fig. 5—Outline And Drilling Plan For The External Resistor Used In The HKB Relay Control Circuit. For Reference Only.**

Further assume that on minimum internal ground faults, 400 amperes is fed in from one end, and 100 amperes from the other end.

Positive Sequence Current Tap

Secondary Values:

$$\text{Load Current} = 300 \times \frac{5}{400} = 3.75 \text{ amperes} \quad (1)$$

Minimum Phase-To-Phase Fault Current:

$$600 \times \frac{5}{400} = 7.5 \text{ amperes} \quad (2)$$

Fault detector FD1 setting (three phase) must be at least:

$$\frac{3.75}{0.75} = 5 \text{ amperes (0.75 is dropout ratio of fault detector)} \quad (3)$$

so that the fault detector will reset on load current.

In order to complete the trip circuit on a 7.5 ampere phase-to-phase fault, the fault detector FD1 setting (three-phase) must be not more than:

$$7.5 \times \frac{1}{0.866} \times \frac{1}{1.25} = 6.98 \text{ amperes} \quad (4)$$

$$1.25 = \frac{\text{FD2 pick up}}{\text{FD1 pick up}}$$

Sequence Combination Tap

From a comparison of (3) and (4) above, it is evident that the fault detector can be set to trip under minimum phase fault condition, yet not operate under maximum load. In this case, tap C on the lower left tap block would be used (see Table 1, Comb. 1) as there is sufficient difference between maximum load and minimum fault to use the full three-phase sensitivity.

Zero Sequence Tap

Secondary Value:

$$100 \times \frac{5}{400} = 1.25 \text{ amperes minimum ground fault current}$$

With the upper tap 6 in use, the fault detector FD1 pickup currents for ground faults are as follows:

Lower right tap G 1/4 x 6 = 1.5 amp.
Minimum trip = 1.25 x 1.5 = 1.875 amp.

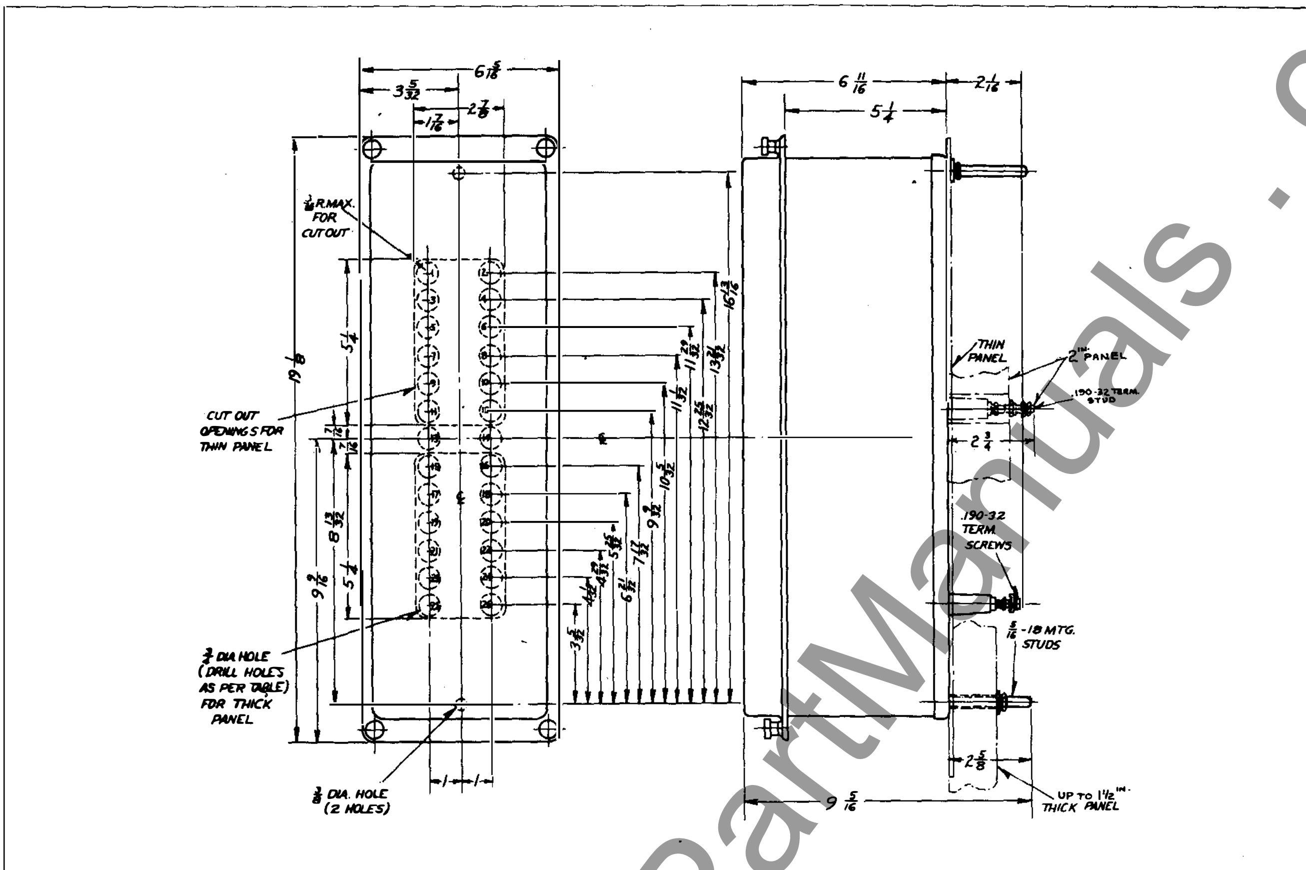



Fig. 6—Outline And Drilling Plan For The M-20, Projection Type FT Flexitest Case. See The Internal Schematic For The Terminals Supplied. For Reference Only.

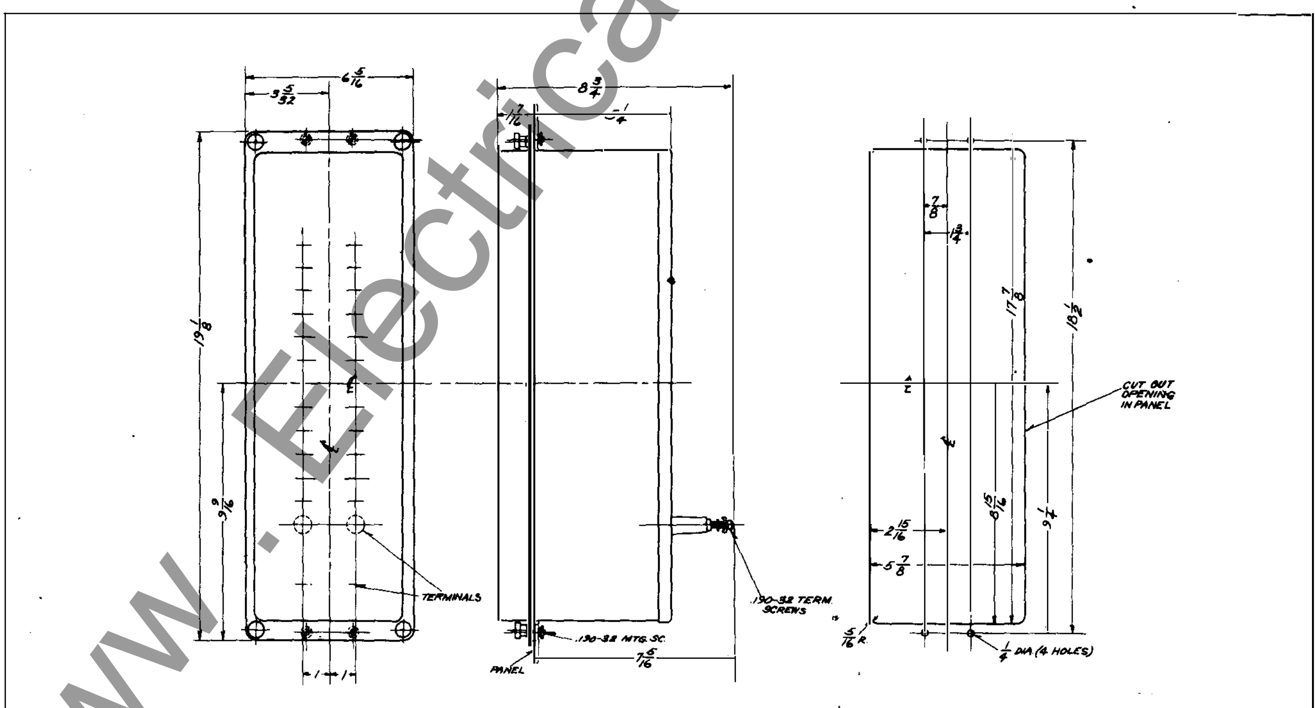



Fig. 7—Outline And Drilling Plan For The M-20 Semi-Flush Type FT Flexitest Case. For Reference Only.

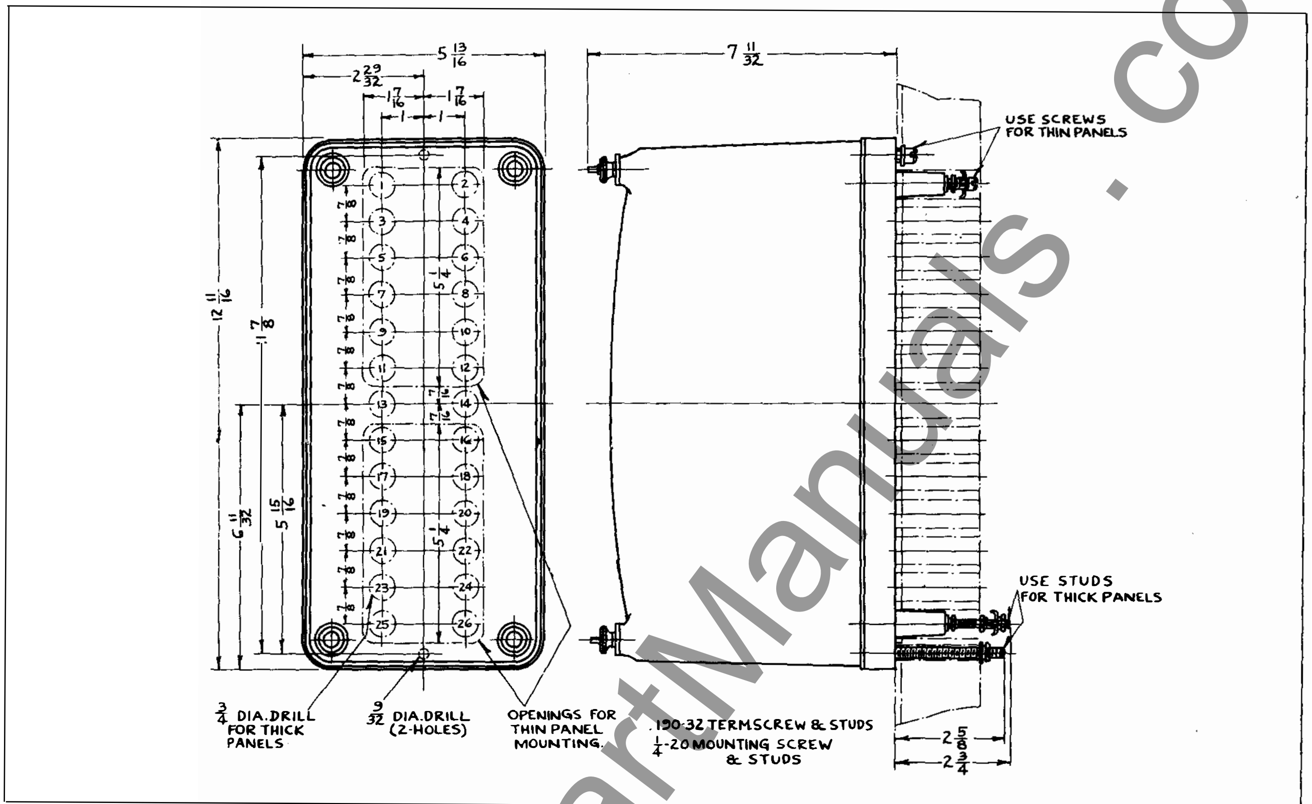



Fig. 8—Outline And Drilling Plan For The Standard Projection Case. See The Internal Schematic For The Terminals Supplied. For Reference Only.

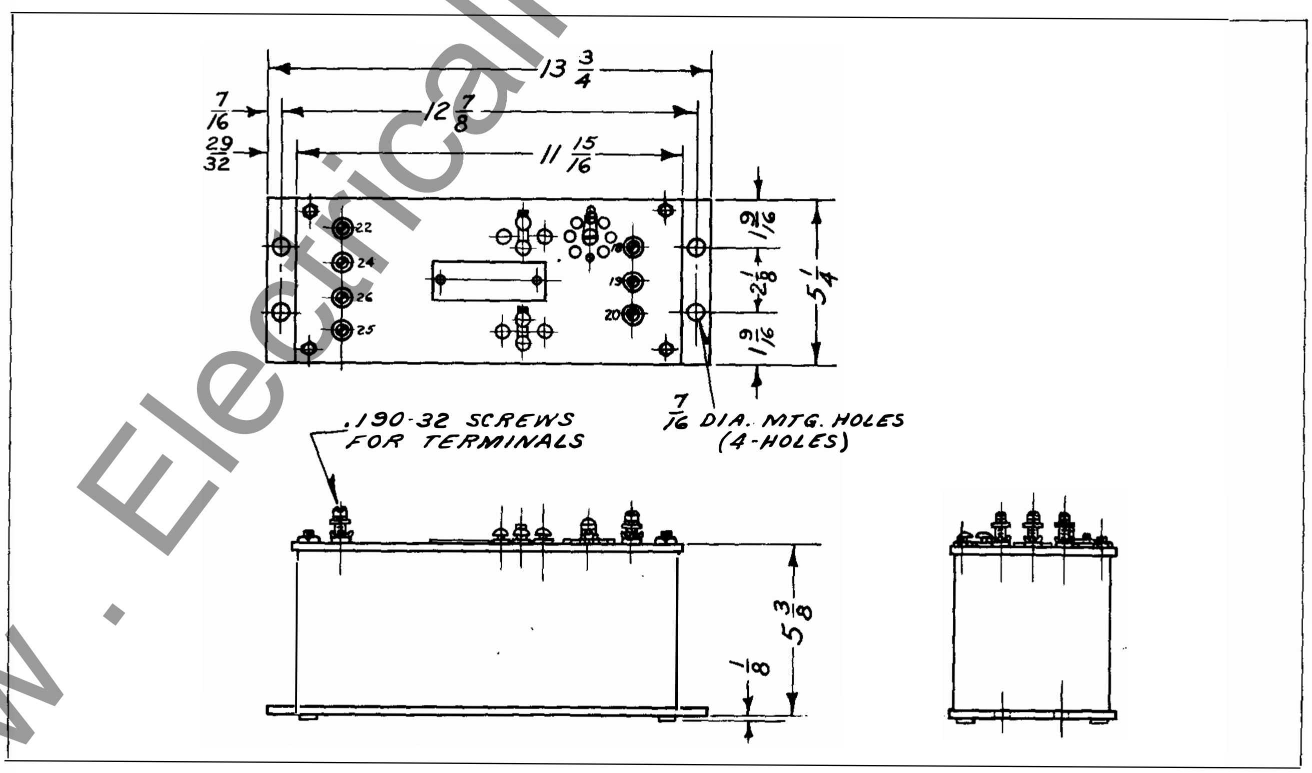



Fig. 9—Outline And Drilling Plan For The Sequence Filter Used With The Type HKB Relay In The Standard Case. For Reference Only.

Lower right tap H 1/8 x 6 = 0.75 amp.
Minimum trip = 1.25 x 0.75 = 0.938 amp.

From the above, tap H would be used to trip the minimum ground fault of 1.25 amperes.

CASE II

Assume the same fault currents as in Case I, but a maximum load current of 500 amperes. In this example, with the same sequence combination as in Case I, the fault detectors cannot be set to trip on the minimum internal three-phase fault, yet remain inoperative on load current. (Compare (5) and (6) below). However, by connecting the filter per Combination 2 on Table I, the relay can be set to trip on minimum phase-to-phase fault, although it will have only half the sensitivity to three-phase faults. This will allow operation at maximum load without picking up the fault detector, and provide high speed relaying of all except light three-phase faults.

In order to complete the trip circuit on a 7.5 ampere phase-to-phase fault, the fault detector tap must now be not more than:

$$7.5 \times \frac{1}{1.25} = 6.0 \text{ amperes} \qquad (5)$$

To be sure the fault detector FD1 will reset after a fault, the minimum tap setting is determined as follows:

$$\text{Load Current} = 500 \times \frac{5}{400} = 6.25 \text{ amps} \qquad (6)$$

$$\frac{6.25}{0.75} = 4.17 \qquad \frac{8.33}{2} = 4.17 \qquad (7)$$

Since the fault detector pickup current for three-phase faults is twice tap value, half the above value (Eq. 7) should be used in determining the minimum three-phase tap.

$$\frac{8.33}{2} = 4.17 \qquad (8)$$

From a comparison of (5) and (8) above, tap 5 would be selected.

With the three-phase tap 5 in use, the fault detector pickup current for ground faults will be as follows:

Tap G 1/4 x 5 = 1.25 a.
Minimum trip = 1.25 x 1.25 a. = 1.56 amp.
Tap H 1/8 x 5 = 0.625 a.
Minimum trip = 1.25 x 0.625 a. = 0.78 amp.

Therefore, tap H would be used to trip the minimum ground fault of 1.25 ampere.

## INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration and heat. Mount the relay vertically by means of the two mounting studs for the type FT projection case or by means of the four mounting holes on the flange for the semi-flush type FT case. Either of the studs or the mounting screws may be utilized for grounding the relay. The electrical connections may be made direct to the terminals by means of screws for steel panel mounting or to terminal studs furnished with the relay for ebony-asbestos or slate panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the studs and then turning the proper nut with a wrench.

External Resistor

A resistor is required in the carrier start fault detector circuit, as shown in Fig. 12 connected between HKB relay terminal 8 and battery positive. Its function is to avoid short circuiting the station battery through the normally-closed contact of the carrier start fault detector FD1.

The values of this resistor are tabulated below.

| Style No. | D.C. Supply | Ohms | Outline & Drilling |
|---|---|---|---|
| 1337179 | 125 volts | 250 | Fig. 5a |
| 1337181 | 250 volts | 625 | Fig. 5b |

This resistor can be mounted on the rear of the switchboard in any convenient location.

## ADJUSTMENTS AND MAINTENANCE

**CAUTION**

1. Make sure that the neon lamp is in place whenever relay operation is being checked. This is necessary to limit the voltage peaks in the filter output at high currents so as to prevent damage to the Rectox Units.

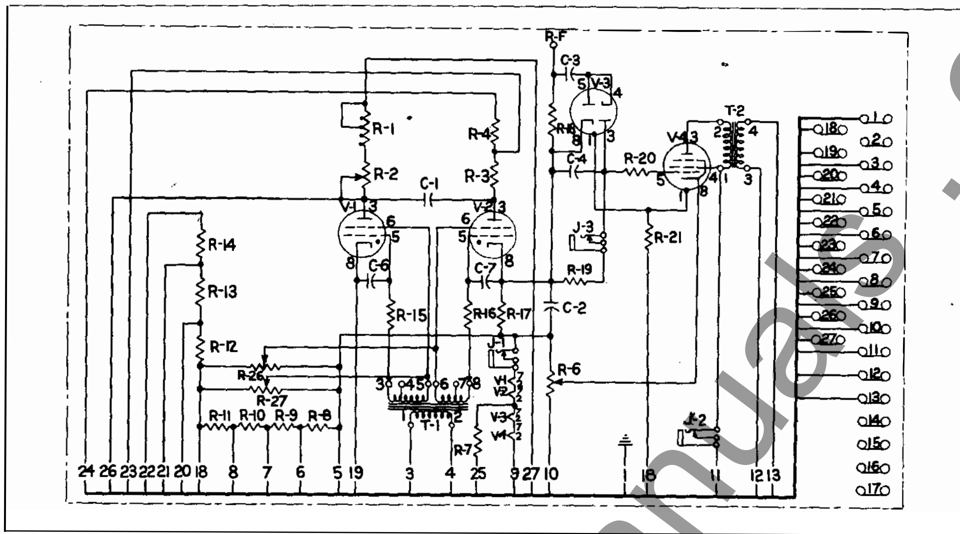



Fig. 10—Internal Schematic Of The Type HKB Control Unit.

2. When changing taps under load, the spare tap screw should be inserted before removing the other tap screw.

3. All contacts should be periodically cleaned with a fine file. S#1002110 file is recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

4. The proper adjustments to insure correct operation of this relay have been made at the factory and should not be disturbed after receipt by the customer. If the adjustments have been changed, the relay taken apart for repairs, or if it is desired to check the adjustments at regular maintenance periods, the instructions below should be followed.

Sequence Filter

There are no adjustments to make in the filter.

The following mechanical adjustments are given as a guide, and some deviation from them may be necessary to obtain proper electrical calibration.

Fault Detector FD1 (Lower Polarized Relay Element)

Back off contact screws so that they do not make contact. Screw magnetic shunts into the all out position. The armature should remain against whichever side it is pushed with this adjustment.

Contact Adjustment

Push the armature to the right. Adjust the right-hand contact until it barely makes a light circuit. A flickering light is permissible. Give the contact screw 2/3 turn to obtain the proper follow. Lock in position by tightening the nut on the contact screw.

Now push the armature to the left. Adjust the left hand contact until it barely makes a light circuit, then give the contact screw an additional 2/3 turn to obtain the proper contact follow. Lock in position.

Calibration

During calibration, connect a 10,000 ohm resistor across terminals 19 and 20 or switch jaws B and C to simulate the load of the transformer in the Control Unit. Approximate adjustments are as follows: Screw in the right hand magnetic shunt until the top air gap is shunted. With the upper tap on 4, and the lower taps on C and H, pass 3.46 amperes, 60 cycles in phase A and out phase B, and screw in the left hand shunt until the armature closes the right hand contact. Reduce the current until the armature resets; this should happen at not less than 75% of the pick up value. Lock the shunts in position and recheck the calibration several times. The action of the armature should be snappy. It may be necessary to increase the contact follow to obtain the required dropout. As finally adjusted, the contact gap must be at least .016 inch.

Fault Detector FD2 (Upper Polarized Relay Element)

Contact Adjustment

Adjust the single contact the same as the right hand contact on the lower polar element.

Calibration

Connect the 10,000 ohm resistor across relay terminals 19 and 20 or switch jaws B and C. Set the relay taps on 4, C and H as before. Screw in the right hand shunt until the top air gap is shunted. Pass 4.33 amperes in phase A and out phase B, and screw in the left hand shunt until the armature closes its contact. Reduce the current until the armature resets; this should happen at not less than 75% of the pick up value. Lock the shunts in position and recheck the calibration several times. The action of the armature should be snappy. It may be necessary to increase the follow on the contact to obtain the required dropout. As finally adjusted, the contact gap must be at least .016 inch.

Operating Element (Telephone Type Relay)

Check contact adjustment to see that stationary contact is deflected 5 to 10 mils after contact closes.

Calibration

Connect a d-c milliammeter (0-25 ma) across test switch jaws H1 and I1 (relay out of case). Connect a source of variable a-c voltage (0 to 10 volts) between terminals 9 and 10 (or switch jaws F1 and G1). The element is to be adjusted for 7.5 to 8.5 ma. d-c pick up and 3 to 5 ma. dropout. The contact spring tension and the armature set screw can be adjusted to obtain these values.

For the relay in the standard case, apply the a-c voltage across terminals 9 and 10 and insert a test plug connected to a d-c milliammeter in the single test switch jack of the relay. If clip leads are used, it will be necessary to slip a strip of insulating material such as fiber into the test switch jack after opening the switch blade to obtain a reading.

Contactor Switch

Adjust the stationary core of the switch for a clearance between the stationary core when the switch is picked up. This can be most conveniently done by turning the relay upside-down. Screw up the core screw until the moving core starts rotating. Now, back off the core screw until the moving core stops rotating. This indicates the point where the play in the moving contact assembly is taken up, and where the moving core just separates from the stationary core screw. Back off the stationary core screw one turn beyond this point and lock in place. This prevents the moving core from striking and sticking to the stationary core because of residual magnetism. Adjust the contact clearance for 3/32 inch by means of the two small nuts on either side of the Micarta disc. The switch should pick up at 2 amperes d-c. Test for sticking after 30 amperes d-c have been passed thru the coil. The coil resistance is approximately 0.25 ohm.

Operation Indicator

Adjust the indicator to operate at 1.0 ampere d-c gradually applied by loosening the two screws on the under side of the assembly, and moving the bracket forward or backward. If the two helical springs which reset the armature are replaced by new springs, they should be weakened slightly by stretching to obtain the 1 ampere calibration. The coil resistance is approximately 0.16 ohm.

## RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

## ENERGY REQUIREMENTS

Burdens measured at a balanced three-phase current of five amperes.

| Relay Taps | Phase A VA | Phase A Angle | Phase B VA | Phase B Angle | Phase C VA | Phase C Angle |
|---|---|---|---|---|---|---|
| A-F-3 | 2.4 | 5° | 0.6 | 0° | 2.5 | 50° |
| A-H-10 | 3.25 | 0° | 0.8 | 100° | 1.28 | 55° |
| B-F-3 | 2.3 | 0° | 0.63 | 0° | 2.45 | 55° |
| B-H-10 | 4.95 | 0° | 2.35 | 90° | 0.3 | 60° |
| C-F-3 | 2.32 | 0° | 0.78 | 0° | 2.36 | 50° |
| C-H-10 | 6.35 | 342° | 3.83 | 80° | 1.98 | 185° |

Burdens measured at a single-phase to neutral current of five amperes.

| Relay Taps | Phase A VA | Phase A Angle | Phase B VA | Phase B Angle | Phase C VA | Phase C Angle |
|---|---|---|---|---|---|---|
| A-F-3 | 2.47 | 0° | 2.1 | 10° | 1.97 | 20° |
| A-H-10 | 7.3 | 60° | 12.5 | 53° | 6.7 | 26° |
| B-F-3 | 2.45 | 0° | 2.09 | 15° | 2.07 | 10° |
| B-H-10 | 16.8 | 55° | 22.0 | 50° | 12.3 | 38° |
| C-F-3 | 2.49 | 0° | 1.99 | 15° | 2.11 | 15° |
| C-H-10 | 31.2 | 41° | 36.0 | 38° | 23.6 | 35° |

The angles above are the degrees by which the current lags its respective voltage.

## PART II – TYPE HKB CONTROL UNIT

**CAUTION** When adjusting this equipment, allow the tube heaters to warm up for at least 30 seconds before applying plate voltage (by operating the relay fault detector). This precaution is necessary to prevent damage to the Type 2050 thyratrons.

## CONSTRUCTION

The HKB Control Unit consists of an electronic trigger circuit employing two thyratrons; a rectifier-doubler vacuum tube for the received carrier and a vacuum "relay" tube which compares the phase positions of the local and distant line currents.

The general appearance and construction of the Type HKB Control Unit is shown by the outline drawing, Figure 11. The entire equipment, with the exception of the accessories, is mounted on a standard 3/16" thick aluminum panel 19" wide and 8-23/32" high with standard notching. The front of the panel is black wrinkle finished, and the rear is Nasat. The tubes protrude through the front panel for convenient installation and replacement.

Jacks are provided on the front of the panel for current metering as follows:

| | |
|---|---|
| J1(top jack) | Heater current |
| J2(center jack) | Relay tube emission current |
| J3(bottom jack) | Rectifier-doubler output current |

## INSTALLATION

When used with the Type JY Transmitter and Receiver, the HKB Control Unit is mounted in the same cabinet with these panels and immediately beneath the Receiver panel. The Instruction Book for the complete assembly of which this unit is a part should be referred to for additional mounting instructions.

Upon delivery, the unit should be very carefully checked for damaged parts. Particular attention should be given to any parts which may have become loose in shipment, or wires which may have broken because of vibration. Each HKB Control Unit is supplied with an accessory group of components for adapting it for operation from 125 volts d-c or 250 volts d-c. These components should be checked for damage and to see that none are missing, and checked against the order or requisition and the parts list in this book as well as the instruction sheet furnished with each accessory package. Any shortage should be immediately reported to the transportation company and to the nearest district office of the manufacturer. The dummy resistor plug furnished with the HKB accessories is for use in the JY Transmitter amplifier cathode circuit. Remove the resistor regularly furnished with the JY Transmitter and replace with this dummy plug.

The necessary connections from the JY (cabinet) assembly terminal blocks to the switchboard, relays, etc., should be made in suitable conduit. Number 12 gauge wire is recommended for these connections. The connection diagrams in the instruction book for the complete assembly should be followed. Be sure to ground terminal #1 on the HKB Unit and also cabinet terminal #1.

CIRCUIT ADJUSTMENT - GENERAL

Do not insert the tubes into the HKB Control Unit until the following paragraphs dealing with circuit adjustments have been read.

The HKB Control Unit is designed to use the same tubes for either 125 volt or 250 volt operation. When used on 250 volts d-c, the proper value of plate voltage for the Type 25L6 Relay Tube is obtained from a connection at the positive end of the transmitter tube heaters.

In order to obtain bias voltage for both the HKB Control Unit and the associated carrier transmitter, the entire d-c current drain of both units is caused to flow through a combination of resistors in the Control Unit. In this way, adjustable bias for the Type 2050 thyratrons and fixed bias of two different values, for the power amplifier tubes of the transmitter is obtained. Because the adjustment procedure will follow the tabulations shown on Tables I and II as closely as possible, it is important to become thoroughly familiar with the tables. Five columns are included in these tables. The first column indicates the quantity to be checked. The second column indicates the minimum value permissible. The third column indicates the normal value. The fourth column indicates the maximum value permissible. The fifth column should be filled in at the time of installation, to indicate the actual value which was obtained. The last column is of great importance and should be filled in as soon as the HKB Control Unit is installed. All quantities must be brought within the minimum and maximum value specified before the equipment can be considered to be in satisfactory operating condition. A copy of these values should be kept with the equipment for checking purposes. All letters of inquiry to the manufacturer regarding the operation of this unit should be accompanied by a list of actual values of the eight quantities tabulated on Table I or II.

The maximum and minimum limits of the values in the table do not all correspond to the same percentage. In the case of the power supply or battery voltage, the limits given are the maximum and minimum at which the unit can be properly adjusted to operate; and these limits include the maximum variation in power supply voltage. For instance, the HKB unit with 125 volt accessories can be adjusted to function properly on any battery which never exceeds 150 volts or drops below 100 volts. But once the normal voltage is established and adjustments are made for operation on that voltage, it should not be permitted to fluctuate normally more than plus or minus five percent.

The Unit has been designed to use either glass or metal tubes of types 25L6 and 25Z6, and the adjustment data is the same for either.

CIRCUIT ADJUSTMENTS - 125 VOLT EQUIPMENT

The numbers at the beginning of the following paragraphs correspond to the line numbers in the Adjustment Data Tables.

1. The first line in the Adjustment Data Table is the power supply or battery voltage, which is to be measured at the cabinet terminals before any of the equipment is turned on. The actual value of this voltage at the time of installation should be entered on the line in the fifth column of the data table. If it is not within the limits of 100 to 150 volts d-c, do not proceed.

2. Adjustment of the HKB Control Unit tube heater current is now to be carried out. Since the bias resistor (combination of R8, R9, R10, R11 and R5) is common to the heater circuits of both the carrier transmitter-receiver and the HKB Control Unit, adjustment of heater current of the one unit will affect that of the other. In order to avoid difficulty, the bias resistor mentioned is to be temporarily shorted out during the adjustment of heater current for both the transmitter-receiver and the HKB Control Unit. BEFORE PROCEEDING, REFER TO THE INSTRUCTION BOOK FOR THE ASSEMBLY OF WHICH THIS UNIT IS A PART AND CARRY OUT THE DIRECTIONS THEREIN FOR INSERTING MAXIMUM RESISTANCE INTO THE TRANSMITTER-RECEIVER

HEATER CIRCUIT. Connect a jumper wire across terminals #5 and #18 of the HKB Control Unit. The adjusting clip on resistor R6 is to be set roughly in the center of the resistor. The adjusting clips on the two adjustable resistors R23 and R24, which are external heater series resistors mounted on a separate panel. are to be set so as to short out the least possible amount of these resistors. Remove the dummy resistor plug from its clips in the transmitter amplifier cathode return circuit. The tubes are now to be inserted into the HKB assembly of which the HKB Unit is a part. Plug a d-c ammeter of 1 ampere range into jack J1 and adjust the shorting clips of external resistors R23 and R24 to obtain the correct heater current as given in line #2 of the table. It is desirable to keep the amount shorted out of each of these two resistors about equal so as to distribute the heat produced equally between them. When the power is first applied, the tube heater current will be above normal due to the low resistance of the cold heater elements. Consequently power should be applied for at least two minutes before readings are taken. After the heater current of the HKB Control Unit and the heater current of the transmitter-receiver have each been adjusted, remove the jumper wire from terminals #5 and #18 of the HKB Unit. Replace the dummy resistor plug in its clips in the transmitter.

3. After the adjustments on the transmitter have been completed and the transmitter is in normal operation measure again the heater current of the HKB Unit at Jack J1. If not within the limits of line #3 in the Data Table, make such slight changes to the setting of the external resistors R23 and R24 as may be required to correct it. (A similar operation should be carried out on the transmitter-receiver.)

4. After the above adjustments are completed, measure at the other two metering jacks. J2 and J3. to see that no current is flowing. Under the condition of the bias resistor R6 being set near the center, the Relay Tube, V4, is biased well beyond plate current cut-off, so that the current at jack J2 should be well below the limit of .1 milliampere. Under the condition of no r-f signal received, the current at jack J3 should be well below the limit of .1 ma. Any excessive current flow should be investigated and the fault cleared before proceeding with the tests. (Make final check with 1.5 milliampere range of meter.)

5. Measure the d-c bias voltage between terminals #5 and #18.

6. This adjustment is for the purpose of obtaining the correct Master Oscillator plate voltage for the transmitter. The transmitter must be completely adjusted and in a state of normal operation (ready to be controlled by the HKB Unit). In making this adjustment it is necessary to have $V_1$ thyratron continuously ignited. For Control Unit S#867954A, a single resistor R5 is in place of resistors R26 and R27. Remove the lead from the R5 tap nearer the panel and connect this lead to terminal #19 of the Control Unit. For Control Unit S#1471841. remove the lead from the R27 tap and connect to terminal #19. Now turn on the equipment and allow the thyratrons to heat up for one minute. Block open the back contact of the HKB lower fault detector. Thyratron V1 will fire and remain conducting. Connect a d-c voltmeter of at least 1000 ohm-per-volt resistance between terminal #5 and terminal #19. Adjust R1 and R2 to obtain the required voltage as given in the Table in the Transmitter Instruction Book. The transmitter should now be sending out carrier at its full output power. Restore all connections to normal.

7. The object of the following adjustment is to set the firing point of the thyratrons V1 and V2 to the proper value by adjusting their grid bias. Two resistors, R26 and R27, are provided for separate adjustment of V1 and V2 grid bias in Control Unit S#1471841. Control Unit S#867954A has a single resistor with two sliders (R5) for adjustment of V1 and V2 grid bias. The bias can be measured between each slider and terminal #5.

In making this adjustment, it is necessary to apply a simulated fault to the HKB relay and associated carrier set. If the current circuits of the relay are not connected to the line current transformers, a single-phase 60 cycle current from a variable test source can be applied to the HKB relay terminals 24 and 25, simulating a single-phase-to-ground fault. If the relay current circuits are connected to the line, open test switches D, E, F, G H, I and J. Test switch J opens the trip circuit. This switch should be opened first and left open during all adjustments. The current circuits to the relay have been shorted by opening switches D, F, and H, but the relay is still connected to the current transformers through the test jacks on switches E, G and I. These circuits are opened by inserting current test plugs or strips of insulation into the test jacks on switches E, G and I. The relay is now entirely disconnected from the current transformers, and the single phase test source can be connected between switch jaws F and G.

Put the upper tap screw in tap 4 and the lower tap screws in the C and H taps. This sets the pickup current of the relay fault detector at 0.5 ampere for a single-phase-to-ground fault. Adjust the sliders on R5 or R26 and R27 for maximum grid bias on the thyratrons (sliders away from the panel). Block open the normally closed contact on the carrier start fault detector (lower polar element). Insert a milliammeter in jack J1 of the carrier transmitter to read oscillator cathode current. Apply the single-phase test current to the relay and increase it to 0.3 amperes. Now gradually reduce the bias on thyratron V1 by moving R5 slider #1 (the one nearer the panel) or the slider on R27 toward the panel. A point will be reached where V1 fires to start carrier. This will be indicated by reading on the d-c milliammeter in transmitter Jack J1. Tighten the slider at this point. Check this setting by reducing the test current to zero and momentarily removing the blocking in the FD1 back contact to extinguish V1. Increase the test current until V1 fires. This should occur at 0.3 ampere ± 10%.

With V1 fired and the test current set at 0.3 ampere, gradually reduce the bias on thyratron V2 by moving R5 slider #2 (the one further from the panel) or the slider on R26 toward the panel. A point will be reached where V2 fires and triggering will then take place with thyratrons V1 and V2 firing on alternate half cycles of the applied test current. Triggering will be indicated by a reduction in the milliammeter reading at transmitter jack J1 to 50 or 60% of its initial value. Tighten the slider at this point. Check the setting by reducing the test current to zero and momentarily removing the blocking in the FD1 back contact to extinguish V1 or V2 (either may remain fired). Increase the test current until triggering begins. This should occur at 0.3 ampere ± 10%.

Note: Taps are provided on the secondary of transformer T1 to compensate for variation in tubes. The lead shown connected to transformer T1 terminal #3 may be connected to terminal #4, and similarly for terminal #7 and #8.

8. The following adjustment covers the setting of the relay tube (V4) grid bias. With the test current circuit applied to the relay (described in paragraph 7), increase the a-c current until the neon lamp in the HKB relay lights. Plug a d-c milliammeter into the current jack on test switch I1 on the relay to measure the operating element coil current. Reduce the grid bias on the relay tube by adjusting the slider on resistor R6 until the operating element coil current is 20 milliamperes. The relay tube grid bias is measured between the slider on R6 and terminal #5 of the Control Unit. A voltmeter of at least 1000 ohms-per-volt resistance should be used. Carrier from the distant line terminal should not be transmitted during this adjustment. When the relay tube grid bias is adjusted as described, the overall characteristic of the HKB relaying system is shown in Figure 2. All test circuits and meters may now be removed, and the relay test switches returned to normal. The switch with the red handle should be closed last as this connects the relay to the breaker trip circuit.

CIRCUIT ADJUSTMENTS - 250 VOLT EQUIPMENT

1. The first line in the Adjustment Data

Table is the power supply or battery voltage, which is to be measured at the cabinet terminals before any of the equipment is turned on. The actual value of this voltage at the time of installation should be entered on the line in the fifth column of the data table. If it is not within the limits of 200 to 300 volts d-c, do not proceed.

2. Adjustment of the HKB Control Unit tube heater current will be accomplished along with the adjustment of the transmitter heater current, because all the heaters of the assembly are connected in series. The necessary external heater series resistors are a part of the accessories for the assembly of which this Unit is a part; and the instructions for their adjustments are to be found in the instruction book for the complete assembly. After the adjustment is completed record the value of current as measured at jack J1. The heater currents of the Control Unit and the transmitter should be within the limits tabulated on Table II.

External accessory resistor R25 is connected in shunt to the HKB tube heaters. By bypassing .3 ampere, it enables their operation in series with the tube heaters of the transmitter, which draw .9 ampere. Resistor R25 is adjusted at the factory to 208 ohms plus or minus 1 percent and should not be changed from the above value.

3. The plate circuit supply voltage is to be measured between terminal #5 and terminal #10.

4. After the above adjustments are completed, measure at the other two metering jacks, J2 and J3, to see that no current is flowing. Under the condition of the bias resistor R6 being set near the center, the Relay Tube, V4, is biased well beyond plate current cut-off, so that the current at jack J2 should be well below the limit of .1 milliampere. Under the condition of no r-f signal received, the current at jack J3 should be well below the limit of .1 ma. Any excessive current flow should be investigated and the fault cleared before proceeding with the tests. (Make final check with 1 milliampere range of meter).

5. Measure the d-c bias voltage between terminals #5 and #18.

6. Oscillator Plate Voltage. Adjustments are exactly the same as for 125 volt equipment. See paragraph 6 of previous section. Refer to values on Table II.

7. Thyratron Grid Bias Volts. Adjustments are exactly the same as for 125-volt equipment. See paragraph 7 of previous section. Refer to values on Table II.

8. Relay Tube Grid Bias Volts. Adjustments are exactly the same as for 125-volt equipment. See paragraph 8 of previous section. Refer to values on Table II.

## OVERALL TEST OF COMPLETE INSTALLATION

After the complete equipment has been installed and adjusted, the following tests can be made which will provide an overall check on the relay and carrier equipment. The phase rotation of the three-phase currents can be checked by measuring the a-c voltage across relay terminals 19 and 20 or test switches B and C with a high resistance a-c voltmeter of at least 1000 ohms per volt. The reading obtained should be approximately 0.9 volts per ampere of balanced three-phase load current (secondary value) with relay taps 4, C and H.

This test requires that a balanced three-phase load current of at least 1.0 ampere (secondary) be flowing through the line-section protected by the HKB relays. At both terminals of the protected line-section, remove the HKB relay cover and open the trip circuit by pulling the test switch blade with the long red handle. Put the tap screw on the upper tap plate in the 4 tap, and on the lower one in the C and H taps. Be sure to insert the spare tap screw before removing the connected one. Now open test switches D and E on the relay at one end of the line section (Station A) and insert a current test plug or strip of insulating material into the test jack on switch E to open the circuit through that switch. The above operation shorts the phase A to neutral circuit ahead of the sequence filter and disconnects the phase A

TABLE I

ADJUSTMENT FOR HKB CONTROL UNIT ON 125 VOLTS

See text of Instruction book for discussion of the following table. Numbers preceeding data refer to test paragraph numbers.

| Quantity | Min. | Normal | Max. | Actual |
|---|---|---|---|---|
| 1. Power Supply Volts | 100 | 125 | 150 | |
| 2. Heater Amperes, Preliminary Adjustment # | .59 | .62 | .65 | |
| 3. Heater Amperes, Final Adjustment + | .54 | .56 | .58 | |
| 4. Current at jack J2, Milliamperes | 0 | 0 | .10 | |
| Rectifier-doubler Output Milliamperes at J3 * | 0 | .05 | .10 | |
| 5. Total Bias Volts | 11 | 14 | 17 | |
| 6. Master Oscillator Plate Volts---------------------See transmitter instruction book. | | | | |
| 7. Thyratron Grid Bias Volts | 4.0 | 6.0 | 10.0 | |
| 8. Relay Tube Grid Bias Volts | 20 | 26 | 32 | |
| HKB Relay Operating Element Current, Ma. | 18 | 20 | 22 | |

# - The total tube heater current of the associated transmitter should be adjusted to this value also.

+ - The final value of the tube heater current of the transmitter should be within these limits for the total, and half of these values for each branch.

* - With no carrier being received.

TABLE II

ADJUSTMENT DATA FOR HKB CONTROL UNIT ON 250 VOLTS

See text of instruction book for discussion of the following table. Numbers preceeding data refer to text paragraph numbers.

| Quantity | Min. | Normal | Max. | Actual |
|---|---|---|---|---|
| 1. Power Supply Volts | 200 | 250 | 300 | |
| 2. Tube Heater Amperes - Control Unit | .54 | .56 | .58 | |
| " " " - Transmitter | .81 | .85 | .89 | |
| 3. Plate Circuit Supply Volts | 95 | 135 | 165 | |
| 4. Current at jack J2, Milliamperes | 0 | 0 | 0.1 | |
| Rectifier-doubler Output Milliamperes at J3 * | 0 | .05 | 0.1 | |
| 5. Total Bias Volts | 17 | 22 | 28 | |
| 6. Master Oscillator Plate Volts---------------------See transmitter instruction book. | | | | |
| 7. Thyratron Grid Bias Volts | 4.0 | 7.0 | 12.0 | |
| 8. Relay Tube Grid Bias Volts | 20 | 26 | 32 | |
| HKB Relay Operating Element Current, Ma. | 18 | 20 | 22 | |

* - With no carrier being received.

lead from the filter. This causes the phase B and C currents to return to the current transformers through the zero-sequence resistor in the filter, thus simulating a phase A-to-ground fault fed from one end of the line only. As a result, both the fault detector and operating element at Station A should close their contacts. Completion of the trip circuit can be checked by connecting a small lamp (not over 10 watts) across the terminals of test switch J.

Now perform the above operations at the opposite end of the line-section (Station B) without resetting the switches at Station A. This simulates a phase-to-ground fault external to the protected line-section. The fault detector, but not the operating element at B should pick up, and the operating element at A should reset. Restore test switches D and E at Station A to normal (closed). The line conditions now represent a phase-to-ground fault fed from Station B only. The fault detector At A should reset and the operating element at B should pick up. Restore test switches D and E at Station B to normal, and both elements of the relay in the standard case, the above test can be performed using suitable external test switches.

The above tests have checked phase rotation, the polarity of the sequence filter output, the interconnections between the relay and the carrier set and the Phase A current connections to the relay at both stations. Phase B and C can be similarly checked by opening test switches F and G for phase B, and switches H and I for phase C. The same procedure described for Phase A is then followed.

If all the tests have been completed with satisfactory results, the test switches at both line terminals should be closed (close the trip circuit test switch last) and the relay cover replaced. The equipment is now ready to protect the line-section to which it is connected.

## MAINTENANCE

Since the Control Unit has no front-of-panel controls, it requires no attention except maintenance as described in the following paragraphs. The unit cannot be taken out of service without taking the entire assembly out of service.

Every three months an overall inspection should be made to see that no excessive corrosion has developed due to fumes or condensation of moisture. Any accumulated dust and dirt should be cleaned out, as often as once a month in some localities.

Tubes

At the end of each year of operation, the tubes should be removed from their sockets, and their contacts inspected for possible dirt or corrosion. If there is any discoloration, it may be removed by the use of very fine sandpaper. In order to assure maximum tube life, it is very important that the resistance of the contacts be kept to an absolute minimum. If necessary, this cleaning operation should be performed more frequently than indicated above.

Resistors

The resistors are operated well within their ratings, and should not fail during the life of the unit. In the accessory equipment, the ferrule resistors should be removed from their clips at the end of each year's operation, and the ferrules and clips cleaned of corrosion with crocus cloth or very fine sandpaper. In a corrosive atmosphere a film of vaseline will reduce trouble.

TYPE JY HKB CONTROL UNIT COMPONENT PARTS

125/250 volts d-c
Style: 1471841

Electrical Parts per Component. Parts List (Dwg. 7615216), except resistors R23, R24, and R25 and tubes. Style: 1471840 - as above, but with tubes.

ACCESSORY GROUP COMPONENTS

Note: Item 1 or 2 will be supplied with the HKB Control Unit for the appropriate application. Tubes are included with the Control Unit.

1. Accessory Group for 125 volts.
   Style: 867955
   Electrical Parts - Resistors R23 & R24.
   Mounting panel for R23 & R24.
   Dummy resistor for JY Transmitter.

2. Accessory Group for 250 volts (less external heater series resistor).
   Style: 867956
   Electrical Parts - Resistor R25
   Mounting panel for R25
   Dummy resistor for JY transmitter.

ORDERING INFORMATION

The Westingnouse Electric Corporation is prepared to supply any of the listed parts for servicing this unit. Orders should specify that they are for the Type JY, HKB Control Unit, and mention the unit style number and circuit symbol where it is given. All orders must specify the rating as well.

# PART III – TYPE HKB TEST FACILITIES

## APPLICATION

The type HKB test facilities provide a simple manually operated test procedure that will check the combined relay and carrier equipment. The test can be performed without the aid of instruments. The results give assurance that all equipment is in normal operating condition without resorting to more elaborate test procedures.

## OPERATION

A multi-contact switch is provided at each line terminal which serves the dual functions of a carrier on-off switch and a test switch. This switch is arranged to apply a single phase current to the HKB relay to simulate internal and through fault conditions. Relay operation is noted by observing a blue indicating lamp connected in the HKB relay trip circuit. During the test the HKB trip circuit to the line breaker is opened and a red warning light is energized through auxiliary contacts on the test switch.

## CONSTRUCTION

Test Switch

The type W test switch is provided with eight pairs of contacts, two pairs of which are closed in the "carrier on" position. The contact arrangement is shown in Fig. 12, and the outline and drilling plan in Fig. 15. These contacts are used to complete the HKB trip circuit and the alarm circuit as indicated in Fig. 12 by contacts 1, 2, and 7, 8. In the "carrier off" position the HKB trip circuit is opened through contacts 1 and 2, but the alarm circuit remains closed. Two test positions to the right of the "carrier off" positions are provided. When the switch is moved to either of these positions, the relay trip and alarm circuits are interrupted and a red alarm light is turned on by switch contact 3 and 4. Moving the switch to the TEST 1 position will connect the output of the auxiliary test transformer directly to the HKB terminals number 25 and 26, through the type W contacts number 9 and 10, and 11 and 12. Moving the switch to the TEST 2 position will connect the test transformer with a reversed polarity to the HKB relay through switch contacts 13, 14 and 15, 16.

Auxiliary Test Transformer

The auxiliary test transformer is designed to operate from a 115 volt, 60 cycle power source. Four secondary taps numbered 1, 2, 3 and 4 are provided to vary the magnitude of the test current. The tap numbers equal the current in amperes that will be passed through the relay when ground tap H is used. If the relay is connected to use ground tap G, approximately two times the transformer tap value (2, 4, 6 or 8 amperes) will be passed through the relay. The outline and drilling plan of the transformer is shown in Fig. 13.

Indicating Lamps

The red and blue indicating lamps are standard rectangular Minalites. Outline and drilling dimensions are given in Fig. 15.

## ADJUSTMENT

Choose a transformer tap that will provide approximately two times the phase-to-ground current setting of the HKB relay as previously determined.

## OPERATION

Use of the auxiliary test equipment is to be limited to provide a simplified test after the initial installation tests have been performed as described in part II of this instruction leaflet.

The test apparatus is to be connected as shown in Fig. 12 with the auxiliary test transformers energized from 115 volt, 60 cycle power sources at each line terminal that are in phase with each other. The following operation procedure assumes that the same polarity is used in connecting the test transformer at each line terminal.

1. Turn the carrier test switch at both line terminals to CARRIER OFF.

2. Turn the carrier test switch to TEST 1 at line terminal #1. The local relay should operate to transmit half cycle impulses of carrier, and trip. Tripping will be indicated by the blue light.

3. Turn the HKB test switch at the remote line terminal #2 to TEST 1. This will simulate an internal fault fed from both line terminals. The relay at line terminal #2 will trip, and the relay at line terminal #1 will remain tripped. Tripping will be indicated by the blue lights at each line terminal. Carrier will be transmitted in half cycle impulses simultaneously from each end of the line.

4. Reset the HKB test switch at line terminal #1. The relay at terminal #1 will reset and turn off the blue light. The relay at terminal #2 will hold its trip contact closed, lighting the blue light.

5. Turn the HKB test switch at line termi-

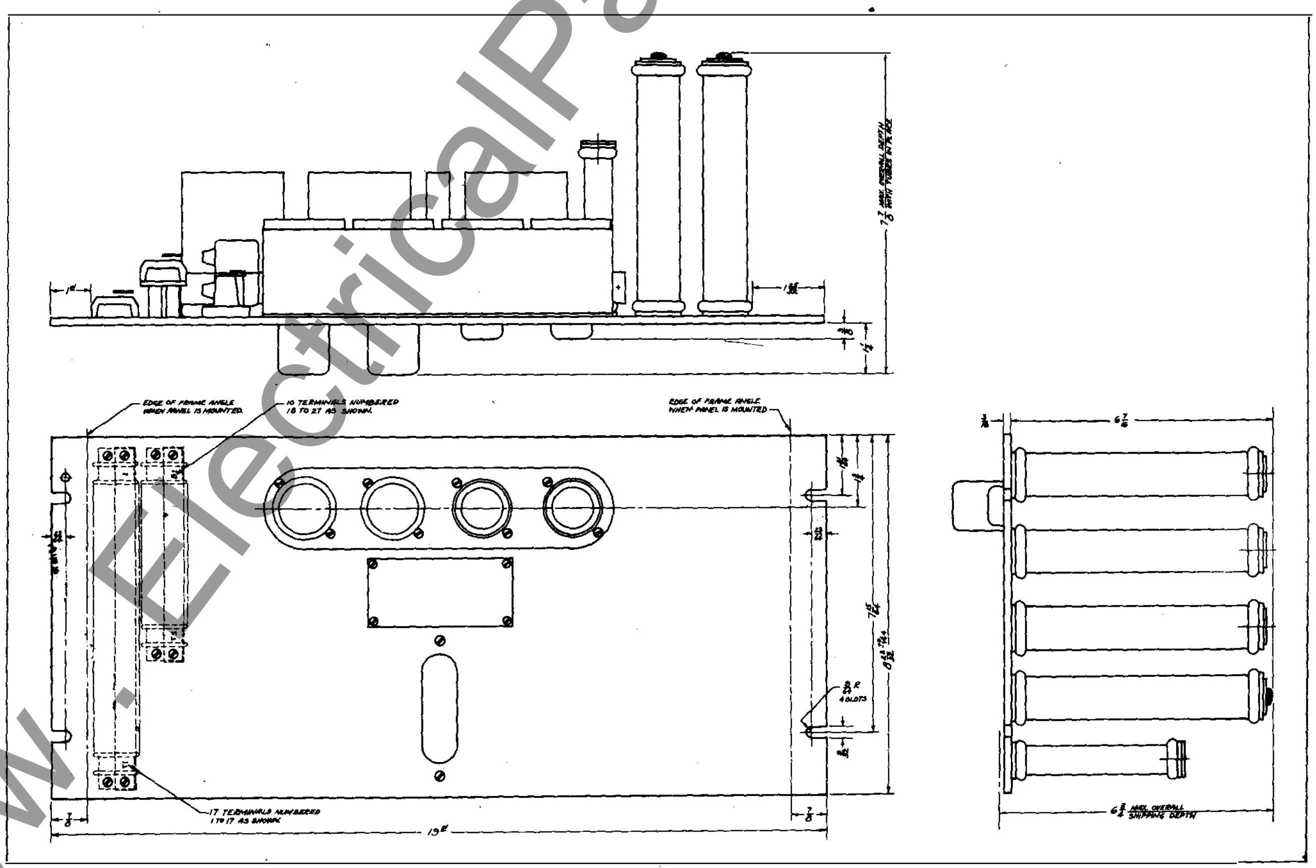


**Fig. 11—Outline And Mounting Plan Of The Type HKB Control Unit. For Reference Only.**

COMPONENT PARTS

| SYMBOL | NUMBER REQUIRED | NAME | RATING |
|---|---|---|---|
| | | CAPACITORS | |
| C1 | 1 | Thyratron Plate to Plate | .05 Mfd., 600 V. d-c |
| C2 | 1 | Thyratron Output | .05 Mfd., 600 V. d-c |
| C3 | 1 | Rectifier Doubler Input | .0051 Mfd., 600 V. d-c |
| C4 | 1 | Rectifier Doubler Output | .0051 Mfd., 600 V. d-c |
| C5* | 1 | Transformer By-Pass | .003 Mfd., 500 V. d-c |
| C6 | 1 | Thyratron Grid By-Pass | 27 Mmfd., 500 V. d-c |
| C7 | 1 | Thyratron Grid By-Pass | 27 Mmfd., 500 V. d-c |
| | | METER JACKS | |
| J1 | 1 | Tube Heaters | Western Electric 232A |
| J2 | 1 | Relay Tube Plate & Screen | or |
| J3 | 1 | Rectifier Doubler Output | Cook Electric JK-24 |
| | | REACTORS | |
| L1 * | 1 | Carrier Start Circuit | 7 henries, 25 ma. d-c, 440 ohms d-c resistance |
| | | RESISTORS | |
| R1 | 1 | Carrier Start Thyratron Plate | 16,000 ohms, 22 watt, tapped. |
| R2 | 1 | Carrier Start Thyratron Plate | 2,000 ohms, 12 watt, adjustable (1 band). |
| R3 | 1 | Relay Thyratron Plate | 5,000 ohms, 12 watt. |
| R4 | 1 | Relay Thyratron Plate | 10,000 ohms, 12 watt. |
| R5* | 1 | Thyratron Bias | 50 ohms, 22 watt, adjustable (1 band). |
| R6 | 1 | Relay Tube Bias | 2,000 ohms, 22 watt, adjustable (1 band). |
| R7 | 1 | Heater Shunt | 160 ohms, 22 watt. |
| R8 | 1 | Amplifier Bias | 6.3 ohms, 22 watt. |
| R9 | 1 | Amplifier Bias | 10 ohms, 22 watt. |
| R10 | 1 | Amplifier Bias | 2.5 ohms, 12 watt. |
| R11 | 1 | Amplifier Bias | 4 ohms, 22 watt |
| R12 | 1 | Bias Restoring | 5,600 ohms, 1 watt. |
| R13 | 1 | Bias Restoring | 0.11 megohms, 1 watt. |
| R14 | 1 | Bias Restoring | 91,000 ohms, 1 watt. |
| R15 | 1 | Thyratron Grid | 0.1 megohm, 1 watt. |
| R16 | 1 | Thyratron Grid | 0.1 megohm, 1 watt. |
| R17 | 1 | Thyratron Cathode | 2,400 ohms, 1 watt. |
| R18 | 1 | Rectifier Doubler Input | 2,000 ohms, 1 watt. |
| R19 | 1 | Rectifier Doubler Output | 51,000 ohms, 1 watt. |
| R20 | 1 | Relay Tube Grid | 51,000 ohms, 1 watt. |
| R21 | 1 | Tube Shell Grounding | 0.27 megohms, 1 watt. |
| R22 * | 1 | Reactor Shunt | 5,100 ohms, 1 watt. |
| R23 | 1 | Heater Series | 63 ohms, wire wound, adjustable (1 band). |
| R24 | 1 | Heater Series | 63 ohms, wire wound, adjustable (1 band). |
| R25 | 1 | Heater Shunt | 250 ohms, wire wound, adjustable (2 bands). |
| R26# | 1 | Thyratron Bias | 100 ohms, 22 watt, adjustable (1 band). |
| R27# | 1 | Thyratron Bias | 100 ohms, 22 watt, adjustable (1 band). |
| | | TRANSFORMERS | |
| T1 | 1 | Thyratron Input | 1/4 ratio topped secondary. |
| T2 | 1 | Relay Tube Output | 2500/500 ohms Impedance Ratio. |
| T3 * | 1 | Receiver-Audio | 2500/500 ohms Impedance Ratio. |
| | | TUBES | |
| V1 | 1 | Carrier Start Thyratron-Gas | Type 2050 |
| V2 | 1 | Relay Thyratron-Gas | Type 2050 |
| V3 | 1 | Rectifier Doubler-Vacuum | Type 25Z6 |
| V4 | 1 | Relay Tube-Vacuum | Type 25L6 |
| | | TUBE SOCKETS | |
| X1-X4 | 4 | Octal Ceramic Tube Socket | Amphenol Type MIP8T (From Dwg. T7614215-1). |

*In Control Unit S#867954A only.
#In Control Unit S#1471641 only.

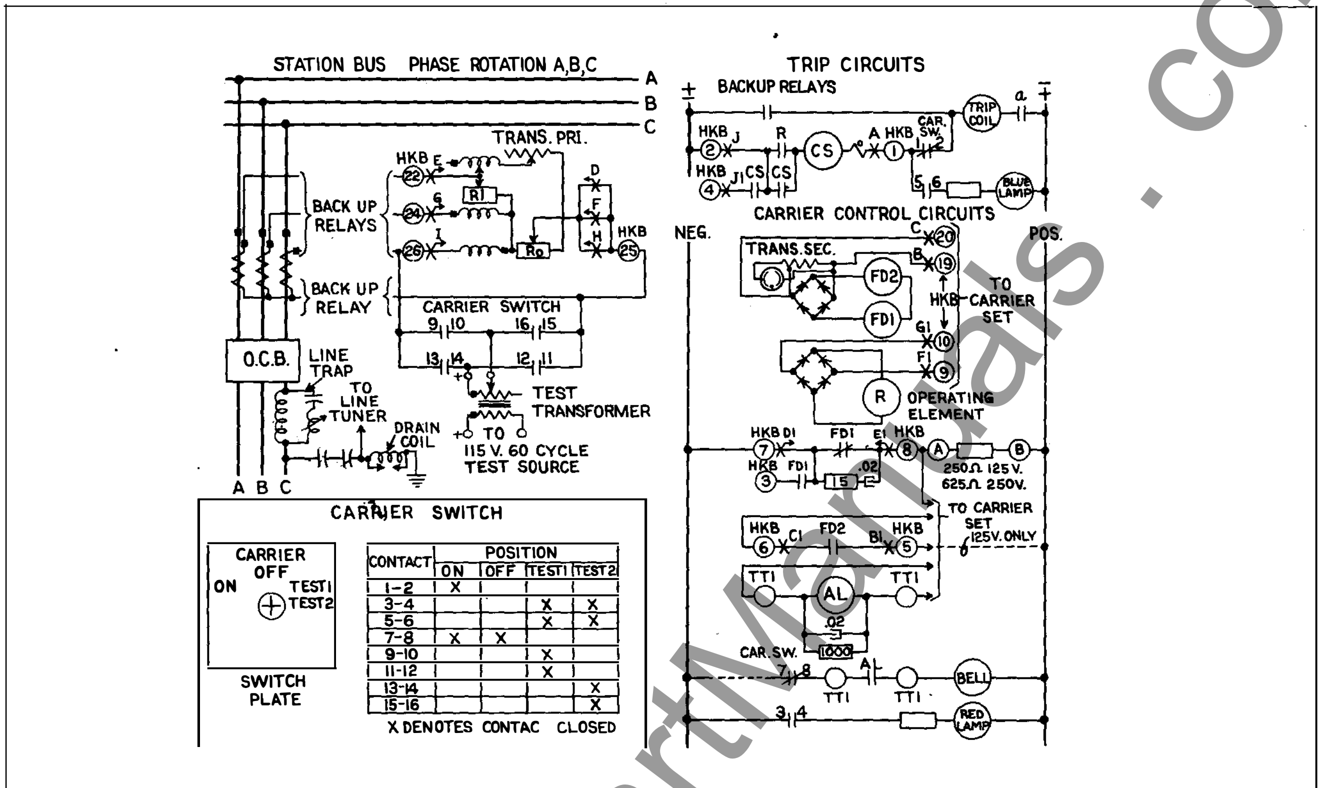
nal #1 to TEST 2. This condition will simulate an external fault. The trip contacts of both relays will be held open and the blue light will be extinguished.

6. Reset the test switches at both line terminals to CARRIER OFF before returning to CARRIER ON for normal service.

This completes the test procedure.

Component Style Numbers

| | |
|---|---|
| Test Transformer | S#1338284 |
| Type W Test Switch | S#1446447 for 1/8" panel mounting. |
| Type W Test Switch | S#1446448 for 1-1/2" panel mounting. |




| CONTACT | ON | OFF | TEST1 | TEST2 |
|---|---|---|---|---|
| 1-2 | X | | | |
| 3-4 | | | X | X |
| 5-6 | | | X | X |
| 7-8 | X | X | | |
| 9-10 | | | X | |
| 11-12 | | | X | |
| 13-14 | | | | X |
| 15-16 | | | | X |

**Fig. 12—Schematic Connections Of Type HKB Relay And Test Facilities.**

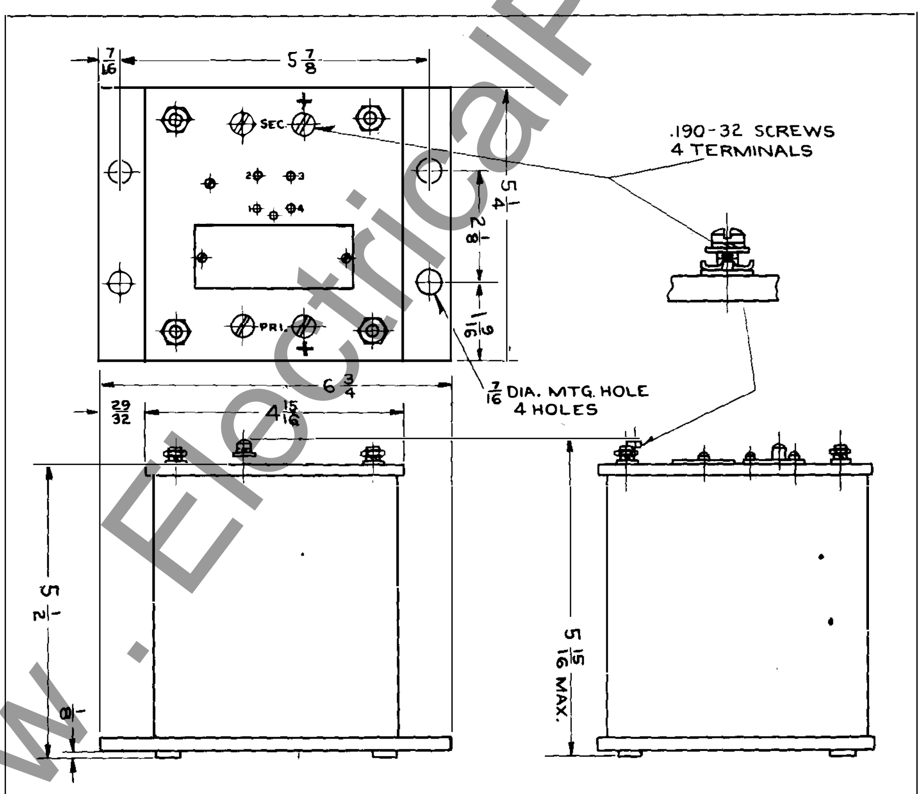



**Fig. 13—Outline And Drilling Plan Of The Type HKB Test Transformer. For Reference Only.**

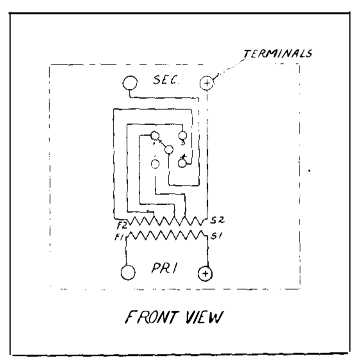



**Fig. 14—Internal Schematic Of The Type HKB Test Transformer.**

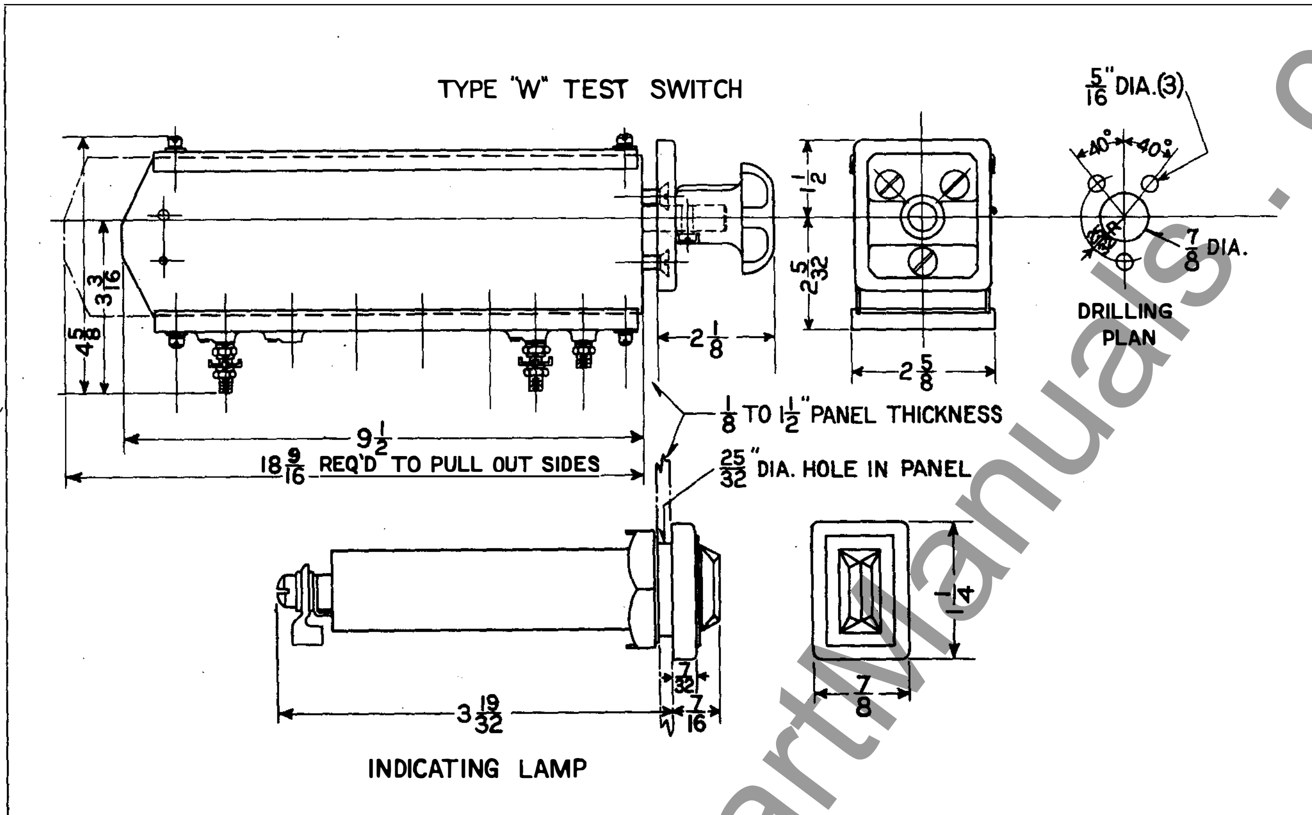



Fig. 15—Outline And Drilling Plan Of The Type W Test Switch And Indicating Lamps Which Are Part Of The Type HKB Test Facilities. For Reference Only.

# Westinghouse

## TYPE HKB RELAY AND CARRIER CONTROL UNIT

### INSTRUCTIONS

### APPLICATION

The type HKB relay is a high speed carrier relay used in conjunction with power-line carrier equipment to provide complete phase and ground fault protection of a transmission line section. Simultaneous tripping of the relays at each line terminal is obtained in three cycles or less for all internal faults within the limits of the relay settings. The relay operates on line current only, and no source of a-c line potential is required. Consequently, the relays will not trip during a system swing or out-of-step condition. The carrier equipment operates directly from the station battery.

### PRINCIPLE OF OPERATION

The HKB carrier relaying system compares the phase positions of the currents at the ends of a line-section over a carrier channel to determine whether an internal or external fault exists. The three-phase line currents energize a sequence filter which gives a single-phase output voltage proportional to a combination of sequence components of the line current. During a fault, this single-phase voltage controls an electronic circuit which allows the transmission of carrier on alternate half-cycles of the power-frequency current. Carrier is transmitted from both line terminals in this manner, and is received at the opposite ends where it is compared with the phase position of the local sequence filter output. This comparison takes place in the grid circuit of a vacuum tube. The polarities of the voltages to be compared are such that for an internal fault, plate current flows on alternate power-frequency half-cycles. A relay connected in the plate circuit of the vacuum tube operates under this condition to complete the trip circuit. During an external fault, the change in direction of current flow causes the plate current to be continuously blocked, and the plate circuit relay does not operate.

Since this relaying system operates only during a fault, the carrier channel is available at all other times for the transmission of other functions.

## PART I - TYPE HKB RELAY

### CAUTION

Before putting relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

### CONSTRUCTION

The relay consists of a combination positive, negative and zero sequence filter, a saturating auxiliary transformer, two Rectox units, two polar relay units, a neon lamp, contactor switch and operation indicator all mounted in a Type M-20 Flexitest Case.

#### Sequence Filter

The currents from the current transformer secondaries are passed thru a filter consisting of a three-winding iron-core reactor and two resistors. The zero-sequence resistor, $R_o$, consists of three resistor tubes tapped to obtain settings for various ground fault conditions. The other resistor $R_1$ is a formed single wire mounted on the rear of the relay sub-base. The output of this filter provides a voltage across the primary of the saturating transformer.

The lower tap block provides for adjustment of the relative amounts of the positive, negative and zero sequence components of current in the filter output. Thus a single relay element energized from the filter can be used as a fault detector for all types of faults.

#### Saturating Auxiliary Transformer

The voltage from the filter is fed into the tapped primary (upper tap plate) of a small saturating transformer. This transformer and a neon lamp connected across its secondary are used to limit the voltage impressed on the fault detector (lower polar relay element) and the carrier Control Unit, thus providing a small range of voltage for a large variation of maximum to minimum fault currents. This provides high operating energy for light faults, and limits the operating energy for heavy faults to a reasonable value.

The upper tap plate changes the output of the saturating transformer, and is marked in amperes required to pick up the fault detector element. For further discussion, see section entitled "Settings".

#### Rectox Units

The secondary of the saturating transformer feeds a bridge-connected Rectox unit, the output of which energizes the polar fault detector element. A second Rectox, energized from the output of the Control Unit, supplies a d-c voltage of the upper polar element which operates only for an internal fault. The use of sensitive polar relays keeps down the energy required from the current transformers and vacuum tube circuits.

not less than 75% of the pick up value. Lock the shunts in position and recheck the calibration several times. The action of the armature should be snappy.

Operating Element (Upper Polarized Relay)

Adjust the single contact in the same manner as the fault detector right hand contact.

Calibration: Connect a d-c milliammeter (0-25 ma) across test switch jaws H1 and I1 (relay out of case). Connect a source of variable a-c voltage (0 to 10 volts) between terminals 9 and 10 (or switch jaws F1 and G1). The element is to be adjusted for 10 ma d-c pick up and 4 to 6 ma dropout. The action of the armature should be snappy. Approximate adjustment for these values are as follows: Screw in the right hand shunt until the top air gap is shunted. Apply 10 ma. d-c (from the a-c source) to the coil, and then screw in the left hand shunt until the armature closes the right hand contact. Reduce the a-c voltage until the armature resets; this should happen between 4 and 6 ma. Lock the shunts in position and recheck the calibration several times.

Contactor Switch

Adjust the stationary core of the switch for a clearance between the stationary core and the moving core when the switch is picked up. This can be most conveniently done by turning the relay up-side-down. Screw up the core screw until the moving core starts rotating. Now, back off the core screw until the moving core stops rotating. This indicates the point where the play in the moving contact assembly is taken up, and where the moving core just separates from the stationary core screw. Back off the stationary core screw one turn beyond this point and lock in place. This prevents the moving core from striking and sticking to the stationary core because of residual magnetism. Adjust the contact clearance for 3/32 inch by means of the two small nuts on either side of the Micarta disc. The switch should pick up at 2 amperes d-c. Test for sticking after 30 amperes d-c have been passed thru the coil. The coil resistance is approximately 0.25 ohm.

Operation Indicator

Adjust the indicator to operate at 1.0 ampere d-c gradually applied by loosening the two screws on the under side of the assembly, and moving the bracket forward or backward. If the two helical springs which reset the armature are replaced by new springs, they should be weakened slightly by stretching to obtain the 1 ampere calibration. The coil resistance is approximately 0.16 ohm.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

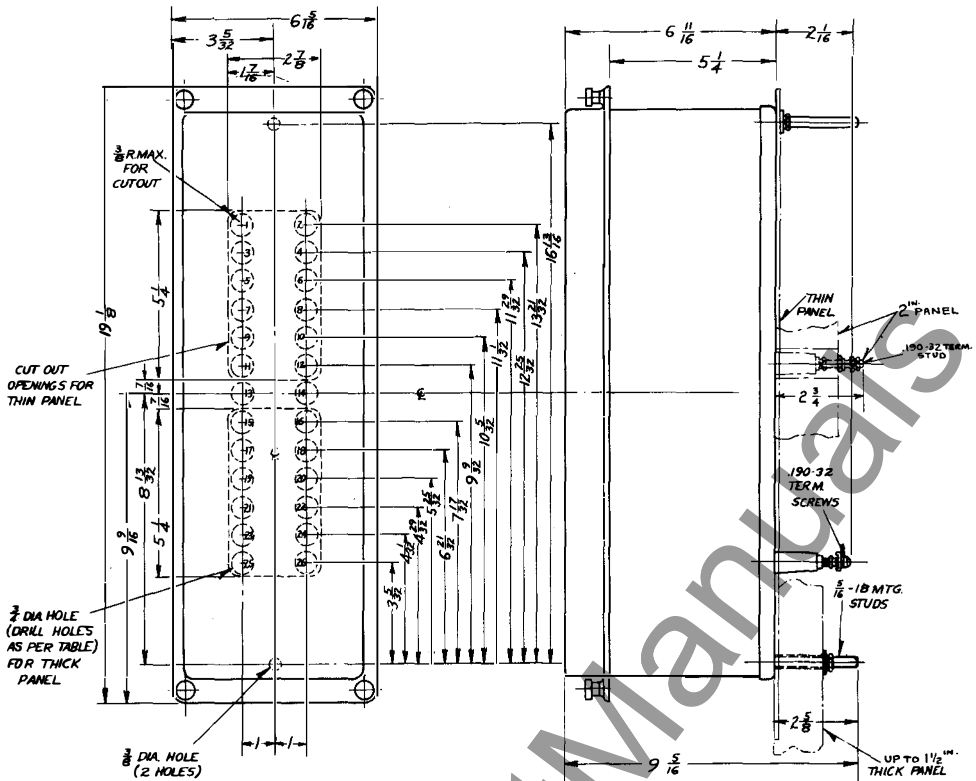
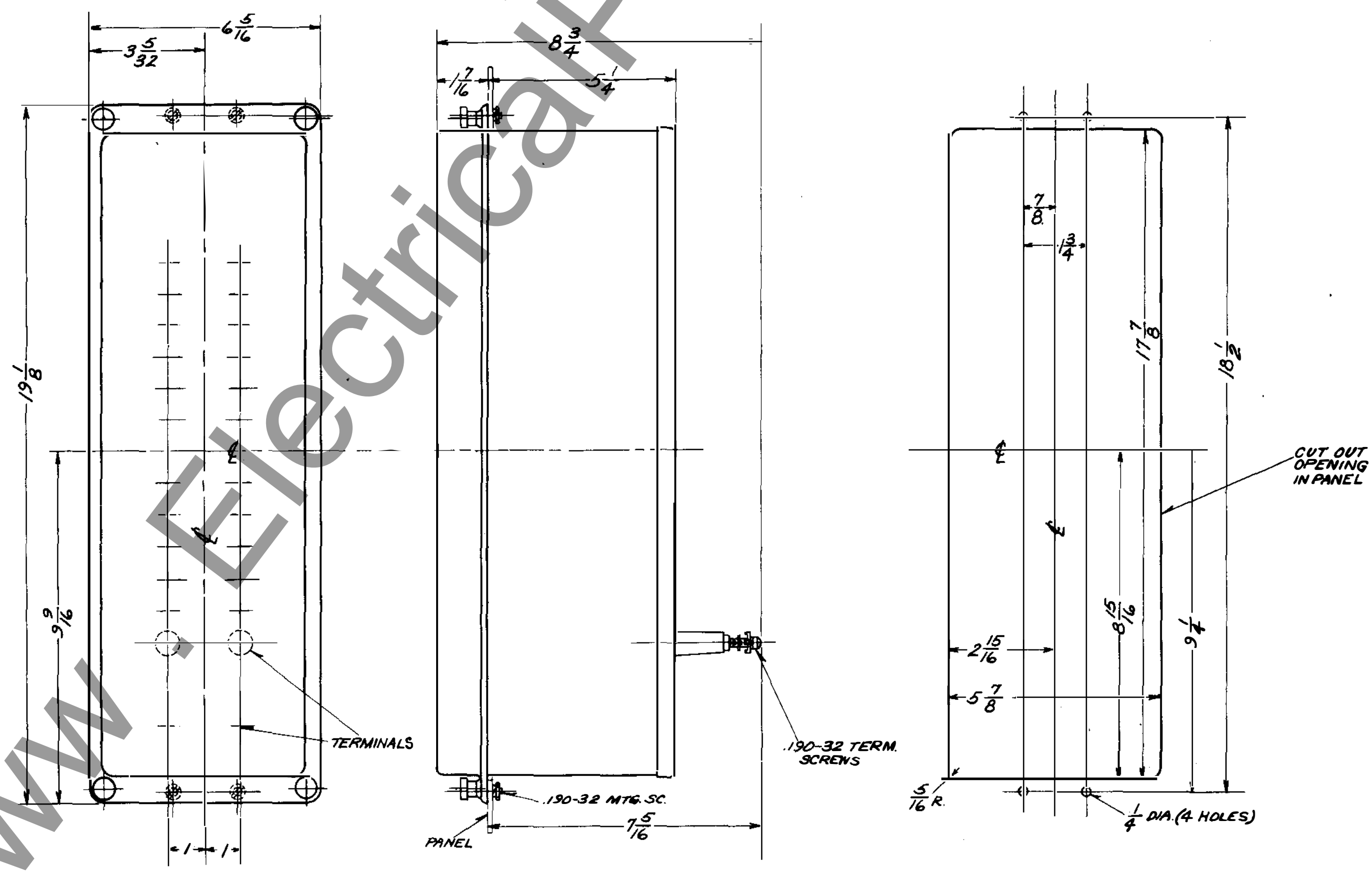



Figure 3
Outline and Drilling Plan for the M20 Projection Type FT Flexitest Case. See the Internal Schematic for the Terminals Supplied. For Reference Only




.Figure 4
Outline and Drilling Plan for the M20 Semi-flush Type FT Flexitest Case. For Reference Only.

## PART II - TYPE HKB CONTROL UNIT

### CONSTRUCTION

The HKB Control Unit consists of an electronic trigger circuit employing two thyratrons; a rectifier-doubler vacuum tube for the received carrier and a vacuum "relay" tube which compares the phase positions of the local and distant line currents.

The general appearance and construction of the HKB Control Unit is shown by the outline drawing, Figure 6. The entire equipment, with the exception of the accessories, is mounted on a standard 3/16" thick aluminum panel 19" wide and 8-23/32" high with standard notching. The front of the panel is black wrinkle finished, and the rear is flat black. The tubes protrude through the front panel for convenient installation and replacement.

Jacks are provided on the front of the panel for current metering as follows:

J1(top jack) Heater current
J2(center jack) Relay tube emission current
J3(bottom jack) Rectifier-doubler output current

### INSTALLATION

When used with the Type JY Transmitter and Receiver, the HKB Control Unit is mounted in the same cabinet with these panels and immediately beneath the Receiver panel.

When used with the Type GO Transmitter Receiver, the HKB Control Unit is housed in a small cabinet mounted above the GO Cabinet.

In either case the Instruction Book for the complete assembly of which this unit is a part should be referred to for additional mounting instructions.

Upon delivery, the unit should be very carefully checked for damaged parts. Particular attention should be given to any parts which may have become loose in shipment, or wires which may have broken because of vibration. Each HKB Control Unit is supplied with an accessory group of components for adapting it for operation from 125 volts d-c or 250 volts d-c. These components should be checked for damage and to see that none are missing, and checked against the order or requisition and the parts list in this book as well as the instruction sheet furnished with each accessory package. Any shortage should be immediately reported to the transportation company and to the nearest district office of the manufacturer. The dummy resistor plug furnished with the HKB accessories is for use in the JY Transmitter amplifier cathode circuit. Remove the resistor regularly furnished with the JY Transmitter and replace with this dummy plug. A suitable dummy resistor plug for use in the GO Transmitter-Receiver is furnished with its accessories.

The necessary connections from the GO or JY (cabinet) assembly terminal blocks to the switchboard, relays, etc., should be made in suitable conduit. Number 12 gauge wire is recommended for these connections. The connection diagrams in the instruction book for the complete assembly should be followed. Be sure to ground terminal #1 on the HKB Unit and also cabinet terminal #1.

### CIRCUIT ADJUSTMENT - GENERAL

Do not insert the tubes into the HKB Control Unit until the following paragraphs dealing with circuit adjustments have been read.

The HKB Control Unit is designed to use the same tubes for either 125 volt or 250 volt operation. When used on 250 volts d-c, the proper value of plate voltage for the Type 25L6 Relay Tube is obtained from a connection at the positive end of the transmitter tube heaters. This is shown in the external connections on Figure 5.

In order to obtain bias voltage for both the HKB Control Unit and the associated carrier transmitter, the entire d-c current drain of both units is caused to flow through a combination of resistors in the Control Unit. In this way, adjustable bias for the Type 2050 thyratrons and fixed bias of two different values for the power amplifier tubes of the transmitter is obtained. Because the adjustment procedure will follow the tabulations shown on Tables I and II as closely as possible, it is important to become thoroughly familiar with the tables. Five columns are included in these tables. The first column indicates the quantity to be checked. The second column indicates the minimum value permissible. The third column indicates the normal value. The fourth column indicates the maximum value permissible. The fifth column should be filled in at the time of installation, to indicate the actual value which was obtained. The last column is of great importance and should be filled in as soon as the HKB Control Unit is installed. All quantities must be brought within the minimum and maximum values specified before the equipment can be considered to be in satisfactory operating condition. A copy of these values should be kept with the equipment for checking purposes. All letters of inquiry to the manufacturer regarding the operation of this unit should be accompanied by a list of actual values of the eight quantities tabulated on Table I or II.

The maximum and minimum limits of the values in the table do not all correspond to the same percentage. In the case of the power supply or battery voltage, the limits given are the maximum and minimum at which the unit can be properly adjusted to operate; and these limits include the maximum variation in power supply voltage. For instance, the HKB unit with 125 volt accessories can be adjusted to function properly on any battery which never exceeds 150 volts or drops below 100 volts. But once the normal voltage is established and adjustments are made for operation on that voltage, it should not be permitted to fluctuate normally more than plus or minus five percent.

The Unit has been designed to use either glass or metal tubes of types 25L6 and 25Z6, and the adjustment data is the same for either.

### CIRCUIT ADJUSTMENTS - 125 VOLT EQUIPMENT

The numbers at the beginning of the following paragraphs correspond to the line numbers in the Adjustment Data Tables.

1. The first line in the Adjustment Data Table is the power supply or battery voltage, which is to be measured at the cabinet terminals before any of the equipment is turned on. The actual value of this voltage at the time of installation should be entered on the line in the fifth column of the data table. If it is not within the limits of 100 to 150 volts d-c, do not proceed.

2. Adjustment of the HKB Control Unit tube heater current is now to be carried out.

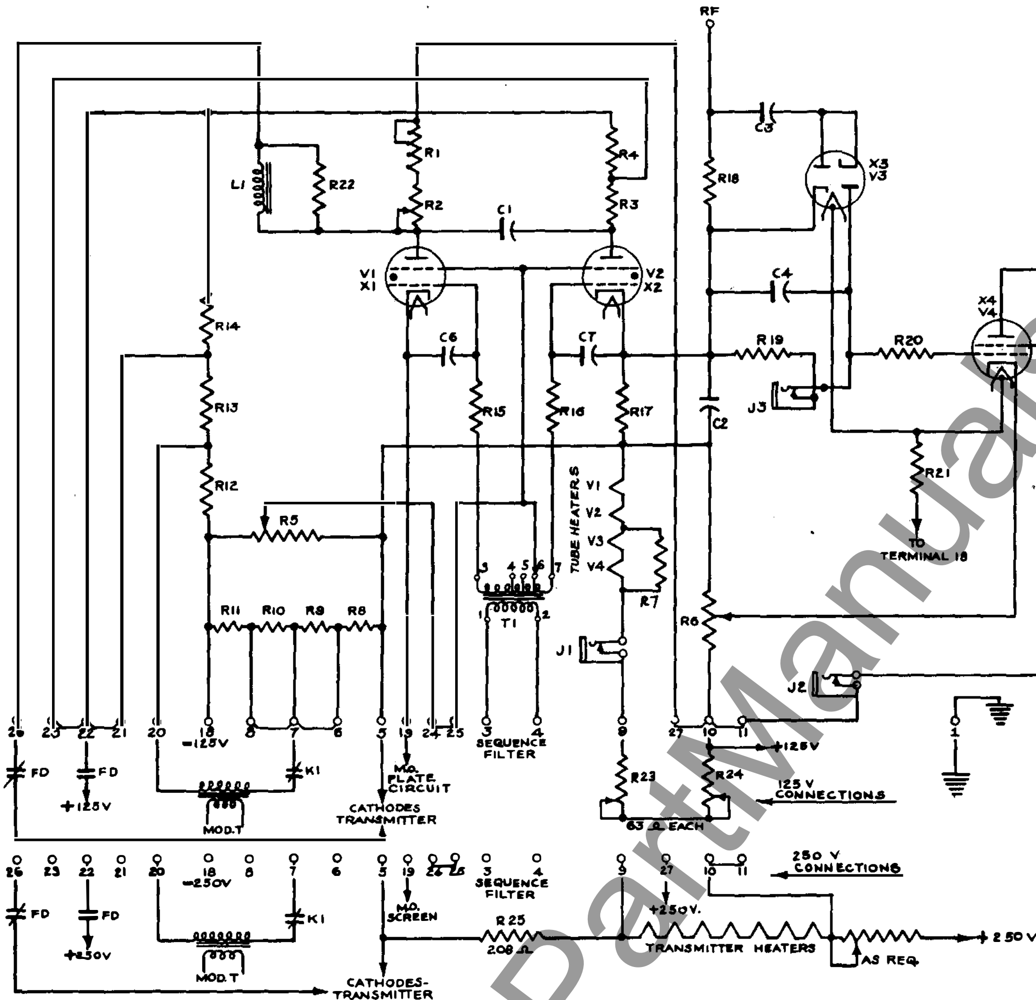


Figure 5
Internal Schematic of the Type HKB Control Unit.

Since the bias resistor (combination of R8, R9, R10, R11 and R5) is common to the heater circuits of both the carrier transmitter-receiver and the HKB Control Unit, adjustment of heater current of the one unit will affect that of the other. In order to avoid difficulty, the bias resistor mentioned is to be temporarily shorted out during the adjustment of heater current for both the transmitter-receiver and the HKB Control Unit. BEFORE PROCEEDING, REFER TO THE INSTRUCTION BOOK FOR THE ASSEMBLY OF WHICH THIS UNIT IS A PART AND CARRY OUT THE DIRECTIONS THEREIN FOR INSERTING MAXIMUM RESISTANCE INTO THE TRANSMITTER-RECEIVER HEATER CIRCUIT. Connect a jumper wire across terminals #5 and #18 of the HKB Control Unit. The adjusting clip on resistor R6 is to be set roughly in the center of the resistor. The adjusting clips on the two adjustable resistors R23 and R24, which are external heater series resistors mounted on a separate panel, are to be set so as to short out the least possible amount of these resistors, Remove the dummy resistor plug from its clips in the transmitter amplifier cathode return circuit. The tubes are now to be inserted into the HKB Control Unit. Turn on the power switch of the assembly of which the HKB Unit is a part. Plug a d-c ammeter of 1 ampere range into jack J1 and adjust the shorting clips of external resistors R23 and R24 to obtain the correct heater current as given in line #2 of the table. It is desirable to keep the amount shorted out of each of these two resistors about equal so as to distribute the heat produced equally between them. When the power is first applied, the tube heater current will be above normal due to the low resistance of the cold heater elements. Consequently power should be applied for at least two minutes before readings are taken. After the heater current of the HKB Control Unit and the heater current of the transmitter-receiver have each been adjusted, remove the jumper wire from terminals #5 and #18 of the HKB Unit. Replace the dummy resistor plug in its clips in the transmitter.

3. After the adjustments on the transmitter have been completed and the transmitter is in normal operation measure again the heater current of the HKB Unit at Jack J1. If not within the limits of line #3 in the Data Table, make such slight changes to the setting of the external resistors R23 and R24 as may be required to correct it. (A similar operation should be carried out on the transmitter-receiver.)

4. After the above adjustments are completed, measure at the other two metering jacks, J2 and J3, to see that no current is flowing. Under the condition of the bias resistor R6 being set near the center, the Relay Tube, V4, is biased well beyond plate current cut-off, so that the current at jack J2 should be well below the limit of .1 milliampere. Under the condition of no r-f signal received, the current at jack J3 should be well below the limit of .1 ma. Any excessive current flow should be investigated and the fault cleared before proceeding with the tests. (Make final check with 1 milliampere range of meter.)

5. Measure the d-c bias voltage between terminals #5 and #18.

6. This adjustment is for the purpose of obtaining the correct Master Oscillator plate voltage for the transmitter. The transmitter must be completely adjusted and in a state of normal operation (ready to be controlled by the HKB Unit). In making this adjustment it is necessary to have V1 Thyratron continuously ignited. Remove the external connection wire from terminal #26 of the HKB Unit. Remove the external jumper wire from terminal #25. Connect terminal #25 to terminal #19. Thyratron V1 should fire and remain ignited. Connect a d-c voltmeter of at least 1000 ohms-per-volt resistance between terminal #5 and terminal #19. Adjust R1 and R2 to obtain the required voltage as given on the Table in the transmitter instruction book. The transmitter should now be sending out carrier at its full output power. Reconnect the wires that were removed from terminals #3, #4 and #26.

7. The object of the following adjustment is to set the firing point of the thyratrons V1 and V2 to the proper value by adjusting their grid bias. The bias voltage is measured between terminal #5 and terminal #25, and is adjusted by means of the slider on resistor R5. The tap on the secondary of transformer T1 should be on terminal #5 of the transformer.

In making this adjustment, it is necessary to apply a simulated fault to the HKB relay and associated carrier set. If the current circuits of the relay are not connected to the line current transformers, a single-phase 60 cycle current from a variable test source can be applied to the HKB relay terminals 24 and 25, simulating a single-phase-to-ground fault. If the relay current circuits are connected to the line, open test switches D, E, F, G, H, I and J. Test switch J opens the trip circuit. This switch should be opened first and left open during all adjustments. The current circuits to the relay have been shorted by opening switches D, F and H, but the relay is still connected to the current transformers through the test jacks on switches E, G and I. These circuits are opened by inserting current test plugs or strips of insulation into the test jacks on switches E, G and I. The relay is now entirely disconnected from the current transformers, and the single-phase test source can be connected between switch jaws F and G.

Put the upper tap screw in tap 4 and the lower tap screws in the C and H taps. This sets the pickup current of the relay fault detector at 0.5 ampere for a single-phase-to-ground fault. Adjust the slider on R5 for maximum grid bias on the thyratrons. With all connections to the carrier set normal, apply the single-phase test current to the relay and increase it gradually. At 0.5 ampere, the fault detector should pick up. Increase the current to 0.625 ampere which is 125% of the fault detector setting. Now gradually decrease the grid bias on the thyratrons. A point will be reached where thyratron V1 fires to start carrier. A faint purplish glow may be noticed in thyratron V1 between the cathode and the plate or anode. If the relaying carrier receiver is operating, a plate current of about 20 milliamperes will flow. Continue to reduce the grid bias until thyratron V2 fires, and trigger action begins. This will be evidenced by picking up of the operating element in the relay, and a reduction of the receiver plate current to about half its previous value. This is the correct adjustment of bias for the thyratrons. Tighten the slider on resistor R5. Reducing the test current below 0.625 ampere should stop triggering action, but V1 will remain conducting, and carrier will be on continuously. Reduce the test current to zero. When the fault detector resets, V1 will be extinguished, thus stopping carrier. Check the adjustment by gradually increasing the current again. The fault detector should pick up at 0.5 ampere and carrier should start. At 0.625 ampere, the operating element R should pick up.

8. The following adjustment covers the setting of the relay tube (V4) grid bias. With the test current circuit applied to the relay (described in paragraph 7), increase the a-c current until the neon lamp in the HKB relay lights. Plug a d-c milliammeter into the current jack on test switch I1 on the relay to measure the operating element coil current. Reduce the grid bias on the relay tube by adjusting the slider on resistor R6 until the operating element coil current is 25 milliamperes. The relay tube grid bias is measured between the slider on R6 and terminal #5 of the Control Unit. A voltmeter of at least 1000 ohms-per-volt resistance should be used. Carrier from the distant line terminal should not be transmitted during this adjustment. When the relay tube grid bias is adjusted as described, the overall characteristic of the HKB relaying system is as shown in Figure 2. All test circuits and meters may now be removed, and the relay test switches returned to normal. The switch with the red handle should be closed last as this connects the relay to the breaker trip circuit.

CIRCUIT ADJUSTMENTS - 250 VOLT EQUIPMENT

1. The first line in the Adjustment Data Table is the power supply or battery voltage, which is to be measured at the cabinet terminals before any of the equipment is turned on. The actual value of this voltage at the time of installation should be entered on the line in the fifth column of the data table. If it is not within the limits of 200 to 300 volts d-c, do not proceed.

2. Adjustment of the HKB Control Unit tube heater current will be accomplished along with the adjustment of the transmitter heater current, because all the heaters of the assembly are connected in series. The necessary external heater series resistors are a part of the accessories for the assembly of which this Unit is a part; and the instructions for their adjustments are to be found in the instruction book for the complete assembly. After the adjustment is completed, record the value of current as measured at jack J1. The heater currents of the Control Unit and the transmitter should be within the limits tabulated on Table II.

External accessory resistor R25 is connected in shunt to the HKB tube heaters. By bypassing .3 ampere, it enables their operation in series with the tube heaters of the transmitter, which draw .9 ampere. Resistor R25 is adjusted at the factory to 208 ohms plus or minus 1 percent and should not be changed from the above value.

3. The plate circuit supply voltage is to be measured between terminal #5 and terminal #10.

4. After the above adjustments are completed, measure at the other two metering jacks, J2 and J3, to see that no current is flowing. Under the condition of the bias resistor R6 being set near the center, the Relay Tube, V4 is biased well beyond plate current cut-off, so that the current at jack J2 should be well below the limit of .1 milliampere.

TABLE I

**ADJUSTMENT FOR HKB CONTROL UNIT ON 125 VOLTS**

See text of Instruction book for discussion of the following table. Numbers preceeding data refer to test paragraph numbers.

| | Quantity | Min. | Normal | Max. | Actual |
|---|---|---|---|---|---|
| 1. | Power Supply Volts | 100 | 125 | 150 | |
| 2. | Heater Amperes, Preliminary Adjustment # | .59 | .62 | .65 | |
| 3. | Heater Amperes, Final Adjustment + | .54 | .56 | .58 | |
| 4. | Current at jack J2, Milliamperes | 0 | 0 | .10 | |
| | Rectifier-doubler Output Milliamperes at J3 * | 0 | .05 | .10 | |
| 5. | Total Bias Volts | 11 | 14 | 17 | |
| 6. | Master Oscillator Plate Volts--------------------See transmitter instruction book. | | | | |
| 7. | Thyratron Grid Bias Volts | 6.0 | 10.0 | 14.0 | |
| 8. | Relay Tube Grid Bias Volts | 20 | 30 | 40 | |
| | HKB Relay Operating Element Current, Ma. | 24 | 25 | 26 | |

\# - The total tube heater current of the associated transmitter should be adjusted to this value also.

\+ - The final value of the tube heater current of the transmitter should be within these limits for the total, and half of these values for each branch.

* - With no carrier being received.

TABLE II

**ADJUSTMENT DATA FOR HKB CONTROL UNIT ON 250 VOLTS**

See text of instruction book for discussion of the following table. Numbers preceeding data refer to text paragraph numbers.

| | Quantity | Min. | Normal | Max. | Actual |
|---|---|---|---|---|---|
| 1. | Power Supply Volts | 200 | 250 | 300 | |
| 2. | Tube Heater Amperes - Control Unit | .54 | .56 | .58 | |
| | " " " - Transmitter | .81 | .85 | .89 | |
| 3. | Plate Circuit Supply Volts | 95 | 135 | 165 | |
| 4. | Current at jack J2, Milliamperes | 0 | 0 | 0.1 | |
| | Rectifier-doubler Output Milliamperes at J3 * | 0 | .05 | 0.1 | |
| 5. | Total Bias Volts | 17 | 22 | 28 | |
| 6. | Master Oscillator Plate Volts--------------------See transmitter instruction book. | | | | |
| 7. | Thyratron Grid Bias Volts | 6.0 | 11.0 | 16.0 | |
| 8. | Relay Tube Grid Bias Volts | 20 | 30 | 40 | |
| | HKB Relay Operating Element Current, Ma. | 24 | 25 | 26 | |

* - With no carrier being received.

Under the condition of no r-f signal received, the current at jack J3 should be well below the limit of .1 ma. Any excessive current flow should be investigated and the fault cleared before proceeding with the tests. (Make final check with 1 milliampere range of meter.)

5. Measure the d-c bias voltage between terminals #5 and #18.

6. The following adjustment is for the purpose of obtaining the correct Master Oscillator plate voltage for the transmitter. The transmitter must be completely adjusted and in a state of normal operation (ready to be controlled by the HKB Unit). In making this adjustment it is necessary to have V1 Thyratron continuously ignited. Remove the external connection wire from terminal #26 of the HKB Unit. Remove the external jumper wire from terminal #25. Connect terminal #25 to terminal #19. Thyratron V1 should fire and remain ignited. Connect a d-c voltmeter of at least 1000 ohms-per-volt resistance between terminal #5 and terminal #19. Adjust R1 and R2 to obtain the required voltage as given on the Table in the transmitter instruction book. The transmitter should now be sending out carrier at its full output power. Reconnect the wires that were removed from terminals #3, #4 and #26.

7. Thyratron Grid Bias Volts. Adjustments are exactly the same as for 125-volt equipment. See paragraph 7 of previous section. Refer to values on Table II.

8. Relay Tube Grid Bias Volts. Adjustments are exactly the same as for 125-volt equipment. See paragraph 8 of previous section. Refer to values on Table II.

## OVERALL TEST OF COMPLETE INSTALLATION

After the complete equipment has been installed and adjusted, the following tests can be made which will provide an overall check on the relay and carrier equipment. The phase rotation of the three-phase currents can be checked by measuring the a-c voltage across relay terminals 19 and 20 or test switches B and C with a high resistance a-c voltmeter of at least 1000 **ohms** per volt. The reading obtained should be approximately 1.1 volts per ampere of balanced three-phase load current (secondary value).

This test requires that a balanced three-phase load current of at least 1.0 ampere (secondary) be flowing through the line-section protected by the HKB relays. At both terminals of the protected line-section, remove the HKB relay cover and open the trip circuit by pulling the test switch blade with the long red handle. Put the tap screw on the upper tap plate in the 4 tap, and on the lower one in the C and H taps. Be sure to insert the spare tap screw before removing the connected one. Now open test switches D and E on the relay at one end of the line section (Station A) and insert a current test plug or strip of insulating material into the test jack on switch E to open the circuit through that switch. The above operation shorts the phase A to neutral circuit ahead of the sequence filter and disconnects the phase A lead from the filter. This causes the phase B and C currents to return to the current transformers through the zero-sequence resistor in the filter, thus simulating a phase A-to-ground fault fed from one end of the line only. As a result, both the fault detector and operating element at Station A should close their contacts. Completion of the trip circuit can be checked by connecting a small lamp (not over 10 watts) across the terminals of test switch J.

Now perform the above operations at the opposite end of the line-section (Station B) without resetting the switches at Station A. This simulates a phase-to-ground fault external to the protected line-section. The fault detector, but not the operating element at B should pick up, and the operating element at A should reset. Restore test switches D and E at Station A to normal (closed). The line conditions now represent a phase-to-ground fault fed from Station B only. The fault detector at A should reset and the operating element at B should pick up. Restore test switches D and E at Station B to normal, and both elements of the relay at Station B should reset.

The above tests have checked phase rotation, the polarity of the sequence filter output, the interconnections between the relay and the carrier set and the Phase A current connections to the relay at both stations. Phase B and C can be similarly checked by opening test switches F and G for Phase B, and switches H and I for phase C. The same procedure described for Phase A is then followed.

If all the tests have been completed with satisfactory results, the test switches at both line terminals should be closed (close the trip circuit test switch last) and the relay cover replaced. The equipment is now ready to protect the line-section to which it is connected.

## MAINTENANCE

Since the Control Unit has no front-of-panel controls, it requires no attention except maintenance as described in the following paragraphs. The unit cannot be taken out of service without taking the entire assembly out of service.

Every three months an overall inspection should be made to see that no excessive corrosion has developed due to fumes or condensation of moisture. Any accumulated dust and dirt should be cleaned out, as often as once a month in some localities.

### Tubes

At the end of each year of operation, the tubes should be removed from their sockets, and their contacts inspected for possible dirt or corrosion. If there is any discoloration, it may be removed by the use of very fine sandpaper. In order to assure maximum tube life, it is very important that the resistance of the contacts be kept to an absolute minimum. If necessary, this cleaning operation should be performed more frequently than indicated above.

### Resistors

The resistors are operated well within their ratings, and should not fail during the life of the unit. In the accessory equipment, the ferrule resistors should be removed from their clips at the end of each year's operation, and the ferrules and clips cleaned of corrosion with crocus cloth or very fine sandpaper. In a corrosive atmosphere a film of vaseline will reduce trouble.

## TYPE JY HKB CONTROL UNIT COMPONENT PARTS

125/250 volts d-c

Style: 867954

Electrical Parts per Component Parts List (Dwg. 7615215), V1 to V4 except resistors R23, R24, and R25 and tubes.

COMPONENT PARTS

| SYMBOL | NUMBER REQUIRED | NAME | RATING |
|---|---|---|---|
| | | CAPACITORS | |
| C1 | 1 | Thyratron Plate to Plate | .05 Mfd., 600 V. d-c |
| C2 | 1 | Thyratron Output | .05 Mfd., 600 V. d-c |
| C3 | 1 | Rectifier Doubler Input | .0051 Mfd., 600 V. d-c |
| C4 | 1 | Rectifier Doubler Output | .0051 Mfd., 600 V. d-c |
| C5 | 1 | Transformer By-Pass | .003 Mfd., 500 V. d-c |
| C6 | 1 | Thyratron Grid By-Pass | 27 Mmfd., 500 V. d-c |
| C7 | 1 | Thyratron Grid By-Pass | 27 Mmfd., 500 V. d-c |
| | | METER JACKS | |
| J1 | 1 | Tube Heaters | Western Electric Cat. 232C 1 ckt. opening |
| J2 | 1 | Relay Tube Plate & Screen | Western Electric Cat. 232C 1 ckt. opening |
| J3 | 1 | Rectifier Doubler Output | Western Electric Cat. 232C 1 ckt. opening |
| | | REACTORS | |
| L1 | 1 | Carrier Start Circuit | 7 henries, 25 ma. d-c, 440 ohms d-c resistance |
| | | RESISTORS | |
| R1 | 1 | Carrier Start Thyratron Plate | 16,000 ohms, 22 watt, tapped. |
| R2 | 1 | Carrier Start Thyratron Plate | 2,000 ohms, 12 watt, adjustable (1 band). |
| R3 | 1 | Relay Thyratron Plate | 5,000 ohms, 12 watt. |
| R4 | 1 | Relay Thyratron Plate | 10,000 ohms, 12 watt. |
| R5 | 1 | Thyratron Bias | 50 ohms, 22 watt, adjustable (1 band). |
| R6 | 1 | Relay Tube Bias | 2,000 ohms, 22 watt, adjustable (1 band). |
| R7 | 1 | Heater Shunt | 160 ohms, 22 watt. |
| R8 | 1 | Amplifier Bias | 6.3 ohms, 22 watt. |
| R9 | 1 | Amplifier Bias | 10 ohms, 22 watt. |
| R10 | 1 | Amplifier Bias | 2.5 ohms, 12 watt. |
| R11 | 1 | Amplifier Bias | 4 ohms, 22 watt |
| R12 | 1 | Bias Restoring | 5,600 ohms, 1 watt. |
| R13 | 1 | Bias Restoring | 0.11 megohms, 1 watt. |
| R14 | 1 | Bias Restoring | 91,000 ohms, 1 watt. |
| R15 | 1 | Thyratron Grid | 0.1 megohm, 1 watt. |
| R16 | 1 | Thyratron Grid | 0.1 megohm, 1 watt. |
| R17 | 1 | Thyratron Cathode | 2,400 ohms, 1 watt. |
| R18 | 1 | Rectifier Doubler Input | 2,000 ohms, 1 watt. |
| R19 | 1 | Rectifier Doubler Output | 51,000 ohms, 1 watt. |
| R20 | 1 | Relay Tube Grid | 51,000 ohms, 1 watt. |
| R21 | 1 | Tube Shell Grounding | 0.27 megohms, 1 watt. |
| R22 | 1 | Reactor Shunt | 5,100 ohms, 1 watt. |
| R23 | 1 | Heater Series | 63 ohms, wire wound, adjustable (1 band). |
| R24 | 1 | Heater Series | 63 ohms, wire wound, adjustable (1 band). |
| R25 | 1 | Heater Shunt | 250 ohms, wire wound, adjustable (2 bands). |
| | | TRANSFORMERS | |
| T1 | 1 | Thyratron Input | 1/4 ratio topped secondary. |
| T2 | 1 | Relay Tube Output | 2500/500 ohms Impedance Ratio. |
| T3 | 1 | Receiver-Audio | 2500/500 ohms Impedance Ratio. |
| | | TUBES | |
| V1 | 1 | Carrier Start Thyratron-Gas | Type 2050 |
| V2 | 1 | Relay Thyratron-Gas | Type 2050 |
| V3 | 1 | Rectifier Doubler-Vacuum | Type 25Z6 |
| V4 | 1 | Relay Tube-Vacuum | Type 25L6 |
| | | TUBE SOCKETS | |
| X1-X4 | 4 | Octal Ceramic Tube Socket | E.F. Johnson Co. Cat. 228 (From Dwg. T7614215-1) |

ACCESSORY GROUP COMPONENTS

Note: Item 1 or 2 will be supplied with the HKB Control Unit for the appropriate application.

1. Accessory Group for 125 volts

   Style: 867955

   Electrical Parts - R23, R24 & tubes V1 to V4 of Component Parts List.

2. Accessory Group for 250 volts less external heater series resistor.

   Style: 867956

   Electrical Parts - R25 and tubes V1 to V4 of Component Parts List.

ORDERING INFORMATION

The Westinghouse Electric and Manufacturing Company is prepared to supply any of the listed parts for servicing this unit. Orders should specify that they are for the Type JY, HKB Control Unit, Style #867954, and mention the circuit symbol where it is given. All orders must specify the rating as well.

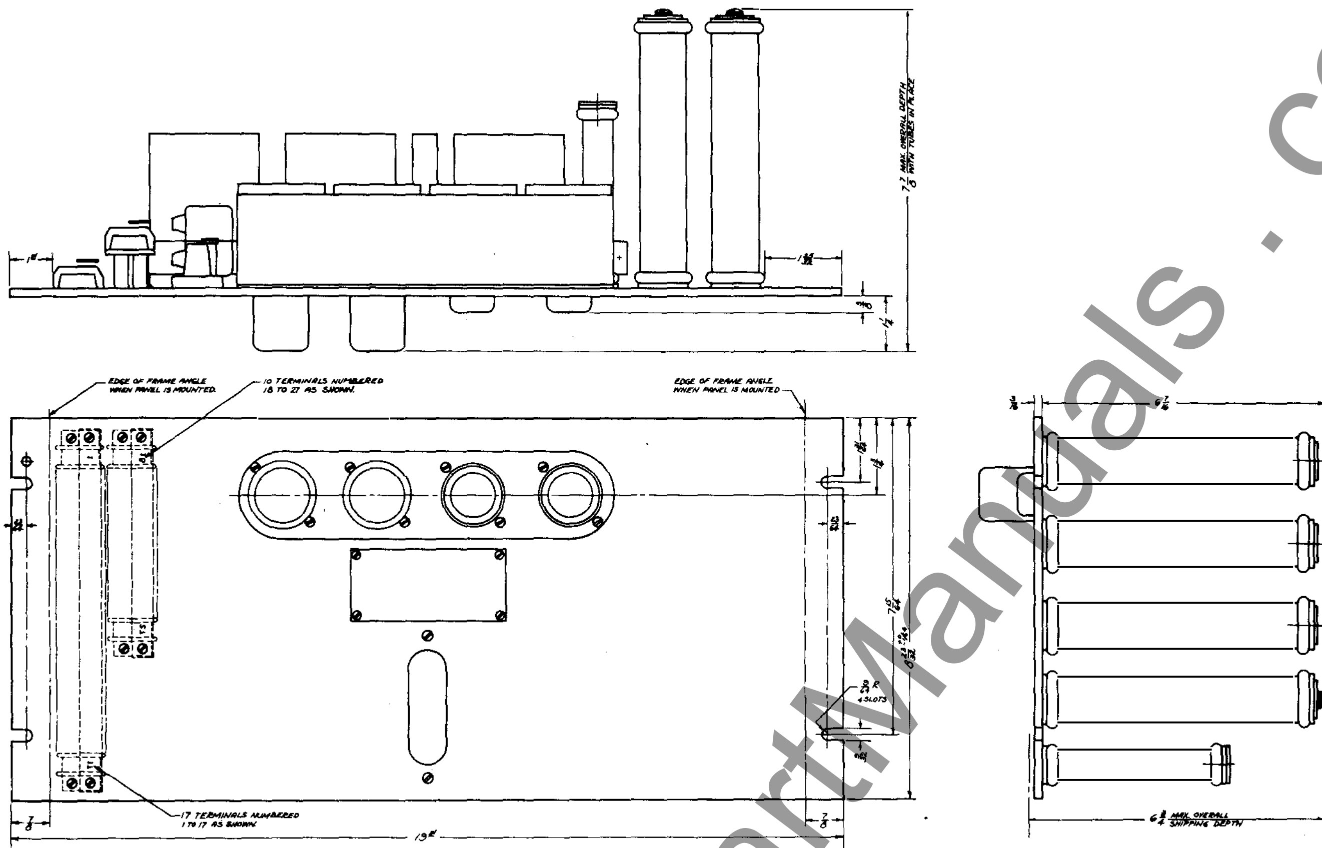



Figure 6
Outline & Mounting Plan of the Type HKB Control Unit.