Aug. 7, 1962 C. W. SLOCUM 3,048,028

SWITCH CALIBRATION APPARATUS

Filed Dec. 27, 1960 2 Sheets-Sheet 1

Fig. 1.

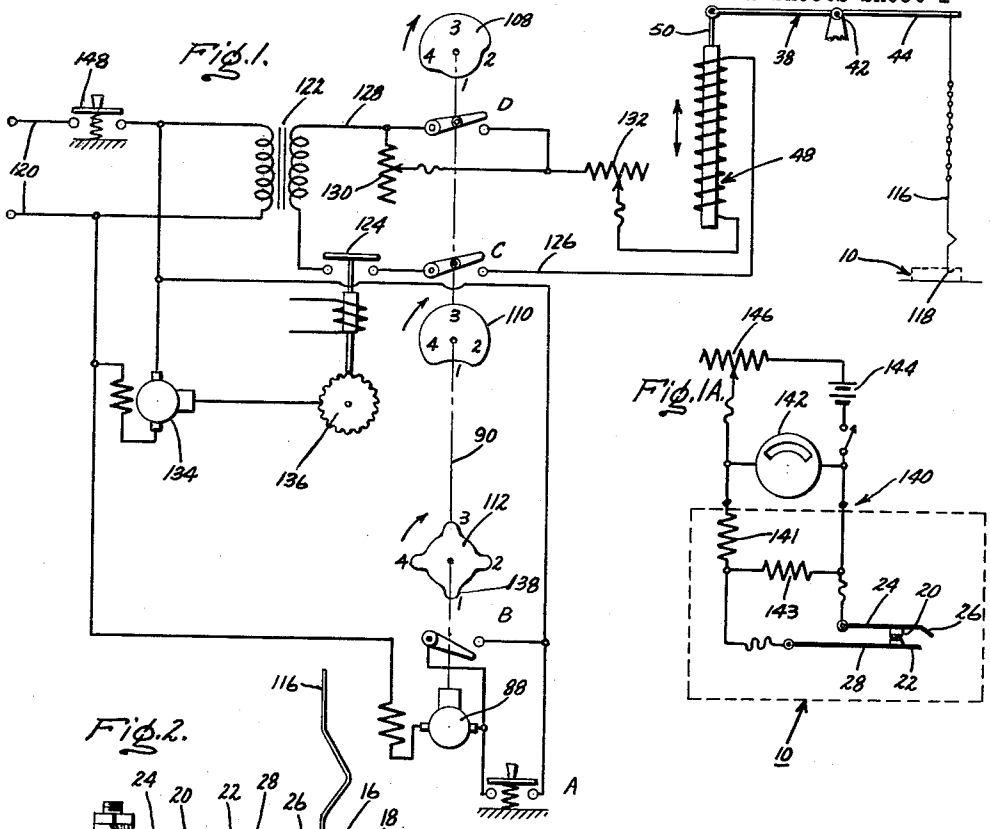


Fig. 1A.

Fig. 2.

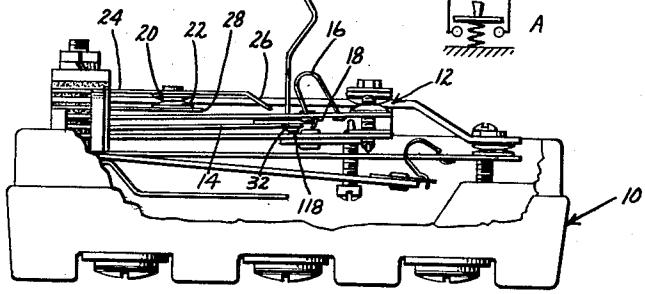
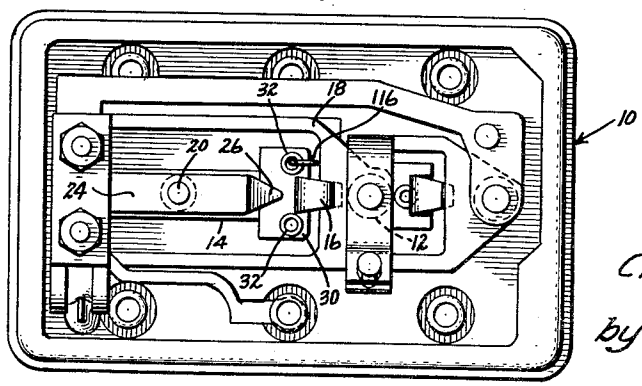


Fig. 3.



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SWITCH CALIBRATION APPARATUS

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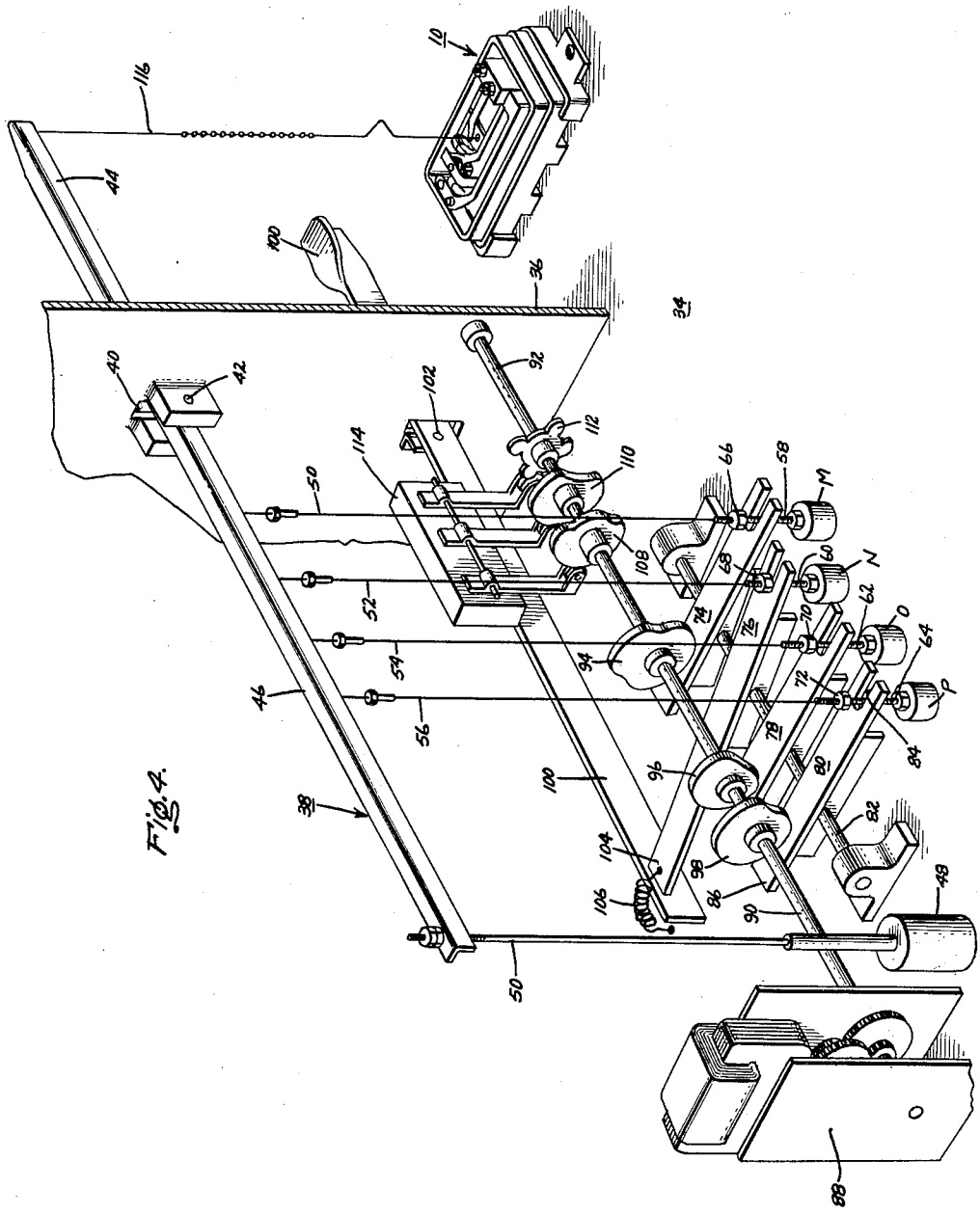


Fig. 4.

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3,048,028

SWITCH CALIBRATION APPARATUS

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Filed Dec. 27, 1960, Ser. No. 78,543
6 Claims. (Cl. 73—1)

The present invention relates to a switch calibration apparatus and method of calibrating a switch, and more particularly to an apparatus and method useful in connection with the adjustment and calibration of switch contacts controlled in the opening and closing thereof by a temperature-sensitive member through which an electrical current is passed.

Relays or switches with which the present invention is particularly concerned are commonly used in combination with single-phase, induction motors. Such induction motors are operated from a source of single-phase alternating current, a rotating field being provided by two sets of windings which are electrically and physically displaced so that current flowing in one of the windings is phase-displaced from the current flowing in the other winding. In such a motor, the two-phase rotating magnetic field causes the motor to start. It is conventional practice thereafter to disconnect one of the windings, generally referred to as the starting winding, so that the motor runs under the influence of the magnetic flux provided by the other winding alone, generally referred to as the main or running winding.

The relays or switches, as mentioned above, are used in disconnecting the starting winding after the motor has attained its running speed and further provide overload protection which disconnects the running winding also in the event the motor is subjected to a damaging overload.

One such relay or switch is disclosed and claimed in Slocum Patent No. 2,781,485 issued February 12, 1957. The relay of this patent not only includes two different switches for disconnecting the starting and running windings respectively of the motor, but additionally includes a set of auxiliary contacts further useful in connection with motor overload protection. If the motor is subjected to a sudden and heavy overload condition, the auxiliary switch operates to insert a heating element into the relay mechanism which rapidly opens the contacts in circuit with the running winding for removing all power from the motor.

More specifically, this relay of the aforesaid Patent No. 2,781,485 is a thermal device in which several current-conducting, bimetallic members control the operation of the various switches. For example, under starting conditions, when a current of four amperes passes through one of the bimetallic members, the same flexes in such a direction as to open a set of "start" contacts which serve to disconnect the starting winding of the motor from the line. So long as a current of sufficient magnitude maintains, the "start" contacts will remain open and the motor will run normally.

However, the relay is so constructed that should the motor be subjected to an overload current, for example, of eight amperes, it being assumed that this current is of motor-damaging proportions, this same bimetallic member is heated to a correspondingly higher temperature, causing it to flex an additional amount. This additional or overload flexure is utilized to actuate an auxiliary switch, opening the contacts thereof to introduce into the relay circuitry an auxiliary heating element which serves in opening the "running" switch of the relay.

Obviously, it is necessary to calibrate the switch such

that the auxiliary contacts remain closed except under the specific overload conditions just described, and it is this calibration feature to which the present invention relates.

Since the bimetallic member which actuates the auxiliary switch flexes an amount corresponding to the current flowing therethrough, it is possible to simulate this current by applying a load or force to the member which flexes the same by the same amount. In other words, the bimetallic member will flex a given distance in response to a current of four amperes. This bimetallic member may be flexed mechanically by applying a force thereto which flexes it by the same amount as the current, the magnitude of this force thereby corresponding to the current needed to produce the flexure.

The present invention utilizes this concept of simulating different electrical currents passing through the bimetallic member by the application of known loads or forces thereto, these forces being applied sequentially in a predetermined manner as the switch mechanism is adjusted to certain predetermined positions. Once the cycle of adjustment has been completed, the auxiliary switch is calibrated and will function properly in response to electrical current flowing through the bimetallic member.

It is therefore an object of this invention to provide an apparatus for use in calibrating the switch contacts of a thermal relay.

It is another object of this invention to provide an apparatus useful in connection with the adjustment of switch contacts which are opened and closed in response to actuation of a temperature-sensitive member, this member responding to heat developed therein by an electrical current, such apparatus imposing mechanical load conditions on various elements of the relay which simulate predetermined electrical currents through the aforementioned temperature-sensitive member.

It is still another object of this invention to provide a calibrating apparatus capable of mechanically simulating electrical current conditions in the thermally-sensitive relay whereby contacts in the relay may be adjusted in a fast, economical and efficient manner.

It is another object to provide a method of adjusting the contacts of a thermally responsive switch.

Other objects will become apparent as the description proceeds.

The above-mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself will be best understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a diagram of the electrical current used in this invention;

FIG. 1*a* is a circuit diagram of the metering circuit used in connection with this invention;

FIG. 2 is a side elevation, partially broken away, of a typical relay which may be calibrated by the apparatus of this invention;

FIG. 3 is a top plan view of the relay of FIG. 2; and

FIG. 4 is a perspective illustration, partly sectioned, of the apparatus used in conjunction with the circuitry of FIG. 1.

Referring to the drawings, and more particularly to FIGS. 2 and 3, a combination overload and starting relay is shown, this being the same relay as is disclosed and claimed in Patent No. 2,781,485. Since all of the details of this relay are completely illustrated and described in this prior patent, only so much of the relay mechanism will hereafter be described as is necessary for a clear understanding of the details of the present invention.

The relay, indicated generally by the reference nu-

meral 10, includes a set 12 of normally closed "start" contacts which may be opened by a bimetallic cantilever or member 14 which is secured into the assembly at its left-hand end. This bimetallic member 14 carries on its outer end a toggle 16 which is connected to a cantilever spring arm 18 which carries on the right-hand end thereof one of the contacts of the set 12. The bimetallic member 14 is so constructed that when it is heated it curves or flexes upwardly such that the outer end operates the toggle 16, thereby depressing the outer end of the arm 18. This results in opening the "start" contacts 12.

As described in Patent 2,781,485, the bimetallic member 14 is connected in series with the running winding, so that current passes through the bimetallic member at all times during which power is applied to the motor.

As explained in the preamble, during "start" conditions, both the "start" and "run" windings are connected to the power line, but when the motor draws a predetermined value of current, the bimetallic member 14 flexes to a point at which the "start" contacts are opened. This disconnects the "start" winding, thereby permitting the motor to operate with only the "run" winding in circuit.

The switch 10 is also provided with a set of normally closed contacts, indicated respectively by the reference numerals 20 and 22. The contact 20 is mounted on a cantilever spring arm 24 secured into the assembly at its left-hand end and bent downwardly at its right-hand end to provide a tip 26. Another cantilever spring arm 28 is secured at its left-hand end into the assembly and carries contact 22 on its right-hand end. In a typical, properly operating relay, the contacts 20 and 22 normally engage each other with a force of twenty-five (25) grams.

As shown more clearly in FIG. 3, the distal end of the tip 26 is juxtaposed over the outer end of the bimetallic member 14. This outer end carries a small plate 30 of suitable insulating material (mica, for example) to which the toggle 16 is in turn connected. The insulator 30 thereby prevents the bimetallic member 14 from being short-circuited via the toggle 16 to the switch arm 18.

The insulator 30 is also located immediately beneath the tip 26 and is engageable therewith.

Two suitable eyelet type rivets 32 are used to secure the insulator 30 to the right-hand end of the bimetallic member 14.

Considering now the operation of the auxiliary contacts 20 and 22, as is described in Patent 2,781,485, these serve in protecting the electric motor used in combination with the relay 10 against damaging overloads. This happens in the following way. Assuming that a motor is connected to the relay 10 and is running at normal speed, the "start" contacts 12 will be held open by the bimetallic member 14. If it is now assumed that the motor is suddenly subjected to an excessive overload or locked rotor condition, a much heavier current will pass through the bimetallic member 14 to the motor. This causes the bimetallic member 14 to flex upwardly even further until finally the tip 26 of a switch arm 24 is engaged by insulator 30 and moved upwardly a distance sufficient to open the contacts 20 and 22. Upon the opening of these contacts, an electrical device (which need not here be described) is introduced into the operation of the relay 10, which aids in the protection of the motor against drawing damaging currents.

As a result of the opening of these contacts 20 and 22, the motor is disconnected from the power line, thereupon terminating the current normally passing through the bimetallic member 14. After a given time, the bimetallic member 14 cools sufficiently to straighten to a point at which the contacts 20 and 22 are permitted to close, following which the "start" contacts 12 also close.

The apparatus of the present invention is primarily concerned with the adjustment or calibration of the auxiliary switch contacts 20, 22. In this calibration, the contacts 20 and 22 should engage each other with a force of approximately twenty-five (25) grams in one commercial design of the relay 10. Also, with four (4) amperes flowing through the bimetallic member 14, the "start" contacts 12 should just open. As will now be explained, the apparatus of FIGS. 1 and 4 is used in obtaining this calibration with an accuracy particularly suitable in the mass production of the relays 10.

Referring now to FIGS. 1 and 4, a base or chassis 34 has an upright panel 36 mounted thereon. A lever or beam 38 passes through an opening 40 in the panel 36 and is pivotally mounted by means of a pin 42 to the panel. One arm 44 of the beam thereby projects forwardly of the panel 36 while the other arm 46 extends rearwardly.

A conventional solenoid 48 is connected to the left-hand extremity of the arm 46 by means of a rod 50. By this means, energization of the solenoid 48 will cause rectilinear movement of the rod 50 and swinging movement of the beam 38 around its pivot 42. Preferably, the solenoid 48 is mounted on the chassis 34.

Suspended on flexible cords or wires 50, 52 54 and 56 are four (4) weights or loads, indicated by the letters M, N, O and P, respectively. These loads are of different weight and are provided with externally threaded stems 58, 60, 62 and 64 which are connected at the upper ends to the wires 50, 52, 54 and 56.

Collars or nuts 66, 68, 70 and 72, which serve as abutments, are threaded on the upper ends of the respective stems 58, 60, 62 and 64 and serve a purpose which will become apparent from the following description.

Associated with each of the weights M, N, O and P are a plurality of levers or tappets 74, 76, 78 and 80. Since these tappets are substantially identical to each other, the description of one will suffice for all. Considering the tappet 80, it is a simple lever mounted intermediate its ends on a pivot shaft 82. As clearly illustrated in FIG. 4, all of the tappets are mounted on this shaft 82. The right-hand end of the tappet is provided with a longitudinal slot 84 which straddles the stem 64 between the weight P and the abutment 72. The shaft 82 is positioned above the chassis 34 such that when the left-hand end 86 of the tappet is depressed, the right-hand end is raised sufficiently to engage the abutment 72 so as to remove the weight of the load P from the beam 38. As will now be obvious, the tappets 74, 76, 78 and 80 are individually, selectively pivotable on the shaft 82 for controlling the application of the loads M, N, O and P to the beam 38. By selective operation of these tappets, one or more of the weights M, N, O and P may be applied simultaneously or sequentially to the beam 38.

In the following is described a mechanism for controlling the selective application of the loads to the beam. This mechanism comprises a gear motor 88 having a shaft 90 journaled at its right-hand end 92 in the panel 36. This shaft extends over the left-hand ends of the tappets 74, 76, 78 and 80 and carries in registry with the tappets 74, 78 and 80, respectively, three (3) rotary cams 94, 96 and 98. These cams are secured to the shaft 90 and therefore rotate with it. The cams have perimeters which are shaped such as to alternately depress and permit the raising of the left-hand ends of the tappets. Considering, by way of example, the cam 98, it is so shaped that during one portion of the revolution the left-hand end 86 of the tappet 80 will be engaged to swing the tappet in a direction to lift the weight P off the beam 38. Another portion of the cam 98 is undercut, permitting the tappet 80 to swing or gravitate downwardly to its illustrated position, thereby applying the weight of load "P" to the beam 38.

It should be understood at this point that the tappets 74, 78 and 80 preferably are balanced such that they tend to gravitate in a clockwise direction, or, in other words, the load ends of the tappets normally depress.

The cams 94, 96 and 98 all have different perimetral shapes so that different loads M, O and P or combinations of these loads may be sequentially applied to the beam

38. This will be explained in more detail in the following paragraph.

The tappet 76 is not operated by a cam, but, instead, is controlled by a manually operable lever 100 which extends through the panel 36 and is pivoted to the latter by means of a pin 102.

The left-hand end of the lever 100 is connected to the rear end 104 of the tappet 76. A tension spring 106 is connected between this left-hand end and the chassis 34 tending to swing the tappet 76 in a direction which removes the load N from the beam 38. Tappet 76 therefore normally is in its illustrated position in which the weight N is lifted off the beam 38. By depressing the right-hand end of the lever 100, the right-hand end of the tappet 76 depresses, thereby applying the load N to the beam.

Also mounted on the shaft 90 for rotation therewith are three (3) switch cams 108, 110 and 112. These cams are respectively operatively associated with three micro-switches D, C and B supported in a frame or housing 114 which is suitably fastened to the panel 36. The perimeters of these switch cams are so shaped as to selectively operate the micro-switches as, will be explained in more detail hereinafter.

On the forward end of the beam arm 44 is connected a chain, flexible cord or the like 116 having a hook 118 (see FIG. 1).

In FIG. 1 is illustrated the electrical portion of the apparatus of FIG. 4. Like numerals indicate like parts. A conventional 110-volt power line, indicated by the numeral 120, is connected to the primary of a step-down transformer 122. The winding of the solenoid 48 is connected across the secondary of this transformer 122 through a series of switches indicated by the letters C and D and numeral 124. The switches 124 and C are connected in series with the line 126 extending from the lower end of the transformer secondary while the switch D is connected in series with the line 128 extending from the upper end of the transformer secondary. The switch D is connected across a variable resistor 130 and in series with another variable resistor 132. Adjustment of these variable resistors determines the magnitude of the voltage applied to the solenoid 48.

Connected across the power line 120 is a gear motor 134 which drives a toothed wheel 136. The switch 124 is operatively connected to this wheel 136 such that rotation of the latter alternately opens and closes the contacts of the switch 124. The frequency of this opening and closing is conveniently selected, for example, to fall in the range of fifteen to twenty (15 to 20) switching cycles per minute.

The electric motor 88 is also connected across the power line 120 through a manually operable switch A. The second switch B is connected in shunt with the switch A. These switches are normally open.

As explained earlier, the three switch cams 108, 110 and 112 are operatively associated with the respective switches D, C and B for opening and closing the same in response to rotation of the shaft 90. The shapes of the cams are more clearly illustrated in FIG. 1 as are the relative angular positions thereof with respect to each other. Corresponding angular portions of the cams are indicated by the numerals 1, 2, 3 and 4, respectively, which are spaced ninety degrees (90°) apart.

The connections between the cams and switches are such that in the illustrated position (FIG. 1) of cam 112, the normally closed switch B is held open by the lobe 138. However, upon about five degrees (5°) clockwise rotation of the shaft 90, the lobe 138 allows switch B to close, thereby "holding in" the circuit to the motor 88. Continued rotation of the cam 112 through about ninety degrees (90°) rotation results in opening the switch B, cam portion 2 indexing to the position previously occupied by portion 1. Thus, as will now appear obvious, each ninety degrees (90°) rotation of the cam 112 results in alternately opening and closing of the switch B.

With respect to cam 110, it opens and closes the switch C only once for one complete revolution of the shaft 90; the cam portions 2, 3 and 4 are larger in diameter than portion 1. In operation, the switch C is opened for the illustrated position of the cam 110 but closed for the remaining positions at which portions 2, 3 and 4 are indexed sequentially by angles of ninety degrees (90°).

Cam 108 is formed such as to hold switch D open for the illustrated position and the position at which portion 2 indexes clockwise ninety degrees (90°). Switch D is closed by portions 3 and 4 as they are indexed. Since all of the cams 108, 110 and 112 rotate in unison, it is thus seen that these switches B, C and D will be opened and closed according to an established pattern.

A circuit indicated by the numeral 140 (FIG. 1*a*) is used in determining when the auxiliary contacts 20 and 22 are opened and closed. This circuit includes a milliammeter 142 which is connected across a suitable battery 144 through a variable resistor 146. One resistor 141, which represents one portion of the internal circuit resistance of the relay 10, is connected at one end to one terminal of the meter 142. The other end of this resistor 141 is connected to contact 22. Another resistor 143, which represents another portion of the internal circuit resistance of the relay 10 is connected between contact 22 and the other terminal of the meter 142. The remaining contact 20 is connected to this latter-mentioned terminal of the meter 142.

The resistor 146 is adjusted such as to provide for full scale deflection of meter 142 when the relay 10 (as represented by the dashed line portion, FIG. 1*a*) is disconnected from the meter terminals. When the relay is connected and contacts 20 and 22 are open, the meter reads something less than full scale, depending upon the internal relay resistances 141, 143, respectively, for example, one-quarter scale. Closure of contacts 20 and 22 causes the meter to read perceptibly lower as circuit resistance 143 is shorted out. Thus, as the contacts 20 and 22 are alternately opened and closed, the meter shifts between these latter two readings.

In explaining the operation of the apparatus, the functioning of the various parts in the absence of calibrating a relay 10 will first be explained. Referring to FIGS. 1 and 4, closure of the line switch 148 results in energization of the motor 134 and consequent rotation of the wheel 136. The switch 124 is thereupon alternately opened and closed. No circuit from the secondary of the transformer 122 is established to the solenoid 48 since both of the switches C and D are open, assuming that the starting position of the apparatus is that illustrated.

As the next step in operation, the switch A is only momentarily closed. This results in the energization of the motor 88, causing the shaft 90 and the three cams 108, 110 and 112 to rotate. This momentarily closure results in the shaft 90 rotating about five degrees (5°), whereupon the lobe 138 on the cam 112 permits the switch B to close thereby maintaining the energization of the motor 88. The motor continues to rotate until the next lobe engages and opens the switch B. At this moment, the motor 88 stops as does the shaft 90, the cams 108, 110 and 112 having moved into the number two position which is ninety degrees (90°) removed from that illustrated. The switch C is therefore closed and the switch D remains open. Upon the closure of switch C, an energizing circuit is established to the solenoid 48 which results in the plunger of the latter being alternately drawn in and released in response to the alternate opening and closing of the switch 124. This results in a vibrating motion being transferred to the beam 38, causing the latter to pivotally vibrate about its pivot 42. It may now be stated that the purpose of the switch 124 is to produce a pivotal vibration of the beam 38.

If the switch A is again momentarily depressed then

released, the motor 88 will be correspondingly energized, causing rotation of the shaft 90 and the cams. The next flat on the cam 112 permits the switch B to close, which remains closed until opened by the next lobe upon ninety degrees (90°) rotation of the shaft 90. This brings the three cams 108, 110 and 112 to the third position, which is one hundred eighty degrees (180°) removed from the starting position.

At this third position, the switch B is opened, the switch C is closed, and the switch D is closed. The operation is the same as the position number two, with the exception that now the variable resistor 130 is shorted thereby providing more excitation for the solenoid 48 causing the latter to vibrate the beam 38 more vigorously.

Another momentary operation of the switch A causes the motor 88 to index another ninety degrees (90°), moving the switch cams to the fourth and last position. At this position, the switch B is opened, the switch C is closed, and the switch D is closed. The solenoid 48 has the same potential applied thereto as for the preceding third position.

Referring now to FIG. 4, it will be recognized that the cams 94, 96 and 98 are rotated in synchronism with the switch cams 108, 110 and 112. These cams 94, 96 and 98 have shapes which operate the tappets 74, 78 and 80 in a sequence as noted in the following table:

Position	Switches			Weights		
	B	C	D	M	O	P
1	Open	Open	Open	Off	Off	Off.
2	do	Closed	do	On	do	Do.
3	do	do	Closed	do	On	On.
4	do	do	do	do	do	Off.

In the first position, all of the tappets 74, 78 and 80 are operated by the cams to lift the weights M, O and P from the beam 38. At the second position, the cam 94 releases the tappet 74, thereby permitting the load M to be applied to the beam. The other three weights N, O and P are still lifted off the beam. For the third position, all the cams 94, 96 and 98 release the respective tappets 74, 78 and 80 to apply loads M, O and P to the beam. In the fourth position, the cams 94 and 96 release the tappets 74 and 78 to apply the loads M and O to the beam, the remaining cam 98 operating the tappet 80 to lift the load P off the beam.

Thus it will be seen that one complete revolution of the shaft 90 will result in the weights M, O and P being applied to the beam 38 in a predetermined sequence.

The load N is controlled in its application to the beam by manual operation of the lever 100, as explained previously.

The operation of the apparatus as used in calibrating the auxiliary switch contacts 20 and 22 of the relay 10 will now be explained. With the apparatus set to its illustrated starting position (FIG. 1), a relay 10 is clamped on the chassis 34 (FIG. 4). The hook 118 on the cord 116 is inserted through one of the eyelets 32 on the bimetallic member 14 (FIGS. 2 and 3).

Switch A (FIG. 1) is momentarily closed, causing the motor 88 to index all of the cams to the second position. In this position, load M is applied to the arm 46 of the beam 38 thereby exerting an upward force on the cord 116. This results in flexing the bimetallic member 14 upwardly by an amount corresponding to the applied force. The weight of the load M is so selected as to flex the bimetallic member upwardly by an amount equal to a selected current passing through the bimetallic member. This load therefore simulates this given current. At this flexed position, tip 26 on the switch arm is bent to a point just short of touching the insulator 30 on bimetallic member 14.

The operator next operates the finger lever 100 to apply the load N to the beam arm 46. This causes the bimetallic member 14 to flex upwardly by a corresponding additional amount. In this condition, if the tip 26 has been bent to its proper position, it will just touch the bimetal insulator 30 enough to vibrate in unison therewith. As explained earlier, in this second position, the solenoid 48 is continually vibrating the beam 38. This vibratory motion when imparted to the tip 26 causes corresponding vibration of the switch arm 24 which may be observed by the operator. If the vibration is not obvious to the naked eye, a microscope or magnifying glass may be used as an aid.

Recapitulating briefly, with the lever 100 depressed, the tip 26 should just touch the bimetal insulator 30 and vibrate herewith. Release of the finger level 100 should position the bimetal insulator 30 just short of touching tip 26.

Next, switch A is momentarily energized to index the cams to the third position. In this position, loads M, O and P are applied to beam arm 46. This load is preselected such as to curve the bimetal 14 to a position corresponding to a value of current at which contacts 20 and 22 should just break or open when the contacts are properly calibrated. In this third position, the operator bends the lower switch arm 28 to a point at which the contacts 20 and 22 just touch or have a dwell-time of fifty percent (50%); in other words, the contacts open and close at an equal rate under the vibration imparted by the solenoid 48. This dwell-time is observed on the meter 142 (FIG. 1*a*) which fluctuates with the opening and closure of contacts 20 and 22 and tends to maintain a predetermined scale reading.

The switch A is once more momentarily operated to index the cams to the fourth position. This results in the application of loads M and O and the removal of load P, this load corresponding to the maximum abnormal running current of a motor connected to the relay 10. In this position, the tip 26 should not touch the bimetal insulator 30, and this condition is observed by no vibration of the arm 24. However, the addition of load N by operation of lever 100 should cause vibration of arm 24. The switch is now properly calibrated.

A final momentary actuation of the switch A results in the cams indexing to the starting position at which the calibrated relay 10 may be removed from the apparatus and another relay inserted in its place.

The successive calibration of a plurality of relays in accordance with the procedure just outlined results in the auxiliary contacts 20 and 22 being normally closed with the same force of engagement. Further, the contacts 20 and 22 of all of the relays will just open with a given current passing through the bimetallic member 14. Thus it is observed that all of the relays have identical operating characteristics insofar as the auxiliary contacts 20 and 22 are concerned.

Preferably, the arms carrying the two contacts 20 and 22 are preliminarily bent just enough to hold the contacts open before the procedure of calibration is started. This permits the bending adjustment of arm 24 and tip 26 without having any force applied thereto from the arm 28.

Specific weights of the loads M, N, O and P have not been given inasmuch as this is dependent upon the calibration desired in the switch; the precise weights may be determined empirically dependent upon the calibration desired in the finished relay.

The determination of these weights for the relay of FIGS. 2 and 3 may be accomplished as follows. Starting with a relay having the arms 24, 28 and contacts 20, 22 properly adjusted, the weight of load M should be selected such as to flex the bimetallic member insulator 30 to a position just short of touching the tip 26 when the arm 28 is manually flexed downwardly to open contacts 20 and 22. The weight of load N when added to load M on the beam should flex the bimetallic member 14 upwardly just enough to touch tip 26, causing it to vi-

brate as previously explained. This weight of load N is the minimum at which the touching engagement is achieved.

The combined weights of loads M, O and P (as used for the third apparatus position) should flex bimetallic member 14 upwardly a distance which springs arm 24 to a position at which contacts 20 and 22 just open and close under vibration.

Lastly, for the fourth apparatus position, the combined weight of loads M and O (with arm 23 in its proper adjusted position) should flex bimetallic member insulator 30 and to a position just short of touching point 26 and with application of N to just touch. It will, of course, be understood that the precise weights will be dependent upon the moment arms which may be selected to suit design desiderata.

While I have illustrated and described specific embodiments of my invention, further improvements and modifications will be provided by those skilled in the art, and I desire, therefore, in the appended claims to cover all modifications which do not depart from the spirit and scope of my invention.

What is claimed is:

1. Apparatus for use in adjusting the contacts of a switch comprising a beam pivotally mounted between its ends for vertical swinging movement, a plurality of loads individually suspended by respective flexible elements from one arm of said beam, each load having an upright stem and each stem having an abutment thereon spaced from the respective load, a plurality of tappets pivotally mounted between the ends thereof for vertical swinging movement, there being one tappet for each load, one end of each tappet having a slot which receives the respective stem, each tappet being movable to engage the respective abutment to lift and release the respective load off said beam, a plurality of rotary cams mounted on a single shaft, said cams operatively engaging the opposite ends of said tappets respectively to actuate selectively the latter for changing the total load on said beam, a motor connected to said single shaft for rotating said cams, a solenoid connected to said beam to vibrate the latter in response to energization of said solenoid, a first electrical circuit connected to said solenoid, a second electrical circuit connected to said motor, first and second series connected switches in said first circuit, a vibratory mechanism connected to said first switch to open and close the same at a predetermined rate, a third switch in said second circuit connected in series with said motor and two rotary switch cams mounted on said single shaft for rotation therewith, said two cams having operative connections with said second and third switches respectively to control the opening and closing thereof, the cam connected to said second switch being shaped such as to hold the latter closed for a given angular movement of said single shaft, the cam connected to said third switch being shaped such as to open and close the latter at a plurality of angular increments of movement of said single shaft for controlling the starting and stopping of said motor, whereby said solenoid and said motor are selectively energized to change loadings on and to vibrate said beam.

2. The apparatus of claim 1 but including a manually operated lever connected at one end to the opposite end of one of said tappets for actuating selectively the latter for changing the loading on said beam.

3. The method of calibrating a thermal switch having two resilient arms carrying engageable contacts and a bimetallic member operatively associated with one of said arms to open said contacts comprising the steps of flexing said bimetallic member a given amount and adjusting said one arm to a point just short of engagement with said member, and flexing said member an additional given amount to deflect said one arm by a corresponding amount and adjusting the other arm to a point at which said contacts just touch.

4. The method of calibrating a thermal switch having two resilient arms carrying engageable contacts and a bimetallic member operatively associated with one of said arms to open said contacts comprising the steps of flexing said bimetallic member a given amount and adjusting said one arm to a point just short of engagement with said member, flexing said member an additional given amount to deflect said one arm by a corresponding amount and adjusting the other arm to a point at which said contacts just touch, and vibrating said member a given amount during the aforesaid flexing steps.

5. The method of calibrating a thermal switch having two resilient arms carrying engageable contacts and a bimetallic member operatively associated with one of said arms to open said contacts comprising the steps of mechanically moving said bimetallic member a given amount and adjusting said one arm to a point just short of engagement with said member, mechanically moving said member an additional given amount at which said one arm should engage said member, and mechanically moving said member a further additional amount to deflect said one arm by a corresponding amount and adjusting the other arm to a point at which said contacts just touch.

6. The method of calibrating a thermal switch having two resilient arms carrying engageable contacts and a bimetallic member operatively associated with one of said arms to open said contacts comprising the steps of mechanically moving said bimetallic member a given amount in a direction which resiliently deforms the same and adjusting said one arm to a point just short of engagement with said member, mechanically moving said member to a given point in the same direction to further resiliently deform the same and vibrating said member a given amount about said point and adjusting the other arm to a point at which said contacts open and close at an equal rate.

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