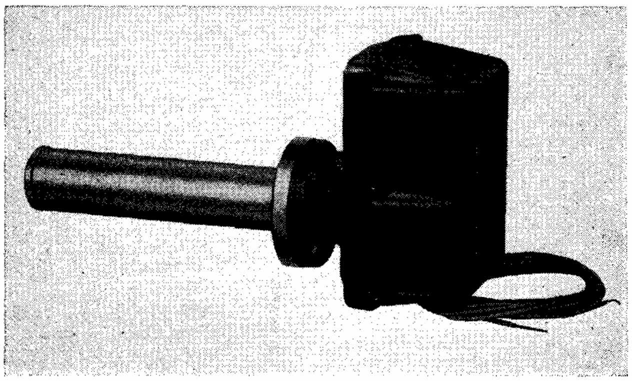
DESCRIPTION • OPERATION • MAINTENANCE

INSTRUCTIONS

THERMAL RELAY
TYPE TRO



THE TYPE TRO THERMAL RELAY is used on power transformers to automatically control air blast fans from the winding temperature, to operate a warning light if the temperature continues to rise, and finally, to trip and lock out the circuit breaker when the windings approach an unsafe temperature.

The relay is designed for operation by the winding temperature. It uses a bimetal thermal element which is heated in part by the top oil and in part by current proportional to the line current. This bimetal heating current is furnished by a current transformer connected in the line. By proper design of the heater element, the relay is accurately coordinated with the actual copper temperature of the winding.

DESCRIPTION

The internal construction of the TRO relay is shown in Fig. 1. 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 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 line current. This heating coil may be either single-phase or three-phase, depending upon the application.

Each micro-switch is mounted with a spring pressing it against a contact adjusting screw (see Fig. 2) which is used when making calibration adjustments. The switch contacts should never be used on direct current nor above 120 volts alternating current (nominal 120-volt circuit).

The switches are applied well below their maximum current rating to insure long life and the contacts are used only to control interposing relays.

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

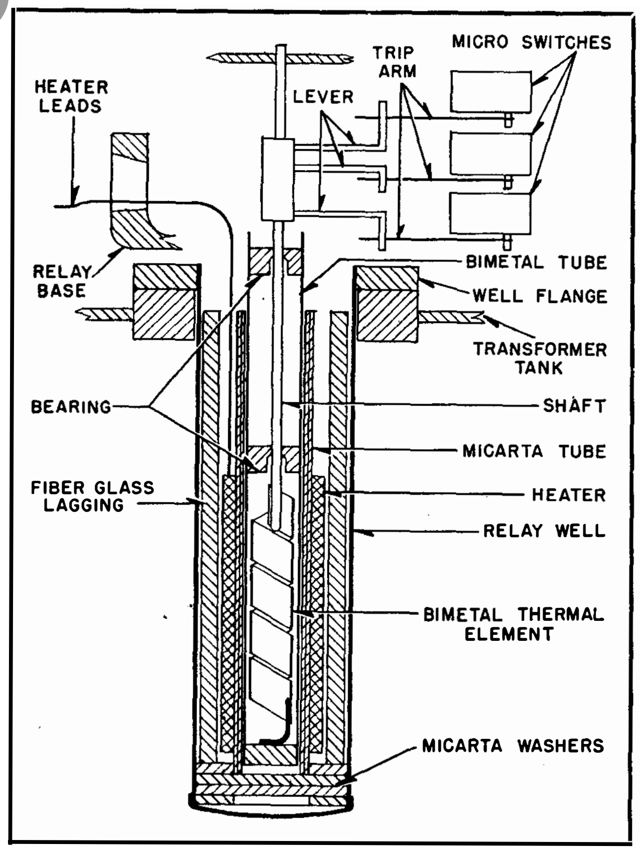


FIG. 1. Cross Section of TRO Relay Showing Internal Construction.

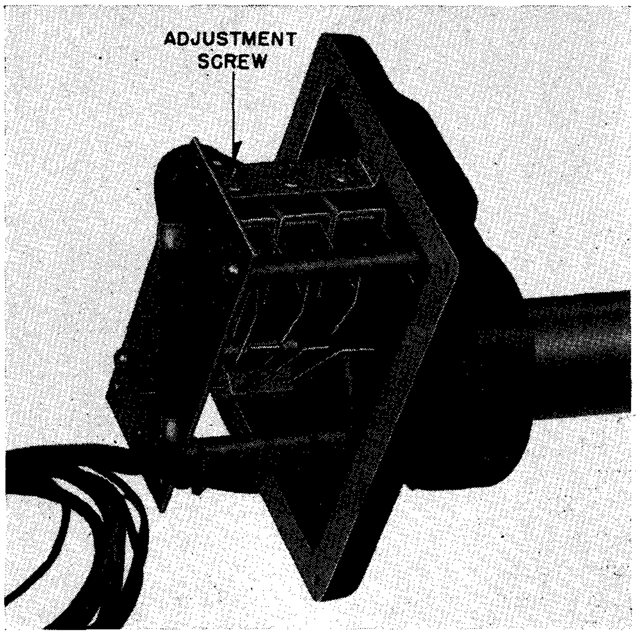


FIG. 2. Cover Removed Showing Adjusting Screw.

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 may 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. The relay can be tested or removed without taking the transformer out of service.

INSTALLATION

The TRO relay is usually mounted on the transformer tank wall so that the well extends into the top oil zone. This top oil zone is considered to be the zone above the coils and below the minimum oil level. However, on some units it may be necessary to place the well in an enlarged radiator tube header.

In most cases, the relay will be shipped mounted on the transformer and will be ready for operation. However, if for any reason the relay is shipped separately (the well in place), it can be added in the field without opening the transformer or breaking its 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.

To install the relay:

1. Remove the blind flange and connection box plug.

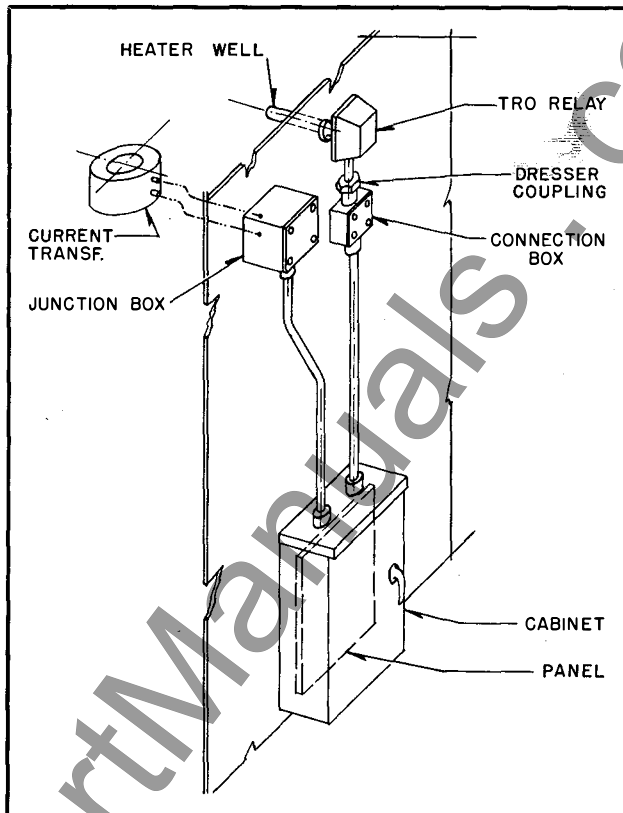


FIG. 3. Sketch Showing Relay Mounted on Transformer Tank Wall.

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.

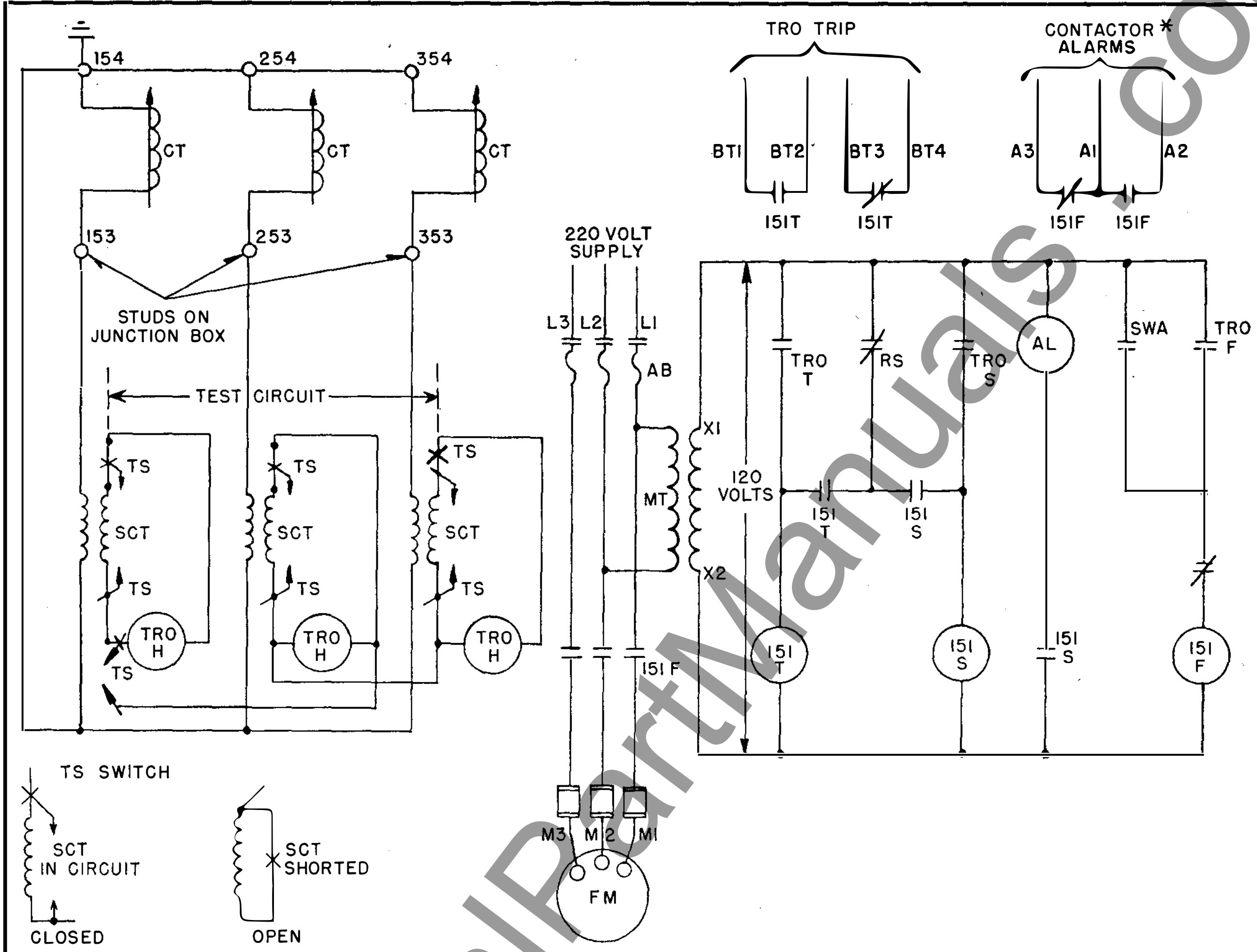
4. Tighten the dresser coupling.

To remove the TRO relay, reverse this procedure.

Since all leads from the relay and heater are brought outside through the base of the relay, there is no need, 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.

OPERATION

When the oil temperature plus the gradient between the bimetal and oil equals the temperature for which the contact has been adjusted, the bimetal thermal element has turned the shaft lever which engages the switch arm and closed the micro-switch contact. Since the gradient depends on the current, this operation coordinates the relay operation with actual winding temperatures.



LEGEND

CT	CURRENT TRANSFORMERS
SCT	SATURATING CURRENT TRANSFORMERS
MT	CONTROL TRANSFORMER (TYPE "MT" 220 TO 120 V)
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
151-S	SIGNAL RELAY
151-F	FAN RELAY
RS	TRIP AND SIGNAL RELAY RESET
SWA	TO START FANS MANUALLY-NORMALLY OPEN
SWB	TO STOP FANS MANUALLY-NORMALLY CLOSED
AB	AB BREAKER
TS	TRO RELAY TEST SWITCH
M1-M2-M3	FAN MOTOR LEADS
AL	SIGNAL LIGHT
FM	FAN MOTOR
*	USED ON 3-PHASE FAN CONTROL ONLY

FIG. 4. Typical Connection of TRO Relay.

Fig. 4 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, 220 volts alternating current must be connected to the control transformer primary, MT, when it is supplied, or 120 volts alternating current across X1X2 when the control transformer is not supplied. This diagram is for a three-phase application using one TRO relay with a three-phase heater. Relays can be supplied with one or three heaters. Current is supplied to the three-phase heater from three 5-ampere secondary through-type current transformers (mounted in the transformer tank) and 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.

As the winding temperature increases, the bimetal will twist and thereby turn the shaft and close the fan switch, thus causing the fan relay to energize the air blast fan motors. The fan will continue to operate as long as the gradient between bimetal and oil plus the oil temperature is greater than the temperature for which the fan contact is adjusted. The opening point is actually about 8 degrees below the closing point. If the temperature decreases below this point, due to decreased load, 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 the winding temperature continues to increase, the bimetal element will turn until a second switch, the signal switch, closes. This signal switch energizes the signal relay which in turn energizes a warning light (AL). The signal relay is self-sealing so that the light will not go off until the reset switch is opened.

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 the trip relay which then seals itself in. The trip relay closes a contact that trips the circuit breaker and opens a contact to lockout 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.

Short Time Characteristics—The TRO thermal relay is designed with sufficient time delay to prevent it from operating ahead of the regular protective relays under severe overload 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.

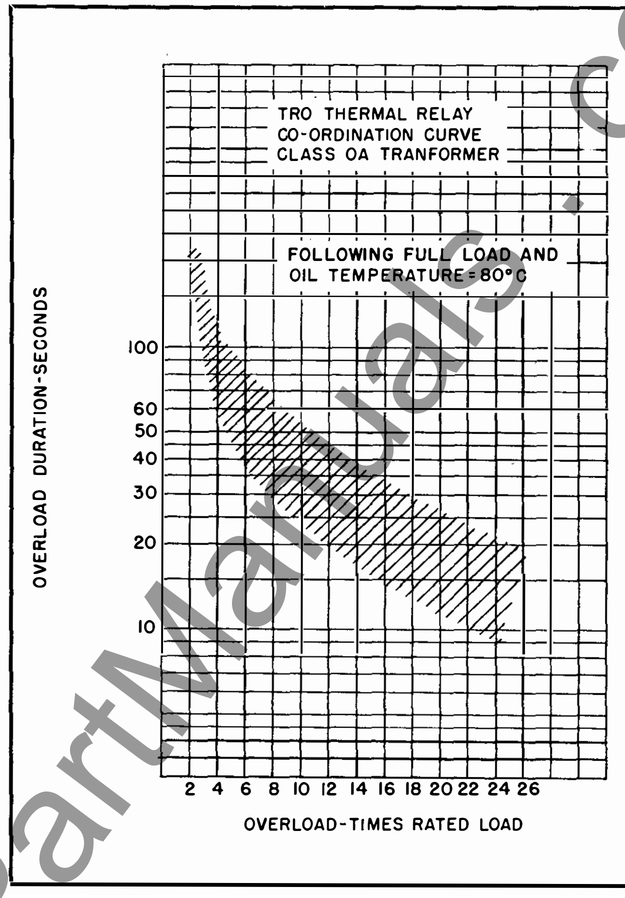


FIG. 5. TRO Relay Coordination Curve for Overloads Following Full Load at an Oil Temperature of 80° C.

The coordination curve shown in Fig. 5 is for overloads following full load at an oil temperature of 80 degrees 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. 5.

MAINTENANCE

No maintenance of the type TRO thermal relay is required. It is of rugged construction and 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 are rugged and should require no inspection.

The operation of the relay can be easily checked without taking the transformer out of service by means of the connections which are provided at a test block on the control panel. See instructions under sections on checking in oil bath and checking relay with heater and well on a transformer. Do not remove the relay cover unless it is done in a place where the relay can be treated as a precision instrument since dust, dirt, and careless adjustments will impair its operations.

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, the 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.

Checking in Oil Bath. 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 the signal lights so that the operation of the three switches can be determined. The signal light circuit should not be over 130 volts, 25 or 60 cycles, and should preferably use 6-watt lamps. Refer to Table 1 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 temperatures outlined in Table I.

TABLE I

SWITCH AND WIRE COLOR AND CODE	OPERATING TEMPERATURE OF SWITCHES (CLOSE DIRECTION) *	
	NORMAL	LIMITS
Relay S# 1484097		
Black (Fan)	70°C	68– 72°C
Green (Signal)	85°C	83– 87°C
Red (Trip)	95°C	93– 97°C
Relay S# 1484098		
Black (Fan)	70°C	68– 72°C
Green (Signal)	90°C	88– 92°C
Red (Trip)	100°C	98–102°C
Relay S# 1484099		
Black (Fan)	70°C	68– 72°C
Green (Signal)	95°C	93– 97°C
Red (Trip)	105°C	103–107°C

* The operating temperature of the switch is the temperature of the bimetal at which the switch is closed. It should not be confused with hot spot winding temperature.

Relays not bearing the above style numbers are specially calibrated to meet the requirements of the particular transformer on which they are mounted. It will be necessary to refer to the Instruction Book furnished with the unit or consult the factory to determine the relay settings.

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 is provided on the control panel for each 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, a fourth switch is provided and so wired that opening all the switches connects the three heater coils in series. The same calibration data can then be used for three-element heaters as for single 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.

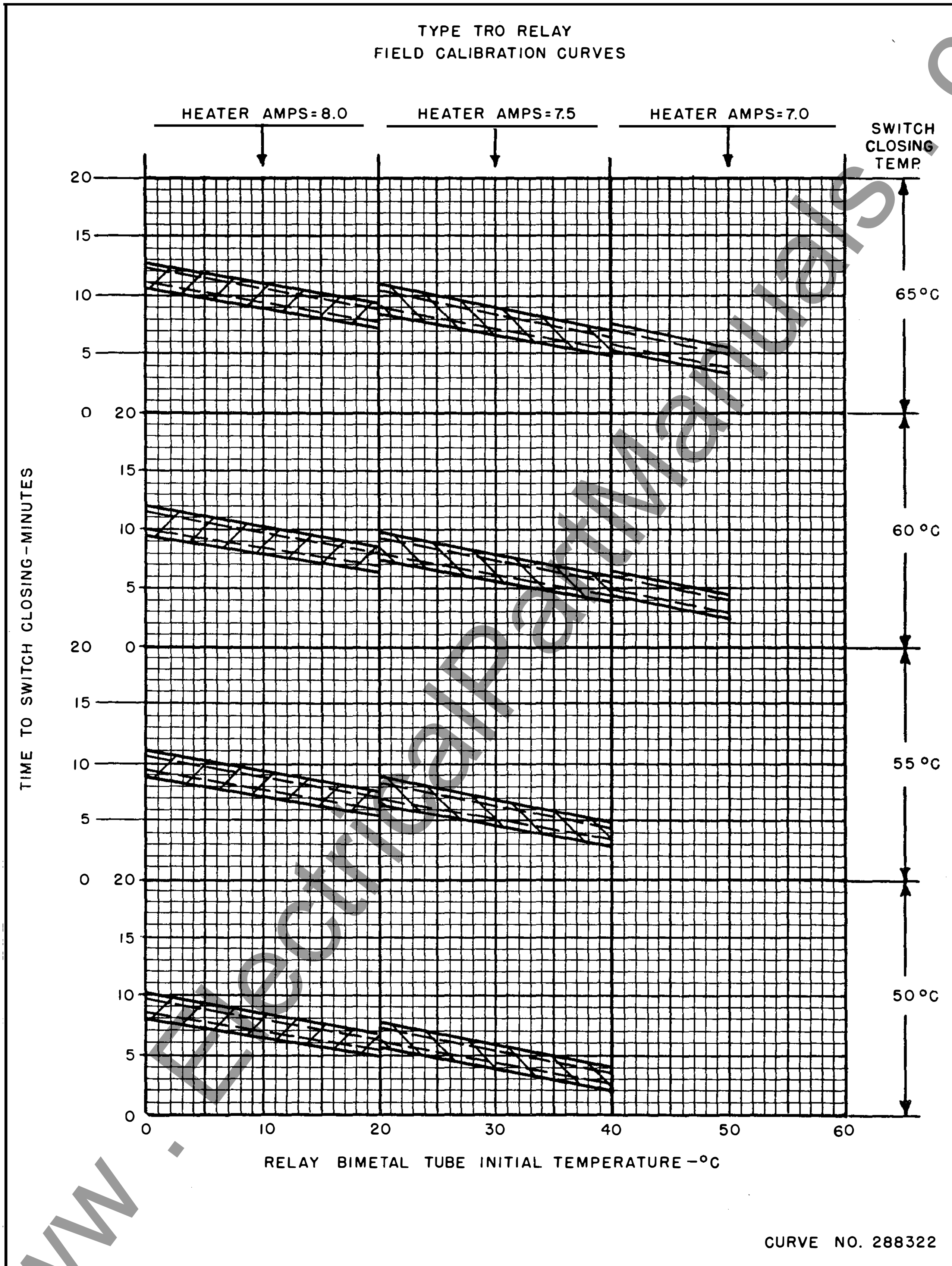


FIG. 6. TRO Relay Calibration Curve Showing Switch Closing Temperatures from 50 to 65 degrees C.

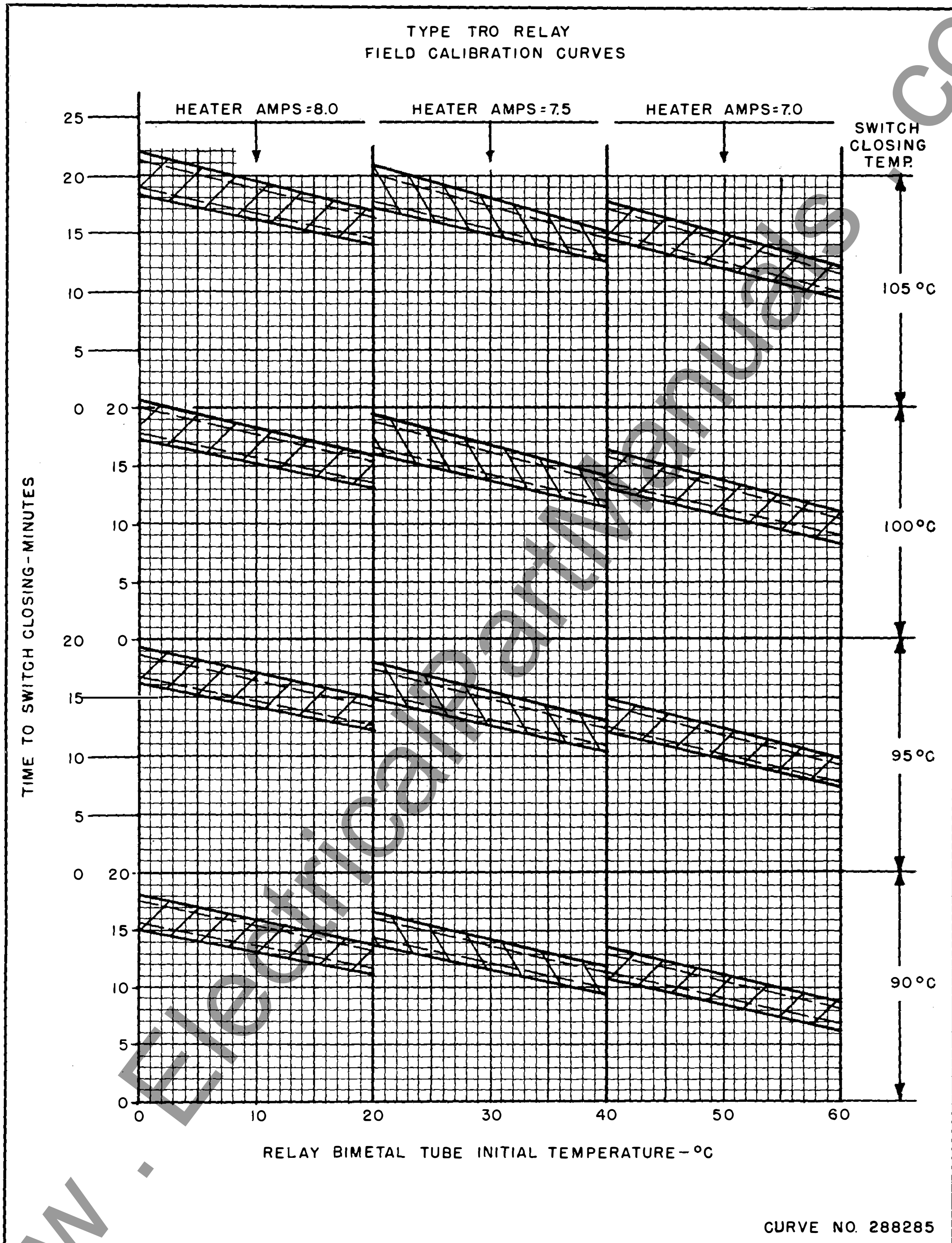


FIG. 8. TRO Relay Calibration Curve Showing Switch Closing Temperatures from 90 to 105 degrees C.

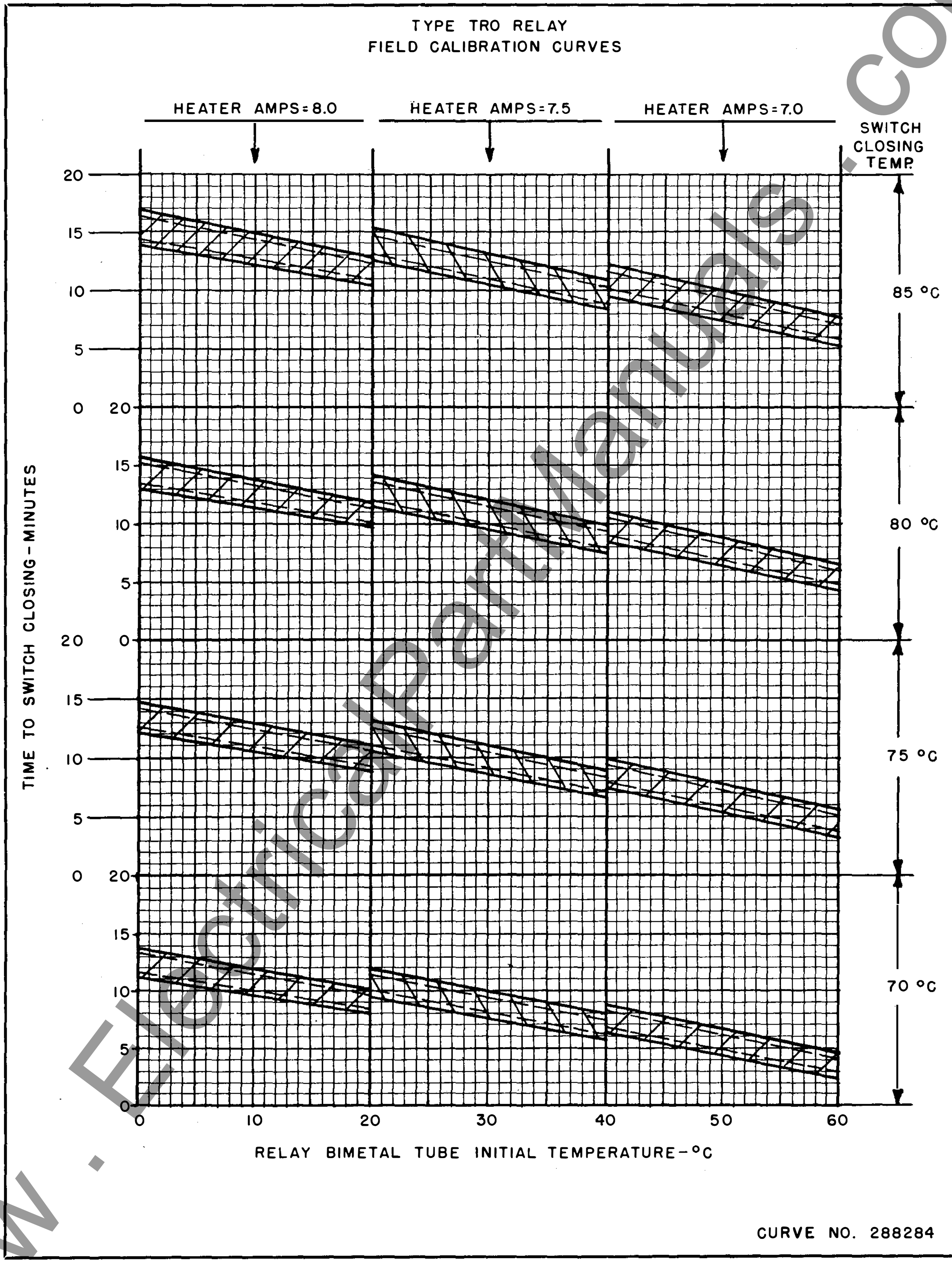


FIG. 7. TRO Relay Calibration Curve Showing Switch Closing Temperatures from 70 to 85 degrees C.

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.

Observe the temperature of the oil and determine the test current from the calibration data shown in Figs. 6, 7 and 8. 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.

To test the relay, open the knife switches to isolate the heater coils and allow the heater and bimetal to return to oil temperature as explained above. Be sure voltage is supplied to the control relays and that the tripping circuit is open to avoid dropping the load. Set fan control (when supplied) for "automatic" operation, and put the cut-off switch at the "on" position. 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 this sequence:

1. Starts the fans.
2. Lights the signal light.
3. Closes the trip contact of the tripping relay.

When the calibration run has been completed, the observed closing times should be compared with the data on the curves in Figs. 6, 7 and 8. The proper switch closing temperatures can be determined from the style number on the TRO relay case and the tabulation given under instructions for checking in oil bath in Table I.

Example:

To check calibration on relay S#1484098, refer to Table I. Fan switch closes normally at 70 degrees C; signal switch closes normally at 90 degrees C; trip switch closes normally at 100 degrees C.

Assume observed oil temperature is 30 degrees; then the heater will require 7.5 amps.

Record the time from applying heater current until switches close and compare with time as shown in Figs. 6, 7 and 8 for 7.5 amps. and 70, 90 and 100 degrees C switch closing temperatures.

Time falling above the bands indicates too high switch closing temperature and below the bands too low switch closing temperature. The actual closing temperature will be indicated by the time band within which the switch operates and its corresponding switch closing temperatures.

Adjustments. Do not make any adjustments to the relay unless the precautions enumerated in the previous paragraphs have been taken.

The relay switch operating temperatures may be adjusted 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. Counterclockwise rotation of the screw will raise the operating temperature.

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.

RENEWAL PARTS

In case it becomes necessary to repair the instrument, contact the nearest Westinghouse Electric Corporation office. Complete instructions will then 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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