Nov. 24, 1964 W. F. CARR 3,158,795

MAGNETIC SWITCH OVERLOAD DEVICE

Filed July 2, 1963

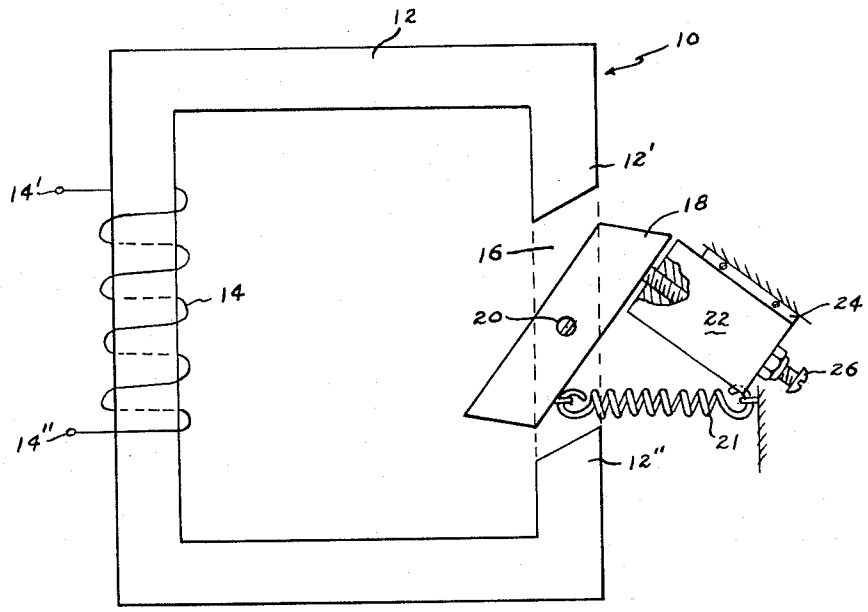


Fig-1

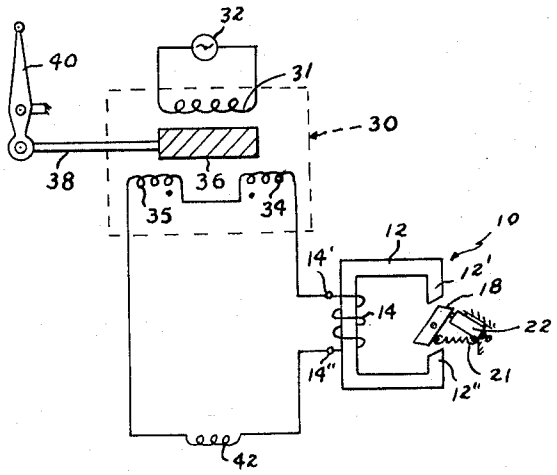


Fig-2

INVENTOR.
WILLIAM F. CARR
BY Wade Kroutter
ATTORNEY

AGENT

United States Patent Office 3,158,795 Patented Nov. 24, 1964

3,158,795

MAGNETIC SWITCH OVERLOAD DEVICE

William F. Carr, Santa Monica, Calif., assignor to the United States of America as represented by the Secretary of the Air Force

Filed July 2, 1963, Ser. No. 292,504
3 Claims. (Cl. 317—172)

This case relates to an overload device and, particularly, to a magnetic switch overload device which is sensitive to abnormally high currents for protective purposes.

An object of the invention is to provide a contactless magnetic switch having a positive switching motion.

Another object of the invention is the provision of a quick-acting magnetic switch performing the reduction of an electrical current without the use of purely electrical devices.

A further object of the invention is to provide a magnetic switch which is simple in construction and reliable in operation.

In accordance with the foregoing objects, the magnetic switch of the invention contemplates the use of a discontinuous magnetizable core having a drive coil wound thereon, two pole pieces defining an air gap, and a rotor of magnetizable material pivotally mounted between the pole pieces for affecting the magnetic field in the gap according to its position. With a current of normal value energizing the drive coil the rotor is biased, by a permanent magnet, to a normal position out of alignment with the pole pieces in which the air gap is large. The biasing force exerted by the permanent magnet is adjustable and is opposed by the action of a spring member coupled to the rotor. Through appropriate selection of the spring characteristics and the biasing force of the permanent magnet, the rotor is retained in its normal position until an excessive current in the drive coil increases the magnetic field in the air gap. The increased magnetic field causes a torque on the rotor tending to rotate it and, finally, such a torque that the rotor, under the aiding influence of the spring member, rotates abruptly to a second position to more fully close the gap. By virtue of the fact that the greatest percentage of the magnetic reluctance is located in the air gap, the reluctance of the core is materially reduced bringing about a corresponding increase in the reactance of the drive coil. This latter effect acts to cut down to a safe level the current fed to any electrical load in series with the drive coil.

Complete understanding of the invention and an introduction to other objects and features not specifically mentioned may be had from the following detailed description of a specific embodiment thereof when read in conjunction with the appended drawings, in which like reference characters refer to like elements in each of the several views, and wherein:

FIG. 1 is a view of a magnetic switch embodying the invention; and

FIG. 2 is a schematic diagram of a control circuit using the magnetic switch shown in FIG. 1.

Referring now to FIG. 1, **10** generally indicates a magnetic switch embodying the invention which comprises a discontinuous magnetizable core **12** having a winding **14** thereon adapted to be energized by a source of alternating current applied between terminals **14'** and and **14''**. Pole faces **12'** and **12''** of the core define an air gap **16**. A magnetizable rotor or armature **18** is rotatably mounted in air gap **16** on a pin **20** centrally disposed between the pole pieces. Rotor **18** is biased, in opposition to the action of a spring member **21**, to a first or normal position in which the air gap is large, by any suitable keeper means, herein shown as a permanent magnet **22** depending from a bracket **24**. Spring **21** is similarly anchored at its end opposite to the connection to rotor **18**.

In order to enable triggering of the rotor at various excitation levels of the current in coil **14**, an adjusting screw **26** longitudinally extending internally of magnet **22** is provided. In the absence of all other forces acting on it the rotor is rotated by spring **21** to a second position in which the air gap is shortened and, in fact, substantially completely filled. The dashed lines indicate the latter position of the rotor.

When the coil **14** is connected in series with a seat of E.M.F. and an element representing an electrical load and the load current is within a predetermined safe operating range, the magnetic potential force across the air gap though coupled with the effect of spring **21** is insufficient to overcome the holding power of magnet **22**. If, however, a predetermined value of load current is exceeded, the resultant field in the gap causes a torque to be exerted on rotor **18** tending to rotate it. As the current continues to increase, the attractive force which magnet **22** has been set to exert on the rotor is exceeded. The greater torque on the rotor, coupled with the force of spring **21**, now causes the rotor to rotate suddenly to a position into the air gap thereby substantially completely closing the magnetic current. Since most of the magnetic reluctance, i.e., the resistance to the passage of magnetic flux in the circuit, is in the air gap, the reluctance simultaneously falls to its minimum value, which acts to increase greatly the reactance of coil **14** to current therein.

The decrease in the reluctance of the magnetic path, once the rotor occupies its gap-filling position, has made possible reductions of current in ratios of greater than 10:1.

Until the descriptive condition is corrected rotor **18** is held "closed" by spring **21**. Thereafter, either manual or automatic rotor-repositioning means may be employed to return the rotor to the controlling attractive influence of magnet **22**, the type and configuration of such means not being germane to the invention per se and hence not being shown.

The circuit shown in FIG. 2 is similar to that described and claimed in co-pending application for United States Letters Patent of William F. Carr, Serial No. 292,506, filed July 2, 1963, for Electrical Primary Flight Control System, now Patent No. 3,136,504. Briefly, one use for which the circuit of FIG. 2 is well suited is in an aircraft control system in which the aircraft control surfaces are actuated primarily by electrical and power apparatus, rather than by using more conventional mechanical linkage paths. The circuit comprises a transducer generally indicated **30** whose primary winding **31** is fed by an alternating current generator **32**. The two secondary windings **33** and **34** of the transducer are differentially wound, i.e., wound in such a manner that flux cutting the secondary windings will induce voltages of opposite polarity in the respective secondary windings. The transducer includes a movable magnetic core **36** which is mechanically coupled through a suitable nonmagnetic extension **38** to a pilot's control stick **40**. As is evident, displacing the control stick varies the mutual coupling of the transducer windings thereby giving rise to electrical command signals. Thus, for a fixed value of excitation current in primary winding **32**, the voltage induced in each secondary winding will vary directly with the position of core **36**. With the core in a central position with respect to the secondary windings, as is shown, equal and opposite voltages are induced in the secondary windings. Hence, an unbalanced secondary voltage has a sign and amplitude which is a direct func-

tion of the displacement of core 36 from the indicated center position.

As shown in FIG. 2, the drive coil 14 of the switch of FIG. 1 is connected in series with a load, represented herein as on inductor 42, across the output terminals of the secondary windings. A typical load device may be the stick control winding of an A.C. torque motor (not shown). From the standpoint of winding 14 and inductor 42 the secondary windings form a seat of E.M.F. so that the level of the current fed to the load may either remain unaffected or be reduced to a very low value, depending, respectively, on whether rotor 18 is nonaligned or aligned with the pole pieces. Thus, in the event that a short circuit or such serious malfunction causes the normal load current to exceed a predetermined value, rotor 18 will be actuated, with a sudden movement, into the air gap. An immediate decrease in the reluctance of the magnetic circuit results. The consequent diminution in reluctance causes the reactance of coil 14 to increase greatly and the series current thereby is reduced in corresponding proportion. Thus, in one particular use for which the magnetic switch is adapted, an abnormally high current due to component failure or disruption, may be avoided in a control channel, in effect, deactivating the defective channel.

From the foregoing description, it is apparent that the magnetic switch of the invention is particularly suitable in (1) systems which must operate on alternating current at power levels high enough to require no amplification, and (2) systems in which the use of contact-type switches, relays, or circuit breakers is undesired.

It will be understood that various changes and modifications affecting the arrangement of the parts which have been herein described and illustrated to explain the nature of the invention may be made by those skilled in the art within the spirit and scope of the appended claims.

I claim:

1. A contactless magnetic overload device comprising a discontinuous core having an air gap, a winding on the body of said core, a magnetizable member mounted rotatably in the air gap for rotation between first and second positions characterized by relatively high and greatly reduced magnetic reluctances in the air gap, respectively, keeper means magnetically coupled to said member for biasing it to its first position, and mechanical spring means coupled to said member for opposing the biasing force of said keeper means to such a degree that when the flux density in the air gap exceeds a predetermined intensity the net magnetic and mechanical moment with respect to the axis of rotation of said member is sufficient to annul the biasing force of said keeper means and thereby cause said member to be actuated to its second position with a snap action.

2. A contactless magnetic overload device comprising a discontinuous core having an air gap, a winding on the body of said core, a magnetizable rotor disposed in the air gap and being mounted for rotary movement between a first "normal" position characterized by an air gap of relatively large dimension and a second "overload" position characterized by an air gap which is substantially closed, a permanent magnet magnetically coupled to said rotor in a manner to maintain said rotor in its first position in the absence of a current in said winding above a predetermined level, and spring connected to and acting on said rotor in a direction tending to close the air gap, the net mechanical and magnetic moment with respect to the axis of rotation of said rotor being adjusted to permit retention of said rotor in its first position where the current in said winding is below said predetermined level and, where the flux density in the air gap reaches a critical intensity due to an overload current in said winding, to cause said rotor to rotate from its first to its second position thereby to increase the reactance of said winding.

3. A contactless magnetic overload device as claimed in claim 2 wherein said permanent magnet is provided with an adjusting screw to enable tripping of said rotor to its second position at variable intensities of flux density.

References Cited by the Examiner

UNITED STATES PATENTS

2,296,123 9/42 Stimson ..... 200—98

JOHN F. BURNS, *Primary Examiner.*