

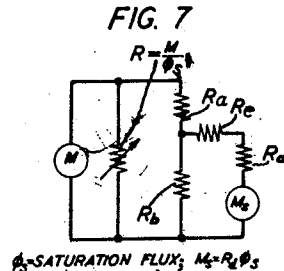
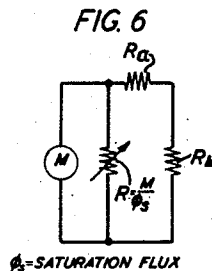
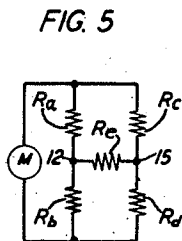
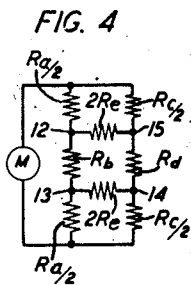
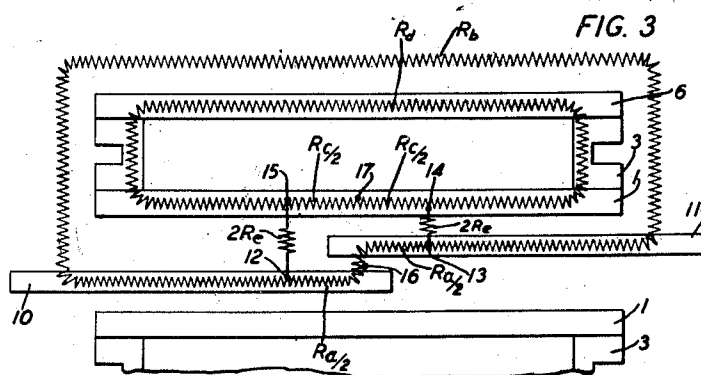
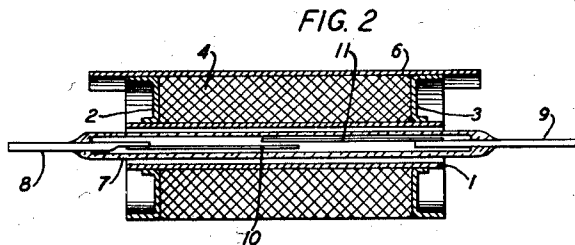
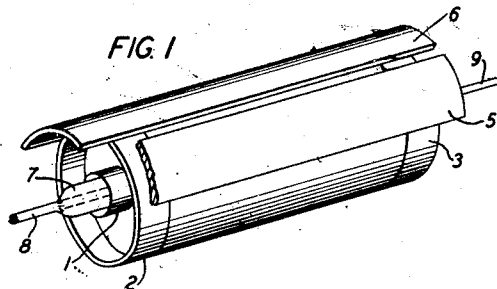
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RELAY

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RELAY

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2 Claims. (Cl. 200—97)

This invention relates to electromagnetic switching devices and particularly to relays for use in communication systems.

The object of the invention is to produce a relay of simple and economical design having given characteristics for use under given circuit conditions. The sealed reed contact unit consisting essentially of a pair of magnetic reeds sealed in an envelope containing a gas which will prevent oxidation or corrosion of the contacts and which may be placed within a coil so that the gap in the magnetic circuit is at the ideal point in the center of the coil is extremely fast operating and sensitive. Certain circuit conditions require a slower operating relay and so a relay employing the sealed reed contact device has been produced by a novel means which broadly stated, consists of surrounding the coil of the relay with a low reluctance magnetic circuit which is effectively, in shunt with the magnetic circuit including the magnetic contact reeds. The relay so produced is comparable in most respects with a commercially available relay of conventional design while being superior in some respects and considerably more economical to produce.

The relay of the present invention is formed of a winding placed on a bobbin of low reluctance magnetic material with the contact unit inserted in the center and along the axis of the bobbin. Thus a magnetic shield is placed directly between the winding and the magnetic reed contact but this acts not as a shield but only as a shunt. The direction of the lines of force will be along the longitudinal axis of the contact device and therefore along the longitudinal dimension of the reeds, so that the contact device need not be oriented in any manner other than to be inserted in the hole formed by the inside of the cylindrical part of the bobbin.

A feature of the invention is a winding for a relay wound on a bobbin of low reluctance magnetic material with a contact device inserted in the bobbin along the axis thereof.

Another feature of the invention is a winding for a relay wound on a bobbin of low reluctance magnetic material with low reluctance magnetic paths provided outside the coil from one to the other of the bobbin heads whereby a closed magnetic circuit is formed about the winding.

Another feature of the invention is means for rendering a relay or other electromagnetic structure slow acting comprising an auxiliary energy diversion magnetic path interlinked with the electrical winding thereof and being substantially in parallel with the main magnetic path of the

structure. If this said auxiliary path is saturable then energy diversion will take place during current changes in the said electrical winding and the ultimate sensitivity of the structure will not be affected.

Other features will appear in the following description:

The drawing consists of a single sheet with five figures, as follows:

Fig. 1 is a perspective view, partly broken away, of the relay of the present invention;

Fig. 2 is a cross-sectional view of the same along the axis of the tube;

Fig. 3 is a diagram of the flux paths of the relay; shown in the form of a mesh diagram extending in the general directions taken by the lines of force set up by the magnetomotive force created by the current flowing through the winding of the relay.

Figs. 4 to 7 are circuit diagrams illustrating the coupling of the reluctance paths of the relay and useful in explaining the action of the relay and the theory of its operation.

The relay consists of a cylinder 1, of magnetic material, by way of example, the well-known 4 per cent molybdenum permalloy. Two bobbin heads 2 and 3 are secured to the cylinder 1 in any well-known manner, such as spot-welding. Upon the spool thus formed a winding 4 is placed and lastly a number of strips 5 and 6 are spot-welded to the bobbin heads 2 and 3. The strips 5 and 6, like the cylinder 1 and the bobbin heads 2 and 3, are of the same kind of low reluctance magnetic material so the winding or coil of the relay is interlinked with a closed magnetic path of low reluctance.

A glass-sealed relay contact device is placed longitudinally within the cylinder 1. This consists of an envelope 7 having electrical terminals 8 and 9 sealed into either end thereof. Two magnetic reeds 10 and 11 are welded to the lead in terminals 8 and 9, respectively. The reeds have their ends overlapping and normally separated by a small amount from each other. When the coil 4 is energized, the two reeds will move their free ends toward each other and make an electrical contact with each other. Due to the fact that the contacting ends of the reeds have been prepared by a very thin plating of gold and the atmosphere within the envelope 7 is devoid of oxygen, the reeds act as reliable contacting devices.

The action of the glass-sealed contact device is, under ordinary conditions, extremely fast and very sensitive, so much so in fact that in order

to produce a relay to be used in a given circuit arrangement as a substitute for a conventional type relay, the novel expedient of interlinking a closed magnetic path with the winding has to be employed. The simplicity of the present device leads to great economy, particularly where as relays they are used in great numbers.

The theory of operation of this device may best be explained by the help of Figs. 3 to 7 inclusive, and the following discussion.

The typical electromechanical relay may be considered, fundamentally, as a network having three sections; an electric section, in which are located the input terminals; a magnetic section; and a mechanical section containing the load element (usually a spring).

The most efficient design for a slow-acting relay would be one in which the energy stored in the load spring on operation is a maximum for a given amount of power input to the electrical mesh in the operated condition. As the required delay is increased, the attainment of this maximum efficiency tends in general to result in increased physical dimensions. Because of space limitations and the convenience of using available parts, relays which are appreciably below this maximum efficiency are commonly used. That is, some form of energy diversion is added to an existing fast-acting relay in such a way as to retard its operation without having any appreciable effect on its ultimate sensitivity.

In the relay proper, this modification has most commonly consisted in adding a low resistance electrical linkage around the normal magnetic circuit—a copper slug around the relay core, for instance. In the electrical mesh of the original relay, which can ordinarily be approximated simply by the winding resistance in the series arm, this auxiliary electrical linkage appears as a shunt resistance across the output terminals, where the input to the magnetic circuit appears essentially as an inductance. Energy dissipation takes place in these resistances when the relay is operated.

A second method for introducing delay in a given relay without affecting its ultimate sensitivity involves a provision for energy diversion in the magnetic mesh in accordance with the present invention. Specifically, this method consists in adding an auxiliary low reluctance linkage around the operating winding. The reluctance of this auxiliary magnetic path appears directly across the input terminals of the magnetic mesh in parallel with the magnetomotive force generated by the current through the coil. At the output of the electrical mesh the addition appears simply as an inductance in series with the normal input inductance of the relay. The energy which is diverted from operation is stored in the added inductance. This increase in inductance may be utilized for an auxiliary function in the circuit.

In the use of an auxiliary magnetic circuit to obtain delay, the requirements regarding current sensitivity necessitate some special precautions which are unnecessary when an auxiliary electrical linkage is used. This comes from the fact that, whereas it is ordinarily possible to separate two electrical circuits practically completely by insulation, the finite magnetic permanence of air always results in some coupling between the main and auxiliary magnetic circuits.

The general effect of the magnetic coupling is illustrated for the relay of the present invention by the network of Fig. 4, corresponding to major flux paths indicated in Fig. 3. For convenience,

these networks represent the distributed reluctance and magnetomotive force of the relay in terms of lumped values, the arrangement of which is believed to be a sufficiently close approximation for the present discussion. Terminals 11 and 12 are taken as the terminals of the operating gap. Terminals 13 and 14 are contiguous terminals in the auxiliary circuit.

Converting from the symmetrical form, the circuit of Fig. 4 reduces to the circuit shown in Fig. 5.

R_a and R_b comprise the main or operating circuit. R_a represents the operating gap. R_b represents the normal return path with the auxiliary circuit removed. In this case R_b is made up of the reeds and an air return path on the outside of the coil.

R_c and R_d comprises the auxiliary magnetic circuit, made of permalloy parts welded together. R_c is in a mesh which effectively shunts the operating gap. R_d is in a mesh effectively in series with the operating gap. That is, an increase in R_c or a decrease in R_d will tend to increase the flux in the main gap. The coupling between the main and auxiliary circuits is indicated by R_e .

m represents the magnetomotive force generated by the operating winding. m is shown applied at the center of R_a and R_c , although this location has no particular significance. The magnetomotive force of the coil can be considered as applied in series with each flux path which completely surrounds the coil. Some flux linkage occurs inside of the winding but this has been omitted as unimportant compared with that of the auxiliary circuit.

From Fig. 5 it is apparent that for any condition in which

$$\frac{R_a}{R_b} = \frac{R_c}{R_d}$$
no flux will flow in the coupling reluctance R_e and the auxiliary circuit will have no effect on the flux distribution in the main circuit.

If

$$\frac{R_a}{R_b} < \frac{R_c}{R_d}$$
the auxiliary circuit will cause an increase in the flux through the operating gap over that which would be obtained without the auxiliary circuit. From this a general rule for the application of an auxiliary magnetic circuit may be stated as follows.

An auxiliary low reluctance circuit for the purpose of increasing delay or input inductance may be added to any electromagnetic device without reducing its ultimate current sensitivity, provided that the ratio of reluctances in the parts of the circuit which are in meshes effectively in shunt and in series, respectively, with the operating gap, is equal to or less than the ratio of the reluctance of the operating gap to that of the return path normally in series with it. By ultimate current sensitivity is meant the sustained value of direct current at which the relay operates or releases.

In the relay illustrated in Fig. 3 the permalloy spool which includes reluctance R_c and part of R_d becomes saturated, saturation taking place at approximately one-sixth of the ampere turns required for operation. The reason for this is that the cross-section of the spindle is smaller than that of the rest of the auxiliary circuit, the difference being sufficient to overbalance any effects that might be caused by the relatively small flux in the main circuit. Considering this

spool as an addition, and, therefore, not including the air path which it displaces as part of the auxiliary circuit, and noting that points 13 and 14 are inside of the end of the spindle, the flux entering point 13 from R_c and that leaving 13 to enter R_a are each equal to the saturation flux of the spindle under operating conditions. Therefore, the flux into 13 from R_c must be zero and the distribution of flux in the operating circuit is independent of the presence of the auxiliary circuit. The equivalent circuit thus reduces to that of Fig. 6, where the auxiliary circuit appears as an independent variable shunt across the applied magnetomotive force m .

Tests on the actual relay, where the magnetomotive force and reluctance are distributed rather than being lumped, show that essentially this effect is obtained. That is, except for delay caused by building up the saturation flux in the auxiliary circuit, the characteristics of the relay are almost unchanged from those of the plain winding with the auxiliary magnetic circuit removed. The effect of the auxiliary circuit is to increase the direct current inductance of the relay at the operating current by a factor by about 15 to 1. As the total flux is substantially constant above about one-sixth of the operating current, a maximum increase of about 90 to 1 in direct current inductance is obtained at low current values. The general conditions involving saturation of this kind might be stated as follows:

An auxiliary low reluctance magnetic circuit may be added to an electromagnetic device without appreciably affecting its ultimate current sensitivity if at the current where the device normally operates, the auxiliary magnetic circuit is saturated throughout that part of its length which is coupled through relatively low reluctances to the normal operating magnetic path.

Assume now that R_c is the only part of the auxiliary magnetic circuit which saturates. The circuit then becomes equivalent to Fig. 7. This arrangement can be expected to increase the operating sensitivity over that of the plain coil without an auxiliary magnetic circuit, provided that R_a is made low in reluctance. In a given

relay, for instance, the insertion of .008 inch Permalloy collars around the glass sealed unit to increase the effective cross-section of the spindle at all points except for a short section opposite the gap, was found to decrease the operating and release currents of the standard relay by about 5 per cent and 7 per cent, respectively. This leads to a third generalization.

A large increase in the operating delay and input inductance of an electromagnetic device can be obtained without decreasing the ultimate current sensitivity of the device, by adding an auxiliary magnetic path composed entirely of ferromagnetic material of high permeability and adequate cross-section, provided that the part of the auxiliary magnetic circuit which is in a mesh effectively in shunt with the operating gap is smaller in cross-section than the remainder of the auxiliary circuit, and is saturated under normal operating conditions. In an auxiliary magnetic circuit as described the total flux will be substantially constant throughout its length and saturation will tend to be confined to the part having smaller cross-section.

What is claimed is:

1. A relay comprising a bobbin consisting of a cylinder and a pair of spool heads all of low reluctance magnetic material, an energizing coil wound upon said bobbin, strips of low reluctance magnetic material affixed to said spool heads outside said winding for completing a low reluctance magnetic path interlinked with said winding and a magnetic reed contact device centered within and along the axis of said cylinder.

2. A relay comprising a bobbin consisting of a cylinder and a pair of spool heads all of low reluctance magnetic material, an energizing coil wound upon said bobbin, and a magnetic reed contact device centered within and along the axis of said cylinder, said bobbin acting as a shield interposed between said winding and said contact device to divert magnetic energy from said contact device until the magnetic energy produced by said coil has increased to and above a predetermined amount through the energization of said winding.

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