INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE HKB RELAY AND TEST EQUIPMENT FOR TYPE TC CARRIER

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.

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.

The HKB is available with indicating contactor switches with either a 1 ampere or a 0.2/2.0 ampere rating. The 0.2/2.0 ampere rating is recommended where a lockout relay is energized or where a high impedance auxiliary tripping relay is utilized.

PART 1–TYPE HKB RELAY

CONSTRUCTION

The relay consists of a combination positive, negative and zero sequence network, a saturating auxiliary transformer, one diode rectifier assembly, two polar relay units a telephone-type relay, a Zener clipper, and an indicating contactor switch all mounted in an FT42 Flexitest case.

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 unit 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 Zener clipper connected across its secondary are used to limit the voltage impressed on the fault detectors (polar relay units) 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 unit. For further discussion, see section entitled, "Setting".

Rectifier Unit

The secondary of the saturating transformer feeds a bridge-connected diode unit, the output of which energizes the polar fault detector units. The use of sensitive polar relays keeps down the energy required from the current transformers.

Polar Units

These units consist of a rectangular shaped mag-

Supersedes I.L. 41-951.3A
*Denotes change from superseded issue

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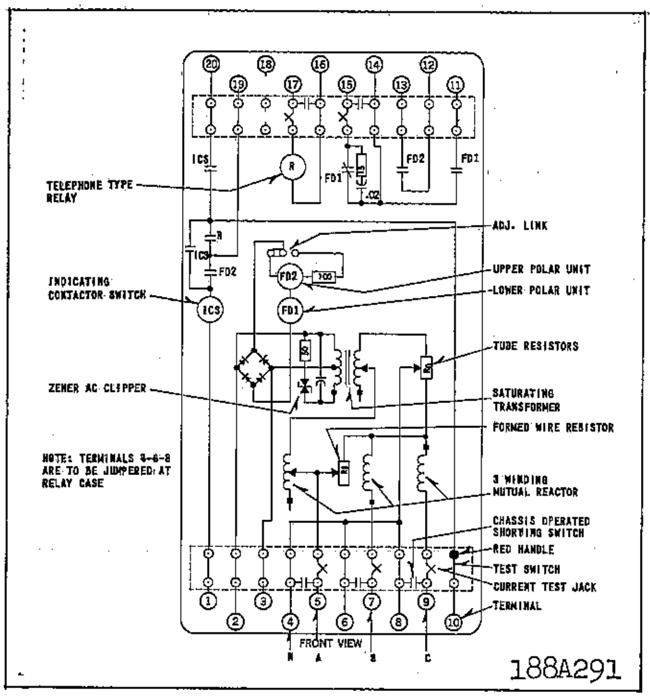


Fig. 1. Internal Schematic of the HKB Relay with 1.0 Ampere I.C.S. in the FT42 Case. (Relay with 0.2/2.0 Ampere I.C.S. Unit has identical wiring except that the I.C.S. Coil is tapped on terminal 1.)

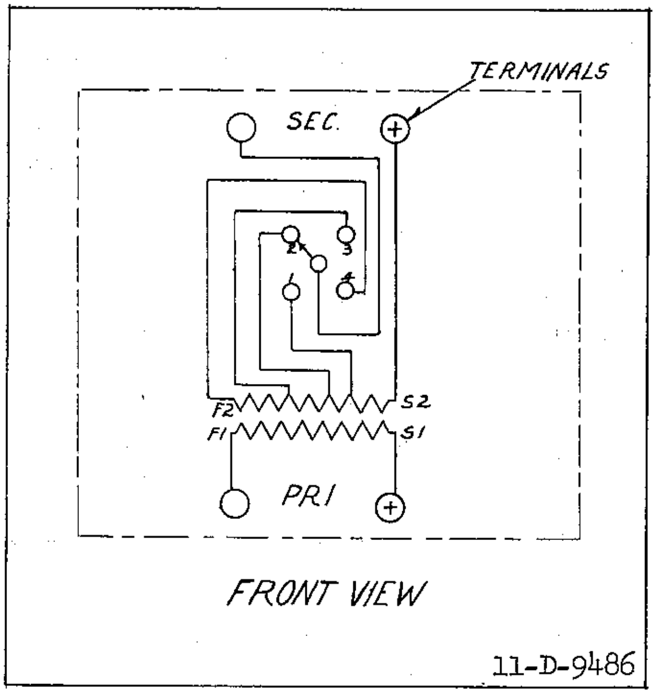


Fig. 2. Internal Schematic of the Type HKB Test Transformer.

netic 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 unit 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.

Indicating Contactor Switch Unit (ICS)

The d-c indicating contactor switch is a small clapper type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contacts, completing the trip circuit. Also during this operation two fingers on the armature deflect a spring located on the front of the switch, which allows the operation indicator target to drop. The target is reset from the outside of the case by a push rod located at the bottom of the cover.

The front spring, in addition to holding the target, provides restraint for the armature and thus controls the pickup value of the switch.

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. If they are of the correct phase position for an internal fault, after a 4-millisecond delay during the half cycle in which carrier is not transmitted, tripping will be initiated through operation of the flip-flop and trip amplifier circuits. Current transformer connections to the sequence networks at the two terminals are such that carrier is transmitted on the same half cycles from both terminals during an internal fault, thus allowing tripping during the half cycles that carrier is not transmitted. However, if the fault is external to the protected line section, carrier is transmitted on alternate half cycles from opposite terminals. Thus each terminal blocks the opposite terminal during the half cycle when it is attempting to trip.

The four-millisecond delay previously mentioned is added to allow for differences in current transformer performance at opposite line terminals, relay coordination, and momentary interruptions in carrier caused by arcing over of protective gaps in the tuning equipment.

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

CHARACTERISTICS

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 three phase amperes which will pick up the lower or carrier start fault detector (FD1). The upper polar unit (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 network arranged for positive, negative and zero sequence output, there are some applications where the maximum load current and minimum fault current are to 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 about 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.

Trip Circuit

The main contacts will safely close 30 amperes at 250 volts d-c and the seal-in contacts of the indicating contactor switch will safely carry this current long enough to trip a circuit breaker.

Trip Circuit Constant

Indicating Contactor Switch (ICS)

0.2 ampere tap 6.5 ohms d-c resistance
2.0 ampere tap 0.15 ohms d-c resistance
1.0 ampere tap 0.1 ohms d-c resistance

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 Tap Block		Fault Detector FD1 Pick Up Δ	
		Left Half	Right Half	3 ϕ Fault	ϕ - ϕ 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.

Δ 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.

† When taps A and 3, or B and 3 are used, the relay pickup currents for FD1 and FD2 will be 10 to 15 percent higher than the indicated values because of the variation in self-impedance of the sequence network and the saturating transformer.

Positive-Sequence Current Tap and FD2 Tap

The upper tap plate has value 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 the approximate ground fault sensitivities as listed in Table II. 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 network due to zero-sequence current is eliminated.

NOTE: Because of inherent characteristics of the sequence network, there will be small variations (from the values listed in Tables I and II) in the pickup current for various phase or ground fault combinations.

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

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

Minimum Phase-To-Phase Fault Currents:

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

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:

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

$$\left(1.25 = \frac{\text{FD2 pick up}}{\text{FD1 pick up}}\right)$$

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 (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 amper phase-to-phase fault, the fault detector tap must now be not more than:

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

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

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

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

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.

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

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.

Indicating Contactor Switch (ICS)

No setting is required for relays with a 1.0 ampere unit. For relays with a 0.2/2.0 ampere unit, connect the lead located in front of the tap block to the desired setting by means of the connecting screw. When the relay energizes a 125– or 250-volt d-c type WL relay switch, or equivalent, use the 0.2 ampere tap; for 48-volt d-c applications set the unit in a tap 2 and use a type WL relay with a S#304C209G01 coil, or equivalent.

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 four mounting holes on the flange for semi-flush mounting or by means of the rear mounting stud or studs for projection mounting. Either a mounting stud or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel panel mounting or to the terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the stud and then turning the proper nut with a wrench.

For detailed FT case information refer to I.L. 41-076.

ADJUSTMENT AND MAINTENANCE

CAUTION

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

2. All contacts should be periodically cleaned. A contact burnisher S#182A836H01 is recommended. The use of abrasive material is not recommended because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

3. 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 units is adjusted by means of two magnetic, screw-type shunts at the rear of the unit. 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 drop out current will be lower. In adjusting the polar units, 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.

Connect the panel link to the left-hand terminal. Set the relay taps on 5, C, and H.

A. Lower polar Unit (FD1) – Adjust the contact screws to obtain an .930" 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 .025", and the action of the armature should be snappy at the pickup and dropout points.

B. Upper Polar Unit (FD2) – Adjust the contact screws to obtain an .020" 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 Unit (Telephone Type Relay)

Adjust the contact gap to .0.014". 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 contact follow of a few thousands of an inch after the contact closes.

Apply d-c current in series with a d-c milliammeter (0-25 ma). to terminals 17 and 16. The relay should pick up at 6 to 8 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 3 to 4 ma. The contact spring tension can be changed, if necessary, to obtain these values.

Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient d-c current through the trip circuit to close the contacts of the ICS. This value of current should not be greater than the particular ICS tap setting being used. The indicator target should drop freely.

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	Phase A		Phase B		Phase C	
Taps	VA	Angle	VA	Angle	VA	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	Phase A		Phase B		Phase C	
Taps	VA	Angle	VA	Angle	VA	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 – HKB CONTROL UNIT (TC CARRIER)

The construction, operation, and adjustment of the Control Unit used with the HKB relay are covered in a separate instruction book identified as I.L. 41-944.5. The Control Unit is a part of the Type TC carrier assembly.

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 2 and 3 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.

The following 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 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 4 and 5 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 5 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 detectors and operating element at Station A should close their contacts. Completion of the trip circuitcan be checked by connecting a small lamp (not over 10 watts) across the terminals of test switch 10.

Now perform the above operations at the opposite end of the line section (station B) and momentarily open and reclose test switch 12. This simulates a phase-to-ground fault external to the protected line section. The fault detectors, but not the operating unit should operate. Test switch 12 operation is required to make sure that "flip flop" stage in the control unit is in reset position. Now open and reclose switch 12 at station A in order to reset "flip flop" stage from previous "trip" condition. The operating unit at station A should stay open now. Restore test switches 4 and 5 at Station A to normal (closed). The line conditions now represent a phase-to-ground fault fed from Station B only. The fault detectors at A should reset and the operating unit at B should pick up. Restore test switches 4 and 5 at Station B to normal, and all 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 6 and 7 for phase B, and switches 8 and 9 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 #10 test switch last) and the relay cover replace. The equipment is now ready to protect the line-section to which it is connected.

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-2 test switch is a four-position, three-stage switch. The contact arrangement is shown in Fig. 3, and the outline and drilling plan in Fig. 4. "Carrier On" contacts are used to complete the HKB trip circuit and the alarm circuit. These contacts are indicated in Fig. 3 by contacts C5-D5 and A1-B1. In the "Carrier Off" position, the HKB trip circuit is opened through contact C5-D5, but the alarm circuit remains closed through contact A1Z-B1Z. Two test positions to the left of the "Carrier Off" position 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 contacts A6-B6 and A7-B7. Moving the switch to the "Test 1" position will connect the output of the auxiliary test transformer directly to the HKB terminals number 8 and 9. Moving the switch to the "Test 2" position will connect the test transformer with a reversed polarity to the HKB relay.

Auxiliary Test Transformer

The auxiliary test transformer is designed to operate from a 120-volt, 60-cycle power source. Four secondary taps numbered 1, 2, 3, and 4 are provided to vary the magnitude of the test current, as follows:

Trans. Tap	Relay Tap	
	G	H
1	3 amp.	2 amp.
2	5	4
3	7.5	5.5
4	9.5	7

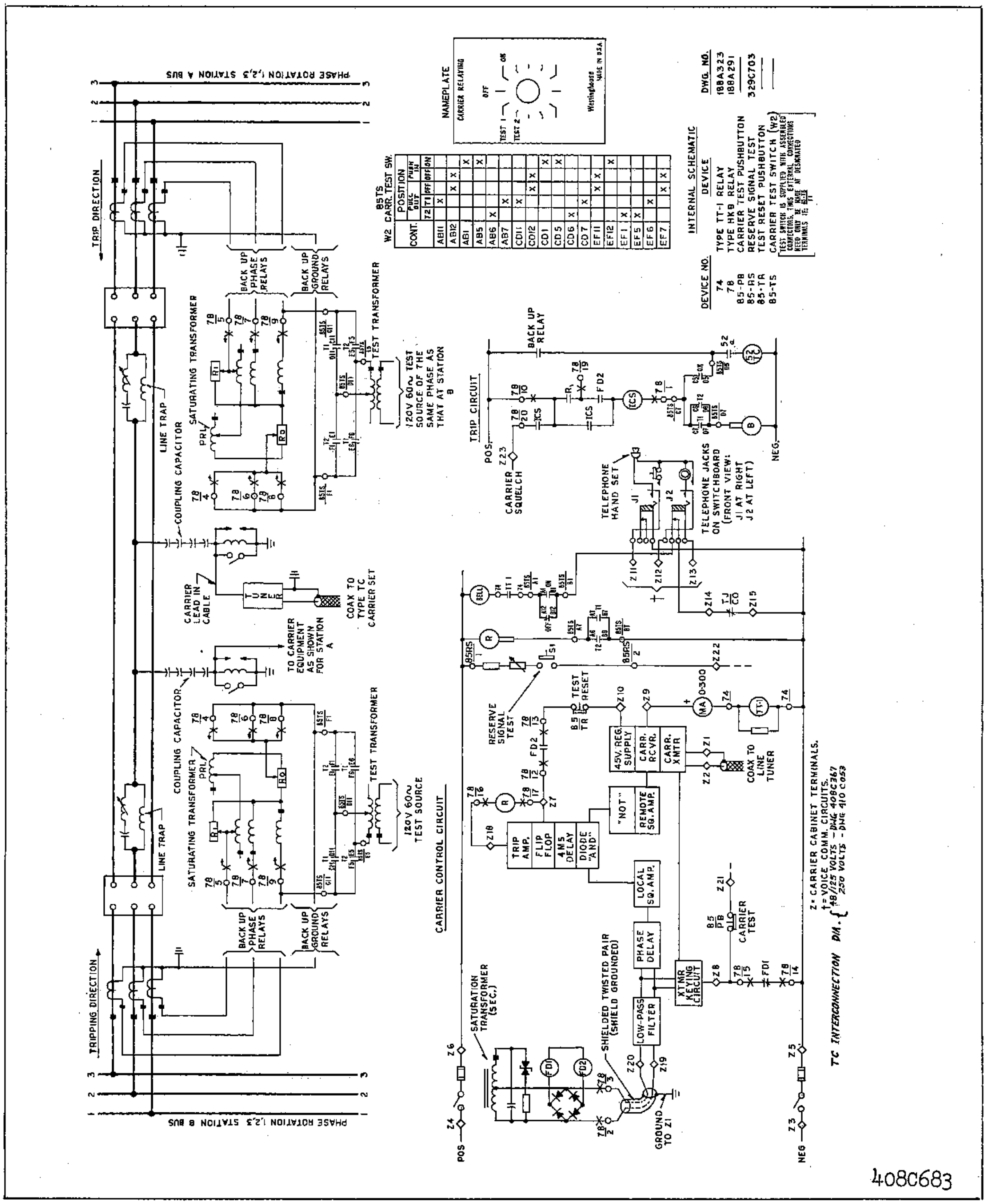
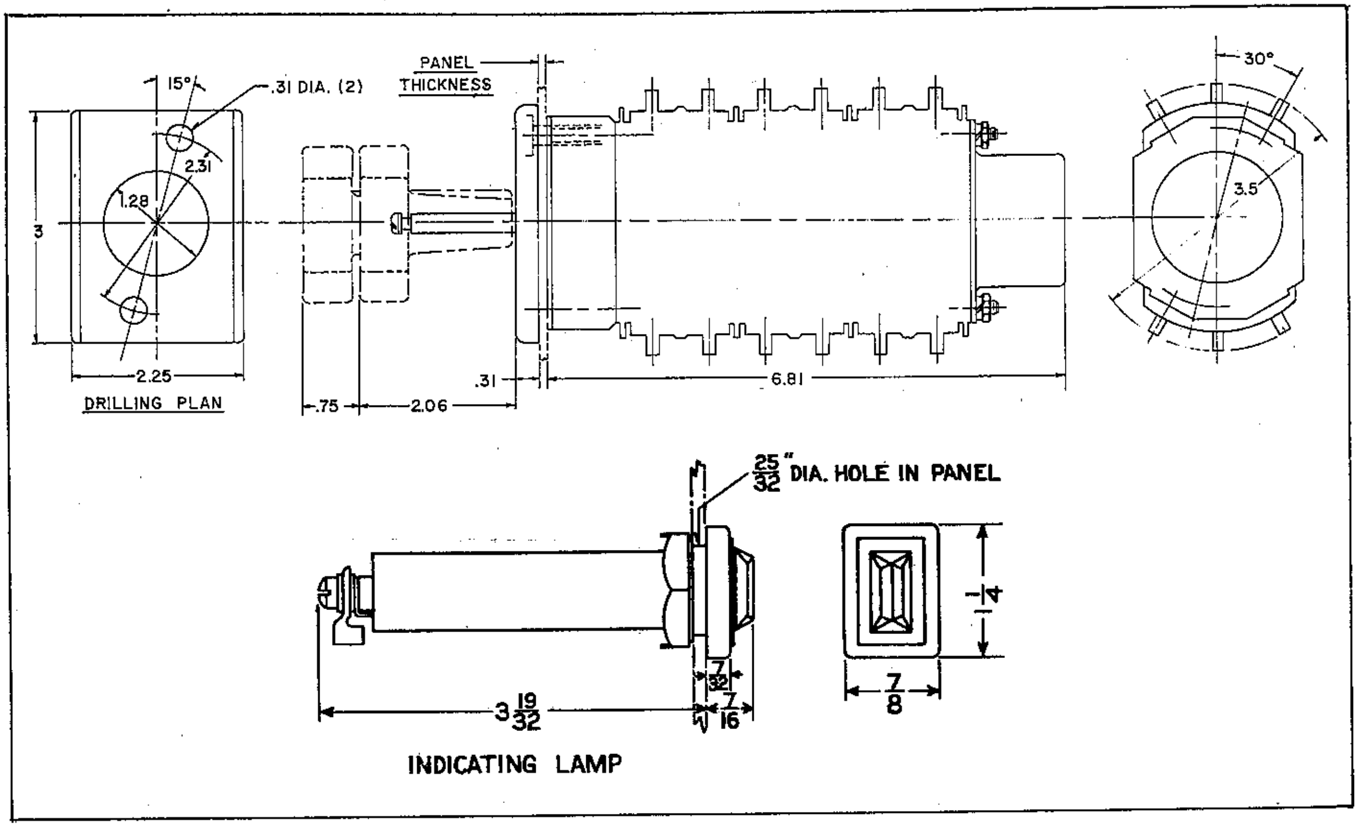


Fig. 3. External Schematic of the HKB Relay and Test Facilities, with TT-1 Alarm Relay.



* *Fig. 4. Outline and Drilling Plan of the Type W-2 Test Switch and Indicating Lamps Used for HKB Testing.*

The outline and drilling plan of the transformer is shown in Fig. 5.

Indicating Lamps

The red and blue indicating lamps are standard rectangular minalites. Outline and drilling dimensions are given in Fig. 4.

ADJUSTMENT

Choose a transformer tap that will provide approximately two times the phase-to-ground current setting of the FD-2 fault detector 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. 3 with the auxiliary test transformers energized from 120 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 Station A. The "A" 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 Station B to TEST 1. This will simulate an internal fault fed from both line terminals. The relay at Station B will trip, and the relay at Station A 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 Station A. The relay at Station A will reset and turn off the blue light. The relay at Station B will hold its trip contact closed, lighting the blue light.

5. Turn the HKB test switch at Station A to TEST 2. Depress Test Reset pushbutton momentarily to reset Flip-Flop stage that may have operated during switching the test switch to position 2. Operate Test Reset pushbutton at Station B to reset Flip-Flop stage from previous tripped position. Both blue lights should be off at this point, which represents an external fault.

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-2 Test Switch	S#505A742G01 for 1/8" panel mounting.
Type W-2 Test Switch	S#505A742G02 for 1-1/2'' panel mounting.

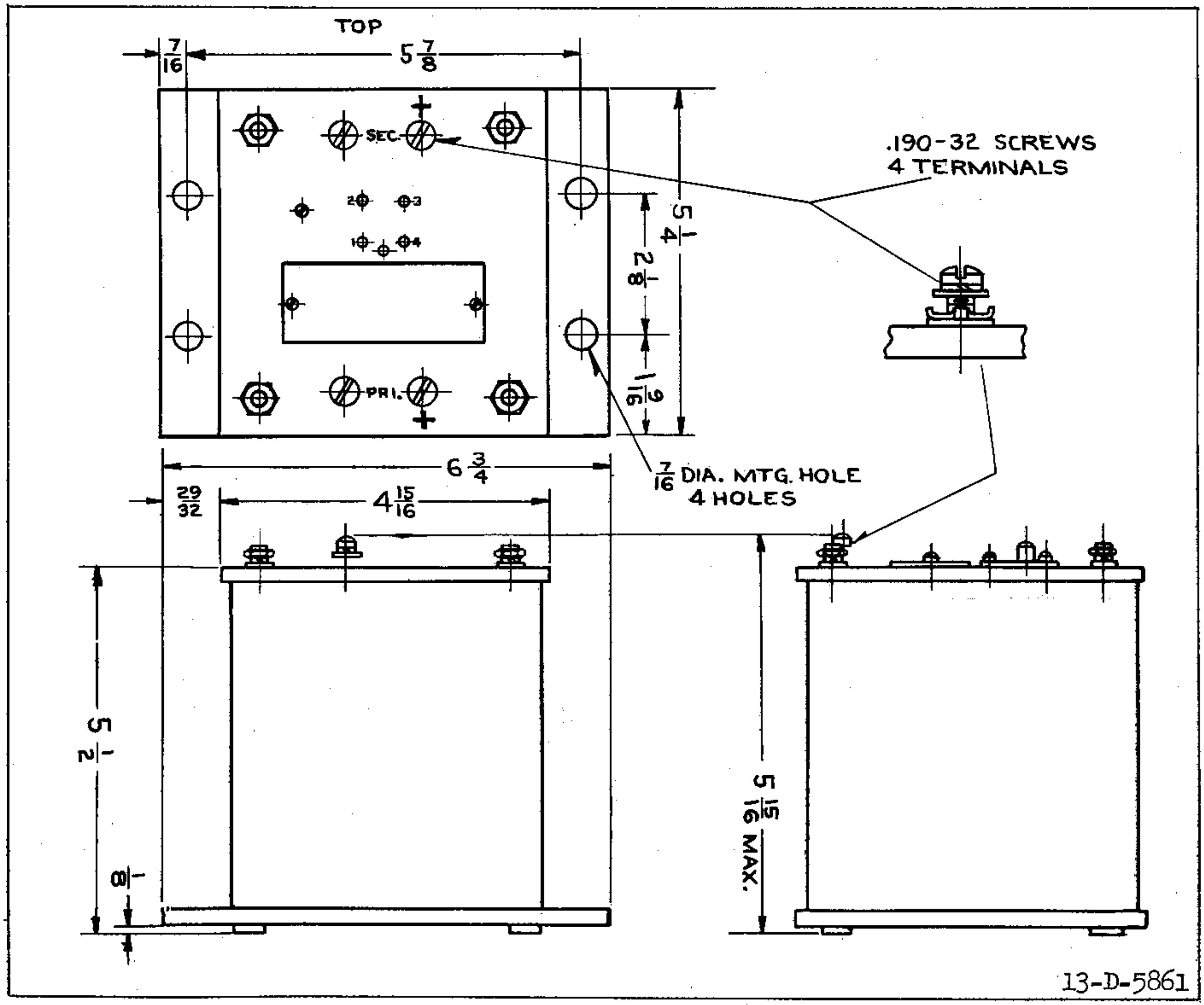


Fig. 5. Outline and Drilling Plan of the HKB Test Transformer.

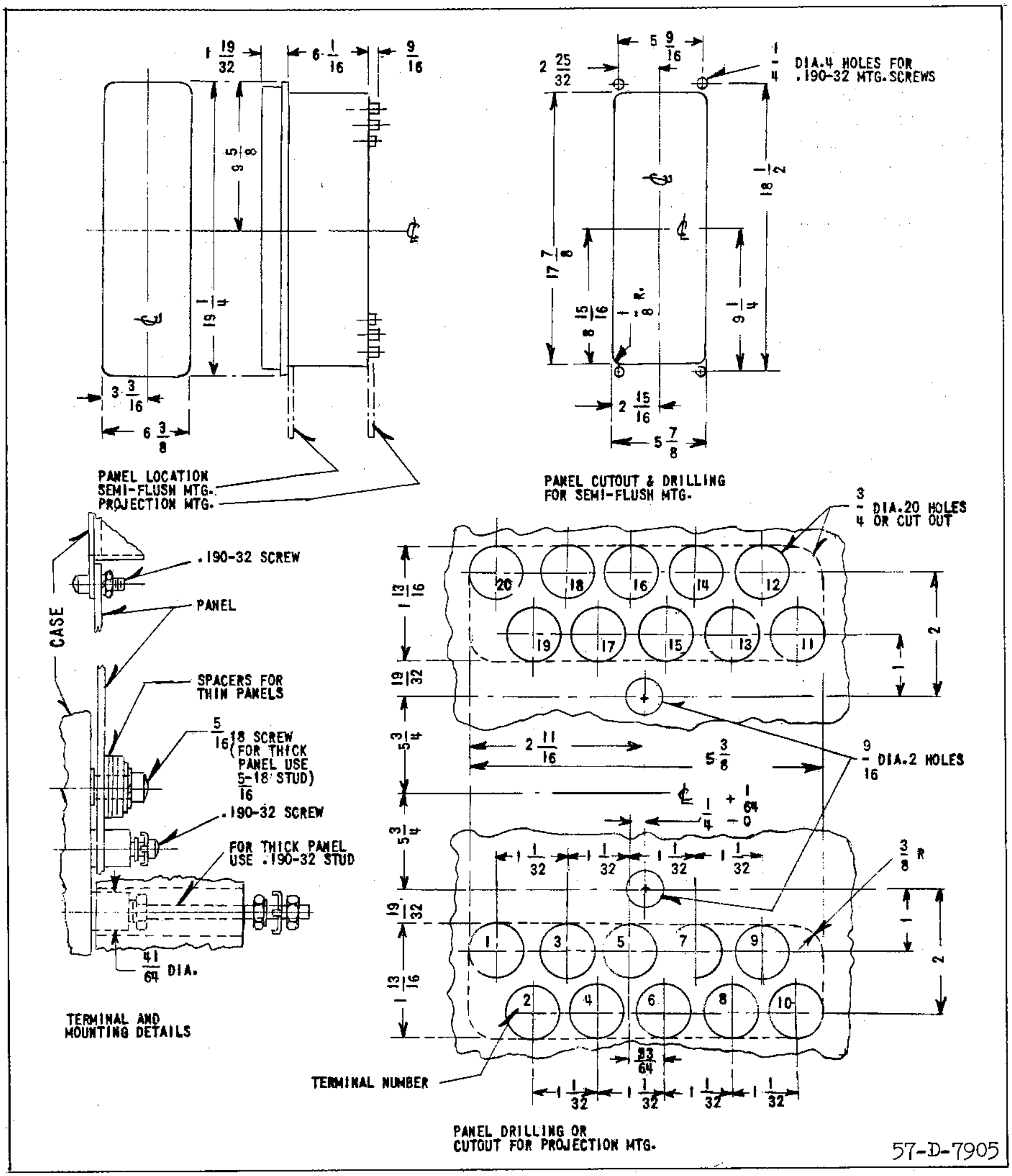


Fig. 6. Outline and Drilling Plan of the HKB Relay in the FT42 Case.