Jan. 16, 1962 C. HUETTEN 3,017,474

MINIATURE RELAY

Filed Feb. 9, 1960 2 Sheets-Sheet 1

FIG. 4

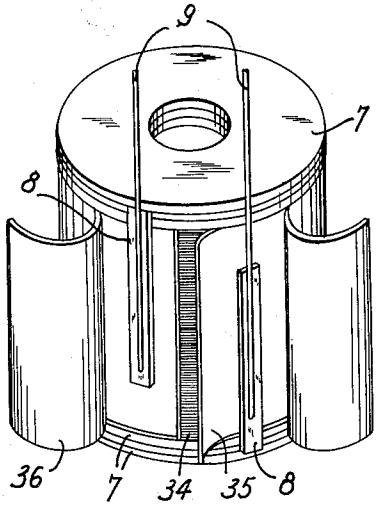


FIG. 1

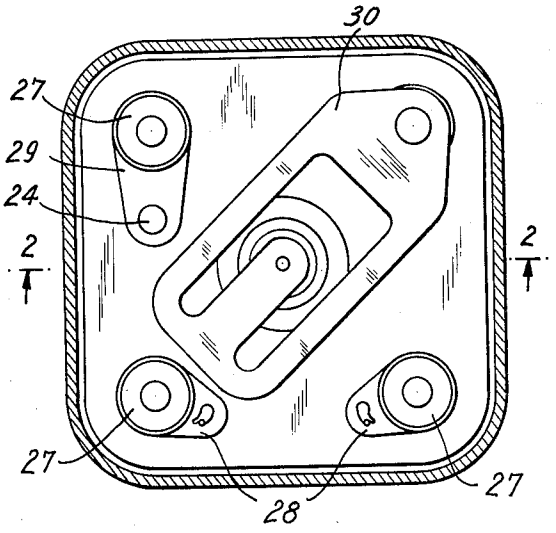


FIG. 3

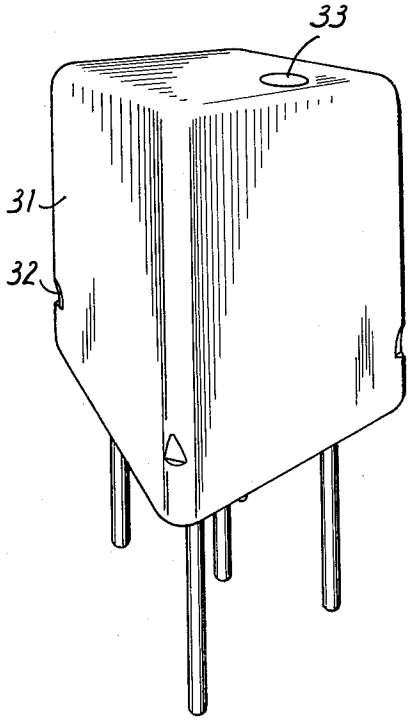
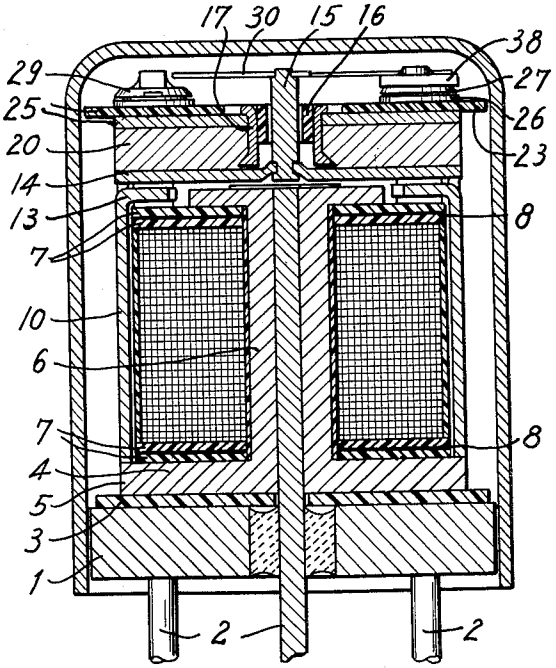


FIG. 2



INVENTOR.
CLARENCE HUETTEN

BY Nicholas Lang Jr.

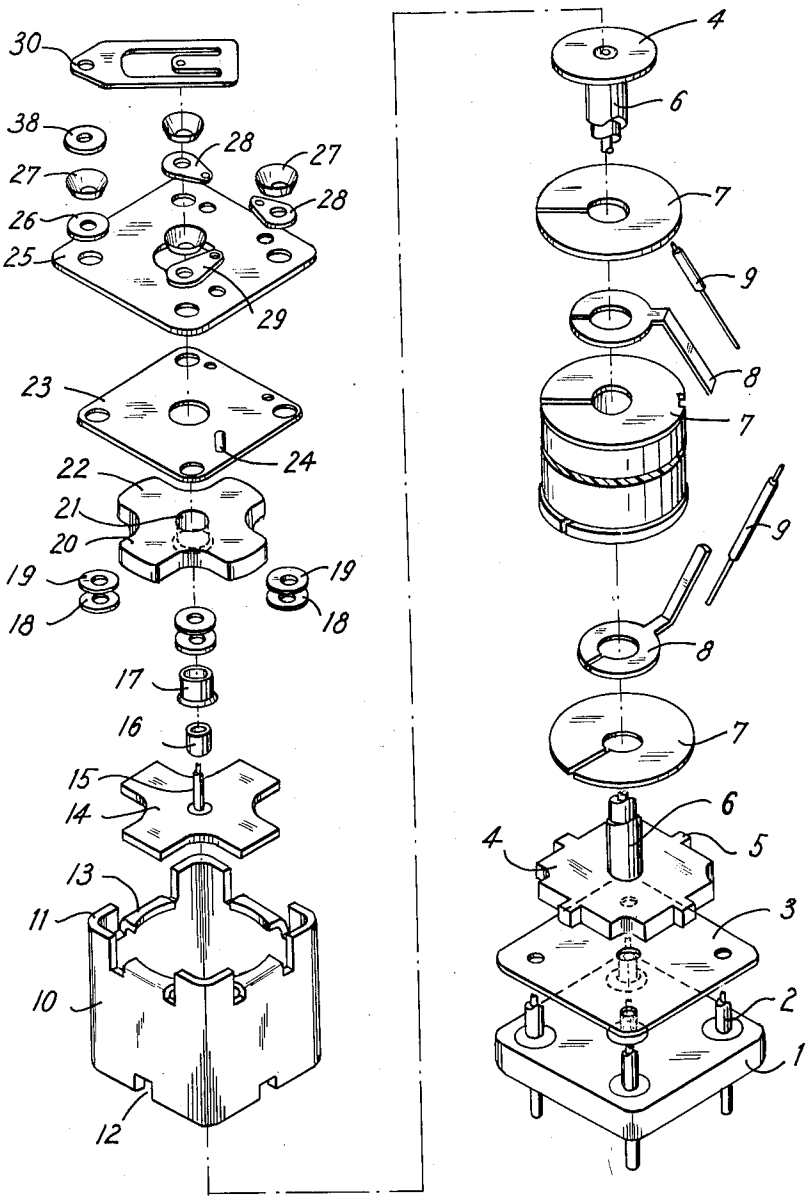
ATTORNEY

Jan. 16, 1962 C. HUETTEN 3,017,474

MINIATURE RELAY

Filed Feb. 9, 1960 2 Sheets-Sheet 2

FIG.5



INVENTOR.
CLARENCE HUETTEN

BY

ATTORNEY

United States Patent Office 3,017,474 Patented Jan. 16, 1962

3,017,474
MINIATURE RELAY

Clarence Huetten, Indianapolis, Ind., assignor to P. R. Mallory & Co., Inc., Indianapolis, Ind., a corporation of Delaware

Filed Feb. 9, 1960, Ser. No. 7,702
9 Claims. (Cl. 200—93)

This invention relates generally to electromagnetic switches and more particularly to microminiature relays capable of being hermetically sealed and used in printed circuits and the like.

Relays using permanent magnets to establish coil polarization for special purpose applications are known in the art. However, up to now, a microminiature relay utilizing a permanent magnet to replace the springs commonly used to provide the holding force of the normally closed contacts in a relay has not been available. The importance of the present springless relay is to be understood from the fact that relays incorporating usual spring mechanisms to maintain comparable contact forces during the period of deactivation generally require a relatively larger operating power and a longer operating time. This is so because the electromagnet must, for the entire period it is activated, overcome the resisting force of the spring. Spring actuated relays normally contain relatively more parts and require individual and exacting mechanical adjustments. When such relays must operate through a wide range of ambient temperatures, these adjustments become critical—particularly in multiple-pole units. Again, under conditions of vibration, springs may, unless carefully designed and adjusted, resonate within the range of vibrational frequencies to which the relay may be subjected.

Most relays, microminiature or otherwise, are not suited for automatic assembly. The present invention of a microminiature relay offers simplicity of design and a minimum number of parts with many of these parts performing multiple functions. It further provides an assembly suitable for hermetic sealing and automatic assembly.

Several other advantages occur from the construction of the relay. Relatively low operating power is required since, to actuate the relay, the electromagnet needs only to reverse the polarity of the armature until the magnetic intensity in the armature balances the magnetic intensity due to the permanent magnet. At that instant that the intensities are balanced, there is no restraining force on the armature. With further increase in electromagnetic intensity, the permanent magnet repels the armature while the electromagnet attracts it to the normally open contacts and closes them. Further, high speed operation is attained inasmuch as there is no restraining force applied during the period that the armature is in motion. Inasmuch as it is only necessary to magnetize and stabilize the magnet to the desired holding force that establishes the operating characteristics, the only mechanical adjustment is the initial placement of the magnet and related parts. No additional mechanical adjustments are required for high temperature operation because the magnets can be stabilized to operate at any reasonable maximum temperature by initially cycling them to that temperature. In addition, the elimination of springs results in improved vibrational characteristics. Further vibration resistance is attained through the greater magnetic force-to-armature mass ratio possible in the improved relay design. This high force-to-mass ratio also promotes higher speed operation with reduced contact bounce.

The relay contact and coil terminals may be suitably spaced to fit grid systems used on printed circuit boards designed for automatic assembly and can be mounted to a printed circuit board without accessory hardware. These

mountings can be made individually or in groupings inasmuch as the relay unit may be considered modular and can be utilized for multiple-pole, multiple-throw applications.

In addition to the features above described, the present relay incorporates several unique design features. It provides an optimum closed iron magnetic path, reducing leakage and assuring low reluctance, and a "floating" type of armature to provide a much greater contacting area and much improved freedom of armature motion. With this type of armature arrangement, at least three points of contact are always present and, when one contact increases in resistance, due to foreign particles, contact erosion, and the like, the major portion of the current is taken over by the two remaining points of contact. In addition, the hammering action of the armature against the contact surfaces during cyclic operation tends to flatten out any irregularities in the contact surfaces, thus creating continually variable points of low resistance contact. Due to this contact redundancy, the danger from insulating foreign particles is greatly reduced. If the probability of such a particle causing trouble in a single contact in P, it is of the order of P^n for n parallel contacts. The contact redundancy is expected to be particularly valuable for dry circuit applications since the simultaneous high contact resistance of three or more contacts is unlikely.

Many attempts to combine contacts and cooperating magnetic parts have been unsuccessful because, if the contacts have reasonable thickness, corresponding gaps are introduced into the magnetic circuit which, in turn, lead to one or more of lower sensitivity, larger size, lower contact force, slower operating speed, and reduced reliability. The present relay uses a very thin contact coating such as a silver plate 0.001-inch thick. This coating not only serves as a contact surface but also provides the small residual gap needed in all relays of this type. If transfer occurs at a single contact point, the amount of transfer is limited by the contact film thickness because, once the base material is exposed, contact resistance increases and the bulk of the contact current passes through other contact points of lower resistance.

In some relays employing light forces, contacts may tend to stick, such as by welding, and magnetic forces may be insufficient to break the circuit. In the proposed relay, forces are exerted evenly around the periphery of the armature. If the armature sticks on one side, there is a very high mechanical advantage to break the circuit resulting from forces on the diametrically opposite side of the armature. The peripheral support of the armature provides outstanding stability under shock and vibration. Most spring-supported masses have resonant frequencies under 2000 c.p.s. so that malfunctions are apt to occur. Even balanced, rotary type armatures are subject to unwanted motions because of rotary components of vibrational or shock forces.

With an armature controlled almost entirely by magnetic forces, it might be expected that a make before break situation could occur. At the instant any portion of the armature breaks contact, the forces on the break side are greatly reduced and the forces on the other side greatly increased. Thus even for very small spacings, the distributed peripheral magnetic forces tend to pull the armature in evenly.

For a given fixed working gap and a given amount of magnetic energy, the force exerted by a magnetic device is directly proportional to the areas of the attracting surfaces. The proposed relay design exploits this principle by employing maximum areas on the armature and the pole faces. This feature provides positive, high-speed action and reduces contact bounce. Contact bounce is

further reduced by some pneumatic damping between the mating, flat contact surfaces and by impact damping due to the multiple-point type of contact.

Generally speaking, the present microminiature relay of exceedingly small dimensions is constructed to provide a springless relay featuring a novel contact switching arrangement, improved magnetic characteristics, and high performance. No "muxing" or adjustment of springs is required, as in most relays, to obtain proper contact forces, contact spacings, and operating characteristics. Spring forces generally vary as the cube of the thickness and only special materials are suitable for high temperature usage. Adjustments and spring designs are therefore quite critical and spring materials must be chosen in accordance with their intended use. Permanent magnets however, of suitable materials, may be stabilized for performance at 500° C. and above. The large area-to-mass ratio of the armature, in conjunction with the large pole face areas, constitutes a multiple-point contacting system capable of counteracting any tendancy for contacts to stick, while maintaining consistently low contact resistances. The stacked-type of relay assembly permits mechanical spacings to be fixed by selection of relay parts. Adjustment for operating characteristics is controlled by the intensity of magnetization of the permanent magnet, and the size of wire used in the electromagnet coil. The relay offers sensitive operation, permits substantial miniaturization, high temperature operation, and high speed. It is especially adapted to mechanized assembly, adjustment, and testing, thus leading to a low-cost device.

It is therefore an object of the present invention to provide an improved electromagnetic relay of the springless type.

Another object of the present invention is to provide an electromagnetic relay having few mechanical parts and wherein the armature operates between poles without the use of springs.

Still another object of the present invention is to provide an improved microminiature relay in which minimum mechanical adjustments are necessary, and which can be made swiftly, easily, and precisely. Still another object of the present invention is to provide, in a microminiature relay, permanent magnet means to eliminatae the springs formerly used to establish the holding force of normally closed contacts.

Yet another object of the present invention is to provide a microminiature relay having a novel armature construction and which is adapted for use as a hermetically sealed relay for printed circuit applications.

Another object of the present invention is to provide a microminiature relay whose electrical contacts provide a plurality of points of engagement, thereby insuring low contact resistance and limiting contact erosion, transfer, and the like.

Still another object of the present invention is to provide a microminiature relay requiring relatively low operating power.

These and other objects of the invention will become apparent from the description taken in conjunction with the drawings. The relay illustrated in the drawings depicts a single-pole-double-throw unit such as might be used as a separate unit or part of a modular assembly. This, in no way, restricts the possibility of several single-pole-double-throw relays being assembled on a header equipment with several sets of terminals so that the relays may be connected to function as a single multiple-pole-multiple throw relay.

Referring to the drawings, FIG. 1 shows a top view of the relay with the upper portion of the relay enclosure removed.

FIG. 2 is a vertical, cross-sectional view of the relay taken along line A—A of FIG. 1. This view also shows the full section of the relay enclosure.

FIG. 3 is a perspective view of the complete, hermetically sealed relay.

FIG. 4 is a detail view of the electromagnet coil subassembly illustrating the manner in which the coil leads are attached and brought out for connections.

FIG. 5 is an exploded view of the relay showing, in perspective, the arrangement of the various parts.

Parts comprising subassemblies of the relay are best illustrated in FIG. 5. FIGURES 1 and 2 clearly demonstrate the manner in which subassemblies are stacked to build the complete relay unit. Three basic subassemblies are utilized in constructing the relay. These are: (*a*) the header subassembly (parts **1–3** inclusive); (*b*) the coil subassembly (parts **4–13** inclusive); and the permanent magnet and armature subassembly (parts **14–24**). The top insulator **25**, fastening devices and terminals **26–29** inclusive, armature connector **30**, and relay enclosure **31**, complete the assembly.

The header subassembly is made on a substantially square base **1**, and incorporates five terminals **2**, one in each corner and one in the center. Terminal extensions above the header are fitted with suitable tubular insulators.

The coil subassembly (see FIGS. 4 and 5) includes the coil bobbin **4**, the lower flange of which is punched to form edge projections **5**. The bobbin core **6** is insulated for its entire length and is center-drilled to provide access for the center terminal of the header subassembly. A countersunk area in the upper flange of the bobbin **4**, provides space for permanently connecting the header center terminal to the bobbin by soldering, or other means.

Two split, insulating discs **7** are placed on either end of the insulated bobbin core **6**. A coil connector tab **8** is placed between each pair of insulating discs **7**. The coil wire **34** is wound on the bobbin **4** between the insulating discs **7** and is insulated from the coil connector tabs **8** by a thin insulating wrap **35**. Wire leads **9** are soldered to the connector tabs **8** together with the coil wire **34** terminations. An outer layer of insulating material **36** is then wrapped around the coil and retained in place by glass thread **37** or other suitable material.

The coil enclosure **10** is placed over the coil-bobbin group with the notches **12** of the enclosure **10** in alignment with the projections **5** of the coil bobbin **4**. After pressing these parts snugly together, the projections **5** are stacked to expand against and overlap the notches **12** of the enclosure **10** to securely retain all subassembly parts in proper position.

The coil enclosure **10** is the basic unit of the stacked relay assembly and provides a projection **11** at each of its four corners to support the superstructure to be described in succeeding paragraphs. The coil enclosure **10** also embodies the normally-open relay contacts **13** which are formed by bending over portions of the four sides of the enclosure **10**.

The permanent magnet-armature subassembly is held together by means of an eyelet **17** which is inserted through the center hole **21** of the permanent magnet **20** and thence through the permanent magnet support plate **23**. These parts are aligned so that, when the four corner holes of the support plate **23** are fitted over the four header terminal extensions **2** emerging from the four corners of the coil enclosure **10**, the four lobes **22** of the permanent magnet **20** will be in direct alignment with the four contact tabs **13** of the coil enclosure **10**. The eyelet **17** is then upset against the support plate **23** to retain this alignment.

The armature shaft bearing **16** is pressed into the eyelet **17** and the armature shaft **15** is inserted through the bearing **16**. The radially-magnetized permanent magnet **20** magnetically aligns the armature plate **14** in proper position and holds it in that position.

Final relay assembly involves stacking the subassemblies previously described, applying fastening devices, making electrical connections, fitting the relay enclosure, soldering the enclosure to the header base, evacuating and

backfilling with a suitable atmosphere, and sealing. The procedure is as follows.

The coil subassembly is fitted on the header subassembly with the center terminal projecting through the center of the bobbin core and the corner terminals projecting through the four corners of the coil enclosure. With the coil subassembly held snugly against the header, the center terminal is fastened to the upper bobbin flange by soldering or other suitable means. The terminal length and any fastening material must be controlled so that the joint is slightly below the surface of the upper bobbin flange.

Insulating spacers **18** and metal shims **19** are applied to each of the corner terminals **2** to obtain a predetermined gap between the normally open contacts **13** and the armature **14**. The spacers bear upon the projections **11** of the coil enclosure **10**. The permanent magnet support plate **23** bears, in turn, upon the metal shims **19** and fixes the position of the permanent magnet-armature subassembly with relation to the other subassemblies.

The top insulator **25** is then applied over the assembled parts and the coil connectors **28** are applied over the appropriate header terminals **2** and coil leads **9** which project through holes provided in the permanent magnet support plate **23** and the top insulator **25**. The permanent magnet or normally closed contact connector **29** is applied over the projecting pin **24** from the permanent magnet support plate **23** and the adjacent header terminal. A round washer **26** is applied over the armature terminal.

Compression washers **27** are then applied to all four projecting terminals and are pressed with a suitable tool until they become essentially flat. Flattening these washers causes the inner diameter to reduce slightly whereupon the washers actually press small grooves into the header terminals to retain the stacked subassemblies in compression. These washers **27** are then soldered into place to provide additional mechanical strength and good electrical conductivity. An additional spacer washer **38** is applied to the armature terminal and the armature connector **30** is soldered in place to the terminal and to the end of the armature shaft **15**.

The relay assembly is completed by fitting the relay enclosure **31** over the assembled unit, pressing the enclosure **31** down until the header base **1** engages with the formed projections **32** on the inner surface of the enclosure corners, and soldering the enclosure **31** to the header base **1**. The relay is evacuated through the pretinned evacuation port **33** and backfilled with a suitable atmosphere, whereupon the evacuation port **33** is filled with solder to complete the hermetic seal.

The relay here described is adaptable to multiple pole, multiple throw operation by combining two or more single-pole units. Coils may be connected to operate at the particular voltages available. The adaptability of the relays to mechanized assembly and testing is apparent from the extreme simplicity of construction which provides a low cost relay with great reliability potential. It advances the relay art considerably by providing features of extreme miniaturization without reducing contact current. It provides sensitive operation, high temperature operation, and high speed operation to a fraction of a millisecond. Moreover, the provision of multiple points of contact insures low contact resistance and minimizes the effects of contact erosion and transfer, which are definite limiting factors for reliability of conventionally designed relays.

What is claimed is:

1. A relay comprising, in combination, a coil wound on a bobbin core, an iron coil enclosure having a top and a bottom surrounding said coil, portions of said top being bent inwardly to form flat electrical contacts, a radially magnetized permanent magnet placed above and spaced from said contact of said iron coil enclosure, and an armature having a shaft connected to its center placed in the space between said enclosure contacts and said permanent magnet, said armature free to move between said enclosure contacts and said permanent magnet upon said coil being energized, said permanent magnet being apertured to receive said armature shaft therethrough and to provide clearance for said shaft movement thereby.

2. A relay comprising, in combination, a coil wound on a bobbin core, an iron coil enclosure of rectangular shape having a top and a bottom surrounding said coil, integrally formed contacts connected thereto, opposite mid portions of said top being bent inwardly to form flat electrical contacts, a radially magnetized permanent magnet placed above and spaced from said contact of said iron coil enclosure, and a flat multi-lobed armature having a shaft connected to the center point placed in the space between said enclosure contact and said permanent magnet, said armature free to move in a vertical direction between said enclosure contacts and said permanent magnet upon said coil being energized, said permanent magnet being centrally apertured to receive said armature shaft therethrough and to provide clearance for movement of said armature shaft thereby.

3. A relay comprising, in combination, a coil wound on a bobbin core, an iron coil enclosure of rectangular shape having a top and a bottom surrounding said coil, opposite mid portions of said top being bent inwardly to form flat electrical contacts, a radially magnetized permanent magnet having a plurality of lobes placed above and spaced from said contacts of said iron coil enclosure, and a flat multi-lobed armature having a shaft connected to its center placed in the space between said enclosure contacts and said permanent magnet, said armature free to move between said enclosure contacts and said permanent magnet upon said coil being energized, said permanent magnet being apertured to receive said armature shaft therethrough and to provide clearance for movement of said armature shaft thereby.

4. A relay comprising, in combination, a coil wound on a bobbin core, an iron coil enclosure of rectangular shape having a top and a bottom surrounding said coil, integrally formed contacts connected thereto being bent inwardly to form flat electrical contacts, a radially magnetized permanent magnet placed above and spaced from said contacts of said iron coil enclosure, and a flat armature having a shaft connected to ts center placed in the gap between said enclosure contacts and said permanent magnet, said armature acting as the common pole of said relay being free to move in a vertical direction in the air gap between said enclosure contacts and said permanent magnet upon said coil being energized, said permanent magnet being centrally apertured to receive said armature shaft therethrough and to provide clearance for movement of said armature shaft thereby.

5. A relay comprising, in combination, a header terminal base, an insulator, a bobbin base having projections extending therefrom, a coil wound on a bobbin core, an iron coil enclosure of rectangular shape having a top and a bottom surrounding said coil, said bottom having alignment cut-outs for encompassing said projections, integrally formed surfaces connected to the top of said enclosure being bent inwardly to form flat electrical contacts, a radially magnetized permanent magnet placed above and spaced from said contacts of said iron coil enclosure, said permanent magnet being suitably coated and acting as a second contacting means, and a flat multi-lobed armature having a shaft connected to its center placed in the space between said enclosure contacts and said permanent magne contacting means, said armature acting as the common contacts of said relay, said armature free to move in the space between said enclosure contacts and said permanent contacting means upon coil being energized, said permanent magnet being centrally apertured and a bushing placed therein to receive said armature shaft therethrough and to provide an insulated clearance hole to permit movement of said armature shaft thereby.

6. A relay comprising, in combination, a header terminal base, an insulator, a bobbin base having projections extending therefrom, a coil wound on a bobbin core, an iron coil enclosure of rectangular shape having a top and a bottom surrounding said coil, said bottom having alignment cut-outs for encompassing said projections, integrally formed surfaces connected to the top of said enclosure being bent inwardly to form flat electrical contacts, a radially magnetized permanent magnet placed above and spaced from said contacts of said iron coil enclosure, said permanent magnet being suitably coated and acting as contacting means, and a flat multi-lobed armature having a shaft connected to its center placed in the gap between said enclosure contacts and said permanent magnet contacting means, said armature acting as the common contact of said relay being free to move in a plane parallel to said permanent magnet in a vertical direction in the gap between said enclosure contacts and said permanent magnet contacting means when said coil is energized, said permanent magnet being centrally apertured and having a bushing therein to receive said armature shaft therethrough so as to provide clearance for vertical movement of said armature thereby, supporting posts at the top of said coil enclosure, permanent magnet retaining means supported thereon, said gap between said magnet and said enclosure contacts being determined by insulators and gap spacers placed between said magnet support plate and support posts of said coil enclosure.

7. A relay comprising, in combination, a header terminal base, an insulator, a bobbin base having projections extending therefrom, a coil wound on a bobbin core, an iron coil enclosure of rectangular shape having open ended top and bottom surfaces surrounding said coil, said bottom surface having a plurality of alignment cut-outs for fitting over said bobbin base projections, integrally formed surfaces connected to the top of said enclosure being bent inwardly to form flat L shaped electrical contacts, a radially magnetized multi-lobed permanent magnet placed above and spaced from said contacts of said iron coil enclosure, said permanent magnet being suitably coated and acting as contacting means, and a flat multi-lobed armature having a shaft connected to its center placed in the gap between said enclosure contacts and said permanent magnet contacting means, said armature acting as the common contact of said relay being free to move in a vertical direction in the gap between said enclosure contacts and said permanent magnet contacting means when said coil is energized, said permanent magnet being centrally apertured and having a bushing therein to receive said armature shaft therethrough so as to provide an insulated clearance hole to permit movement of said armature thereby, supporting posts at the top of said coil enclosure, permanent magnet retaining means supported thereon, said gap between said magnet and said enclosure contacts being determined by insulators and gap spacers placed between said magnet support plate and support posts of said coil enclosure.

8. A relay comprising, in combination, a terminal header having an insulator, a bobbin base having projections extending therefrom, a coil wound on a bobbin core, an iron coil enclosure of rectangular shape having open ended top and bottom surfaces surrounding said coil, said bottom surface having a plurality of alignment cut-outs for fitting over said bobbin base projections, integrally formed surfaces connected to the top of said enclosure being bent inwardly to form flat L shaped electrical contacts, a radially magnetized multi-lobed permanent magnet placed above and spaced from said contacts of said iron coil enclosure, said permanent magnet being suitably coated and acting as contacting means, a flat multi-lobed armature having a shaft connected to its center placed in the gap between said enclosure contacts and said permanent magnet contacting means, said armature acting as the common contact of said relay being free to move in a vertical direction in the gap between said enclosure contacts and said permanent magnet contacting means when said coil is energized, said permanent magnet being centrally apertured and having a bushing therein to pass said armature shaft therethrough so as to provide an insulated clearance hole to permit movement of said armature shaft thereby, supporting posts at the top of said coil enclosure, permanent magnet retaining means supported thereon, said magnet being eyeleted to said retaining means, said gap between said magnet and said enclosure contacts being determined by an insulator and a gap spacer placed between said magnet and support post of said coil enclosure.

9. A relay comprising, in combination, a header terminal base with upright terminals having an insulator thereon, a bobbin base having projections extending therefrom, placed thereon, a coil wound on a bobbin core, said coil being insulated, an iron coil enclosure of rectangular shape having open ended top and bottom surfaces surrounding said coil, said bottom surface having a plurality of alignment cut-outs for fitting over said bobbin base projections, integrally formed extensions connected to the top surface of said enclosure being bent inwardly to form flat electrical contacts, a radially magnetized multi-lobed permanent magnet placed above and spaced from said contacts of said iron coil enclosure, said permanent magnet being suitably coated and acting as contacting means, a flat multi-lobed armature having a shaft connected to its center placed in the gap between said enclosure contacts and said permanent magnet contacting means, said armature acting as the common contact of said relay and being normally held against said permanent magnet, said armature free to move in a vertical direction in the gap between said enclosure contacts and said permanent magnet contacting means when said coil is energized, said permanent magnet being centrally apertured and having a bushing therein to pass said armature shaft therethrough and to provide clearance for movement of said armature shaft thereby, supporting posts at the top of said coil enclosure, permanent magnet retaining means supported thereon, said magnet being eyeleted to said retaining means, said gap between said magnet and said enclosure contacts being determined by an insulator and a gap spacer placed between said magnet and support posts of said coil enclosure, and means connecting said coil, said enclosure contacts, said armature and said permanent magnet contacting means to said base header terminals.

References Cited in the file of this patent

UNITED STATES PATENTS

2,871,312	Curry	Jan. 27, 1959
2,916,584	Molyneux	Dec. 8, 1959
2,919,323	Drescher	Dec. 29, 1959
2,919,324	Schuessler	Dec. 29, 1959
2,951,134	Lazich	Aug. 30, 1960