July 18, 1961 J. S. ZIMMER 2,993,104

ELECTROMAGNETIC RELAY

Filed Jan. 21, 1959 2 Sheets-Sheet 1

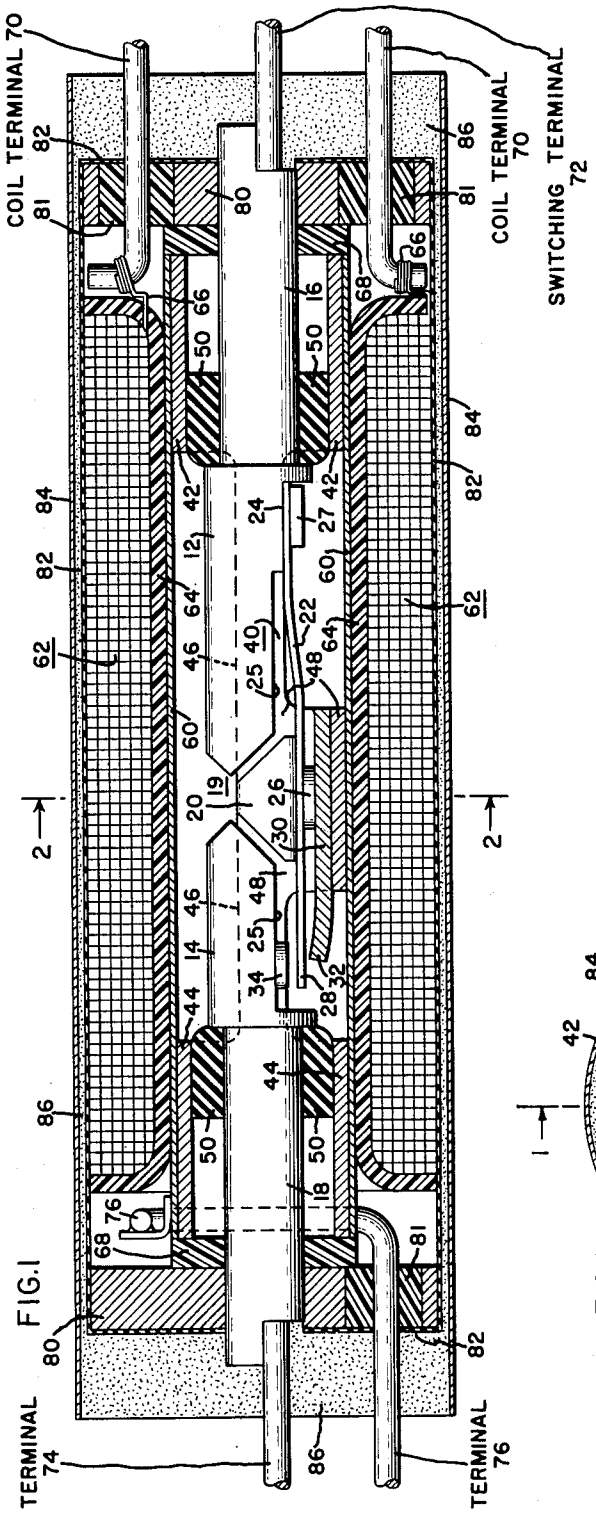


FIG. 1

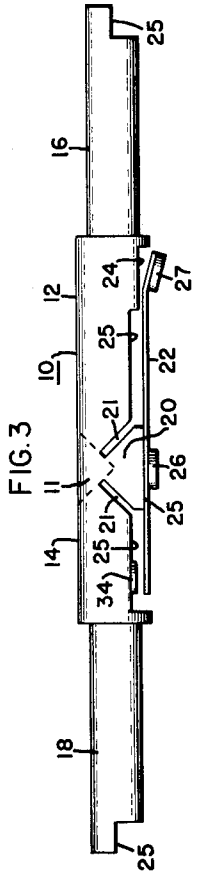


FIG. 3

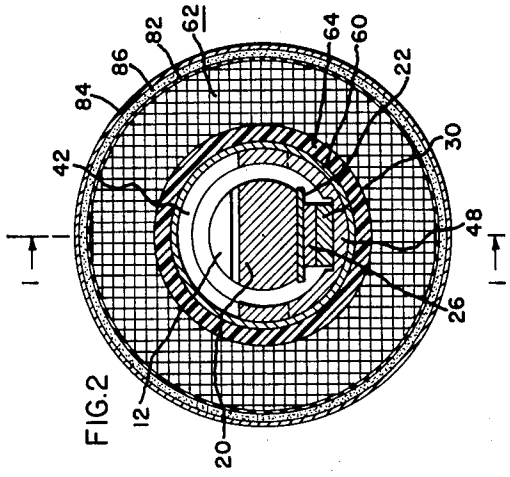


FIG. 2

INVENTOR:
JOHN S. ZIMMER,

BY James J. Williams
HIS ATTORNEY

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FIG. 4

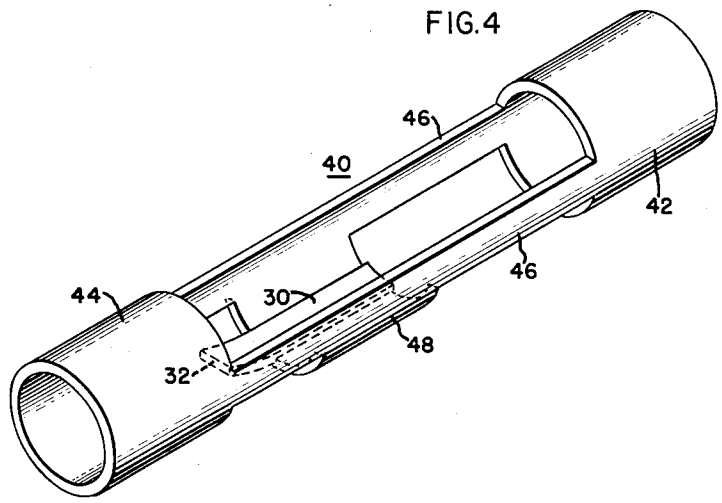


FIG. 5

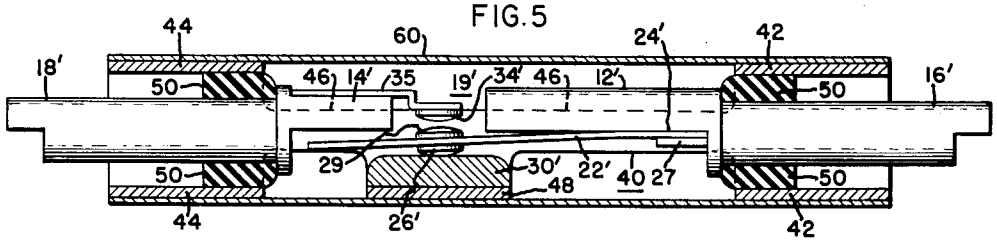
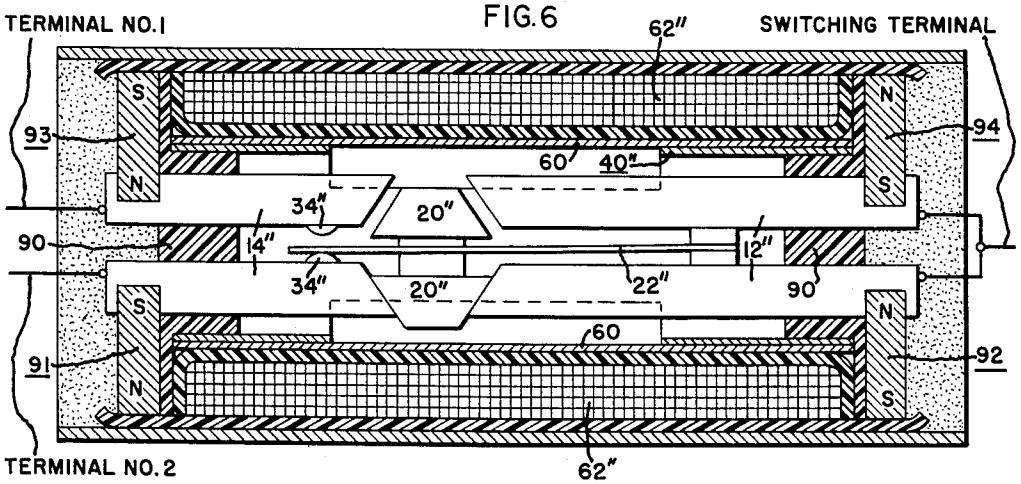


FIG. 6



INVENTOR:
JOHN S. ZIMMER,

BY James J. Williams
HIS ATTORNEY.

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2,993,104

ELECTROMAGNETIC RELAY

John S. Zimmer, Waynesboro, Va., assignor to General Electric Company, a corporation of New York

Filed Jan. 21, 1959, Ser. No. 788,197
11 Claims. (Cl. 200—103)

The invention relates to an electromagnetic relay and its manufacture, and particularly to an electromagnetic single-pole double-throw relay that may have relatively small dimensions, and that can be manufactured in large quantities with mass-production methods.

An object of the invention is to provide an improved electromagnetic single-pole double-throw relay that may have relatively small physical dimensions.

Another object of the invention is to provide an improved electromagnetic single-pole double-throw relay that can be manufactured with mass-production methods.

Another object of the invention is to provide an improved method of manufacturing an electromagnetic relay.

These and other objects are accomplished in accordance with the invention by an electromagnetic relay which, briefly, comprises a core having first and second elements of magnetic material, the two elements being separated by a gap. An elongated spring has one end fastened to the first core element and the other end positioned in the vicinity of but normally separated from the second core element. In one embodiment of the invention, an armature of magnetic material is fastened to the spring so that the armature is positioned in the vicinity of the gap but normally separated from the two core elements. In another embodiment of the invention, the spring itself is formed from a magnetic material and serves as the armature. A stationary contact is positioned adjacent the spring and the spring is biased so that the spring normally engages the contact. And finally, an energizing coil is positioned around the core elements, the spring, the armature, and the contact. The spring and first core element form a common terminal for the relay, the contact forms the normally closed switch terminal for the relay, and the second core element forms the normally open switch terminal for the relay. When the coil is de-energized, a closed electrical circuit is provided between the first core element and the contact. When the coil is energized, a closed electrical circuit is then provided between the first core element and the second core element.

The invention will be better understood from the following description taken in connection with the accompanying drawing and its scope will be pointed out in the claims. In the drawing:

FIGURE 1 shows a longitudinal cross-sectional view of a preferred embodiment of an electromagnetic relay in accordance with the invention, the view being taken along the lines 1—1 of FIGURE 2;

FIGURE 2 shows a transverse cross-sectional view of the electromagnetic relay taken along the lines 2—2 of FIGURE 1;

FIGURE 3 shows an elevation view of the core elements and spring of the electromagnetic relay of FIGURE 1 during a stage of manufacture of the relay;

FIGURE 4 shows a perspective view of an inner tube which supports the contact bar and core elements of the relay;

FIGURE 5 shows a longitudinal cross-sectional view of another embodiment of an electromagnetic relay in accordance with the invention; and

FIGURE 6 shows a longitudinal cross-sectional view of another embodiment of an electromagnetic relay in accordance with the invention.

In the figures, the same reference numerals are used to refer to the same elements. A longitudinal cross-sectional view of the complete electromagnetic relay is shown in FIGURE 1, and a transverse cross-sectional view is shown in FIGURE 2. The relay comprises a core having a first core element 12 and a second core element 14 both formed of a magnetic material such as soft iron. A material having low flux retention is preferable in order to aid dropout of the relay when the coil is de-energized. The first and second core elements 12, 14 are formed, in a manner which will be explained, from a blank 10 which is best shown in FIGURE 3. Integral with the core elements 12, 14 are respective back portions 16, 18 for supporting the relay structure and also for providing a good path for the magnetic flux of the relay coil. The core elements 12, 14 are separated by an air gap 19 which, as seen in FIGURE 1, may be generally described as X-shaped, and which is formed by the free or inner end surfaces of the core elements 12, 14. An armature 20 is formed from the same blank 10 as the core elements 12, 14 and has a shape which corresponds to or substantially fits in a portion of the gap 19. The armature 20 is fastened to a spring 22 which in turn is fastened to the first core element 12 at the surface point 24 by any suitable means such as welding. The spring 22 is preferably made of a flat elongated strip of resilient material such as beryllium copper, and is bent or shaped so that it rests substantially in the position shown in FIGURE 1. The spring 22 carries a spring contact 26 preferably formed of a high conductivity metal that is silver plated, the spring carried contact 26 being on the opposite side of the spring 22 from the armature 20. The spring carried contact 26 normally (i.e., when the relay is released) engages a contact bar 30 which is also preferably formed of a high conductivity metal that is silver plated. The contact bar 30 has an extension which is bent to provide a backstop 32 for the free end 28 of the spring 22. The backstop 32 helps to reduce bouncing or oscillation of the spring 22 when the relay is released or dropped out to its normal position. The free end 28 of the spring 22 is positioned in the vicinity of the second core element 14 but is normally separated therefrom. When the relay is energized and pulled up from its normal position, the free end 28 of the spring 22 engages a contact 34 which is preferably formed of a high conductivity metal that is silver plated, and which is fastened to the second core element 14. Since the free end 28 of the spring 22 provides an electrical circuit to the contact 34 on the second core element 14, and since the free end 28 may flex or whip when the relay is released or dropped out so that the free end 28 engages the backstop 32 before the spring carried contact 26 engages the contact bar 30, the entire spring 22 or at least the free end 28 portion may preferably be plated or alloyed with a suitable high conductivity metal such as silver.

The contact bar 30 and its backstop 32 are supported by an inner tube 40, which is shown most clearly in the perspective view in FIGURE 4. The inner tube 40 is formed from a suitable piece of cylindrical, non-magnetic material such as stainless steel so that it has end supports 42, 44 which are joined by two strips 46. On the lower side and between the two strips 46, a semi-cylindrical support 48 is provided. This support 48 carries the contact bar 30 and the backstop 32. The contact bar 30 is preferably fastened to the support 48 before the relay is assembled. The inner tube 40 is supported in an electrically insulated relation between the back portions 16, 18 of the respective core elements 12, 14 by electrically insulating cylindrical beads 50 which surround the back portions 16, 18 and bear against the shoulders formed by the first and second core elements 12, 14 respectively. The cylindrical beads 50 may be rigidly fastened to the

back portions 16, 18 by any suitable means. Glass beads are preferred as they can be fused to the back portions 16, 18 to provide a hermetic seal. When in position, the inner tube 40 is outside the core elements 12, 14, the back portions 16, 18 and the cylindrical beads 50. The inner tube 40 is supported by and rigidly fastened to the beads 50 by its respective end supports 42, 44. A cylindrical metallic tube 60 of non-magnetic material surrounds the inner tube 40 and the relay elements. The cylindrical tube 60 may be fastened to the inner tube 40 around the entire circumference of the inner tube 40 at the end supports 42, 44 respectively under such conditions as to hermetically seal the moving relay parts under the most desirable conditions, such as in an atmosphere of dry inert gas. An operating or energizing coil 62 is wound around a suitable coil form 64, the coil form 64 being made of an electrically insulating material such as a plastic. The ends 66 of the coil 62 are brought out at one end of the coil form 64 for connecting the coil 62 to external terminals. The ends of the inner tube 40 and the cylindrical tube 60 are insulated by bushings 68 which are formed from an electrically insulating material such as a plastic and which are dimensioned so that they pass over the respective end portions 16, 18.

Suitable coil terminals 70 are provided and fastened to the ends 66 of the coils 62. Likewise, a switching terminal 72 is fastened to the back portion 16, a terminal 74 for the normally open contact 34 is fastened to the back portion 18, and a terminal 76 for the normally closed contact bar 30 is fastened to the cylindrical tube 60. These various terminals 70, 72, 74, 76 may be supported by means of metallic discs 80 which have openings for passing the terminals therethrough. The discs 80 are preferably made from a magnetic material to provide a better path for the magnetic flux between the coil 62 and the core elements 12, 14. The various terminals may be electrically insulated from the discs 80 by means of insulation bushings 81 formed from a thermally setting plastic which can be cast in the openings in the discs 80. The complete assembly is wrapped with an electrically insulating tape 82, then placed in a metallic outer cylinder 84, and separated therefrom and supported by a material 86 such as a thermally setting plastic which can be cast and which, when cool, becomes hard. The outer cylinder 84 is preferably made of a magnetic material to provide a better path for the magnetic flux between the coil 62 and the core elements 12, 14.

When the relay is in its normal or released position, the relay elements have the position shown in FIGURE 1. An electrically closed circuit is provided from the switching terminal 72 through the back portion 16, the first core element 12, the spring 22, the spring contact 26, the contact bar 30, the support 48, the inner tube 40, the cylindrical tube 60, and finally to the terminal 76 for the normally closed contact bar 30. An electrically open circuit exists between the switching terminal 72 and the terminal 74 for the normally open contact 34, since the second core element 14 and its back portion 18 are electrically insulated from the remainder of the relay elements. When the coil 62 is energized, however, such as by the application of a suitable potential to the coil terminals 70, the armature 20 is drawn up in the gap 19 towards the core elements 12, 14 until the free end 28 of the spring 22 engages the contact 34. The armature 20 continues to be drawn up into the gap 19 until the faces of the armature 20 contact the corresponding end surfaces of the core elements 12, 14. This over-travel of the armature 20 provides a desirable wiping of the free end 28 of the spring 22 across the contact 34. An electrically closed circuit is thus provided between the switching terminal 72 and the terminal 74 through the back portion 16, the first core element 12, the spring 22, the free end 28, the contact 34, the second core element 14, the back portion 18, and the terminal 74. An electrically open circuit then exists between the switching terminal 72 and the terminal 76 in this condition because the spring contact 26 is disengaged from the contact bar 30. With the armature 20 contacting the core elements 12, 14, a good magnetic path is provided between the core elements 12, 14, and the energizing coil 62. This path includes the outer cylinder 84, the right-hand disc 80, the back portion 16, the first core element 12, the armature 20, the second core element 14, the back portion 18, the left-hand disc 80, and the outer cylinder 84. However, a gap of non-magnetic material remains between the outer cylinder 84 and the discs 80 so that the relay will drop out readily when the coil 62 is de-energized.

The relay described has been successfully built and operated in an embodiment having very small physical dimensions. This embodiment had an over-all length of approximately 0.89 inch and a diameter of approximately 0.26 inch. Electrically, this relay was capable of switching a current of approximately 1 ampere at 28 volts through at least several hundred thousands of cycles of switching. It will be appreciated that the invention provides a relay which has small physical dimensions but which is durable and rugged. Furthermore, maximum utilization of the magnetic field is attained by the general arrangement and by the armature being near the center of the coil.

The assembly of a relay having the small physical dimensions just described might, under mass-production conditions, normally be expected to be difficult. However, a relay in accordance with the invention is relatively easy to construct and assemble. The ease of construction and assembly results, at least partially, from the novel core blank 10 shown in FIGURE 3. This ease also results from the method by which the core elements 12, 14 and the armature 20 are formed, and by which the spring 22 is aligned with and fastened to the first core element 12. A cylindrical core blank 10 having the configuration shown is ground or machined along parallel planes to provide the flat surfaces 24, 25. If the flat surfaces are formed in one operation, accurate alignment of all the elements to be fastened to the blank 10 is thus assured. After the flat surfaces 24, 25 are formed, two slots or kerfs 21 are formed in the flat surface 25 on each side of the material in the blank 10 that will form the armature 20. The angle between the slots 21 may vary over a wide range, namely from zero (in which case the slots are parallel to each other) to an angle approaching 180 degrees. However, it is preferred that the slots 21 converge at an angle of 90 degrees, which represents a good compromise for the various design factors involved. The contact 34 is then fastened to the flat surface of the second core element 14. The spring 22, which has already been provided with its contact 26 and a welding button 27 (if needed), is fastened to the flat surface between the grooves 21. Then, the spring 22 is provided with a suitable mechanically biasing bend near the end which will be attached to the flat surface 24 of the first core element 12. And then, the end of the spring 22 is suitably fastened to the first core element 12 at the surface 24. After these operations are complete, the beads 50 are fastened to the back portions 16, 18. The inner tube 40, to which the contact bar 30 has been previously fastened, is then passed over the blank 10 and positioned so that the contact bar 30 is adjacent and parallel to the contact 26. This positioning is easily attained. The inner tube 40 is then fastened to the beads 50 by suitable means. Then, the blank 10 and the inner tube 40 are supported in a suitable jig or fixture, and the blank 10 is ground or machined along the dotted lines shown in FIGURE 3 so that the material 11 enclosed by the dotted lines is removed. When this material 11 is removed, the armature 20 is freed from the blank 10, this operation also forming the first and second core elements 12, 14, and the X-shaped air gap 19 bounded by the inner end surfaces of the core elements 12, 14. The various elements are held in the proper alignment by the inner tube 40 after the material 11 is re-

moved. The relay is completed by adding the other elements including the cylindrical tube **60**, the coil **62**, the end portions, the terminals, and the outer cylinder **84**. In addition to holding the various elements in alignment, the inner tube **40** permits access to the elements through the openings between the strips **46** so that the material **11** can be easily removed and so that the certain elements, such as spring **22**, can be adjusted if necessary. The ease of assembly and alignment of the relay elements in accordance with the method described makes the manufacture of such relays readily adaptable to mass-production techniques.

The steps in the method described may be varied, if desired, as follows: After the slot or kerfs **21** are formed, a cement such as an epoxy cement is put in the slots **21**, and the material **11** is then removed. After this, the spring **22** and the beads **50** are added. Then the inner tube **40** is passed over the blank **10** and the beads **50** and positioned so that the contact bar **30** is adjacent and parallel to the contact **26**. Then, a solvent is applied to dissolve the cement in the slots **21**, thus freeing the armature **20**. For the cement mentioned, a suitable solvent would be dichloromethane.

FIGURE 5 shows a longitudinal cross-sectional view of another embodiment of an electromagnetic relay in accordance with the invention, the embodiment of FIGURE 5 being similar to the embodiment previously described. In FIGURE 5, elements substantially identical to those in FIGURE 1 have the same reference numerals, and corresponding elements which may be somewhat different in form have the same reference numerals with a prime suffixed thereto. FIGURE 5 does not show the complete electromagnetic relay, but shows only that portion which would be assembled within the coil form **64** and coil **62**. The embodiment of FIGURE 5 includes first and second core elements **12'**, **14'** having respective back portions **16'**, **18'**. Beads **50** surround the back portions **16'**, **18'** and support the inner tube **40**. The nonmagnetic cylindrical tube **60** surrounds the inner tube **40** and the relay elements. A flat spring **22'** is fastened to the first core element **12'** at the surface point **24'** by any suitable means such as welding. In the embodiment of FIGURE 5, the spring **22'** serves as the armature of the relay, and hence is made of a magnetic material which is also resilient. An example of such material is spring steel. The spring **22'** carries two contacts **26'**, **29** which are fastened to opposite faces of the spring **22'** at a point between the first and second core elements **12'**, **14'**. The spring **22'** is bent or mechanically biased so that its contact **26'** normally engages the contact bar **30'** which is fastened to the semi-cylindrical support **48**. A contact **34'** is supported in the air gap **19'** by a contact support **35** which is fastened to the second core element **14'**. The spring **22'**, its contacts **26'**, **29**, the contact bar **30'**, and the contact **34'** are all positioned and arranged so that the spring contact **26'** normally engages the contact bar **30'** when the relay is de-energized, and so that the spring contact **29** engages the contact **34'** when the relay is energized or pulled up from its normal position. And, it is preferable that the parts be arranged so that there is a wiping action between the contacts, and so that the spring **22'** makes contact with the second core element **14'**. Since the spring **22'** comprises a magnetic material, a good flux path is provided between the first and second core elements **12'**, **14'** when the relay is energized.

The method of assembling the embodiment shown in FIGURE 5 is similar to the method described in connection with the embodiment shown in FIGURE 1. A blank of magnetic material having the configuration shown in FIGURE 5 is ground or machined along parallel planes to provide the flat surfaces needed for attaching the spring **22'** and the contact support **35**. The beads **50** are fastened to the back portions **16'**, **18'**. The inner tube **40**, to which the contact bar **30'** has been previously fastened, is then passed over the blank, and fastened to the beads **50** in such a position that the contact bar **30'** is adjacent and parallel to the surface **24'** to which the spring **22'** will be fastened. Material is then removed from between the portions of the blank which will form the core elements **12'**, **14'** so as to form the air gap **19'**. The openings between the strips **46** of the inner tube **40** readily permit this operation. After the air gap **19'** is formed, the spring **22'** with its contacts **26'**, **29** is fastened to the first core element **12'** at the surface point **24'**. And finally, the contact support **35** with its contact **34'** is fastened to the second core element **14'**. Then the relay may be completed as described in connection with FIGURE 1.

FIGURE 6 shows the embodiment of FIGURE 1 used in connection with a polarized relay. In FIGURE 6, elements which correspond to those in FIGURE 1, but which may be somewhat different in form, have the same reference numerals with a double prime suffixed thereto. The relay shown in FIGURE 6 is essentially comprised of two of the working relay units shown in FIGURE 1, namely two first core elements **12''**, two second core elements **14''**, and two armatures **20''**. These elements are positioned along parallel lines with the same elements correspondingly located. They are held in position by electrically insulating members **90** positioned at their respective ends, the members **90** having openings to receive and firmly hold the core elements **12''**, **14''**. A spring **22''** is fastened at one end at corresponding points on first core elements **12''**. The free end of the spring **22''** is positioned in the vicinity of the contacts **34''** which in turn are fastened at corresponding points on the second core elements **14''**. The spring **22''** is also fastened to the two armatures **20''** at a point intermediate its two ends. In operation, the spring **22''** moves up or down to engage either of the two contacts **34''** and provide an electrical connection from the switching terminal to either terminal No. 1 or terminal No. 2.

If the relay shown in FIGURE 6 is to operate as a polarized relay, four permanent magnets **91–94** are provided at each of the respective ends of the core elements **12''**, **14''**. These permanent magnets **91–94** are formed of semi-circular flat plates, each of which has a semi-circular opening therein that is adapted to be attached to the ends of the core elements **12''**, **14''**. The four permanent magnets **91–94** are arranged with their polarities as shown, and so that the two magnets at each end form a substantially circular frame to support a housing for the relay. If the relay coil **62''** is de-energized, the magnetic flux between the lower set of magnets **91**, **92** is substantially equal to the magnetic flux between the upper set of magnets **93**, **94**. However, the spring **22''** will move toward and engage one of the contacts **34''**, and remain in this position. In FIGURE 6, it is assumed that the spring **22''** moved downward. If the relay coil **62''** is energized with one direction of current so that the magnetic flux provided by the coil **62''** opposes the magnetic flux between the lower set of magnets **91**, **92** by substantially the same amount of flux, and aids the magnetic flux between the upper set of magnets **93**, **94**, then there is very little, if any, magnetic flux in the lower armature **20''** and a relatively large magnetic flux in the upper armature **20''**. Consequently, the spring **22''** moves upward. This provides an electrical connection from the switching terminal to terminal No. 1. However, if the direction of current flow through the relay coil **62''** is reversed with respect to the original current direction, then the spring **22''** will move downward to provide an electrical connection between the switching terminal and terminal No. 2. Thus, polarized operation of a relay in accordance with the invention is provided.

The method by which the relay shown in FIGURE 6 can be manufactured is substantially similar to the method explained in connection with the assembly of the relays shown in FIGURES 1 through 5. The core elements **12''**, **14''**, the armatures **20''**, and the spring **22''**

are assembled and held in position by the inner tube 40''. The inner tube 40'' does not have the semi-cylindrical support 48 shown and described in connection with the relays of FIGURES 1 through 5, as the contacts 34'' for the spring 22'' are carried by the second core elements 14''. With the relay units housed and fastened within the inner tube 40'', the armatures 20'' are freed by machining or grinding, thus providing and insuring the alignment desired. One slight difference might be mentioned in connection with the embodiment of FIGURE 6, namely the shape of the air gaps. In the embodiment shown in FIGURE 6, after the slots have been cut into the respective blanks, and the blanks fastened in the inner tube 40'', the armatures 20'' are freed by removing material in such a manner that the slots are, in effect, continued through the blanks to provide the air gap shape shown. However, this feature is one of design and choice, and may be varied to a great extent without departing from the spirit of the invention.

From the above description, it will be seen that a relay in accordance with the invention may have relatively small physical dimensions and may be manufactured with mass-production methods.

While the invention has been described with reference to particular embodiments, it is to be understood that modifications may be made by persons skilled in the art without departing from the spirit of the invention or from the scope of the claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A magnetic switch comprising a core having first and second elements of magnetic material, said elements being separated by a gap, an elongated spring having one end fastened to said first element and the other end positioned in the vicinity of but normally separated from said second element, said spring comprising an armature of magnetic material positioned in the vicinity of said gap and normally spaced from said elements, a metallic tube positioned at least partially around said elements and said spring comprising said armature, and a contact fastened to said tube and positioned adjacent said spring, said spring being biased so that said spring normally engages said contact.

2. An electromagnetic relay comprising a core having first and second elements of magnetic material, said elements being separated by an air gap, a flat elongated spring having one end fastened to said first element and the other end positioned in the vicinity of but normally separated from said second element, an armature of magnetic material fastened to said spring, said armature being positioned in the vicinity of said gap and normally spaced from said elements, a metallic element surrounding at least a portion of said first and second elements, said spring, and said armature, a contact fastened to said metallic element and positioned adjacent said spring in the vicinity of said gap, said spring being biased so that said spring normally engages said contact, and an energizing coil positioned around at least a portion of said metallic element.

3. An electromagnetic relay comprising a core having first and second elements of magnetic material, said elements being separated by a gap, a flat elongated spring having one end fastened to said first element and the other end free and positioned in the vicinity of but normally separated from said second element, an armature fastened to said spring intermediate the ends thereof, a first contact positioned adjacent said spring in the vicinity of said gap, said spring being biased so that said other end of said spring normally contacts said first contact, and a second contact supported by said second element and positioned in the vicinity of said gap, said spring being normally spaced from said second contact.

4. An electromagnetic relay comprising a core having first and second elements of magnetic material, said elements being separated by a gap, an elongated spring having one end fastened to said first element and the other end positioned in the vicinity of but normally separated from said second element, an armature of magnetic material fastened to said spring, at least a portion of said armature being positioned in said gap and spaced from said elements, a metallic tube having at least one opening therein positioned around said first and second elements, said spring, and said armature, a contact bar fastened to and positioned within said tube and adjacent said spring, said spring being biased so that said spring normally contacts said contact bar, and an energizing coil positioned around said tube whereby said relay provides a closed circuit between said first element and said tube and an open circuit between said first element and said second element in response to said coil being de-energized and whereby, in response to said coil being energized, said spring is drawn toward said second element to provide a closed circuit between said first element and said second element and an open circuit between said first element and said tube.

5. An electromagnetic relay comprising a core having first and second elements of magnetic material, said elements being separated by a gap, an elongated spring formed of magnetic material and having one end fastened to said first element and the other end free and positioned in the vicinity of but normally separated from said second element, a first contact positioned adjacent said spring in the vicinity of said gap, said spring being biased so that said spring normally contacts said first contact, a second contact supported by said second element in the vicinity of said gap and positioned so that said spring is normally separated from said second contact, a metallic inner tube having access openings positioned around said elements and said spring, said tube being fastened to said first contact, and an energizing coil positioned around said inner tube whereby said relay provides a closed circuit between said first element and said inner tube and an open circuit between said first element and said second contact in response to said coil being de-energized and whereby said spring, in response to said coil being energized, is drawn toward said second element to provide a closed circuit between said first element and said second contact and an open circuit between said first element and said inner tube.

6. An electromagnetic relay comprising a core having first and second elements of magnetic material positioned along a common straight line, said elements being separated by a gap formed by adjacent end surfaces of said elements, a flat elongated metallic spring having one end fastened to said first element and the other end positioned in the vicinity of but normally separated from said second element, an armature of magnetic material, means fastening said armature to said spring with said armature being positioned in a registered relation to a portion of said gap but spaced from said end surfaces of said elements, an elongated metallic inner tube having access openings, said inner tube being positioned along said straight line and generally surrounding said elements, said spring, and said armature, a metallic contact bar fastened to said inner tube and positioned adjacent said spring in the vicinity of said gap, said spring being biased so that said spring normally contacts said contact bar, and an energizing coil positioned along said straight line around said inner tube whereby said relay provides a closed circuit between said first element and said inner tube and an open circuit between said first element and said second element in response to said coil being de-energized and whereby said spring, in response to said coil being energized, is drawn toward said second element to provide a closed circuit between said first element and said second element and an open circuit between said first element and said inner tube.

7. An electromagnetic relay comprising a core having first and second substantially cylindrical elements of magnetic material positioned so that their longitudinal

axes lie along a common straight line, said elements being separated by a gap formed by adjacent end surfaces of said elements, said end surfaces lying in converging planes, an elongated metallic spring having one end fastened to said first element and the other end free and positioned in the vicinity of but normally separated from said second element, an armature of magnetic material having substantially the same size as said gap, means fastening said armature to the side of said spring facing said elements with said armature being positioned intermediate the ends of said spring in a registered relation to a portion of said gap but spaced from said end surfaces of said elements, a metallic contact bar positioned adjacent said spring in the vicinity of said gap, said spring being biased so that the side of said spring away from said elements normally engages said contact bar, and an energizing coil positioned along said straight line around said elements, said spring, said armature, and said contact bar whereby said relay provides a closed circuit between said first element and said contact bar and an open circuit between said first element and said second element in response to said coil being de-energized and whereby said spring, in response to said coil being energized, is drawn toward said second element to provide a closed circuit between said first element and said second element and an open circuit between said first element and said contact bar.

8. An electromagnetic relay comprising a core having first and second substantially cylindrical elements of magnetic material positioned so that their longitudinal axes lie along a common straight line, said elements being separated by a gap formed by adjacent end surfaces of said elements, an elongated metallic spring having one end fastened to said first element and the other end positioned in the vicinity of but normally separated from said second element, at least a portion of said spring being comprised of a magnetic material, means fastening a first contact to said spring in the vicinity of said gap so that said first contact faces said gap, means fastening a second contact to said spring in the vicinity of said gap so that said second contact faces away from said gap, a metallic contact bar positioned adjacent said spring in the vicinity of said gap, said spring being biased so that said second contact normally engages said contact bar, a third contact positioned in said gap and supported by said second element so that said first contact is normally separated from said third contact, and an energizing coil positioned along said straight line around said elements, said spring, said contacts and said contact bar whereby said relay provides a closed circuit between said first element and said contact bar and an open circuit between said first element and said second element in response to said coil being de-energized and whereby said spring, in response to said coil being energized, is drawn toward said second element to provide a closed circuit between said first element and said second element and an open circuit between said first element and said contact bar.

9. An electromagnetic relay comprising a core having first and second substantially cylindrical elements of magnetic material positioned so that their longitudinal axes lie along a common straight line, said elements being separated by a gap formed by adjacent end surfaces of said elements, a flat elongated metallic spring having one flat side at one end thereof fastened to said first element so that said one flat side faces said gap and having the other end thereof positioned in the vicinity of but normally separated from said second element, an armature of magnetic material having substantially the same shape and size as at least a portion of said gap, means fastening said armature to said one flat side of said spring with said armature being positioned intermediate the ends of said spring in a registered relation to a portion of said gap but spaced from said end surfaces of said elements, an elongated metallic inner tube having access openings, said inner tube being positioned along said straight line around at least a portion of said elements, said spring, and said armature, a flat metallic contact bar fastened to and positioned within said inner tube and adjacent the flat side of said spring away from said elements in the vicinity of said gap, said spring being biased so that said spring normally contacts said contact bar, and an energizing coil positioned along said straight line around said inner tube whereby said relay provides a closed circuit between said first element and said inner tube and an open circuit between said first element and said second element in response to said coil being de-energized and whereby said spring, in response to said coil being energized, is drawn toward said second element to provide a closed circuit between said first element and said second element and an open circuit between said first element and said inner tube.

10. An electromagnetic relay comprising a core having first and second substantially cylindrical elements of magnetic material positioned so that their longitudinal axes lie along a common straight line, said elements being separated by a substantially X-shaped gap formed by the inner end surfaces of said elements, an insulator fastened to each of said elements in the vicinity of the respective outer ends thereof, a flat elongated metallic spring having one flat side at one end thereof fastened to said first element so that said one flat side faces said gap and having the other end thereof positioned in the vicinity of but normally separated from said second element, an armature of magnetic material having substantially the same shape and size as at least a portion of said gap, means fastening said armature to said one flat side of said spring with said armature being positioned in a registered relation to a portion of said gap but normally spaced from said inner end surfaces of said elements, an elongated metallic contact bar supported between said insulators and adjacent the flat side of said spring away from said elements in the vicinity of said gap, said spring being biased so that said spring normally contacts said contact bar, a hollow metallic cylinder symmetrically positioned with respect to said straight line and surrounding said elements, said spring, said armature, and said contact bar, and an energizing coil surrounding said hollow cylinder whereby said relay provides a closed circuit between said first element and said contact bar and an open circuit between said first element and said second element in response to said coil being de-energized and whereby said spring, in response to said coil being energized, is drawn toward said second element to provide a closed circuit between said first element and said second element and an open circuit between said first element and said contact bar.

11. An electromagnetic relay comprising a core having first and second substantially cylindrical elements of magnetic material positioned so that their longitudinal axes lie along a common straight line, said elements being separated by a substantially X-shaped gap formed by the inner end surfaces of said elements, said inner end surfaces lying in converging planes, an insulating bead fastened around each of said elements in the vicinity of the respective outer ends thereof, a flat elongated metallic spring having one flat side at one end thereof fastened to said first element so that said one flat side faces said gap and having the other end thereof positioned in the vicinity of said second element, said spring being mechanically biased so that said other end thereof is normally separated from said second element, an armature of magnetic material having substantially the same shape and size as at least a portion of said gap, means fastening said armature to said one flat side of said spring with said armature being positioned in a registered relation to a portion a said gap but spaced from said inner end surfaces of said elements, an elongated metallic contact bar supported between said insulators and positioned adjacent the flat side of said spring away from said elements in the vicinity of said gap, said spring being

biased so that said spring normally contacts said contact bar, a hollow metallic cylinder symmetrically positioned with respect to said straight line and surrounding said elements, said spring, said armature, said contact bar, and said insulating beads, and an energizing coil surrounding said hollow cylinder whereby said relay provides a closed circuit between said first element and said contact bar and an open circuit between said first element and said second element in response to said coil being de-energized and whereby said spring, in response to said coil being energized, is drawn toward said second element to provide a closed circuit between said first element and said second element and an open circuit between said first element and said contact bar.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,993,104 July 18, 1961

John S. Zimmer

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 10, line 71, for "a", second occurrence, read -- of --.

Signed and sealed this 19th day of December 1961.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents

USCOMM-DC

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