DESCRIPTION • INSTALLATION

INSTRUCTIONS

TEMPERATURE INDICATORS
Hot Oil Dial Type
Submersible No Switches and One Switch Direct Mounted

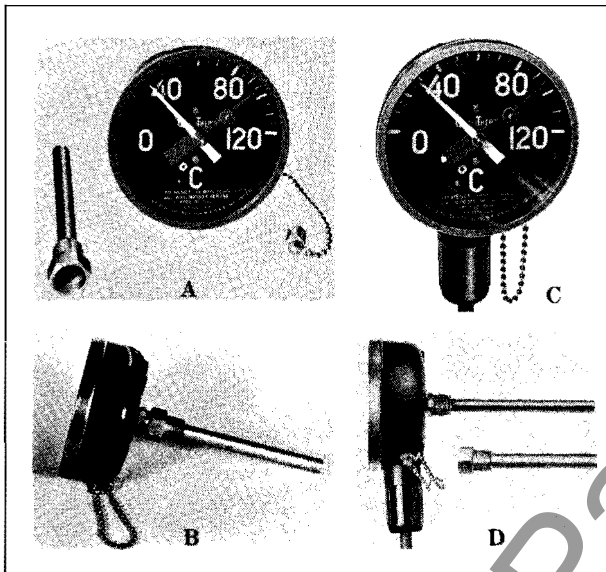

FIG. 1. (A) Front and (B) Side View of Indicator Without Alarm Connections; (C) Front and (D) Side View of Indicator With Alarm Connections.

TEMPERATURE INDICATORS, designed for application on Westinghouse transformers or related apparatus to indicate liquid temperatures, are self-contained, weatherproof and submersible instruments of the dial type, operated by means of bimetallic elements immersed in the liquid.

They are usually shipped mounted on the transformer cases, require no maintenance, and are suitable for oil or Inerteen.

DESCRIPTION

The indicator is a dial type precision instrument whose needle is directly coupled to a bimetallic, spiral actuating element in the stem, which fits closely into a well. The well is of thin-walled construction and screws into a fitting on the transformer case, making an oil-tight connection.

Note: Do not fill the well with a solid or liquid before inserting the stem of the indicator since this may damage the instrument without appreciably helping in the transfer of heat from the oil to the heat sensitive element. The indicator should not be tightened in the well any more than is necessary to place the dial in an upright position.

The dial is calibrated in degrees centigrade and is easily read because of the contrasting black face with yellow characters, graduations, and indicating pointer.

A maximum indicating pointer, red in color, is used to indicate the maximum temperature reached between readings. This hand is reset by wiping a magnet across the face of the dial. The

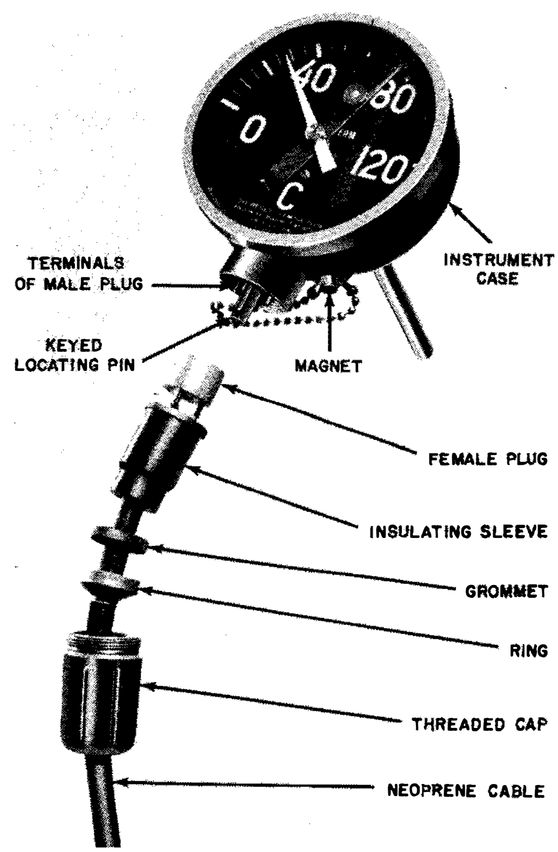

FIG 2. Triple Seal Connection Details.

Instructions for Temperature Indicator Hot Oil Two Switch, Dial Type, Submersible, Direct Mounted

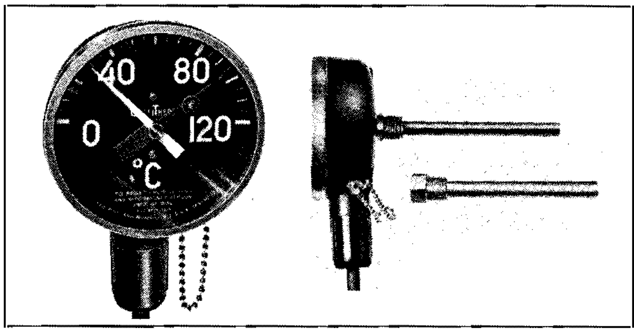

Fig. 1. Front and Side View of Indicator with Alarm Contacts

THE TWO SWITCH TEMPERATURE INDICATOR designed for application on Westinghouse transformers or related apparatus, is used where both fan control and alarm circuits are required. This leaflet covers the hot oil temperature type of indicator. It is a dial type instrument operated by a bimetallic element, and is made weatherproof and submersible.

The two switches of the indicator are set to operate at different temperature levels, the lower level switch controls the fan circuit, and the higher level switch controls the alarm circuit. The fan circuit is used to provide added cooling when the transformer temperature comes within the range of the switch. The alarm circuit operates at a higher temperature to give warning in case the fans, for any reason, do not limit the temperature to a proper range. The circuits are separate so that both a-c and d-c may be used.

The indicator is usually shipped mounted on the transformer case, requires no maintenance, and is suitable for use in oil or Inerteen.

DESCRIPTION

The indicator (Fig. 1) is a dial type precision instrument whose needle is directly coupled to a bimetallic spiral actuating element in the stem which fits closely into a well. The well is of thin-walled construction and screws into the tank wall making an oil tight connection. **NOTE: Do not fill the well with a solid or liquid before inserting the stem of the thermometer since this may damage the instrument without appreciably helping in the transfer of heat from the oil to the sensitive element. The thermometer should not be tightened in the well any more than is necessary to place the dial in an upright position.** The instrument can be removed from the well in the tank wall without loss of liquid and with no need for lowering the oil level. The instrument is weatherproof and submersible. The dial is calibrated in degrees centigrade and may be easily read because of the contrasting black face with yellow characters, graduations and indicating pointer.

A red maximum indicating pointer indicates the maximum temperature reached since last reset. This hand may be easily reset by wiping a magnet across the face of the dial provided the magnet is held with the poles in the proper position so as to attract the maximum indicating pointer. The magnet is attached to a small chain in the instrument case to prevent misplacing after using and is self-supporting in a metallic socket near the underside of the case. The method of resetting the maximum indicating pointer is shown in Fig. 2.

The alarm leads are brought through the underside of the case by means of a triple seal

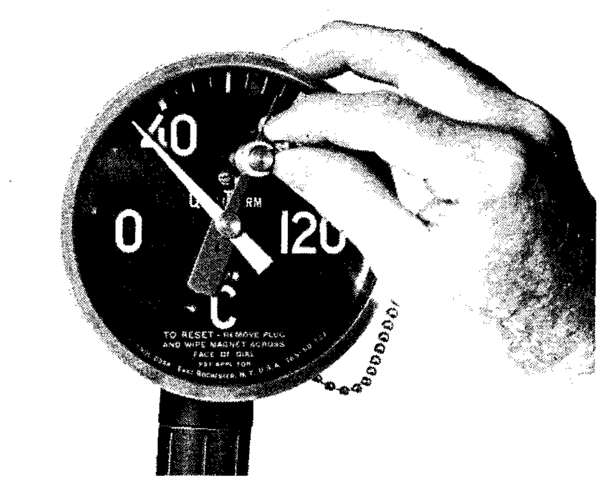

Fig. 2. Method of Resetting Maximum Indicating Pointer

Effective December, 1973 Supersedes I. L. 48-062-2B, April, 1973

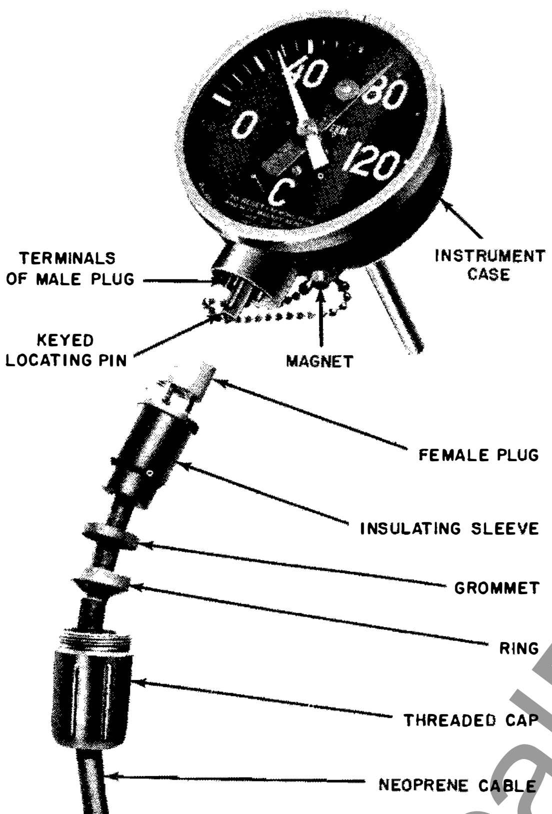

Fig. 3. Triple Seal Connection Details

connector, the details of which are shown in Fig. 3. This connector consists of the following:

1. The male terminals are molded into the case together with a locating pin to prevent making incorrect connections.

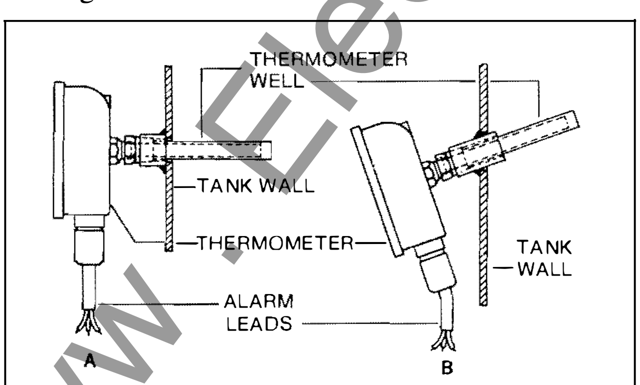

Fig. 4. Indicator Mounted Vertical (A) and Tilted Downward (B).

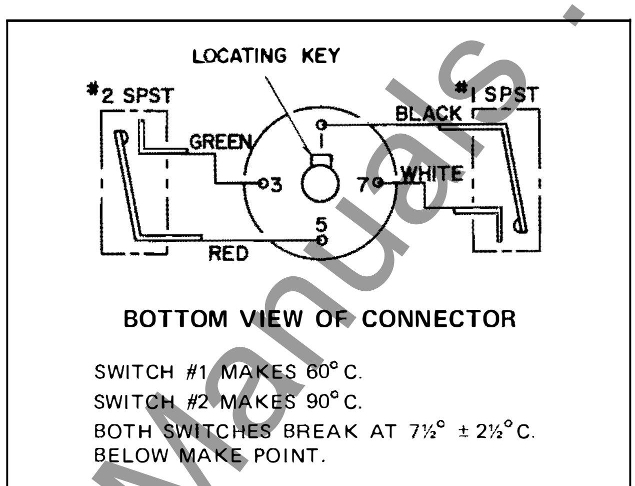

Fig. 5. Oil Temperature Relay With SPST Alarm Switch Wiring Diagram

2. The rubber female plug which has terminals to mate with the terminals in the case, and a hole to match the locating pin. The ends of the leads are tinned and crimped into the terminals of the male plug.

3. A bushing to compress the female plug against the male plug.

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

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

6. A threaded cap to hold the component parts of the connector tight in the case. This threaded cap is screwed into place.

There are two micro-switches in this type temperature indicator. Switch #1 is set to close at 60°C. for the fan circuit, and Switch #2 closes at 90°C. for the alarm circuit. The switches are adjustable over a range of ±10°C. in relation to the above mentioned values. The switches open at 7½° ±2½°C. less than the closing temperature. The ratings for the switches are given in Table No. 1, and the connection diagram are shown in Fig. 5 and Fig. 6.

TABLE NO. 1

VOLTAGE	NON-INDUCTIVE LOAD—AMPS.	INDUCTIVE LOAD AMPS. L/R—.026*
125 A-C	10	10
250 A-C	5	5
125 D-C	0.5	0.05
250 D-C	0.25	0.025

***Equal to or less than .026. If greater, refer to factory for adjusted rating**

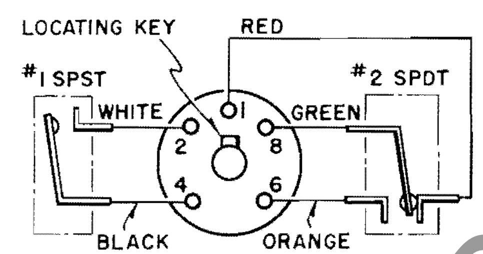

Fig. 6. Oil Temperature Relay With SPDT Alarm Switch Wiring Diagram

Important: Relays, solenoids and motors are inductive loads. When an inductive circuit is opened, a voltage is induced which tends to maintain current flow. The resultant arcing may result in failure of the contacts to interrupt current.

Field Test. Remove the thermometer from its well and submerge the stem up to the brass fitting in a closely controlled temperature, well agitated, oil bath. Check the temperature by placing a thermo-couple or other accurate temperature measuring device on the stem about two inches from the end. The thermometer should be accurate within ±2°C. (allowing 15 minutes for the thermometer to come up to temperature). To adjust a switch to a different value, remove the corresponding numbered sealing plug at the top of the case. Make the proper adjustment of the switch through the opening in the case, and then reseal the case with the sealing plug.

Important. When changing the alarm setting on those temperature indicators with adjustable contacts, be sure to use a non-setting sealing compound on the threads of the sealing plug. Plastic Lead Seal #53351DA is recommended. Loose or improperly sealed plugs will allow moisture to collect in the indicators, and cause eventual shorting of electrical circuits or deterioration of dial markings.

INSTALLATION

The instrument is shipped fixed to the tank wall, so that no installation is necessary. When mounted at a high point, the indicator may be tilted so that it can be read easily from ground level (See Fig. 4).

Important: When checking circuits through this instrument it is necessary to follow 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.

RENEWAL PARTS

If it becomes necessary to repair the instrument, contact the nearest Westinghouse Office.

Westinghouse

THE LEADER OF THE TRANSFORMER INDUSTRY

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Instructions for Thermal Relay Type TRO-2 with Overload Indicating Dial

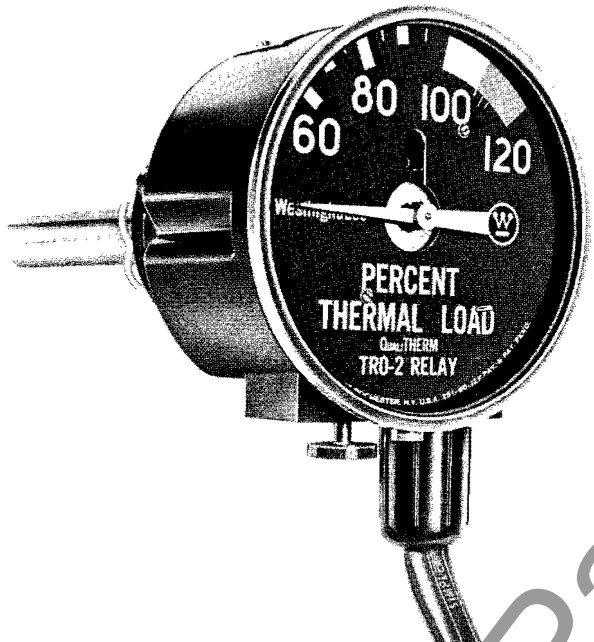

Fig. 1 Front View of TRO-2 Relay

THE TYPE TRO-2 THERMAL RELAY, used on power transformers of all types, combines the initiation of automatic cooling equipment with overload protection and thermal load indication. It is mechanically and electrically interchangeable with the type TRO-1 relay.

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.

DESCRIPTION

The internal construction of the TRO-2 relay housing is shown in Fig. 2. The thermal element consists of a spiral bimetal that is held stationary at the inner end and is coupled to a shaft at the other end. Rotating with this shaft is a set of eccentric cams that engage the tripping arms on the precision switches. 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

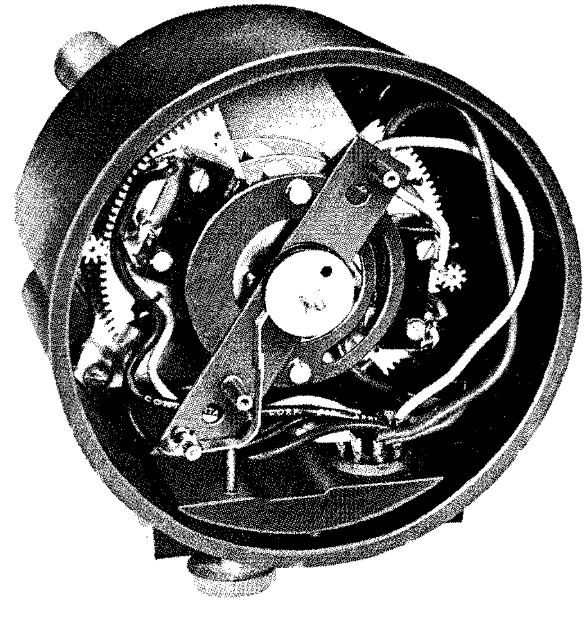

Fig. 2 Internal View of TRO-2 Relay Case

Effective September, 1964
Supersedes I.L. 48-062-17, March, 1962

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 precision switches can be accomplished from the outside of the case. The calibration screws are located on the back side of the relay case.

All contacts are automatically self-resetting. For contact duty rating see Table No. 1.

The bezel or outer assembly shown in Fig. 1 features a spun-on cover and includes a 5-1/2" 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 taking the transformer out of service or lowering the oil.

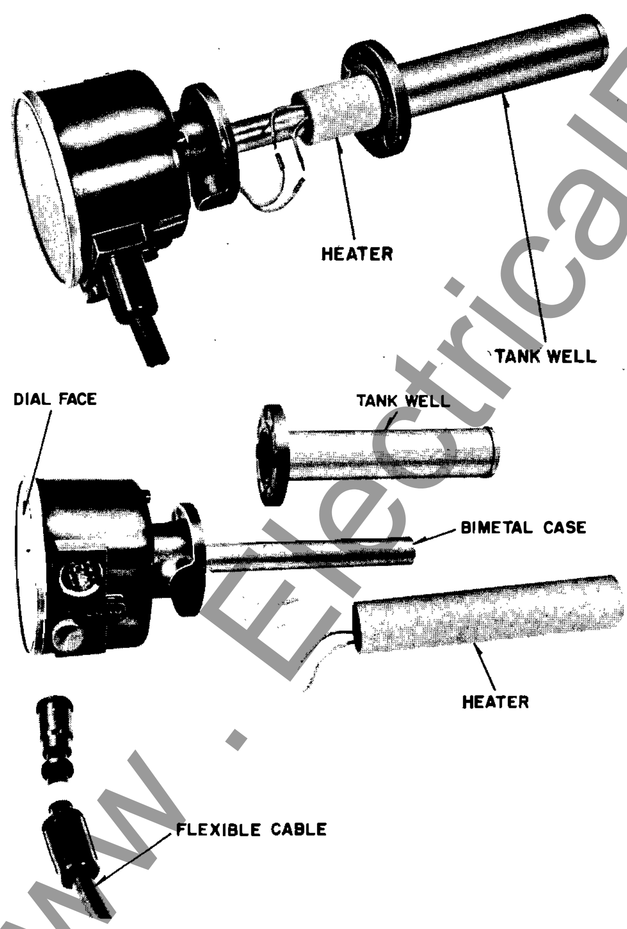

Fig. 3 *Assembly of TRO-2 Relay Tank Well, Heater Coil and Cable Attachment*

Table No. 1 *Interruption Ratings of Switches in Amperes*

	A.C.		D.C.			
			Non-Inductive Load		Inductive Load L/R $\leqq$ .026*	
	125 Volt	250 Volt	125 Volt	250 Volt	125 Volt	250 Volt
TRO Precision Switches	10	5	.5	.25	.05	.025

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

At the base of the relay case near the front is a water-shielded air inlet which prevents the buildup of internal positive and negative pressures. This greatly lessens the danger of glass breakage or of water being drawn into the case and remaining trapped.

The control circuit leads are brought through the underside of the case by means of an 8-conductor plug-in cable attachment, as shown in Figure 5 for the three switch relay.

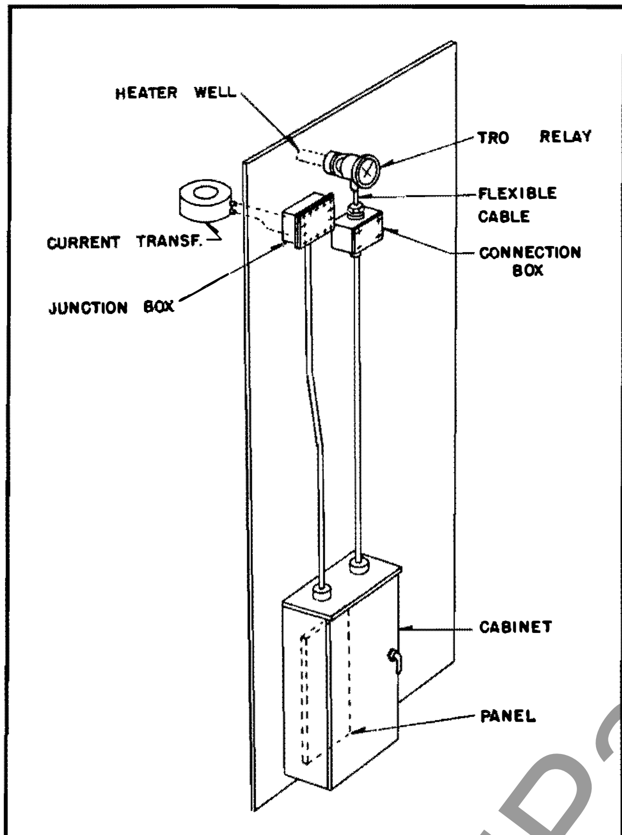

Fig. 4 TRO-2 Relay mounted on Transformer Wall

This conductor 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.

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.

The four switch relay is similar to the three switch relay except the heater leads are brought out seperately at the back of the case. See Fig. 6.

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. <u>Do not at any time handle the relay by the bimetal protective tube</u>. Undue strain on this part may be sufficient to throw the unit out of calibration.

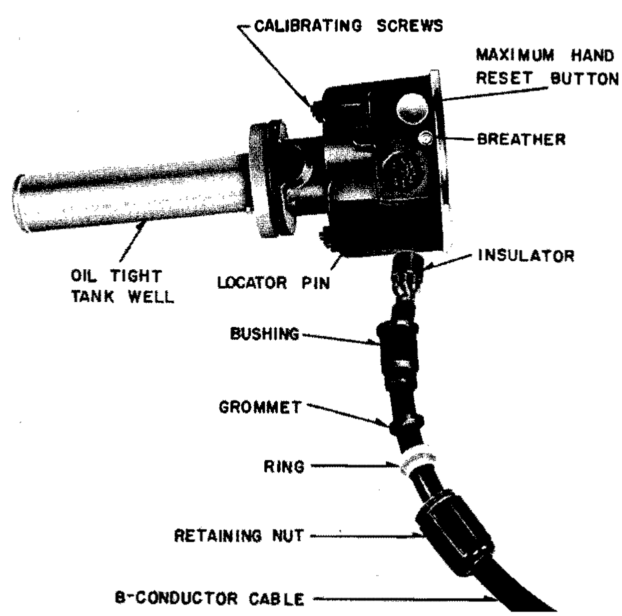

Fig. 5 Bottom View of TRO-2 Relay (Three Switch) Showing Cable Connector and Socket

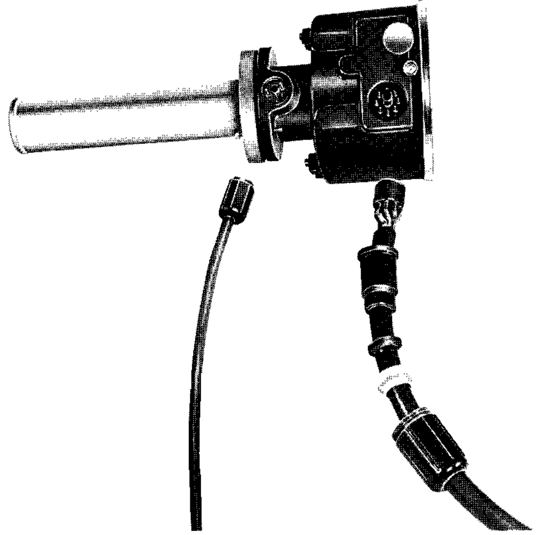

Fig. 6 Bottom View of TRO-2 Relay (Four Switch) Showing Cable Connectors and Sockets

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 brace. In those cases where the cable is shipped as a detail item, it will be necessary to strip back the insulation and connect the cable leads to terminal points as per the wiring diagram furnished with the unit. (See also Fig. 8) Among the details shipped with each cable will be a cable grip entrance fitting and a cable entrance reference drawing for aid to installation

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. 7, 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 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 for corresponding loads.

Refer again to Fig. 7 and the typical thermal relationships existing in a transformer equipped with thermal overload relay S#622D110G05 or 622D111G01. 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 117 degrees C. is generally regarded as the top limit above which continued operation of transformer insulation under the Insuldur system would involve some loss of life above normal. When the hot spot temperature reaches 117 degrees C. under these conditions, the corresponding relay bimetal temperature is 100 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 130 degree level will raise the relay bimetal temperature to 110 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 130 degree mark would involve excessive loss of insulation life. This limiting temperature is indicated whenever the dial needle reaches the 110% mark.

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.

A typical application of this relay is in the control of air blast cooling by winding temperature. When more than one relay is used, like contacts are paralleled in the signal 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 a connector box or separate 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. It also provides the factory with a means for adjusting the bimetal

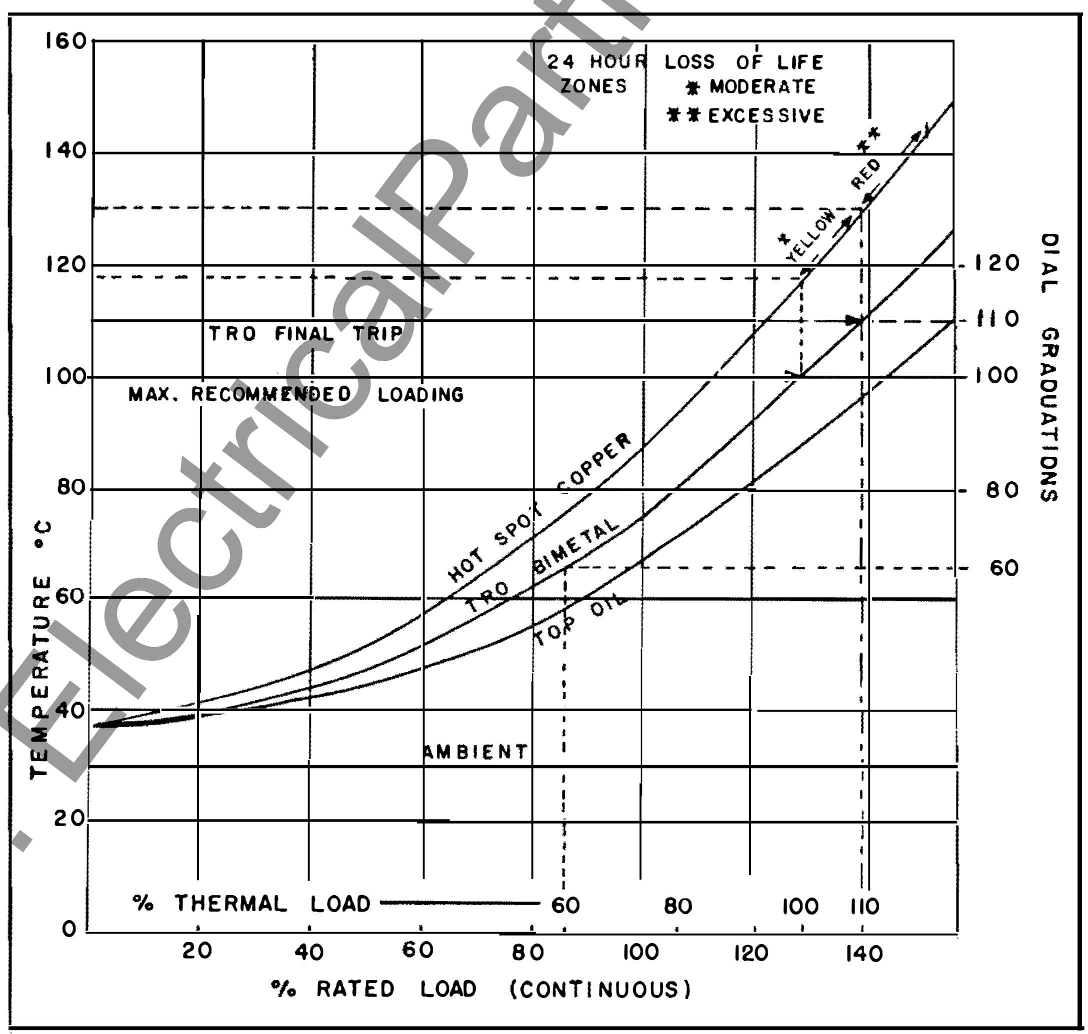

Fig. 7 Typical Thermal Relationships for Relay S#622D110G05 or S#622D111G01. See under "Continuous Overloads"

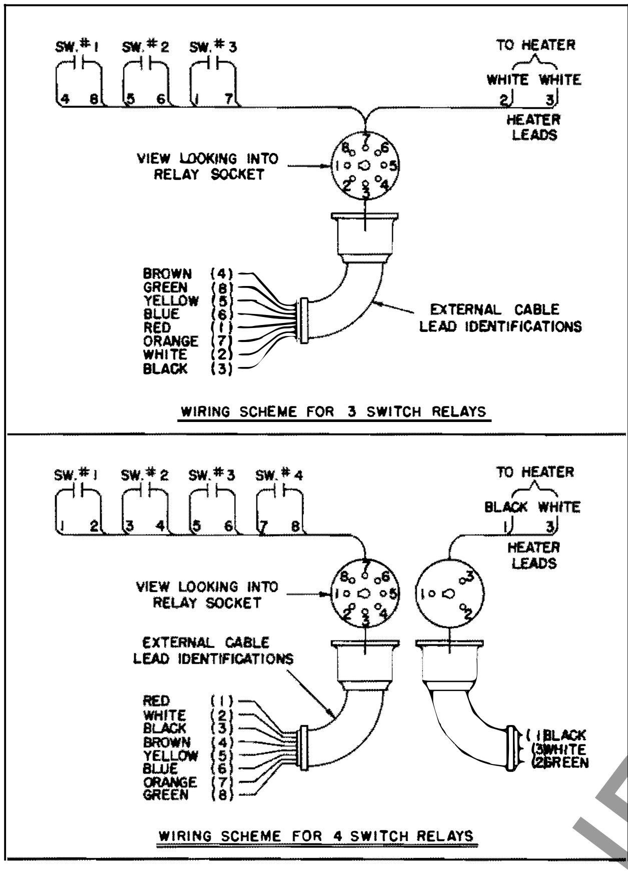

Fig. 8 Sketch of Internal Wiring

heater gradient with relation to the hot spot winding gradient.

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 10 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-2 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. In most cases it is optional with the user if and how the No. 2 switch is used in the alarm circuit. Its primary use is for the second stage of cooling in forced oil systems.

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 to trip the circuit breaker or sound an alarm. With the breaker open, the bimetal will cool and reset the switches.

Sometimes two switches are required in addition to a pair of auxiliary cooling control switches. Consult the wiring diagram supplied with the transformer for the exact equipment supplied. Typical internal wiring is shown in Fig. 8.

Coincidental with the closing of the highest 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.

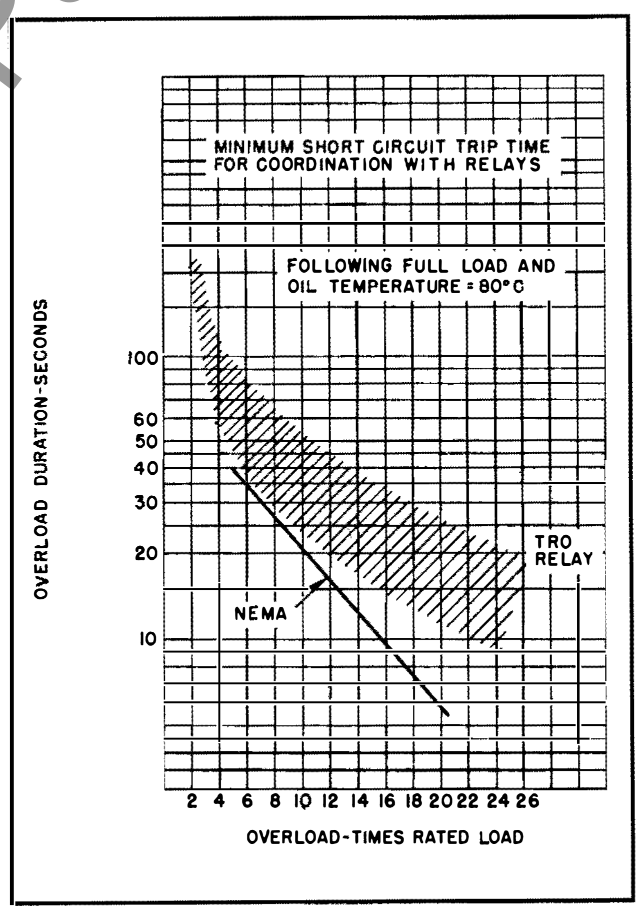

Fig. 9 TRO-2 Relay Coordination Curve for Overloads

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, 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 tripout. 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 1°C. in ambient temperature is virtually equivalent to a 1% change in thermal load.

Referring again to Fig. 7 "percent thermal load" has been shown in its correct relation to "percent rated load" at an ambient temp. of 30 deg. C. The dial graduations are indicated along the right vertical edge to show that they correspond to "percent thermal load". The term "thermal load" should not be confused with "kva load" since rated kva will seldom, if ever, cause the dial to read as high as 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 estimated from the dial without resort to complicated curves and tables.

Fig. 7 has been drawn for illustration purposes only. The values of oil rise, bimetal temperature, and hot spot temperature are not to be regarded as accurate for every transformer to which relay S#622D110G05 or 622D111G01 is applied.

Short-Time Overloads

The TRO-2 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 at some other ambient temperature.

MAINTENANCE

No maintenance of the type TRO-2 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 internal switches should require no replacement when loaded in accordance with Table No. 1 on page 2.

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, and 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.

<u>Checking Relay with Heater and Well On a Transformer. (Recommended Method).</u>

The calibration of the relay may be checked at the panel (see Fig. 4) when the transformer is in service and without disturbing the relay unless adjustments are required.

Opening the connection between saturating current transformer secondary terminals 1 and 2 and the heater leads will isolate each heater coil for test.

NOTE: There is no danger involved in opening the current circuit on the secondary side of the saturating current transformer (SCT) while the main CT is carrying normal current. The open-circuit voltage appearing on any pair of output terminals will not exceed 5 volts.

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. Table No. 2 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 Table No. 2 and choose that style for the reference data. 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 switches can be checked by raising the bimetal temperature above that of the highest numbered switch and noting the dial reading as each switch closes. The heat source for this rise in temperature is provided by circulating an abnormal amount of current through the heater coil.

1. Be sure voltage is supplied to any 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 switch it is necessary to observe the switch limitations of Table No. 1. This means that a low voltage bell ringer should not 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 switches of similar capacities.

2. Apply test current to the heater coil using the terminals left vacant by the removal of the SCT leads. 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 last switch closes.)

(1) Starts the fans.

(2) Operates switch No. 2 or starts 2nd fan bank.

(3) Operates switch No. 3.

Table No. 2 *Dial Reading (in % thermal load) versus Bimetal Temp. (°C)*

Percent Thermal Load	Bimetal Temp. (°C.)					
	622D110G01	622D110G02	622D110G03	622D110G04	622D111G01 / 622D110G05	622D110G06
50	.	.	49.5	54.5	59.5	64.5
51	.	.	50	55	60	65
52	.	.	50.5	55.5	60.5	65.5
53	.	.	51.5	56.5	61.5	66.5
54	.	.	52	57	62	67
55	.	47.5	52.5	57.5	62.5	67.5
56	.	48.5	53.5	58.5	63.5	68.5
57	.	49	54	59	64	69
58	.	49.5	54.5	59.5	64.5	69.5
59	.	50.5	55.5	60.5	65.5	70.5
60	46	51	56	61	66	71
61	46.5	51.5	56.5	61.5	66.5	71.5
62	47	52	57	62.5	67.5	72
63	47.5	52.5	58	63	68	73
64	48.5	53.5	58.5	63.5	68.5	73.5
65	49	54	59	64.5	69.5	74
66	49.5	54.5	60	65	70	74.7
67	50.5	55.5	60.5	65.5	71	75.5
68	51.5	56	61.5	66.5	71.5	76
69	52	56.5	62	67	72	77
70	52.5	57.5	62.5	67.5	72.7	77.7
71	53.5	58.5	63.5	68.5	73.5	78.5
72	54.5	59	64.5	69	74.5	79.5
73	55	60	65	70	75	80
74	56	60.5	66	71	76	81
75	56.5	61.5	67	72	76.5	81.5
76	57.5	62.5	67.5	73	77.5	82.5
77	58.5	63.5	68.5	73.5	78.3	83.5
78	59.5	64	69	74.5	79	84
79	60	65	70	75.5	80	85
80	61	66	71	76	81	86
81	62	66.5	72	77	81.5	86.5
82	63	67.5	72.5	78	82.5	87
83	64	68.5	73.5	79	83.5	88
84	64.5	69.5	74.5	80	84	89
85	65.5	70.5	75.5	81	85	90
86	66.5	71	76.5	81.5	86	91
87	67.5	72	77.5	82.5	87	92
88	68.5	73	78.5	83.5	88	93
89	69	74	79.5	84.5	89	94
90	70	75	80	85	90	95
91	71	76	81	86	91	96
92	72	77	82	87	92	97
93	73	78	83	88	93	98
94	74	79	84	89	94	99
95	75	80	85	90	95	100
96	76	81	86	91	96	101
97	77	82	87	92	97	102
98	78	83	88	93	98	103
99	79	84	89	94	99	104
100	80	85	90	95	100	105
101	81	86	91	96	101	106
102	82	87	92	97	102	107
103	83	88	93	98	103	108
104	84	89	94	99	104	109
105	85	90	95	100	105	110
106	86	91	96	101	106	111
107	87	92	97	102	107	112
108	88	93	98	103	108	113
109	89	94	99	104	109	114
110	**90**	**95**	**100**	**105**	**110**	**115**
111	91	96	101	106	111	116
112	92	97	102	107	112	117
113	93.5	98.5	103.5	108.5	113	118
114	94.5	99.5	104.5	109.5	114	119
115	95.5	100.5	105.5	110.5	115	120
116	96.5	101.5	106.5	111.5	116	121
117	98	102.5	107.5	112.5	117.5	122.5
118	99	104	109	114	118.5	123.5
119	100	105	110	115	120	125
120	101	106	111	116	121	126

(4) Operates switch No. 4 (when used).

3. When the calibration run has been completed, the observed dial readings should be compared with the data in Table No. 2.

Example:

To check calibration of relay S#622D110GO2, refer to Table No. 3. Switch No. 1 closes at 65 degrees; Switch No. 2 closes at 70 degrees C; Switch No. 3 closes at 95 degrees 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 Table No. 2, curve for S#622D110GO2 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 calibration.

Table No. 3 *Standard Relay Switch Alignment*

Nameplate Style No.	* Switch Operating Temp. (°C.)				Dial Reading At Close of Highest Switch
	Range 60-95	Range 70-105	Range 80-115	Range 90-125	
	No. 1	No. 2	No. 3	No. 4	
	Brown Green	Yellow Blue	Red Orange		
622D110G01	65	70	90		110%
622D110G02	65	70	95		110%
622D110G03	65	70	100		110%
622D110G04	65	70	105		110%
622D110G05	65	70	110		110%
622D110G06	65	70	115		110%
	Brown Green	Green Yellow	Blue Red	Red Orange	
622D111G01	65	70	100	110	110%
	Red White	Black Brown	Yellow Blue	Orange Green	
261D378G01	65	70	100	110	110%
S.O. Number	See Relay Nameplate				See Relay Nameplate

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

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 Table No. 2 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 6-1/2 inches, but not more than 8 inches.

1. Connect the leads to signal lights so that the operation of the switches can be determined. The signal light circuit must be kept within the capacity limits shown in Table 1. Refer to Table No. 3 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. With this setup the relay contacts should close within the limits out-

lined in Table No. 3. Observe the dial reading at close of switch No. 3 in the case of a 3-switch relay; switch No. 4 in the case of a 4-switch relay.

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 switches at the back of the relay case. See Fig. 10. A cement seal must first be broken to permit adjustment of the calibration screws. Refer to Fig. 10 for location of screws for each switch.

The relay may be recalibrated in place on the tank wall if an offset screw driver is available. If such is not available, it will be necessary to unbolt the relay from the well flange. In some cases it may also be necessary to unplug the flexible cable from the relay case.

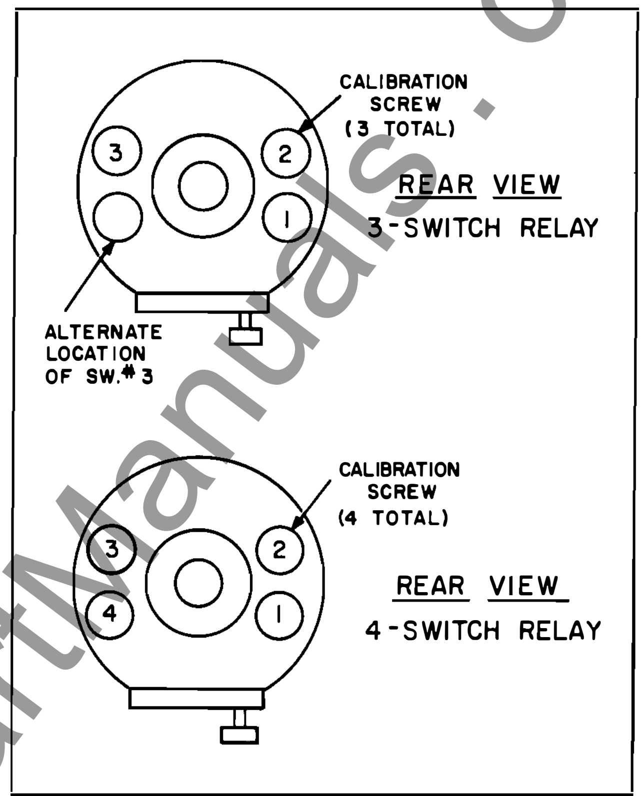

Fig. 10 TRO-2 Relay, Location Sketch for Switch Calibration Screws

SWITCH RECALIBRATION

The required number of degrees adjustment of a switch should be divided by the factor 15 to determine the exact part of a turn required to change the switch closing temperature. Clockwise rotation of the adjusting 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 shown in Table No. 3. See Fig. 10 for location of the correct alignment screw.

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 15 calls for 1 clockwise turn of the adjusting screw. Insert a screw driver into the No. 2 adjustment slot, then give it one full clockwise turn.

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 verified.

If an oil bath is available, a simple method of rechecking is as follows:

Bring the oil bath as quickly as possible to a temperature at least 2 degrees above that of the highest switch. Make sure all relay switches to be tested are still wired to lamp indicators. Don't begin the test until the bimetal tube 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 data of Table No. 2 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". (Page 8)

COMPONENT 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.

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

Replacement Bezel Kit--S#455C606GO1

Model TRO-2 relays are received with a spun-on cover rim that cannot be reused after removal. It is possible to purchase at anytime a bezel replacement kit that will enable the glass to be replaced and, if necessary, the dial plate removed for internal inspection of the relay in the field. It should be clearly understood that the purchaser of these kits assumes all risk for possible malfunction of relays after the replacement bezels are installed. Kit S#455C606GO1 consists of the following components:

Replacement Bezel	Mult. 1
Front Glass Disc	Mult. 1
Rubber Rim Gasket	Mult. 1
Clamping Lug	Mult. 3
Bezel Hardware	1 Set

Instructions for removal and replacement of relay bezel are as follows:

1. With a pair of cutting pliers or a hacksaw, cut and remove the aluminum spun-on rim.

2. Remove glass disc.

3. At this point, if inspection of the relay mechanism is desired do not loosen the needles but proceed as indicated. Otherwise skip to Step No. 11.

4. Push red reset button so that red hand coincides with yellow hand.

5. Remove two screws holding dial plate.

6. Rotate dial plate until keyhole shaped slot is directly opposite the pointer end of both needles.

7. Tilt the dial plate so that portion containing the keyhole slot passes above the yellow needle.

8. Rotate dial plate 1/2 turn until keyhole slot is directly underneath pointer end of both needles.

9. With a combination lift and sliding motion in the direction indicated by the dial pointer, remove the dial plate completely. If the needles become bent upward slightly,

they can be later straightened with the fingers when the dial plate is reinstalled.

10. When inspection is completed, reset maximum hand and then reverse the procedure covered in Steps 5 to 9 until dial plate is back in position.

11. Lay the replacement bezel backside up on a flat surface.

12. If glass has been broken or cracked, fit new glass disc inside the bezel, making sure rubber rim is in place. Be sure glass surface is clean.

13. Lower the relay case into the bezel ring and check location of thru-holes around circumference of the case. Rotate if necessary in order to position one of the holes about half way between the air inlet and the cable plug.

14. Position the clamping rings such that they overlap the narrow flange around the relay case.

15. Install screws lockwashers and nuts, 9 total, from front of bezel. Do not tighten completely until all screws are fairly secure.

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.

MEMORANDUM

MEMORANDUM

DESCRIPTION • INSTALLATION • OPERATION

INSTRUCTIONS

TEMPERATURE INDICATOR
HOTTEST SPOT DIAL TYPE
Non-Submersible Three and Four Switch Direct Mounted

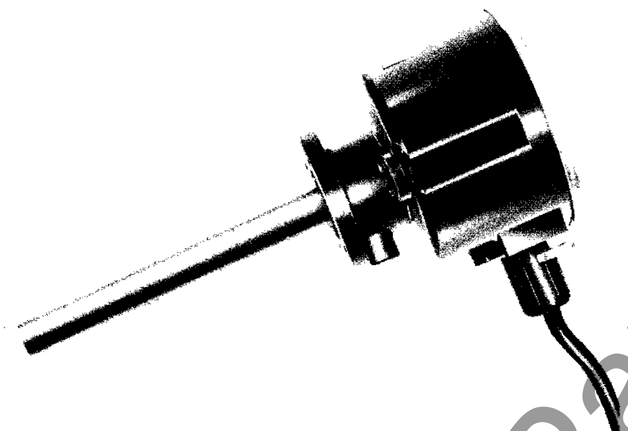

FIG. 1. Side View of Indicator

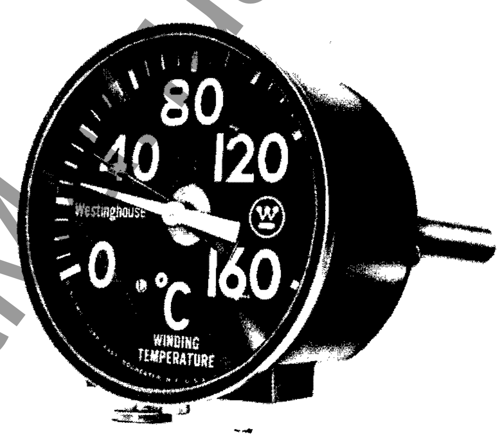

FIG. 2. Front View of Indicator

THE THREE OR FOUR SWITCH TEMPERATURE INDICATOR designed for application on Westinghouse transformers or related apparatus, is used where both fan control and alarm circuits are required. This leaflet covers the type of indicator which depends on the winding temperature. The indicator is a dial type instrument operated by a bimetallic element and is a self-contained weatherproof unit designed for outdoor application on transformers. The heating coil is designed to heat the bimetallic element to the temperature of the hottest spot in a transformer winding, when receiving a current proportional to that in the transformer winding.

The switches of the indicator are set at different temperature levels: the lower level switches operate the fan control circuit, and the higher level switches controls the alarm circuit. The fan control circuits serve to give added cooling when the transformer temperature comes within the ranges of the switches. The alarm circuit operates at a higher temperature range to give warning in case the fans, for any reason, do not limit the temperature to a proper range. The circuits are separate so that both a-c and d-c may be used.

DESCRIPTION

The internal construction of the indicator housing is shown in Fig. 3. The thermal element consists of a spiral bimetal that is held stationary at the inner end and is coupled to a shaft at the other end. Rotating with this shaft is a set of eccentric cams that engage the tripping arms on the precision switches. The bimetal and operating shaft are enclosed in a steel tube mounted on the relay base as shown in Fig. 4. 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.

The bezel or outer assembly shown in Fig. 1 and Fig. 2 includes a 5½" dial with indicating needle, maximum hand and reset mechanism. The dial is calibrated in degrees centigrade and is easily read because of the contrasting black face with yellow characters, graduations, and indicating pointer. The maximum indicating pointer, red in color, is resettable by means of a push button projecting out

EFFECTIVE SEPTEMBER, 1964
SUPERSEDES I.L. 48-062-10A, November, 1963

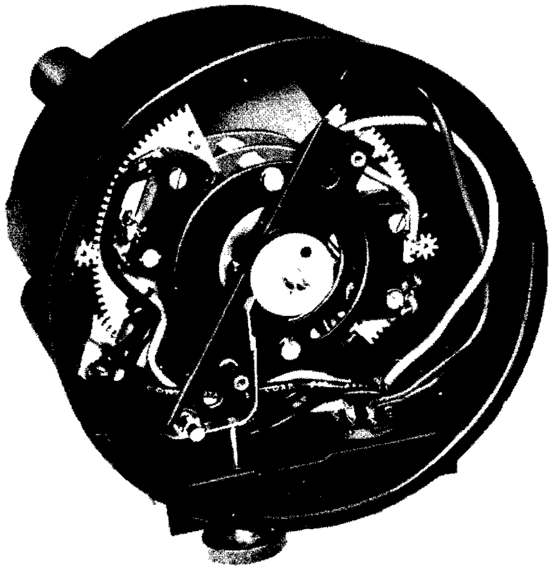

FIG. 3. Internal View of Indicator Case

through the bottom of the dial bezel. The button is spring-loaded so as to return to its inoperative position when released.

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 Fig. 6. 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.

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 the connector tight in the case. This retaining nut is screwed into place.

There are three precision switches in this type temperature indicator. Switch No. 1 is set to close at 70°C for a control circuit. Switch No. 2 is set to close at 75°C for the other control circuit, and switch No. 3 is set to close at 117°C for the alarm circuit. These are nominal values and will be supplied unless otherwise ordered. All switches open at 7½° ± 2½°C less than the closing temperature. The ratings for the switches are given in Table No. 1, and the connection diagram is shown in Fig. 8. The switches are adjustable over a range of ± 17½°C in relation to the above mentioned values.

The four switch indicator is similar to the three switch indicator except the heater leads are brought out separately at the back of the case. See Fig. 7.

TABLE NO. 1

VOLTAGE	NON-INDUCTIVE LOAD—AMPS.	INDUCTIVE LOAD AMPS. L/R .026*
125 AC	10	10
250 AC	5	5
125 DC	0.5	0.05
250 DC	0.25	0.025

*Equal to or less than .026. If greater refer to factory for adjusting rating

A change in the calibration of the precision switches can be accomplished by the switch calibration screws at the rear of the case. (See Fig. 5). Calibrating screws No. 1 and No. 2 are for the control circuits. Calibrating screws No. 3 and No. 4

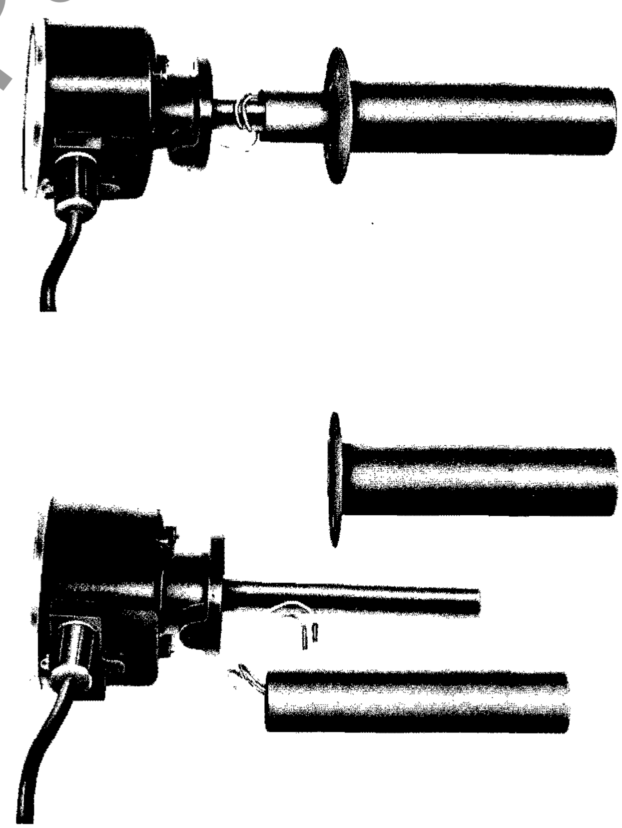

FIG. 4. Assembly of Indicator, Tank Well, Heater Coil and Cable Attachments

are for the alarm circuits or other required circuits. Clockwise rotation of the screw increases the temperature at which the given switch will close. Counterclockwise rotation will reduce the temperature. The indicator may be adjusted to any temperature in the range of 52½ to 134½°C. The result of changing the calibration should be verified before placing the indicator back in service.

When checking circuits through this instrument 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 precision switches of similar capacities.

The heating coil leads are spliced to the two heater leads coming from the body of the indicator. These two heater leads in turn are soldered to the proper terminals moulded in the case.

The indicator well is mounted on the tank wall and extends within the transformer case (See Fig. 10) in the hot oil zone. The indicator base is bolted to the well flange so that the indicator can be removed without taking the transformer out of service or lowering the oil.

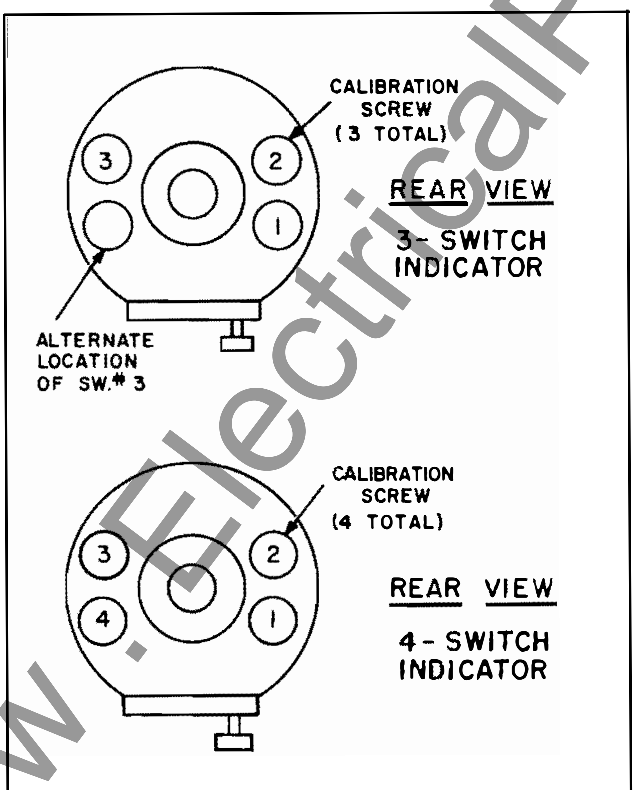

FIG. 5. Temperature Indicator, Location Sketch for Switch Calibration Screws

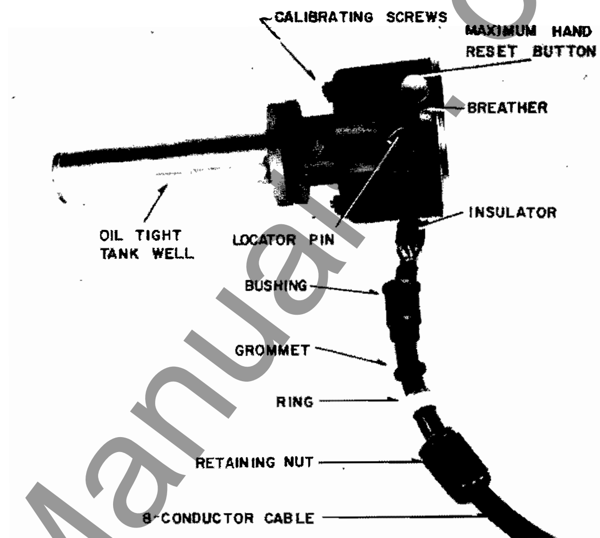

FIG. 6. Bottom View of Three Switch Indicator Showing Cable Connections and Socket

SHIPPING AND RECEIVING

The current transformer is generally shipped as part of the main transformer. It is usually of the through type which is slipped over the lower end of the bushing and mounted on the under side of the cover. Sometimes it will be mounted on the top of the terminal, bridges, or end frames. In this case, a Micarta tube will probably be used to conduct the current transformer leads to the terminal box. This tube will be installed in place on the current transformer. If the main transformer is not shipped

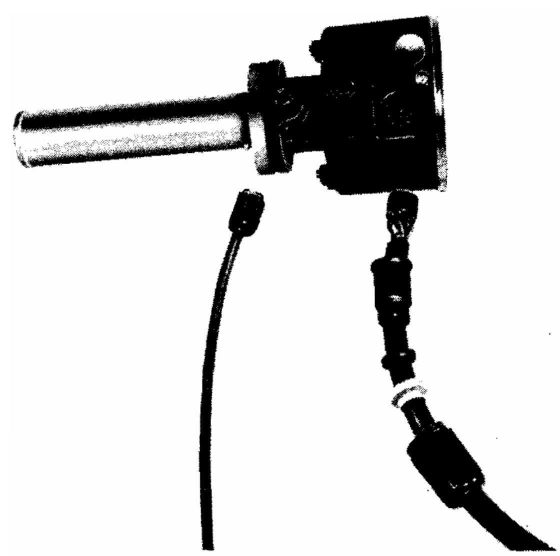

FIG. 7. Bottom View of Four Switch Indicator Showing Cable Connections and Sockets

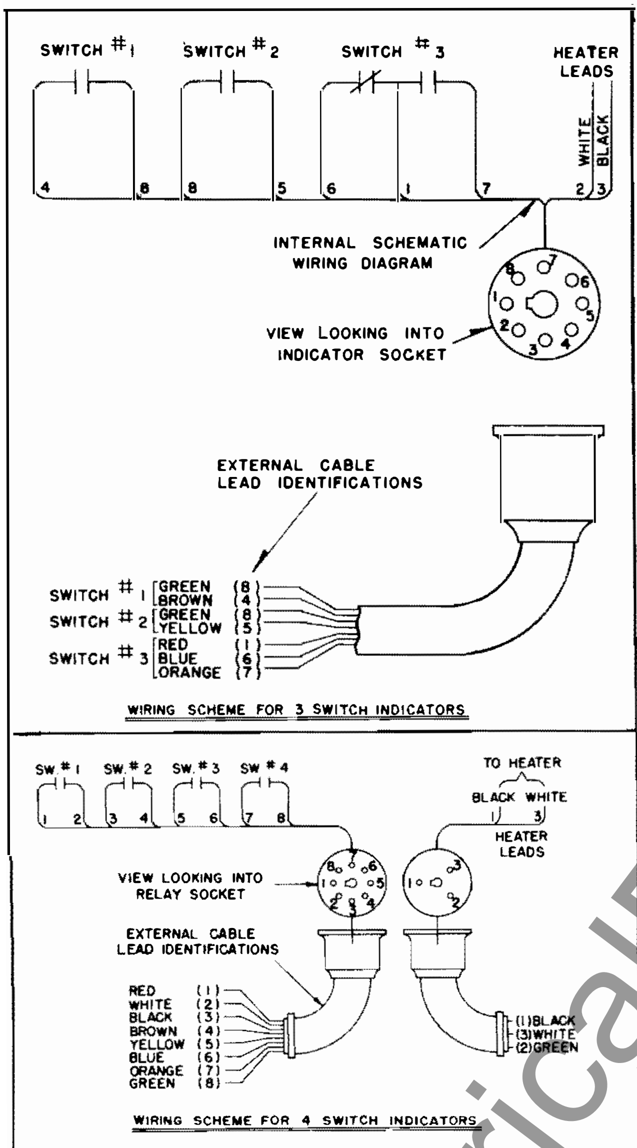

FIG. 8. Sketch of Internal Wiring

in its tank, the tube is slid down or removed and tied to the current transformer.

The hot spot temperature indicator and the heating coil are shipped mounted on the well on the tank wall, so that no installation is necessary.

OPERATION

The current transformer is mounted inside the case of the transformer, usually on a bushing. Its primary winding carries the main current of one of the transformers windings and its secondary winding delivers to the heating coil a reduced current which is at all times proportional to the load current. The insulation of the current transformer serves to protect the heating coil and temperature indicating equipment from the high voltage of the

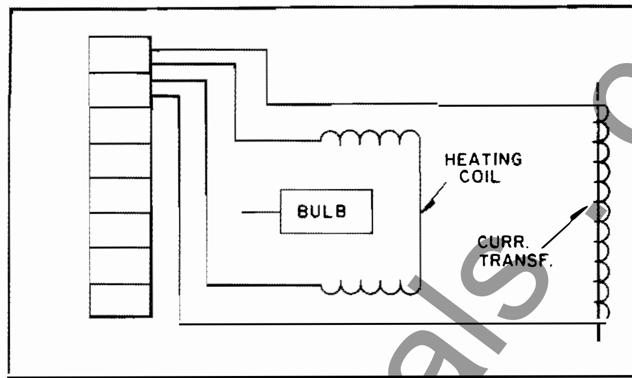

FIG. 9. Connection Diagram for Current Transformer and Heating Coil

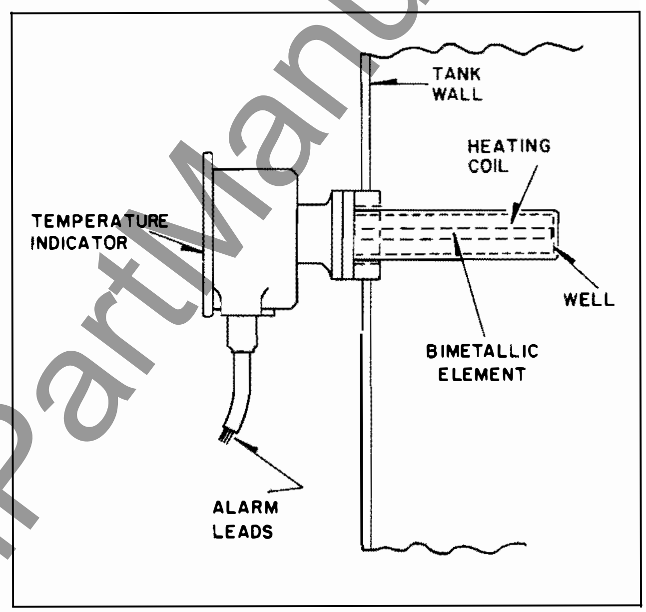

FIG. 10. Section View of Transformer Showing Mounting of Indicator

main transformer windings.

The heating coil is placed in the hot oil and its windings are worked at the same current density as the main transformer. In addition, the insulation of the heating coil winding has the same elevation in temperature above the oil as the windings of the main transformer. By these methods the temperatures inside the transformer windings are duplicated in the area surrounding the bimetal element of the indicator.

RENEWAL PARTS

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.

Instructions for Load Break Air Switch, Type LBF, for Power Centers

The Westinghouse Type LBF Switch is an air insulated, gang operated, three pole, two position link type load interrupter switch. The switch is mounted in a separate free standing compartment which can be bolted to air cooled or liquid filled power center transformers. See Fig. 1. LBF Switches, 5 KV or 15 KV, will interrupt load currents of 600 amperes. In addition, the LBF Switch will close on fault currents of 61, 000 amperes at 5 KV and 40, 000 amperes at 15 KV.

At times a feeder selector switch and an LBF switch are combined within a single enclosure. In these cases the feeder selector switch is located in a separate compartment immediately to the rear of the LBF Switch in the same housing.

OPERATION

LBF Switch. The small operating mechanism door must be unlocked and the operating handle withdrawn from the receptacle at the right hand of the opening. Insert the handle into the socket provided in the operating cam and move the handle to the desired position. The operating mechanism is powered by torsion bars, and will not move the blades until the handle is advanced beyond a certain point. At this time, the blades will move at a predetermined speed which is independent of the operator.

Feeder Selector Switch. In specific cases, a no load feeder selector switch is coupled to an LBF Switch. To operate the feeder switch, first place the LBF Switch in the open position, using the procedure outlined above. A mechanical interlock is thus released so that the main LBF Switch door can be opened, revealing the feeder switch operating handle. Pivot the feeder handle hand grip to disengage the locking pin, and rotate the handle 180° in the direction indicated to select the proper feeder.

Since the feeder switch is a no load switch, speed of operation is not essential to operator safety. However, to insure good contact when changing feeders, first disengage the contacts, then rapidly and forcefully rotate the operating handle to the desired feeder position.

Fuses. To gain access to the fuses, first place the LBF Switch in the open position. This action releases the mechanical interlock so that the main LBF Switch door can be opened, revealing the fuses in the bottom portion of the compartment. Use caution at this point to be certain the transformer is not energized by an additional source of power, either high voltage or low voltage. The switch cannot be reclosed until the main door has been closed.

INSTALLATION

During the installation of the switch, a general inspection should be made for shipping or handling damage. The switch should be operated several times to check the blade alignment and operating mechanism. Check the key interlock if supplied to be certain the switch and breaker interlocks are keyed alike.

MAINTENANCE

The LBF Switch and feeder selector switch, if supplied should be inspected a minimum of once a year. The following points should receive special care during the inspection:

1. Main Switch blade contacts.
2. Quick-break blade contacts.
3. Arc chutes.

All blades with burned or pitted contacts should be replaced to insure trouble free operation. Arc chute erosion, and/or burned quick-break blade contacts would indicate burned arc chute contacts, requiring replacement of the arc chutes.

Effective February, 1966 Supersedes I. L. 47-066-18, December, 1965

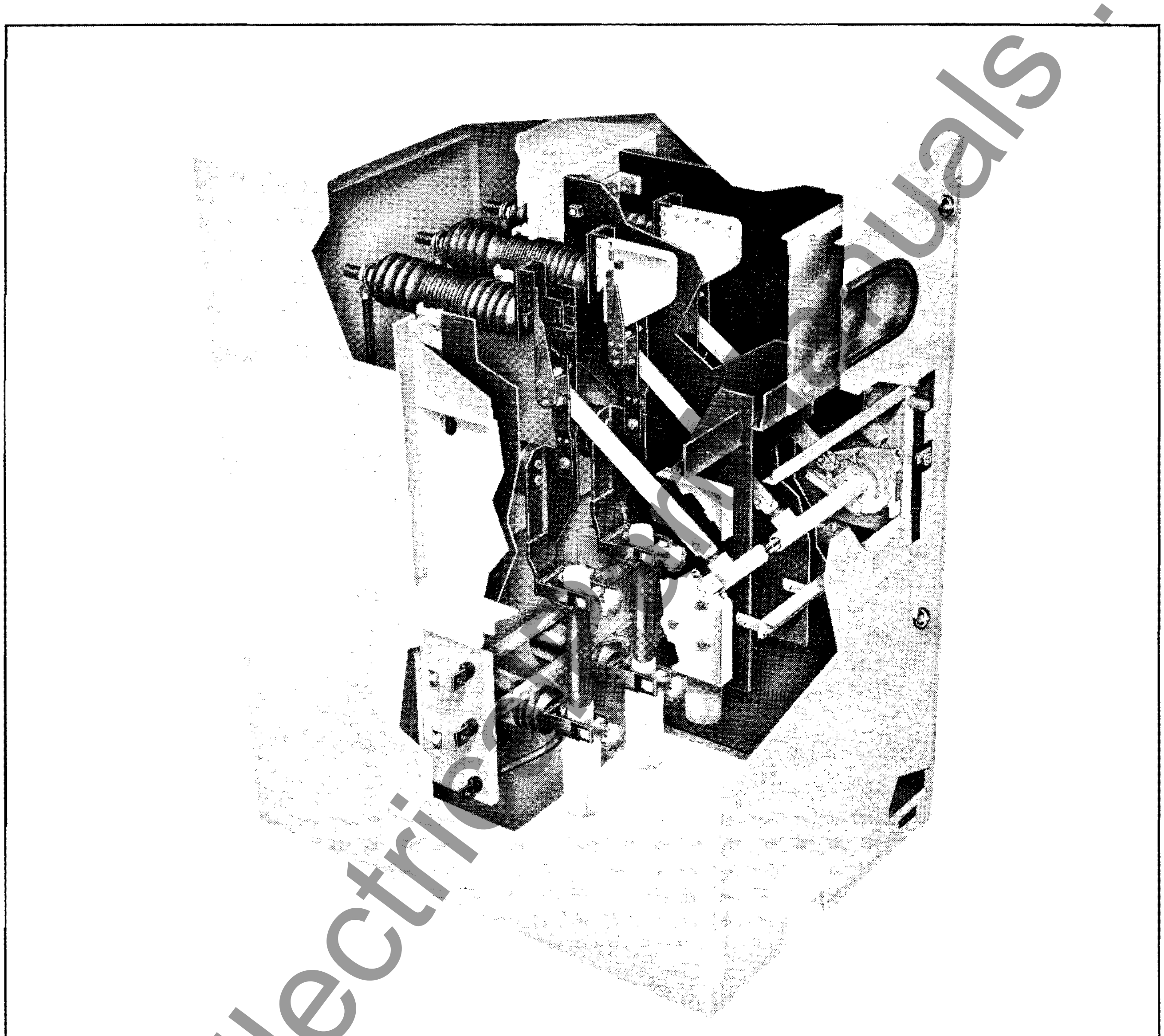

Fig. 1 Load Break Air Switch, Type LBF

RENEWAL PARTS

If renewal parts are required, order from the nearest Westinghouse Sales Office, giving description of parts wanted, with transformer serial number and rating as stamped on transformer instruction plate.

DESCRIPTION • INSTALLATION • OPERATION

INSTRUCTIONS

TEMPERATURE INDICATOR

HOTTEST SPOT DIAL TYPE

Non-Submersible Three and Four Switch Direct Mounted

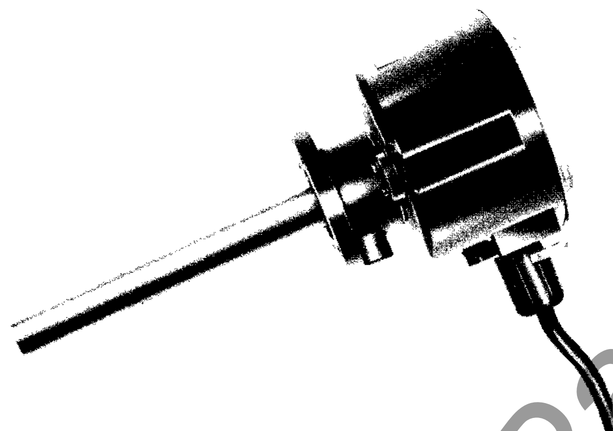

FIG. 1. Side View of Indicator

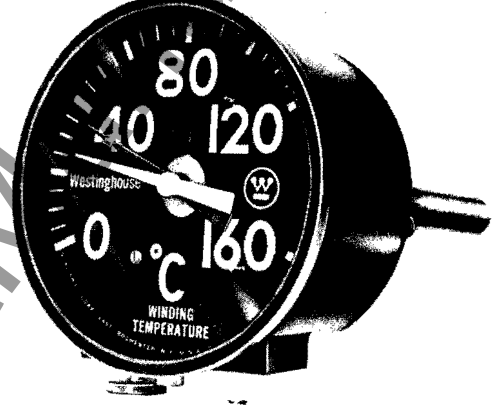

FIG. 2. Front View of Indicator

THE THREE OR FOUR SWITCH TEMPERATURE INDICATOR designed for application on Westinghouse transformers or related apparatus, is used where both fan control and alarm circuits are required. This leaflet covers the type of indicator which depends on the winding temperature. The indicator is a dial type instrument operated by a bimetallic element and is a self-contained weatherproof unit designed for outdoor application on transformers. The heating coil is designed to heat the bimetallic element to the temperature of the hottest spot in a transformer winding, when receiving a current proportional to that in the transformer winding.

The switches of the indicator are set at different temperature levels: the lower level switches operate the fan control circuit, and the higher level switches controls the alarm circuit. The fan control circuits serve to give added cooling when the transformer temperature comes within the ranges of the switches. The alarm circuit operates at a higher temperature range to give warning in case the fans, for any reason, do not limit the temperature to a proper range. The circuits are separate so that both a-c and d-c may be used.

DESCRIPTION

The internal construction of the indicator housing is shown in Fig. 3. The thermal element consists of a spiral bimetal that is held stationary at the inner end and is coupled to a shaft at the other end. Rotating with this shaft is a set of eccentric cams that engage the tripping arms on the precision switches. The bimetal and operating shaft are enclosed in a steel tube mounted on the relay base as shown in Fig. 4. 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.

The bezel or outer assembly shown in Fig. 1 and Fig. 2 includes a 5½″ dial with indicating needle, maximum hand and reset mechanism. The dial is calibrated in degrees centigrade and is easily read because of the contrasting black face with yellow characters, graduations, and indicating pointer. The maximum indicating pointer, red in color, is resettable by means of a push button projecting out

EFFECTIVE SEPTEMBER, 1964
SUPERSEDES I.L. 48-062-10A, November, 1963

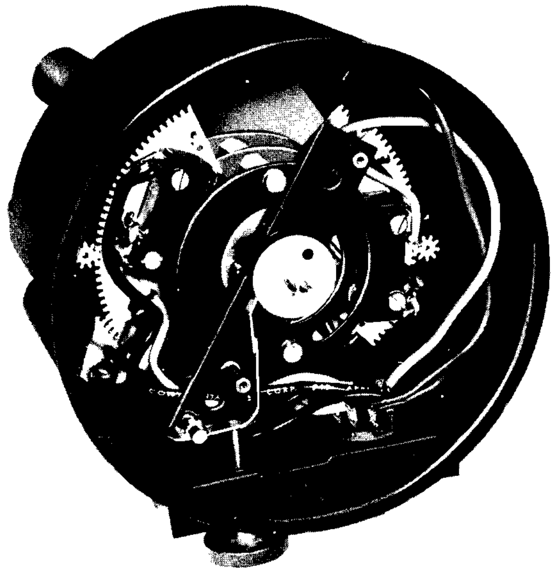

FIG. 3. Internal View of Indicator Case

through the bottom of the dial bezel. The button is spring-loaded so as to return to its inoperative position when released.

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 Fig. 6. 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.

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 the connector tight in the case. This retaining nut is screwed into place.

There are three precision switches in this type temperature indicator. Switch No. 1 is set to close at 70°C for a control circuit. Switch No. 2 is set to close at 75°C for the other control circuit, and switch No. 3 is set to close at 117°C for the alarm circuit. These are nominal values and will be supplied unless otherwise ordered. All switches open at 7½° ± 2½°C less than the closing temperature. The ratings for the switches are given in Table No. 1, and the connection diagram is shown in Fig. 8. The switches are adjustable over a range of ± 17½°C in relation to the above mentioned values.

The four switch indicator is similar to the three switch indicator except the heater leads are brought out separately at the back of the case. See Fig. 7.

TABLE NO. 1

VOLTAGE	NON-INDUCTIVE LOAD—AMPS.	INDUCTIVE LOAD AMPS. L/R .026*
125 AC	10	10
250 AC	5	5
125 DC	0.5	0.05
250 DC	0.25	0.025

*Equal to or less than .026. If greater refer to factory for adjusting rating

A change in the calibration of the precision switches can be accomplished by the switch calibration screws at the rear of the case. (See Fig. 5). Calibrating screws No. 1 and No. 2 are for the control circuits. Calibrating screws No. 3 and No. 4

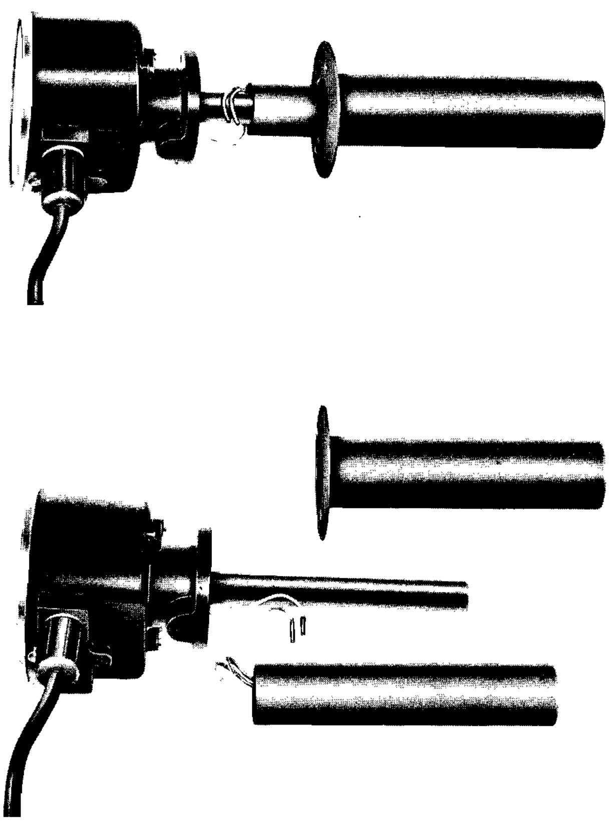

FIG. 4. Assembly of Indicator, Tank Well, Heater Coil and Cable Attachments

are for the alarm circuits or other required circuits. Clockwise rotation of the screw increases the temperature at which the given switch will close. Counterclockwise rotation will reduce the temperature. The indicator may be adjusted to any temperature in the range of 52½ to 134½°C. The result of changing the calibration should be verified before placing the indicator back in service.

When checking circuits through this instrument 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 precision switches of similar capacities.

The heating coil leads are spliced to the two heater leads coming from the body of the indicator. These two heater leads in turn are soldered to the proper terminals moulded in the case.

The indicator well is mounted on the tank wall and extends within the transformer case (See Fig. 10) in the hot oil zone. The indicator base is bolted to the well flange so that the indicator can be removed without taking the transformer out of service or lowering the oil.

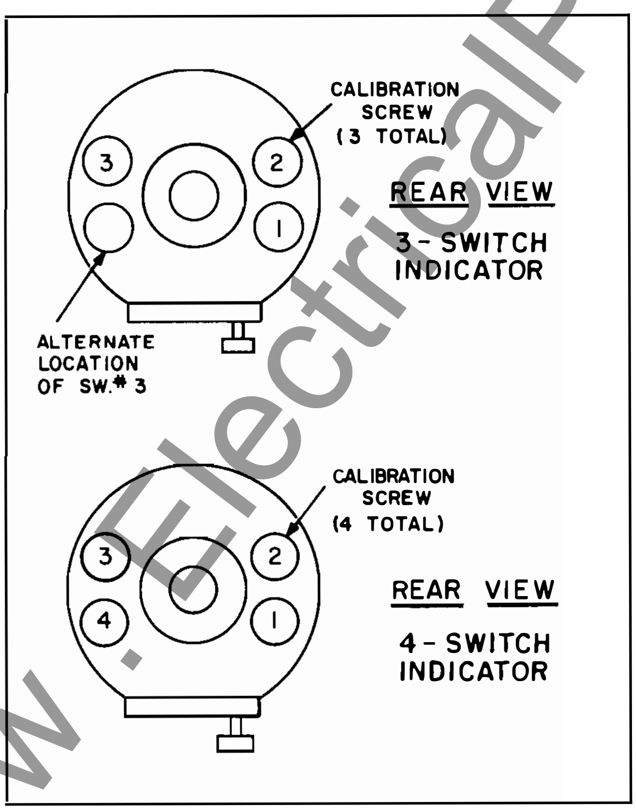

FIG. 5. Temperature Indicator, Location Sketch for Switch Calibration Screws

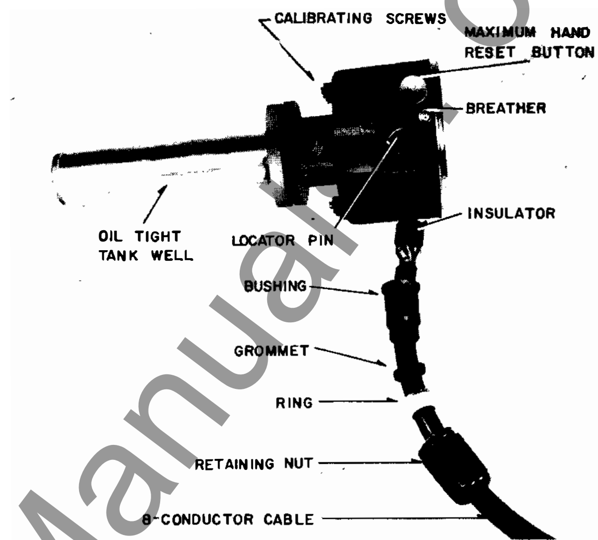

FIG. 6. Bottom View of Three Switch Indicator Showing Cable Connections and Socket

SHIPPING AND RECEIVING

The current transformer is generally shipped as part of the main transformer. It is usually of the through type which is slipped over the lower end of the bushing and mounted on the under side of the cover. Sometimes it will be mounted on the top of the terminal, bridges, or end frames. In this case, a Micarta tube will probably be used to conduct the current transformer leads to the terminal box. This tube will be installed in place on the current transformer. If the main transformer is not shipped

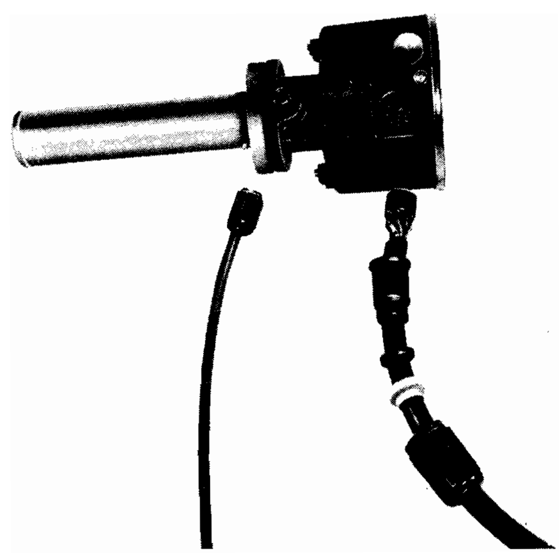

FIG. 7. Bottom View of Four Switch Indicator Showing Cable Connections and Sockets

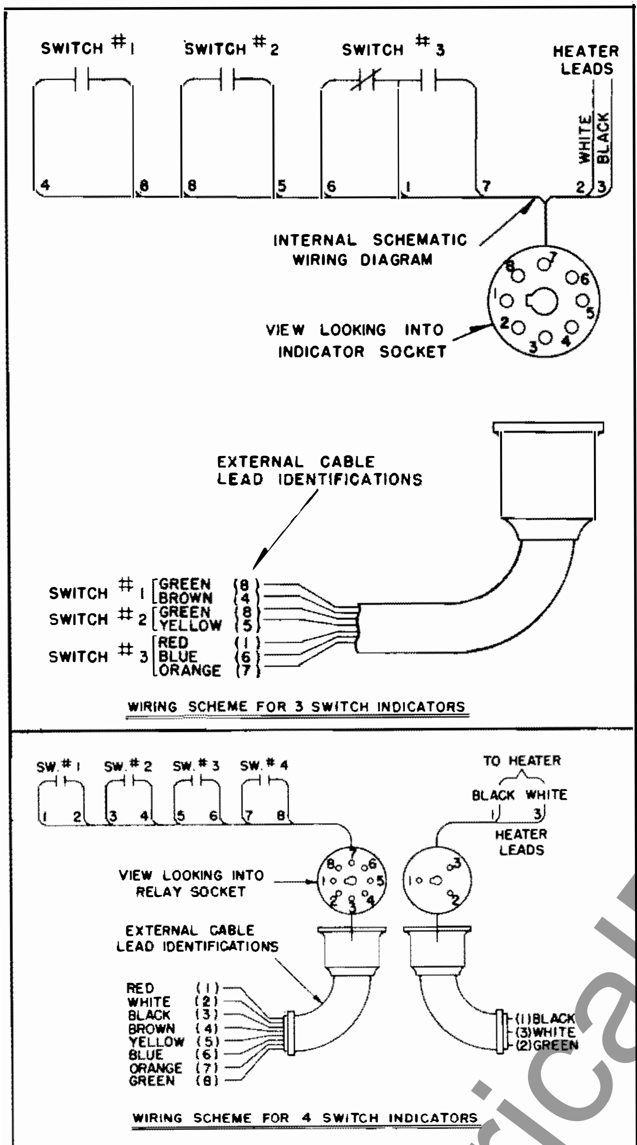

FIG. 8. Sketch of Internal Wiring

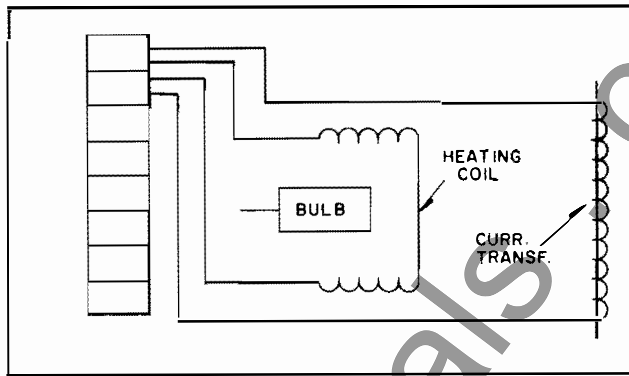

FIG. 9. Connection Diagram for Current Transformer and Heating Coil

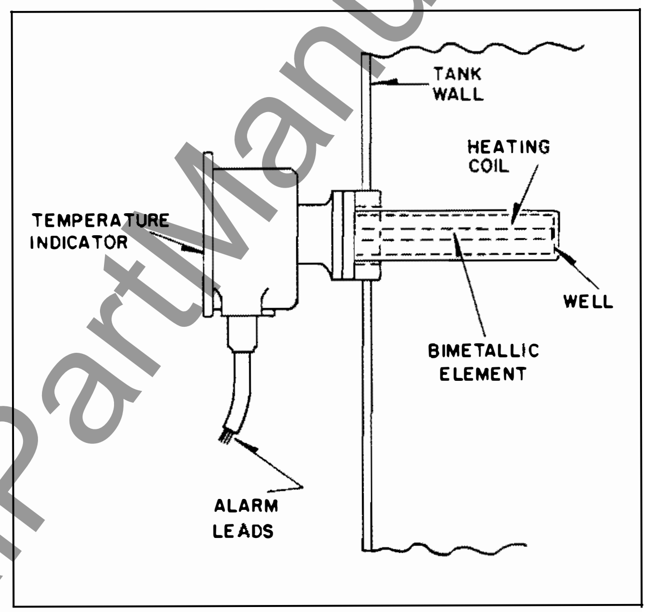

FIG. 10. Section View of Transformer Showing Mounting of Indicator

in its tank, the tube is slid down or removed and tied to the current transformer.

The hot spot temperature indicator and the heating coil are shipped mounted on the well on the tank wall, so that no installation is necessary.

OPERATION

The current transformer is mounted inside the case of the transformer, usually on a bushing. Its primary winding carries the main current of one of the transformers windings and its secondary winding delivers to the heating coil a reduced current which is at all times proportional to the load current. The insulation of the current transformer serves to protect the heating coil and temperature indicating equipment from the high voltage of the main transformer windings.

The heating coil is placed in the hot oil and its windings are worked at the same current density as the main transformer. In addition, the insulation of the heating coil winding has the same elevation in temperature above the oil as the windings of the main transformer. By these methods the temperatures inside the transformer windings are duplicated in the area surrounding the bimetal element of the indicator.

RENEWAL PARTS

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.

WESTINGHOUSE ELECTRIC CORPORATION
POWER TRANSFORMER DIVISION, SHARON, PA.
Printed in U.S.A.

Instructions for Temperature Indicator Hot Oil Two Switch, Dial Type, Submersible, Direct Mounted

I. L. 48-062-2C

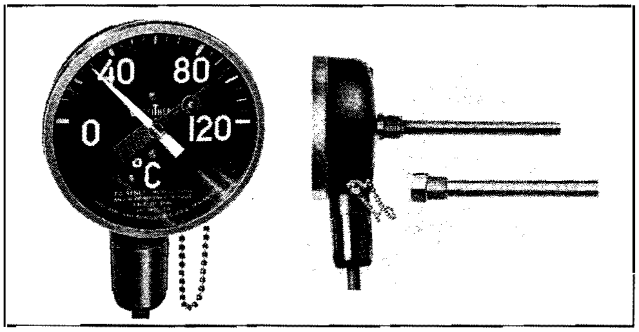

Fig. 1. Front and Side View of Indicator with Alarm Contacts

THE TWO SWITCH TEMPERATURE INDICATOR designed for application on Westinghouse transformers or related apparatus, is used where both fan control and alarm circuits are required. This leaflet covers the hot oil temperature type of indicator. It is a dial type instrument operated by a bimetallic element, and is made weatherproof and submersible.

The two switches of the indicator are set to operate at different temperature levels, the lower level switch controls the fan circuit, and the higher level switch controls the alarm circuit. The fan circuit is used to provide added cooling when the transformer temperature comes within the range of the switch. The alarm circuit operates at a higher temperature to give warning in case the fans, for any reason, do not limit the temperature to a proper range. The circuits are separate so that both a-c and d-c may be used.

The indicator is usually shipped mounted on the transformer case, requires no maintenance, and is suitable for use in oil or Inerteen.

DESCRIPTION

The indicator (Fig. 1) is a dial type precision instrument whose needle is directly coupled to a bimetallic spiral actuating element in the stem which fits closely into a well. The well is of thin-walled construction and screws into the tank wall making an oil tight connection. **NOTE: Do not fill the well with a solid or liquid before inserting the stem of the thermometer since this may damage the instrument without appreciably helping in the transfer of heat from the oil to the sensitive element. The thermometer should not be tightened in the well any more than is necessary to place the dial in an upright position.** The instrument can be removed from the well in the tank wall without loss of liquid and with no need for lowering the oil level. The instrument is weatherproof and submersible. The dial is calibrated in degrees centigrade and may be easily read because of the contrasting black face with yellow characters, graduations and indicating pointer.

A red maximum indicating pointer indicates the maximum temperature reached since last reset. This hand may be easily reset by wiping a magnet across the face of the dial provided the magnet is held with the poles in the proper position so as to attract the maximum indicating pointer. The magnet is attached to a small chain in the instrument case to prevent misplacing after using and is self-supporting in a metallic socket near the underside of the case. The method of resetting the maximum indicating pointer is shown in Fig. 2.

The alarm leads are brought through the underside of the case by means of a triple seal

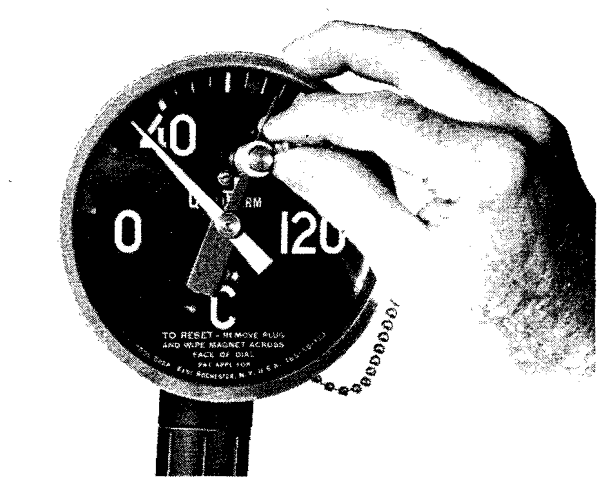

Fig. 2. Method of Resetting Maximum Indicating Pointer

Effective December, 1973 Supersedes I.L. 48-062-2B, April, 1973

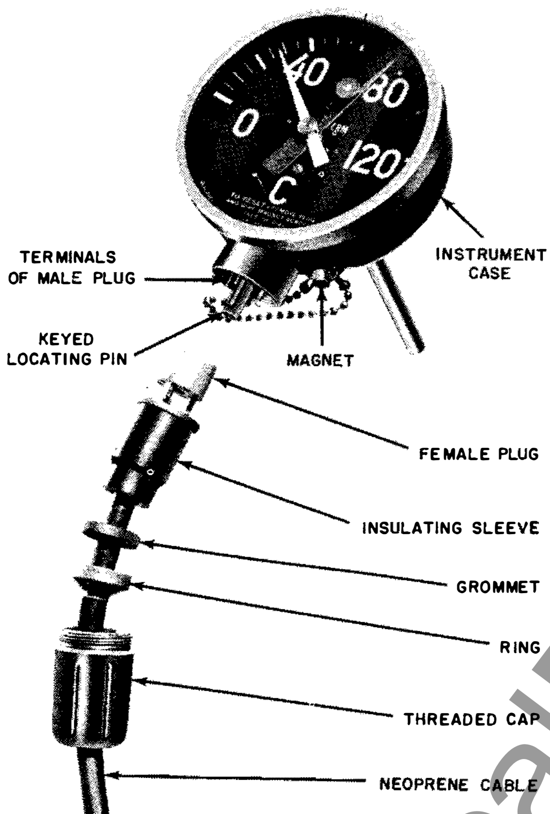

Fig. 3. Triple Seal Connection Details

connector, the details of which are shown in Fig. 3. This connector consists of the following:

1. The male terminals are molded into the case together with a locating pin to prevent making incorrect connections.

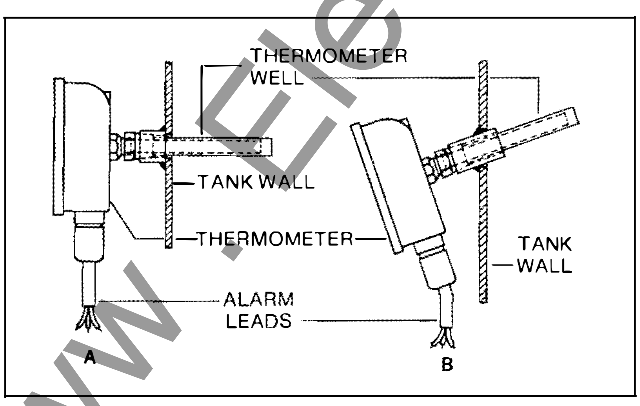

Fig. 4. Indicator Mounted Vertical (A) and Tilted Downward (B).

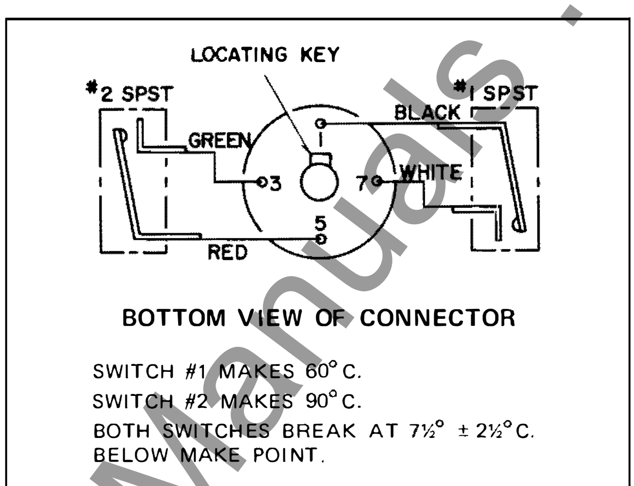

Fig. 5. Oil Temperature Relay With SPST Alarm Switch Wiring Diagram

2. The rubber female plug which has terminals to mate with the terminals in the case, and a hole to match the locating pin. The ends of the leads are tinned and crimped into the terminals of the male plug.

3. A bushing to compress the female plug against the male plug.

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

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

6. A threaded cap to hold the component parts of the connector tight in the case. This threaded cap is screwed into place.

There are two micro-switches in this type temperature indicator. Switch #1 is set to close at 60°C. for the fan circuit, and Switch #2 closes at 90°C. for the alarm circuit. The switches are adjustable over a range of ±10°C. in relation to the above mentioned values. The switches open at 7½° ±2½°C. less than the closing temperature. The ratings for the switches are given in Table No. 1, and the connection diagram are shown in Fig. 5 and Fig. 6.

TABLE NO. 1

VOLTAGE	NON-INDUCTIVE LOAD—AMPS.	INDUCTIVE LOAD AMPS. L/R—.026*
125 A-C	10	10
250 A-C	5	5
125 D-C	0.5	0.05
250 D-C	0.25	0.025

***Equal to or less than .026. If greater, refer to factory for adjusted rating**

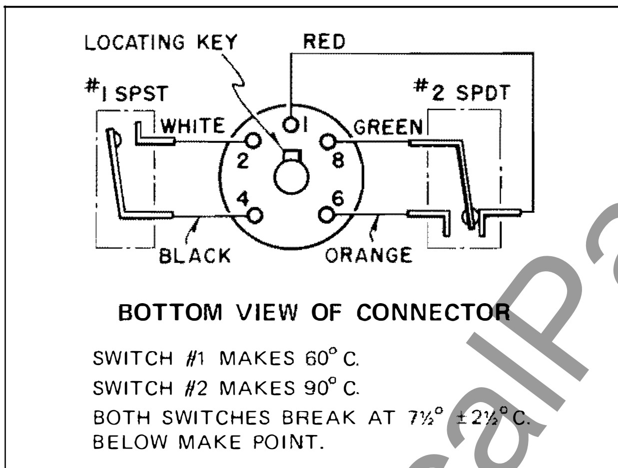

Fig. 6. Oil Temperature Relay With SPDT Alarm Switch Wiring Diagram

Important: Relays, solenoids and motors are inductive loads. When an inductive circuit is opened, a voltage is induced which tends to maintain current flow. The resultant arcing may result in failure of the contacts to interrupt current.

Field Test. Remove the thermometer from its well and submerge the stem up to the brass fitting in a closely controlled temperature, well agitated, oil bath. Check the temperature by placing a thermo-couple or other accurate temperature measuring device on the stem about two inches from the end. The thermometer should be accurate within ±2°C. (allowing 15 minutes for the thermometer to come up to temperature). To adjust a switch to a different value, remove the corresponding numbered sealing plug at the top of the case. Make the proper adjustment of the switch through the opening in the case, and then reseal the case with the sealing plug.

Important. When changing the alarm setting on those temperature indicators with adjustable contacts, be sure to use a non-setting sealing compound on the threads of the sealing plug. Plastic Lead Seal #53351DA is recommended. Loose or improperly sealed plugs will allow moisture to collect in the indicators, and cause eventual shorting of electrical circuits or deterioration of dial markings.

INSTALLATION

The instrument is shipped fixed to the tank wall, so that no installation is necessary. When mounted at a high point, the indicator may be tilted so that it can be read easily from ground level (See Fig. 4).

Important: When checking circuits through this instrument it is necessary to follow 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.

RENEWAL PARTS

If it becomes necessary to repair the instrument, contact the nearest Westinghouse Office.

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Instructions for Thermal Relay Type TRO-2 with Overload Indicating Dial

I.L. 48-062-17A

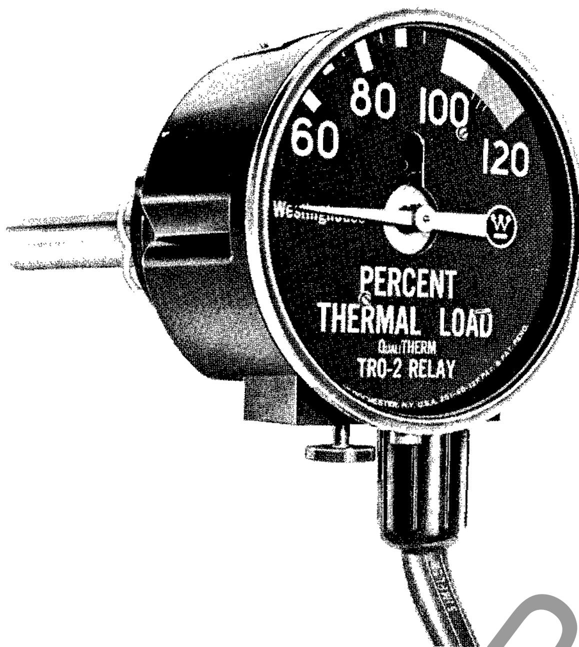

Fig. 1 Front View of TRO-2 Relay

THE TYPE TRO-2 THERMAL RELAY, used on power transformers of all types, combines the initiation of automatic cooling equipment with overload protection and thermal load indication. It is mechanically and electrically interchangeable with the type TRO-1 relay.

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.

DESCRIPTION

The internal construction of the TRO-2 relay housing is shown in Fig. 2. The thermal element consists of a spiral bimetal that is held stationary at the inner end and is coupled to a shaft at the other end. Rotating with this shaft is a set of eccentric cams that engage the tripping arms on the precision switches. 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

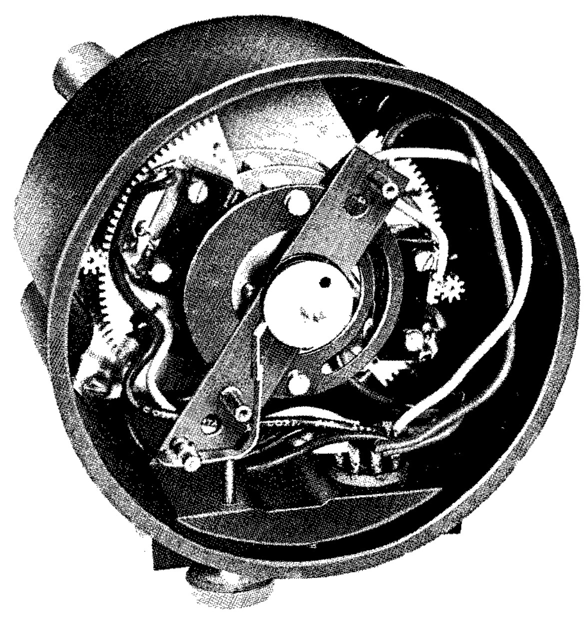

Fig. 2 Internal View of TRO-2 Relay Case

Effective September, 1964
Supersedes I.L. 48-062-17, March, 1962

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 precision switches can be accomplished from the outside of the case. The calibration screws are located on the back side of the relay case.

All contacts are automatically self-resetting. For contact duty rating see Table No. 1.

The bezel or outer assembly shown in Fig. 1 features a spun-on cover and includes a 5-1/2" 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.

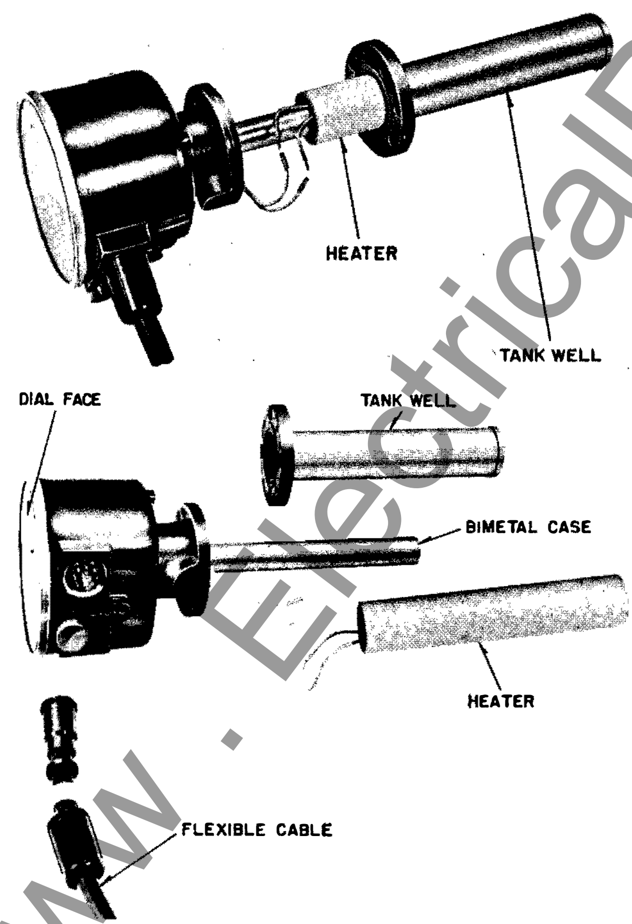

Fig. 3 *Assembly of TRO-2 Relay Tank Well, Heater Coil and Cable Attachment*

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 taking the transformer out of service or lowering the oil.

Table No. 1 *Interruption Ratings of Switches in Amperes*

	A. C.		D.C.			
			Non-Inductive Load		Inductive Load L/R $\lessapprox$ .026*	
	125 Volt	250 Volt	125 Volt	250 Volt	125 Volt	250 Volt
TRO Precision Switches	10	5	.5	.25	.05	.025

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

At the base of the relay case near the front is a water-shielded air inlet which prevents the buildup of internal positive and negative pressures. This greatly lessens the danger of glass breakage or of water being drawn into the case and remaining trapped.

The control circuit leads are brought through the underside of the case by means of an 8-conductor plug-in cable attachment, as shown in Figure 5 for the three switch relay.

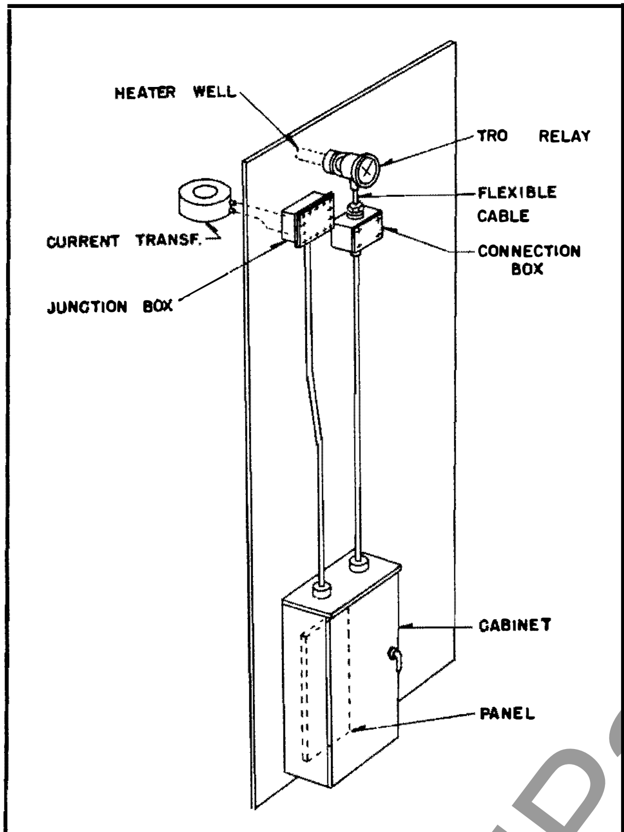

Fig. 4 TRO-2 Relay mounted on Transformer Wall

This conductor 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.

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.

The four switch relay is similar to the three switch relay except the heater leads are brought out seperately at the back of the case. See Fig. 6.

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.

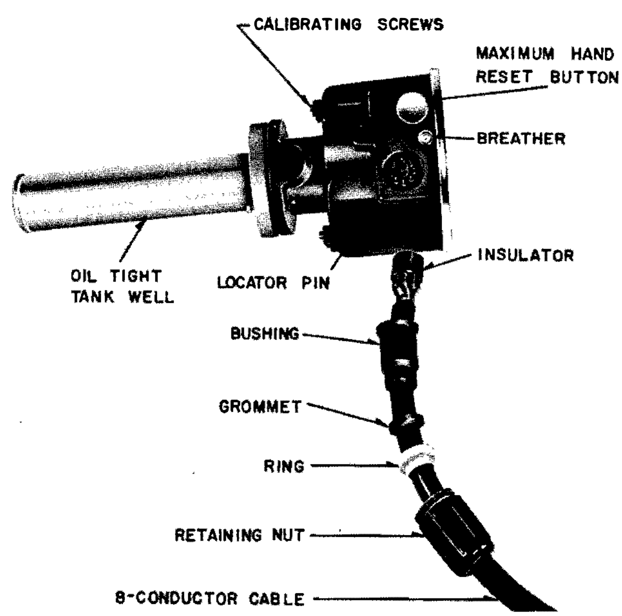

Fig. 5 Bottom View of TRO-2 Relay (Three Switch) Showing Cable Connector and Socket

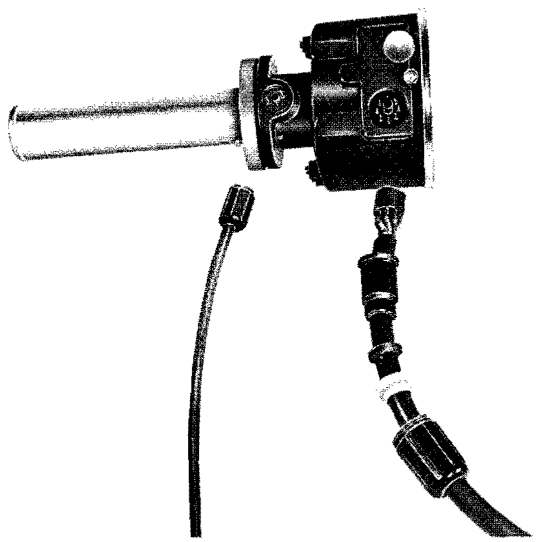

Fig. 6 Bottom View of TRO-2 Relay (Four Switch) Showing Cable Connectors and Sockets

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 brace. In those cases where the cable is shipped as a detail item, it will be necessary to strip back the insulation and connect the cable leads to terminal points as per the wiring diagram furnished with the unit. (See also Fig. 8) Among the details shipped with each cable will be a cable grip entrance fitting and a cable entrance reference drawing for aid to installation

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. 7, 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 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 for corresponding loads.

Refer again to Fig. 7 and the typical thermal relationships existing in a transformer equipped with thermal overload relay S#622D110GO5 or 622D111GO1. 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 117 degrees C. is generally regarded as the top limit above which continued operation of transformer insulation under the Insuldur system would involve some loss of life above normal. When the hot spot temperature reaches 117 degrees C. under these conditions, the corresponding relay bimetal temperature is 100 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 130 degree level will raise the relay bimetal temperature to 110 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 130 degree mark would involve excessive loss of insulation life. This limiting temperature is indicated whenever the dial needle reaches the 110% mark.

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.

A typical application of this relay is in the control of air blast cooling by winding temperature. When more than one relay is used, like contacts are paralleled in the signal 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 a connector box or separate 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. It also provides the factory with a means for adjusting the bimetal

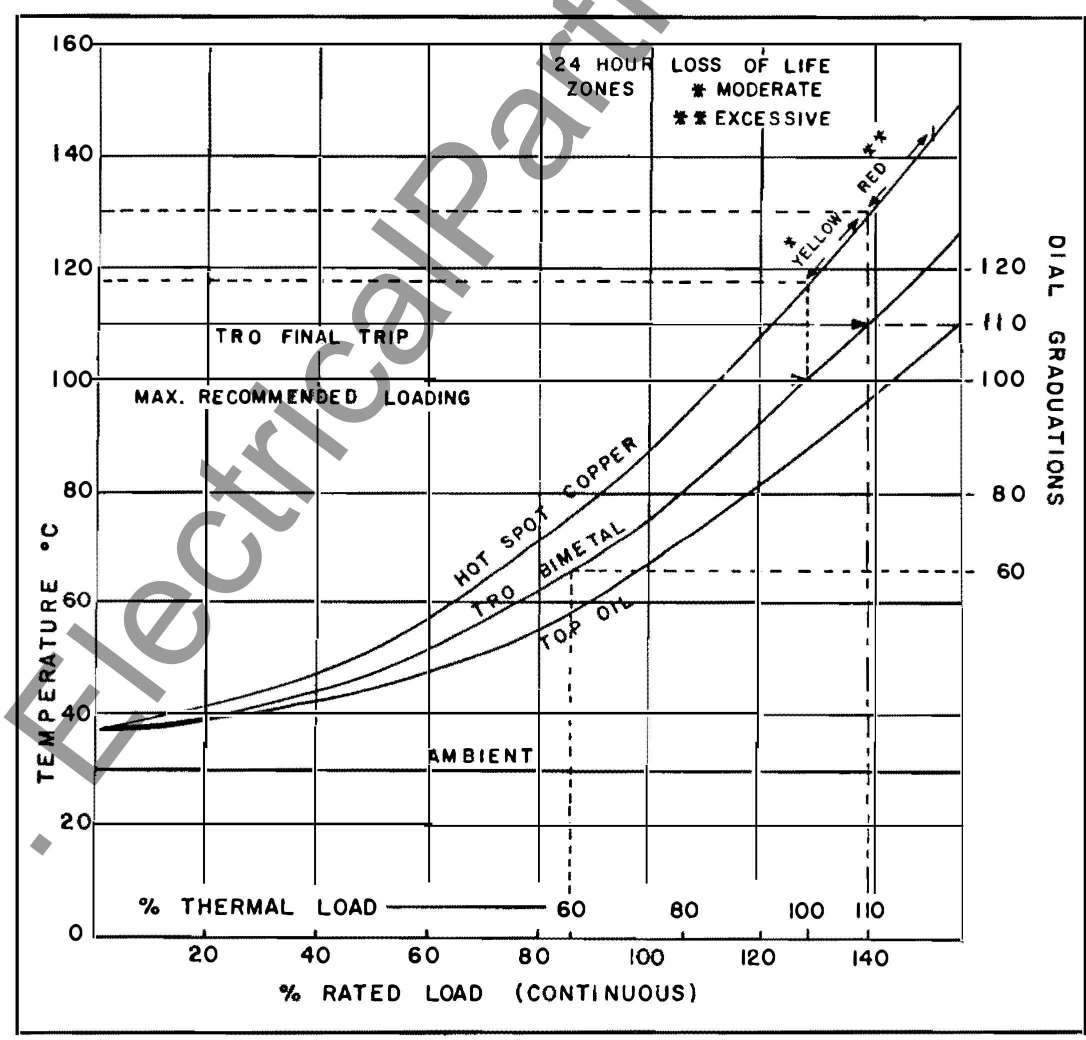

Fig. 7 Typical Thermal Relationships for Relay S#622D110G05 or S#622D111G01. See under "Continuous Overloads"

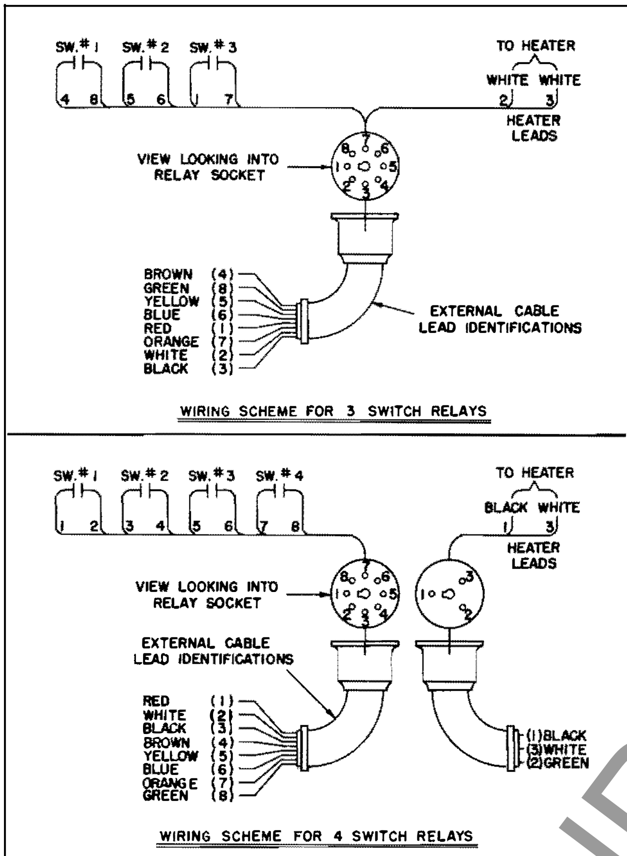

Fig. 8 Sketch of Internal Wiring

heater gradient with relation to the hot spot winding gradient.

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 10 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-2 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. In most cases it is optional with the user if and how the No. 2 switch is used in the alarm circuit. Its primary use is for the second stage of cooling in forced oil systems.

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 to trip the circuit breaker or sound an alarm. With the breaker open, the bimetal will cool and reset the switches.

Sometimes two switches are required in addition to a pair of auxiliary cooling control switches. Consult the wiring diagram supplied with the transformer for the exact equipment supplied. Typical internal wiring is shown in Fig. 8.

Coincidental with the closing of the highest 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.

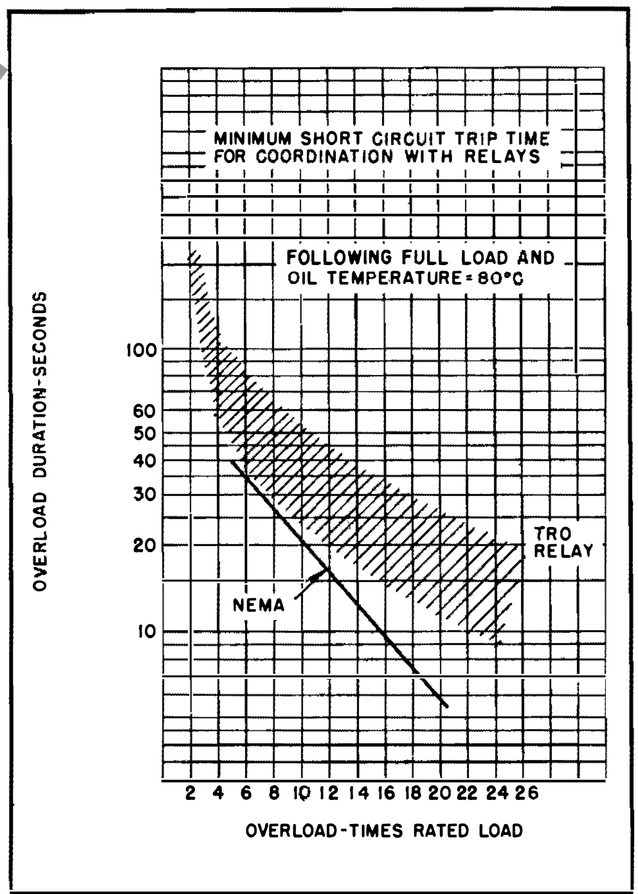

Fig. 9 TRO-2 Relay Coordination Curve for Overloads

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, 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 tripout. 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 $1^{o}C$. in ambient temperature is virtually equivalent to a 1% change in thermal load.

Referring again to Fig. 7 "percent thermal load" has been shown in its correct relation to "percent rated load" at an ambient temp. of 30 deg. C. The dial graduations are indicated along the right vertical edge to show that they correspond to "percent thermal load". The term "thermal load" should not be confused with "kva load" since rated kva will seldom, if ever, cause the dial to read as high as 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 estimated from the dial without resort to complicated curves and tables.

Fig. 7 has been drawn for illustration purposes only. The values of oil rise, bimetal temperature, and hot spot temperature are not to be regarded as accurate for every transformer to which relay S#622D110GO5 or 622D111GO1 is applied.

Short-Time Overloads

The TRO-2 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 at some other ambient temperature.

MAINTENANCE

No maintenance of the type TRO-2 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 internal switches should require no replacement when loaded in accordance with Table No. 1 on page 2.

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, and 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^{O}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 Transformer. (Recommended Method).

The calibration of the relay may be checked at the panel (see Fig. 4) when the transformer is in service and without disturbing the relay unless adjustments are required.

Opening the connection between saturating current transformer secondary terminals 1 and 2 and the heater leads will isolate each heater coil for test.

NOTE: There is no danger involved in opening the current circuit on the secondary side of the saturating current transformer (SCT) while the main CT is carrying normal current. The open-circuit voltage appearing on any pair of output terminals will not exceed 5 volts.

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. Table No. 2 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 Table No. 2 and choose that style for the reference data. 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 switches can be checked by raising the bimetal temperature above that of the highest numbered switch and noting the dial reading as each switch closes. The heat source for this rise in temperature is provided by circulating an abnormal amount of current through the heater coil.

1. Be sure voltage is supplied to any 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 switch it is necessary to observe the switch limitations of Table No. 1. This means that a low voltage bell ringer should not 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 switches of similar capacities.

2. Apply test current to the heater coil using the terminals left vacant by the removal of the SCT leads. 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 last switch closes.)

(1) Starts the fans.

(2) Operates switch No. 2 or starts 2nd fan bank.

(3) Operates switch No. 3.

Table No. 2 *Dial Reading (in % thermal load) versus Bimetal Temp. (°C)*

Percent Thermal Load	Bimetal Temp. (°C.)					
	622D110G01	622D110G02	622D110G03	622D110G04	622D111G01 / 622D110G05	622D110G06
50	.	.	49.5	54.5	59.5	64.5
51	.	.	50	55	60	65
52	.	.	50.5	55.5	60.5	65.5
53	.	.	51.5	56.5	61.5	66.5
54	.	.	52	57	62	67
55	.	47.5	52.5	57.5	62.5	67.5
56	.	48.5	53.5	58.5	63.5	68.5
57	.	49	54	59	64	69
58	.	49.5	54.5	59.5	64.5	69.5
59	.	50.5	55.5	60.5	65.5	70.5
60	46	51	56	61	66	71
61	46.5	51.5	56.5	61.5	66.5	71.5
62	47	52	57	62.5	67.5	72
63	47.5	52.5	58	63	68	73
64	48.5	53.5	58.5	63.5	68.5	73.5
65	49	54	59	64.5	69.5	74
66	49.5	54.5	60	65	70	74.7
67	50.5	55.5	60.5	65.5	71	75.5
68	51.5	56	61.5	66.5	71.5	76
69	52	56.5	62	67	72	77
70	52.5	57.5	62.5	67.5	72.7	77.7
71	53.5	58.5	63.5	68.5	73.5	78.5
72	54.5	59	64.5	69	74.5	79.5
73	55	60	65	70	75	80
74	56	60.5	66	71	76	81
75	56.5	61.5	67	72	76.5	81.5
76	57.5	62.5	67.5	73	77.5	82.5
77	58.5	63.5	68.5	73.5	78.3	83.5
78	59.5	64	69	74.5	79	84
79	60	65	70	75.5	80	85
80	61	66	71	76	81	86
81	62	66.5	72	77	81.5	86.5
82	63	67.5	72.5	78	82.5	87
83	64	68.5	73.5	79	83.5	88
84	64.5	69.5	74.5	80	84	89
85	65.5	70.5	75.5	81	85	90
86	66.5	71	76.5	81.5	86	91
87	67.5	72	77.5	82.5	87	92
88	68.5	73	78.5	83.5	88	93
89	69	74	79.5	84.5	89	94
90	70	75	80	85	90	95
91	71	76	81	86	91	96
92	72	77	82	87	92	97
93	73	78	83	88	93	98
94	74	79	84	89	94	99
95	75	80	85	90	95	100
96	76	81	86	91	96	101
97	77	82	87	92	97	102
98	78	83	88	93	98	103
99	79	84	89	94	99	104
100	80	85	90	95	100	105
101	81	86	91	96	101	106
102	82	87	92	97	102	107
103	83	88	93	98	103	108
104	84	89	94	99	104	109
105	85	90	95	100	105	110
106	86	91	96	101	106	111
107	87	92	97	102	107	112
108	88	93	98	103	108	113
109	89	94	99	104	109	114
110	90	95	100	105	110	115
111	91	96	101	106	111	116
112	92	97	102	107	112	117
113	93.5	98.5	103.5	108.5	113	118
114	94.5	99.5	104.5	109.5	114	119
115	95.5	100.5	105.5	110.5	115	120
116	96.5	101.5	106.5	111.5	116	121
117	98	102.5	107.5	112.5	117.5	122.5
118	99	104	109	114	118.5	123.5
119	100	105	110	115	120	125
120	101	106	111	116	121	126

(4) Operates switch No. 4 (when used).

3. When the calibration run has been completed, the observed dial readings should be compared with the data in Table No. 2.

Example:

To check calibration of relay S#622D110GO2, refer to Table No. 3. Switch No. 1 closes at 65 degrees; Switch No. 2 closes at 70 degrees C; Switch No. 3 closes at 95 degrees 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 Table No. 2, curve for S#622D110GO2 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 calibration.

Table No. 3 *Standard Relay Switch Alignment*

Nameplate Style No.	* Switch Operating Temp. (°C.) Range 60-95	Range 70-105	Range 80-115	Range 90-125	Dial Reading at Close of Highest Switch
	No. 1	No. 2	No. 3	No. 4	
	Brown Green	Yellow Blue	Red Orange		
622D110G01	65	70	90		110%
622D110G02	65	70	95		110%
622D110G03	65	70	100		110%
622D110G04	65	70	105		110%
622D110G05	65	70	110		110%
622D110G06	65	70	115		110%
	Brown Green	Green Yellow	Blue Red	Red Orange	
622D111G01	65	70	100	110	110%
	Red White	Black Brown	Yellow Blue	Orange Green	
261D378G01	65	70	100	110	110%
S.O. Number	See Relay Nameplate				See Relay Nameplate

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

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 Table No. 2 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 6-1/2 inches, but not more than 8 inches.

1. Connect the leads to signal lights so that the operation of the switches can be determined. The signal light circuit must be kept within the capacity limits shown in Table 1. Refer to Table No. 3 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. With this setup the relay contacts should close within the limits out-

lined in Table No. 3. Observe the dial reading at close of switch No. 3 in the case of a 3-switch relay; switch No. 4 in the case of a 4-switch relay.

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 switches at the back of the relay case. See Fig. 10. A cement seal must first be broken to permit adjustment of the calibration screws. Refer to Fig. 10 for location of screws for each switch.

The relay may be recalibrated in place on the tank wall if an offset screw driver is available. If such is not available, it will be necessary to unbolt the relay from the well flange. In some cases it may also be necessary to unplug the flexible cable from the relay case.

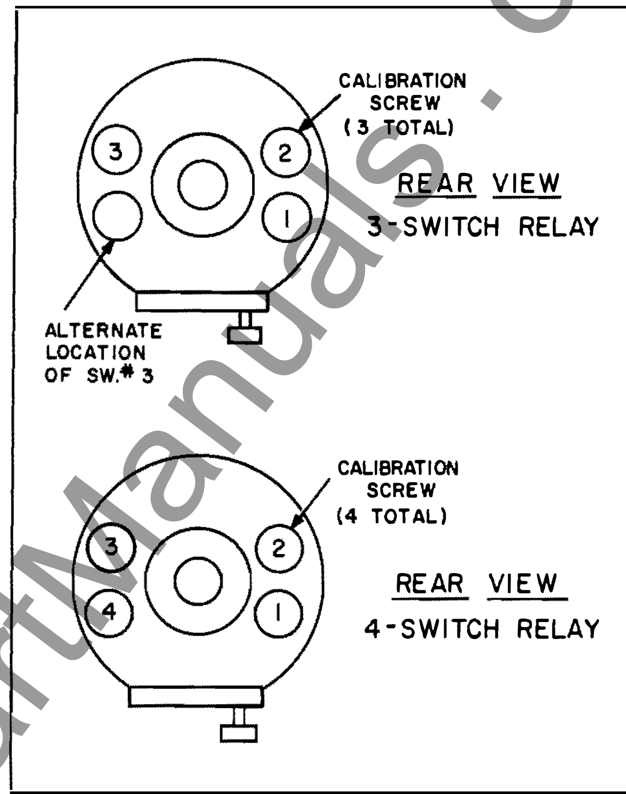

Fig. 10 TRO-2 Relay, Location Sketch for Switch Calibration Screws

SWITCH RECALIBRATION

The required number of degrees adjustment of a switch should be divided by the factor 15 to determine the exact part of a turn required to change the switch closing temperature. Clockwise rotation of the adjusting 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 shown in Table No. 3. See Fig. 10 for location of the correct alignment screw.

Example:

It is desired to change the setting of switch No. 2 from its standard operating point of 70^{o}C. to a new operating point of 85^{o}C. The difference of 15^{o} divided by 15 calls for 1 clockwise turn of the adjusting screw. Insert a screw driver into the No. 2 adjustment slot, then give it one full clockwise turn.

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 verified.

If an oil bath is available, a simple method of rechecking is as follows:

Bring the oil bath as quickly as possible to a temperature at least 2 degrees above that of the highest switch. Make sure all relay switches to be tested are still wired to lamp indicators. Don't begin the test until the bimetal tube 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 data of Table No. 2 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". (Page 8)

COMPONENT 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.

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

Replacement Bezel Kit--S#455C606GO1

Model TRO-2 relays are received with a spun-on cover rim that cannot be reused after removal. It is possible to purchase at anytime a bezel replacement kit that will enable the glass to be replaced and, if necessary, the dial plate removed for internal inspection of the relay in the field. It should be clearly understood that the purchaser of these kits assumes all risk for possible malfunction of relays after the replacement bezels are installed. Kit S#455C606GO1 consists of the following components:

Replacement Bezel	Mult. 1
Front Glass Disc	Mult. 1
Rubber Rim Gasket	Mult. 1
Clamping Lug	Mult. 3
Bezel Hardware	1 Set

Instructions for removal and replacement of relay bezel are as follows:

1. With a pair of cutting pliers or a hacksaw, cut and remove the aluminum spun-on rim.

2. Remove glass disc.

3. At this point, if inspection of the relay mechanism is desired do not loosen the needles but proceed as indicated. Otherwise skip to Step No. 11.

4. Push red reset button so that red hand coincides with yellow hand.

5. Remove two screws holding dial plate.

6. Rotate dial plate until keyhole shaped slot is directly opposite the pointer end of both needles.

7. Tilt the dial plate so that portion containing the keyhole slot passes above the yellow needle.

8. Rotate dial plate 1/2 turn until keyhole slot is directly underneath pointer end of both needles.

9. With a combination lift and sliding motion in the direction indicated by the dial pointer, remove the dial plate completely. If the needles become bent upward slightly,

they can be later straightened with the fingers when the dial plate is reinstalled.

10. When inspection is completed, reset maximum hand and then reverse the procedure covered in Steps 5 to 9 until dial plate is back in position.

11. Lay the replacement bezel backside up on a flat surface.

12. If glass has been broken or cracked, fit new glass disc inside the bezel, making sure rubber rim is in place. Be sure glass surface is clean.

13. Lower the relay case into the bezel ring and check location of thru-holes around circumference of the case. Rotate if necessary in order to position one of the holes about half way between the air inlet and the cable plug.

14. Position the clamping rings such that they overlap the narrow flange around the relay case.

15. Install screws lock washers and nuts, 9 total, from front of bezel. Do not tighten completely until all screws are fairly secure.

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.

MEMORANDUM

MEMORANDUM