Nov. 18, 1969 G. C. UNDERWOOD 3,479,627

ELECTROMAGNETIC RELAY AND METHOD OF MANUFACTURE THEREOF

Filed Sept. 15, 1966

FIG. 1

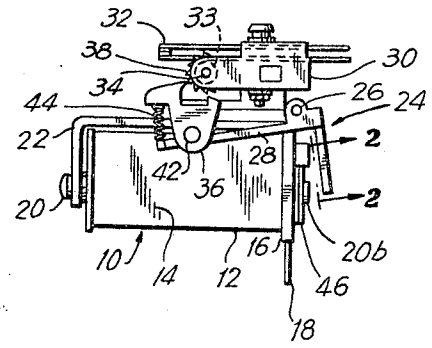


FIG. 2

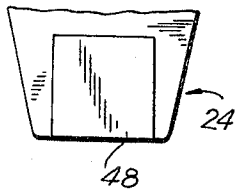


FIG. 3

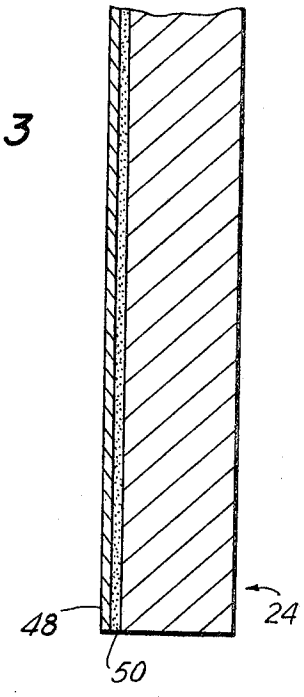
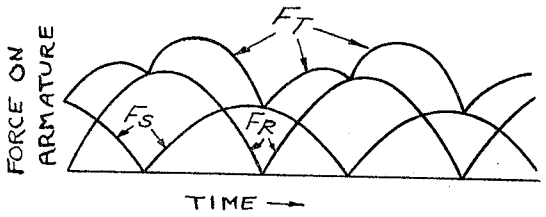


FIG. 4



INVENTOR.
GEORGE C. UNDERWOOD

BY

Richard W. Rathe

ATTORNEY

United States Patent Office 3,479,627
Patented Nov. 18, 1969

3,479,627

ELECTROMAGNETIC RELAY AND METHOD OF MANUFACTURE THEREOF

George C. Underwood, Raleigh, N.C., assignor to Cornell-Dubilier Electric Corporation, a corporation of Delaware

Filed Sept. 15, 1966, Ser. No. 579,771
Int. Cl. H01f 7/08, 3/00
U.S. Cl. 335—271 6 Claims

ABSTRACT OF THE DISCLOSURE

Electromagnetic relay having improved life characteristics wherein a cushioned non-magnetic layer is interposed between the armature and the pole face to cushion the closing of the armature against the pole face and to avoid fatigue of the non-magnetic layer.

This invention relates to an electromagnetic relay having improved life characteristics and to a method of manufacture therefor. The invention is particularly applicable to program relays having long life requirements.

An object of this invention is to provide an electromagnetic relay capable of a large number of operations with increased resistance to the deleterious effects of such use.

Another object of this invention is the provision of an improved program relay having novel anti-stick means.

Yet another object of this invention is the provision of a relay having improved fatigue resisting properties.

A further object of this invention is the provision of a relay provided with improved means for absorbing the closing shock thereof.

Still another object of the invention is the provision of a novel method of manufacturing armatures for electromagnetic relays.

These and other objects and advantages of the invention are achieved in one embodiment of the invention illustrated in the accompanying drawings and described in detail below. In the illustrative embodiment an electromagnetic relay having novel means for obtaining the desired anti-stick properties of the armature to the relay core is provided. The anti-stick means includes a layer of non-magnetic material which is resiliently cushioned to better accept the force of repeated operations of the relay. A better understanding of the invention and its various aspects will be gained from the accompanying description when taken in conjunction with the accompanying drawings in which:

FIG. 1 is a side elevation view of a program relay;

FIG. 2 is a greatly enlarged section of the armature of the program relay in FIG. 1 as viewed along the plane 2—2 of FIG. 1;

FIG. 3 is a cross section view on an even larger scale of the portion of the armature shown in FIG. 2; and

FIG. 4 is a diagrammatic representation of the variation of the forces attracting the armature to the core while the relay coil is energized.

Referring to the drawing, a program relay **10** is illustrated which includes an electromagnet **12** that is composed of a conductive winding **14** about an insulating bobbin **16**. The start and end turns of winding **14** are connected to terminals **18** (only one being shown) which are mounted on the bobbin. The magnetic circuit of the relay includes a ferromagnetic core **20** positioned within the insulated bore of the bobbin and an L-shaped magnetic frame member **22**. The relay armature **24** is pivoted on non-magnetic pin **26** carried at one end of the frame **22**. Armature **24** is provided with a pair of arms **28** (only one is shown) which are disposed on opposite sides of the frame and winding assembly.

Switch bracket **30**, of insulation, is secured to the frame **22** and mounts a series of relay type switch contacts **32** (only one being shown). These contacts are of spring-like material and they are sequentially operated by a series of cams **33** disposed along a shaft journal in the bracket **30**. One cam **33** is provided for each switch position. Armature **24** is provided with a double-toothed pawl **36** which engages a toothed gear **38** mounted on shaft **34** so as to provide step by step rotation of the shaft **34** for each complete operation of the armature. Pawl **36** is secured to the arm **28** of the armature **24** by a pivot pin **42** and is biased in a gear **38** engaging direction by a spring **44** that reacts between arm **28** and the pawl. A return spring (not shown) for the armature reacts between the bracket **30** and the other armature arm, the hidden arm also being provided with a transversely extending portion which limits the open or de-energized position of the armature. A shading coil **46** which, as is well known in the art, is used to reduce vibration or chatter of the armature when the relay is operated on an alternating current, is mounted on the core end **20***b* adjacent the armature.

What has been described heretofore is common in the art. However, in the illustrative embodiment of the invention, a layer **48** of non-magnetic material is secured to the inner face of the armature **24** so as to be interposed between the core end **20***b* and the armature when the armature is attracted to the core by energization of the winding **14**. The non-magnetic layer provides a gap between the armature and the core to offset the residual magnetism of the core which produces "sticking" of the armature in the energized position although the coil current is off. The non-magnetic layer **48** is preferably of stainless steel for wear-resistance and is secured to the armature by an equal sized layer of cured resilient adhesive **50**. As will be explained in greater detail below the resilient adhesive cushions the closing force of the armature on the core end **20***b* and dampens any vibrations of the layer **48** by virtue of its being interposed therebetween. More importantly the resilience of the adhesive layer is believed to disperse the impact between the stainless steel layer **48** and the core end **20***b* so as to avoid fatigue failure of the layer **48** due to repeated closing operations and due to the cumulative effect of the vibration or oscillation of the armature toward the core as the applied alternating current passes through zero. I have found that a particularly successful adhesive is sold by the 3M Company as their "Scotch" Brand Electrical Tape No. X–1140 and is described as a 2.0 mil thermosetting rubber resin pressure sensitive adhesive transfer film.

Although the return spring and the multiple spring-like switches absorb a considerable percentage of the closing momentum generated by the attraction of the armature to the core, a considerable closing force remainder must be dissipated by contact between the armature and the core. While in each stroke the force may seem inconsiderable, it must be remembered that relays of this type must operate in excess of 5,000,000 cycles without failure. Failure in this sense being the magnetic sticking of the armature to the core face with an attractive force greater than the force of the return spring. In prior constructions the anti-stick layer of non-magnetic material had been secured to the armature by spot welding or by riveting. This form of connection inevitably resulted in fatigue failure of the anti-stick layer due to flexing about the point or points of securement to the armature. The use of plated layers of non-magnetic material has likewise proven to be without merit. The plated layer being subject to wear and the plating process accelerating failure by virtue of hydrogen embrittlement.

I have found that use of layer **48** of stainless steel of .002 inch thickness which is secured to the armature **24**

by a thin layer (.002 inch) of cured resilient adhesive **50** provides a successful anti-stick armature capable of well over 5,000,000 operations without failure. The cured rubber resin, although thin, is sufficiently resilient to absorb a large part of the closing shock and to inhibit deleterious flexing of the stainless steel layer **50**.

Flexing of the anti-stick layer, which may cause failure, occurs due to the changes in electromagnetic forces while the armature is in its energized position. In an AC relay such as that described herein, the force F_T (FIG. 4) on the armature is the sum of the forces F_S due to the magnetic flux passing through the shading coil and F_R the magnetic flux passing through the remainder of the core face. Both F_R and F_S vary in accordance with the frequency of the applied current. F_T, the sum of F_R and F_S, is aslo a freqeuncy dependent variable. The pulsating form of F_T can produce deleterious flexing of the anti-stick layer if it is single point supported. It has been found that by use of the resilient adhesive securing means **50** the deleterious effect of the flexing or vibration is negated.

The resilient material, before being cured by baking, is in the form of a pressure sensitive adhesive film releasably carried on one face by a peelable liner. The film is cut to size, together with the liner and attached to the armature **24** at the place of securement of the anti-stick layer. Subsequently, the liner is removed and the anti-stick layer is positioned on the armature and held in place by the adhesive layer. The armature, adhesive and steel layer are next subjected to baking at 240° F. for three hours which cures the adhesive and bonds the anti-stick layer to the armature. Alternatively, the adhesive may be applied to the stainless steel layer while it is in strip form then the steel layer and adhesive may be cut simultaneously and, after the liner is stripped away, simultaneously attached to the armature. Subseqeuntly, the assembly is baked to set the adhesive layer.

To further serve in the identification of the properties of the adhesive material the following data is presented:

Physical	Units	Value	Test method
Adhesion to steel	Ozs./in.	40	ASTM D-1000
Adhesion, overlap shear before cure.	Ozs./in.	18	3M [1]
Adhesion, overlap shear after cure.	Ozs./in.	78	3M [1]

[1] 3M Test Method; in part, a one square inch section of tape was overlapped to steel plates, pressed together for thirty seconds under 1000 gram weight and pulled apart at the rate of .5 inch per minute.

While the use of a particular adhesive material in film form has been described in great detail it will be recognized by those skilled in the art that uniform layers of other adhesives having similar resilient and other properties may be employed as described herein without departing from the spirit and scope of the invention.

What is claimed is:

1. An electromagnetic relay including a core of magnetizable material, an energizing winding on said core, a magnetic frame, a movable armature for said core pivoted on said frame, said core, said frame and said armature comprising the magnetic circuit of said relay, a thin layer of solid metallic non-magnetic material located between the opposed magnetically cooperating surfaces of said core and said armature and a layer of non-magnetic resilient adhesive material interposed between said opposed cooperating surfaces, said non-magnetic metallic layer preventing said armature from sticking to said core, and said layer of resilient material adhering said metallic layer to one of said opposed cooperating surfaces and cushioning said metallic layer.

2. An electromagnetic relay according to claim **1** wherein said non-magnetic layer is stainless steel.

3. An electromagnetic relay according to claim **1** wherein said adhesive layer is a cured thermosetting rubber resin.

4. An electromagnetic relay according to claim **1** wherein said non-magnetic layer is stainless steel and said adhesive layer is a cured thermosetting rubber resin.

5. An electromagnetic relay according to claim **1** wherein said non-magnetic metallic layer is adhered to said core.

6. An electromagnetic relay according to claim **1** wherein said non-magnetic metallic layer is adhered to said armature.

References Cited

UNITED STATES PATENTS

2,284,621	6/1942	Kuhn et al.	335—279 XR
2,374,017	4/1945	Iglehart et al.	335—279 XR
2,412,304	12/1946	Staley	335—279 XR
2,735,967	2/1956	Lewus	335—247 XR
2,825,013	2/1958	Krenke	335—279 XR
3,389,354	6/1968	Ahlberg	335—248
3,263,135	7/1966	Dobes	335—248
1,226,748	5/1917	Burnham	335—247

OTHER REFERENCES

"Scotch" Brand Electrical Tape No. X-1140, Properties and Prices, Mar. 29, 1965, Electrical Products Division 3M Company.

BERNARD A. GILHEANY, Primary Examiner

D. M. MORGAN, Assistant Examiner

U.S. Cl. X.R.

335—277, 279