

# United States Patent

**[11] 3,634,793**

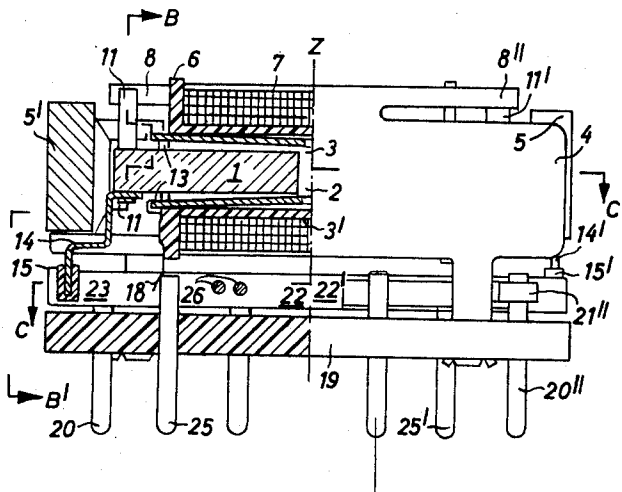
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|------|-----------|----------------------------------------------------------------|
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| [21] | Appl. No. | <b>2,916</b>                                                   |
| [22] | Filed     | <b>Jan. 14, 1970</b>                                           |
| [45] | Patented  | <b>Jan. 11, 1972</b>                                           |
| [73] | Assignee  | <b>Matshushita Electric Works, Ltd.</b><br><b>Osaka, Japan</b> |
| [32] | Priority  | <b>Jan. 20, 1969</b>                                           |
| [33] |           | <b>Germany</b>                                                 |
| [31] |           | <b>P 19 02 610.9</b>                                           |

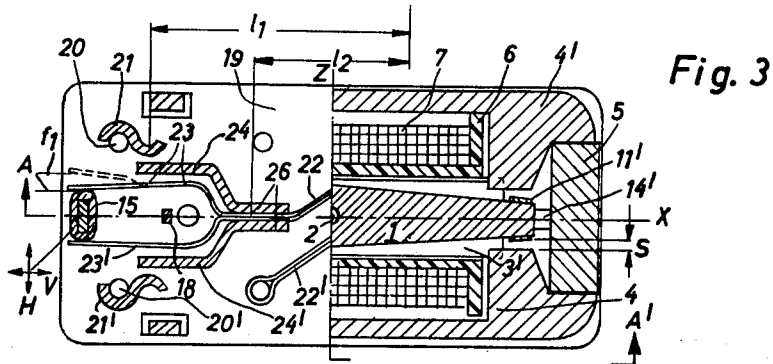
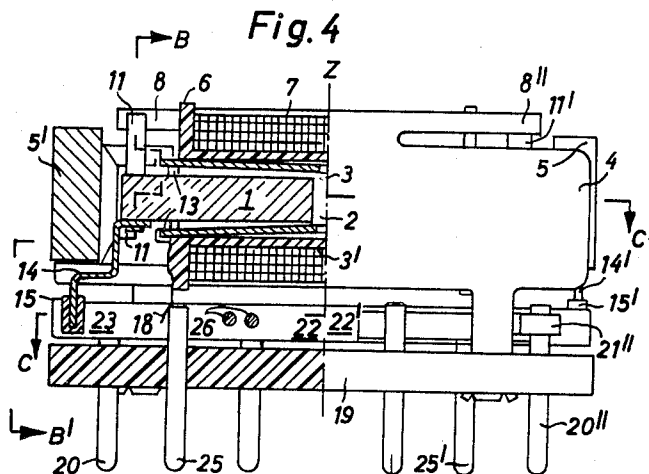
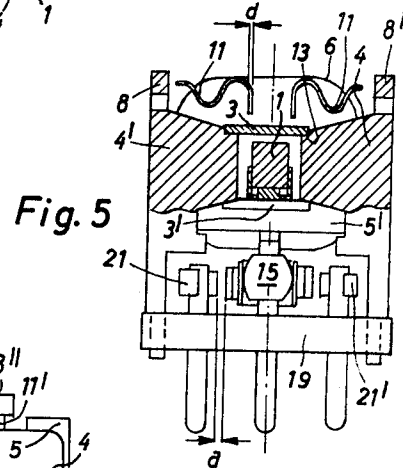
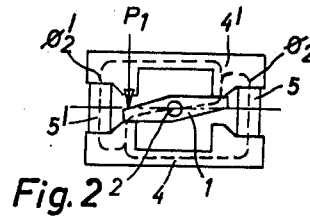
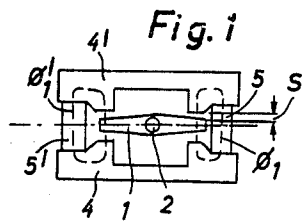
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| <i>Primary Examiner—Harold Broome</i> |                              |              |         |
| <i>Attorney—Edmund M. Jaskiewicz</i>  |                              |              |         |

**[54] ELECTROMAGNETIC RELAY**  
**6 Claims, 11 Drawing Figs.**

|      |                 |                                       |
|------|-----------------|---------------------------------------|
| [52] | U.S. Cl.        | 335/78,<br>335/229                    |
| [51] | Int. Cl.        | H01h 51/27                            |
| [50] | Field of Search | 335/78, 81,<br>86, 125, 217, 230, 229 |

**ABSTRACT:** An electromagnetic relay has a hollow coil with two facing pole shoes and an armature pivotally mounted within the hollow coil. A pair of permanent magnets having different temperature coefficients are positioned adjacent the armature. Contact springs which are actuated by the armature have mounted thereon contacts for engaging with stationary contacts.





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Fig. 6

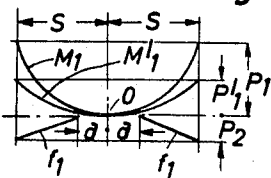


Fig. 7

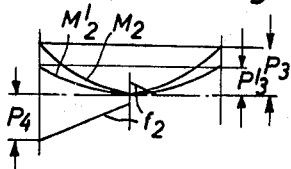


Fig. 8

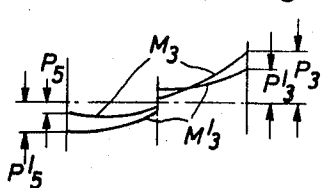


Fig. 9

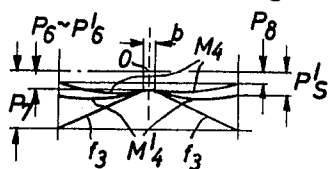


Fig. 10

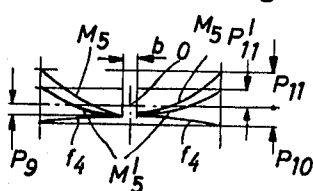
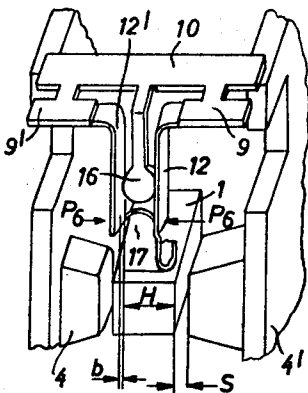


Fig. 11



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## ELECTROMAGNETIC RELAY

The present invention relates to a novel and improved electromagnetic relay, more particularly, to an electromagnetic relay which is capable of withstanding high temperatures.

A disadvantage of an electromagnetic relay is that its operating temperature is dependent on the resistance of the windings in the coil. Thus, a wider and also a higher range of operating voltages is required, especially in view of the temperature fluctuations caused by the environments in which the relays are intended to function. Moreover, the resulting higher operating power also requires a greater contact pressure, that is, a larger number of contacts, is needed for its successful operation.

The present invention directs itself generally to the provision of a novel type of relay basically and uniquely capable of overcoming these disadvantages and meeting the above-mentioned objectives and others as will hereinafter more fully appear.

The above-mentioned disadvantages are avoided in the electromagnetic relay structure of the present invention. The environmental temperature and the number of contacts that is, the preset contact pressure, required for operation have no substantial effect upon the operating power.

The electromagnetic relay of the present invention includes the following features:

a. the armature is exposed to a permanent magnetic force of attraction of which a substantial part is stored in the contact springs;

b. at least one permanent magnet is provided which has a magnetic flux that falls with rising temperature; and

c. the permanent magnetic forces of attraction stored in the contact springs determines the contact pressure.

These features cause the preadjusted contact pressure to be constant within a relatively wide range of environmental temperature fluctuations as well as when the operating power varies.

An object of the invention is to provide an electromagnetic relay capable of withstanding high temperatures.

Another object of the invention is to provide an electromagnetic relay capable of operating over a wide range of temperatures.

Still another object of the invention is to provide an operating electromagnetic relay having at least two permanent magnets, one of which has a temperature coefficient below 0.05 and the other has a temperature coefficient above 2.0.

A further object of the invention is to provide an electromagnetic relay of the foregoing type which can be inexpensively and accurately manufactured and calibrated so that it will operate to perform its desired function.

These and other features, objects and advantages of the invention will become more fully evident from the following description thereof by reference to the accompanying drawing.

FIG. 1 is a schematic presentation of the construction of a permanent magnet system generating magnetic fluxes  $\theta_1$ ,  $\theta'_1$  when the armature is in its central position.

FIG. 2 is a schematic representation of the construction of the system in FIG. 1 in which the armature has a unilateral position of rest producing fluxes  $\theta_2$ ,  $\theta'_2$ . The flux  $\theta_1$  is negligibly small in relation to  $\theta_2$  and this fact alone shows that permanent magnet systems having two corresponding airgaps have a much better efficiency than systems with only one airgap. High efficiency of the permanent magnet system gains in importance when useful forces therefrom and/or reserves are stored for compensating thermal effects.

FIG. 3 is a section C-C' of the symmetrically designed polarized relay in FIG. 4.

FIG. 4 is a section taken on the line A-A' in FIG. 3.

FIG. 5 is a section taken on the line B-B' in FIG. 4.

FIGS. 6 to 10 illustrate the interplay of forces of the magnet system when cold and warm with several compensating springs in the deflection range of the armature.

FIG. 11 is a modified form of the central holding arrangement for the armature.

The illustrated magnet system is symmetrical about its X and Y axes so that not all the mirror symmetrical parts and forces are actually shown and/or indicated.

The armature 1 is mounted in diamagnetic bearing plates 3, 3' inside the coil 7, and is deflectable about the armature bearing 2 between ferromagnetic pole shoes 4, 4'. This arrangement improves efficiency because no electromagnetic leakage flux exists in the coil center and the generated electromagnetic flux is fully utilized. The bearing plates 3, 3' are located on shoulders 13, 13' and are spot welded to the pole shoes 4, 4'. Both the actuating members 14, 14' and the adjustable springs 11, 11' which bear against the flanks of the armature and which at the same time serve as magnetic separators are riveted or spot welded to the ends of the armature 1. Located between the pole shoes 4, 4' are permanent magnets 5, 5', preferably having different temperature coefficients to provide as good as possible a compensation of the temperature coefficient of the coil within the maximum possible temperature range. For this purpose, the permanent magnet 5 or 5' may be composed of a plurality of magnets having different temperature coefficients and cooperating in parallel or in series. The actuating members 14, 14' are provided with pips 15, 15' formed by an insulating heat shrinkable tube. The flanges 6 of the coil body carry coil connectors 18 which come into contact with the coil terminal pins 25, 25' as soon as the magnet system is secured to the baseplate 19 in conventional manner. The baseplate 19 is fitted with the contact terminals 20, 20', 20'' and the coil terminal pins 25, 25'. The contacts 21, 21', 21'' are brazed or spot welded to the contact terminals 20, 20', 20''. The contact springs 22, 22' are doubled back upon themselves and likewise brazed or spot welded to a terminal pin in conventional manner. The center contacts 24, 24' are spot welded or brazed at joint 26 to the contact spring 22 and they extend fork-shaped alongside the likewise bifurcated contact springs 23, 23' so that upon operation the contact deflection path 2a (FIG. 6) exceeds the deflection path of the joint 26 approximately in the ratio of 1/1.2. Between the contact springs 23, 23' are the pips 15 and 15' respectively which operate the spring contact in H-direction when the armature moves.

The curve  $M_1$  (FIG. 6) shows the force-deflection curve of the armature 1 in FIGS. 1 and 2 when the permanent magnet 5, 5' is cold; whereas curve  $M'_1$  is that obtained when the permanent magnet having a corresponding temperature coefficient is warm. Consequently, the deflection force  $P'_1$  is smaller than  $P_1$ . Point O in FIG. 6 corresponds to the center position of the armature in FIGS. 1, 3 and 5 and  $s$  is therefore half the total available armature deflection. During the deflection of the armature 1 out of its center position O in an H direction, the pip 15 moves the contact spring 23 or 23' practically without resistance until the center contact 24 or 24' touches the contact 21 or 21'. The graph in FIG. 6 shows the contact gap 2a and it also shows that the contact gap is transversed with only insignificant effort. In the further course of armature deflection the force-deflection curve  $M_1$ ,  $M'_1$  progressively rises until the deflection force is  $P_1$ ,  $P'_1$  defined by the formula:

$$\theta^2 s / \mu F d$$

wherein

$\theta$  = the permanent magnet flux in the airgap,

$s$  = the armature deflection in either direction measured from its central position,

$\mu$  = permeability,

$F$  = pole area, and

$d$  = thickness of separator plate or remaining airgap.

In order to move the armature 1 with a deflecting force  $P_1$  into the opposite position, the energizing flux  $\theta_E$  must exceed  $s \theta / d$ . However, if part of this actuating force  $P_1$  representing the contact pressure  $P_2$  is stored in a spring having a spring rate  $f_1$ , then the energizing flux may be lower without weakening the permanent magnet flux by the amount otherwise required for generating the contact pressure. Hence for  $P_2$  less than  $P_1$  the following applies:

The greater the contact pressure or the number of contacts that are to be operated the lower will be the energizing power required.

In this connection the above-mentioned steps for raising the permanent magnetic and electromagnetic efficiencies assume greater importance because in the energized state both are factors of a product and naturally the more that can be stored of the resultant force of attraction

$$P_E = S(\theta^2 + \theta_E \theta) / d \cdot \mu \cdot F$$

the more of this force is available.

If the environmental temperature rises while the energizing voltage remains the same the energizing flux  $\theta_E$  weakens, as is well known, according to the change in resistance of the coil, by 0.39 percent per °C. Consequently, the permanent magnetic flux  $\theta$  also ought to become weaker by the same factor 0.39 percent per °C. temperature rise if the operate voltage was required to remain substantially constant. However, this is not desirable because permanent magnets having a temperature coefficient exceeding 0.25 percent per °C. are applicable only within a small temperature range and an excessive loss of permanent magnetic flux interferes with the functionability of the magnet system. However, if according to the invention a substantial portion of the deflecting force  $P_1$  is stored, preferably in the contact springs 23, 23' having a spring rate  $f_1$ , to provide a contact pressure  $P_2$ , then the deflecting force will be reduced according to curve  $M_2$  in FIG. 7 to  $P_3 = P_1 - P_2$  or, when there is a temperature rise according to curve  $M'_2$  to  $P'_3 = P'_1 - P'_2$ , so that the percentage whereby the deflection force is reduced becomes substantially greater than the reduction of the permanent magnet flux due to the temperature rise. Moreover, within the region  $P'_1$  which is smaller than  $P_2$ , the contact pressure  $P_2$  and hence the deflecting force  $P_3$  or  $P'_3$  can be considerably varied by adjusting the pip 15 in V-direction, so that either a magnet with a relatively low-temperature coefficient can be used or at higher temperatures the degree of energization for response can even be lower than at lower temperatures.

Bending of the lug 8 or 8' towards the adjustable springs 11, 11' generates a force  $P_4$  having a spring rate  $f_2$ . Hence, the force-deflection curve  $M_3 = M_2 - f_2$  for armature deflection on the corresponding side is reduced. The same applies at raised temperatures  $M'_3 = M'_2 - f_2$ . In this half of the deflection path the force-deflection curve  $M_3$  or  $M'_3$  moves into the region in which the force changes direction so that the armature lifts off the corresponding pole shoe when energized by the force  $P_5 = P_3 - P_4$  or  $P'_5 = P'_3 - P_4$ . The force relationships when the armature is in position of rest remain unchanged in an armature with a bilateral position of rest as in FIG. 7. This is of particular importance because, as known, polarized relays in which the armature has a position of rest on one side can replace unpolarized relays in nearly every application and the advantages of the invention are therefore also available in applications which were hitherto reserved to unpolarized relays.

In the embodiment according to FIG. 11 adjustable springs 12, 12' are riveted or spot welded to adjustable lugs 9, 9' on a bridge 10 and provide a biasing force  $P_6$  by bearing against an adjustable stool 16. The magnitude of the bias can be adjusted by bending the adjustable lugs 9, 9'. This establishes a stable center position for the armature. The distance  $b$  in FIG. 9 is the necessary clearance between an adjustable spring 12 or 12' and the stop 17 which is firmly connected to the armature forms part thereof. In the further development of the invention the stable center position of the armature thus established can be shifted in the one or the other direction by adjusting the position of the stool 16.

FIG. 9 is the diagram of forces for a center position of rest. In this case  $M_4 = M_2 - f_3$  respectively  $M'_4 = M'_2 - f_3$ .

Since in the region of the center position of the armature no significant permanent magnetic forces are present the armature is located approximately with a force  $P_6$  or  $P'_6$ . The restoring force on each side is  $P_8 = P_3 - P_7$  in the cold state and  $P'_8 = P'_3 - P_7$  in the warm state.

FIG. 10 is the diagram of forces for three stable positions of rest of armature, where the adjustable springs 12, 12' have a flatter spring rate  $f_4$  than  $f_3$  for the center position of rest and hold the armature 1 by means of the stop 17 in a center position with a force  $P_9$ . The force-deflection curve  $M_5 = M_2 - f_4$  respectively  $M'_5 = M'_2 - f_4$  changes the direction of force in the course of armature deflection so that the armature will be urged by a deflecting force  $P_{11} - P_3 - P_{10}$  in the cold state and  $P'_{11} = P'_3 - P_{10}$  in the warm state against the pole shoe 4 respectively 4'. Again in this case a lower deflecting force  $P'_{11}$  must be overcome by the energizing power than in the cold state  $P_{11}$ . All these functions could not be satisfactorily fulfilled without storage of a substantial proportion of the deflecting force to provide the contact pressure  $P_2$ . More particularly, the stable central position of the armature, according to the diagram FIG. 9, and the three stable positions of rest according to the diagram FIG. 10 could not be realized without storage of a force to provide the contact pressure  $P_2$  because the conventional use of only one compensating spring permits only a particular force to be stored for a particular path and the first above described complex relationships in an electromagnetic relay could not be eliminated. The invention not only eliminates all these disadvantages, but also provides a relay which has stable one-sided, double-sided, central and even three stable positions of rest of the armature with and without compensation of temperature effects.

It is understood that this invention is susceptible to modification in order to adapt it to different usages and conditions and, accordingly, it is desired to comprehend such modifications within the invention as may fall within the scope of the appended claims.

What is claimed is:

1. An electromagnetic relay comprising a baseplate, a hollow magnetizing coil structure mounted on said baseplate and having two facing pole shoes, an armature of magnetic material pivotably mounted between said pole shoes and within said hollow coil structure to define with said coil structure magnetic flux circuits, a pair of permanent magnets positioned adjacent said armature for producing a polarized magnetic flux between said pole shoes and said armature, bearing plates on opposite sides of said armature and providing a pivotal support for said armature, contact means operatively associated with said armature and including a pair of contact springs, a pair of actuating elements secured to said armature for transmitting movement of said armature to said contact springs, spring members, adjustable lug members associated with said spring members, a stop member, an adjustable stool member, said spring members straddling said stop member and biased to bear against said stool member to hold said armature in a stable central position.

2. A relay according to claim 1, wherein said stool member is adjustable by bending.

3. A relay according to claim 1, wherein contact always occurs only between at least one spring member and said stop member.

4. An electromagnetic relay comprising spaced pole means for establishing a magnetic field, an armature of magnetic material pivotably mounted between said pole means to define therewith magnetic flux circuits, at least one permanent magnet positioned adjacent said armature for producing a permanent magnetic field acting upon said armature, said permanent magnet having a temperature coefficient of at least 0.2 percent per °C., and contact means operatively associated with said armature and including spring contact means, said contact spring means and the permanent magnet field being such that the force exerted on the armature by the contact spring means is equal to a substantial portion of the force exerted on the armature by said at least one permanent magnet.

5. A relay according to claim 4 wherein said contact means includes a plurality of elongated spring blades, pip means positioned between said spring blades and adjustable in a longitudinal direction and/or in a transverse direction, said contact means including bifurcated contact members fastened on said

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spring blades at a joint therebetween, said contact members having elongated contact areas for contacting said spring blades along a path which exceeds the length of the path of movement of said joint when displaced by said armature.

6. A relay according to 4 and comprising a pair of permanent magnets wherein one of said permanent magnet has a temperature coefficient below 0.05 and the other permanent magnet has a temperature coefficient above 0.2.

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UNITED STATES PATENT OFFICE  
CERTIFICATE OF CORRECTION

Patent No. 3,634,793 Dated January 11, 1972  
Inventor(s) Hans Sauer

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

The assignee should read as follows:

50% interest to MATSHUSHITA ELECTRIC WORKS, LTD.  
Osaka, Japan.

In the specification, column 2 line 60, the formula  
should read as follows:

$$\theta^2 s / \mu F d$$

In the specification, column 3, line 9, the equation  
should read as follows:

$$P_E = s(\theta^2 + \theta_E \cdot \theta) / d \cdot \mu \cdot F$$

Signed and sealed this 17th day of October 1972.

(SEAL)  
Attest:

EDWARD M. FLETCHER, JR.  
Attesting Officer

ROBERT GOTTSCHALK  
Commissioner of Patents

UNITED STATES PATENT OFFICE  
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