ABB Power T&D Company Inc.
Relay Divisions
Coral Springs, FL 33065

Type LC-1 and LC-2 Linear Coupler Relays

Effective: May 1975
Supersedes I.L. 41-342.1C, Dated September 1972
* Denotes Change Since Previous Issue.

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

LC-1 and LC-2 relays are used for bus differential protection in conjunction with Linear Couplers, which are "air core" mutual reactors.

The two relays can be used interchangeably for phase protection; depending upon required sensitivity. It is recommended that the LC-2 be used for phase protection where the relay current is less than 200MA. Where the relay current would otherwise be 50 to 200MA, a 19 ohm resistor S#185A272G21 is recommended across terminal 8 and 9 to reduce the relay current to a value within setting limits.

CONSTRUCTION

The LC-1 relay consists of an impedance matching auto-transformer, main solenoid operating unit, and an indicating contactor switch. The LC-2 relay consists of a two winding impedance matching transformer, a full wave diode bridge, dc polar unit, an indicating-contactor switch (ICS), and an auxiliary switch (VS).

Matching Transformer

Taps 30, 40, 60 and 80 are provided to approximately match the relay and linear coupler impedance.

Main Operating Unit (LC1)

The main unit of the LC-1 relay is a small solenoid switch with a scale calibrated in decimal parts of an inch. This scale refers to the amount of free contact travel. 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.

Main Operating Unit (LC2)

The main unit of the LC-2 is a dc polar unit, fed from full wave rectifiers. It consists of a rectanglar shaped magnetic frame, an electromagnet, a permanent magnet, and an armature. The poles of the crescent shaped permanent magnet bridge the magnetic frame. The frame consists of three pieces joined in the rear with two brass rods and silver solder. These non-magnetic joints are bridged by two adjustable magnetic shunts which are held in position by means of a spring type clamp. The relay coil is wound around the center core. To this core is attached the armature and contact assembly.

Auxiliary Switch (VS)

This is a small D.C. Voltage operated clapper type switch used to minimize the possibility of shock tripping.

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,

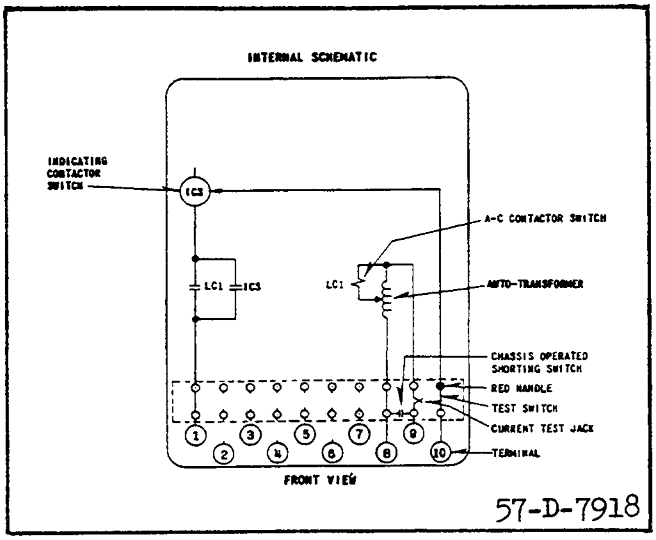


Fig. 1. Internal Schematic of the Type LC-1 Relay in the FT11 Case.

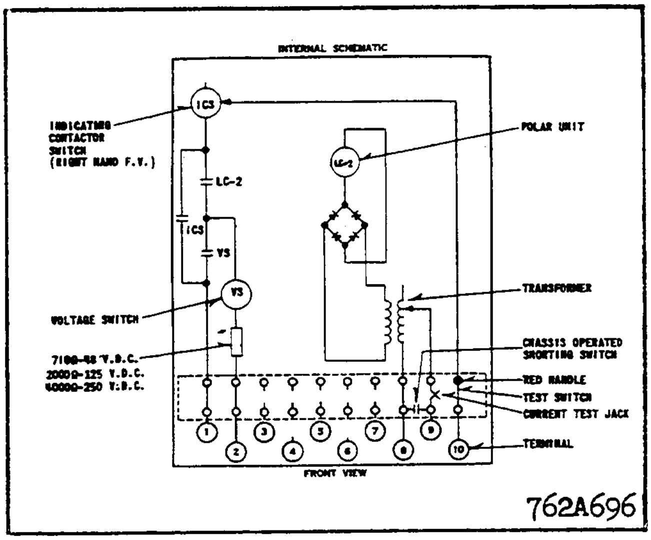


Fig. 2. Internal Schematic of the Type LC-2 Relay in the FT11 Case.

provides restraint for the armature and thus controls the pickup value of the switch.

OPERATION

As shown in figure 3, Linear Coupler protection is a series voltage differential system. Linear Couplers must be connected in series, rather than in parallel like current transformers, because the Linear Couplers have a very low magnetizing impedance as a result of the absence of iron. Because their magnetizing impedance is low, the Linear Coupler secondary can be safely open-circuited.

For external faults, the voltages induced in the linear couplers by currents entering the bus are balanced out by the voltage induced in the linear coupler in the faulted circuit, where the fault current leaves the bus. For the internal fault condition, current entering the bus induces a voltage in the linear coupler circuit. This voltage is not balanced out, since the fault current leaves the faulted phase through a path containing no linear couplers. Thus, a net voltage is induced in the secondary circuit to cause relay operation.

In the LC-2 tripping is effected by VS unit which is energized by the main unit. The VS is used to prevent tripping, if the main unit is momentarily jarred closed.

CHARACTERISTICS

Since Linear Couplers are manufactured to a tolerance of ±1%, application is restricted to those cases where the ratio of maximum external fault current to a minimum internal fault current is 50 to 1. However, the practice has been to apply a 2 to 1 safety factor which reduces the permissable ratio to 25 to 1. An exception to this restriction is where the minimum current occurs for a ground fault. In this case grounds can be cleared with a separate LC-2 relay or relays, in conjunction with an HVS relay.

Characteristic curves are shown in figures 4, 5 and 6. The use of these curves is described under "Setting Calculations". LC-1 sensitivity is about 0.5 V.A. and up. The type LC-2 relay may be set to operate at an energy level ranging from .062 to .0085 volt-amperes. It may also be used to an energy level as low as .0025 V.A. with limitations which will be discussed. This range of application is shown on the typical volt-ampere curves of Fig. 5. Typical impedance curves are shown in Fig. 6. The phase angle of the relay is substantially constant (within 3°) at 22°.

As indicated in Figs. 7, 8 and 9, the four conductor cables used to connect the linear couplers and the relay in series should be transposed with respect to all other circuits. This may be accomplished by using a control cable with a spiral lay to the conductors. The cable may then be placed in the same duct run with other circuits, but there should not be other circuits in the same cable. For example, do not use four conductors of a six conductor cable, even though it has spiral lay, when the two remaining conductors are to be used for some other service.

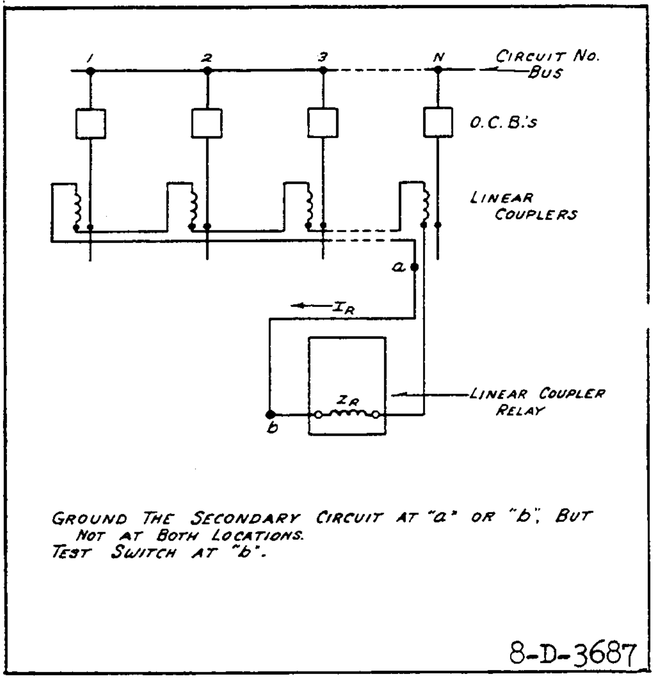


Fig. 3. Simplified External Schematic for Linear Coupler Bus Protection.

Operating Time

LC-1 One cycle or less above 150% of pickup current.

LC-2 1¼ to 1¾ cycles, including ¾ cycle time for VS.

Trip Curcuit

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.

The indicating contactor switch has two taps that provide 2 pickup setting of 0.2 or 2 amperes. To change taps requires connecting the lead located in front of the tap block to the desired setting by means of a screw connection.

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

SETTING CALCULATIONS

The following fundamental equations apply referring to Fig. 3:

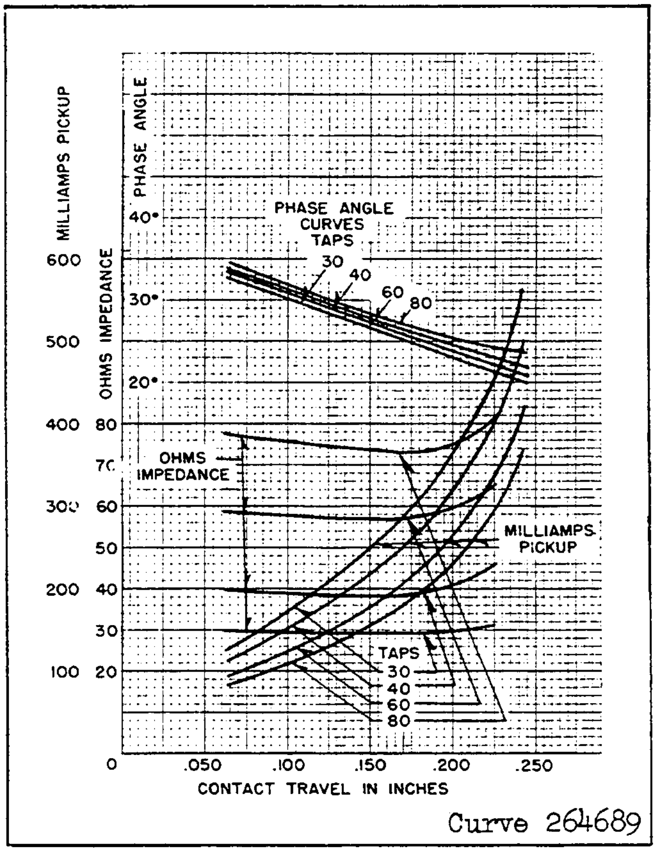


Fig. 4. Typical LC-1 Characteristic Curves.

$$E = I_pM \qquad (1)$$

$$I_r = \frac{E}{Z_s} \qquad (2)$$

$$I_r = \frac{I_pM}{Z_s} = \frac{I_pM}{NZ_c + Z_r} \qquad (3)$$

$$I_p = \frac{I_r Z_s}{M} = \frac{I_r(NZ_c + Z_r)}{M} \qquad (4)$$

where:

E = Voltage induced in linear coupler secondary

I_p = Primary current in linear coupler

M = Mutual inpedance of linear coupler = .005 ohm for 60 cycles.

I_r = Relay current

Z_s = Impedance of Secondary Circuit

N = Number of secondary circuit = Number of linear coupler secondaries in series per phase.

Z_c = Self-impedance of linear coupler secondary.

Z_r = Relay impedance.

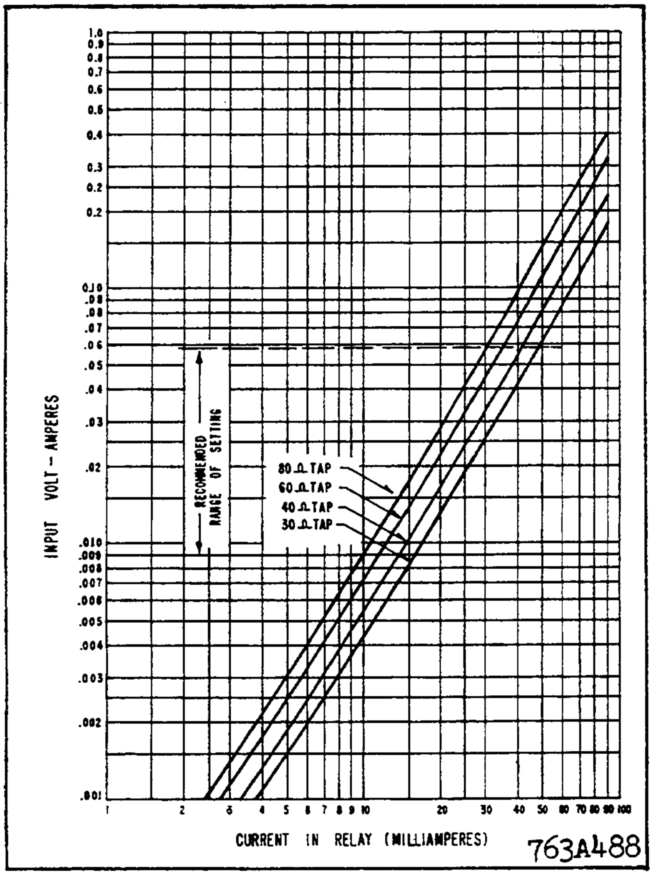


Fig. 5. Typical LC-2 Volt-ampere Curve.

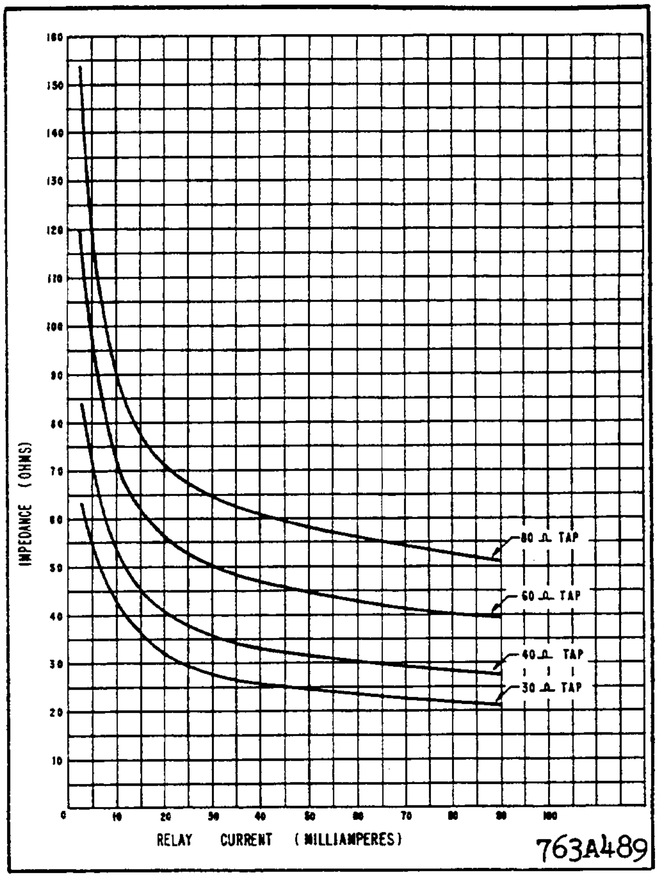


Fig. 6. Typical LC-2 Impedance Curve (Impedance is at 22° angle).

Equation (3) is used to determine the current at which the relay trips for an internal fault on the bus of magnitude, I_p. Equation (4) is used to determine the primary current necessary to trip the relay when it has been adjusted to trip at a known value of relay current. It should be noted, however, that the relay impedance is not constant, but varies with relay current as indicated in Figs. 4 and 6. Therefore, in using equation (3), it is desirable to assume a value of relay impedance equal to the impedance tap, and make a first calculation of the relay current. When this is obtained, a new value of relay impedance should be selected from Fig. 4 or 6 and a second value of relay current calculated. Usually, it will not be necessary to continue the calculation any further, as the values resulting from the second calculation will be sufficiently accurate.

LC-1 Relay Example

Assume a 6 circuit bus, for which the Linear Couplers have a self impedance of $Z_c = 3.7 + j8.9 = 9.64\underline{/67.4°}$. Three type LC-1 relays are used, one per phase, to obtain phase and ground fault protection. The maximum external fault current is 60,000 amperes rms symmetrical. It is desired to set the relays to trip on a minimum internal fault of 5000 amperes. However, since the Linear Couplers and Relays will operate over a 25/1 range with 2 to 1 factor of safety, the relays may as well be set for 2400 amperes, which is 1/25 of 60,000.

The self impedance of the linear coupler secondaries is determined first, as follows:

$$NZ_c = 6\,(3.7 + j8.9) = 22.2 + j53.4 = 57.8\ \underline{/67.4°}$$

For any given primary current, the relay receives maximum energy when its impedance Z_r, is made equal to NZ_c. This feature is utilized by matching Z_r and NZ_c as closely as possible in those cases where it is desirable to obtain the lowest possible minimum tripping current. In other cases, the relay impedance, Z_r and the total Linear Coupler self impedance NZ_c, may be deliberately mismatched in order to extend the range of adjustment to a higher current value. In this example, a first trial calculation will be made on an approximate basis by assuming that the relay impedance is 60 ohms (60 ohm tap) and that this adds arithmetically to the 57.8 ohms of the Couplers (leads being neglected).

$$Z_S = 57.8 + 60 = 117.8 \text{ ohm approximately}$$

$$E = I_pM = 2400 \times .005 = 12.0 \text{ volts}$$

$$I_r = \frac{E}{Z_S} = \frac{12.0}{117.8} = .102 \text{ ampere, approximately}$$

Reference to Figure 4 indicates that the relay can be set to operate at .102 (or 0.100 ampere on either the 60 ohm or 80 ohm tap. Since the desired value is near the minimum obtainable, choose the 60 ohm tap as being the closest match to the value of 57.8 for NZ_C, and make a second more accurate calibration. Using the 60 ohm tap and a contact travel of .075", values read from the curve give a pick up current $I_r = 0.100$: $Z_r = 58.3$ ohms, and an impedance angle of 33° for Z_r.

$$Z_r = 58.3\angle 33° = 48.9 + j31.75$$

$$NZ_C = 57.8\angle 67.4° = 22.2 + j53.4$$

$$Z_r + NZ_C \quad 71.1 + j85.15 = 111\angle 50.1°$$

From Eq. (2), $I_r = \frac{E}{Z_S} = \frac{12.0}{111} = .1081$ ampere

This current is higher than the original assumed current because the calculations were more accurately made, taking into consideration the vector addition of Z_r and NZ. Changing the contact travel to .080" to obtain the pickup current, $I_r = .107$, makes an inconsequential change in the relay ohms, $Z_r = 59$, and a change of approximately 0.5 in the phase angle of the relay impedance. Another trial calculation is therefore unnecessary from a practical standpoint.

LC-2 Relay Example

Assume a six circuit bus has linear couplers with a self-impedance of $Z_C = 3.7 + j8.9 = 9.64\angle 67.4°$. Three type LC-2 relays are used, one per phase, to obtain phase and ground fault protection. The maximum external fault current is 12,000 amperes rms symmetrical. Since the linear couplers and relays will operate over a 25/1 range with a 2 to 1 factor of safety, the relays may be set for 480 amperes, which is 1/25 of 12,000.

The relay operates with maximum energy when its impedance equals the impedance of the linear coupler * circuit, $NZ_C=6(3.7 + j8.9)=22.2 + j53.4=57.8\angle 67.4°$. Therefore, choose a tap setting, $Z_r=60$, for the relay, which is an approximate match. Since the phase angle of Z_r is substantially constant (within 3°) at 22°, $Z_r=60\angle 22°=55.6 + j22.5$.

$$NZ_C = 22.2 + j53.4$$

$$Z_r = 55.6 + j22.5$$

$$Z_S = 77.8 + j75.9 = 108.8 \text{ ohms}$$

$$I_pM = 480 \times .005 = 2.4 \text{ volts}$$

From equation (3)

$$I_r = \frac{I_pM}{Z_S} = \frac{2.4}{108.8} = .0221 \text{ amperes}$$

This is within the recommended setting range of the relay as indicated in Fig. 5.

From Fig. 6, on the 60 ohm tap, at $I_r = .0221$ $Z_r = 54.5\angle 22° = 50.6 + j20.4$.

This new value of Z_r should be used in equation (3).

$$NZ_C = 22.2 + j53.4$$

$$Z_r = 50.6 + j20.4$$

$$Z_S = 72.8 + j73.8 = 103.6 \text{ ohms}$$

$$I_r = \frac{I_pM}{Z_S} = \frac{2.4}{103.6} = .0232 \text{ amperes}$$

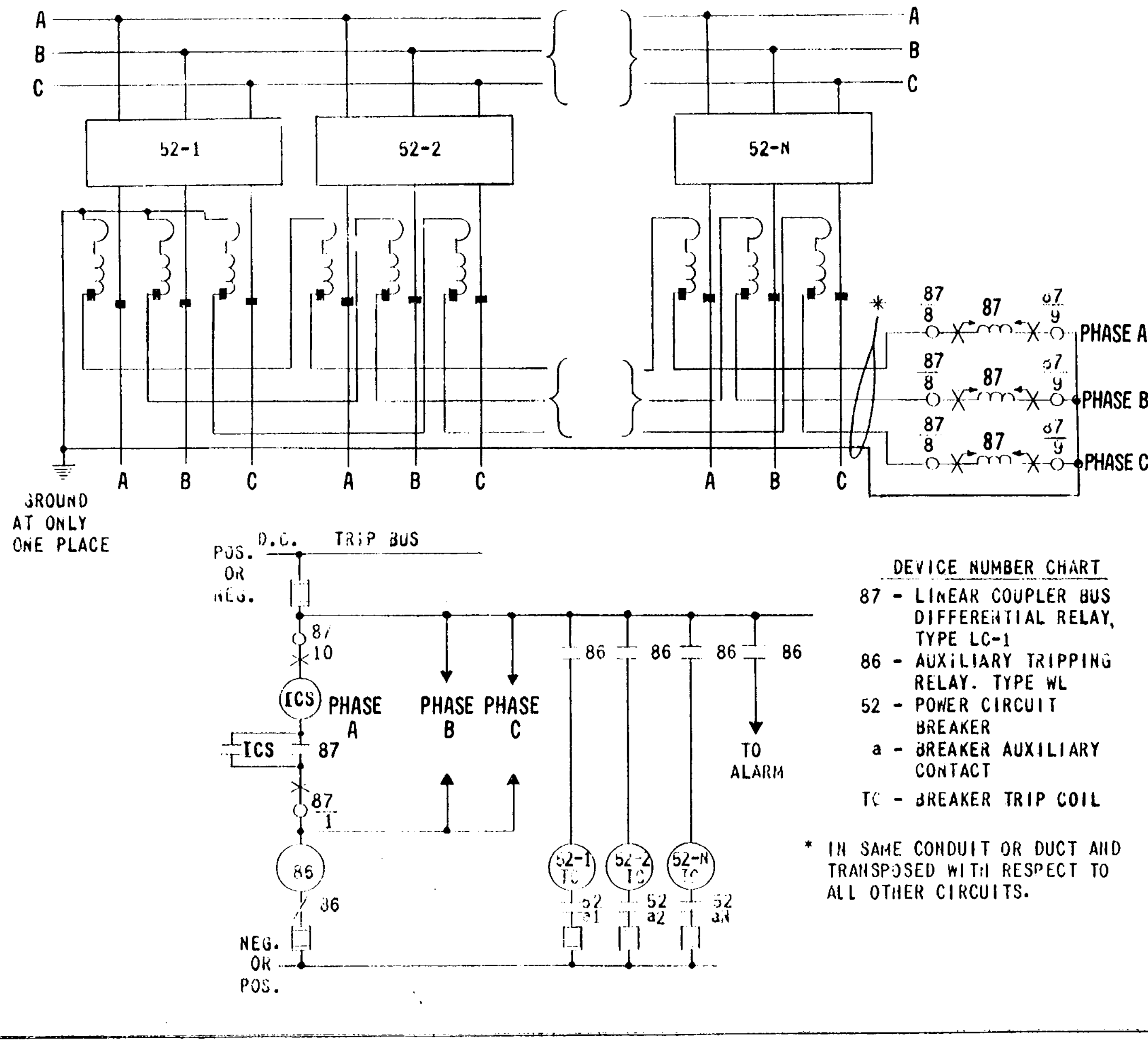
At $I_r = .0232$ on the 60 ohm tap, Fig. 6 indicates that $Z_r = 54$ ohms. Since a value of $Z_r = 54.5$ was used in the above calculation, it is not necessary to carry the calculation any further.

The relay should be adjusted to trip at I = .0232 amperes on the 60 ohm tap using the magnetic shunts at the rear of the polar element assembly.

SETTING THE RELAY

LC-1 Relay

Set transformer tap and main unit contact travel. Loosen the nuts on the bottom of the assembly and screw the Micarta disc to the desired position as indicated on the scale plate.



* Fig. 7. External Schematic of the Type LC-1 Relay in the FT11 Case.

* LC-2 Relay

Set transformer tap and adjust main unit magnetic shunts for required pickup current as described below with the relay in the case.

The sensitivity of the polar unit is adjusted by means of two screw type magnetic shunts at the rear of the assembly. Looking at the relay front view, drawing out the left-hand shunt increases the amount of current required to close the relay contacts. Conversely, drawing out the right-hand shunt decreases the amount of current required to trip the relay. The shunts are held securely in position by means of a spring type clamp.

There is a residual magnetism effect in this relay unit amounting to approximately .001 ampere on the 80 ohm tap. For this reason it is desirable to calibrate the relay after first applying a polarizing current to it. For example, the relay would be adjusted to trip at .010 ampere on the 80 ohm tap, and would then be momentarily subjected to a current of .250 ampere, which is 25 times minimum pickup. The minimum trip current would then be checked and the relay readjusted to trip at .010 ampere. After another momentarily applied polarization of .250 ampere the minimum trip would be rechecked. This process would be repeated back and forth until there were no change in the minimum trip current of .010 ampere after polarization. This manner of calibration is especially important at the low values of minimum trip currents, since the same residual magnetism effect of approximately .001 ampere would amount to a 20 percent change in the minimum trip setting if the relay were set for 5 milliamperes on the 80 ohm tap. It is for this reason that the lower limit of the recommended range of settings has been shown at .010 ampere for tap 80. The limit for the other taps is at the same value of voltamperes. On the other taps, the residual magnetism effect is equal to

$$.001 \sqrt{\frac{80}{T}} \text{ where } T = \text{ohms tap value.}$$

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.

ADJUSTMENTS AND MAINTENANCE

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.

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

Acceptance Tests

The following tests are recommended when the relay is received from the factory. If the relay does not perform as specified below, it either is not properly calibrated or it contains a defect.

LC-1 Main Unit

Set for 0.062 inch contact travel and 30 ohm tap. Apply 60 cycle voltage to terminals 8 and 9 and measure the I_{89} current required to operate the main unit. $I_{89} = 130 \pm 5\%$ ma.

LC-2

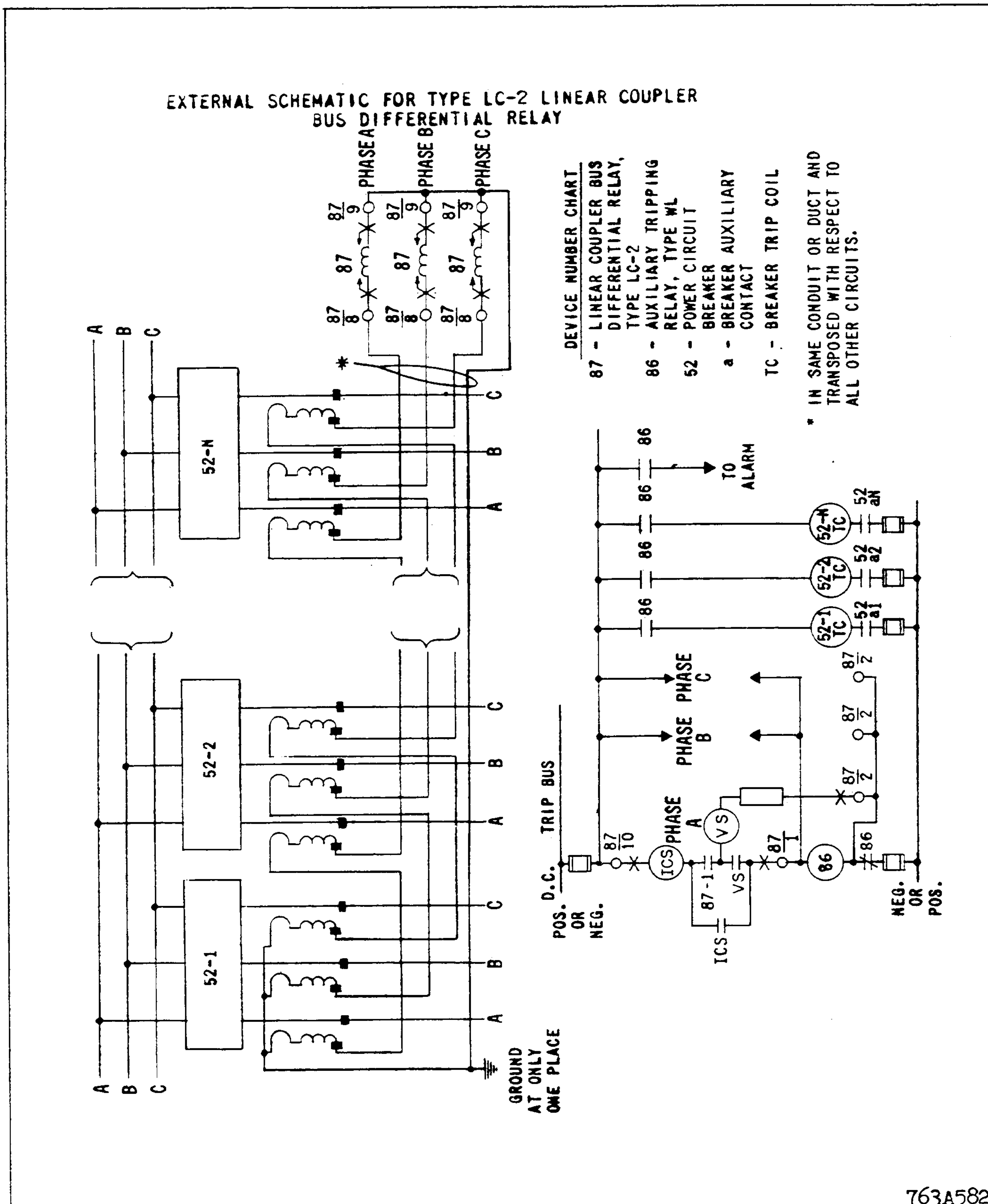
Set in 30 ohm tap and apply 2 volts, 60 cycles to terminals 8 and 9. The main unit should operate. Apply 70% rated dc voltage on terminals 10 and 2. Close the main unit contact. VS should operate.

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.

Installation Test

At the time of the initial installation, the polarity



* *Fig. 8. External Schematic of the Type LC-2 Relay in the FT21 Case.*

of the connections should be checked. This can be done by circulating a high current from a low voltage high current test set through the Linear Coupler primaries. The polarity can be checked by testing the Linear Couplers in pairs. For example, if 500 amps. is passed from feeder to bus in circuit number 1 (figure 4) and from bus to feeder in circuit number 2, then no voltage should be measured by a suitable low reading voltmeter temporarily connected in series with the Relay-Coupler Circuit. If, however, a reading of 5 volts is obtained (500 x .005 x 2), it is an indication that one of the Coupler secondaries is reversed. If a zero reading is obtained, this checks the Couplers of circuits number 1 and 2 against each other. Circuit 2 should then be checked against circuit 3, circuit 3 against circuit 4, and so on until all circuits are checked. This should be done for each phase. A high resistance voltmeter should be used, preferably one having a resistance of 1000 ohms per volt, or more. A similar check may be made using load currents in the circuit if these are high enough to give a satisfactory voltage indication.

Permanent Test Facilities

As shown in Fig. 9, the linear coupler differential circuit can be provided with a test scheme to check the bus differential circuit for major defects while the bus is carrying load current. Defects such as short circuited linear coupler transformers, ground faults and open circuits in the secondary loop, wrong polarity or phasing connections to the linear couplers, and severe steady state stray voltage effects from foreign sources can be revealed by the scheme. The equipment used in the test scheme includes three high resistance Rectox type voltmeters, a one-half ohm resistor, a test transformer, and a test switch with three positions. NORMAL DIFFERENTIAL-OFF-SERIES.

When the test switch is in the NORMAL DIFFERENTIAL position, a voltmeter is connected across each phase relay. On an unfaulted secondary circuit the voltmeters measure the differential voltage induced in the linear coupler secondary by load current in the bus. Due to the tolerance of the linear couplers, the induced voltage may be some low value other than zero. Hence, for each installation, a maximum normal differential load voltage should be determined and recorded.

In the SERIES position, the test switch not only connects the volt-meters across the phase relays, but also applies a low voltage across a one-half ohm resistor in the neutral of the differential secondary circuit. On an unfaulted secondary circuit, the volt-meters read more than the normal differential reading or approximately half of the applied test voltage. While the applied test voltage is not large enough to operate the relays during load current flow, it may reduce the safety factor for relay tripping on external faults. Hence, a contact of the test switch should open the relay's trip circuit. If the trip circuit is not opened by this contact, the series test should not be used if the normal differential voltage is higher than marked.

The periodic test procedure is to turn the test switch first to NORMAL DIFFERENTIAL. This connects the voltmeters across the relays to measure the differential voltages due to load currents. If a voltmeter reads higher than the marked maximum normal differential voltage, it indicates a major defect such as a short circuited linear coupler or a wrong connection in the differential circuit. Since these defects can cause relay tripping on external faults, the relay, or relays, associated with the high voltage should be removed from service until the defect is corrected. If the voltmeter reads zero, it may be an indication of an open circuit in the secondary differential circuit. This should be checked by using the series test.

The next step is to turn the test switch to SERIES. If any voltmeter reads zero, it indicates an open circuit in the coupler portion of the circuit. If the voltmeter reads full scale, it indicates an open circuit in the relay winding.

Routine Maintenance

Check sensitivity by applying a voltage across test switch contact 9 and 10 or equivalent. With switch in "Series Test" position, (See figure 9) the applied voltage should equal 0.005 I_p, where I_p is the primary current at desired pickup point. The relays should operate. Where a portable voltmeter is used, a 5000 ohm per volt, sensitivity is recommended.

Calibration

If the factory calibration has been disturbed, the following adjustments may be required.

LC-1 Relay

The small a-c solenoid switch has adjustments for pick-up and drop-out. The pick-up characteristics may be checked against Figure 4 which is a typical curve. This check should not be made, however, until the proper drop-out, or "contact follow" adjustments, has been made. To do this, connect the relay on 30 tap, and pass 130 ma 60 cycles in terminals 8 and 9. See that the plunger is picked up. Loosen the locknut at the top of the assembly, and move the core screw up and down by means of a screw driver. It will be observed that as the core screw is raised, the plunger will try to rise higher until a point is reached where the pull of the helical spring is greater than the magnetic pull, at which point the plunger will drop down part way, although not necessarily opening the contacts. This action can be observed best by looking at the shoulder on the plunger just above the silver disc assembly. The core screw should be adjusted so that the plunger rises the maximum amount, at the minimum current given above and the lock nut tightened to secure this adjustment. This gives the maximum deflection on the helical spring and thus maximum contact pressure.

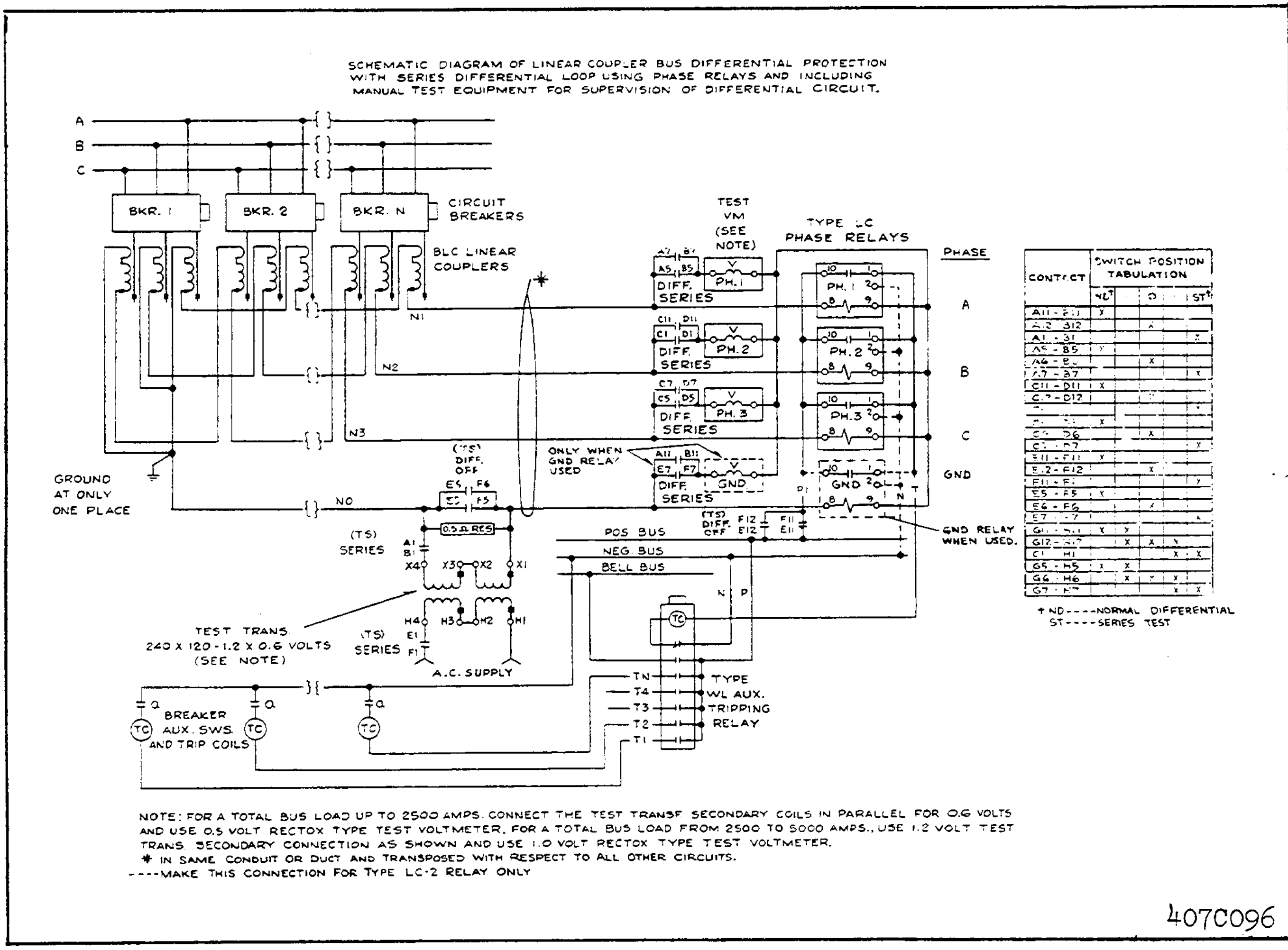
LC-2 Relay

1. Contacts

Allow the armature rivet to strike the right hand pole face and bring up the stationary contact screw until the contact circuit just makes. Give the stationary contact screw an additional one-half to one turn before locking it in place with the lock nut provided. With the contacts in the closed position, bring up the backstop screw until it just touches the moving contact. Then back off one turn and lock in place.

2. Minimum Trip Current

The sensitivity of the polar unit is adjusted by means of two screw type magnetic shunts at the rear of the assembly. Looking at the relay front view, drawing out the left-hand shunt increases the amount of current required to close the relay contacts. Conversely, drawing out the right-hand shunt decreases the amount of current required to trip the relay. It will usually be possible to set the relay to the desired tripping value by leaving the right-hand shunt at the extreme "in" position and make all the adjustments with left-hand shunt. The shunts are held securely in
* position by means of a spring type clamp. Calibrate relay in the case.



* *Fig. 9. Schematic of Permanent Test Facilities for Linear Coupler System.*

There is a residual magnetism effect in this relay unit amounting to approximately .001 ampere on the 80 ohm tap. For this reason it is desirable to calibrate the relay after first applying a polarizing current to it. For example, the relay would be adjusted to trip at .010 ampere on the 80 ohm tap, and would then be momentarily subjected to a current of .250 ampere, which is 25 times minimum pickup. The minimum trip current would then be checked and the relay adjusted to trip at .010 ampere. After another momentarily applied polarization of .250 ampere the minimum trip would be rechecked. This process would be repeated back and forth until there were no change in the minimum trip current of .010 ampere after polarization. This manner of calibration is especially important at the low values of minimum trip currents, since the same residual magnetism effect of approximately .001 ampere would amount to a 20 percent change in the minimum trip setting if the relay were set for 5 milliamperes on the 80 ohm tap. It is for this reason that the lower limit of the recommended range of settings has been shown at .010 ampere for tap 80. The limit for the other taps is at the same value of voltamperes. It is possible, however, to set the relay down to an energy level of .0025 voltamperes as indicated on curve of Fig. 5. On the other taps, the residual magnetism effect is equal to

$$.001\sqrt{\frac{80}{T}}$$ where T = ohms tap value.

3. Auxiliary Switch (VS)

The auxiliary switch (VS) should have a contact gap 0.047 $\pm\frac{0.0}{.016}$ inch between the bridging contact and the adjustable stationary contacts. The moving contacts should touch both stationary contacts simultaneously.

The unit should pick-up with 60% of rated voltage applied to the series connected switch and resistor.

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 be not greater than the particular ICS tap setting being used. The operation indicator target should drop freely.

The contact gap should be approximately .047" between the bridging moving contacts and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

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.

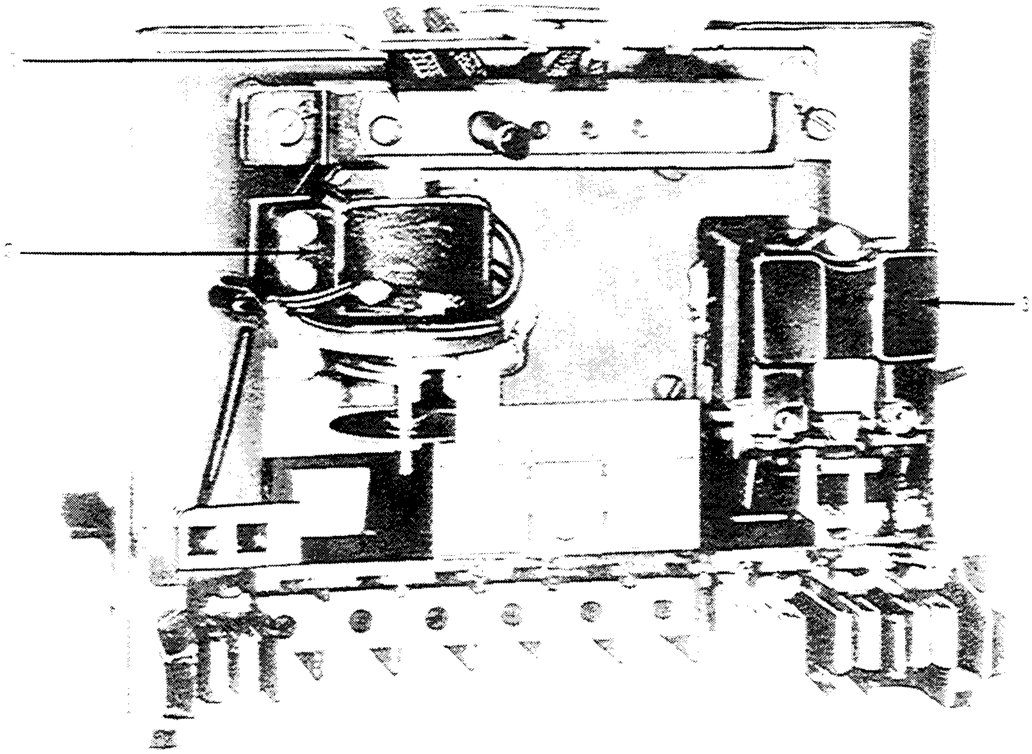


Fig. 10. Type LC-1 Relay — 1. Impedance Transformer Taps. 2. Solenoid Operating Unit. 3. Indicating Contactor Switch (ICS).

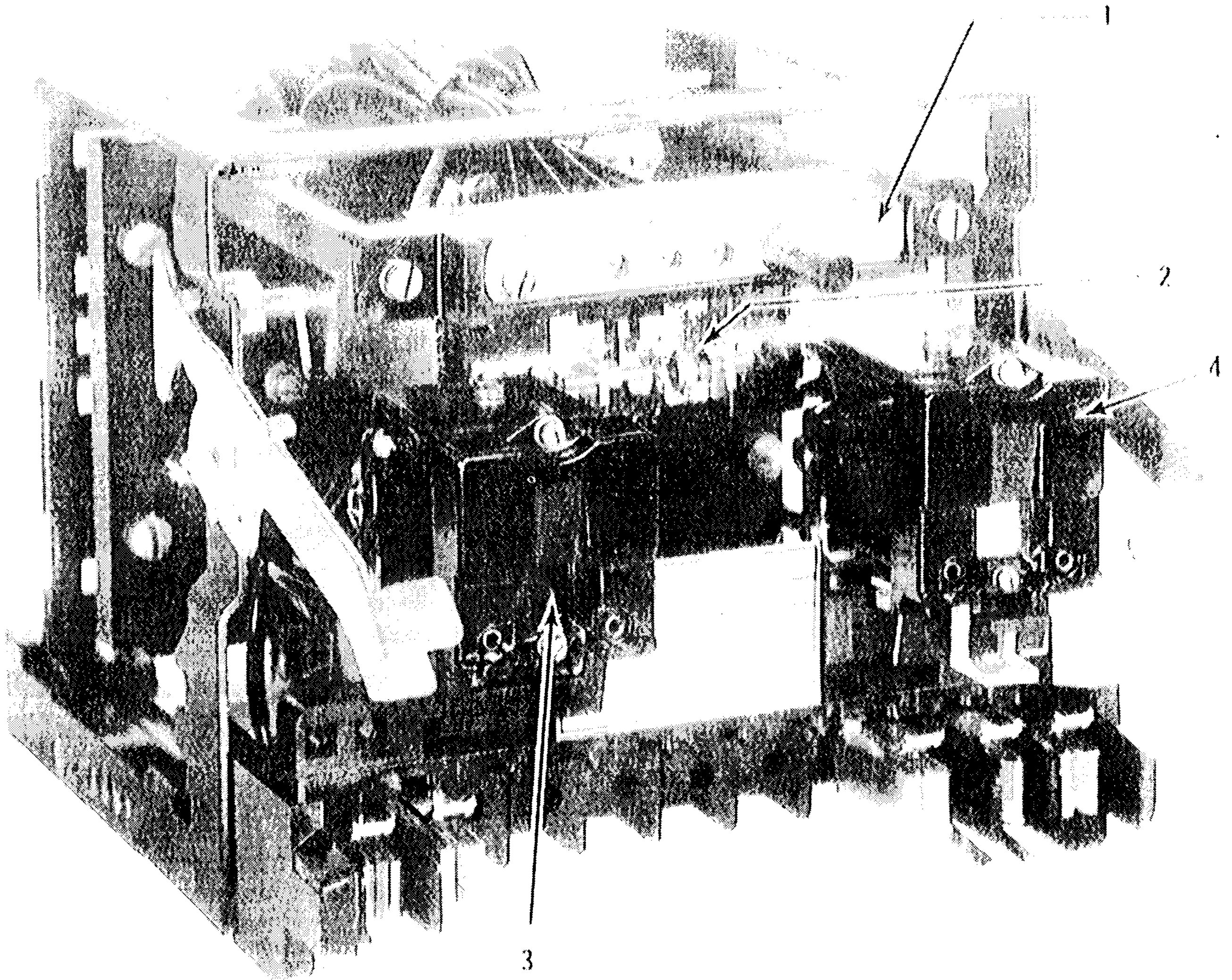


Fig. 11 Type LC-2 (Front View) – 1. Impedance Transformer Taps. 2. Polar Unit. 3. Auxiliary Contactor Switch (VS). 4. Indicating Contactor Switch (ICS).

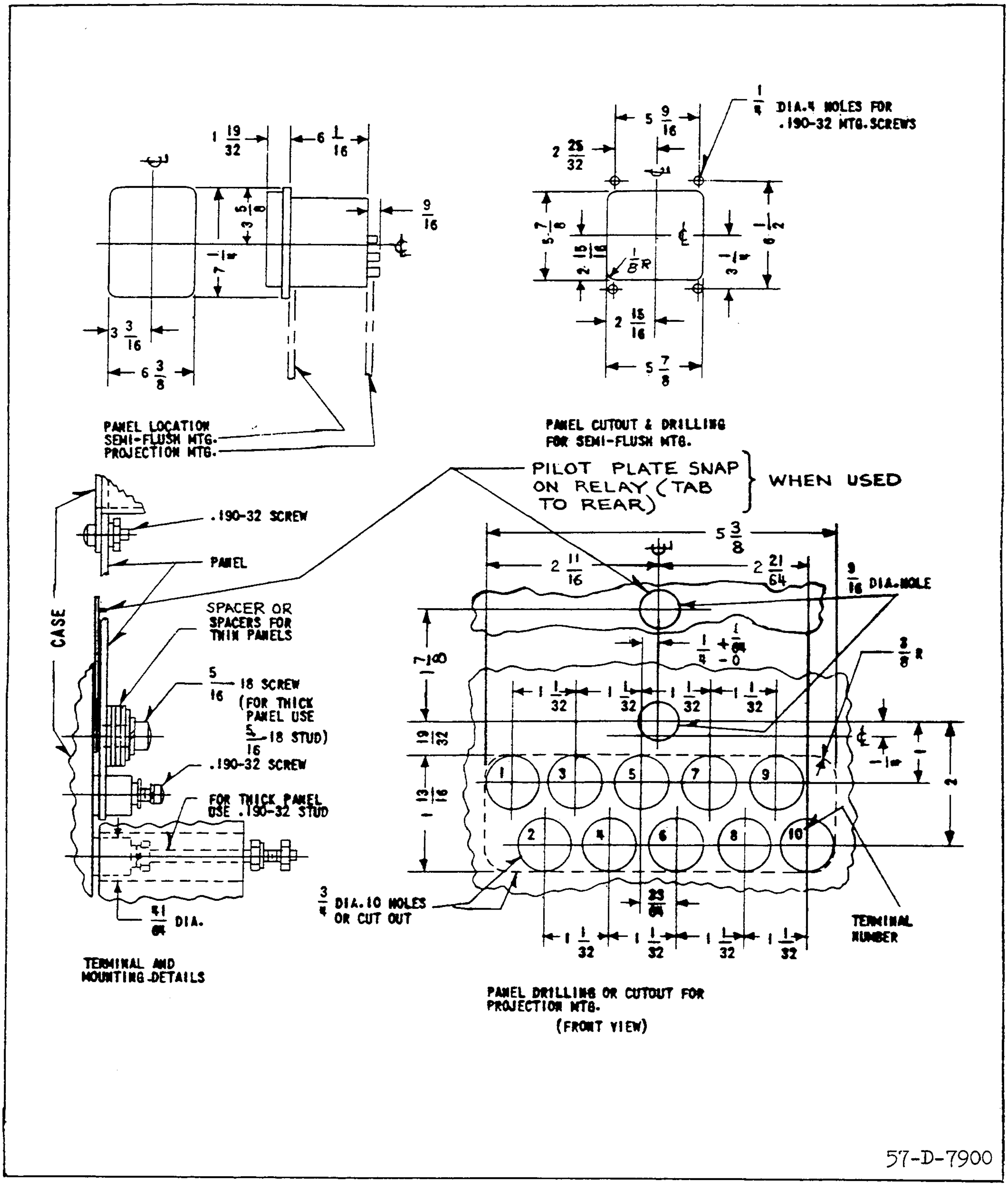


Fig. 12. Outline and Drilling Plan for the Type LC-1 and LC-2 Relay in FT11 Case.