Jan. 18, 1944. H. E. BUCKLEN, JR 2,339,676

RELAY

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Fig. 1.

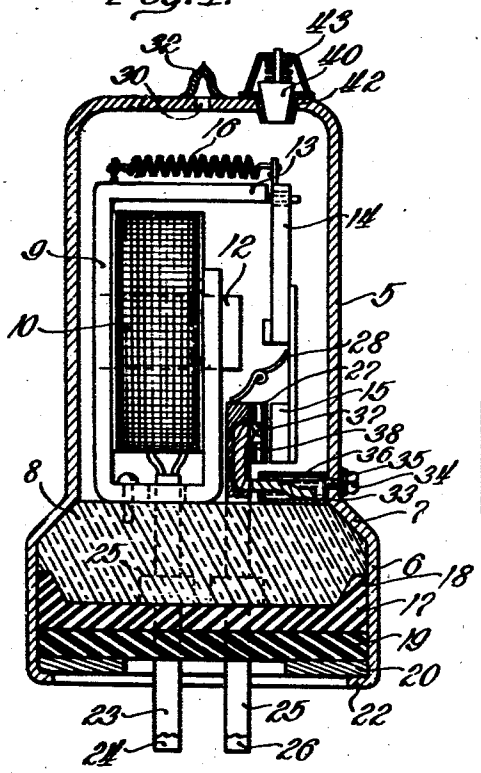


Fig. 2.

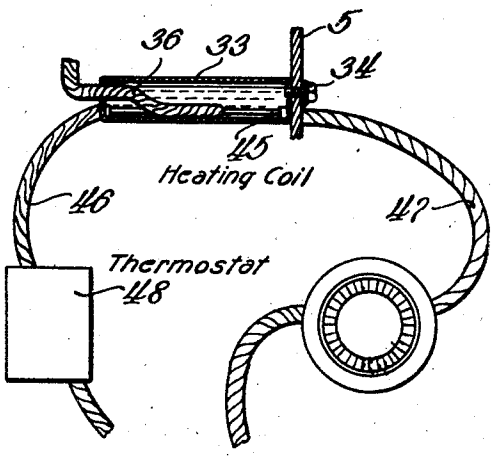


Fig. 5.

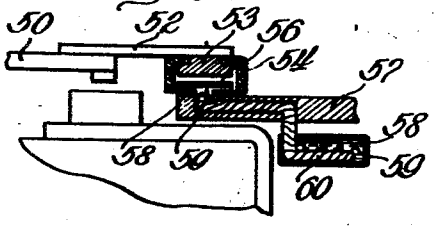


Fig. 6

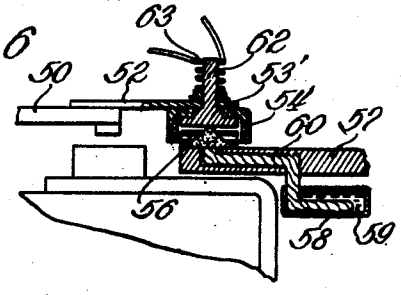


Fig. 7.

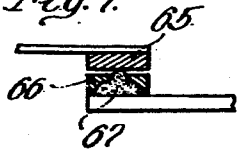
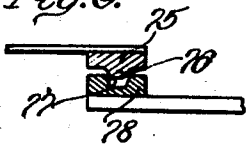


Fig. 8.



Fig. 9.



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RELAY

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Fig. 3.

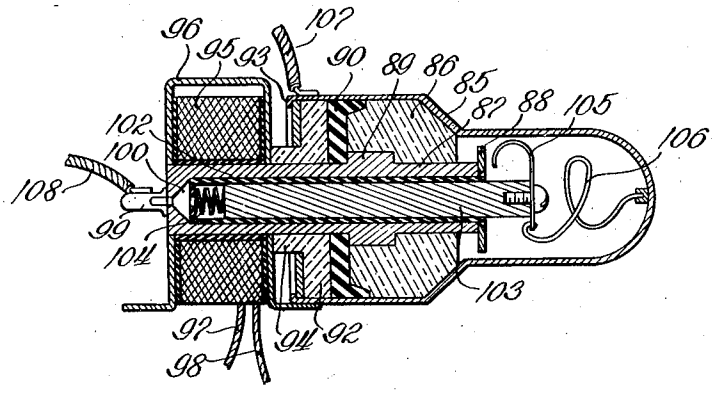
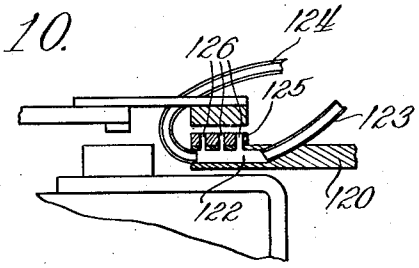


Fig. 10.



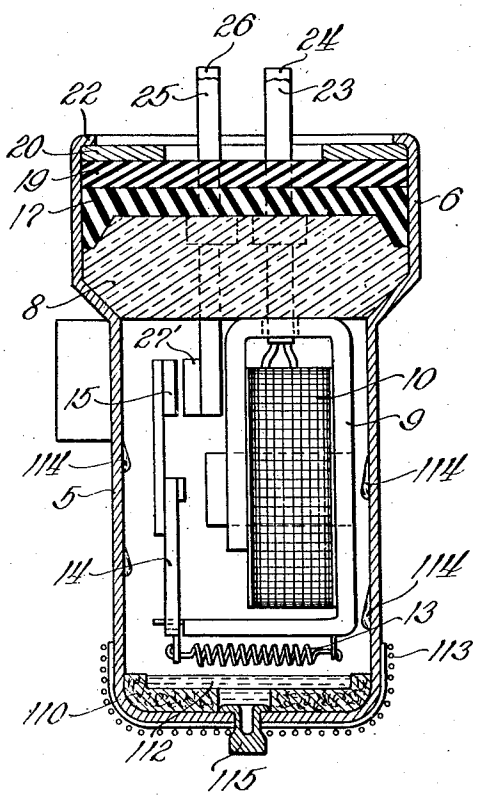


Fig. 4.

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RELAY

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Fig. 11.

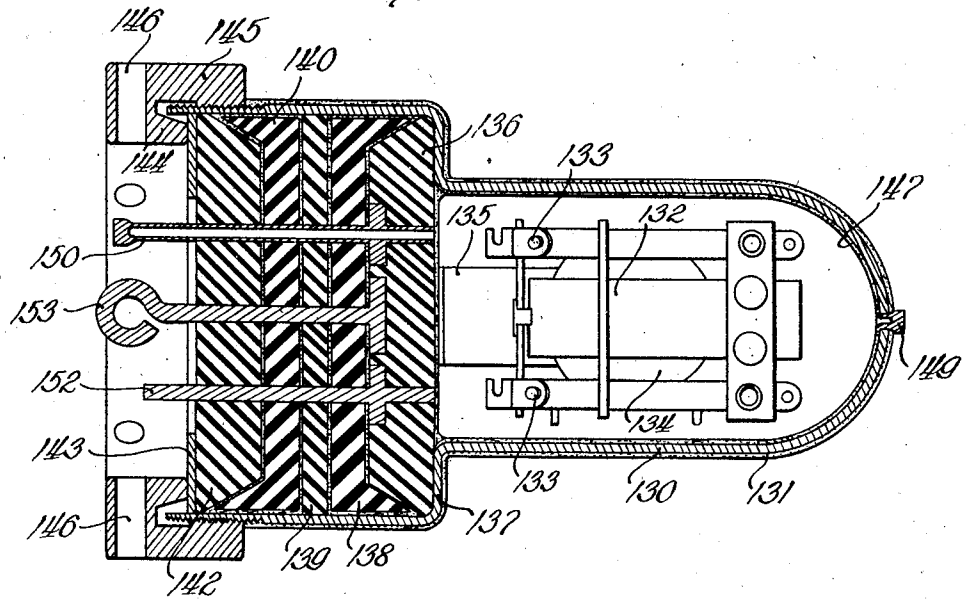
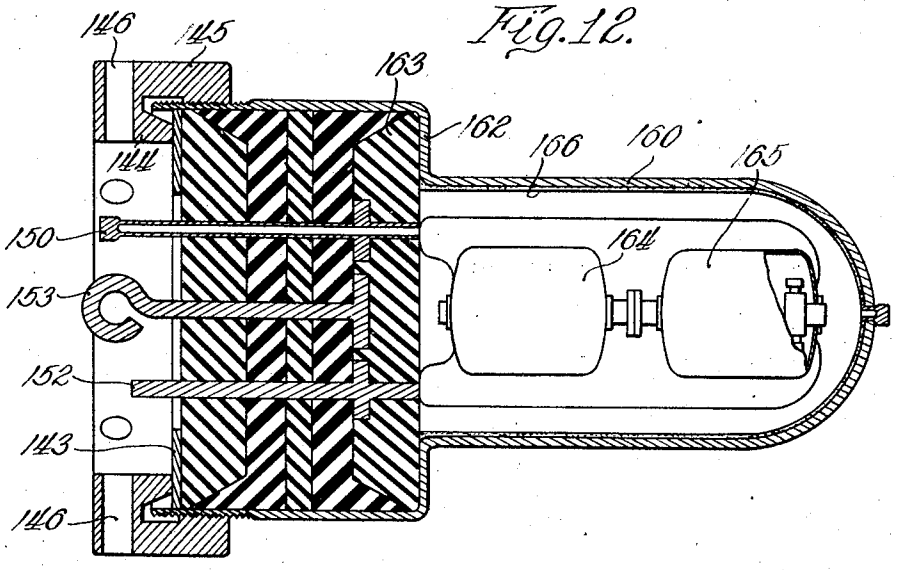


Fig. 12.



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Patented Jan. 18, 1944

2,339,676

UNITED STATES PATENT OFFICE

2,339,676

RELAY

Herbert E. Bucklen, Jr., Elkhart, Ind.

Application March 9, 1942, Serial No. 433,851

17 Claims. (Cl. 200—144)

This invention relates to relays, and more particularly is concerned with relays useful in aviation where high altitudes are encountered at low atmospheric pressures, and where quick turns and drops cause separation of the normal relay contacts. The invention is also applicable to relays of the high cycling type where rapid making and breaking of the circuit causes corresponding rapid deterioration of the contacts and requires frequent replacement.

The invention also contemplates, within its general premises, the use of an enclosed type relay or an open contact type relay, the particular type being dependent upon the service to which it is subjected.

Broadly speaking, the present invention is based upon the use of a relay having contact arrangements which prevent corrosion or oxidation of the contacts, and which eliminates to a large extent the arcing and consequent pitting of such contacts or overheating thereof, and is an improvement and modification of the invention shown and described in the copending application of H. E. Bucklen, et al., Serial No. 384,542, filed March 21, 1941.

The invention further contemplates the use of both liquid and gas cooled contacts, and the use of a fluid around and adjacent the contacts which will provide lubrication cooling and resultant reduction of deterioration of such contact.

In considering the broad aspects of the present invention, consideration must first be given to the fact that the arcing between a pair of contacts is a direct function under given current conditions of the gap between the contacts and the medium therebetween, whether it be air or some other form of gas. For example, under similar conditions of temperature and pressure, I have found that, while only 1.4 amperes can be safely carried through a relay of predetermined design in open air, if this relay is placed in a hydrogen atmosphere, approximately 100 amperes can be so carried without arcing. This is of extreme importance when it is considered that relays for aviation work must operate both at sea level pressures and at 40,000 feet altitude. At such a high altitude, the atmospheric pressure is reduced to approximately 15% of the pressure at sea level. The duration of an electrical arc when interrupted between two relay contacts has been found to be six times longer at one-half atmospheric pressure than at normal atmospheric pressure. In addition, if a relay is enclosed under normal atmospheric pressure when flown to an altitude of 40,000 feet, the temperature drops to such a point that the air pressure may be reduced to three-fourths atmospheric. The duration of the arc would then be almost three times longer than at normal sea level. The law governing this states that the sparking potential of a gas is a function only of the product of the opening between the relay contacts and the pressure of the gas, or, in other words, of the mass of gas between the electrodes.

Thus, it is obvious that a relay with open contacts would be quickly destroyed in operation at high altitudes. The best gas for short arc duration and maximum interrupting ability appears to be hydrogen at the highest possible pressure, since nitrogen has been found to be substantially similar to air.

Also, in aviation work, the relay cannot be of the gravity operated type, inasmuch as the instrument must be capable of operation in any position. Thus, mercury relays do not lend themselves readily to this use. Glass enclosed mechanical relays are too fragile for the service which is encountered in aviation. Furthermore, such envelopes of glass cannot be sealed off with a pressure higher than three-fourths atmosphere due to the fact that the heat from the sealing torch expands the gas within the envelope. As a consequence, most glass tubes of this type are sealed off at a pressure of nine pounds per square inch, as compared with the normal atmospheric pressure of 14.2 pounds. It therefore appears, and my developments have led me to the conclusion, that the solution of this problem is to use relay mechanisms of the mechanical open contact type, and enclose and seal them within a metal envelope which is designed to stand a high pressure of hydrogen gas. Hydrogen gas is very superior to practically any other gas due partly to the fact that it has the ability to absorb about seven times more heat than the corresponding amount of air, and also apparently is many times more effective so far as maximum interruption currents are concerned in open contact type relays.

Therefore, the present invention contemplates as one of its objects, the provision of an enclosed type relay for aviation use consisting of a mechanical relay; i. e., the normal open contact type enclosed within a metal envelope, which is so arranged that it can be sealed against the entrance or exit of gases. This seal can be of the type shown in the Bear Patent No. 2,251,011, issued July 29, 1941, in which the end of the envelope is crimped over to form a locking joint, or the seal can be of the screw end type suitably

arranged for pressure. The relay placed within this envelope is surrounded by hydrogen gas, preferably under a pressure of 4 to 6 atmospheres, the envelope and the relay having first been subjected to a hydrogen annealing process such as shown in Hedin application, Serial No. 325,154, filed March 21, 1940, now Patent No. 2,284,899, issued June 2, 1942. This provides a relay having high resistance against arcing, and which is capable of operation regardless of the surrounding pressure of the atmosphere. Furthermore, the relay is fully protected by the metal envelope against damage and is spring operated rather than gravity operated.

In conjunction with the use of such an enclosed structure, I preferably also provide an improved type of seal for a hydrogen filled envelope. I have found that in place of ordinary pure rubber as a gasketing material, the use of synthetic rubber, such as thiokol or neoprene, which has been treated with polyvinyl alcohol to close the pores thereof, provides a synthetic flexible sealing means, which is approximately ten times more resistant to the passage of hydrogen gas than the former pure rubber gaskets. The relay structure itself is firmly anchored to a suitable insulating member carried in the envelope, and is rigidly held in position to take the jars and shocks encountered in aviation work without in anywise affecting the operating characteristics of the relay.

In connection with the use of rubber gaskets as seals, I have also found that by dipping these gaskets in a wax, such as a wax known commercially as Johnson's Liquid Wax, #RG-101, or the equivalent, and then baking the gasket at 200 to 250 degrees Fahrenheit, the pores of the gaskets may be sealed closed to prevent any possibility of hydrogen escaping from the interior of the switch envelope.

With such gasket means as described above, the relay envelope may be provided with a screw threaded cap to allow for taking apart of the assembly for servicing or inspection if so desired.

The present invention also contemplates, in addition to the envelope, hydrogen gas and relay structure combination just described, the use of a synthetic liquid which has distinct advantages insofar as maintaining the contacts in proper condition. This synthetic liquid, I have found from long research and experiment, should be an anhydrous, alkaline liquid capable of absorbing moisture if any is present, and having certain characteristics of viscosity which render it extremely valuable in this use. Such a liquid is triethanolamine. This liquid has relatively low viscosity which gives it a viscous lubrication quality, allowing it to adhere to the contact surfaces. It also has high dielectric characteristics, and also physical properties extremely desirable for such use. Its boiling point is above 350° Fahrenheit, so that it will remain in a liquid stage under normal operation, and its freezing point is below zero Fahrenheit. Furthermore, upon volatilization, it gives off hydrogen and provides for gas quenching at the contacts. In addition, due to the vaporization under arcing characteristics at the relay, the conversion of the liquid into the gas form produces a marked cooling effect, allowing the relay to operate at a cool temperature approximating room condition.

This synthetic liquid, by reason of its viscous vacuum action, maintains the two contacts in adherence when the relay is closed, thus tending to overcome the tendency for them to fly apart should an airplane drop or change direction suddenly. Furthermore, it prevents premature contact or flashing across due to the fact that the two bodies must press against the liquid and displace it before they can contact. Thus, coating of either one or both of the contact members with this liquid is desirable since it requires a firm closure of the relay in order to squeeze out the insulating liquid and gives a no-arc complete contact. When the contacts start to spread apart, they have to overcome the viscous character of the liquid, and practically no arc can start under the liquid layer.

In applying the use of this liquid to the relays of the present invention, I propose a contact structure in which the liquid can be fed to the contact surfaces by means of a wick fed from a liquid reservoir or from any other suitable source, or by providing liquid pockets in the contact with a hooded arrangement to confine the gases arising upon heating so that the contacts will be bathed in the liquid and its associated quenching gas.

Under extreme conditions of temperature, it may be desirable that the liquid be heated to maintain it in a fluid condition, and the present invention contemplates also an automatic control means responsive only to temperature or pressure for electrically heating the liquid under such extremely low temperatures. Similarly, if the relay is of the high cycling type, it may be necessary to maintain the liquid cool in order to prevent its rapid vaporization, and I also contemplate in the present invention the provision of means for circulating either water or a refrigerant liquid through the contact to maintain the same at the proper operating temperature.

The use of such a liquid prevents any plating or possible welding of the contacts shut, and has the advantage that, upon volatilization, the heat produced is dissipated rapidly to the walls of the envelope so that no localized hot spots can be developed within the relay.

It is also an object of the present invention to provide an open contact switch of the non-enclosed type, in which the contacts are arranged, with this synthetic liquid being fed to them in any one of a number of ways, certain examples of which will be described in detail hereinafter, and being either cooled or heated, as circumstances may require, to maintain the liquid at its best operating condition. In such connection, it may be desirable to hood one of the contacts with an insulating ceramic or shielding member which will confine the vapors so that they are retained around the contact surfaces. Also, the contacts may be provided with radial channels to insure delivery of the arc quenching liquid to all surfaces of the contacts. The heating or cooling, of course, is provided as has been described in connection with the enclosed type of relay.

A further object of the present invention is to provide an enclosed type of relay structure, which may employ an operating coil removed from the metal relay envelope, this solenoid coil being capable of operating a plunger extending through the envelope for operating switch contacts therein. Such a construction is extremely desirable to prevent premature closing or opening of the contacts caused by shock or sudden turns, and also allows the envelope to be made of any desired metal not necessarily non-magnetic.

In connection with the enclosed type relay, I

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may provide for the relay actuating coil to be disposed within the metal envelope, in which case the envelope need not be of non-magnetic material, or the actuating coil may surround the envelope, as disclosed in my previous application, Serial No. 373,597, filed January 8, 1941, or as shown in Hedin application, Serial No. 311,915, filed December 30, 1939, in which the magnetic coil surrounds the envelope, and the envelope must then be of non-magnetic material, such as austenitic steel or the like.

With the open contact unenclosed type of relay, it is of course a relatively simple problem to feed the synthetic quenching liquid to the contact surfaces. However, in the enclosed type of relay, this may be done through a reservoir which carries an appreciable supply of the liquid, or the reservoir may be arranged for access from the exterior of the envelope to refill the same, in which case, suitable means is provided for reheating the interior of the envelope to drive out any air that may have been admitted during the filling operation, since normally the envelopes are evacuated and filled through a tubulation which is then sealed off.

It is apparent that the present invention contemplates a wide range of constructional details insofar as the arrangement of the envelope and the sealing means therefor is concerned, as well as the type and arrangement of the relay within the envelope and the various contact arrangements for such a relay. While the present description shows certain embodiments and designs which I have found advisable, it is by no means to be considered as limited to such forms, but only as illustrative of some ways in which the invention may be embodied.

Other objects and advantages of the constructions herein disclosed will become more apparent to those skilled in the art from the following detailed description which, taken in conjunction with the accompanying drawings, discloses the construction and operation of preferred forms of the present invention.

In the drawings:

Figure 1 is a sectional view through one form of enclosed relay embodying the present invention;

Figure 2 illustrates the manner in which the synthetic quenching liquid can be heated to maintain it at the desired operating temperature.

Figure 3 is a sectional view through a modified form of construction, in which the relay coil is disposed exteriorly of the envelope;

Figure 4 is a sectional view disclosing another form of enclosed relay structure embodying the use of a cup-shaped member which contains the arc-quenching liquid, which may be heated externally;

Figure 5 is a sectional view showing a modified contact arrangement, which may be used either with an enclosed or open air type relay;

Figure 6 is a corresponding view of another modified contact construction;

Figure 7 is a sectional view of a still further modification of the contact structure;

Figure 8 illustrates a contact structure in which the synthetic liquid may be replaced through the medium of an oil can or the like;

Figure 9 is a sectional view of an open well type contact structure;

Figure 10 is a view of a relay contact structure embodying means for cooling the liquid at the contacts;

Figure 11 is a sectional view of a further modification of the enclosed type relay structure; and

Figure 12 is a sectional view of a still further modified enclosed switch arrangement.

Referring now in detail to Figure 1, there is shown in this form of the invention a metallic shell or envelope **5** which may be cup-shaped in general form having the enlarged end portion **6**. Seated within this end portion against the shoulder **7** is an insulating bushing **8** which may be a ceramic or hard rubber, or other substantially non-resilient insulating material. Mounted on the inner face of the bushing **8** is the bracket member **9** carrying a relay coil **10** surrounding an armature **12**. Pivotally mounted on one end **13** of the bracket is the armature arm **14** carrying the contact member **15** at the end thereof and normally held away from the core **12** by means of the spring **16**. The relay structure described may be considered as any standard type of relay, or may be a relay of special design, but it will be noted that it is entirely disposed within the envelope and is sealed thereby from the atmosphere.

Backing up the bushing **8** is a resilient gasket member or sealing means **17**, which has an annular flange or skirt **18** disposed within a suitable recess portion of the bushing to provide a greater length of seal along the internal wall of the envelope. The gasket **17** is compressed in position by means of a disc-like compression member **19**, which may be hard rubber, ceramic or the like, and the compression member **19** is locked in compressed position by means of the retaining washer **20** and the spun-over edge **22** of the envelope. This type of locking arrangement is disclosed and described more clearly in Bear patent, No. 2,251,011, issued July 29, 1941, and provides a very positive seal for the open end of the envelope. The two terminals for the relay coil **10** are indicated at **23** and **24**, and are provided intermediate their ends with shoulder portions **25** which hold them against axial movement by seating in recesses formed in the outer face of the bushing **8** being held in such recesses and sealed by the resilient gasket **17**. Similarly a second pair of terminal members **25** and **26** extend through the bushing **8** in a similar manner. The terminal member **25** is provided at its inner end with a fixed contact portion **27** to be described in more detail hereinafter. The other terminal member **26** is connected through the flexible pigtail **28** to the armature contact **15**, whereby a circuit is completed between the contacts **25** and **26** when the armature core **12** attracts the armature arm **14** to close the contacts **15** and **27**.

The interior of the envelope in which the relay is mounted is preferably adapted to be evacuated completely, it being understood that the envelope **5** may be subjected to a hydrogen annealing process, as described in Uno C. Hedin application, Serial No. 325,154, filed March 21, 1940, now Patent No. 2,284,899, whereby all occluded gases are driven out of the pores of the metal and they are filled with hydrogen to prevent any leakage of hydrogen therethrough. After evacuation, the envelope is filled with dry hydrogen gas under appreciable pressure such as from 4 to 6 atmospheres, the evacuation and filling being accommodated by the port **30** in the closed end of the envelope, which may be provided with a tubulation or may be sealed over by means of a plastic seal such as the seal **32**

after the hydrogen gas under pressure has been introduced into the shell.

Mounted on the inner face of the bushing **8** is a receptacle or reservoir **33** which is provided with a fill plug **34** extending through the wall of the envelope and having suitable gasket means **35** for sealing the same. The reservoir is adapted to contain the liquid previously described, which is used for coating the contacts to prevent corrosion or welding thereof, and which also prevents any oxidation. Further, this liquid is of such physical characteristics that it has a tendency to quench any arcing between the relay contacts, and is of sufficient viscosity that it prevents premature flash-over before the two contacts come together, requiring that the force of closing the contacts be sufficient to squeeze out the liquid therebetween before the circuit can be closed. The liquid has a relatively low vaporizing point, about 350° F. and the vapor acts as an arc quenching gas to both dissipate heat and to resist arcing. This liquid is preferably an anhydrous alkaline liquid, such as triethanolamine, and is transmitted to the contact **27** by means of the wicking **36**, which extends into the reservoir **33** and thence through the terminal stud **25** into a suitable recess **37** formed in the contact **27** and communicating with all portions of the contact by reason of the channels **38**. The liquid is transmitted through the wicking to the contact **27** and acts as a cooling medium as well as an arc quenching means.

Further, due to the hydrogen fill within the envelope, it is apparent that little or no arcing can take place, since the hydrogen is more than 100 times as effective in reducing the sparking potential between the contacts than air or hydrogen. Consequently, for producing the shortest arc duration and maximum interrupting ability, the use of hydrogen under appreciable pressure is extremely desirable. The use of hydrogen in contact with the contacts maintains them clean and bright, while the use of the liquid prevents any fusion of the contacts together and also serves as a heat dissipating medium since the liquid when vaporized moves as a gas, and when it contacts the walls of the envelope it condenses, thereby dissipating heat throughout the envelope.

It may be desirable to provide the envelope with a suiitable safety pressure device to prevent building up too great a pressure therein, although the seal is capable of withstanding pressures up to two or three thousad pounds per square inch. I therefore may provide the pressure release valve **40**, which normally is closed in the tapered valve seat **42**. The valve is normally pressed into sealing engagement in the seat by means of the spring **43**, but of course under extreme pressures, will be forced outwardly to allow escape of pressure.

In some cases, such as when operating a relay of this type at high altitudes, the rarified atmosphere and consequent low temperature may cause the liquid in the reservoir **33** to congeal, since it passes into the solid state at a little below the zero degree Fahrenheit. To remedy this condition there is shown in Figure 2 a construction which provides for maintaining the liquid in the reservoir **33** in a proper condition. This is accomplished by means of a heating coil **45** which is connected to an electric circuit through conductors **46** and **47**. A suitable thermostat **48** controls the operation of the circuit, and produces a heating of the liquid whenever the temperature gets to a point where there is possibility of congealing of the same.

In Figures 5 to 9, inclusive, there is disclosed a number of other contact arrangements which may be provided for switches or relays of this type whether they are operated within an envelope or in open air. For example, the construction shown in Figures 5 and 6 are especially advantageous for open air operation where it is desired that the contacts be prevented from pitting or from fusing or from oxidation.

Considering Figure 5, the relay arm **50** in this construction is provided with the contact arm **52** carrying the contact **53**. This contact is provided with a ceramic enclosing hood **54** open at the bottom. Disposed within the confines of the hood is the fixed contact **56** mounted on the terminal stud **57**. A suitable liquid reservoir **58** is provided which is filled, as indicated at **59**, with the alkaline liquid. A suitable wicking **60** transfers the liquid up through the terminal post **57** to the contact **56**, the contact **56** being provided with radial channels **58** and a central recess **59** in which the wicking terminates. It will be apparent that with such a construction vaporization of the liquid under rapid cycling of the relay will result in the gas being trapped within the hood **54**, thereby flowing over and around the contact surfaces. This vaporization of course, produces a concurrent cooling, and also bathes all the contact surfaces with a liquid or gas to maintain them clean and bright and to quench any arcs that might be struck therebetween, as well as preventing premature flash-overs.

Due to the presence of the gas or liquid over the contact surfaces, it is apparent that as the two contacts move toward each other, there will be no initial arcing since it is necessary to physically displace the liquid or gas before an air gap is produced, and consequently, no air gap will be produced before the contacts come together. As a result, the sparking potential is materially increased, which results in much greater life and more efficient operation of the relay.

The construction shown in Figure 6 is similar except that the contact **53'** is provided with a vertical extension **62** about which is mounted a heating coil **63**. The heating coil **63** transmits heat through the metal of the contact **53'**, which in turn vaporizes the liquid within the contact **56**, this vapor being trapped within the hood **54**, and consequently flowing over and coating the surfaces of the two contacts. Thus, in effect, a gas filled contact structure is provided even in an open air contact relay, and since the liquid, upon vaporization, produces a gas rich in hydrogen, it is apparent that a hydrogen atmosphere is produced about the contacts, which materially increases the resistance to sparking or arcing, and thus prevents any possible fusion or corrosion of the contacts.

Figure 7 discloses a simplified form of contact structure in which the movable contact **65** is adapted to engage a fixed contact **66** which is recessed and provided with a packing or wicking **67** saturated with the liquid. A portion of this wicking may project a slight distance above the surface of the contact **66** so as to provide for wetting of this contact surface with the liquid. This provides a pressure head resisting engagement of the contacts until they have displaced this liquid, thereby preventing any premature arcing or flash-overs. The liquid in the contact **66** may be renewed, as required, by means of an

oil can or any other suitable means of introducing the liquid into the recess.

In Figure 8 a pair of vertical contacts are disclosed, the movable contact 70 being adapted to move toward and away from the fixed contact 72. The fixed contact 72 is recessed as at 73 to provide a channel for the liquid, which, because of its viscous nature, will stay within the passageway 73, and will vaporize at the base of the contact 72 to provide the gas essential to prevent arcing at the contacts. The liquid may be renewed either by a wicking introduced into the open end of the recess 73, or by means of an oil can or any similar means.

The construction in Figure 9 shows a pair of contacts having mating contact surfaces, the movable contact 75 having a projection or boss 76 adapted to extend into a well or recess 77 in the fixed contact 78. This well or recess is filled with the liquid, and the liquid is displaced over the contact surface and partially vaporized by the heat produced between the contacts to provide a gaseous atmosphere of hydrogen about the contacts during operation of the relay.

Thus it will be seen that in all of these various types of contact structures the liquid is brought into close proximity to the contact surfaces, and is so arranged that it can be readily vaporized by the heat of contact to provide the gaseous hydrogen atmosphere about the contacts during operation of the relay.

Considering now the construction shown in Figure 3, this construction is particularly desirable for fast operating airplanes in which rapid turns and changes of direction would, through the influence of gravity and centrifugal force, cause possible misoperation of a normal type relay.

In this form of the invention, the metal envelope 85 comprises a cup-shaped shell having the bushing 86 seated in the open end thereof, the bushing being provided with an axial bore through which extends a brass or austenitic steel sleeve 87. This may be a stainless steel sleeve or any non-magnetic material. At its inner end, the sleeve 87 is provided with a contact disc 88 which may be coin silver or any other approved contact material.

The sleeve 87 is provided with a shouldered portion 89 seating in a corresponding recess in the bushing 86 and held in position by means of the resilient gasket 90, which in turn is compressed in position by the rigid compression member 92. The compression member 92 is locked in position by the spun over end 93 of the envelope 85, and is provided with a reduced cylindrical extension 94 forming an abutment against which the magnetic actuating coil 95 is disposed within its casing 96. The coil 95 is provided with the two conductors 97 and 98 which connect it to a suitable circuit for energization. The end of the sleeve is closed, and is provided with a tubulation 99 which, through the hollow bore 100 in the sleeve, is capable of being used for evacuating the envelope 85 and filling the same with hydrogen under pressure. Mounted within the bore 100 of the sleeve 87 is a Bakelite sleeve 102 forming a guide for the reciprocating plunger 103. This plunger is normally pressed inwardly toward the closed end of the envelope 85 by means of a spring 104 seated in the outer end of the sleeve 87. The plunger 103 is formed of magnetic material such as iron, and carries at its inner end a resilient contact member 105 which, through the resilient connection 106, is electrically connected to the shell 85, a suitable conductor 107 forming one side of the circuit controlled by the contacts 88 and 105. The opposite side of the circuit is connected from the contact 88 through the sleeve 87 and the tubulation 99 to a conductor 108.

In the operation of this construction, the actuation of the coil 95 results in the plunger 103 being drawn to the left, as viewed in Figure 3, closing the contacts and completing the circuit between the conductors 107 and 108. Upon release of the magnetic action of the coil 95, the spring 104 abruptly moves the plunger 103 inwardly, breaking the contact. The use of the hydrogen gas within the envelope of course protects these contacts against deterioration.

The construction shown in Figure 4 involves a relay of the same general type as shown in Figure 1, except that it is mounted in inverted position and has a somewhat different means for introducing the liquid in vapor form around the contact surfaces. The same reference numerals however will be used to indicate corresponding parts.

However, the contact 27' in this form of the invention is not recessed, and has no direct connection to any source of liquid supply. Mounted in the closed end of the envelope 5 which is at the bottom of the structure, there is provided a cup-shaped insulating retaining member 110, which may be formed of asbestos or the like, and which is adapted to contain the liquid 112. Surrounding the outer portion of the envelope adjacent this end is a fiber insulating cap which carries on its surface the electrical heating coil 113, which applies heat through the metal to the liquid within the cup 110, vaporizing this liquid and causing it to rise upwardly into proximity to the contacts 15 and 27'. As the liquid contacts the cooler walls of the envelope, it condenses and drips back downwardly, as indicated at 114. This provides, in addition to the hydrogen gas under pressure sealed within the envelope by means of the tubulation 115, a circulating gaseous medium, which has excellent arc quenching, heat dissipating and lubricating characteristics. This provides very efficient protection of the surfaces against any possibility of damage by arcing or flash-overs, and together with the hydrogen gas, insures that the contacts will always remain clean and bright.

Considering Figure 10 in detail, in this construction there is shown a contact arrangement somewhat similar to that shown in Figures 5 and 6. However, the fixed contact terminal post 120 in this form of the invention is provided with an end recess 122 to which extends an inlet conduit 123 and an outlet conduit 124. The contact 125 mounted on the post 120 is provided with ports 126 communicating with the recess 122.

By the use of this construction, the liquid can be circulated through the contact arrangement, and can be maintained cool so that it will not vaporize too rapidly, and due to its viscosity it will not be forced outwardly through the ports 126 in too rapid a manner, but will vaporize and maintain the contacts cool even when the relay is of the high cycling type. This provides a continuous flow of the liquid to the contacts, and insures that they will always be surrounded by the desirable gaseous hydrogen atmosphere. The conduits 123 and 124 may be connected to a cooling system or to a heat exchanger, as desired.

In Figure 11 I have shown a modified construction in which the metal envelope 130, which may be of iron, or 18–8 stainless steel, is coated over

its entire outer surface with thiokol, as indicated at 131. Within the envelope there is disposed a relay structure comprising the armature arm 132, the contacts 133 and the energizing coil 134. This relay structure is supported by means of the bracket 135 upon a Bakelite or equivalent gasket member 136 seated against the shoulder 137 formed in the envelope.

A suitable resilient gasket 138 seals the insulator 136 in position, and is compressed by means of an intermediate compression member 139. To provide additional sealing, a second resilient gasket 140 is provided formed of 50% thiokol and 50% neoprene. Against this gasket is disposed a Bakelite gasket 142, which is held in position by means of a retaining washer 143 pressed in position by the inner flanged lip 144 of a cap member 145 threaded over the outer end of the shell. The cap member 145 is provided with radial openings 146 adapted to receive a wrench or the like for tightening it over the end of the shell to provide the desired compression of the gaskets. Within the interior of the envelope there is provided a coating of polyvinyl alcohol, or the equivalent, which is shown as forming a lining 147 about the interior of the shell and over the inner face of the bushing 136. This material is also painted over the gaskets and on the inside and outside surfaces of the synthetic rubber to close the pores against the escape of hydrogen. Preferably, the gasket 138 is of pure gum rubber to retain a resilient pressure on the gasket 136. The joint between the gasket 136 and shoulder 137 of the envelope is also coated with polyvinyl alcohol before assembly. This coating is impervious to the passage of hydrogen, and consequently all hydrogen introduced to the envelope through the tubulation 149 is locked therein against escape. If desired, the interior of the envelope may be evacuated and filled through the tubulation 150, which also serves as one of the terminal studs extending into the envelope. The other terminal stud is indicated at 152, and it is understood that four such terminals are provided, two for the actuating coil and two for the pairs of contacts.

In the construction shown in Figure 11, I have also provided means for disassembling the structure, this comprising a hook 153 which is seated in the bushing 136. By engaging the hook after the cap 145 has been removed, the entire inner assembly of the shell can be removed if it is desired to inspect the contacts or to replace the relay, and it is understood that the coating material may again be applied after such removal before the new assembly is introduced into position.

In the structure shown in Figure 12, I have disclosed a metal envelope or shell 160 having the shoulder 162 providing an abutment for the rigid insulating bushing 163. The remaining gasket structure is similar to that described in connection with Figure 11, and may be coated in the same manner as described in connection therewith.

Mounted within the envelope in any suitable manner is a motor generator set, indicated at 164 and 165, respectively, which, being placed within the envelope which is sealed and filled with hydrogen under pressure, allows a higher voltage commutation, and thus can be used with a relatively small motor generator set for generating D. C. current for aviation purposes. The interior of the envelope and the gaskets are coated with a liquid wax or with the polyvinyl alcohol, as indicated at 166, to seal the same against the escape of any hydrogen by closing the pores of the metal and the pores of the gasket material. This is provided by painting the same with the alcohol or by coating the same with the wax and baking it for a period of approximately one minute at 200 to 250 degrees Fahrenheit.

The use of an enclosed envelope with a hydrogen atmosphere under pressure therein for a motor generator set, such as indicated in Figure 12, is highly desirable. Hydrogen has the characteristic of both cooling and keeping clean those places in such a set which are inaccessible, while the cooling characteristics of the gas convey the heat to the surrounding outside jacket and to the large body of surrounding hydrogen to dissipate the same, thereby eliminating hot spots. The coils of the armature rotating in their orbit tend to create isolated hot spots, and the presence of the hydrogen gas at these coils materially reduces their tendency to overheat. The higher the pressure of the gas, the greater is the quenching action on the parts of the motor generator set.

This provide an effective control of temperature under these adverse conditions without employing outside air currents with their possible dust and other contaminations. A motor generator set does not have the commutation limitations found in open air work when enclosed in this manner. Further, there would be no tendency of one segment bar to fuse across to the next, and the surface heat of the brush to the bar caused by oxidation of the surfaces would be eliminated.

It will be apparent that in all of the constructions shown, the use of either hydrogen or a synthetic liquid, such as triethanolamine or the like which produces a hydrogen atmosphere upon vaporization, provides for protection of the contact surfaces, whether operating in air or within an enclosure permitting much greater capacity in the relays without any danger of arcing or corrosion of the contacts. The various methods for maintaining the liquid in proper operating condition at the contact surfaces and for preventing the escape of the hydrogen which is under pressure in the envelope serve to add long life and further enhance the operating characteristics of the structures.

I am aware that various changes may be made in certain details of the present construction, and therefore do not intend to be limited except as defined by the scope and spirit of the appended claims.

I claim:

1. A relay construction comprising a sealed metal envelope, a relay assembly supported in said envelope having a pair of magnetically controlled cooperating contacts, a filling of hydrogen gas under pressure in said envelope, a body of an anhydrous alkaline liquid within said envelope, and means within said envelope for conducting said liquid to the surface of at least one of said contacts.

2. The construction of claim 1 further characterized in the provision of means located externally of said envelope and connected to said body of liquid for maintaining said liquid at a predetermined temperature in said envelope regardless of ambient temperature variations.

3. The construction of claim 1 wherein said liquid comprises triethanolamine.

4. The construction of claim 1 including a liquid reservoir in said envelope, and fill plug means accessible from outside of said envelope for re-

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plenishing said liquid from the exterior of said envelope.

5. In combination, a relay structure including a fixed contact and a contact movable into engagement therewith, said fixed contact having a series of lateral outlet ports below the face thereof provided with a common inlet port, reservoir means separated from said contacts and containing an arc quenching liquid, means for conducting said liquid to said inlet port, said liquid being capable of volatilizing upon heating of said contact to release hydrogen-rich gas, and hood means carried by and movable with said other contact and extending downwardly below said ports when said contacts are engaged for confining said gas about said contacts.

6. The combination of claim 5 further characterized in means for maintaining said liquid at a predetermined temperature.

7. The combination of claim 5 including a circulating system for cooling said liquid connected through said one contact.

8. The combination of claim 5 including means for heating said liquid to maintain its viscosity substantially constant under varying ambient temperatures.

9. In combination, a cup-shaped metal envelope, a rigid insulating bushing in one end thereof supporting a pair of cooperating contacts within said envelope, resilient gasket means sealing said bushing in said envelope, a hydrogen gas under pressure in said envelope, and insulating means coating the interior of said envelope and said bushing and gasket means to close the pores thereof against escape of said gas.

10. The combination of claim 9 wherein said coating means comprises a wax applied in liquid form and baked on under application of heat.

11. The combination of claim 9 wherein said coating means comprises polyvinyl alcohol.

12. The combination of claim 9 wherein said gasket means comprises a first sealing member of pure gum rubber, an intermediate rigid insulating disc, and a second sealing member formed of thiokol and neoprene in substantially equal proportions, said last-named sealing means being impervious to the passage of gas therethrough.

13. In combination, a cup-shaped metal envelope, an insulating insert seated in one end thereof, a normal open air contact type relay rigidly supported in said envelope by said insert, resilient gasket means sealing the end of said envelope against escape of gas, a filling of hydrogen gas under pressure in said envelope, a reservoir in said envelope containing a volatile arc-quenching liquid and capable when volatilized of giving off hydrogen gas, an insulating cap over the end of said envelope adjacent said reservoir, and heating means carried by said cap for volatilizing said liquid.

14. In combination, a cup-shaped metal envelope, an insulating insert seated in one end thereof, a normal open air contact type relay rigidly supported in said envelope by said insert, resilient gasket means sealing the end of said envelope against escape of gas, a filling of hydrogen gas under pressure in said envelope, a reservoir in said envelope containing a volatile arc-quenching liquid and capable when volatilized of giving off hydrogen gas, means for conducting liquid from said reservoir to said contact, and lateral ports in said contact adjacent the face thereof providing for escape of said volatilized gas upon heating of said contact by arcing.

15. In combination, a relay construction including a pair of cooperating contacts, one of said contacts having a cavity therein adapted to contain an arc-quenching liquid, and the other of said contacts having a projection extending into said cavity when said contacts are closed for displacing said liquid over the surfaces of said contacts.

16. In combination, a metal cup-shaped envelope having an enlarged externally threaded open end, an insulating insert in said end, a relay structure supported within said envelope by said ceramic, the interior of said envelope and said insert being coated with an impervious layer of insulating material, resilient gasket means also coated with said insulating material disposed in the end of said envelope against said insert, rigid compression means engaging the outer face of said gasket means, and a cap member threaded over the end of said member and having an annular axially projecting shoulder engaging said compression means within the end of said envelope for holding said gasket means in compressed position.

17. In combination, a tubular cup-shaped metallic envelope, electrically operated means rigidly supported within said envelope including contacts, means for sealing the open end of said envelope, hydrogen gas under pressure in said envelope for quenching arcs at said contacts and preventing oxidation thereof, and means comprising a layer of insulating material impervious to the passage of hydrogen therethrough coating the interior of said envelope and said sealing means.

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