DESCRIPTION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TRO
THERMAL RELAY
With Thermal Load Indicating Dial

FIG. 1. Front View of TRO Relay.

TYPE TRO THERMAL RELAY is used on power transformers of all types as a combination overload protective device and thermal load indicator. Its three bimetal-operated switches are normally (see Note below) used to control (automatically) air blast cooling equipment, operate a signal switch, then a trip switch, all in the order of increasing winding temperature.

Note: On triple-rated power transformers in which the TRO Relay controls all auxiliary cooling equipment, it is customary to use the second or signal contact for cutting in the second stage of cooling. In most of these applications the word "signal" is omitted from the face of the dial.

In addition, a yellow indicating pointer shows continuously the operating position of the relay relative to the normal signal and trip points 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.

DESCRIPTION

The internal construction of the TRO relay is shown in Fig. 2. The thermal element consists of a spiral bimetal that is held stationary at the inner end and is fastened to a shaft at the other end. There are three levers 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.

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 winding current. The heating coil may be either single or three phase.

Each micro-switch is mounted with a spring pressing it against a contact adjusting screw which is used when making calibration adjustments.

All contacts are automatically self-resetting, but the signal and trip contacts are made self-sealing by auxiliary SG relays. For contact duty rating of the micro-switches and SG relays, see Table No. 1. *Do not use* these micro-switches to open a D.C. circuit and *do not apply* at greater than 125 volts.

Referring again to Fig. 2, the motion of the bimetal shaft is transmitted through a variable-length torque-arm to a gear drive with an amplification factor of 7⅓ times. The indicator shaft is directly coupled to the gear drive shaft by a slip coupling,

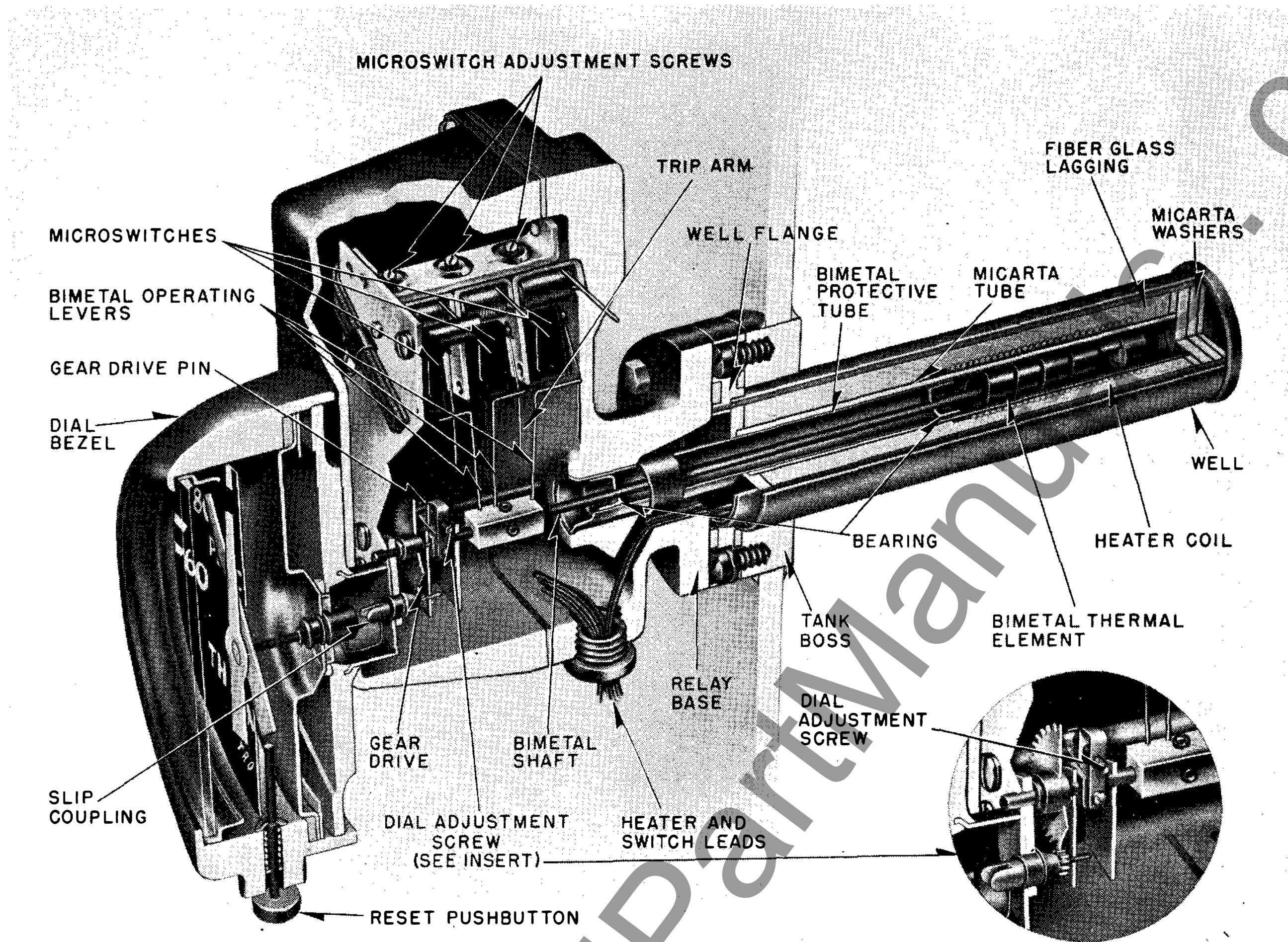


FIG. 2. Cross-Section of TRO Relay Showing Internal Construction.

enabling removal of the relay cover for inspection or adjustment of the calibration.

Table No. 1 AMPERES MAXIMUM CURRENT AT 125 VOLTS

	CONTINUOUS CURR. RATING (A.C. OR D.C.)	CLOSING CURR. RATING (A.C. OR D.C.)	OPENING CURR. RTG.	
			A.C.	D.C.
MICRO-SWITCH	3	3	3	0
SG RELAY	12	30	30	2.4

The bezel or outer assembly shown in Fig. 1 includes a 5½″ dial with indicating needle, maximum hand and reset mechanism. The standard (see Note, page 1) dial is marked to show the signal and trip points and, since the relay is always designed for a particular transformer's thermal characteristics, the signal point coincides with the 100% index mark on the thermal load scale. On all dials the word "trip" appears at 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 (see Fig. 3) in the hot oil zone. The relay base is bolted to the well flange so that the relay can be removed without taking the transformer out of service. The contact and heater leads are brought from the relay case through conduit into the connection box where, to remove the relay, the leads must be disconnected.

Test switches are provided on the control panel in the control cabinet (see Fig. 3) 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 plug will be fitted into the upper conduit connection of the small connection box.

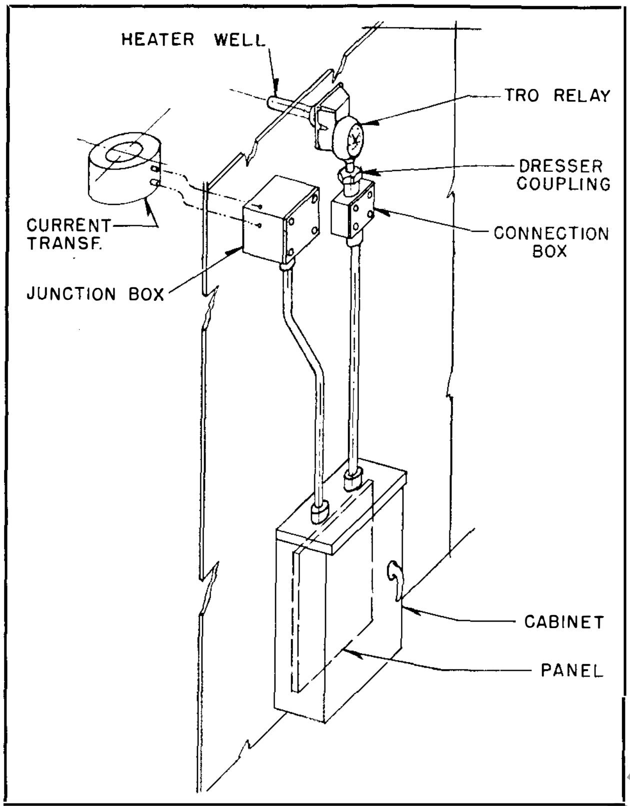


FIG. 3. TRO Relay Mounted on Transformer Wall.

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.

Note: Unless you must make relay adjustments or internal inspection, do not remove dial assembly from relay case. Where necessary to remove dial assembly, refer to section entitled "Adjustments" on page 8 for proper procedure.

To Install the Relay:

1. Remove the blind flange and connection box plug.

2. Slip the heater coil and lagging over the bimetal tube without removing the relay cover; thread wires through conduit hole in relay base, and through conduit into the connection box.

3. Make connections according to wiring diagram.

4. Tighten the dresser coupling.

5. Push the mechanical reset knob upward. Failure of the red hand to line up with the yellow hand when near or below the lowest scale reading is not unusual.

Note: When removing the relay with the unit in service, first be sure to short-circuit the current transformer by means of the test switches 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. 4, for continuous overloads there is a proportional difference between the relay bimetal setting and the top oil temperature. When the oil temperature plus this difference equals the temperature for any contact adjustment setting, the bimetal will have turned the shaft lever, engaging the switch arm, and will have closed that particular micro-switch contact. Since the difference (or gradient) 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 gradient is purposely made less than the calculated hot spot gradient of the winding.

Refer again to Fig. 4 and the typical thermal relationships existing in a transformer equipped with thermal overload relay S#1643 238. Each point on the curves represents the ultimate temperature that would exist in a typical transformer if the load

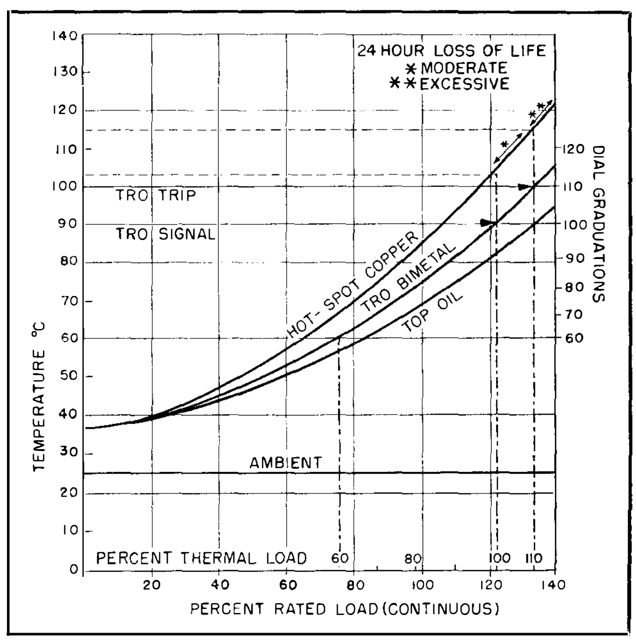
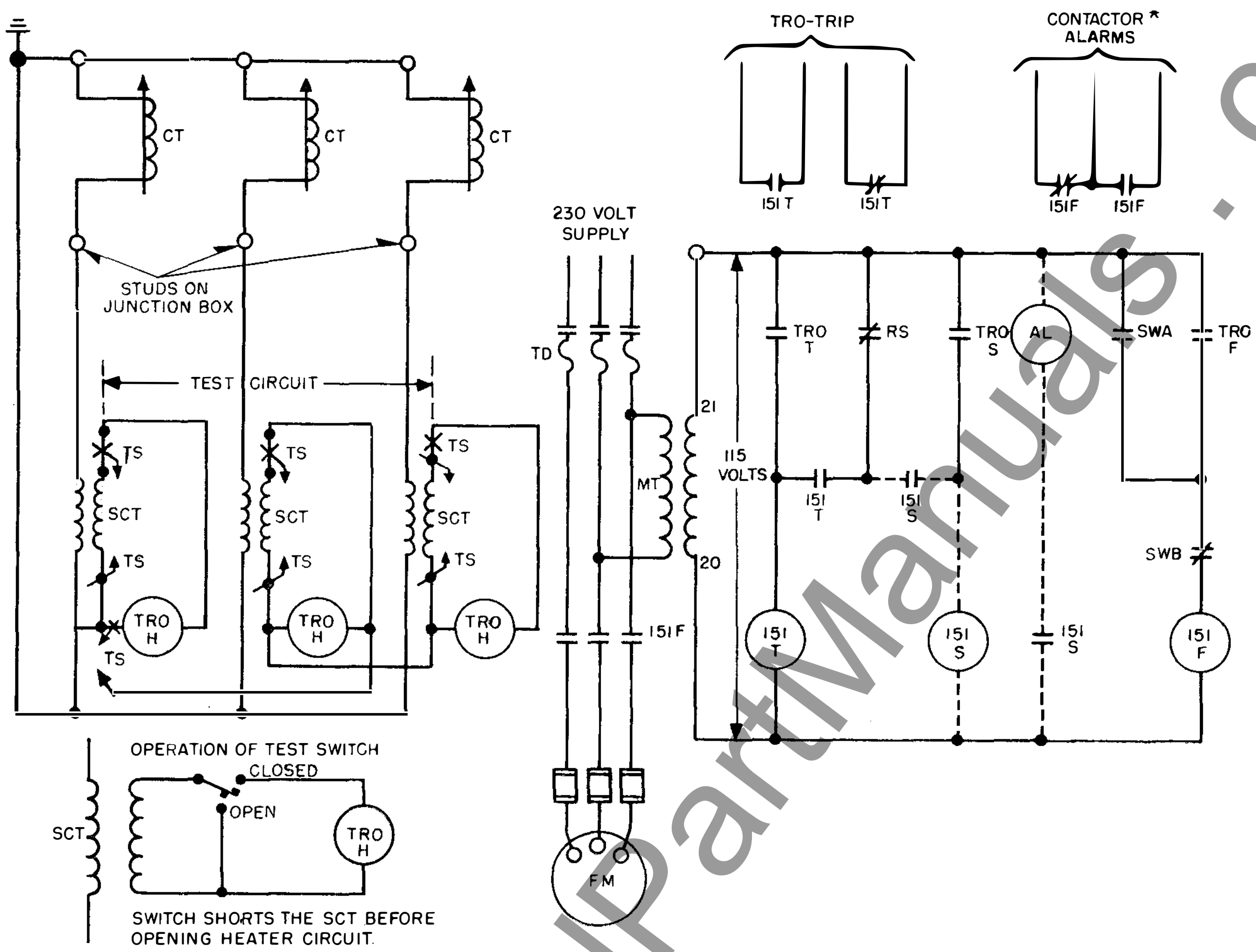


FIG. 4. Typical Thermal Relationships, Shown for Relay S#1643238 at 25°C Ambient on Continuous Loading Basis.



LEGEND

CT	CURRENT TRANSFORMERS
SCT	SATURATING CURRENT TRANSFORMERS
MT	CONTROL TRANSFORMER (TYPE "MT" 230 TO 115V)(WHEN USED)
TRO-H	TRO RELAY HEATER ELEMENT
TRO-F	TRO RELAY FAN CONTACT (FIRST TRIP)
TRO-S	TRO RELAY SIGNAL CONTACT (SECOND TRIP)
TRO-T	TRO RELAY TRIP CONTACT (THIRD TRIP)
151-T	TRIP RELAY (TYPE SG)
151-S	SIGNAL RELAY (TYPE SG)(WHEN USED)
151-F	FAN RELAY (WHEN USED)
RS	TRIP AND SIGNAL RELAY RESET
SWA	TO START FANS MANUALLY-NORMALLY OPEN
SWB	TO STOP FANS MANUALLY-NORMALLY CLOSED
TD	THERMAL DISCONNECTING DEVICE
TS	TRO RELAY TEST SWITCH
AL	SIGNAL LIGHT (WHEN USED)
FM	FAN MOTOR
*	USED ON 3-PHASE FAN CONTROL ONLY

FIG. 5. Typical Connections of TRO Relay.

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 105 degrees C. under these conditions, the corresponding relay bimetal temperature is 90 degrees C. at which point the signal switch operates. Any increase in the load which raises the hot spot winding temperature to the 115 degree level will raise the relay bimetal temperature to 100 degrees, at which time the relay closes another 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 for an equal loss of life. The signal switch on a standard relay is set to close at a bimetal temperature which indicates that the transformer is just passing into the zone of moderate loss of life, regardless of the size and duration of the overload. Such a result is made possible by placing the signal switch closing temperature a set amount below the greatest recommended hot spot winding temperature for continuous operation. This temperature difference then determines the relation between the bimetal gradient and the hot spot gradient at the greatest recommended loading.

Fig. 5 shows a typical connection for this relay as used with three-phase air blast fan motors. When the TRO relay is used without fan control, 230 volts alternating current must be connected to the control transformer primary, MT, when it is supplied, or 115 volts alternating current across 20-21 when the control transformer is not supplied. This diagram is for a three-phase application using one TRO relay with a three-element heater. Relays can be supplied with one or three-element heaters. Current is supplied to the heater coils from three 5-ampere secondary current transformers (mounted in the transformer tank) through three small multi-ratio saturating current transformers 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.

As the winding temperature increases, the bimetal shaft rotates to close the fan switch and energize the contactor. The fans will continue to operate as long as the bimetal temperature is greater than the opening temperature of the fan switch.

The opening temperature is actually about 6 to 12 degrees below the closing temperature. If the temperature now decreases, the bimetal will reverse its motion, allowing the fan switch to cut off the fans. Thus, the TRO 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, the signal switch, closes. It is optional with the user how the signal switch is used in the alarm circuit. Fig. 5 shows in dotted lines a standard scheme used on unit equipment before the advent of the dial-equipped relay. This signal switch energizes a signal relay which in turn energizes a warning light (AL). The signal relay is self-sealing so that the light will not go out until the reset switch is opened. The dial indicators on all standard TRO relays are adjusted at the factory to read 100% thermal load when this signal switch closes. This indicates to the operator that the transformer insulation is entering the zone of moderate (under 1% per overload) loss of life and enables him to better judge the transformer's thermal capabilities.

If the temperature of the winding further increases after the signal switch closes, the bimetal element will continue to turn until the trip switch closes. Closing the trip switch energizes a trip relay which also seals itself in. The trip relay closes a contact that may be used to trip the circuit breaker. It opens a contact available for locking out the recloser relay. With the breaker open, the bimetal will cool and reset the micro-switches, but the circuit breaker will not automatically reclose until the trip relay is de-energized 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 (151T) of the trip relay. Consult the wiring diagram supplied with the transformer for the exact panel equipment supplied.

Coincidental with the closing of the trip 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 Overloads. 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. Such a condition would result in a dial reading of 100%, coincidental with the closing of the signal switch on a standard relay.

Every transformer has some reserve capacity which may be tapped from time to time without

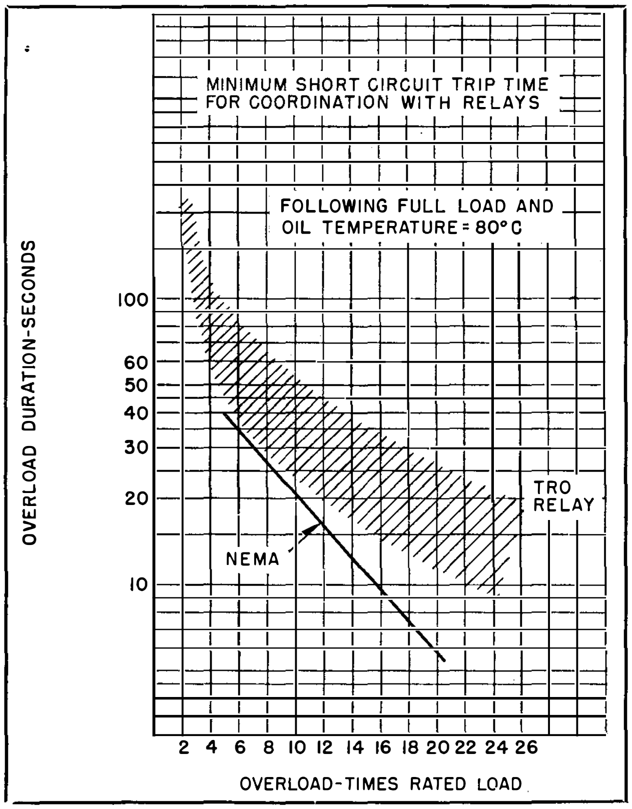


FIG. 6. TRO Relay Coordination Curve for Overloads Following Full Load at an Oil Temperature of 80°C.

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. 4, "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.

Short-Time Overloads. The TRO thermal relay is designed with sufficient time delay to prevent it from 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 AIEE Relay Committee.

The coordination curve shown in Fig. 6 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 Class OA 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. 6.

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 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.

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 possibility of error is greater, usually it will be more desirable to test the relay mounted on the transformer since this method requires less time and equipment. The oil bath method may be used to check spare relays without well and heater or to verify the electrical method of calibration. If a spare heater and well are available, an oil tank may be used and the relay tested as if on the transformer. No provision for heating the oil is required for the electrical method of testing the relay. For either method of testing, one should take the following steps:

1. Obtain contact-closing temperatures directly from a nameplate mounted on relay or from Table No. 2 below. A plus or minus 2 degree C. tolerance is normally allowed for these values.

2. Obtain proper dial readings from Table No. 2. A tolerance of plus or minus 1% is normally allowed for these values.

3. Reset the maximum indicator needle before beginning the test. It is not necessary that the maximum needle line up with the yellow needle at the lowest scale readings.

When observing the relay operation note that, due to the gear amplification and the rapid rate of temperature rise, a certain jerkiness in the advancing needle is to be expected and is not evidence of defective operation. Since all leads from the relay and heater are brought outside through the base of the relay, there is no need for opening the relay, nor is it recommended that the relay be opened unless it is done in a place where the device can be treated as an instrument.

Table No. 2 STANDARD RELAY CALIBRATIONS

NAMEPLATE STYLE NO.	*CLOSING TEMPERATURE DEGREES C. OF SWITCHES 1st (Black)	2nd (White)	3rd (Red)	DIAL READING AT SWITCH CLOSING 2nd (White)	3rd*** (Red)
1643 237	70	85	95	100%	110%
1643 238	70	90	100	100%	110%
1643 239	70	95	105	100%	110%
1722 160	70	75	100	.....	110%
S.O. Number	See Relay Nameplate			**100%	110%

* Temperatures listed are bimetal temperatures—not to be confused with hot spot winding temperatures.

** If word "SIGNAL" is on dial, make dial check on contact #2 and #3. Otherwise make dial check only on contact #3.

*** When specially requested by customer, 3rd contact is made to close at 100%, in which case it becomes a "SIGNAL" contact.

Checking Relay with Heater and Well On A Transformer. The calibration of the relay may be checked at the panel in the cabinet (see Fig. 3) when the transformer is in service and without disturbing the relay unless adjustments are required.

A knife-switch having short-circuiting jaws (See Fig. 5.) 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. In the case of three-element heaters, four switches are provided and so wired that raising all the switch levers connects the three heater coils in series. The same calibration data can then be used for three-element heaters as for single-element heaters.

A finely adjustable voltage supply, such as can be obtained from a Variac, variable from approximately 3 to 5 volts at up to 10 amperes, a 10 ampere meter, and a stop watch are required.

If the transformer is in service and carrying a load, at least three-quarters of an hour should be allowed after opening the test switches to permit the heater and bimetal to return to the same temperature as the oil. At least one and one-half hours should be allowed between successive tests. This waiting time is important if satisfactory results are to be obtained. Use following test procedure.

1. Observe the temperature of the oil to approximate the bimetal tube temperature and determine the test current from the calibration data shown in Figs. 9, 10, and 11. It is desirable to pre-set the current (heater coil by-passed) so that a minimum amount of time will be lost in getting the exact current setting. Continuous adjustment of the current will be required throughout the test as the increase in resistance of the heater coil will tend to reduce the current.

2. 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 (SWA open) and put the SWB switch in the closed position. Do not put micro-switches directly in a d-c bell ringer alarm circuit. See Table No. 1.

3. Apply test current to the terminals designated on the wiring diagram furnished with the transformer. Hold the current constant at the value corresponding to the observed oil temperature as obtained from the calibration data and observe the time at which the relay performs all the functions in the following sequence. (Record also the dial reading at time of switch closing.)

(1) Starts the fans.

(2) Operates the signal or starts 2nd fan bank.

(3) Closes the trip contact.

4. When the calibration run has been completed, the observed closing times should be compared with the data on the curves in Figs. 9, 10 and 11. Example:

To check calibration of relay S#1643 237, refer to Table No. 2. Fan switch closes at 70 degrees; signal switch closes at 85 degrees C; trip switch closes at 95 degrees C.

Assume bimetal tube initial temperature is 30 degrees; then the heater will require 8.25 amps.

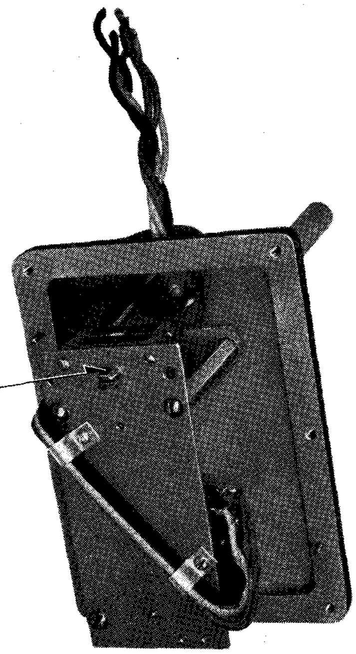


FIG. 7. TRO Relay with Cover Removed Showing Slotted Drive Coupling.

Record the time from applying heater current until switches close and compare with time as shown in Figs. 10 and 11 for 30 degree C. initial temperture and 70, 85 and 95 degrees C. switch closing temperatures.

Time falling above the bands indicates too high a switch closing temperature and below the bands too low a switch closing temperature.

Checking 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.

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

Connect the leads to signal lights so that the operation of the three switches can be determined. The signal light circuit should not be over 125 volts, 25 or 60 cycles, and should preferably use 6-watt lamps. Refer to Table No. 2 for switch and wire color code.

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 be held at the desired temperature within plus or minus one degree C. The oil bath should be provided with an adequate stirrer and the temperature measured at a point about 2½ inches from the lowest end of the bimetal tube. The relay should not be subjected to excessive vibration during this calibration check. With this setup the relay contacts should close at the temperature outlined in Table No. 2.

Temperature Allowance for Dial Removal. Unless absolutely necessary, do not remove the dial mechanism for this test. If it is necessary to check relay calibration with dial mechanism disengaged, contacts will close anywhere from 2°C to 5°C lower than shown in Table No. 2. The exact amount varies according to the friction of the individual unit, and each has been individually compensated. Use minus 3°C as average allowance for friction (in addition to 2°C± as explained under "Calibration").

ADJUSTMENTS.

Do not make any adjustments to the relay unless the precautions enumerated in the previous paragraphs have been taken. Adjustment of the switch and/or dial calibration may be necessary:

1. If it is indicated by previous tests that the relay may be out of calibration by more than the normally allowed tolerances. (If the calibration is off according to the heating coil method of test it is best to double-check this by the more exact oil bath method before attempting to make any adjustments.)

2. If it is desirable to change the calibration from those settings engraved on the relay nameplate. (Before raising any signal or trip switch setting **above** the nameplate temperature, the factory should be consulted).

Removing Dial Mechanism. Before making any relay adjustments it will first be necessary to

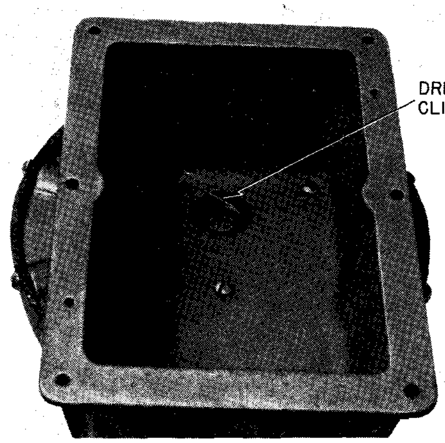


Fig. 8. Inside of TRO Relay Cover Showing Dial Drive Clip.

remove the outer cover assembly (See Figs. 7 and 8). Remove the cover and dial assembly (in one piece) by removing the six screws holding the cover to the case. Unless there is a special reason for doing so, **do not at any time** remove the dial bezel from the top cover casting.

Adjusting Switch Calibration With Relay on Tank Wall. If the amount by which a switch calibration is to be changed is definitely known and is no greater than 3 degrees C., the operating temperature may be adjusted with fair accuracy with the relay in place on the tank wall.

The closing temperature of the micro switches can be altered by turning the adjusting screws shown in Fig. 2. Clockwise turning of the screw will lower the temperature at which the switch closes by approximately one degree C for each one-quarter turn of the screw. Counter-clockwise rotation of the screw will raise the closing temperature. Always seal the micro switch adjusting screws with red lead cement or the equivalent. For changes of magnitude greater than 3 degrees or where the required amount of change is unknown, the relay should be removed from the tank well and calibrated by the "separate oil bath" method explained below.

If changes are made in the signal and trip switches, the dial needle will likely require adjustment.

Dial Adjustment. If the dial needle reads out of the desired tolerance at the moment of switch closing it can be adjusted by turning the Allen-head screw in the gear drive mechanism (See Fig. 2). For this adjustment a 1/16 in. Allen wrench is required. In general, a 1/8 turn of this screw in a clockwise direction will advance the needle 1% in a like direction. Conversely, a 1/8 turn in a counter-clockwise direction will make the needle read 1% lower.

Adjusting Calibration by Separate Oil Bath. (Alternate Method). The most accurate method of adjusting the switch calibration is outlined below where a separate oil bath is available and the precautions listed under "Checking in Oil Bath" are observed. Proceed as follows:

1. Set the oil bath for the calibration temperature of lowest temperature switch to be adjusted (minus the allowance of 3°C. See page 8).

2. Before placing the relay in the bath, turn the adjusting screw for the micro-switch one full turn or more in a counterclockwise direction to prevent premature tripping. Do this for every switch which is to be adjusted.

3. Place the relay in the bath after first removing the heater coil and connect switch leads as per instructions outlined on page 8 in paragraph entitled "Checking in Oil Bath".

4. When the bath has been at the desired calibration temperature for at least 15 minutes, the bimetal can be assumed to be at virtually the same temperature. If a switch trips prematurely, the relay should be removed from the bath and allowed to cool in air until the switch opens. After giving the micro-switch adjusting screw another full turn counterclockwise, place the relay back in the bath and wait 10 minutes before step 5.

5. Now turn the micro-switch adjusting screw slowly in a clockwise direction until the micro-switch closes.

(The range of the adjusting screw may be insufficient to cause the switch to operate at the desired temperature. In this case the arm on the operating shaft should be bent in the required direction. The bend should be made at the junction of the arm and boss and should be done after first gripping the boss with a pair of pliers or other suitable tool. Care should be taken to avoid bending the bimetal shaft. Final adjustments are to be made with the screw.)

6. Set the oil bath for the next higher calibration level minus the 3°C. allowance and repeat steps 4 and 5.

7. When the last switch has been calibrated, seal all Micro-Switch adjusting screws with red lead cement or the equivalent, in preparation for replacing the dial mechanism.

Replacing the Dial Mechanism.

1. If the relay is still at or near the temperature used in calibrating the highest temperature switch, pick up the relay cover assembly and with the fingers manipulate the dial drive clip until the yellow needle reads 110%. *If you are attempting to assemble the relay at some other temperature,* a rough approximation of the proper shaft alignment will be obtained by setting the dial needle to read a percent equal to the estimated bimetal temperature plus 10. Leave maximum indicator needle at its highest setting.

If the cover is properly positioned over the relay chassis, the dial actuator clip should be lined up with the slotted drive coupling projecting through the brass relay mounting plate. Make a visual check of this, and if necessary, move the drive clip to get as nearly exact alignment as possible before seating the cover flange. Fasten cover in place with at least two screws at opposite corners. Next reset the maximum indicator to assure that proper dial engagement has been made. If the indicator

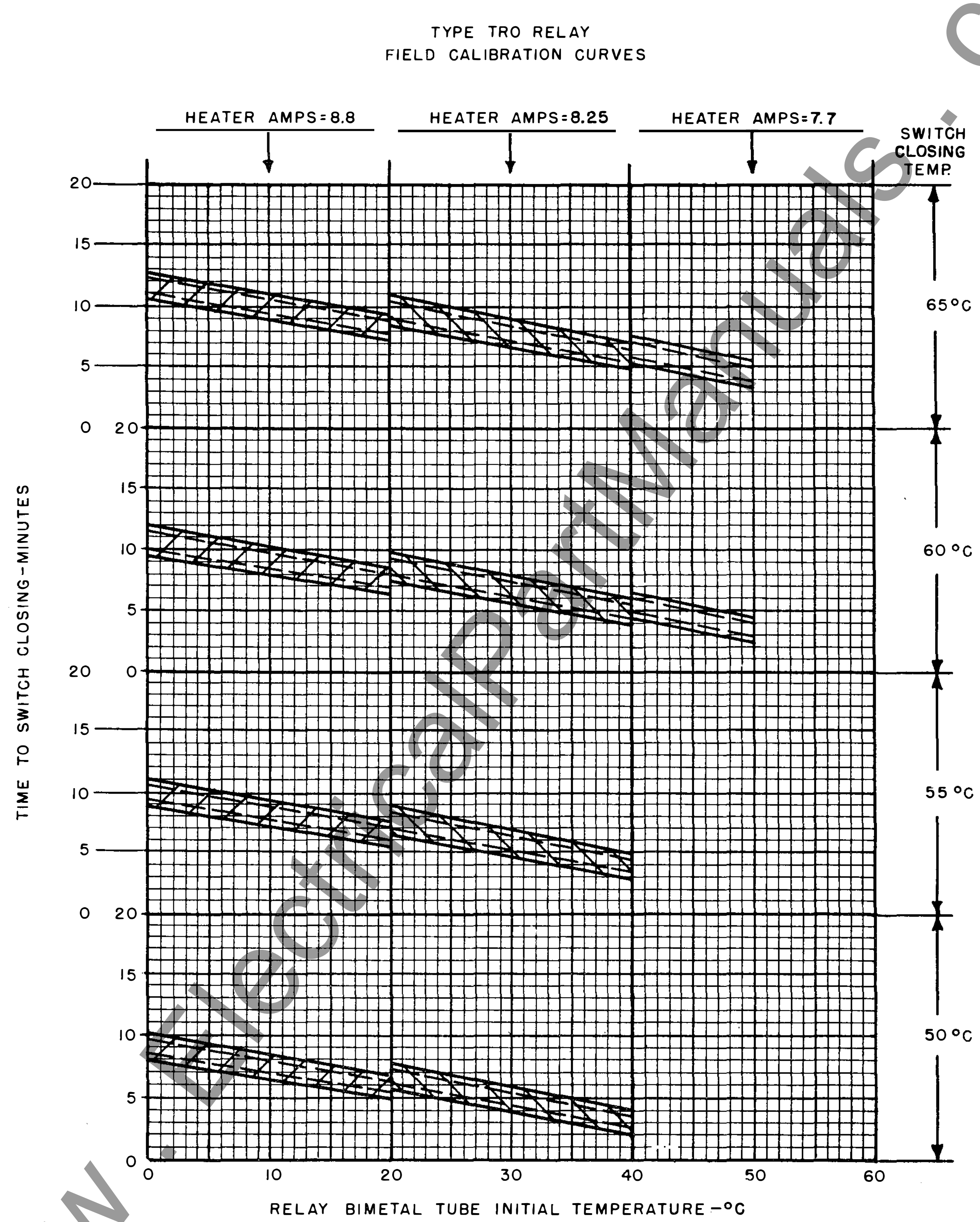


FIG. 9. TRO Relay Calibration Curve Showing Switch Closing Temperatures from 50 to 65 Degrees C.

will not reset it means the coupling is not positively made. Several trials may be necessary to get proper engagement.

2. Remove the relay from the hot bath and allow bimetal to cool in air. Watch for any tendency of the yellow needle to stick in one position during this cooling period. It will be a further sign of improper assembly.

Rechecking Calibration and Final Dial Adjustment.

1. Because there is some doubt as to the exact negative allowance required for switch calibrations with the cover removed (See page 8) a recheck should be made of the switch calibrations now that the cover is in place. Use method outlined under "Checking in Oil Bath" on page 8. If such a test should show that a negative allowance greater than 5°C. is required due to removal of the cover, the relay should be returned to Westinghouse for repair or replacement.

2. If desired, the dial readings can with proper care be adjusted to within plus or minus 1% of the readings listed in Table 2. If it reads out of this tolerance, remove the cover once more and turn the Allen-head screw in the gear drive mechanism, remembering that for every 1/8 turn, the pointer will move 1% in a like direction. (Example: Needle reads 112%—should read 110%. Turn screw 1/4 turn counterclockwise with Allen wrench. A 1/16-in. Allen wrench will be required.) For adjustments outside the range of this Allen-head screw, the relay should be referred to the manufacturer for proper adjustment procedure.

Any dials which need adjusting should be given a repeat check to verify that the adjustment has brought it within the desired tolerance. To do this first allow relay to cool in air. Before making this final check, be sure that all switch leads are still wired to the test board. After the needle has returned to about 60% scale reading, place the relay in the hot bath and reset the maximum hand Note carefully the dial reading at the moment each switch closes on its way back up to the top of the scale. If the dial should "jump" through a small interval at the moment a switch closes, take as your reading the midpoint of that range.

3. Complete assembly of cover to case.

RENEWAL PARTS

In case it becomes necessary to repair the instrument, 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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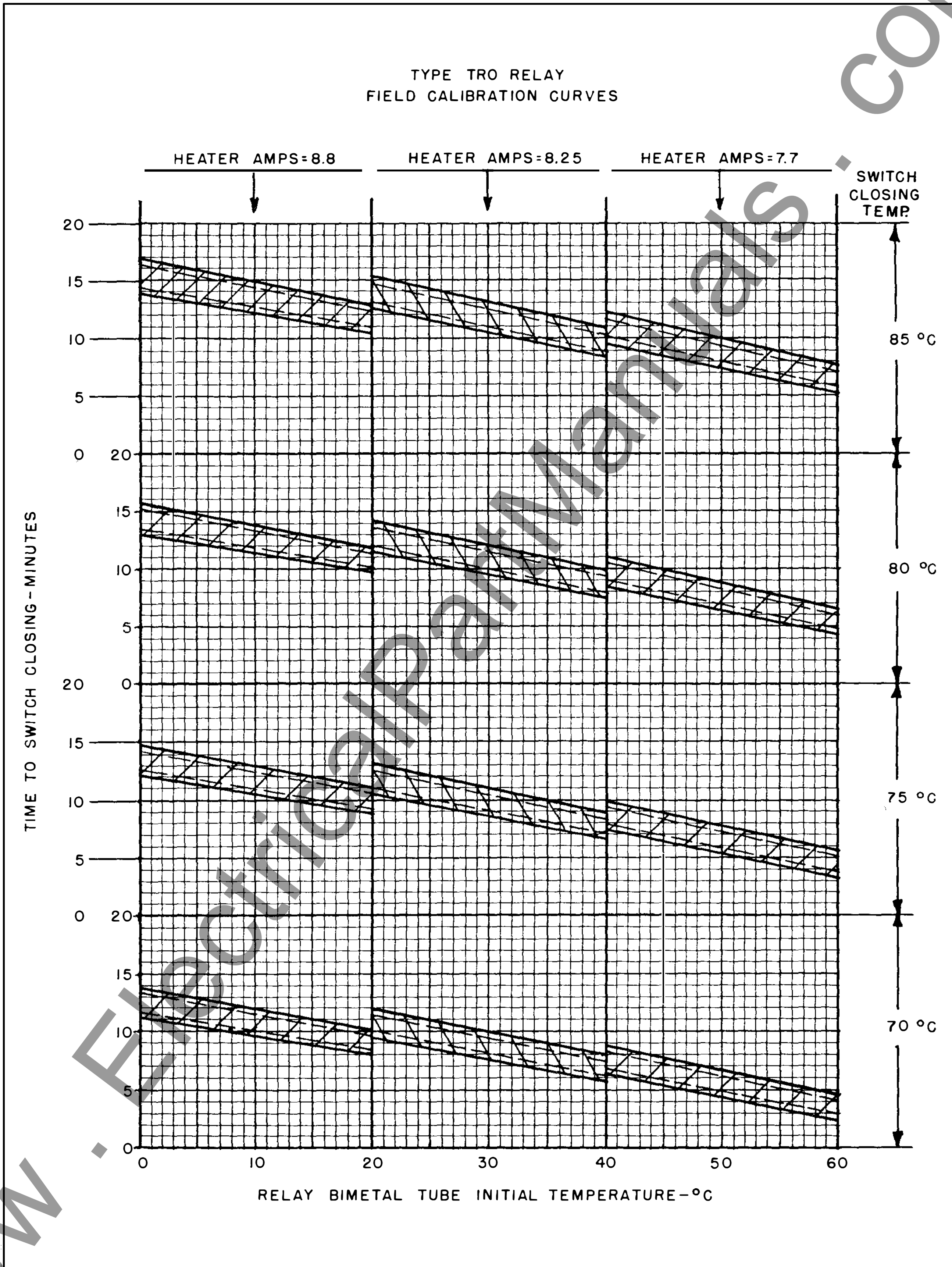

Fig. 10. TRO Relay Calibration Curve Showing Switch Closing Temperatures from 70 to 85 Degrees C.

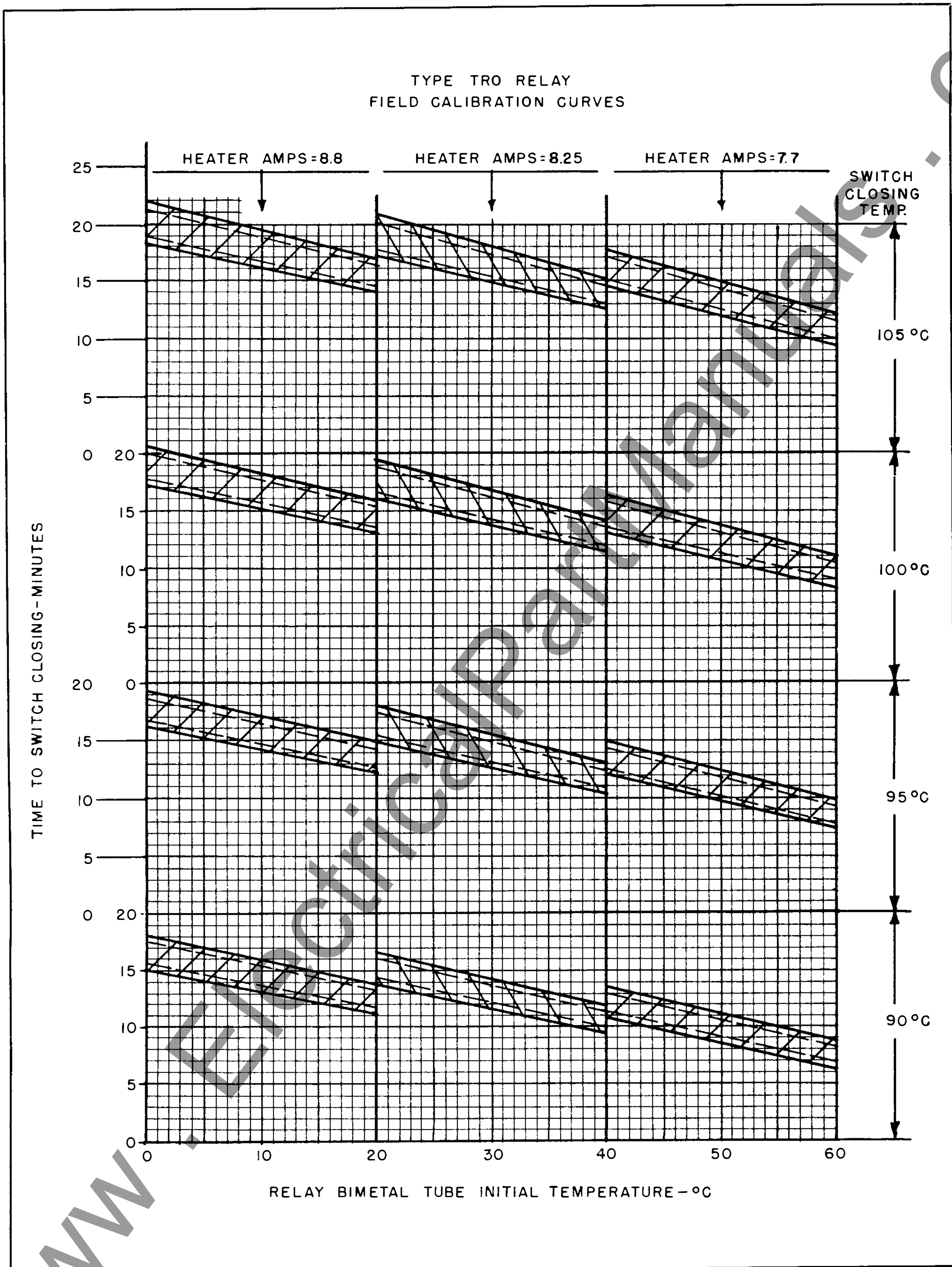

FIG. 11. TRO Relay Calibration Curve Showing Switch Closing Temperatures from 90 to 105 Degrees C.