United States Patent

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[73] Assignee **Torr Laboratories, Inc.**
Los Angeles, Calif.
Continuation-in-part of application Ser. No. 840,380, July 9, 1969.

[54] **MAGNETICALLY OPERATED ENVELOPE ENCLOSED HIGH-VOLTAGE RELAY**
7 Claims, 10 Drawing Figs.

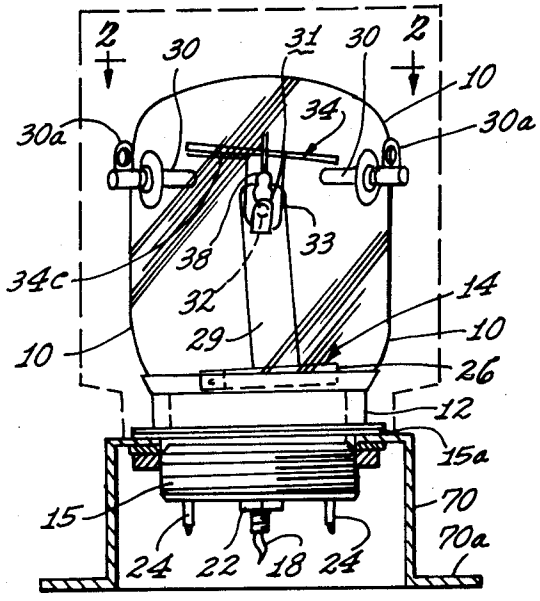
[52] **U.S. Cl.** **200/144,** 335/153, 335/203
[51] **Int. Cl.** **H01h 33/66**
[50] **Field of Search** ..... 200/144.2, 166 H; 335/204, 151–154

[56] **References Cited**
UNITED STATES PATENTS

1,879,349	9/1932	Lederer	200/166 H
2,834,847	5/1958	Jennings	200/144 B X
2,912,539	11/1959	Jennings	200/144 B X
2,920,162	1/1960	Steward et al.	335/151
3,250,886	5/1966	De Lucia	200/144 B X
3,483,492	12/1969	Mirbeth	335/202 X

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ABSTRACT: A high-voltage vacuum relay is provided of the double-pole, double-throw type and which has particular application to medical purposes, although it is not limited to uses. The movable and fixed contacts of the relay are mounted with an envelope, with the movable contacts supported by the envelope for pivotal movement, and for selective engagement with the fixed contacts in a manner such that under no conditions will one contact of any pair open without the other.



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SHEET 1 OF 2

Fig. 1

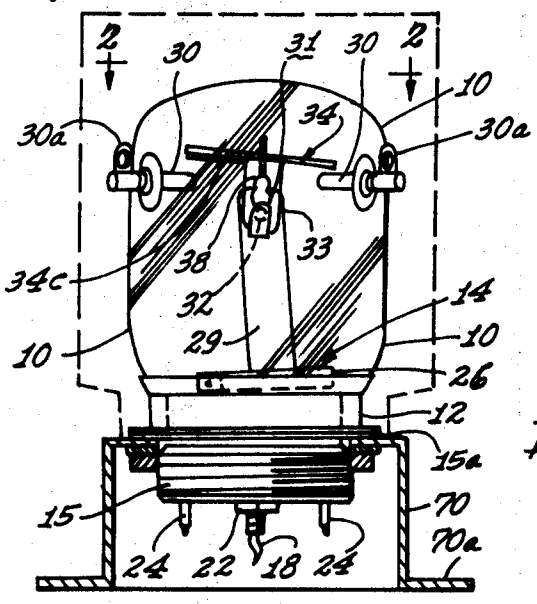


Fig. 2

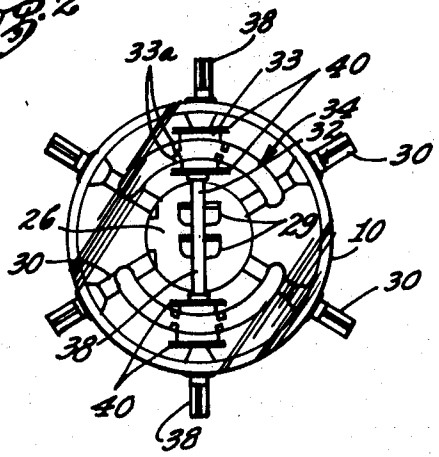


Fig. 3

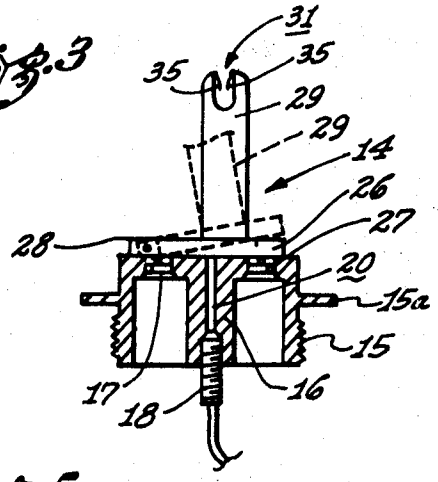


Fig. 4

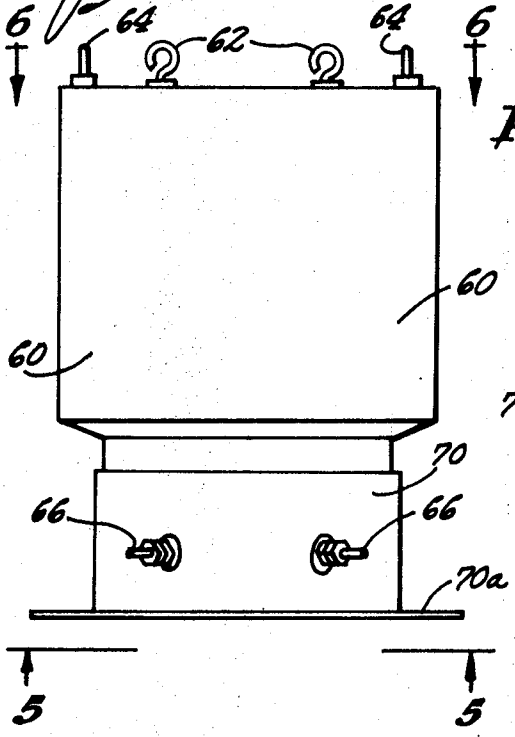
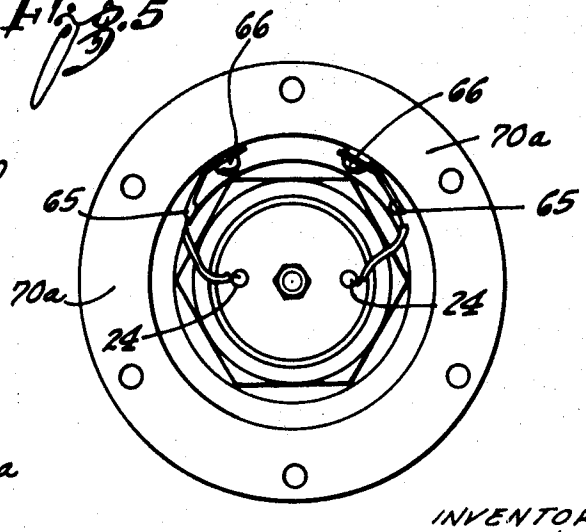


Fig. 5



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Fig. 6

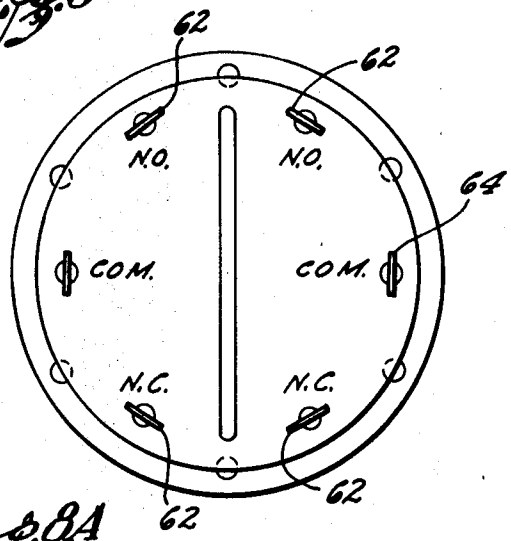


Fig. 7

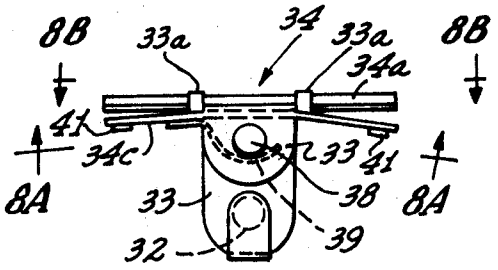


Fig. 8A

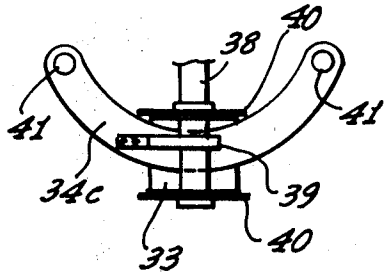


Fig. 8B

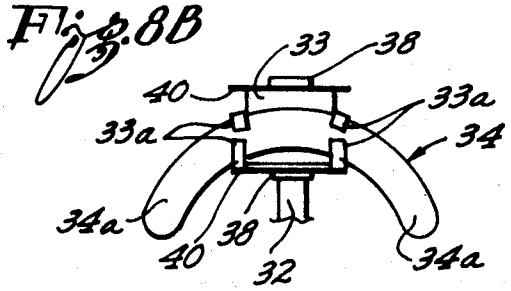
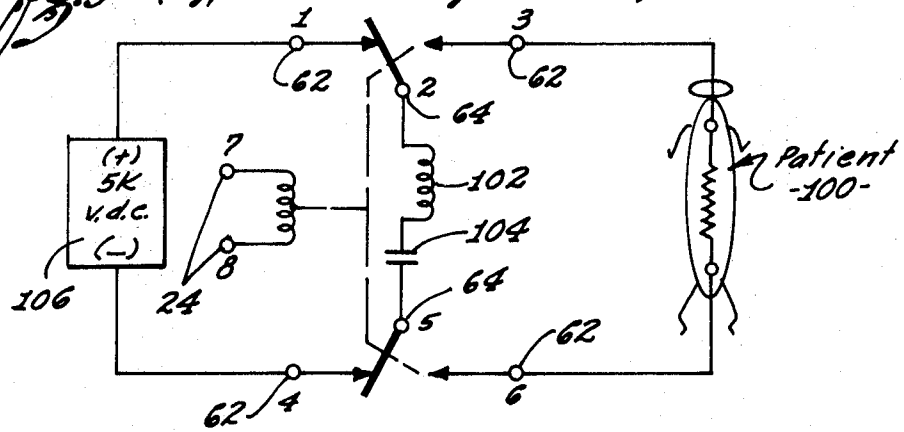


Fig. 9 (Typical Discharge Circuit)



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MAGNETICALLY OPERATED ENVELOPE ENCLOSED HIGH-VOLTAGE RELAY

BACKGROUND OF THE INVENTION

This application is a continuation-in-part of copending application Ser. No. 840,380 which was filed July 9, 1969, in the name of the present inventor.

The relay of this invention is of the same general type as the relay described in U.S. Pat. No. 3,250,886, which issued May 10, 1966, and which is assigned to the present assignee. As pointed out in the patent, in defribrillator systems, for example, a double-pole, double-throw relay is used selectively to introduce a high voltage to the heart of the patient under precisely controlled conditions.

The relay is required to operate at high voltages, so that vacuum relays are well suited for the purposes because their contacts are enclosed within an evacuated envelope, and contact deterioration is materially reduced. However, ionization effects in the vacuum relays has substantially limited their usefulness in this area. The relay of the present invention incorporates an envelope filled with a pressurized dielectric gas, such as sulfur hexafluoride (SF_6) to reduce the ionization within the envelope and also to provide a cooling effect.

In order to obviate any possible hazard which could otherwise be caused due to the use of such gas, a rubberlike resilient enclosure is provided in the relay of the invention formed, for example, of a suitable silicone rubber, which is molded to and surrounds the envelope of the relay so as to eliminate the possibility of breakage of the envelope. Such breakage should be prevented due to the fact that sulfur hexafluoride has a tendency to break down into dangerous components in the event of envelope breakage with resulting explosion, the components including corrosive fluorides.

With the inclusion of the aforesaid protective enclosure, the hexafluoride pressure within the envelope can be increased up to, for example, 10 atmospheres, so as to provide improved dielectric effects to prevent ionization, and also to improve cooling. The aforesaid enclosure not only protects against accidental breakage of the envelope, but also seals any cracks which might occur.

In the practice of the invention, it has also been found that mixtures of sulfur hexafluoride with 0–30 argon, and 0–10 nitrous oxide, also provides an effective gaseous atmosphere within the relay to prevent the aforesaid ionization effects, and to provide desired cooling. Also, activated alumina may be included into the housing as a getter for the corrosive fluorine compounds, in order to prevent harmful effect should the sulfur hexafluoride tend to break down.

In the heart defribrillator systems, for example, it is most important that both of the normally closed contacts of the relay open when the relay is energized and that both of the normally open contacts open when the relay is deenergized. In either instance, should one contact open without the other, deleterious effects on the patient could result. The improved relay of the present invention is particularly constructed to operate over extended intervals of time at high voltages, and is ideally suited for defribrillation uses, although not limited to such uses.

As described above, the inclusion of the pressurized sulfur hexafluoride within the relay envelope minimizes ionization within the relay, and the protective enclosure of the relay prevents any envelope breakage hazard, with resulting explosion and reduction of the pressurized sulfur hexafluoride into corrosive flourides and fluorines.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side elevation, partly in section, and with the protective casing shown in shadow form, of an improved relay constructed in accordance with one embodiment of the invention;

FIG. **2** is a section taken along the line **2**—**2** of FIG. **1**;

FIG. **3** is a side elevation, partly in section, and showing certain operating components of the relay of FIG. **1**;

FIG. **4** is a side elevation of the relay and showing particularly the configuration of the outer protective casing;

FIG. **5** is a bottom view of the relay taken along the line **5**—**5** of FIG. **4**;

FIG. **6** is a top view taken along the line **6**—**6** of FIG. **4**;

FIG. **7** is a side view of the movable contact assembly used in the relay of FIG. **1**;

FIG. **8A** is a bottom view of the movable contact assembly taken along the lines **8A**—**8A** of FIG. **7**;

FIG. **8B** is a top plan view of the movable contact assembly taken along the line **8B**—**8B** of FIG. **7**; and

FIG. **9** is a typical discharge circuit in which the relay of the present invention may be included.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENT

The relay illustrated in the drawing includes, for example, and envelope **10** which may be formed of glass or other suitable vitreous material. The envelope **10** may have a generally cylindrical configuration with a closed top and an open bottom. A metal ring **12**, formed of appropriate material such as Kovar, is sealed to the periphery of the open end of the envelope **10**, and the ring **12** includes an integral lower radially extending flange portion.

An armature assembly, designated generally as **14**, is mounted to the ring **12**, and the armature assembly extends into the envelope **10**, as shown in FIG. **1**. The envelope **10** is filled with a suitable inert gas, as will be described. The top of the envelope **10** has a bulblike configuration for added strength to withstand the internal pressure of the inert gas. The armature assembly includes, for example, a cylindrical-shaped member **15** formed of appropriate magnetic material and including a peripheral radially extending flange **15***a*. The housing **15** is mounted to the ring **12**, as shown in FIG. **1**, by welding the flange **15***a* to the flange of the ring **12**, or by otherwise affixing the two flanges to one another. The lower portion of the magnetic cylindrical member **15** is threaded, as shown in FIG **3**, for example, for mounting purposes.

A central core member **16** formed of appropriate magnetic material is mounted concentrically within the cylindrical-shaped magnetic housing **15**, and is held in place, for example, by means of a washer **17** of nonmagnetic material and which is welded to the housing **15** and to the central core **16**. The energizing coil for the relay is supported within the cylindrical housing **15** and extends around the central core **16**.

A tube **18** is threaded into the lower end of the core **16**, and communicates with a passageway **20** which extends through the core **16** and into the interior of the envelope **10**. The sulfur hexafluoride, or its equivalent, may be introduced into the interior of the envelope **10**, through the tube **18** until a desired pressure is reached. The tube **18** is then pinched off and sealed, as shown in FIG. **1**. The remaining part of the tube **18** may be securely held in the core **16** by means, for example, of a nut **22**, also shown in FIG. **1** which also serves to retain the energizing coil within the cylindrical member **15**. Appropriate terminals **24** are provided for the energizing coil within the cylindrical member, so that the coil may be appropriately energized.

Other insert gases such as argon or nitrous oxide may be used in place of the sulfur hexafluoride, or as a mixture therewith. A satisfactory mixture of gases has been used comprising 85percent sulfur hexafluoride, 10 percent argon and 5 percent nitrous oxide. As mentioned above, the inert gas, or gases, are introduced into the interior of the envelope through the passageway **20** extending through the central pole of the magnetic core **16**, and which includes an internally threaded lower end portion for receiving the threaded tube **18**, the tube **18** and the central part of the core **16** serving additionally not only as a passageway for the gas introduced into the envelope, but also as a support for the nut **22** which retains the energizing coil within the cylindrical housing **15**.

Helium may be introduced into the interior of the envelope together with the other gases referred to above as a coolant.

The high pressure gas within the envelope prevents ionization in that there is no current flow through the relay until actual contact is made. This use of a dielectric gas within the envelope is important when the relay is used for medical purposes, since it prevents preionization within the envelope and a precontact jolt of electrical current to the patient.

The armature assembly **14** includes a magnetic armature **26** which is hinged to a member **28**, and which extends across the upper end of the core **16**, and across the annular space between the core and the upper edge of the magnetic housing **15**. The member **28** is affixed to the upper end of the housing **15**, for example, by spot welding or other suitable means. A spring **27** (FIG. 3) is mounted in a recess formed in the upper end of the housing **15**, in a position to surround the upper end of the core **16**. The spring **27** bears against the armature **26**, and biases it in a clockwise direction in FIGS. **1** and **2**. The armature assembly **14** includes a pair of upright support arms **29** which are welded, or otherwise affixed to the armature **26**, and which extend upwardly within the envelope **10**, as shown in FIGS. **1**, **2** and **3**.

The support arms **29** each have a slot **31** in its upper end, as shown in FIGS. **1** and **3**. When the relay is deenergized, the spring **27** causes the armature **26** to be biased in a counterclockwise direction, as mentioned above, so that the support arms **29** normally have a tilted inclination, as shown in FIG. **1**, and as shown by the dotted line in FIG. **3**. Then, when the relay is energized, the armature **26** is pulled down against the bias of the spring **27**, so that the support arms **29** assume the upright position shown by the solid line in FIG. **3**.

The relay assembly includes four terminal pins, which are designated **30** in FIGS. **1** and **2**, and which, as best shown in FIG. **2**, extend through the envelope **10** in a radial direction. The terminal pins **30** also serve as fixed contacts for the relay, as will be described. A further pair of terminal pins, designated **38** in FIGS. **1** and **2**, extends through the wall of the envelope **10**, between the pins **30**, as shown clearly in FIG. **2**. The terminal pins, designated **38** in FIGS. **1** and **2**, extends through the wall of the envelope **10**, between the pins **30**, as shown clearly in FIG. **2**. The terminal pins **38**, for example, constitute the movable contact terminals for the relay in the double-pole, double-throw embodiment disclosed herein. In one position of the relay, for example, the pins **38** are respectively connected to the pins **30** to the left of FIG. **2**, and in the second position of the relay, the pins **38** are connected respectively to the pins **30** at the right of FIG. **2**.

The selective connection between the pins **38** and the pins **30** is achieved by means of a pair of arcuate movable contacts **34**, which are pivotally supported on the respective pins **38**, and which are interconnected by means of a rod **32** composed of sapphire or other appropriate insulating material. As shown in FIG. **1**, the rod **32** is displaced down form the common axis of the pin **38**, and it extends into the slot **31** at the top of the support arms **29**. The rod **32** is mechanically coupled to the respective arcuate contacts **34** by means of respective U-shaped clips **33** which are mounted to the arcuate contacts **34** by means, for example, of bent over ears **33***a*. A pair of resilient strips **35** may be mounted in the slot **31** to bear against the rod **32** to provide coaction between the rod and the support arms **29**.

The use of the two-spaced support arms **29** extending between the armature and the sapphire rod **32** has been found to be more advantageous than a single support arm in that there is less tendency for the two support arms to fracture the rod **32** than is the case of a single support arm. In a constructed embodiment, the two support arms were spaced five-eights inch apart, and were found to have the added advantage in that there is not tendency with the two support arms for the movable contact assemblies to twist in the event that a contact should become welded, and positive action of the assembly is assured. When the relay is used for medical purposes, it is important that every precaution be taken so that the contacts open and close only as a pair, and not individually.

A pair of washers **40** (FIG. **2**) formed, for example, of molybdenum or other appropriate material are mounted on each of the terminal pins **38** between the corresponding movable contact assemblies and the inner wall of the envelope **10** and on the opposite sides thereof, the washers **40** being in contact with the respective U-shaped clips **33**. These washers serve to carry the current from the pins **38** to the movable contact assemblies and thereby prevent erosion around the holes in the clips **33** which receive the pins **38** as the electric current flows from the pins to the movable contacts. The outer washers **40** also serve to prevent the movable contact assemblies from riding against the inner surface of the envelope **10**. Further to prevent such erosion, conductive tabs, such as the tabs **39** in FIGS. **7** and **8A** may be welded on the underside of each movable contact assembly and resiliently biased against the corresponding terminal pin **38**.

As shown in FIGS. **7**, **8A** and **8B**, for example, the arcuate contact assemblies **34** each include a rigid arcuate body portion **34***a* which is composed, for example, of steel or Kovar, or other appropriate material, with a conductive plating of, for example, copper, on its lower face in FIG. **7**. Each contact assembly **34** also includes an arcuate resilient leaf portion designated **34***c*, and which may be integral with the clip **33**. The resilient leaf portion **34***c* also has an arcuate shape, matching the member **34***a*. The leaflike resilient member **34***c* may be formed, for example, of molybdenum, and is bowed out from the solid rigid member **34***a*, as best shown in FIG. **7**. The clip **33**, for example, may be formed of an appropriate material such as nickel. The ears **33***a* are used to attach the clips **33** and leaf portions **34***c* to the rigid portions **34***a*. This obviates any need to weld the portions together, which is difficult with refractory materials, such as molybdenum, and which tends to crystalize and deteriorate the materials.

Tungsten contact buttons **41** are mounted on the ends of the leaf portions **34***a*. The purpose of the buttons **41** is to make the contact area small so that a higher current flows between the movable contacts and the fixed contacts for higher temperature. The high temperatures serves to break down the insulating film of the electrolyte gas which tends to form over the contact areas.

The bowed resilient leaf section **34***c* is the first part of the movable contact assembly **34** to engage a pin **30** when the relay is moved to one position and is the last part of the movable contact assembly **34** to leave the corresponding terminal pin **30** when the relay is moved to the other position. The assembly is such that contact bounce is prevented, and the relay may be operated at an extremely high rate of speed, with clean pulses being produced each time the contacts make, and with a minimum contact erosion.

As shown in FIG. **1**, for example, the threaded portion of the housing **15** may extend down into a metallic collar designated **70**, and which may include an apertured flange **70***a*, for mounting purposes. The terminals **24** for the energizing coil of the relay may be connected to appropriate terminal connections **66** extending radially through the mounting collar **70**, and insulated therefrom. The connections from the terminals **24** to the terminals **26** may be achieved, for example, by wires **65** shown in FIG. **5**.

The tubular envelope **10** is preferably surrounded by a resilient casing **60**, which is molded directly to the envelope and to the upper end of the collar **70**. The casing **60** is formed, for example, of an appropriate rubberlike substance, and silicone is appropriate for the purpose. The molded rubberized casing **60** serves as a protection for the relay unit, and it precludes any possibility of breakage of the envelope **10**, with the resulting explosion and escape of the pressurized gas within the envelope. The terminal pins **30** and **38** are equipped with apertured connector tabs **30***a*, **38***a* and wires **62** and **64** are soldered to the tabs and protrude through the upper end of the casing **60**, as shown in FIGS. **4** and **6**.

As mentioned above, the relay of the invention has utility in the medical field, and particularly for heart defribrillation purposes. However, it is to be understood, of course, that such a

use is referred to herein for illustrative purposes only, since the relay does have general utility.

A typical discharge circuit for the relay, when used for heart defibrillation purposes, is shown in FIG. **9**. For example, the normally open fixed contacts **62** of the relay may be connected to the patient, who is designated **100**. The common contacts **64** may be connected to a series combination of a coil **102** and capacitor **104**. The coil **102**, for example, may have an inductance of **42** millihenries, and the capacitor may have a capacity of **35** microfarads. The normally closed contacts **62** are connected across a 5 kilovolt direct current source designated **106**.

When the relay is in the deenergized condition shown in FIG. **9**, the capacitor **104** is charged to a peak value. Then, when the relay is energized, the charge on the capacitor is passed through the patient.

A constructed double-pole, double-throw embodiment of the relay, such as described above, exhibits the following characteristics:

Peak Operating Voltage	—12 kilovolts direct current
Continuous Operating Current	—20 amperes
Maximum Discharge Pulse Energy	—450 watts per second
Normal Coil Voltage at 25° C.	—40 volts direct current
Coil Resistance	—65 ohms ±10°
Maximum Pull-in Voltage	—25 volts direct current
Maximum DropOut Voltage	—20 volts direct current
Maximum Pull-In Time at 50 volts DC	—25 milliseconds
Maximum Contact Bounce	—500 microseconds.

The aforesaid parameters, of course, are provided merely by way of example, and are not intended to limit the invention in any way.

What is claimed is:

1. A relay including: an envelope having a generally tubular configuration; a first electrically conductive contact pin extending radially into said envelope; a first arcuately shaped movable contact extending transversely to the axis of said first contact pin; electrically conductive means affixed to an intermediate part of said movable contact and pivotally mounted on said first contact pin to cause said movable contact to be electrically connected to said first contact pin; a pair of further electrically conductive pins extending radially into said envelope on each side of said first pin to be engaged selectively by the ends of said movable contact as it is moved pivotally between a first and a second angular position; and magnetic armature means mounted in said envelope and mechanically coupled to said movable contact to rotate said movable contact selectively about the axis of said first contact pin between said first and second angular positions.

2. The combination defined in claim **1**, in which said envelope is filled with a high pressure gas to prevent ionization between said contacts and to provide cooling therefor, a protective casing completely enclosing said envelope and formed of a resilient plastic material, and which includes electric wires connected to said electrically conductive pins and protruding through said protective casing.

3. The relay defined in claim **1**, and which includes a second electrically conductive contact pin extending radially into said envelope diametrically opposite said first pin and coaxially therewith; a second arcuate movable contact pivotally mounted on said second contact pin at an intermediate part of said arcuate movable contact; a second pair of further electrically conductive contact pins extending radially into said envelope on each side of said second pin to be engaged selectively by said second movable contact as it is rotated between a first and a second angular position about the the common axis of said first and second contact pins; and insulating rod interconnecting said first and second movable contacts parallel to said common axis but displaced therefrom, said magnetic armature means being mechanically coupled to said last-named rod.

4. The combination defined in claim **1**, and which includes a washer mounted on said first contact pin between the inner wall of said envelope and said first movable contact to prevent said first movable contact from moving against said wall and to act as a current shunt between said first contact pin and said first movable contact.

5. The relay defined in claim **1**, in which said first movable contact includes an arcuate rigid portion, and an arcuate resilient leaf portion adjacent said rigid portion and being bowed outwardly therefrom so as to provide a resilient engagement with said further electrical contact pins as said movable contact is moved between its first and second angular positions to minimize contact chatter and bounce as said movable contact engages said further contact pin, said leaf portion being composed of refractory electrically conductive material and being mounted on said rigid portion by bent over ears, and a pair of contact buttons mounted on said resilient leaf portion at the ends thereof selectively to engage said further contact pins.

6. The relay defined in claim **3**, and which includes a pair of support arms mounted in spaced relationship on said magnetic armature means and extending to spaced positions along said insulating rod to mechanically couple said magnetic armature means to said insulating rod.

7. The relay defined in claim **1**, and which includes a resilient lug affixed to said movable contact and resiliently engaging said first contact pin to serve as an electric path between said first contact pin and said movable contact.