Aug. 21, 1956 J. C. RILEY 2,760,027

HIGH SPEED RELAY

Filed May 12, 1953

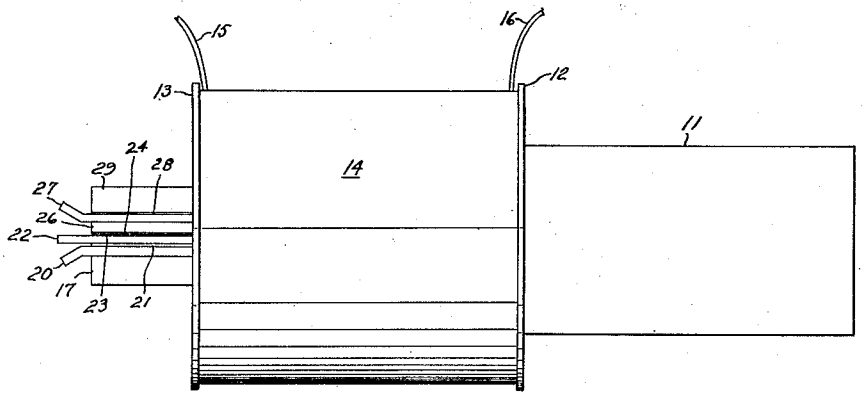


FIG. 1.

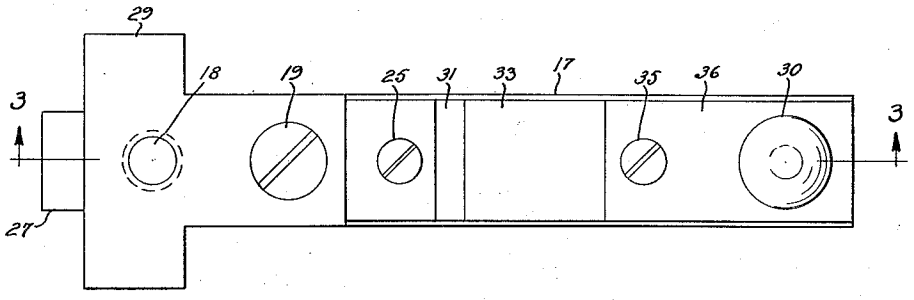


FIG. 2.

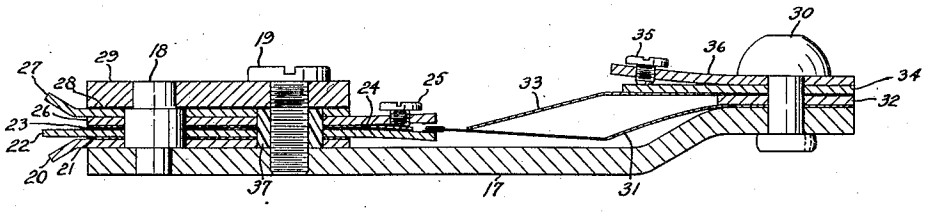


FIG. 3.

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2,760,027

Patented Aug. 21, 1956

2,760,027

HIGH SPEED RELAY

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Application May 12, 1953, Serial No. 354,525

7 Claims. (Cl. 200—87)

This invention relates generally to electric switches of the type having a stationary contact and a moving contact, the moving contact being carried on a movable magnetizable element in a magnetic circuit in which the magnetomotive force varies as a function of two variables, one of the variables being an air gap in the magnetic circuit and the other variable being the ampere turns in a coil enclosing a part of the magnetic circuit.

More particularly this invention is an improved high speed relay in which the inductance of the operating coil circuit is kept at a minimum value, the intertia of the movable part of the magnetic circuit is kept at a minimum value, and in which contact "bounce" is minimized by means adapted to dissipate the kinetic energy which otherwise would build up to nuisance values in the movable part of the magnetic circuit as it moves to shorten the flux path through the magnetic circuit.

To appreciate the novelty and utility of this invention it should be understood that this invention is a miniature relay applicable to high speed switching, in a precisely controlled manner, of communication circuits of small amperage required in the control of aviation direction and ordnance apparatus. In a particular instance of use of this high speed relay, a thirty cycle, twenty-five per cent duty cycle pulse timing current is continuously applied to the operating coil of the relay. The relay is a single pole double throw switching mechanism with the blade biased normally to close against one stationary contact, the blade being a thin steel reed, the normally open stationary contact structure including low loss, highly permeable, steel parts and the coil surrounding the part of the magnetic circuit which includes the contact air gap, the contact end of the movable blade and the contact ends of the stationary contact structure. Both the bias of the switch blade and the separation of the stationary contacts are micrometrically adjustable by tiny screws.

With the thirty cycle twenty-five per cent duty cycle unidirectional pulse current applied to the coil, the coil is energized to produce a unidirectional magnetic flux axially thereof every thirty-three and one-third milliseconds, and is energized for about 8 milliseconds of this time. The coil current starts and rises to a maximum in about one and one-half milliseconds, is maintained at maximum value for about six and one-half milliseconds and is cut off to decay to zero in about one and one-tenth milliseconds.

It is a requirement of the relay that the blade structure be non-resonant at the pulse frequency and that the blade follow very closely the timing and strength of the magnetic field so that with no current in the coil the movable switch contact carried by the blade structure will lie in contact with the stationary contact toward which it is biased but when the coil current starts and magnetic flux traverses the other throw contact gap from the magnetic structure of the other throw stationary contact to the magnetic blade structure the movable contact will move away from the stationary contact towards which it is biased and by the time the coil current reaches a maximum will have

traversed the air gap and come into contact with the normally open or other throw stationary contact. The required throw cycle of the switch therefore is that every thirty-three and one-third milliseconds the movable contact must leave the normally closed stationary contact and within two milliseconds must come to rest in contact with the normally open contact to stay firmly in contact with it for about six and one-half milliseconds and then transfer back to the normally closed stationary contact in a little over one millisecond. In other words the normally closed throw contacts must be closed for about 24 milliseconds, then within two milliseconds the normally closed contacts will be opened and the normally closed contacts will be closed to remain closed for about six and one-half milliseconds, at which time the coil current is stopped. In a little over one millisecond after the coil current is stopped the normally open contacts will be opened and the normally closed contacts closed in their starting position. This switch duty cycle is repeated thirty times every second.

It is critical that the normally open throw of the switch be closed on time and for the right amount of time for this throw of the switch is required to continue a critical operating circuit for five milliseconds of the total possible six and one-half milliseconds it could be closed. To be satisfactory the movable contact bounce on striking the stationary contact must be minimized and in addition the entire switch structure must be sufficiently unaffected by extremes of atmospheric temperature so that the switch never fails to repeat its required duty cycle.

In previous switches it has been found necessary in order to minimize contact bounce to limit the contact spacing to as little as three ten-thousandths of an inch and thus to limit the velocity attained by the movable contact. While it has been possible to adjust these previous switches so that they would be satisfactory on tests they have been found to be very temperamental and unsatisfactory in use. The reason for this has been the very small contact gap and the difficulty of providing a structure that would maintain this gap under actual field conditions.

In working with switches of this type I have discovered that a larger contact gap is an essential of mass production and maintained calibration and that with the larger gap contact bounce must be suppressed.

It is therefore an object of this invention to provide a high speed relay with a relatively large allowable contact spacing and with means for limiting the velocity of the movable contact in the contact space.

It is a second object to provide such a switch with means closely adjacent the contacts for micrometrically adjusting the contact space.

It is a third object to provide such a switch with means for limiting the build up of kinetic energy in the moving blade of the switch.

It is a fourth object to provide closely adjacent the blade reed and blade biasing means a micrometric adjustment of the bias of the biasing means.

It is a fifth object to provide such a switch with a biasing means for its switch blade reed having a rubbing contact on the reed adapted to dissipate the terminal kinetic energy of the reed and its biasing means.

How these and other objects are attained will be understood from the following description referring to the attached drawing in which

Fig. 1 shows a side elevation of the complete assembly of the functional parts of my high speed relay.

Fig. 2 shows a plan view of the single pole double throw switch of my relay.

Fig. 3 shows a vertical section along the line 3—3 of Fig. 2.

Like numerals of reference refer to like parts in the several figures of the drawing.

Referring now to the drawing it is seen from Figs. 2 and 3 that the switch mechanism of my invention stacks into a substantially square elongated overall shape with a T head at the left end and the switch terminals extending therefrom.

As shown in Fig. 1 the elongated section of the switch inserts into the substantially square sectioned tunnel of a molded insulating member 11 having a pair of circular flange elements 12 and 13 molded integrally therewith. Between the flange elements 12 and 13 the member 11 is molded with an external cylindrical surface on which is wound a switch operating coil 14 having terminal wires 15 and 16.

As shown in Figs. 2 and 3 the switch structure of my high speed relay comprises a stiff brass frame member 17 about one and one-half inches long and one-fourth inch wide except that its width is increased at the head end to about one-half inch for a length of three-sixteenths of one inch. The thickness of frame 17 is about one-twentieth of an inch.

On the left end of frame 17, oriented by insulator 18 and secured in place by screw 19 threaded into frame member 17, is stacked the stationary contact and terminal structure of my switch structure. In sequence on the left end of frame member 17 is stacked bronze terminal strip 20, mica sheet insulator 21, bronze stationary contact and terminal strip 22, mica sheet insulator 23, spring steel abutment strip 24 for stationary contact adjustment screw 25, magnetizable steel stationary contact and magnetic flux path member 26 through which is threaded adjustment screw 25, bronze stationary contact terminal strip 27, mica sheet insulator 28, and brass clamp plate 29.

Secured in place on the right end of frame member 17 by metal rivet 30 are moving contact magnetizable steel blade 31, bronze spacer 32, blade biasing magnetizable steel leaf spring 33, bronze abutment strip 34 for blade bias adjustment screws 35, and bronze blade bias adjustment plate 36 through which screw 35 is threaded.

It is to be noted that parts 17, 19, 20, 29, 30, 31, 32, 33, 34, 35 and 36 are always in electrical contact at the switch blade potential while stationary contact and terminal strip 22 is electrically isolated from the rest of the switch structure by mica sheets 21 and 23 and the nylon sleeve 37 surrounding screw 19. Similarly stationary contact member 26 and terminal strip 27 are isolated except when contacted by moving contact blade 31. Of course stationary contact strip 22 takes the potential of blade 31 when contacted thereby and blade 31 is normally in contact with strip 22 because of the biasing force on blade 31 of resilient steel leaf 33. This biasing force is adjustable by screw 35.

The spread of stationary contact strips 22 and 26 is adjustable by screw 25 threaded into the relatively stiff member 26 and abutting flexible spring steel strip 24 which presses on mica sheet 23 which in turn presses against flexible contact member 22.

Normally, then movable blade 31 rests against stationary contact member 22 and a circuit through the switch is complete from terminal 20 to terminal 22 through parts 20, 17, 31 and 32. When, however, coil 14 is energized with a pulsing direct current a magnetomotive force proportional to the amplitude of the current in the coil is set up longitudinally of the space within the coil resulting in a proportional similarly placed magnetic flux. Since this flux tends to take a path of least reluctance, much of the flux is concentrated in contact member 27, blade 31 and leaf 33, and traverses the air gap between member 27 and blade 31, tending to shorten the air gap by pulling the blade 31 away from member 22 and towards member 24 while overcoming the biasing force of leaf 33 on blade 31. The balance between the magnetic force and the biasing force can be finely adjusted by the settings of adjusting screws 25 and 35 so that the coil current at which blade 31 leaves contact with member 22 and the acceleration of the tip of blade 31 in the air gap are adjusted to working requirements.

It should be noted that contact members 22 and 26 and blade 31 are tipped with nonmagneitc contact metal so that the magnetic parts 26 and 31 never actually come into contact.

It should also be remembered that in a high speed relay of the present type the forces involved and the travel distances of the moving parts as well as the time intervals of motion are small and contact bounce of any appreciable amount not only would tend to destroy the contacts involved but also would use up valuable time. In the present switch, even though a relatively large maximum length of air gap is used, the balancing of the magnetic force and the biasing force limits the blade acceleration and contact bounce, but not sufficiently to make the switch as reliable in operation as desired. I have discovered that by introducing a small friction factor into the blade motion the required bounce limitation requirement can be met. Accordingly particular attention is called to the condition of sliding friction, when the blade is in motion, at the contact of the free end of biasing leaf spring 23 where it bears on the blade 31 near its free end. While this movement is very small it has the effect of damping the oscillatory or bounce movement of the contact end of blade 31 when the blade strikes either stationary contact member 22 or member 26. By the addition of this feature to the switch its reliability in operation over a wide range of temperatures and a long life span has been improved over that of any similar device previously known.

Having thus made known some of the objects of my invention, depicted and described a successful form of my invention and described its operation, I claim

1. A high speed relay comprising a single pole double throw switch and electromagnetic means for operating said switch, said switch comprising a rigid elongated frame of non-magnetic material, a pair of spaced stationary switch contacts each insulatedly mounted on the same one end of said support, a resilient switch blade of magnetic material carrying a pair of movable contacts at one end and secured at its other end to the other end of said support, one of said stationary contacts being carried on said same one end of said support on a strip of non-magnetic material, the other of said stationary contacts being carried on said same one end of said support on a strip of magnetic material, said non-magnetic strip being sufficiently resilient to be adapted to a small adjustment of the distance between said two stationary contacts, a biasing means adapted to bias said resilient switch blade towards contact of one of said movable contacts with said stationary contact carried on said nonmagnetic material, said biasing means comprising a resilient magnetic biasing blade secured at one end to said other end of said support in a spaced relation to the secured end of said switch blade on its side away from the stationary contact towards which it is biased, the free end of said biasing blade being adapted to press slidably on said switch blade adjacent its contact end, and said means for operating said switch comprising an insulated coil of insulated wire spaced from and surrounding said magnetizable stationary contact strip and the movable ends of said magnetizable blade whereby when said coil is energized to operate said switch a magnetic flux will traverse the air gap between said magnetizable stationary contact strip and said switch blade and urge said switch blade to shorten said gap with a force increasing inversely with the length of said gap and said biasing means will urge said switch blade to lengthen said gap with a force increasing inversely with the length of said gap and whereby the mechanical and magnetic effect of said biasing blade on said switch blade when said blades are in motion will be to dampen the motion of natural vibration of said switch blade.

2. A high speed relay comprising an electric switch including a magnetizable movable contact blade having

a first position and a second position, magnetizable means adapted yieldingly to bias said switch blade towards said first position, electromagnetic means adapted to move said switch blade to said second position, and means adapted to dampen the movement of said switch blade, said electromagnetic means comprising said magnetizable switch blade, a magnetizable strip means having one end adjacent the movable end of said blade when said blade is in said second position and an insulated coil of insulated wire adapted to carry an electric current for magnetizing said blade and said strip, said blade and said strip being arranged in end to end relation axially of said coil to form a series magnetic flux path, and said blade movement dampening means comprising a combined magnetic and frictional sliding contact means forming the sole contact of said switch blade biasing means with said switch blade.

3. A magnetic switch comprising a support, a first flexible reed, contact making armature of magnetic metal supported as a cantilever beam from one end to said support, a second flexible reed of magnetic metal supported as a cantilever beam from said one end of said support and having its fixed end spaced from the fixed end of said armature, a first contact member of non-magnetic material insulatedly supported from the other end of said support, a second contact member of magnetic material insulatedly supported from said other end of said support in spaced insulated relation to said first contact member, the free end of said armature being positioned between adjacent ends of said contact members, and the free end of said second flexible reed being positioned to press against the free end of said armature to bias said armature towards said first contact member.

4. The device of claim 3 including means for magnetically energizing said magnetic parts in a magnetic path including said second contact member in series with said flexible reeds in parallel.

5. The device of claim 3 including means associated with both said contact members adapted to adjust the separation of said adjacent ends of said contact members.

6. In a magnetic switch including a first flexible reed magnetic armature, a magnetic stationary contact member, means adapted to energize said armature and said contact member in a series magnetic path and biasing means adapted mechanically to bias said armature away from said contact member, the improvement in which said biasing means comprises a second flexible magnetic reed spaced at one end from one end of said armature and

adapted at its other end continuously to contact said armature near its other end, said other end of said armature being adapted to move into contact with said stationary contact member against the bias of said biasing means when said armature and said stationary contact are magnetically energized and said second flexible reed being adapted when said armature is magnetically energized to be magnetically energized in like polarity whereby said mechanically biasing means will provide a magnetic additional bias to said armature.

7. A high speed relay comprising an electric switch and electromagnetic means for operating said switch, said switch comprising a rigid elongated frame of non-magnetic material, a magnetic stationary contact support insulatedly carried on one end of said frame, a resilient switch blade of magnetic material secured at one end to the other end of said frame, said switch blade carrying a movable switch contact at its free end, a biasing blade of resilient magnetic material secured at one end to said other end of said frame in spaced relation to the secured end of said switch blade, the free end of said biasing blade being positioned slidably to press on said switch blade near its contact end to bias said movable contact away from said stationary contact and said means for operating said switch comprising means for setting up a magnetic field in the space occupied by said contact support and said blades longitudinally thereof whereby a concentration of said magnetic field will be set up in said contact support in series with said blades in parallel, the contact end of said contact support will be of opposite magnetic polarity to the free ends of said blade, said movable contact will be drawn into contact with said stationary contact and said free end of said biasing blade will exert an additional magnetic bias on said switch blade urging said movable contact away from said stationary contact.

References Cited in the file of this patent

UNITED STATES PATENTS

2,264,124	Schreiner	Nov. 25, 1941
2,264,746	Ellwood	Dec. 2, 1941
2,491,907	Reifel et al.	Dec. 20, 1949
2,629,033	Dale	Feb. 17, 1953
2,678,360	Bellis	May 11, 1954
2,687,503	Attura	Aug. 24, 1954

FOREIGN PATENTS

294,682	Great Britain	July 30, 1928