DESCRIPTION • OPERATION • MAINTENANCE

INSTRUCTIONS

THERMAL RELAY
TYPE TRO-1
With Overload Indicating Dial

FIG. 1. Front View of TRO-1 Relay

THE TYPE TRO-1 THERMAL RELAY, used on power transformers of all types, combines the initiation of automatic cooling equipment with overload protection and thermal load indication.

The first two bimetal-operated switches, in the order of increasing winding temperature, are generally used for the initiation of successive stages of auxiliary cooling while the No. 3 contact is used for remote alarm or tripping of a circuit breaker upon excess overload. On transformers using only one stage of auxiliary cooling the No. 2 contact (as a general rule) is unused.

Regardless of how the relay is applied, a yellow indicating pointer shows continuously the operating position of the relay relative to the zones of unsafe operation and gives a reference reading expressed in "percent thermal load". A red resettable maximum indicator registers the highest attained position of the indicator needle since the last resetting. Fig. 1 shows the external appearance of the dial-equipped relay.

The relay is designed for operation by winding temperature. It uses a bimetal thermal element which is heated in part by the top oil and in part by a heater coil carrying current proportional to the load in the main winding. It is factory-applied to each transformer. Proper selection of heater current and switch operating temperatures causes the relay to perform its functions at predetermined winding temperatures.

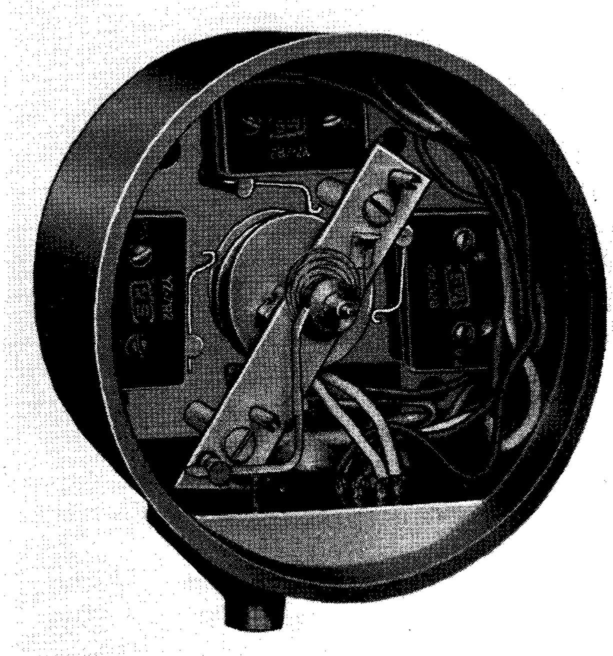

FIG. 2. Internal View of TRO-1 Relay Case

DESCRIPTION

The internal construction of the TRO-1 relay housing is shown in Fig. 2. The thermal element

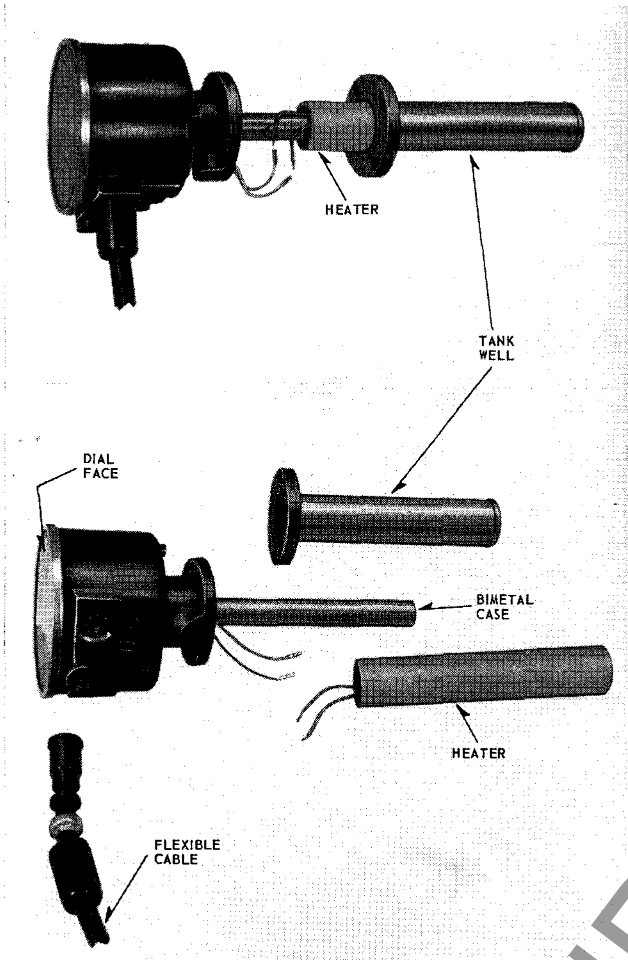

FIG. 3. Assembly of TRO-1 relay, tank well, heater coil and cable attachment

consists of a spiral bimetal that is held stationary at the inner end and is coupled to a shaft at the other end. There are three eccentric cams on the shaft that engage the tripping arms on the three micro-switches in sequence as the shaft turns. The bimetal and operating shaft are enclosed in a steel tube mounted on the relay base as seen in Fig. 3. An indicator shaft is directly coupled without intermediate gearing to the main operating shaft.

The bimetal case is surrounded outside the tube by a heating coil wound on a Micarta® tube and supplied with current from a source proportional to the transformer winding current.

Calibration of the micro-switches can be accomplished from the outside of the case by engaging any of three set screws with a special calibration tool. The calibration entrance holes are located adjacent to the cable connector socket as seen in Fig. 5.

All contacts are automatically self-resetting, but the No. 3 contact (when used for breaker tripping) is made self-sealing by an auxiliary SG relay. For contact duty rating of the micro-switches and SG relay, see Table No. 1.

The bezel or outer assembly shown in Fig. 1 features a spun-on cover to assure a hermetic seal against the elements and includes a 5½" dial with indicating needle, maximum hand, and reset mechanism. The dial is marked to show the percentage thermal loading and, since the relay is always designed for a particular transformer's thermal characteristics, the greatest recommended loading coincides with the 100% index mark on the thermal load scale. On all dials the No. 3 switch or "Trip" switch closes at approximately the 110% scale mark, coincidental with the highest permissible thermal loading. The maximum hand is resettable by means of a pushbutton projecting out through the bottom of the dial bezel. The button is spring-loaded so as to return to its inoperative position when released.

The relay well is mounted on the tank wall and extends within the transformer case (see Fig. 4) in the hot oil zone. The relay base is bolted to the well flange so that the relay can be removed without

Table No. 1

INTERRUPTING RATINGS OF SWITCHES IN AMPERES

	A.C.		D.C.			
			Non-Inductive Load		Inductive Load L/R ≦ .026*	
	125 V.	250 V.	125 V.	250 V.	125 V.	250 V.
TRO-1 Micro-Switches	10	5	.5	.25	.05	.025
SG Auxil. Relay	30	20	2.4	.75	2.4	.75

* For L/R ratio greater than .026 refer to factory for adjusted rating.

taking the transformer out of service or lowering the oil.

The control circuit leads are brought through the underside of the case by means of an 8-conductor plug-in cable attachment, the details of which are shown in Figure 5. This connector consists of the following items of which items 2 and 3 form a sub-assembly:

1. Eight protruding terminals moulded in the case and a locator key to prevent making incorrect connections.

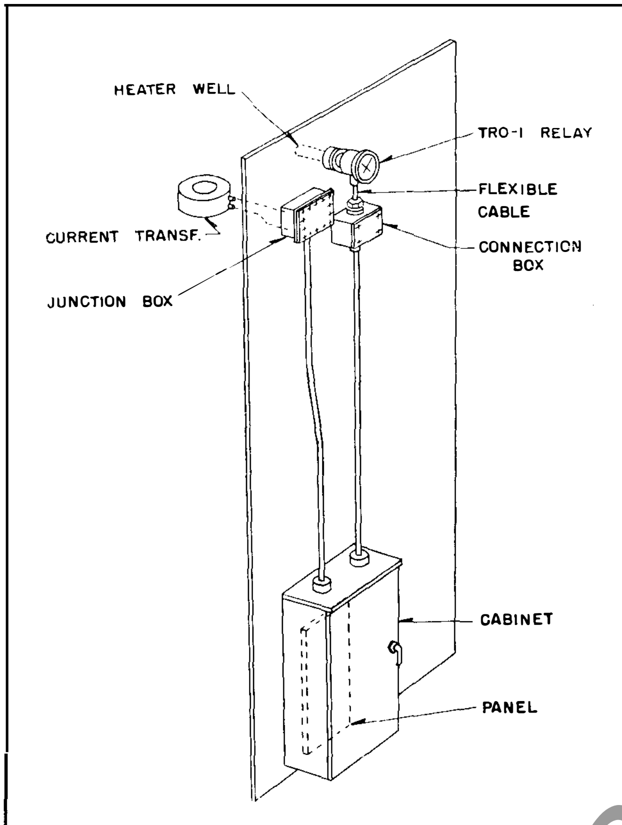

FIG. 4. TRO-1 Relay Mounted on Transformer Wall

2. A rubber insulator which has eight terminals to mate with the terminals in the case, and a hole to match the locating pin. The ends of the cable leads are soldered to the terminals of the insulator.

3. A bushing to compress the insulator against the instrument case. Wax surrounds the wires within the cavity formed by the bushing.

4. A grommet to make a seal between the rubber covered cable and the bushing.

5. A ring to compress the grommet against the cable.

6. A retaining nut, to hold the component parts of connector tight in the case. This retaining nut is screwed into place.

A test switch is provided on the control panel in the control cabinet (see Fig. 4) so that the relay may be tested while the transformer is in service.

INSTALLATION

In most cases, the relay will be shipped mounted on the transformer and will be ready for operation. If for any reason the relay is shipped separately, the well will be installed so that the relay can be added in the field without opening the transformer or breaking the seal. For separate shipping, a blind flange will be bolted to the well flange and a screwed cap will be fitted into the tapped hole in the relay for the cable connection. The relay and heater coil will be shipped already assembled in a dummy well or protective case.

The relay requires no special attention at the time of installation other than a superficial inspection to assure that there has been no shipping damage. Give the relay the care in handling due any precision instrument. **Do not at any time handle the relay by the bimetal protective tube.** Undue strain on this part may be sufficient to throw the unit out of calibration.

To Install the Relay When Shipped Detail:

1. Remove the blind flange from the tank well.

2. Remove the metal protective tube from the relay heater assembly and retain for future use.

3. Rotate heater assembly on bimetal tube until the wires coil into rear flange recess, then insert relay and heater coil in tank well. Bolt securely against the gasket.

4. Remove the protective cap from tapped hole in base of relay case and retain for future use.

5. Plug the flexible cable into the relay socket and screw retaining nut on end of cable securely into tapped hole.

6. Push the mechanical reset knob upward to reset maximum hand on face of relay dial.

7. The flexible cable is normally shipped with one end already wired into a connector box or tank

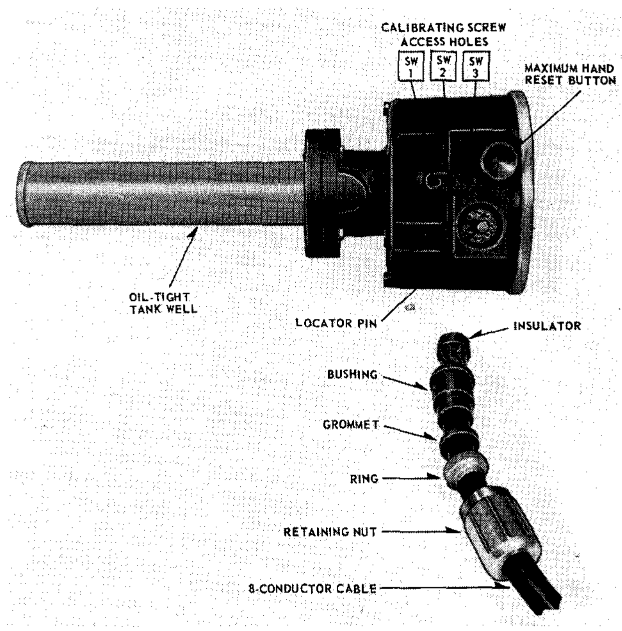

FIG. 5. Bottom View of TRO-1 Relay showing Cable Connector and Socket

brace. In those cases where the cable is shipped as a detail item, it will be necessary to strip back the insulation and join the cable leads to the other control leads as per the wiring diagram furnished with the unit (see also Fig. 8). Among the details shipped with each cable will be a Pyle-National entrance fitting, a set of splicing terminals, and a cable entrance reference drawing for aid to installation.

NOTE: When detaching the cable from the relay with the unit in service, first be sure to short-circuit the current transformer by means of a test switch provided on the panel.

OPERATION

When the transformer and the relay are first energized the dial needle will be below the lowest scale reading. Barring unusually high ambient temperature conditions, when the transformer is loaded at rated kva the needle will seek a position still somewhat below the 100% scale mark.

As shown in Fig. 6, for continuous overloads there is a proportional difference between the temperature of the relay bimetal and the top oil. When the oil temperature plus this difference equals the temperature for any contact adjustment setting, the bimetal will have turned the cam engaging the switch arm and will have closed that particular micro-switch contact. Since the temperature difference between bimetal and top oil is in relation to the current, the relay operation is coordinated with the actual hot spot winding temperature. In order to permit hot spot temperatures under various conditions of loading in line with ASA Recommended Practices for Overloading Transformers, this bimetal temperature difference is purposely made less than the expected hot spot temperature difference of the winding.

Refer again to Fig. 6 and the typical thermal relationships existing in a transformer equipped with thermal overload relay S#1800 770. Each point on the curves represents the ultimate temperature that would exist in a typical transformer if the load were carried continuously. The hot spot temperature can be assumed to follow the upper curve while that of the thermal relay bimetal would follow the middle curve. A temperature of 105 degrees C. is generally regarded as the top limit above which continued operation of Class A insulation would involve some loss of life above normal. When the hot spot temperature reaches 104 degrees C. under these conditions, the corresponding relay bimetal temperature is 90 degrees C. at which point the relay dial indicates 100% Thermal Load. Any increase in the load which raises the hot spot winding temperature to about the 115 degree level will raise the relay bimetal temperature to 100 degrees, at which time the relay closes a contact that may be used to trip the unit off the line. The implication here is that any continuous operation above the 115 degree mark would involve excessive loss of insulation life.

The temperature limits just mentioned apply only when held continuous for 24 hours. Much higher temperatures are permitted for shorter times with an equal loss of life. Attaining the 100% level of loading indicates that the transformer is just passing into the zone of moderate loss of life, regardless of the size and duration of the preceding overload.

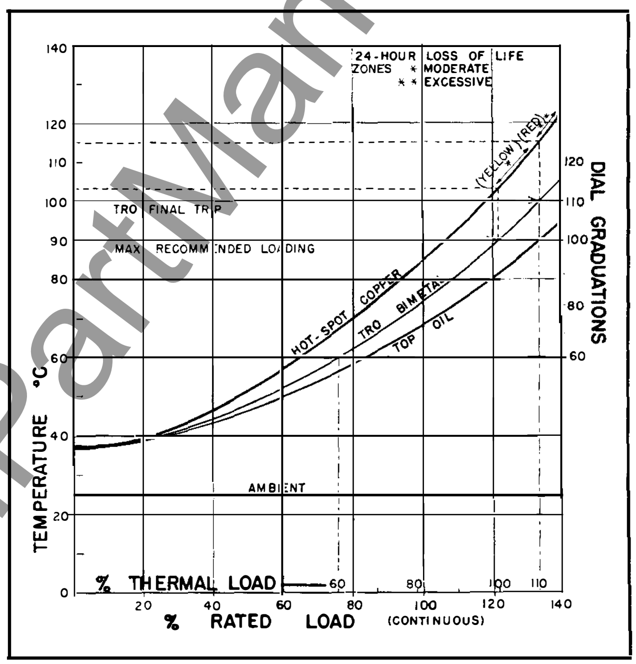

FIG. 6. Typical Thermal Relationships, shown for Relay S#1800 770 at 25°C. Ambient

Fig. 7 shows a typical connection for this relay as used with three-phase air blast fan motors. When the TRO-1 relay is used without fan control, 115 or 230 volts alternating current must be connected to the control bus. When more than one relay is used, like contacts are paralleled in the control circuit. Current is supplied to the heater coil from a 5-ampere secondary current transformer (mounted in the transformer tank) through a small multi-ratio saturating current transformer mounted in the control cabinet. The saturating current transformer limits the current to the heater on a short-circuit and hence retards the heating to give a time delay characteristic to the relay and allow other protective devices to operate first on overcurrent.

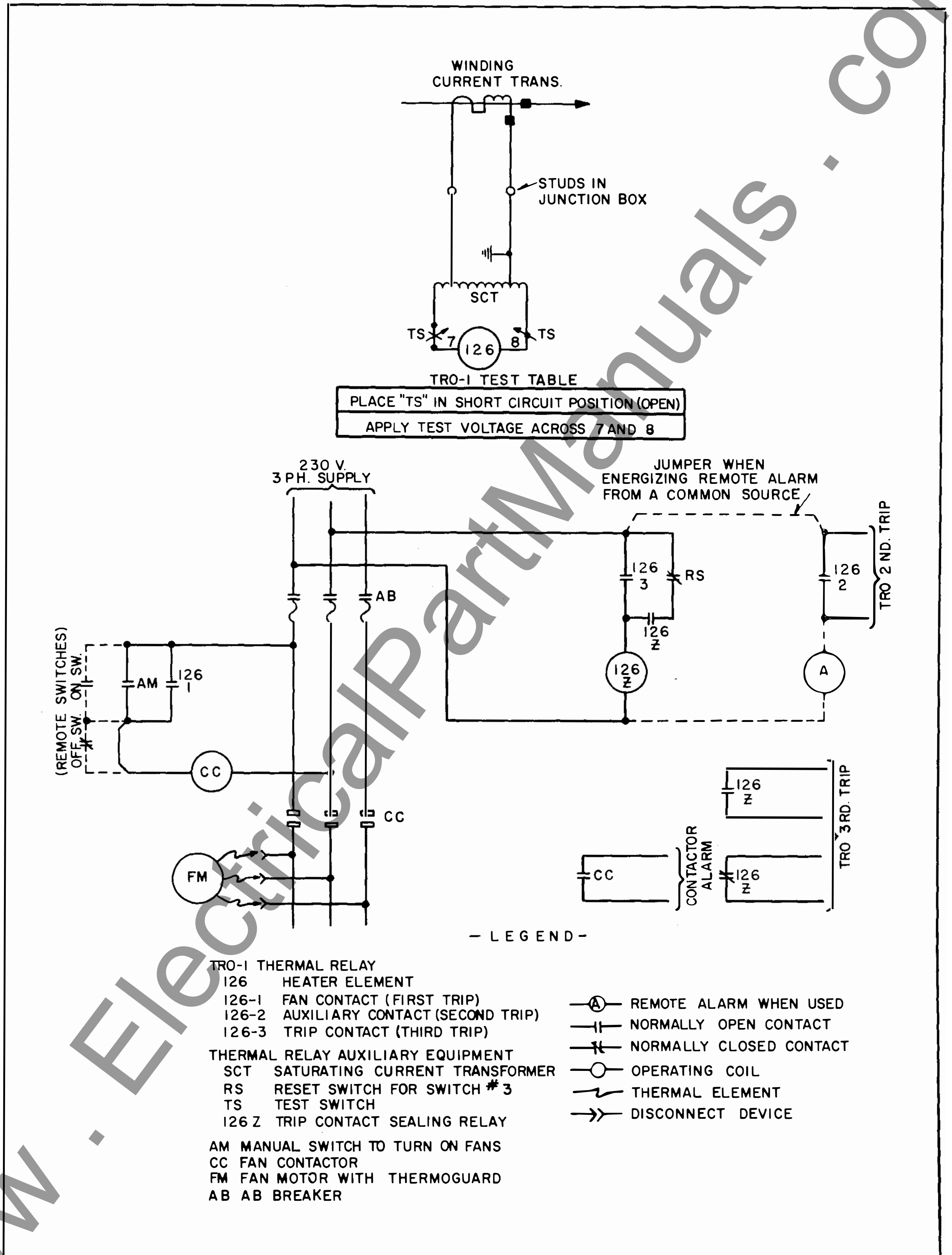

FIG. 7. Typical Connections of TRO-1 Relay

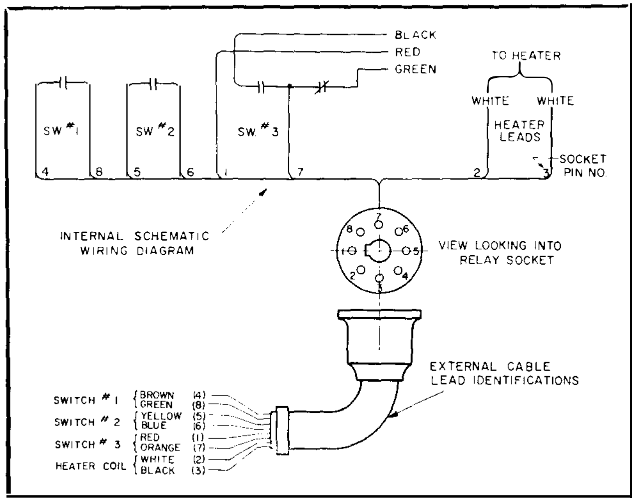

FIG. 8. Sketch of Internal Wiring

As the winding temperature (hence the bimetal temperature) increases, the bimetal shaft rotates to close No. 1 switch and energize the fan contactor. The fans will continue to operate as long as the bimetal temperature is greater than the opening temperature of No. 1 switch.

The opening temperature is actually about 4 to 8 degrees below the closing temperature. If the temperature now decreases, the bimetal will reverse its motion, allowing the No. 1 switch to cut off the fans. Thus, the TRO-1 relay will automatically control the air blast fans from winding temperature.

If, however, the winding temperature continues to increase, the bimetal element will turn until a second switch closes. It is optional with the user if and how the No. 2 switch is used in the alarm circuit. Fig. 7 shows in dotted lines an optional scheme using a remote lamp operated by No. 2 switch and energized either from a separate or common source.

If the temperature of the winding further increases after the No. 2 switch closes, the bimetal element will continue to turn until the third switch closes. Closing switch No. 3 energizes an auxiliary relay which seals itself in. The auxiliary relay closes a contact that may be used to trip the circuit breaker or sound an alarm. It opens a contact available for locking out the recloser relay. With the breaker open, the bimetal will cool and reset the microswitches, but the circuit breaker will not automatically reclose until the trip relay is deenergized with the reset switch.

When the final trip is used only as an alarm, the sealing feature may be cut out by disconnecting the seal-in contact of the trip relay. Consult the wiring diagram supplied with the transformer for the exact panel equipment supplied.

Coincidental with the closing of the No. 3 contact the dial indicator on a standard relay will read 110% thermal load, signifying to the operator that the transformer is now entering the zone of excessive (above 1% per overload) loss of life compared to the normal loss rate. Any further advance of the pointer should not be allowed except under extreme circumstances.

Continuous Overoads. A new concept in thermal indication, the term "percent thermal load" has a universal meaning under any ambient condition and may be interpreted as follows: When a transformer is 90% thermally loaded it is carrying approximately 9/10 of the load it can continuously carry at the existing ambient temperature. A rise of 10 degrees C in the ambient temperature or an 11% load increase would under this condition bring the transformer to the limit of its thermal capacity, resulting in a dial reading of 100%.

Every transformer has some reserve capacity which may be tapped from time to time without undue loss of insulation life. Any overload which carries the dial needle above the 100% scale reading is using up some of that reserve capacity and, if allowed to continue, will shorten transformer life and possibly endanger an automatic trip-out. For long and satisfactory transformer life, it is recommended that the transformer be operated at all times below 100% thermal load with whatever margin experience shows to be advisable for anticipated rises in ambient. In that region of the dial above 80%, a change of one degree C. in ambient temperature is virtually equivalent to a 1% change in thermal load.

Referring again to Fig. 6, "percent thermal load" has been shown in its correct relation to "percent rated load" at an ambient temp. of 25 deg. C. The dial graduations are indicated along the right vertical edge to show that they correspond to "percent thermal load". While the curve is typical, it serves as a good illustration for any transformer to which the load-indicating relay is applied. The term "thermal load" should not be confused with "kva load" since rated kva will seldom, if ever, cause the dial to read 100%. However, the dial is so calibrated that (for a constant ambient and a steady load) the needle will show the approximate relation between the existing kva and that which would position the dial needle at the 100% mark.

By using 100% as a reference, the ability of the transformer to withstand safely a steady overload can thus be computed from the dial without resort to complicated curves and tables.

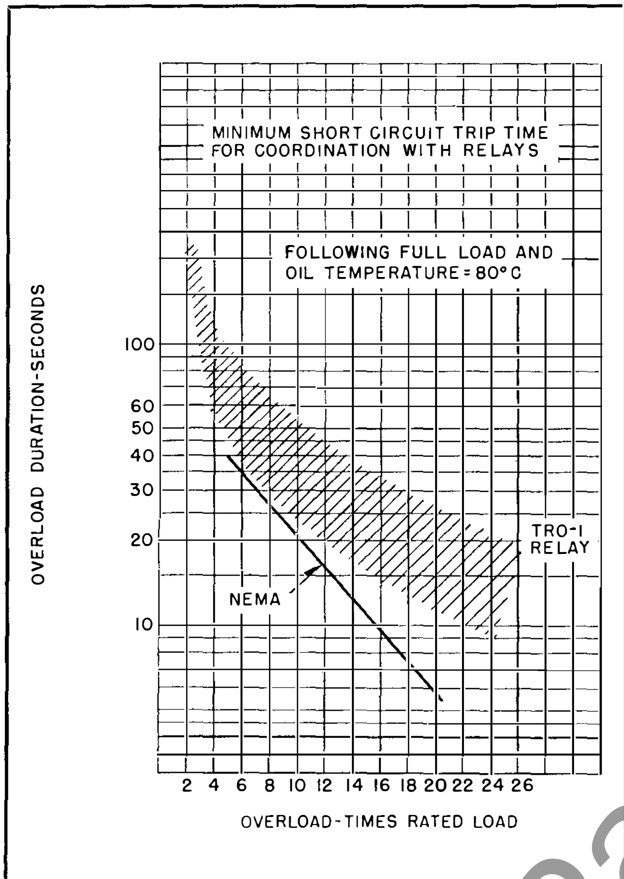

FIG. 9. TRO-1 Relay Coordination Curve for Overloads.

Short-Time Overloads. The TRO-1 thermal relay is designed with sufficient time delay to prevent its operating ahead of the regular protective relays under severe overcurrent conditions. The time delay characteristic is properly coordinated through the relay mass, lagging and the saturating current transformer, and has been designed to meet the recommendations of the NEMA Relay Committee.

The coordination curve shown in Fig. 9 is for overloads following full load at an oil temperature of 80 degree C. The band form of curve is used because of the wide range of normal heater currents, depending upon the usual range of design constants for Classes OA and FOA power transformers. When an overload is placed on the transformer, the relay contacts will not close at a time less than the overload duration shown in Fig. 9.

The effect of such suddenly-occurring heavy overloads on the transformer is graphically depicted on the dial by the farthest advance of the needle, shown by the position of the maximum indicator. An overload which does not carry the needle above the 100% point is of little consequence in the life of the insulation.

The effect of expected load cycles can be predicted with the aid of the maximum indicator. A record should be kept of maximum readings and ambient temperature. Knowing the nature of the load cycle it is possible to estimate the effect of similar load cycles of any average kva.

MAINTENANCE

No maintenance of the type TRO-1 thermal relay is required. It is made of non-corrosive parts. Its calibration is not impaired or affected by any normal operating hazards to which any transformer is subject. The micro-switches should require no replacement when loaded in accordance with Table No. 1.

CHECKING CALIBRATION

The following information is furnished to permit field checking of the relay calibration. The calibration may be checked with the relay either mounted on the transformer tank or in an oil bath, where the temperature can be controlled. Although the method is not as rigorous, usually it will be more desirable to test the relay mounted on the transformer since this method requires much less time and equipment. The oil bath method may be used to check spare relays without well and heater to verify the heater coil method of checking the calibration. If a spare heater and well or protective cover tube are available, an oil tank of any temperature may be used and the relay tested as if on the transformer. No provision for heating the oil is required for the heater coil method of testing the relay. For either method of testing, one should take the following steps:

1. Obtain the correct contact-closing temperatures and the dial positioning directly from a nameplate mounted on the top of the relay case. Bear in mind that a plus or minus 2°C. tolerance is normally allowed for the temperature calibration.

2. Reset the maximum indicator needle before beginning the test.

Checking Relay with Heater and Well On a Tranformer. (Recommended Method). The calibration of the relay may be checked at the panel in the cabinet (see Fig. 4) when the transformer is in service and without disturbing the relay unless adjustments are required.

A knife-switch having short-circuiting jaws (see Fig. 7) is provided on the control panel for the heater element. Opening the knife-switch short-circuits the saturating current transformer secondary and isolates the heater coil.

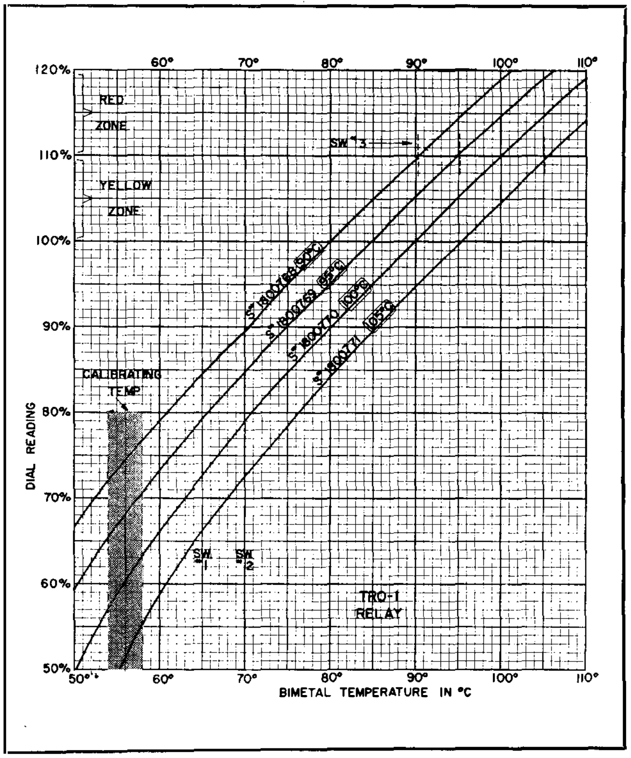

FIG. 10. Dial Calibration Curve

An adjustable voltage supply, such as can be obtained from a Variac, variable from approximately 4 to 7 volts at up to 10 amperes, and a 10 ampere meter, are required.

The basic theory of the heater coil method of testing is as follows:

For each style of relay there is a definite relationship between the bimetal temperature and the dial position at any moment. Fig. 10 shows this relationship.

For a relay that does not bear a style number, check the relay nameplate for the switch temperature corresponding to "110% thermal load." Match this temperature with those boxed in Fig. 10 and choose that style for your reference curve. Temperature settings for individual switches may also be obtained from the relay nameplate.

Provided that the initial temperature of the bimetal is below that of switch No. 1, the operation of all three switches can be checked by raising the bimetal temperature above that of switch No. 3 and noting the dial reading as each switch closes. The heat source for this rise in temperature is provided by circulating an excess amount of current through the heater coil.

1. Be sure voltage is supplied to all control relays and that the tripping circuit is open to avoid dropping the load. Set fan control (when supplied) for "automatic" operation (AM open).

To establish switch continuity directly through a micro-switch it is necessary to observe the switch limitations of Table No. 1. This means that a low voltage bell ringer cannot be used unless switched through a high impedance relay. An indicating light type device is generally recognized as best for checking circuits through instruments containing micro-switches of similar capacities.

2. Apply test current to the terminals designated on the wiring diagram furnished with the transformer. To shorten the testing time fix the current at a value up to a maximum of 10 amperes and observe the dial reading at which the relay performs all the functions in the following sequence. (Shut off the current immediately after the 3rd switch closes.)

(1) Starts the fans.
(2) Operates switch No. 2 or starts 2nd fan bank.
(3) Closes contact No. 3.

3. When the calibration run has been completed, the observed dial readings should be compared with the data on the curves in Fig. 10.

Example:
To check calibration of relay S#1800 769, refer to Table No. 2. Switch No. 1 closes at 65 degrees; switch No. 2 closes at 70 degrees C; switch No. 3 closes at 95 degrees C.

Table No. **2**

STANDARD RELAY CALIBRATIONS

Nameplate Style No.	* Closing Temp. °C. of Switches			Dial Reading At Close of Switch No. 3
	1st (Brown) (Green)	2nd (Yellow) (Blue)	3rd (Orange) (Red)	(Orange) (Red)
1800 768	65	70	90	110%
1800 769	65	70	95	110%
1800 770	65	70	100	110%
1800 771	65	70	105	110%
S.O. Number	See Relay Nameplate			See Relay Nameplate

* Temperatures listed are bimetal temperatures—not to be confused with hot spot winding temperatures. Tolerance limits ±2°C.

The observed dial readings during the heating cycle are as follows: Switch No. 1—80%, Switch No. 2—86%, Switch No. 3—109%. From Fig. 10, the curve for S#1800 769 indicates that for these dial readings the corresponding bimetal temperatures are 66°C., 71°C. and 94°C. These are within a tolerance of plus or minus 2° of the correct figures and the relay will not require recalibration.

4. Measurement of the differential between switch closing and opening temperatures is possible by observing the dial readings coincident with switch opening while the bimetal is cooling down from the above test. Refer to Fig. 10 again for the corresponding bimetal temperature.

Checking Relay In Oil Bath. (Alternate Method). For checking calibration of the relay without heater or well, the relay may be mounted over an oil bath with the bimetal tube pointing downwards, and with the tube immersed in the oil.

In removing the relay from the tank well, the flexible cable must first be unplugged from the relay case and the relay itself unbolted from the well flange. Then the heater coil leads must be detached from the relay leads at the rear of the housing to allow removal of the heater coil.

To remove the heater, untape the spliced joints and unsolder the white leads from the yellow leads. These can later be resoldered and retaped.

IMPORTANT: The tube must extend into the oil at least 6½ inches, but not more than 8 inches.

1. Connect the leads to signal lights so that the operation of the three switches can be determined. The signal light circuit must be kept within the capacity limits shown in Table 1. Refer to Table No. 2 for switch and wire color code. Do not use a low voltage bell ringer unless switched through a high impedance relay.

2. Provide the oil bath with a source of heat which can be controlled so that the rate of rise of the oil bath temperature, for checking the switch operating points, will not exceed one-half degree C. per minute in the zones of expected switch operation. For checking the switch operating points the oil bath temperature should then be held at the desired temperature within +2 or -0°C. The oil bath should be provided with an adequate stirrer and the temperature measured at a point about 3 inches from the lowest end of the bimetal tube. Light tapping of the relay case is permissible. With this setup the relay contacts should close within the limits outlined in Table No. 2. Observe the dial reading at close of switch No. 3.

There is a remote possibility that the oil bath method may indicate the switches to be closing at the correct temperature but that the dial positioning is off by more than 2% in one direction. The relay should then be returned to the factory for repair or replacement. While it is not essential to the automatic protection of the transformer that the relay dial registers correctly, there is a good possibility of misleading operators who are depending on the dial to show them the true thermal loading.

SWITCH ADJUSTMENTS

Preparation. Do not make any adjustments to the relay unless the precautions enumerated in the previous paragraphs have been taken. Adjustment of a switch may be necessary:

1. If it is indicated by previous tests that the relay is out of calibration by more than the normally allowed tolerances.

2. If it is desirable to change the calibration from those settings engraved on the relay nameplate. **CAUTION: Before raising any trip switch setting above the nameplate temperature, the factory should be consulted as this reduces the design margin of protection.**

Provision is made for adjustment of the calibration of any of the three switches through holes located in the base of the relay case adjacent to the cable entrance. See Fig. 5. A small cover plate must first be unfastened to expose the three holes.

Since the calibration screws inside the relay rotate with the switch operating cams, it is possible to change the calibration only when the temperature of the bimetal brings the screws opposite the access holes. This occurs on all relays at a bimetal temperature of approximately 54 to 58°C.

Preparation for Recalibration with Relay on the Tank Wall. If the oil in the main transformer is already above 58°C. it may be possible to turn on fans and bring it down to 58°. Otherwise the relay may have to be removed and placed in a controlled oil bath for recalibration. (See below).

If the oil in the main transformer is below 54°C. a small amount of current may be fed into the heating coil from a variable current source to bring it quickly within the range of 54 to 58°C. The selection of the right amount of current to avoid too much overshoot will have to be a trial and error procedure, although it can be roughly determined by the formula

$$I = \sqrt{G}$$

where I is the heater amperes and G is the desired rise in degree C. of the relay bimetal.

In trying to bring the relay temperature into line for calibration, the curves of Fig. 10 will be helpful in determining the actual temperature of the bimetal at all times.

Refer now to later Section entitled "Switch Recalibration".

Preparation for Recalibration by the Separate Oil Bath Method. This method is recommended where the relay is already removed from the tank or where the tank well method of switch recalibration is not practical. For removal of the relay from tank well and precautions for testing, see instructions under a preceding paragraph entitled "Checking Relay in Oil Bath".

1. Set the oil bath for the calibration temperature of 56°C.

2. Place the relay in the bath after first removing the heater coil per previous instructions.

3. When the bath has been at the temperature of 56°C for at least 15 minutes, or as soon as the dial indicates (See Fig. 10) that 56°C has been reached, the instrument is ready for any switch adjustments.

SWITCH RECALIBRATION

The required number of degrees adjustment of a switch should be divided by the factor 13.3 to determine the exact part of a turn required to change the switch closing temperature. Clockwise rotation of the screw increases the temperature at which the given switch will close. Counterclockwise rotation will reduce the temperature. The switch may be adjusted to any temperature in the range of 50 to 105°C. See Fig. 5 for location of the correct alignment hole.

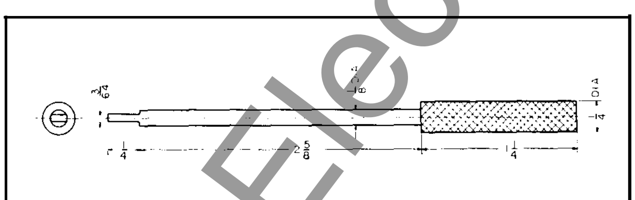

FIG. 11. Calibration Tool S# 1803 442

Example:

It is desired to change the setting of switch No. 2 from its standard operating point of 70°C. to a new operating point of 85°C. The difference of 15° divided by 13.3 calls for 1⅛ clockwise turns of the adjusting screw. Insert the calibration tool pictured in Fig. 11 into the middle adjustment hole until it contacts the adjustment screw. Rotate the tool until the key slips into the slot, then turn 1⅛ turns clockwise. *NOTE: The relay bimetal must be at a temperature of approximately 54-58°C. before engagement of the calibration screw is possible.*

The result of changing the calibration should be verified before placing the relay back in service. The method to be used is at the tester's discretion. However, if the recalibration was performed with relay in place on tank wall, it is only necessary to repeat the process by which the original switch settings were determined.

If the recalibration was performed with the relay bimetal tube immersed in an oil bath, a quick method of rechecking is as follows:

Bring the oil bath as quickly as possible to a temperature at least 2 degrees above that of No. 3 switch. Make sure all relay switches to be tested are still wired to lamp indicators. Don't begin the test until the relay has been cooled below the opening temperature of the lowest temperature switch to be tested. Now place the relay in the hot bath and make a record of the dial reading at the time each switch closes in the upward heat sequence. If the relay dial positioning was originally established as correct, these new readings may be checked against the curves of Fig. 10 to determine the corresponding bimetal temperatures.

For additional information on the use of these curves, see description under heading "Checking Relay with Heater and Well on a Transformer".

MODIFICATION OF SWITCH NO. 3

Depending on the control circuit application, relays are delivered from the factory with contact No. 3 wired either as a front or a back contact. The majority of applications require that this (126-3) contact be wired as a normally open contact as pictured in Fig. 7. Should it become necessary to change the contact to be a back contact, this can easily be done at the rear of the relay case. See Fig. 8 and note that the red colored lead should connect to the black lead when (126-3) is a normally-open contact. To convert it into a normally-closed contact connect the red and green leads instead. Before joining the red and green leads, pull each wire around opposite sides of the bimetal tube for ease of tucking into the flange recess. The unused lead stub and the spliced joint should be covered with at least one layer of rubber insulating tape.

RENEWAL PARTS AND FIELD TESTING EQUIPMENT

The following equipment for aid in the testing, calibration, and repair of relay installations in the field is available from the Sharon Works through any Westinghouse Office.

Calibration Tool—S# 1803 442 (see Fig. 11).

Flexible Connector Cable
- 2 Foot Length—S# 1800 792
- 5 Foot Length—S# 1803 486

Spare Relay Heater—S# 1800 790
Spare Tank Well—S# 1483 920
Spare Gasket
- between relay and well—S# 1484 112
- between well and tank—S# 1800 549

In case it becomes necessary to repair the instrument itself, contact the nearest Westinghouse Office. Complete instructions will be given by the district Engineering and Service Division for the return of the instrument to the factory at Sharon, Pa., to have it repaired and placed in first-class condition.

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