Type KS-3 Out-of-Step Blocking Relay

Effective: February 1997
Supersedes I.L. 41-492.3, Dated April 1985
(|) Denotes Change Since Previous Issue

CAUTION

Before putting protective relays into service 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.

1.0 APPLICATION

Type KS-3 Blocking Relay is a single phase compensator distance type relay used with distance relays to prevent tripping while out-of-step conditions exist on the system. It does not prevent or delay the type KD relay from tripping on phase-to-phase faults within its protective zone that occur during the out-of-step condition, since the phase-to-phase unit does not respond to the out-of-step condition.

2.0 CONSTRUCTION

The type KS-3 Blocking Relay consists of two air-gap transformers (compensators), one tapped auto-transformer, a cylinder type operating unit, and a time-delay telephone type relay, all mounted in the type FT32 relay case.

2.1 COMPENSATORS

The compensators which are designated as T_{ABF} and T_{ABR} are two winding air gap transformers. Each primary current winding has seven taps which terminate at the tap block.

They are marked:

1.5, 2.0, 2.5, 3.51, 5.0, 7.02, 10.0 for forward reach (T_{ABF})

0.87, 1.16, 1.45, 2.03, 2.9, 4.06, 5.8 for reverse reach (T_{ABR})

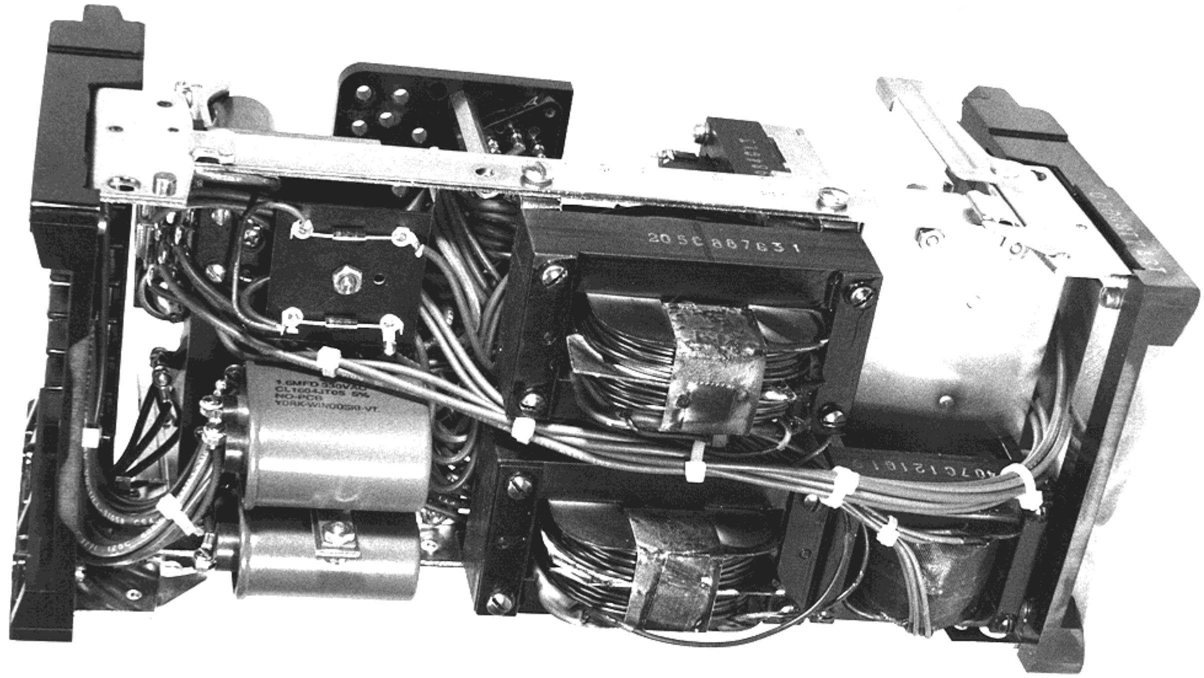
Current flowing through the primary coil provides an MMF which produces magnetic lines of flux in the core.

A voltage is induced in the secondary which is proportional to the primary tap and current magnitude. This proportionality is established by the cross sectional area of the laminated steel core, the length of an air gap which is located in the center of the coil, and the tightness of the laminations. All of these factors which influence the secondary voltage proportionality have been precisely set at the factory. The clamps which hold the laminations should not be disturbed by either tightening or loosening the clamp screws.

The secondary winding has a single tap which divides the winding into two sections. One section is connected subtractively in series with the relay terminal voltage. Thus a voltage which is proportional to the line current is subtracted vectorially from the relay terminal voltage. The second section is connected to a potentiometer and a loading resistor and provides means of adjusting the phase angle relation between primary current and the induced secondary voltage. The phase angle may be set for any value

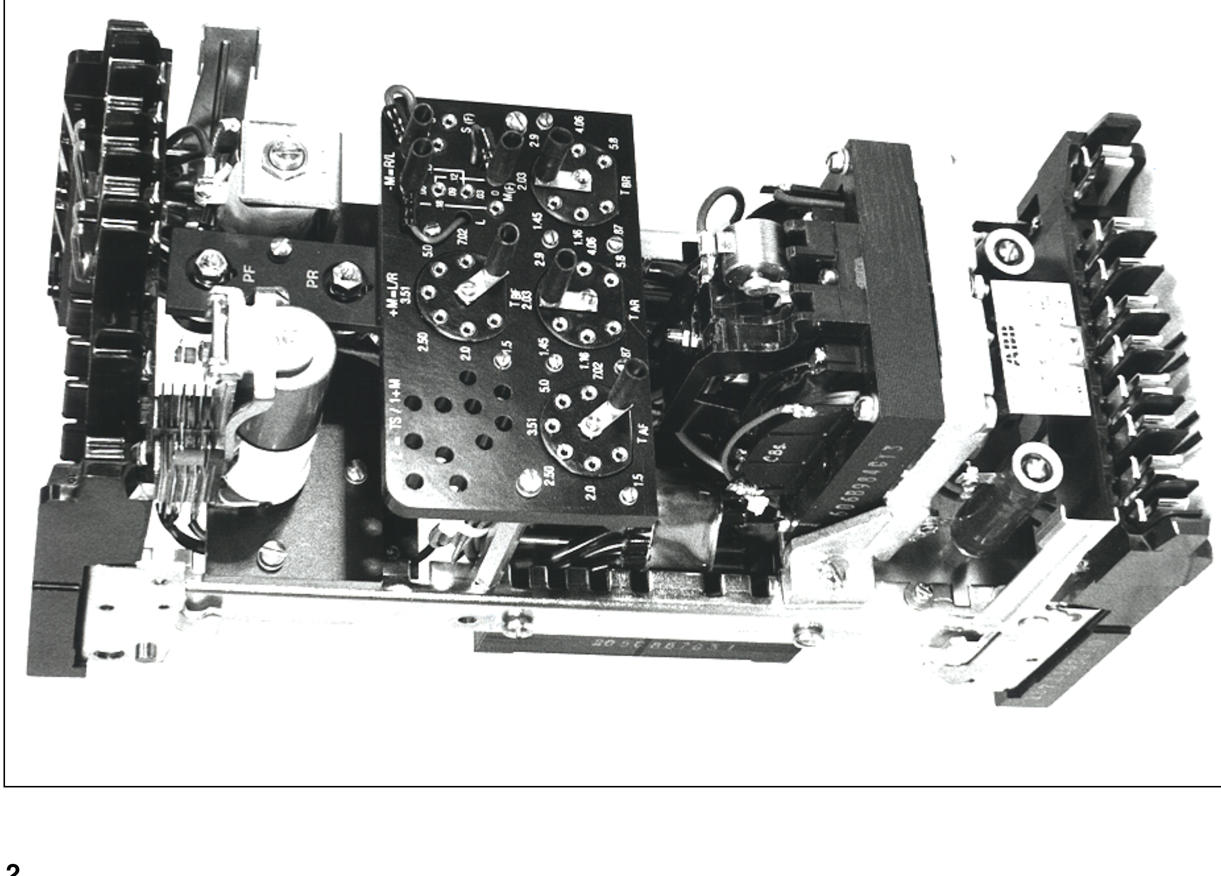
All possible contingencies which may arise during installation, operation or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If further information is desired by purchaser regarding this particular installation, operation or maintenance of this equipment, the local ABB representative should be contacted.

Photo #9664A14



Rear View

Photo #9664A13



Front View

Figure 1. Type KS-3 Out-of-Step Blocking Relay Without Case

between 60° and 80° by adjusting the potentiometer between its minimum and maximum values respectively or for 89° by open circuiting the resistor. The factory setting is for a maximum torque angle of 75° current lagging voltage.

2.1.1 Auto-transformer

The auto-transformer has three taps on its main winding, S, which are numbered 1, 2, and 3 on the tap block. A tertiary winding M has four taps which may be connected additively, or subtractively to inversely modify the 9 setting by any value from -18 to +18.

The sign of M is negative when the R lead is above the L lead. M is positive when L is in a tap location which is above the tap location of the R lead. The M setting is determined by the sum of per unit values between the R and L lead. The actual per unit values which appear on the tap plate between taps are 0, .03, .09 and .06.

The auto-transformer makes it possible to expand the basic range of the T_{ABF} by a multiplier of $\frac{S}{1 \pm M}$. Therefore, any relay ohm setting can be made within ±1.5 percent from 1.3 to 36.7 ohms by combining the compensator taps of $_{TABF}$ with auto-transformer taps S and M.

There is no auto-transformer to modify T_{ABR} taps.

2.1.2 Cylinder Unit

The device which acts to initiate blocking is a four pole cylinder unit which is connected so that one pole pair voltage leads the other by 90° and operates as a two-phase induction motor.

Mechanically, the cylinder unit is composed of four basic components: a die-cast aluminum frame, an electromagnet, a moving element assembly, and a molded bridge.

The frame serves as the mounting structure for the magnetic core. The magnetic core which houses the lower pin bearing is secured to the frame by a locking nut. The bearing can be replaced, if necessary without having to remove the magnetic core from the frame.

The electromagnet has two series-connected coils mounted diametrically opposite one another, to excite each set of poles, and two locating pins. The locating pins are used to accurately position the lower pin bearing, which is mounted on the frame, with respect to the upper pin bearing, which is threaded into the bridge. The electromagnet is secured to the frame by four mounting screws.

The moving element assembly consists of a spiral spring, contact carrying member, and an aluminum cylinder assembled to a molded hub which holds the shaft. The shaft has removable top and bottom jewel bearings. The shaft rides between the bottom pin bearing and the upper pin bearing which is adjustable to .025 inch from the top of the shaft bearing. The cylinder rotates in the air gap formed by the electromagnet and the magnetic core. The stops for the moving element contact arm are an integral part of the bridge.

The bridge is secured to the electromagnet and frame by two mounting screws. In addition to holding the upper pin bearing, the bridge is used for mounting the adjustable stationary contact housing. The stationary contact housing is held in position by a spring type clamp. The spring adjuster is located on the underside of the bridge and is attached to the moving contact arm by a spiral spring. The spring adjuster is also held in place by a spring-type clamp.

In the absence of a disturbance, Z_{OS} contacts (Figure 3) are closed and the electrical connection is made through the spiral spring adjuster clamp to short-circuit the telephone type relay coil (OS). When operating torque causes the contact to open, then the short-circuit is removed from across OS, permitting it to become energized.

2.2 TELEPHONE RELAY

The telephone-type relay unit, OS, is a slow-to-operate type. An electromagnet attracts a right-angle iron bracket which in turn operates a set of make-and-break contacts. The delay in operation is obtained by a copper slug which acts as a lag coil and delays the build-up of magnetic lines of force in the core.

When the telephone-type relay is energized, by the opening of the cylinder unit contacts, it opens its several sets of contacts which are normally connected in series with the KD relay three-phase unit contacts, and thus prevents completing the trip circuit during an out-of-step condition (Figure 2).

3.0 OPERATION

One fundamental difference between a three-phase fault and an out-of-step or out-of-synchronism condition is that a fault suddenly reduces the voltage and increases the current, whereas during the approach of an out-of-step condition, the voltage and current changes are comparatively gradual. When the line impedance to the apparent fault (Z_F) is less than the compensator setting (Z_C). I_{ZC} (compensator output voltage) becomes greater than the line voltage drop to the fault. This reverses the compensated voltage and thereby reverses the polarity of the voltage applied to one pole pair and contact-opening torque is produced in the cylinder unit. Under out-of-step conditions, the apparent impedance measured by the relay anywhere near the electrical center starts at a high value, gradually decreases to a much lower value, and then gradually increase again to a higher value, and thus the system goes through a complete beat oscillation. On the other hand, if the disturbance is a fault, the impedance seen by the relay will suddenly drop to a much lower value, and then either retain this value or slightly increase due to the effects of fault resistance, until the fault is cleared.

The KS-3 relay takes advantage of the distinction between a fault and an out-of-step condition. Under out-of-step conditions, the KS relay will operate followed after a short time delay by zone 2 KD relay operation, as the apparent short circuit drifts toward the relay. In case of a fault, the KS-3 as well as zone 2 and zone 1 (depending on fault) will operate within a very short time, and will not follow the sequence described for an out-of-step condition.

3.1 COMPENSATOR

Sensitivity to the out-of-step condition is provided by compensators designated as T_{ABF} and T_{ABR} in Figure 2. Each compensator is proportioned so that its mutual impedance, Z_C, has known and adjustable values from T = 1.5 ohm to T = 10.0 for forward reaching compensators and from T = .87 ohm to T 5.8 for reverse reaching compensators in 30 percent steps. Compensator mutual impedance Z_C is defined as the ratio of secondary induced voltage to primary current and is equal to T. The secondary (voltage) winding of the compensator is in series with the applied voltage and vectorially subtracts a value from the applied voltage which is proportional to I_Z where I is relay current. The subtraction occurs for forward reaching compensator (T_{ABF}) voltage during fault or out-of-step condition which appear to the relay as faults in forward direction. For reverse reaching compensator (T_{ABR}), its secondary voltage is vectorially added for the condition described above. For reverse appearing faults, the relationships between relay voltage and compensator secondary voltages are correspondingly reversed. The reverse looking compensator (T_{ABR}) is required to produce an impedance characteristic which will be concentrical with the three-phase unit of the KD family relay.

When the line impedance (to the electrical center or to a fault Z_F) is less than the compensator setting (Z_C), I_{ZC} becomes greater than the line voltage drop to the electrical center or fault. This reverses the phase of one of the voltages applied to the relationship cylinder unit and an operating torque is produced.

4.0 CHARACTERISTICS

Referring to Figure 4, the scheme of operation is described below. The impedance circle of the relay is set to encircle the second zone KD relay three-phase unit. The difference between the two circles provides a margin in ohms sufficient to give the telephone-type relay time to operate before the swing condition enters the characteristic circle of zone 2 after having entered the circle of KS-3 relay. The telephone-type relay will open, within 3 to 4 cycles, its OS contacts located between the $^{68}/_{4}$ and $^{68}/_{5}$ terminals shown in the trip circuits section of Figure 2. Thus all of the OS contacts operate to block tripping and also to prevent the short-circuiting and de-energizing of the OS coil as the zone 2 contacts close. When zone 2 operates before OS, as it does for a three-phase fault condition, a short-circuit across the coil, OS, is completed through the KD relay, and DZ2 and OS is not energized even though the ZOS contacts do open.

In case of ground faults, D_O and I_O operate and maintain short circuit across OS coil through DZG.

4.1 GENERAL CHARACTERISTICS

Impedance settings in ohms for forward reach can be made for any value from 1.27 ohms to 36.7 ohms in steps of 3 percent.

The maximum torque angle, which is set for 75° at the factory, may be set for any value from 60° to 80°. A change in maximum torque angle will produce a slight change in reach for any given setting of the relay. Referring to Figure 5 note that the compensator secondary voltage output V, is largest when V leads the primary current, I, by 90°. This 90° relationship is approached, if the compensator loading resistor is open-circuited. The effect of the loading resistor, when connected, is to produce an internal drop in the compensator, which is out-of-phase with the induced voltage, compensator voltage I_{ZC}. Thus the net voltage V is phase-shifted to change the compensator maximum torque angle. As a result of this phase shift the magnitude of V is reduced, as shown in Figure 5.

Tap markings on the tap plate are based upon a 75° compensator angle setting. If the potentiometers PF and PR are adjusted for some other maximum torque angle, the nominal reach is different than indicated by the taps. The reach, Z, varies with the maximum torque angle θ, as follows:

$$Z = \frac{TS \sin\theta}{(1 \pm M)\sin(75°)}$$

TAP PLATE MARKINGS

$\frac{TABF \text{ (Forward)}}{1.5, 2.0, 2.5, 3.51, 5.0, 7.02, 10.0}$

$\frac{TABR \text{ (Reverse)}}{87, 1.16, 1.45, 2.03, 2.90, 4.06, 5.8}$

$\pm$ Values between taps $\frac{M}{.03, .09\ .06}$

Current Circuit Rating in Amperes		
Tap Setting	Continuous	1 Second
10	5	240
7.02	7	240
5.0	10	240
3.51	10	240
2.5	10	240
2.0	10	240
1.5	10	240

4.2 SETTING CALCULATIONS

The type KS-3 relay requires an ohm setting high enough that its impedance circle completely surrounds the impedance circle of the Zone 2 KD-type relay three phase unit with sufficient margin to accommodate the fastest swing rate. Usually a 2 ohm larger radius (Z_{DF}), (Figure 4) for KS-3 relay will suffice. The Z_{DF} reach which should be equal to reverse reach is selected from the seven available taps of T reverse reach compensators .87, 1.16, 1.45, 2.03, 2.9, 4.06, 5.8.

The forward reach Z_L is set according to the following formula:

$$Z_L = (Z_{Zone2} + 2 \text{ ohms}) \quad (1)$$

The equation (1) is applicable where maximum torque angle of KS-3 is the same as of the KD-type relay.

The more general formula for setting the forward reach is required where the maximum torque angle of the KS-3 relay is adjusted for an angle, which is different from 75° to match the angle of the 3-phase unit of KD relay. When we assume that Z_L setting is desired which is greater by 2 ohms than the second zone impedance relay setting then the general formula for setting in ohms is:

$$Z_{L\theta} = Z_L \frac{\sin\theta}{\sin 75} = (Z_{\text{Zone 2}} + 2 \text{ ohms})$$

The terms used in this formula are defined as follows:

$Z_{L\theta}$ =the desired ohmic forward reach of the relay at an angle θ.

$Z_L = \frac{TS}{1 \pm M}$ the forward reach tap plate setting.

where T is T_{AF} and T_{BF} compensator settings

S is S_F auto-transformer primary tap value
θ – relay maximum torque angle

For a standard setting of 75°

$$\frac{\sin\theta}{\sin 75} = 1 \qquad (2)$$

M is MF- Auto-transformer secondary tap value

(This is a Per unit value and is determined by the sum of the values between the “L” and the “R” leads. The sign is positive when “L” is above “R” and acts to lower the Z setting. The sign is negative when “R” is above “L” and acts to raise the Z setting).

Reverse reach is calculated by formula

$$Z_R = \frac{T\sin\theta}{\sin 75} \qquad (3)$$

where T are T_{AR}, T_{BR} compensator settings

θ- relay maximum torque angle for a standard setting of 75°

then $\frac{\sin\theta}{\sin 75} = 1$

SAMPLE CALCULATIONS

An optimum forward setting is obtained by the following procedure:

Step 1. Establish margin to accommodate the fastest swing rate. Usually this margin is selected as 2.03 ohms, other values that can be selected are 5.8, 4.06, 2.9, 1.45, 1.16, and 0.87.

The selected margin determines the reverse reach setting.

Step 2. Determine the desired forward reach Z_L, which is equal to Z_{Zone2} + 2 ohms. Note that 2.03 ohms was selected above as a safe margin for identifying a system swing and is not influenced by the magnitude of $Z_{Zone\ 2}$.

Step 3. Using Table 1, select optimum setting for the forward reach of the relay as following:

a) Locate a table value for the forward reach Z (it will always be within 1.5% or less of the desired value).

b) Read off the table “S, “T”, and “M” settings. “M “column includes additional information for “L” and “R” leads settings for the specified “M” value.

c) Recheck the obtained S, T, M settings by using equation (1).

Example I

Step 1. Select 2.03 ohms tap from available reverse reach compensator settings. Hence $T_{AR} = T_{BR}$ = 2.03 ohm, assuming Zone 2 settings is 7 ohm at 75°.

Step 2. Using equation 1, establish forward reach of the relay.

Z = 7 + 2 = 9 ohms

Step 3. a) From Table 1, we find the 8.9 ohms as the closest value to 9.0 ohms.

b) Then we read off T, S, and M values.
T = 10.0, S = 1,
M = +.12

Hence $T_{AF} = T_{BF}$ = 10.0
S_F = 1
M_F = +.12

and “L” lead should be connected over “R” lead. “L” lead is connected to “.09” tap and “R” lead to “0” tap.

c) Recheck the settings

$$Z = \frac{ST}{1+M} = \frac{1x10}{1+.12} = 8.93$$

Example II

Assume that the Zone 2 three phase unit setting is 7 ohms at 60°, and KS-3 recalibrated to 60°.

Step 1. Select reverse reach as 2.03 ohms which in a relay when recalibrated to a 60 degree angle will be calculated per Eq. 2.

$$Z_R = \frac{T\sin\theta}{\sin 75} = 2.03\frac{\sin 60°}{\sin 75} = 1.82$$

Set $T_{AR} = T_{BR} = 2.03$ (nearest value to 2 ohms at 60°).

Step 2. Find $Z_{LO} = Z_{Zone2} + 2 = 9$.

Correct Z = 9 ohms for recalibration of the compensator to 60°.

$$Z = 9\frac{\sin 75°}{\sin 60°} = 9\frac{.965}{.866} = 10.04 \text{ ohms}$$

Step 3. a) From Table 1, find value closest to 10.04 ohms which is “10.0”.

b) Then we read off T, S, M values as

Hence $T_{AF} = T_{BF} = 10.0$

SF = 1

MF = 0

All “L” and “R” leads should be corrected to taps marked “0” and “0”.

Recheck the settings

$$Z = \frac{ST}{1 \pm M} = \frac{1x10}{1+10} = 10.0 \text{ ohms}$$

5.0 SETTING THE RELAY

The KS-3 relays require settings for the two compensators T_{ABF}, T_{ABR}, the auto-transformer primary (S_F) and secondary (M_F). All of these settings are made with taps on the tap plate.

5.1 COMPENSATORS TABF AND TABR

Each set of compensator taps terminates in inserts which are grouped on a socket and form approximately three quarters of a circle around a center insert which is the common connection for all of the taps. Electrical connections between the common insert and tap inserts are made with a link held in place by two connector screws, one in the common and one in the tap. A compensator tap setting is made by loosening the connector screw in the center. Remove the connector screw in the tap end of the link, swing the link around until it is positioned over the insert for the desired tap setting, replace the connector screw to bind the link to this insert, and retighten the connector screw in the center. As the link and connector screws carry operating current, be sure that the screws are tight but not so tight as to break the tap screw. There are four T taps, two for long reach and two for short reach. The T taps connected in a way to use delta current.

5.2 AUTO-TRANSFORMER PRIMARY (S_F)

Primary tap connections are made through a single lead for each transformer. The lead comes out of the tap plate through a small hole located just below or above the taps and is held in place on the tap by a connector screw.

An “S” setting is made by removing the connector screw, placing the connector in position over the insert of the desired setting, and then replacing and tightening the connector screw. The connector should never make electrical contact with more than one tap at a time.

5.3 AUTO-TRANSFORMER SECONDARY (MF)

Secondary tap connections are made through two leads identified as L and R for each transformer. These leads come out of the tap plate each through a small hole, one on each side of the vertical row of “M” tap inserts. The lead connectors are held in place on the proper tap by connector screws.

An “M” setting can be made for values from -.18 to +.18 in steps of .03. The value of a setting is the sum of the numbers that are crossed when going from the R lead position to the L lead position. The sign of the “M” value is determined by which lead is in the higher position on the tap plate. The sign is positive), if the L lead is higher and negative if the R lead is higher.

An “M” setting may be made in the following manner. Remove the connector screws so that the L and R leads are free. Refer to Table 1 to determine the desired “M” value. Neither lead connector should make electrical contact with more than one tap at a time.

5.4 LINE ANGLE ADJUSTMENT

Maximum sensitivity angle is set for 75° + 5° (current lagging voltage) in the factory. This adjustment need not be disturbed for line angles of 65° or higher. For line angles below 65°, set for a 60° maximum sensitivity angle by adjusting

Table 1:
TABLE OF FORWARD REACH SETTINGS

	S = 1							S = 2		S = 3		"M"		Lead Connection	
T_{AF} & T_{BF}	1.5	2.0	2.5	3.51	5.0	7.02	10.0	7.02	10	7.02	10	+M	-M	"L" Lead	"R" Lead
	1.27	1.69	2.12	2.97	4.24	5.95	8.47	-	16.9	-	25.5	+.18		.06	0
	1.30	1.74	2.17	3.05	4.35	6.10	8.70	12.2	17.4	-	26.1	+.15		.06	.03
	1.34	1.79	2.23	3.13	4.46	6.26	8.93	12.5	17.9	-	26.8	+.12		.09	0
	1.38	1.83	2.29	3.22	4.59	6.44	9.17	12.9	18.3	-	27.5	+.09		.09	.03
	1.42	1.89	2.36	3.31	4.72	6.62	9.43	13.2	18.9	-	28.3	+.06		.06	.09
	1.46	1.94	2.43	3.41	4.85	6.82	9.71	13.6	19.4	-	29.1	+.03		.03	0
	1.50	2.0	2.50	3.51	5.00	7.02	10.0	14.0	20.0	-	30.0	0	0	0	0
	1.55	2.06	2.58	3.62	5.15	7.24	10.3	14.5	20.6	-	30.9		-.03	0	.03
	1.60	-	2.66	3.73	5.32	7.47	10.6	14.9	21.3	-	31.9		-.06	.09	.06
	1.65	-	2.75	3.86	5.49	7.71	11.0	15.4	22.0	-	33.0		-.09	.03	.09
	-	-	2.84	3.99	5.68	7.98	11.4	16.0	22.7	23.9	34.1		-.12	0	.09
	-	-	2.94	4.13	5.88	8.26	11.8	16.5	23.5	24.8	35.3		-.15	.03	.06

the compensator loading resistors PF and PR. Refer to Repair Calibration when a change in maximum sensitivity angle is desired.

6.0 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 the semi-flush type FT case. Either the 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 stud furnished with the relay for thick panel mounting. The terminal stud may be easily removed or inserted by locking two nuts on the stud and then turning the proper nut with a wrench.

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

7.0 ACCEPTANCE TESTS

KS-3 relays have a very small number of moving parts and mechanical devices which might become inoperative. Acceptance tests in general consists of:

1. A visual inspection to make sure there are no loose connections, broken resistors, or broken resistor wires.
2. An electrical test to make certain that the relay measures the balance point impedance accurately.

7.1 DISTANCE UNIT

1. Use the test connection shown in Figure 6.

Set $T_{AF} = T_{BF} = 1\ \theta$

$M_F = +15$, which is equivalent to $Z_L = 8.7$ ohm

$Z_L = 8.7$ ohm

$S_F = 1$

Set $T_{AR} = T_{BR}$ =2.03, which is equivalent to Z_R = 2.03.

2. Adjust the relay voltage (across terminals 7 & 8) for 60 volts A.C.

   Set the relay current to lag the relay voltage by 75°.

   The current required to operate the cylinder unit (opening of its contacts) should be between 3.10 - 3.80 amps ac.

   Note, I_{test} = V/2Z.

   Set the relay current to lag the relay voltage by 255°, and reduce the voltage to 30 Vac.

   The current required to operate the cylinder unit (opening its contacts) should be between 7-8 amps ac.

   If the electrical response is outside the limits, a more complete series of tests outlined in the section "Calibration" may be performed to determine which component is faulty or out of calibration.

   Check the time delay unit (telephone relay) by applying the rated dc voltage across terminals 18 and 20. Opening the cylinder unit contacts should cause the telephone type relay to pick up. It should drop out when the cylinder unit contacts close. Check the direction of Zener diodes between terminals 20 and 1, and 20 and 6 using an ohmmeter to perform this test. The ohmmeter should have battery as its energy source. Blocking should be in direction from 20 to 1 and 6. Forward conduction should be from 1 to 20, and from 6 to 20.

8.0 ROUTINE MAINTENANCE

All relays should be inspected periodically, at such time intervals as may be dictated by experience, to insure that the relays have retained their calibration and are in proper operating condition.

All contacts should be cleaned periodically. A contact burnisher #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.

9.0 REPAIR CALIBRATION

Use the following procedure for calibrating the relay if the relay has been taken apart for repairs or the adjustments disturbed:

Auto-Transformer Check

Auto-transformers may be checked for turns ratio and polarity by using the test connections of Fig. 5 and following the procedure outlined below.

Set S_F on tap number 3. Set the "R" leads of M_F on 0.0 and disconnect the "L" lead. Adjust the relay voltage for 90 volts. Measure the voltage from terminal 8 to the #1 tap of S_F. It should be 30 volts. From 8 to the #2 tap of S_F should be 60 volts.

Set S_F on 1 and adjust relay voltage for 1 0 0 volts. Measure the voltage drop from terminal 8 to each of the M_F taps. The voltage should be equal to 100 (1 + the sum of values between R and the tap being measured). Example- 100 (1 + .03 + .06) = 109 volts.

Transformers that have an output different from nominal by more than 1.0 volt probably have been damaged.

Replace L-Lead.

Settings

Set $T_{AF} = T_{BF} = 10$
$T_{AR} = T_{BR} = 2.03$
$M_{SF} = 1$

9.1 DISTANCE UNIT CALIBRATION

Initial Spring Adjustment

With the stationary contact open so that the moving contact cannot touch, set the moving contact spring adjuster so that the contact floats freely in the gap. Make sure that there is no friction which prevents free movement of the cylinder and contact arm.

The upper pin bearing should be screwed down until there is approximately .025 inch (one complete turn of the screw) between it and the top of the shaft bearing. The upper pin bearing should then be securely locked in position with the lock nut. The lower bearing position is fixed and cannot be adjusted.

9.2 CORE ADJUSTMENT

Apply 120 Vac to relay terminals. Adjust core using a screwdriver so that moving arm is floating in the gap, or restrains slightly.

9.3 COMPENSATOR ANGLE ADJUSTMENT

Use Figure 6 Test Connections.

Apply 20 Vac to relay terminals. Apply 1.15 amp ac to relay current circuit lagging voltage by 75°. Connect high impedance voltmeter across CF capacitor (0.7 uf) and adjust P_F marked potentiometer until voltage across this capacitor is minimum (below 0.5 volts). Readjust current slightly to see if lower minimum voltage can be obtained.

Reconnect voltmeter to C_R capacitor (1.6 ufd), and apply 5 amp ac lagging voltage by 255° to relay terminals. Readjust P I until minimum voltage readings obtained across C_R capacitor (below 0.5 volts).

Readjust current slightly to see if lower minimum voltage can be obtained.

Maximum Torque Sensitivity Angle

Apply 60 volts to relay terminals. Set phase shifter so that current of 4.25 amps ac just opens cylinder unit contacts. Find another angle where contacts just open. The two points of cylinder unit operation (contact opening) should occur at the two angles sum of which when, divided by two is equal to 75 ± 6 degrees. If not, readjust adjustable inductor. Sometimes the coils of the adjustable inductor can be reconnected from parallel to series, or vice versa, connection to bring the maximum sensitivity angle within the desired range of operation.

Adjustable inductor has a retaining nut which has to be loosened before adjusting core, and it should be retightened after adjustment is complete.

9.4 CONTACT ADJUSTMENT

With the moving contact arm against the left-hand side of the bridge, screw the right hand contact in to just touch the moving contact. Then back the contact out one full turn to give approximately 0.031 inch gap.

9.5 SPRING RESTRAINT

Apply 5 volts to relay terminal, set phase shifter for 75 degree current of 0.350 amp ac lagging the voltage.

Set the moving contact spring adjuster so that the contact just floats. Deenergize relay completely. The contacts should stay closed.

9.6 COMPENSATOR CHECK

Accuracy of the mutual impedance Z_C of the compensator is set within very close tolerances at the factory and should not change under normal conditions.

The mutual impedance of the compensators can be checked with very accurate instruments by the procedure below:

1. Disconnect S and L leads.
2. Apply 5 amps to relay.

Current only is applied to relay and voltage terminals (7 & 8) should be left open circuited. Compensator voltage should be equal to compensator tap setting multiplied by 2 times current.

The compensator voltage should be measured for forward reach compensator between lead “L” and either terminal of C_F (0.7 mfd) capacitor or $V_{CF} = 2IT \frac{(\sin\theta)}{\sin 75}$, where I current applied, T compensator tap setting, and angle θ, compensator angle setting.

Example:

If T = 10 I = 5 amp θ75

V_C = 100 volts

For reverse reach compensator voltage is measured from terminal 7 to either terminal of 1.6 mfd capacitors (C_R).

Use the same equation, as above to calculate voltage compensator (V_C) = 20 volts.

Most accurate measurements should be done with R_R and R_F resistors open, which will correspond to θ = 90°, which will increase compensator output.

Compensator which deviate by more than 3 percent with Phase Shifting resistor open circuited should be replaced, or accounted for in reach calculations.

9.7 TELEPHONE RELAY

With the cylinder unit contacts open, energize the telephone relay through terminal 18 and 20 with rated dc voltage and measure the time required for the contacts to open between terminals 4 and 5. This operating time should be between three and four cycles, (50 and 66 milliseconds). The operating time can be adjusted by bending the contact-springs located at the top left-hand side of the OS unit and by changing the armature gap.

THE RELAY IS NOW CALIBRATED AND READY FOR SERVICE.

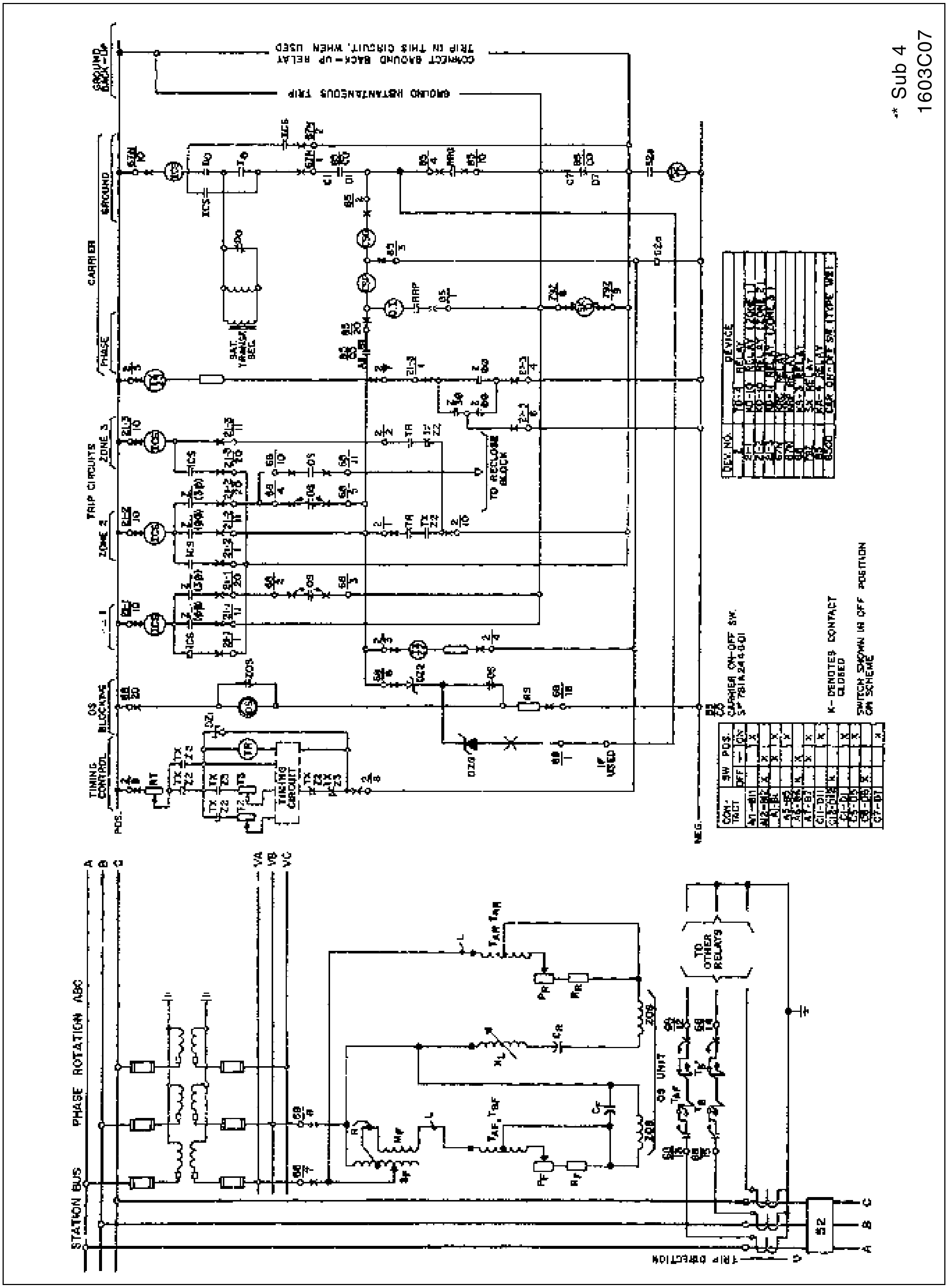


Figure 2. External Connections of KS-3 Relay

* Denotes Change

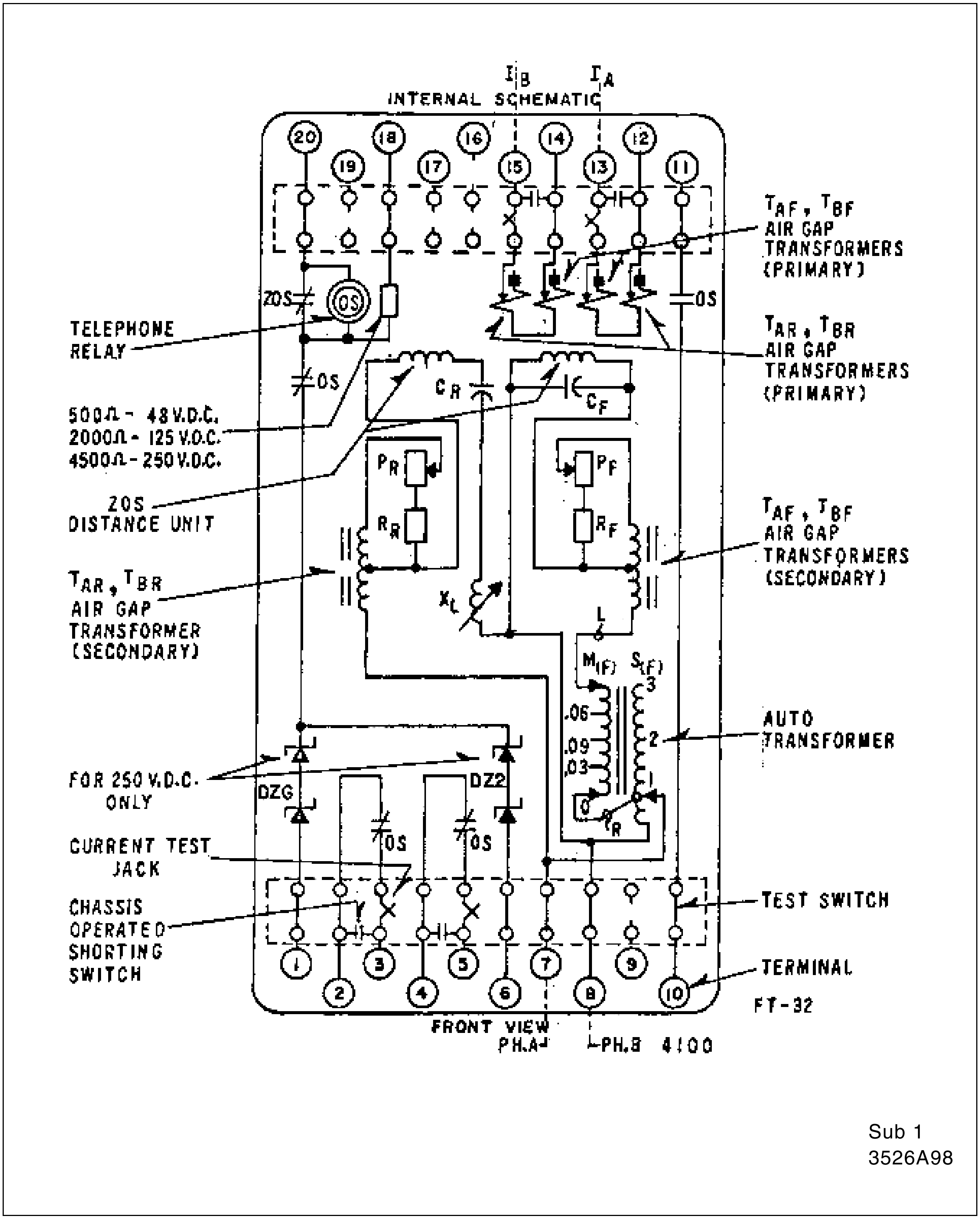
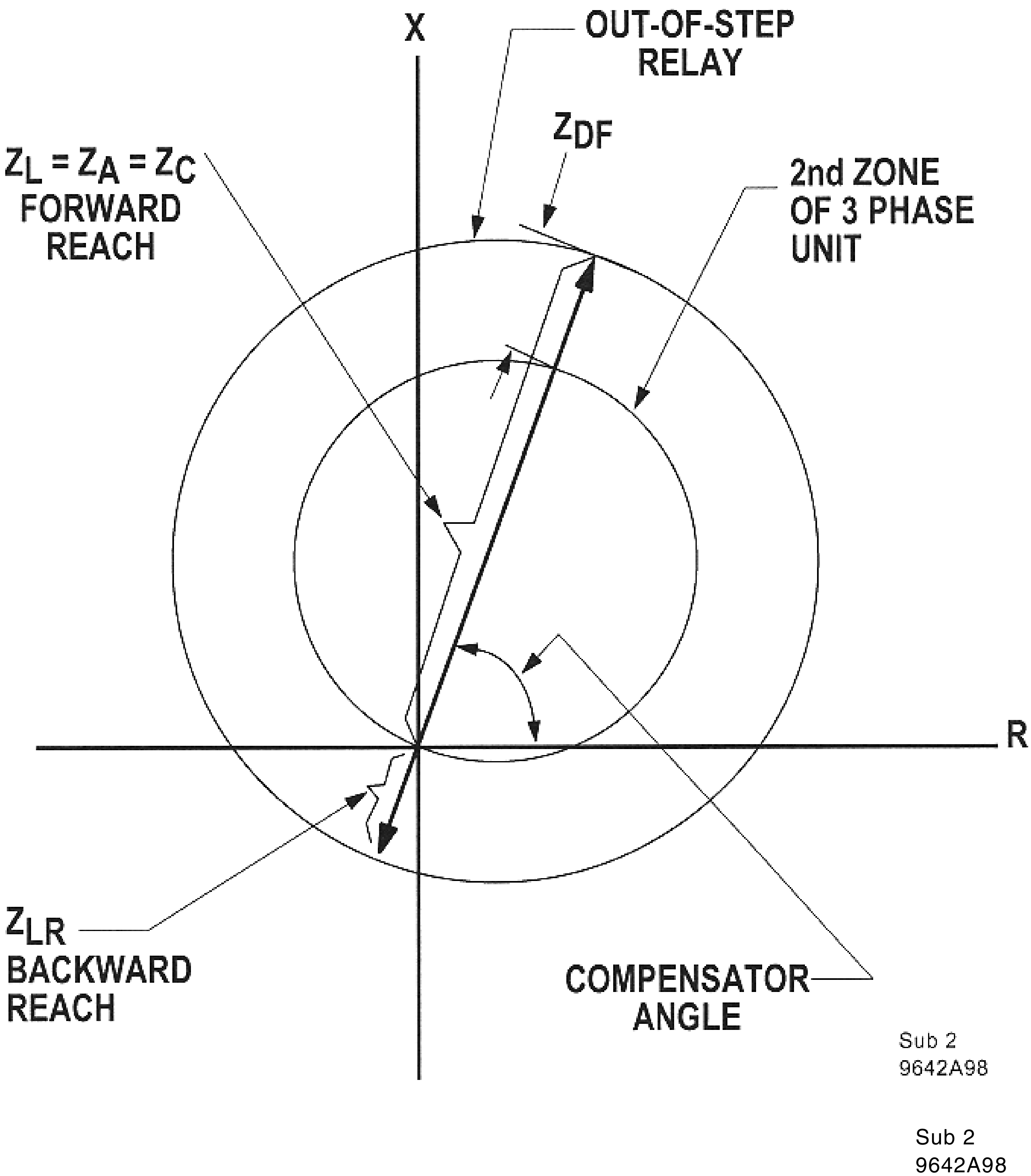
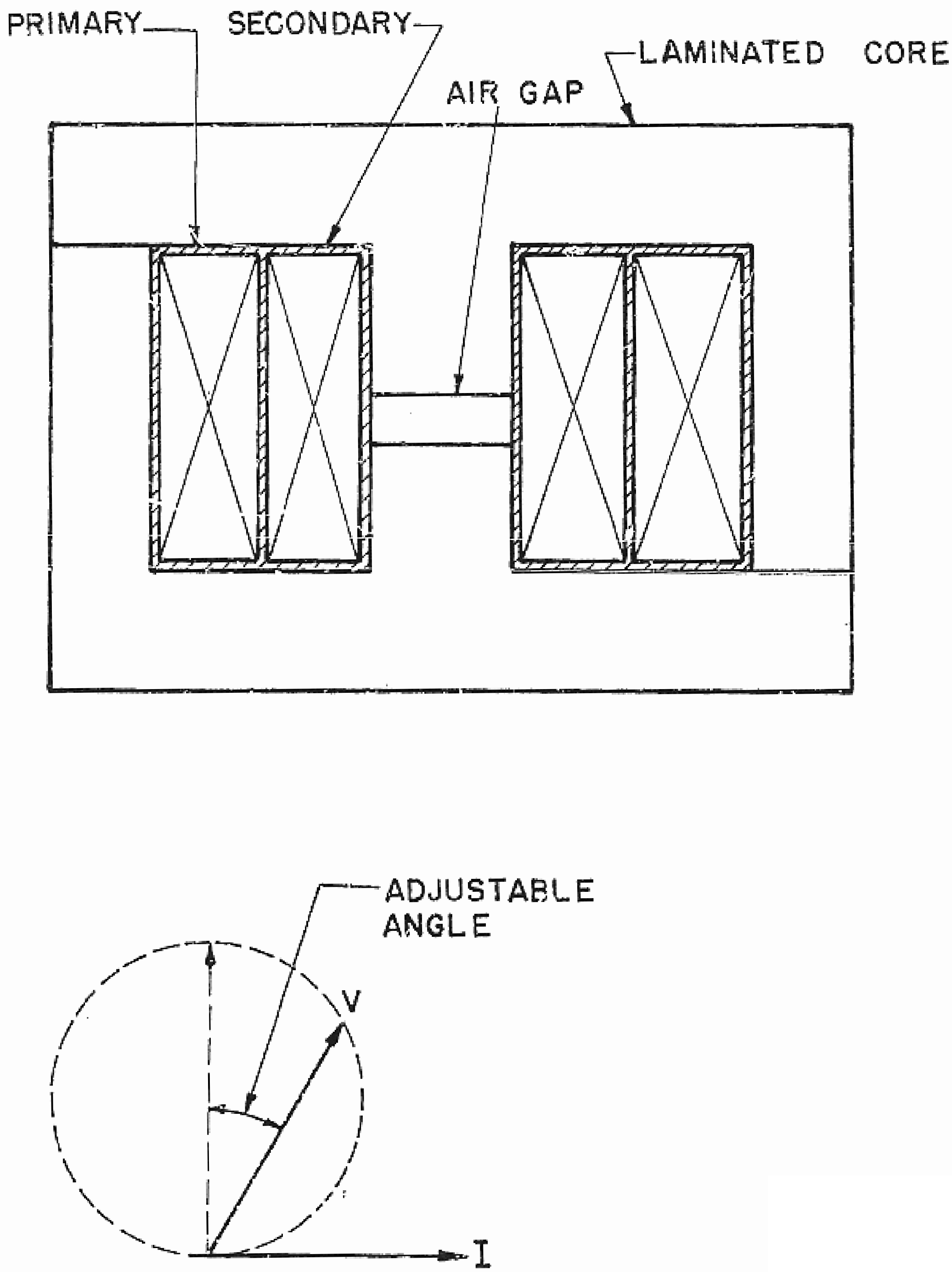


Figure 3. Internal Schematic



Sub 2
9642A98

Figure 4. Relay Characteristic on R-X Diagram



Sub 1
849A034

Figure 5. Compensator Construction

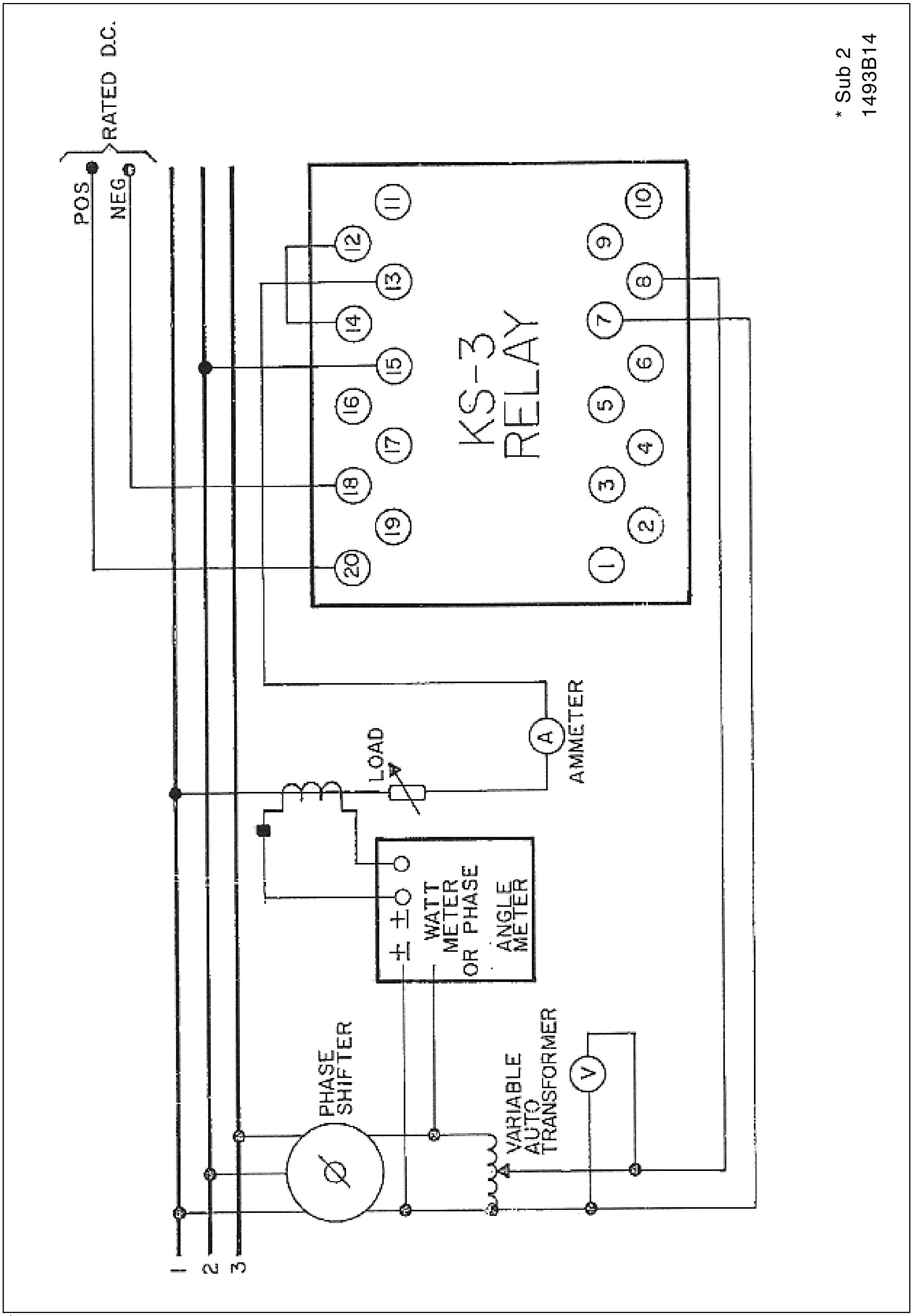


Figure 6. Test Drawing of KS-3 Relay

* Denotes Change

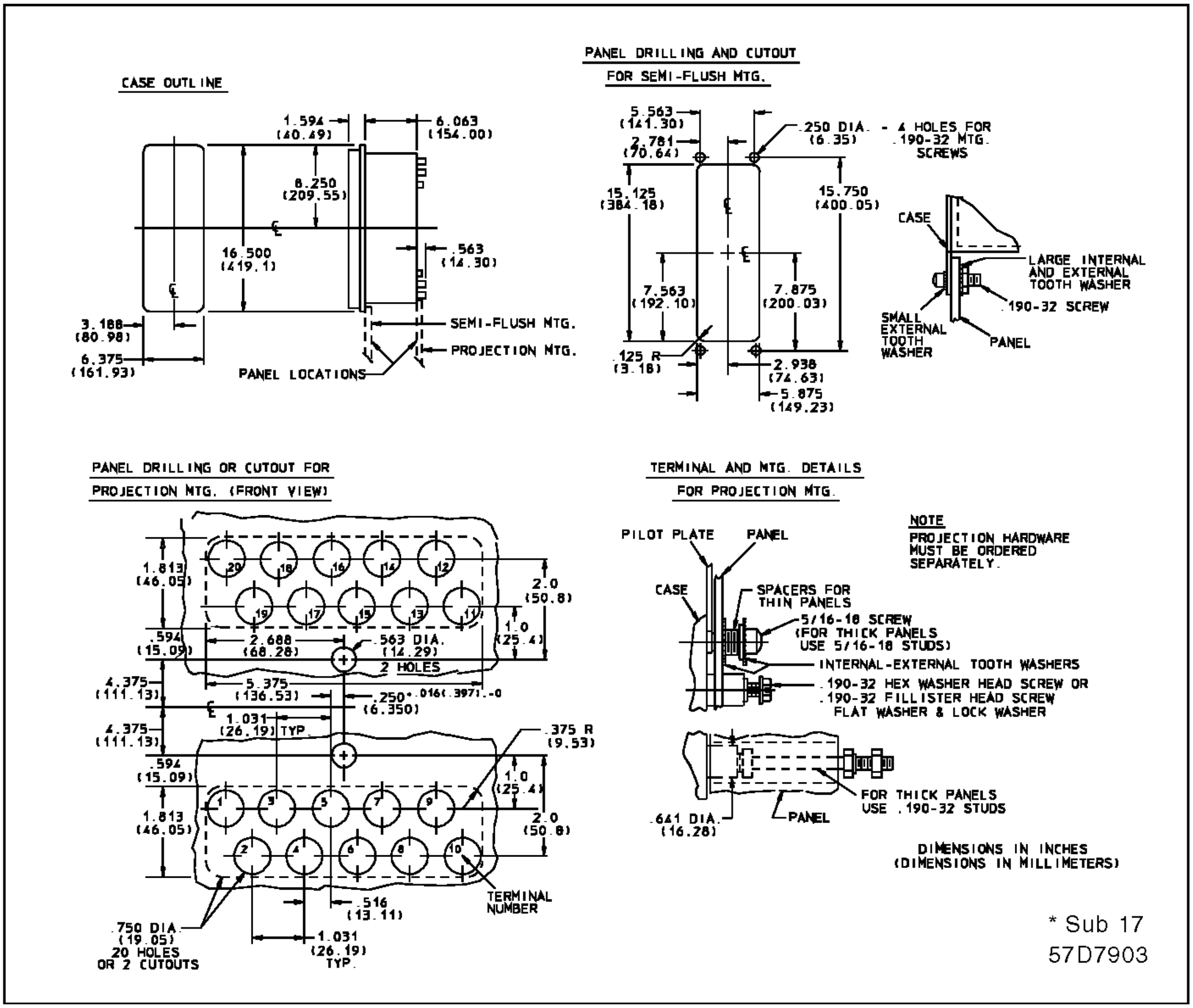


Figure 7. Outline Drilling Plan for the Type KS-3 Relay in FT-32 Case * Denotes Change

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