INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE HA GENERATOR DIFFERENTIAL RELAY

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

APPLICATION

The type HA relays are balanced-beam type relays used for the differential protection of a-c generators and synchronous motors. The relays operate in one cycle (60-cycle per second bases) and are designed so that they are unaffected by d-c transients associated with asymmetrical through short-circuit currents.

The type HA relays may be applied when there is considerable difference between current transformer performance on the two sides of the machine. The limits of variation in the output of these current transformers which will still allow ample safety factors may be determined as follows.

* Current transformer burden in ohms (excluding CT winding resistance) should not exceed $(N_P V_{CL})/133$; further the burden factor, BF, should not differ by more than a 2 to 1 ratio between the two sets of
* CT's. Where the 2 to 1 ratio cannot be met, resistors may be added in the CT leads, provided the total burden meets the $N_P V_{CL}/133$ requirement. The above terms are defined as:

N_P = proportion of total number of CT turns in use

V_{CL} = current transformer 10L accuracy class voltage

$$BF = \frac{1000\ R_B}{N_P V_{CL}}$$

R_B = resistance of the burden, excluding CT winding resistance.

For example, if the 400/5 tap of a 600/5 multi-ratio CT is used, $N_P = 400/600 = 0.67$. If this CT has a 10L200 rating, $V_{CL} = 200$, and the burden should not exceed:

$$\frac{N_P V_{CL}}{133} = \frac{0.67 \times 200}{133} = 1.0 \text{ ohm}$$

Assuming a resistance burden of $R_B = 0.5$ ohms, the burden factor, BF, is:

$$BF = \frac{1000\ R_B}{N_P V_{CL}} = \frac{1000 \times 0.5}{0.67 \times 200} = 3.8$$

The other set of CT's may then have a burden factor as high as 2 x 3.8 = 7.6, or as low as 1/2 x 3.8 = 1.9. If the other set of CT's also has a burden of 0.5 ohms, a 10L100, 10L200, or 10L400 rating would be satisfactory, since the burden factors are 7.6, 3.8 and 1.9, respectively.

In calculating the burden, use the one way lead burden.

* If the operating current can exceed 100 amps, runs symmetrical neglecting CT saturation, varistor protection is recommended to limit voltage stress in the relay circuits. CT saturation will not limit the voltage spikes that are produced each half cycle as the CT comes out of saturation. Size the varistor to limit the peak voltage to 1600 volts at the maximum expected current, neglecting CT saturation and assuming all CT current flowing in the varistor. Connect the varistors across the CT windings carrying the majority of the current, or across the relay terminals (e.g. 19 to 18, 15 to 14, 9 to 8). Where the full winding of a bushing CT is not used, the CT insulation stress across the full winding will be increased due to the autotransformer action. In this case the insulation strength of the CT may be the limiting.

CONSTRUCTION

The type HA relay consists of three differential units, three saturating transformers, three fault detectors, an auxiliary contactor switch, and three operation indicators.

Differential Units

A beam of magnetic material, pivoted in the center is pulled down on the contact end by a cur-

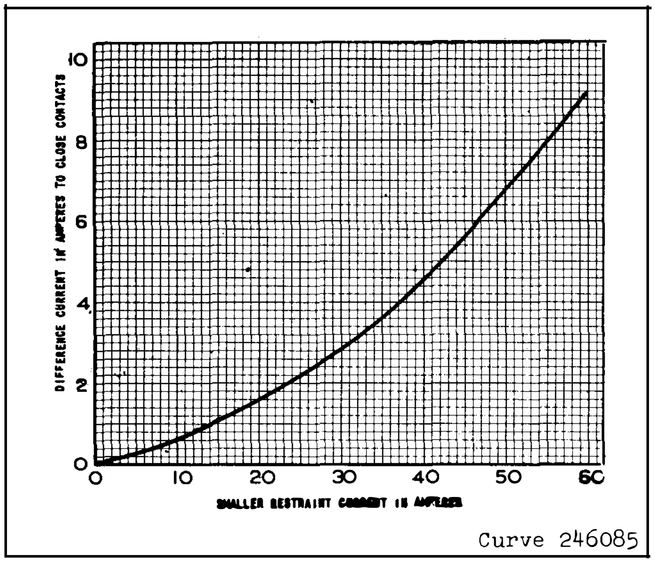


Fig. 3. Typical Variable Ratio Operating Curve Obtained with Test Connections of Figure 5 (No Control of Phase Angle).

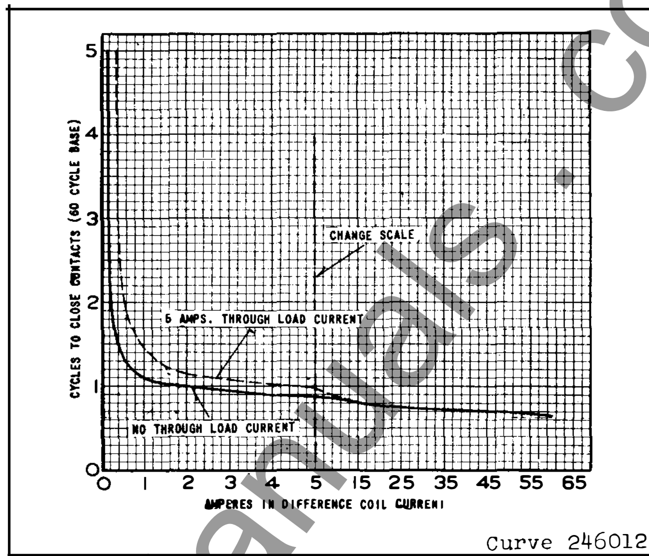


Fig. 4. Typical Time - Current Curve for the Differential Unit.

differential current flows into the operating coil of the differential unit to produce a contact closing torque. However, if the relay has been applied correctly, sufficient restraint torque will exist to prevent the relay contacts from closing. The saturating characteristic of the operating coil circuit limits the operating torque on heavy external faults where the performance of the two sets of current transformers may be quite different.

On internal faults the operating coil current is the sum of the current flowing in both halves of the center leg winding and sufficient operating torque is available to overcome the restraint torque even through the operating circuit saturates.

The contacts of the three fault detector units (one per phase) are connected in series with the differential unit contacts. The coils of the fault detectors are connected in parallel with the operating coils of the differential units. The relays are shipped with the differential units calibrated in conjunction with the fault detectors. Inasmuch as the restraint on the differential unit beam is proportional to the load current, the restraint which exists for light load conditions may be quite small, thus making the differential unit more susceptible to jars and vibrations. The fault detectors are provided to guard against a false trip operation due to the panel being jarred.

The coil of the contactor switch is connected in series with the main contacts of the relay and with the trip coil of the breaker. When the relay contacts close, the coil becomes energized and closes the switch contacts. This shunts the main relay contacts, thereby relieving them of the duty of carrying tripping current. These contacts remain closed until the trip circuit is opened by the auxiliary switch on the breaker.

CHARACTERISTICS

There are no taps on either the relay or the saturating transformer, and consequently, there are no settings to be made.

The characteristic curve is shown in figure 3.

The time curve of the relay is shown in figure 4.

The minimum pick-up of the relay, including the fault detector unit is 0.14 ampere.

The contactor switch operates on a minimum of 2.0 amperes, but the trip circuit should draw at least 4 or 5 amperes in order to keep the time of operation of the switch to a minimum and provide positive operation.

Trip Circuit

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

Trip Circuit Constant

Resistance of 1 ampere target 0.16 ohms
Resistance of 2 ampere contactor switch 0.25 ohms

ENERGY REQUIREMENTS

Restraint Coil Circuit

Continuous Rating	5 amperes
1 Second rating	200 amperes
Volt amperes @ 5 amperes	.20
Power Factor	0.64 lag

Operating Coil Circuit

Continuous rating	5 amperes
1 Second Rating	200 amperes
Volt Amperes Variable @ .5 amp.	13.0
@ 60 amp.	4200

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. 51-076.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory. Upon receipt of the relay, no adjustments should be required.

Receiving Acceptance

The following check is recommended to insure that the relay is in proper working order.

A. Differential Units

Connect the relay per test circuit of figure 7.

The differential units should operate between the values of I_O shown in table I for value of I_R.

Table I

I_R in Amperes	I_O in Amperes
0	0.11 to 0.15
5	0.20 to 0.28
60	7.8 to 10.6

B. Fault Detectors

The fault detectors should operate between the limits of I_O equal to 0.12 to 0.15 amperes.

C. Contactor Switch

Close the relay main contacts and the fault detector contacts. Pass sufficient d.c. current through the trip circuit to close the contacts of contactor switch. The switch should pick up at approximately 2 amperes d.c.

D. Operation Indicator

With the relay main contacts and the fault detector contacts closed, pass sufficient d.c. current through the trip circuit to operate the indicator. The indicator should operate at approximately 1 ampere d.c.

Routine Maintenance

All relays should be checked at least once every year or at such other time intervals as may be dictated by experience to be suitable to the particular application.

All contacts should be periodically cleaned. 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.

Repair Calibration

Use the following procedure for calibrating the relay if the relay has been taken apart for repairs or the adjustments disturbed. This procedure should not be used until it is apparent that the relay is not in proper working order (See "Receiving Acceptance").

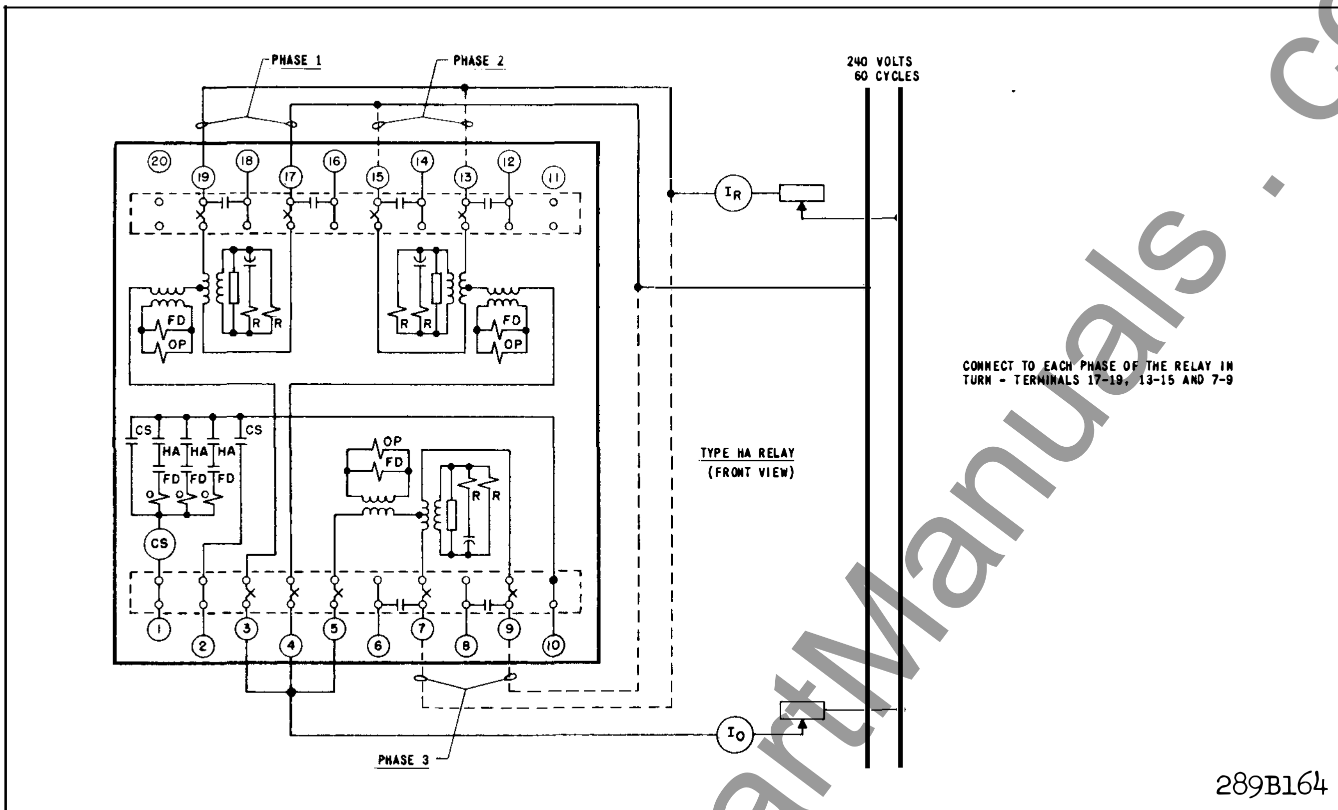
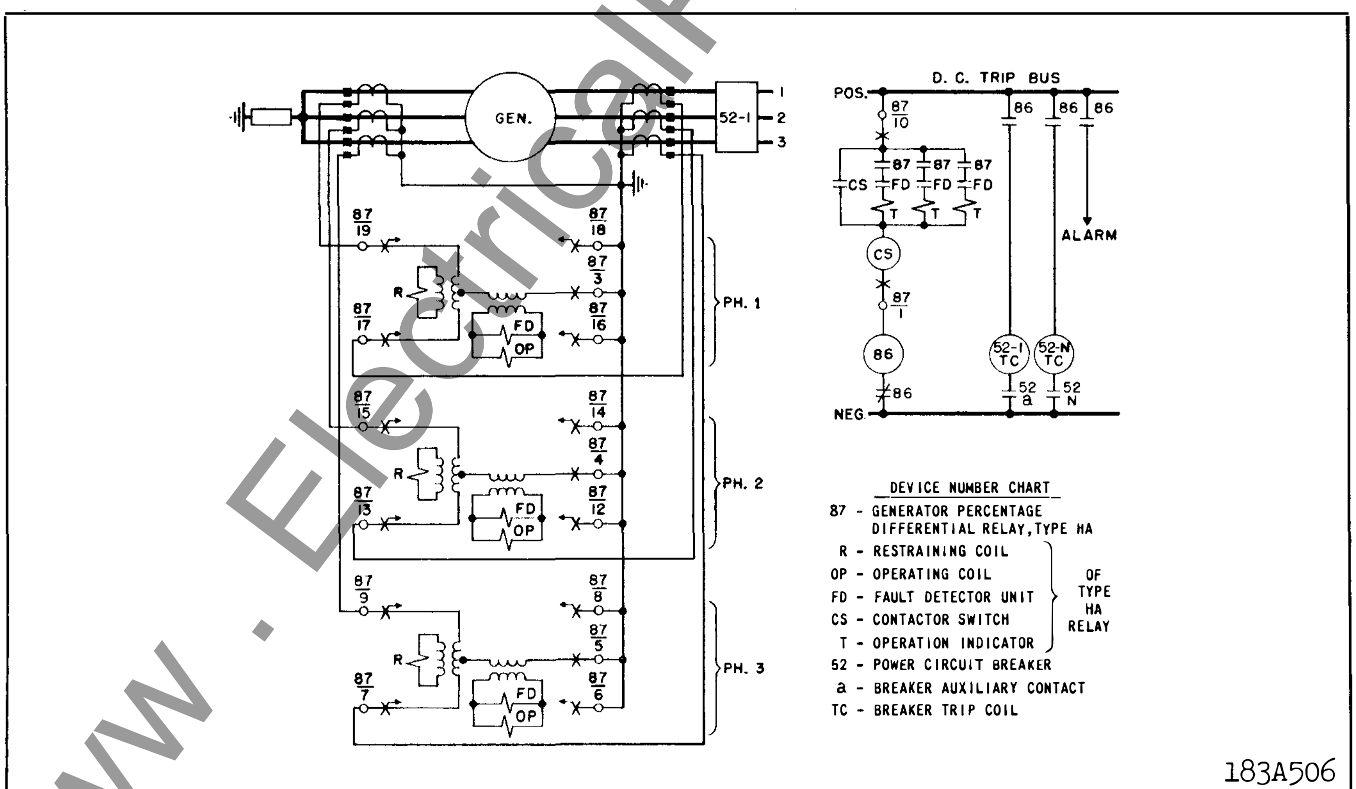


Fig. 5. Diagram of Test Connections



* *Fig. 6. External Schematic for the type HA Relay in the FT42 Case.*

Differential Unit (with fault detector)

Adjust the rear air gap between the iron of the two coils and the rear of the beam for .008 inch by means of the stop screw. Adjust the two air gaps between the adjustable iron and the beam for .004 inch. These are the air gaps between the two rear coils and the beam pivot. These adjustments of the gaps are preliminary and it will be found that the gaps are different from these measurements after final calibration for the 60 ampere point by means of the stop screw as described in the next paragraph.

Adjust the air gap between the front of the beam and the stop pin in the upper core screw for approximately .030 inch. Place a .010 feeler gauge in this gap and with the beam in the operated position adjust the stationary contact until it just touches the moving contact. Screw the lower core screw all the way up and then back off 3/4'' of a turn. Connect the relay as shown in figure 5, and adjust the stop screw at the rear of the beam until the beam trips at I_R = 60 amps., I_O = 7.8 to 10.2 amperes. Set the balance weight to give a minimum trip current of I_O = 0.125 amperes at I_R = 0. Then check the operating current I_O = 0.21 to 0.27 amperes at I_R = 5 amps., adjusting the core screw if necessary. If the core screw setting is changed to get the 5 ampere restraint point, then the 60 ampere restraint point should be rechecked and reset, as one adjustment affects the other.

Fault Detector

Loosen the lock nut at the top of the element and run the core screw down until it is flush with the top of the lock nut. Back off the Micarta disc by loosening the two lock nuts. In the test diagram of figure 7 adjust I_O to 0.14 ampere. Operate the moving element by hand and allow the current to hold the moving contact disc against the stationary contacts. Now, screw up the core screw slowly. This causes the plunger to move up, compressing the spring until a point of maximum deflection is reached. Further upward motion will cause the plunger to drop part way out of the coil, thus diminishing the spring pressure on the contacts. By thus adjusting the core screw up or down the maximum spring deflection for this value of current may be found. Then lock the core screw in place. Next, adjust the deenergized position of the plunger by raising the Micarta disc until the plunger just picks up electrically at the 0.14 ampere value.

Contactor Switch

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

Operation Indicator

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

RENEWAL PARTS

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

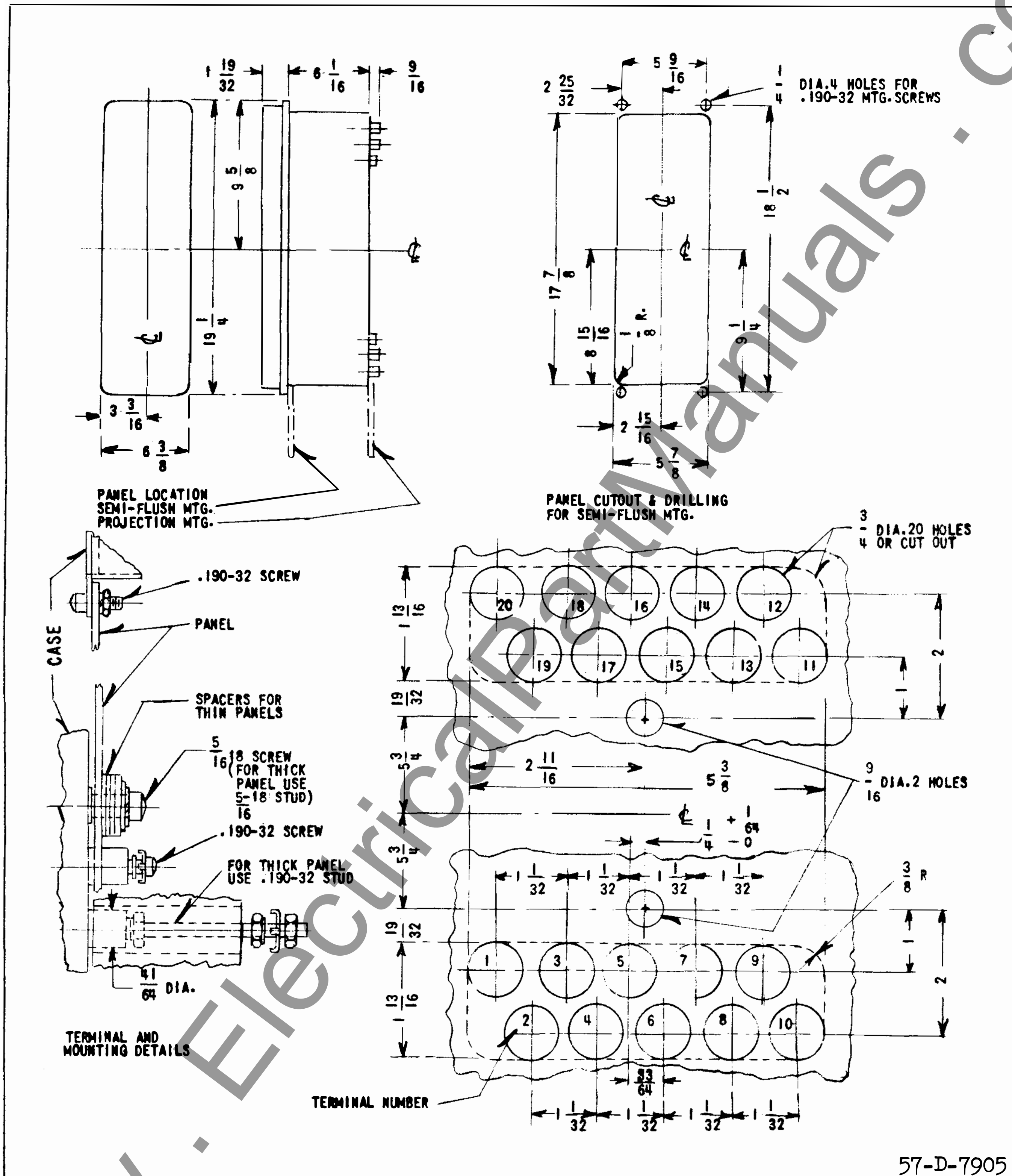


Fig. 7. Outline and Drilling Plan for the Type HA Relay in the FT42 Case.

WESTINGHOUSE ELECTRIC CORPORATION

RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**

Printed in U.S.A.

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APPLICATION

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N_P = proportion of total number of CT turns in use

V_{CL} = current transformer 10L accuracy class voltage

$$BF = \frac{1000\ R_B}{N_P V_{CL}}$$

R_B = resistance of the burden, excluding CT winding resistance.

For example, if the 400/5 tap of a 600/5 multi-ratio CT is used, $N_P = 400/600 = 0.67$. If this CT has a 10L200 rating, $V_{CL} = 200$, and the burden should not exceed:

$$\frac{N_P V_{CL}}{133} = \frac{0.67 \times 200}{133} = 1.0 \text{ ohm}$$

Assuming a resistance burden of $R_B = 0.5$ ohms, the burden factor, BF, is:

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The other set of CT's may then have a burden factor as high as 2 x 3.8 = 7.6, or as low as 1/2 x 3.8 = 1.9. If the other set of CT's also has a burden of 0.5 ohms, a 10L100, 10L200, or 10L400 rating would be satisfactory, since the burden factors are 7.6, 3.8 and 1.9, respectively.

In calculating the burden, use the one way lead burden.

* If the operating current can exceed 100 amps, runs symmetrical neglecting CT saturation, varistor protection is recommended to limit voltage stress in the relay circuits. CT saturation will not limit the voltage spikes that are produced each half cycle as the CT comes out of saturation: Size the varistor to limit the peak voltage to 1600 volts at the maximum expected current, neglecting CT saturation and assuming all CT current flowing in the varistor. Connect the varistors across the CT windings carrying the majority of the current, or across the relay terminals (e.g. 19 to 18, 15 to 14, 9 to 8). Where the full winding of a bushing CT is not used, the CT insulation stress across the full winding will be increased due to the autotransformer action. In this case the insulation strength of the CT may be the limiting.

CONSTRUCTION

The type HA relay consists of three differential units, three saturating transformers, three fault detectors, an auxiliary contactor switch, and three operation indicators.

Differential Units

A beam of magnetic material, pivoted in the center is pulled down on the contact end by a cur-

SUPERSEDES I.L. 41-341.1C
*Denotes change from superseded issue.

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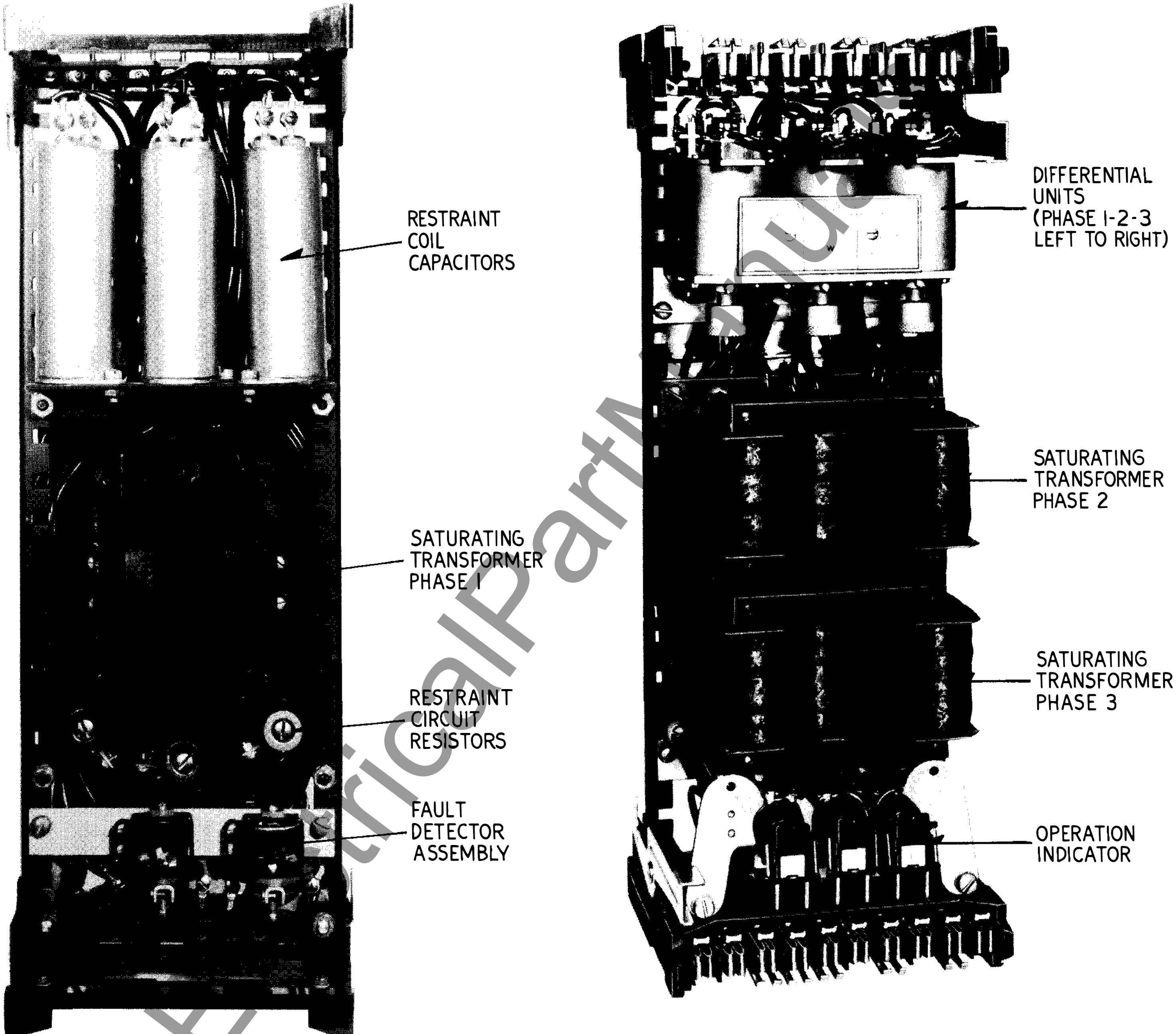


Fig. 1. Type HA Relay — Removed from case.

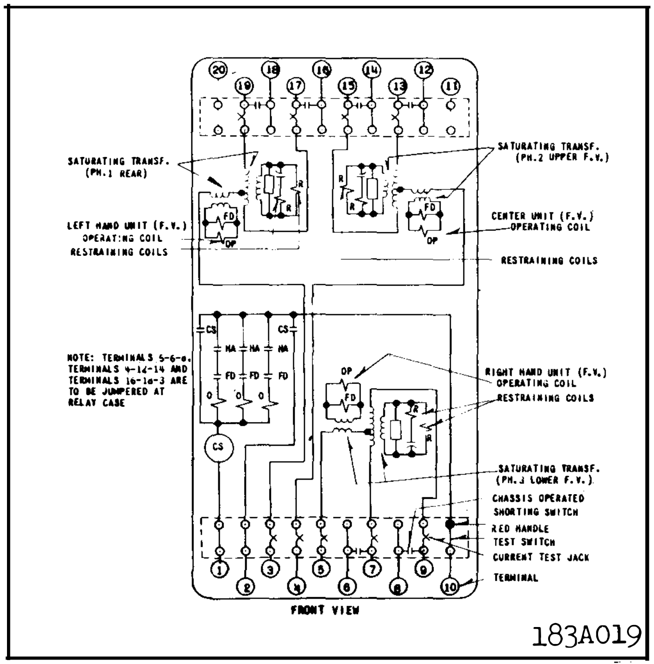


Fig. 2. Internal Schematic of the Type HA Relay in the FT42 Case.

rent-operating coil. This force is opposed by a restraining force produced by two restraining coils acting on the other end of the beam. One restraining coil is connected in series with a capacitor and this combination in parallel with the other coil. The capacitor shifts the phase angle of one of the restraining circuits so that a uniform restraint is provided at all parts of the cycle.

The moving contact is a hollow, silver egg-shaped capsule partially filled with tungsten powder and is mounted on the beam. When this contact strikes the rigid stationary contact, the movement of the tungsten powder creates sufficient friction to absorb practically all the energy of impact. Thus, the tendency of the contact to bounce is reduced to a minimum. This moving contact projects thru a Micarta arm and is free to move against a leaf spring, thus providing contact follow. With this construction the beam continues to move slightly after the contacts close, thus deflecting the leaf spring. Current is conducted into the moving contact by means of an extremely flexible metal ribbon.

Fault Detector

The fault detector is a small solenoid type element. A cylindrical plunger rides up and down on a vertical guide rod in the center of the solenoid coil. The guide rod is fastened to the stationary core, which in turn screws into the unit frame. A silver disc is fastened to the moving plunger through a helical spring. When the coil is energized, the plunger moves upward carrying the silver disc which bridges three conical-shaped stationary contacts. In this position, the helical spring is compressed and the plunger is free to move while the contact remains stationary. Thus, a-c vibrations of the plunger are prevented from causing contact bouncing. A Micarta disc is fastened to the bottom of the guide rod by two small nuts. Its position determines the pick-up current of the element.

Saturating Transformer

The saturating transformer consists of three primary windings wound on a three-legged magnetic circuit. One primary winding is wound on the center leg of the transformer and the other primary windings are wound on the outer legs of the transformer. The outer leg primary windings are connected in series to a center tap on the center leg winding. A secondary winding is associated with each primary winding. The secondary winding of the center leg is connected to the restraint coils of the differential unit while the secondary winding of the outer legs is connected to the operating coils of the differential unit. The outer legs of the transformer are designed to saturate to limit the energy delivered to the operating coil of the differential unit.

Contactor Switch

The contactor switch is similar to the fault detector element except that the coil and magnetic circuits are designed for direct-current instead of alternating current. This makes it unnecessary to have the helical spring, so the silver disc is fastened directly to the moving plunger.

Operation Indicator

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

The primary windings of the saturating transformers are connected to the protected equipment as shown in figure 6. On external faults, the fault current flows through the center leg winding to cause a current to flow in the secondary windings connected to the restraint coils of the differential unit. As a result, a restraint or contact opening torque is produced on the differential unit. If the two sets of generator current transformers have different characteristics, a differential current will flow in the outer leg coils of the saturating transformer. By transformer action, this

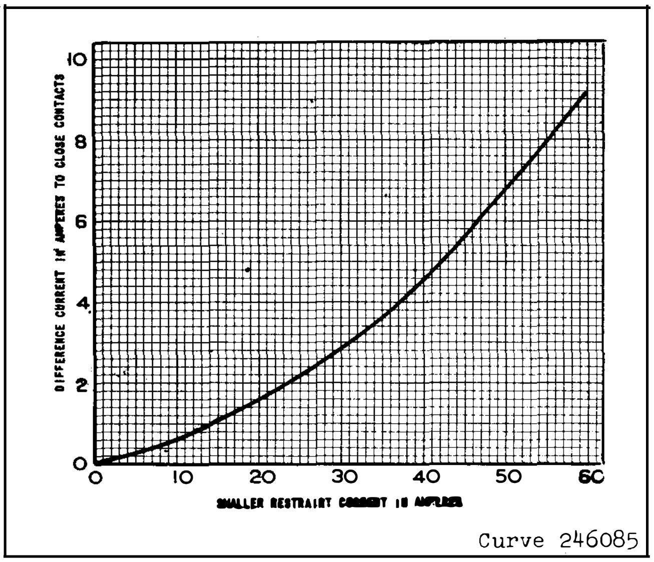


Fig. 3. Typical Variable Ratio Operating Curve Obtained with Test Connections of Figure 5 (No Control of Phase Angle).

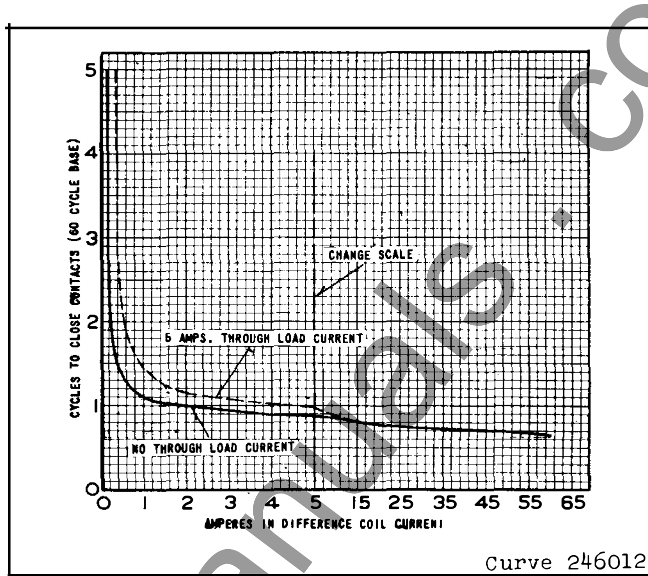


Fig. 4. Typical Time - Current Curve for the Differential Unit.

differential current flows into the operating coil of the differential unit to produce a contact closing torque. However, if the relay has been applied correctly, sufficient restraint torque will exist to prevent the relay contacts from closing. The saturating characteristic of the operating coil circuit limits the operating torque on heavy external faults where the performance of the two sets of current transformers may be quite different.

On internal faults the operating coil current is the sum of the current flowing in both halves of the center leg winding and sufficient operating torque is available to overcome the restraint torque even through the operating circuit saturates.

The contacts of the three fault detector units (one per phase) are connected in series with the differential unit contacts. The coils of the fault detectors are connected in parallel with the operating coils of the differential units. The relays are shipped with the differential units calibrated in conjunction with the fault detectors. Inasmuch as the restraint on the differential unit beam is proportional to the load current, the restraint which exists for light load conditions may be quite small, thus making the differential unit more susceptible to jars and vibrations. The fault detectors are provided to guard against a false trip operation due to the panel being jarred.

The coil of the contactor switch is connected in series with the main contacts of the relay and with the trip coil of the breaker. When the relay contacts close, the coil becomes energized and closes the switch contacts. This shunts the main relay contacts, thereby relieving them of the duty of carrying tripping current. These contacts remain closed until the trip circuit is opened by the auxiliary switch on the breaker.

CHARACTERISTICS

There are no taps on either the relay or the saturating transformer, and consequently, there are no settings to be made.

The characteristic curve is shown in figure 3.

The time curve of the relay is shown in figure 4.

The minimum pick-up of the relay, including the fault detector unit is 0.14 ampere.

The contactor switch operates on a minimum of 2.0 amperes, but the trip circuit should draw at least 4 or 5 amperes in order to keep the time of operation of the switch to a minimum and provide positive operation.

Trip Circuit

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

Trip Circuit Constant

Resistance of 1 ampere target 0.16 ohms
Resistance of 2 ampere contactor switch 0.25 ohms

ENERGY REQUIREMENTS

Restraint Coil Circuit

Continuous Rating	5 amperes
1 Second rating	200 amperes
Volt amperes @ 5 amperes	.20
Power Factor	0.64 lag

Operating Coil Circuit

Continuous rating	5 amperes
1 Second Rating	200 amperes
Volt Amperes Variable @ .5 amp.	13.0
@ 60 amp.	4200

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. 51-076.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory. Upon receipt of the relay, no adjustments should be required.

Receiving Acceptance

The following check is recommended to insure that the relay is in proper working order.

A. Differential Units

Connect the relay per test circuit of figure 7.

The differential units should operate between the values of I_O shown in table I for value of I_R.

Table I

I_R in Amperes	I_O in Amperes
0	0.11 to 0.15
5	0.20 to 0.28
60	7.8 to 10.6

B. Fault Detectors

The fault detectors should operate between the limits of I_O equal to 0.12 to 0.15 amperes.

C. Contactor Switch

Close the relay main contacts and the fault detector contacts. Pass sufficient d.c. current through the trip circuit to close the contacts of contactor switch. The switch should pick up at approximately 2 amperes d.c.

D. Operation Indicator

With the relay main contacts and the fault detector contacts closed, pass sufficient d.c. current through the trip circuit to operate the indicator. The indicator should operate at approximately 1 ampere d.c.

Routine Maintenance

All relays should be checked at least once every year or at such other time intervals as may be dictated by experience to be suitable to the particular application.

All contacts should be periodically cleaned. 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.

Repair Calibration

Use the following procedure for calibrating the relay if the relay has been taken apart for repairs or the adjustments disturbed. This procedure should not be used until it is apparent that the relay is not in proper working order (See "Receiving Acceptance").

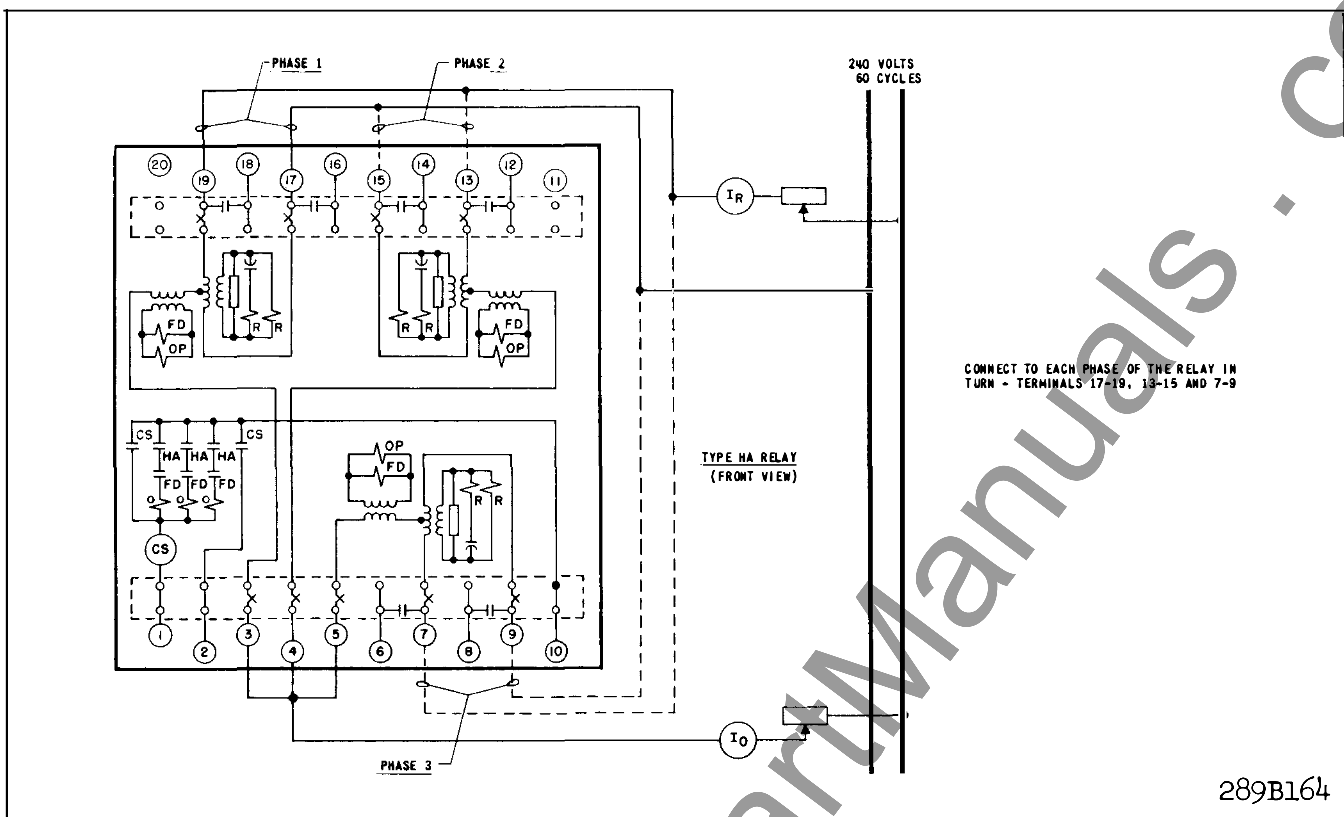
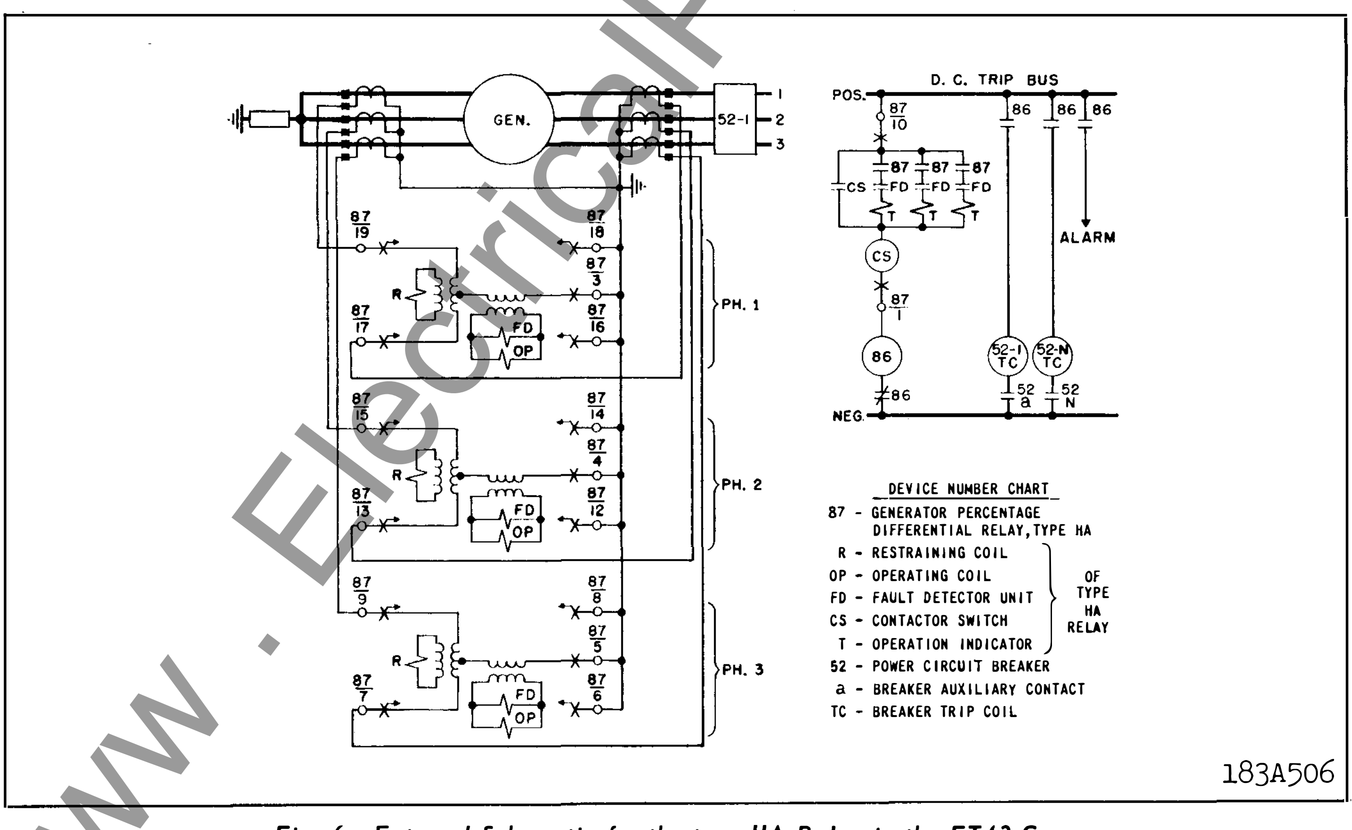


Fig. 5. Diagram of Test Connections



* *Fig. 6. External Schematic for the type HA Relay in the FT42 Case.*

Differential Unit (with fault detector)

Adjust the rear air gap between the iron of the two coils and the rear of the beam for .008 inch by means of the stop screw. Adjust the two air gaps between the adjustable iron and the beam for .004 inch. These are the air gaps between the two rear coils and the beam pivot. These adjustments of the gaps are preliminary and it will be found that the gaps are different from these measurements after final calibration for the 60 ampere point by means of the stop screw as described in the next paragraph.

Adjust the air gap between the front of the beam and the stop pin in the upper core screw for approximately .030 inch. Place a .010 feeler gauge in this gap and with the beam in the operated position adjust the stationary contact until it just touches the moving contact. Screw the lower core screw all the way up and then back off 3/4'' of a turn. Connect the relay as shown in figure 5, and adjust the stop screw at the rear of the beam until the beam trips at I_R = 60 amps., I_o = 7.8 to 10.2 amperes. Set the balance weight to give a minimum trip current of I_o = 0.125 amperes at I_R = 0. Then check the operating current I_o = 0.21 to 0.27 amperes at I_R = 5 amps., adjusting the core screw if necessary. If the core screw setting is changed to get the 5 ampere restraint point, then the 60 ampere restraint point should be rechecked and reset, as one adjustment affects the other.

Fault Detector

Loosen the lock nut at the top of the element and run the core screw down until it is flush with the top of the lock nut. Back off the Micarta disc by loosening the two lock nuts. In the test diagram of figure 7 adjust I_o to 0.14 ampere. Operate the moving element by hand and allow the current to hold the moving contact disc against the stationary contacts. Now, screw up the core screw slowly. This causes the plunger to move up, compressing the spring until a point of maximum deflection is reached. Further upward motion will cause the plunger to drop part way out of the coil, thus diminishing the spring pressure on the contacts. By thus adjusting the core screw up or down the maximum spring deflection for this value of current may be found. Then lock the core screw in place. Next, adjust the deenergized position of the plunger by raising the Micarta disc until the plunger just picks up electrically at the 0.14 ampere value.

Contactor Switch

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

Operation Indicator

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

RENEWAL PARTS

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

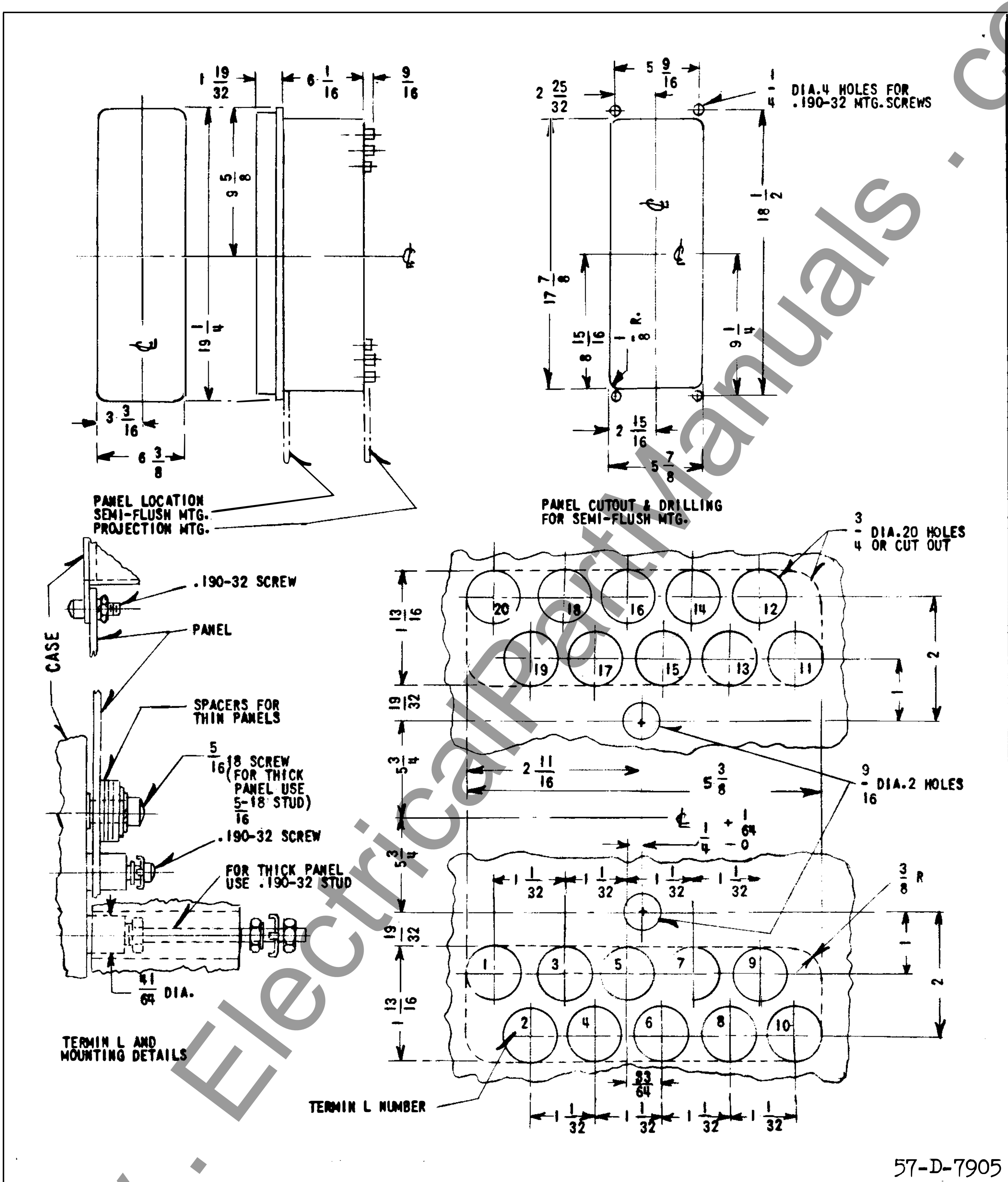


Fig. 7. Outline and Drilling Plan for the Type HA Relay in the FT42 Case.

WESTINGHOUSE ELECTRIC CORPORATION

RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE HA GENERATOR DIFFERENTIAL RELAY

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

APPLICATION

The type HA relays are balanced-beam type relays used for the differential protection of a-c generators and synchronous motors. The relays operate in one cycle (60-cycle per second bases) and are designed so that they are unaffected by d-c transients associated with asymmetrical through short-circuit currents.

The type HA relays may be applied when there is considerable difference between current transformer performance on the two sides of the machine. The limits of variation in the output of these current transformers which will still allow ample safety factors may be determined as follows.

Current transformer burden in ohms should not exceed $(N_P V_{CL})/133$; further the burden factor, BF, should not differ by more than a 2 to 1 ratio between the two sets of CT's. The above terms are defined as:

N_P = proportion of total number of CT turns in use

V_{CL} = current transformer 10L accuracy class voltage

$$BF = \frac{1000\ R_B}{N_P V_{CL}}$$

R_B = resistance of the burden, excluding CT winding resistance.

For example, if the 400/5 tap of a 600/5 multi-ratio CT is used, $N_P = 400/600 = 0.67$. If this CT has a 10L200 rating, $V_{CL} = 200$, and the burden should not exceed:

$$\frac{N_P V_{CL}}{133} = \frac{0.67 \times 200}{133} = 1.0 \text{ ohm}$$

Assuming a resistance burden of $R_B = 0.5$ ohms, the burden factor, BF, is:

$$BF = \frac{1000\ R_B}{N_P V_{CL}} = \frac{1000 \times 0.5}{0.67 \times 200} = 3.8$$

The other set of CT's may then have a burden factor as high as 2 x 3.8 = 7.6, or as low as 1/2 x 3.8 = 1.9. If the other set of CT's also has a burden of 0.5 ohms, a 10L100, 10L200, or 10L400 rating would be satisfactory, since the burden factors are 7.6, 3.8 and 1.9, respectively.

In calculating the burden, use the one way lead burden.

CONSTRUCTION

The type HA relay consists of three differential units, three saturating transformers, three fault detectors, an auxiliary contactor switch, and three operation indicators.

Differential Units

A beam of magnetic material, pivoted in the center is pulled down on the contact end by a current-operating coil. This force is opposed by a restraining force produced by two restraining coils acting on the other end of the beam. One restraining coil is connected in series with a capacitor and this combination in parallel with the other coil. The capacitor shifts the phase angle of one of the restraining circuits so that a uniform restraint is provided at all parts of the cycle.

The moving contact is a hollow, silver egg-shaped capsule partially filled with tungsten powder and is mounted on the beam. When this contact strikes the rigid stationary contact, the movement of the tungsten powder creates sufficient friction to absorb practically all the energy of impact. Thus, the tendency of the contact to bounce is reduced to a minimum. This moving contact projects thru a Micarta arm and is free to move against a leaf spring, thus providing contact follow. With this construction

SUPERSEDES I.L. 41-341.1B
*Denotes change from superseded issue.

EFFECTIVE DECEMBER 1964

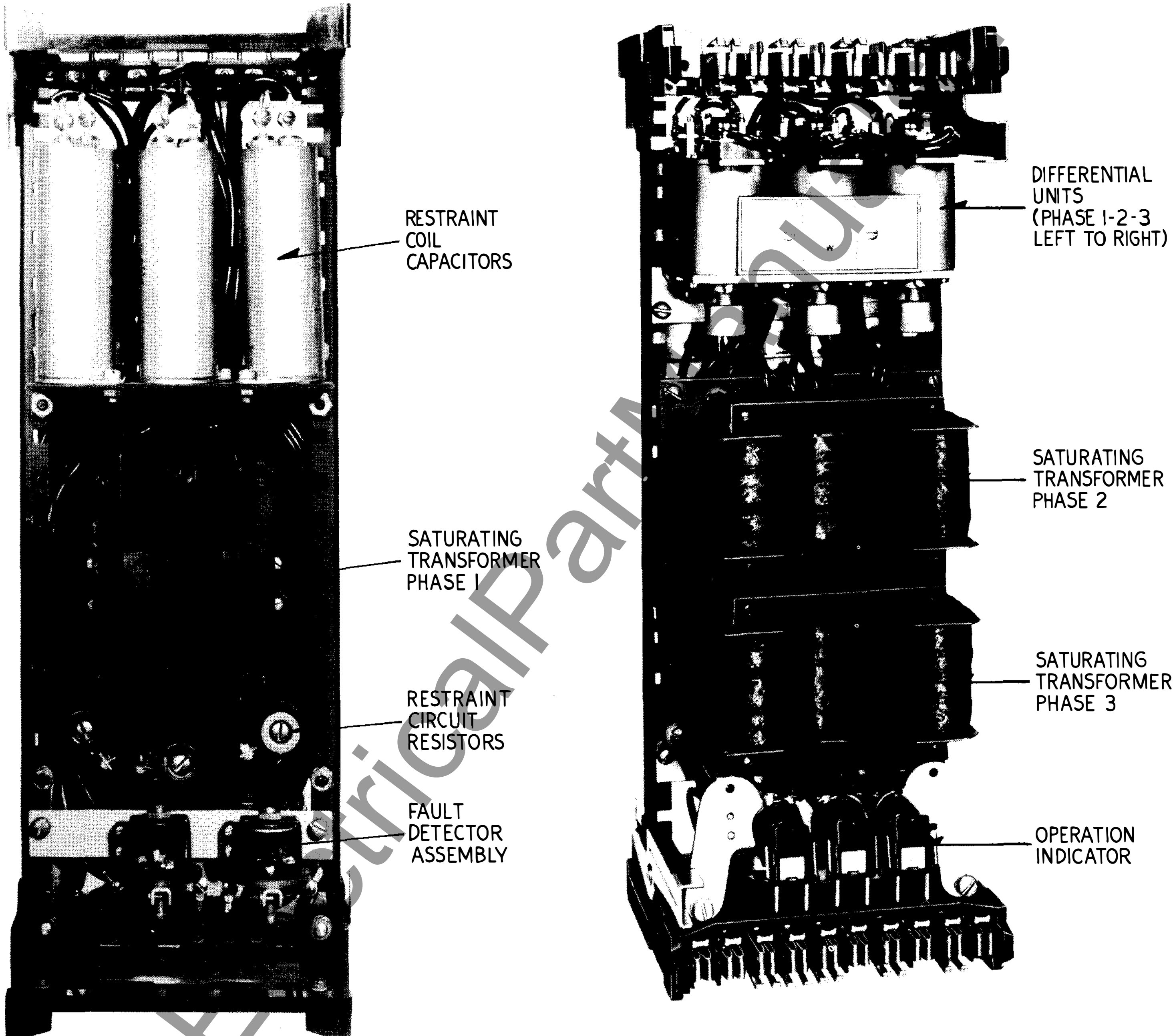


Fig. 1. Type HA Relay — Removed from case.

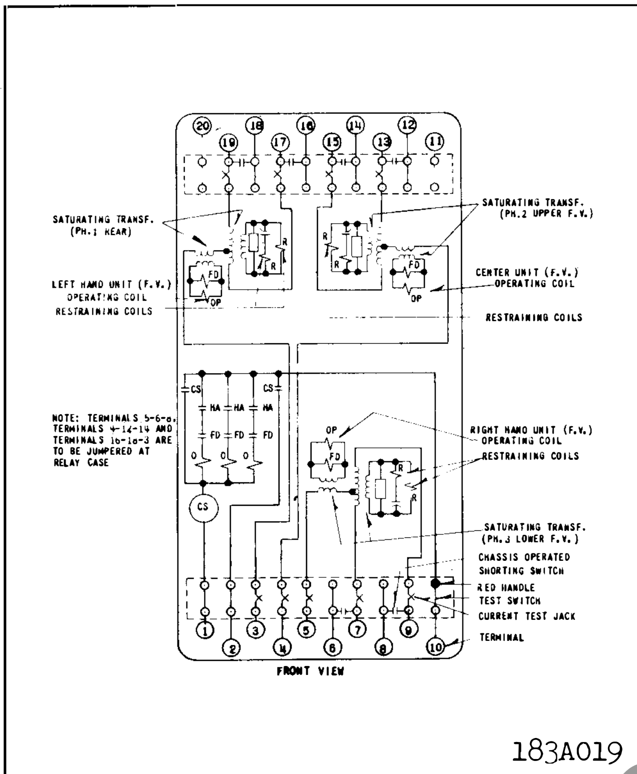


Fig. 2. Internal Schematic of the Type HA Relay in the FT42 Case.

the beam continues to move slightly after the contacts close, thus deflecting the leaf spring. Current is conducted into the moving contact by means of an extremely flexible metal ribbon.

Fault Detector

The fault detector is a small solenoid type element. A cylindrical plunger rides up and down on a vertical guide rod in the center of the solenoid coil. The guide rod is fastened to the stationary core, which in turn screws into the unit frame. A silver disc is fastened to the moving plunger through a helical spring. When the coil is energized, the plunger moves upward carrying the silver disc which bridges three conical-shaped stationary contacts. In this position, the helical spring is compressed and the plunger is free to move while the contact remains stationary. Thus, a-c vibrations of the plunger are prevented from causing contact bouncing. A Micarta disc is fastened to the bottom of the guide rod by two small nuts. Its position determines the pick-up current of the element.

Saturating Transformer

The saturating transformer consists of three primary windings wound on a three-legged magnetic circuit. One primary winding is wound on the center leg of the transformer and the other primary windings are wound on the outer legs of the transformer. The outer leg primary windings are connected in series to a center tap on the center leg winding. A secondary winding is associated with each primary winding. The secondary winding of the center leg is connected to the restraint coils of the differential unit while the secondary winding of the outer legs is connected to the operating coils of the differential unit. The outer legs of the transformer are designed to saturate to limit the energy delivered to the operating coil of the differential unit.

Contoctor Switch

The contactor switch is similar to the fault detector element except that the coil and magnetic circuits are designed for direct-current instead of alternating current. This makes it unnecessary to have the helical spring, so the silver disc is fastened directly to the moving plunger.

Operation Indicator

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

The primary windings of the saturating transformers are connected to the protected equipment as shown in figure 6. On external faults, the fault current flows through the center leg winding to cause a current to flow in the secondary windings connected to the restraint coils of the differential unit. As a result, a restraint or contact opening torque is produced on the differential unit. If the two sets of generator current transformers have different characteristics, a differential current will flow in the outer leg coils of the saturating transformer. By transformer action, this differential current flows into the operating coil of the differential unit to produce a contact closing torque. However, if the relay has been applied correctly, sufficient restraint torque will exist to prevent the relay contacts from closing. The saturating characteristic of the operating coil circuit limits the operating torque on heavy external faults where the performance of the two sets of current transformers may be quite different.

On internal faults the operating coil current is the sum of the current flowing in both halves of the

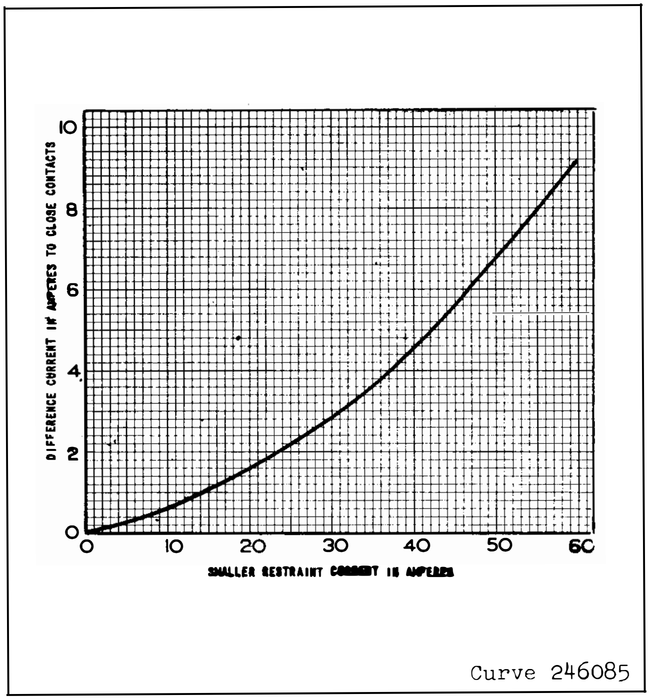


Fig. 3. Typical Variable Ratio Operating Curve Obtained with Test Connections of Figure 5 (No Control of Phase Angle).

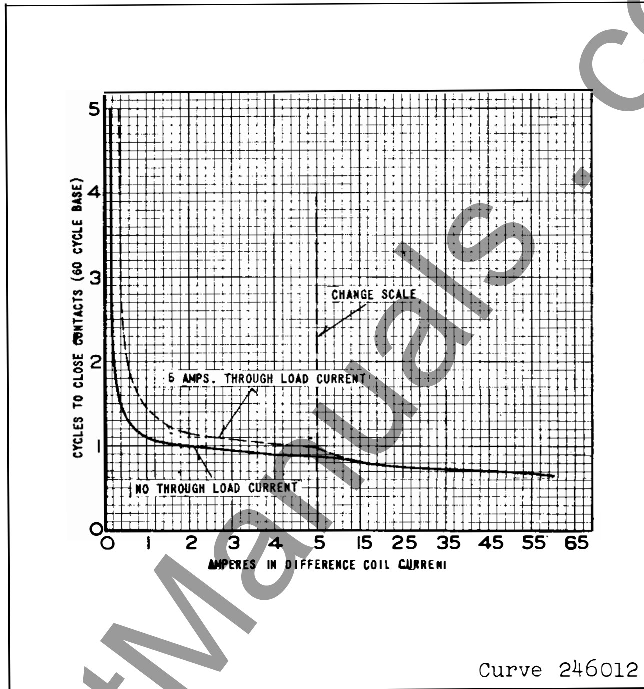


Fig. 4. Typical Time - Current Curve for the Differential Unit.

center leg winding and sufficient operating torque is available to overcome the restraint torque even through the operating circuit saturates.

The contacts of the three fault detector units (one per phase) are connected in series with the differential unit contacts. The coils of the fault detectors are connected in parallel with the operating coils of the differential units. The relays are shipped with the differential units calibrated in conjunction with the fault detectors. Inasmuch as the restraint on the differential unit beam is proportional to the load current, the restraint which exists for light load conditions may be quite small, thus making the differential unit more susceptible to jars and vibrations. The fault detectors are provided to guard against a false trip operation due to the panel being jarred.

The coil of the contactor switch is connected in series with the main contacts of the relay and with the trip coil of the breaker. When the relay contacts close, the coil becomes energized and closes the switch contacts. This shunts the main relay contacts, thereby relieving them of the duty of carrying tripping current. These contacts remain closed until the trip circuit is opened by the auxiliary switch on the breaker.

CHARACTERISTICS

There are no taps on either the relay or the saturating transformer, and consequently, there are no settings to be made.

The characteristic curve is shown in figure 3.

* The time curve of the relay is shown in figure 4.

The minimum pick-up of the relay, including the fault detector unit is 0.14 ampere.

The contactor switch operates on a minimum of 2.0 amperes, but the trip circuit should draw at least 4 or 5 amperes in order to keep the time of operation of the switch to a minimum and provide positive operation.

Trip Circuit

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

Trip Circuit Constant

Resistance of 1 ampere target	0.16 ohms
Resistance of 2 ampere contactor switch	0.25 ohms

ENERGY REQUIREMENTS

Restraint Coil Circuit

Continuous Rating	5 amperes
1 Second rating	200 amperes
Volt amperes @ 5 amperes	.20
Power Factor	0.64 lag

Operating Coil Circuit

Continuous rating		5 amperes
1 Second Rating		200 amperes
Volt Amperes Variable	@ .5 amp.	13.0
	@ 60 amp.	4200

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. 51-076.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory. Upon receipt of the relay, no adjustments should be required.

Receiving Acceptance

The following check is recommended to insure that the relay is in proper working order.

A. Differential Units

Connect the relay per test circuit of figure 7.

The differential units should operate between the values of I_O shown in table I for value of I_R.

Table I

I_R in Amperes	I_O in Amperes
0	0.11 to 0.15
5	0.20 to 0.28
60	7.8 to 10.6

B. Fault Detectors

The fault detectors should operate between the limits of I_O equal to 0.12 to 0.15 amperes.

C. Contactor Switch

Close the relay main contacts and the fault detector contacts. Pass sufficient d.c. current through the trip circuit to close the contacts of contactor switch. The switch should pick up at approximately 2 amperes d.c.

D. Operation Indicator

With the relay main contacts and the fault detector contacts closed, pass sufficient d.c. current through the trip circuit to operate the indicator. The indicator should operate at approximately 1 ampere d.c.

Routine Maintenance

All relays should be checked at least once every year or at such other time intervals as may be dictated by experience to be suitable to the particular application.

All contacts should be periodically cleaned. 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.

Repair Calibration

Use the following procedure for calibrating the relay if the relay has been taken apart for repairs or the adjustments disturbed. This procedure should not be used until it is apparent that the relay is not in proper working order (See "Receiving Acceptance").

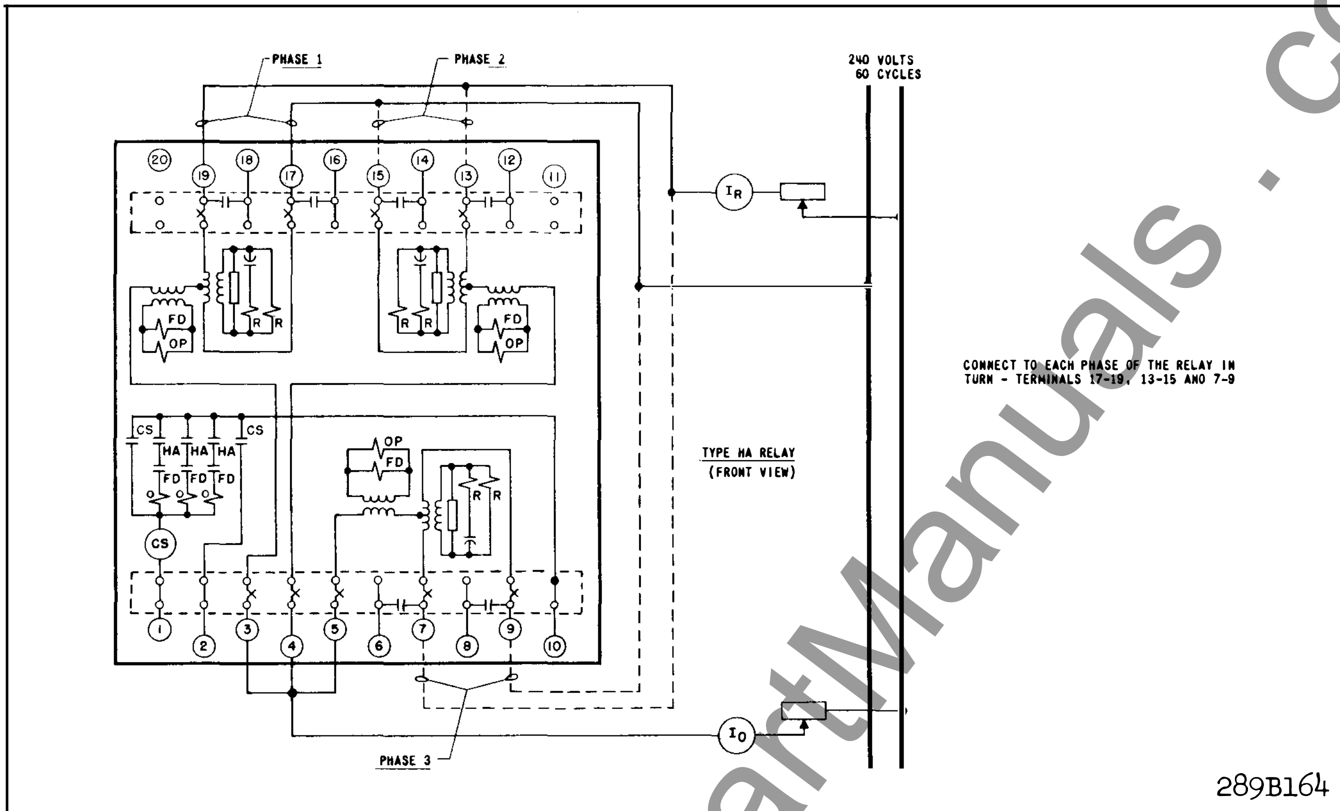


Fig. 5. Diagram of Test Connections

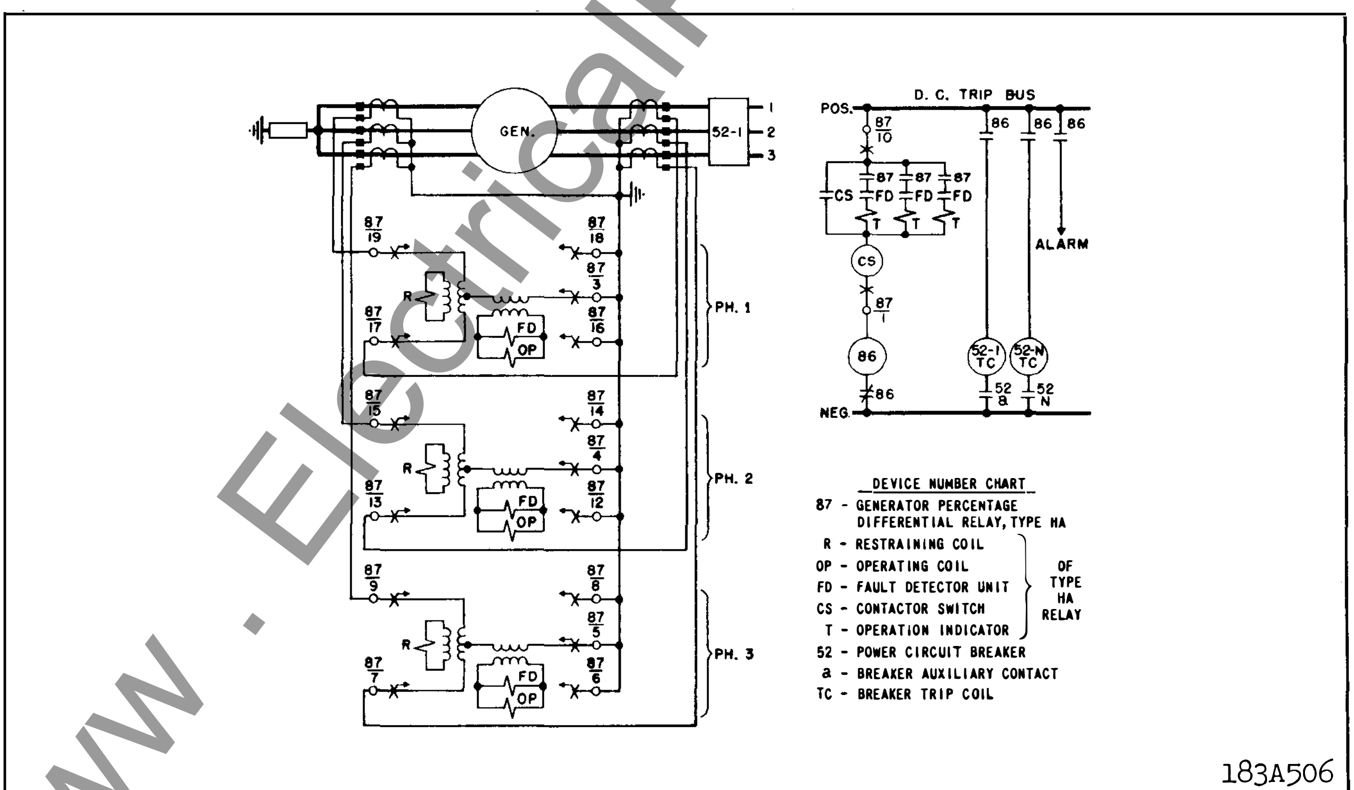


Fig. 6. External Schematic for the type HA Relay in the FT42 Case.

Differential Unit (with fault detector)

Adjust the rear air gap between the iron of the two coils and the rear of the beam for .008 inch by means of the stop screw. Adjust the two air gaps between the adjustable iron and the beam for .004 inch. These are the air gaps between the two rear coils and the beam pivot. These adjustments of the gaps are preliminary and it will be found that the gaps are different from these measurements after final calibration for the 60 ampere point by means of the stop screw as described in the next paragraph.

Adjust the air gap between the front of the beam and the stop pin in the upper core screw for approximately .030 inch. Place a .010 feeler gauge in this gap and with the beam in the operated position adjust the stationary contact until it just touches the moving contact. Screw the lower core screw all the way up and then back off 3/4'' of a turn. Connect the * relay as shown in figure 5, and adjust the stop screw at the rear of the beam until the beam trips at I_R = 60 amps., I_o = 7.8 to 10.2 amperes. Set the balance weight to give a minimum trip current of I_o = 0.125 amperes at I_R = 0. Then check the operating current I_o = 0.21 to 0.27 amperes at I_R = 5 amps., adjusting the core screw if necessary. If the core screw setting is changed to get the 5 ampere restraint point, then the 60 ampere restraint point should be rechecked and reset, as one adjustment affects the other.

Fault Detector

Loosen the lock nut at the top of the element and run the core screw down until it is flush with the top of the lock nut. Back off the Micarta disc by loosening the two lock nuts. In the test diagram of figure 7 adjust I_o to 0.14 ampere. Operate the moving element by hand and allow the current to hold the moving contact disc against the stationary contacts. Now, screw up the core screw slowly. This causes the plunger to move up, compressing the spring until a point of maximum deflection is reached. Further upward motion will cause the plunger to drop part way out of the coil, thus diminishing the spring pressure on the contacts. By thus adjusting the core screw up or down the maximum spring deflection for this value of current may be found. Then lock the core screw in place. Next, adjust the deenergized position of the plunger by raising the Micarta disc until the plunger just picks up electrically at the 0.14 ampere value.

Contactor Switch

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

Operation Indicator

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

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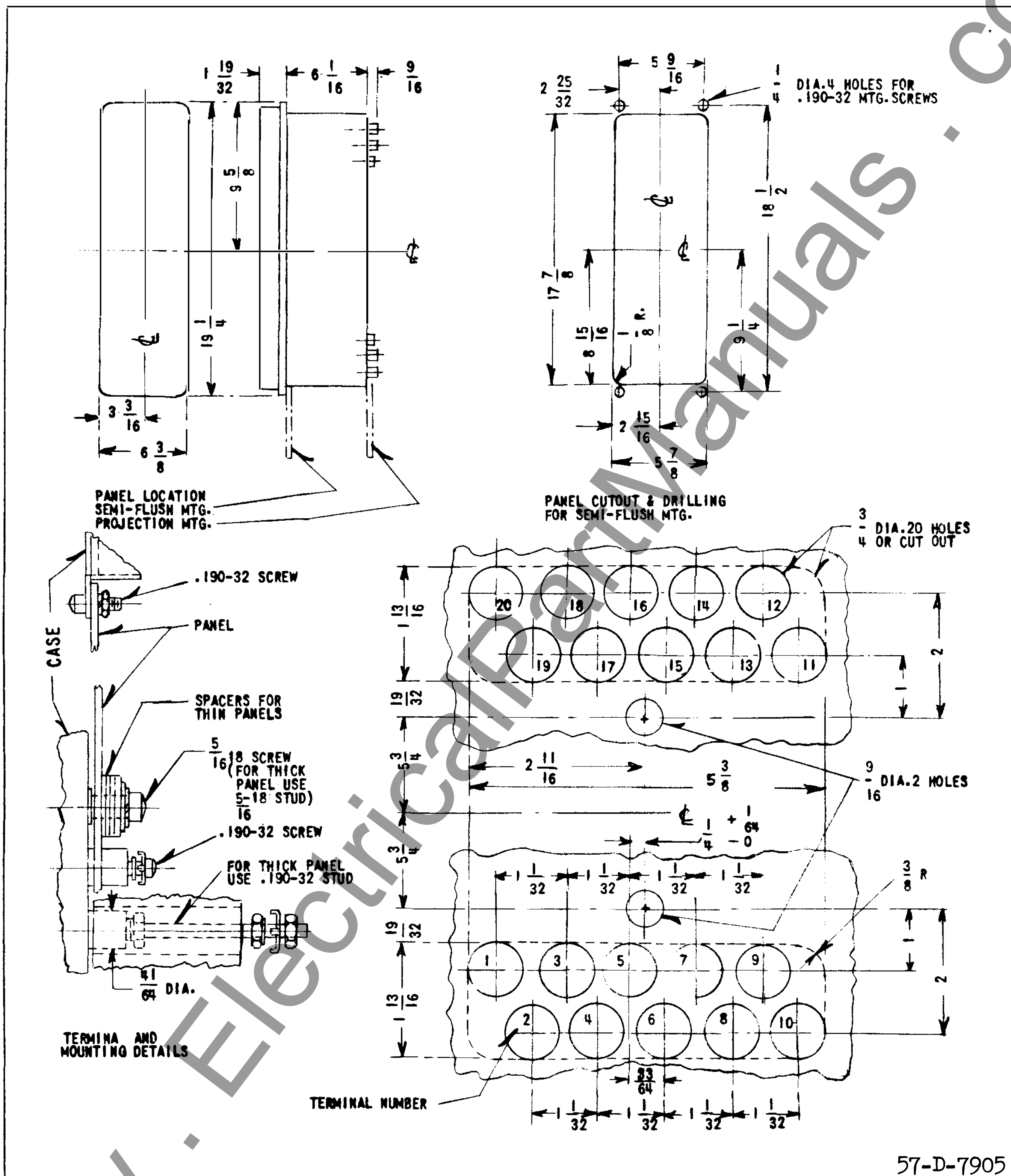

Fig. 7. Outline and Drilling Plan for the Type HA Relay in the FT42 Case.

WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION NEWARK, N. J.
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MEMORANDUM
WESTINGHOUSE FORM 2478 K

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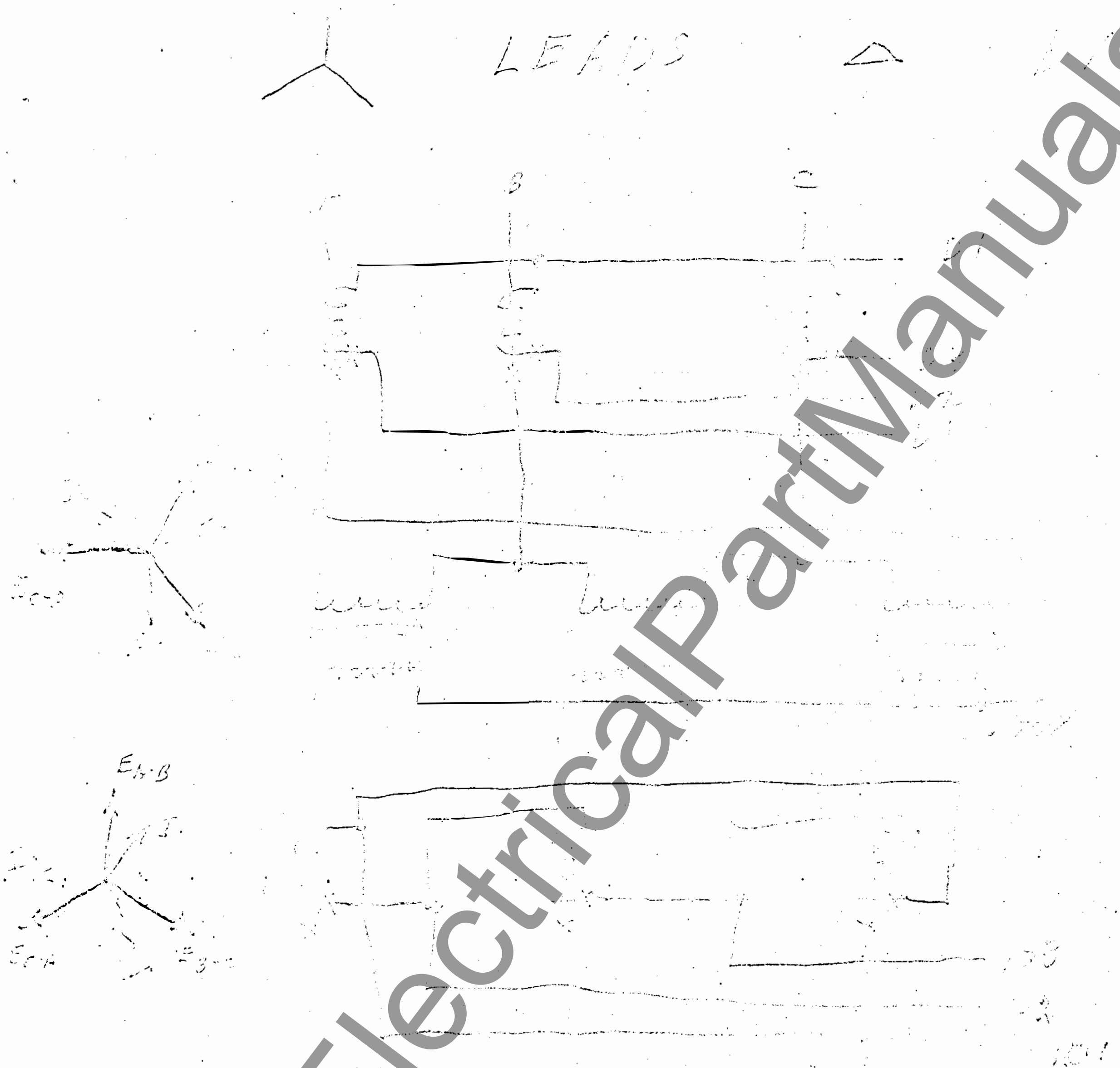
SUBJECT



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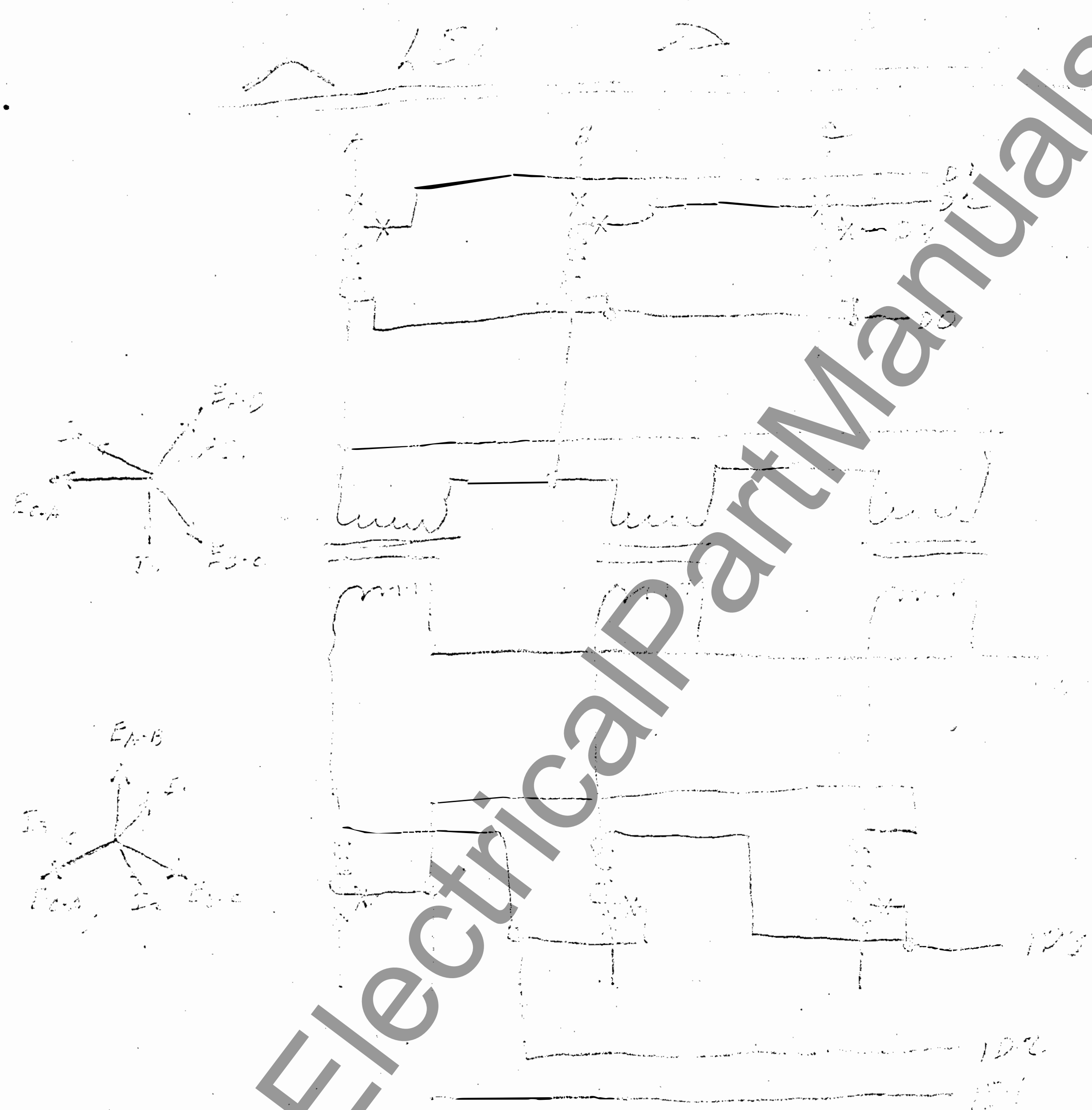

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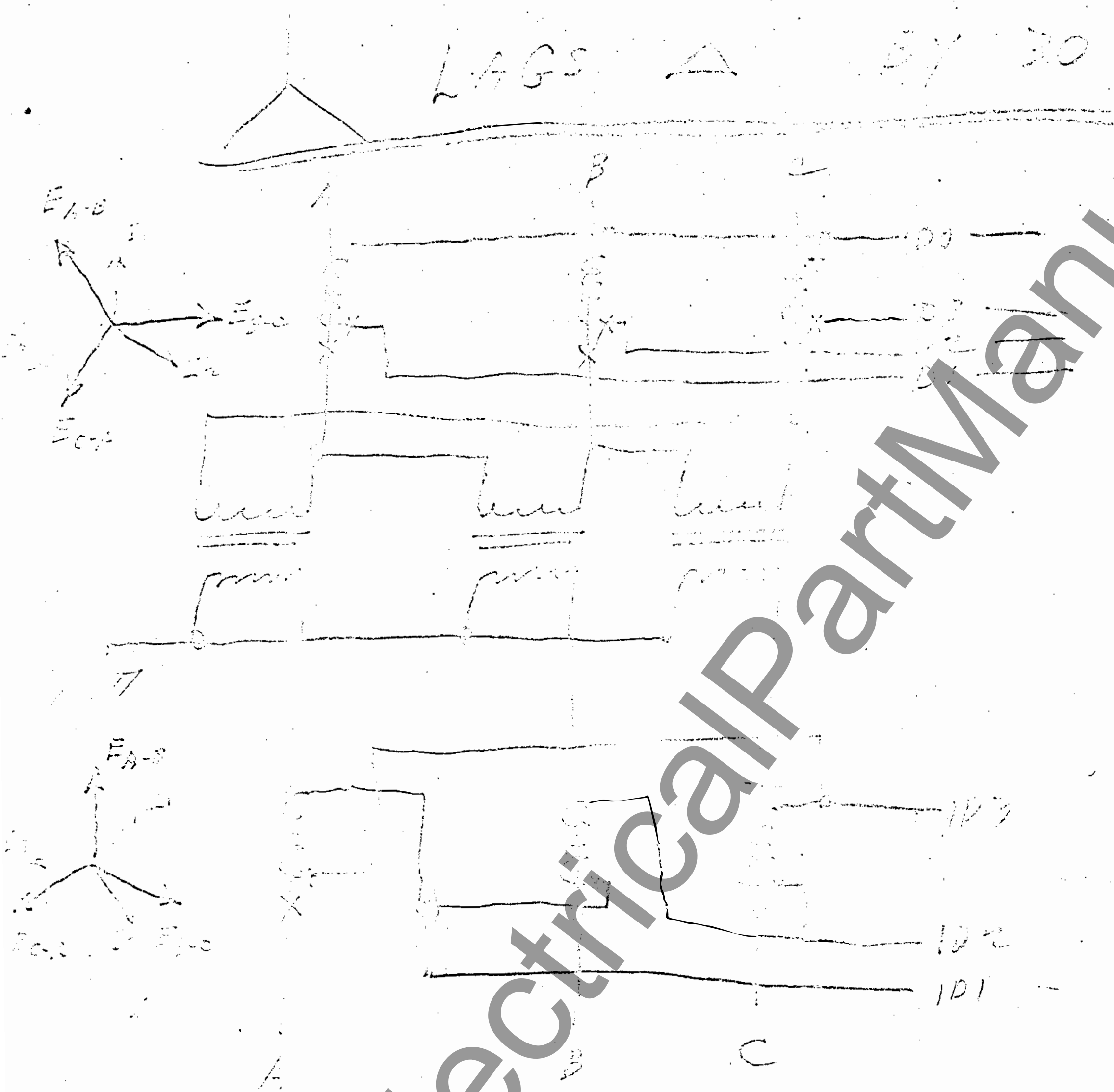

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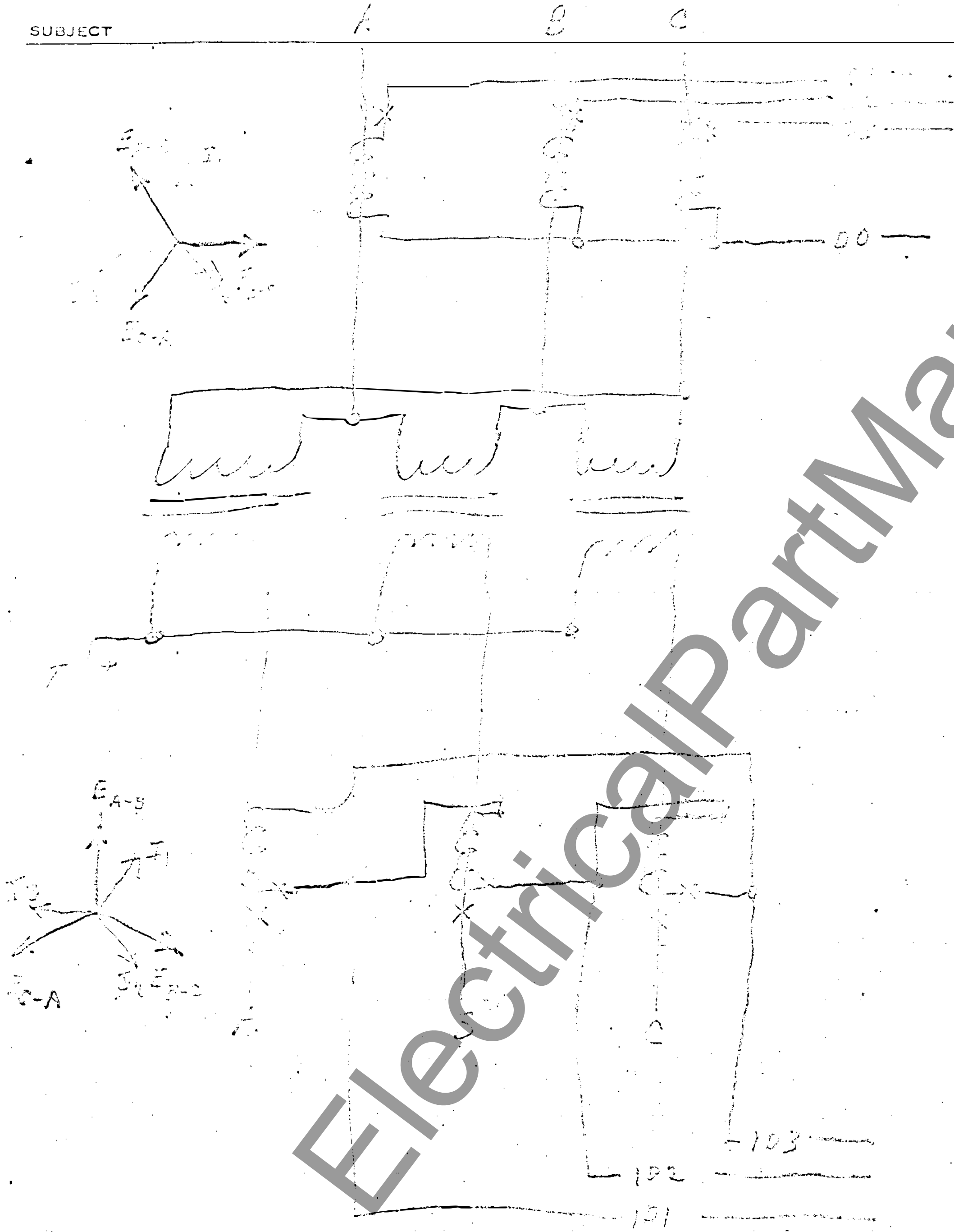

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