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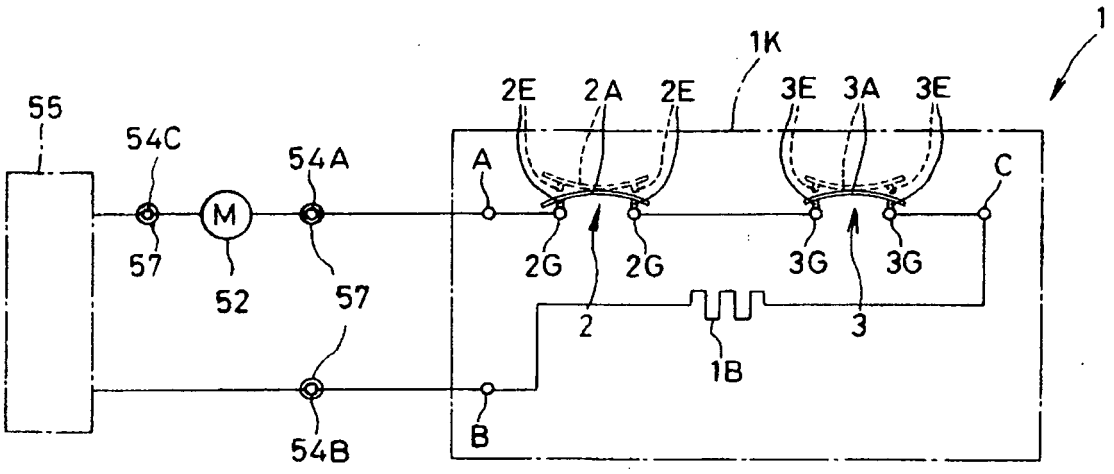
(54) Over current protection device

(57) An over current protection device that surely prevents a burnout by opening a power supply circuit to an electric compressor upon an over current, includes a heater which generates heat by a current flowing through the electric compressor, a first over current relay unit which is serially connected to the heater, is thermoelectrically coupled thereto, and includes a first bimetal contact piece which opens a first contact at a temperature equal to or more than a first temperature, and recovers the first contact at a temperature lower than the first temperature and higher than 0°C, and a second over current relay unit which is serially connected to the heater, is thermoelectrically coupled thereto, and includes a second bimetal contact piece which opens a second contact at a temperature equal to or higher than a second temperature higher than the first temperature, and recovers the second contact only at a temperature lower than 0°C, where both the first over current relay unit and the second over current relay unit open the power supply circuit to the electric compressor.

F I G. 1



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Description

BACKGROUND OF THE INVENTION

(FIELD OF THE INVENTION)

[0001] The present invention relates to an over current protection device which protects an electric compressor used for a refrigerating device such as a refrigerator or a small air conditioner from a burnout caused by an over current generated in an overload state or a locked state thereof.

(DESCRIPTION OF THE RELATED ART)

[0002] Conventionally, in order to protect an electric compressor used for refrigerating devices such as a refrigerator and a small air conditioner from its over current state, there has been provided an over current protection device which employs a bimetallic strip closely attached to a main body case of the electric compressor for sensing a temperature, and operating according to a heat of a heater generating heat in response to an over current flowing through a motor of the electric compressor thereby opening/closing a switch contact piece connected serially between the motor and a power supply of the electric compressor. In this case, the bimetallic strip warps forward when the bimetallic strip reaches an activation temperature due to an abnormal temperature of the main body case of the electric compressor or heat generation by the heater in the over current state, the switch contact piece opens as a result, a power supply to the motor of the electric compressor is interrupted, and a power supply to the heater is also interrupted. Then, when the bimetallic strip is cooled down to a recovery temperature by natural cooling, the bimetallic strip warps backward (recovery warp), the switch contact piece closes, and then the power supply to the electric motor of the electric compressor and the power supply to the heater starts again.

[0003] Though the burnout of the motor of the electric compressor is prevented by the warp action of the bimetallic strip in this way, when the overload state or the locked state of the electric compressor continues, the forward and backward warps of the bimetallic strip repeat, and the switch contact piece opens and closes accordingly. However, if the opening/closing are carried out for a long period, the life of the forward/backward warps of the bimetallic strip ends, the bimetallic strip no longer opens the switch contact piece, the switch contact piece is welded, and the motor of the electric compressor remains in the over current state, resulting in burnout of the motor.

[0004] In order to solve this problem, a connection contact piece including a contact for opening/closing a power supply circuit to the motor of the electric compressor is opened by warp of a first bimetal contact piece in a normal over current state, thereby interrupting the power supply circuit to the electric motor. When the life of the first bimetal contact piece ends and no longer carries out the warp action, the over current remains flowing through the motor of the electric compressor, but a second bimetal contact piece warps due to a high temperature in this state, thereby opening the connection contact piece, and interrupting the power supply circuit to the motor of the electric compressor. The recovery temperature of the second bimetal contact piece is set to a temperature of -50°C, for example, which does not cause the recovery in an ordinary environment, and when the second bimetal contact piece is once activated, the interruption of the power supply to the motor of the electric compressor continues, thereby preventing the burnout of the electric motor, which is a disclosed technology providing a single fail safe feature (for example, Japanese Patent Application Laid-Open No. H07-201262).

[0005] Moreover, there is a technology where a thermo switch unit in which a thermo bimetallic strip warps due to an abnormal temperature of a main body case of an electric compressor thereby opening a power supply circuit to a motor of the electric compressor, and a protector unit in which a heater generates heat due to an over current to the motor of the electric compressor, a main bimetallic strip warps, and a movable contact of the main bimetallic strip opens from a fixed contact, thereby opening the power supply circuit to the motor of the electric compressor are formed, the thermo switch unit, the protector unit, and the heater are stored in one case made of an insulating material, and an adjusting screw for attaching a center portion of the main bimetallic strip and the main bimetallic strip are coupled by heat-melting metal (solder) (for example, Japanese Patent Application Laid-Open No. H09-180612).

[0006] The technology disclosed in Japanese Patent Application Laid-Open No. H09-180612) provides a mechanism in which, though the main bimetallic strip usually warps to open the power supply circuit to the motor of the electric compressor, when the movable contact of the main bimetallic strip is welded to the fixed contact, the heater remains in the heat generation state, the temperature inside the case increases, the heat-melting metal (solder) melts, the coupling between the adjusting screw and the main bimetallic strip breaks, a coil spring attached to the adjusting screw forcedly pushes down the main bimetallic strip, and the movable contact is forcedly detached from the fixed contact, which is the so-called single fail safe feature.

SUMMARY OF THE INVENTION

[0007] Both of the technologies disclosed in Japanese Patent Application Laid-Open No. H07-201262 and Japanese Patent Application Laid-Open No. H09-180612 provide the single fail safe feature, and are common in that the heat generation of the heater, which occurs when the contact, which opens the power supply circuit to the motor of the electric compressor upon the over current,

thereby preventing the burnout of the motor, is welded for some reasons, forcedly detaches the welded contact, thereby maintaining the non-power supply state to the motor, and preventing the burnout.

[0008] However, since the technology disclosed in Japanese Patent Application Laid-Open No. H09-180612 provides the mechanism that since the heat-melting metal (solder) melts and the movable contact is forcedly detached from the fixed contact, the time point of the action of forcedly detaching the movable contact from the fixed contact is influenced by the melting temperature of the heat-melting metal (solder). In other words, the time point of melting depends on the coupled state and the material of the heat-melting metal (solder), and it is fairy difficult to set the time point at which the movable contact is detached from the fixed contact to a desired value.

[0009] Moreover, according to this technology, since the heat-melting metal (solder) melts to forcedly detach the movable contact from the fixed contact, once this action occurs, it is impossible to recover and reuse the over current protection device, and it is necessary to replace the over current protection device to resume the operation of the electric compressor. Moreover, since the movable contact is mechanically forcedly detached from the fixed contact, when the movable contact is welded hard, the detachment may not be attained.

[0010] The technology according to Japanese Patent Application Laid-Open No. H07-201262 is not the technology according to Japanese Patent Application Laid-Open No. H09-180612 which employs the heat-melting metal (solder), and when the second bimetal contact piece, which has once warped, is cooled down to a recovery temperature of, for example, -50°C or lower, the second bimetal contact piece recovers into a reusable state, and the problem of the second technology in which the over current protection device becomes no longer reusable is solved.

[0011] However, the first technology has only the second bimetal contact piece as a portion which interrupts the current supply circuit to the electric compressor. In other words, according to the first technology, there is provided a configuration in which only the one second bimetal contact piece connected and fixed by welding or the like to an end of a conductive piece fixed to a fixed terminal and horizontally extending is provided, the first bimetal contact piece without a bimetal contact is provided therebelow, and the heater is further provided therebelow. Then, upon an ordinary over current, the heat generation of the heater causes the first bimetal contact piece to warp upward, thereby pushing the conductive piece upward, and the second bimetal contact piece is thus separated from the fixed contact, thereby interrupting the power supply circuit to the electric compressor. Then, the movable contact of the second bimetal contact piece is welded to the fixed contact, and an increase in the heat generation of the heater causes the second bimetal contact piece to warp upward, thereby detaching the movable contact of the second bimetal contact piece from the fixed contact, and interrupting the current supply circuit to the electric compressor.

[0012] In this way, the first technology has only the second bimetal contact piece as a portion which interrupts the current supply circuit to the electric compressor, resulting in the single fail safe. In other words, according to the first technology, the portion for interrupting the current supply circuit to the electric compressor does not form an over current protection device providing double fail safe feature. Since the portion for interrupting the current supply circuit to the electric compressor is formed only by the one second bimetal contact piece, and the first bimetal contact piece provides the action to push the conductive piece upward, thereby detaching the movable contact of the second bimetal contact piece from the fixed contact, there poses problems, defects or problems that it is difficult to set operation conditions such as an acting force of the second bimetal contact piece, and the structure is complex. Moreover, since the movable contact is mechanically forcedly detached from the fixed contact, when the movable contact is welded hard, the detachment may not be attained. In this way, since the conventional technologies provide the single fail safe based on only the one contact, the conventional technologies have a very important and fatal defects that when the contact is welded, the fail safe feature is not provided, and consequently, the electric compressor burns out.

[0013] In this way, since the over current protection devices according to prior art provide the single fail safe based on only the one bimetal contact, the conventional technologies have the fatal and very important problems that when the bimetal contact is welded, since the over current continues to flow through the electric compressor, the electric compressor burns out, and these technologies do not provide fail safe feature.

[0014] The present invention, in order to solve the above-mentioned fatal defects and/or very important problems of the conventional single-fail-safe over current protection device, provides a double-fail-safe over current protection device. The present invention is, in order to provide a double fail safe feature of an over current protection device, characterized in that two bimetal contact pieces with different operating temperatures are serially connected, and a serial circuit of a first movable contact which opens/closes a current supply circuit to an electric compressor upon a usual over current, and a second movable contact which continuously opens the current supply circuit to the electric compressor upon the first movable contact being welded is further serially connected to a heater. The present invention, with this configuration, simultaneously realizes an over current protection device, by realizing the double fail safe feature, thereby solving the above fatal defects and very important problems of the conventional technologies, promoting design of operation conditions, and providing a simple structure, and a reusable over current protection device. In other words, the present invention solves the above

fatal defects and very important problems of the conventional technologies, and simultaneously have large advantages which the conventional technologies do not provide, resulting in great effects.

[0015] Moreover, the present invention further advantageously provides, by changing the type of the bimetallic strip and the wire diameter of the heater, an over current protection device increasing degree of freedom in design so as to adapt to various warp action temperatures and various over currents, thereby facilitating production suitable for an electric compressor, and also provides a reusable over current protection device.

[0016] Further, the present invention simultaneously has great advantages that an intended over current protection device is realized by arranging the first bimetal contact piece and the second bimetal contact piece at an angle of approximately 90 degrees, and further, the structure is simple, design of operation conditions is easy, and the assembly is easy.

[0017] As means for solving the above-described problems of the conventional technologies, and realizing the above-described advantages, a first aspect is an over current protection device including a heater and a bimetal contact piece serially connected to a power supply circuit for an electrically-driven element in an electric compressor, the bimetal contact piece interrupting a current supply as a result of heat generation by the heater, in which the bimetal contact piece includes first and second bimetal contact pieces serially connected to the heater, and the first bimetal contact piece interrupts the current supply to the electric compressor by opening a first movable contact at a temperature equal to or more than a first temperature as a result of the heat generation, and closes the first movable contact at a recovery temperature lower than the first temperature and higher than 0°C, and the second bimetal contact piece interrupts the current supply to the electric compressor by opening a second movable contact at a temperature equal to or more than a second temperature higher than the first temperature as a result of the heat generation, and closes the second movable contact at a temperature lower than 0°C.

[0018] A second aspect is the over current protection device according to the first aspect in which the over current protection device is stored in a single heat-resistant insulation case, the first bimetal contact piece and the second bimetal contact piece are mutually arranged at an angle of approximately 90 degrees, and the heater is a signal heater, and can generate heat so as to provide a temperature equal to or more than the second temperature.

[0019] A third aspect is the over current protection device according to the first aspect in which the heater includes a first heater that heats the first bimetal contact piece, and a second heater that is serially connected to the first heater, and heats the second bimetal contact piece.

[0020] A fourth aspect is the over current protection device according to the third aspect in which the first heater can generate heat to provide a temperature equal to or more than the first temperature as a result of an over current supplied to the electric compressor, and the second heater can generate heat to provide a temperature equal to or more than the second temperature as a result of an over current supplied to the electric compressor.

[0021] According to the invention of the first aspect, since the first bimetal contact piece opens the contact at a temperature equal to or more than the first temperature as a result of the heat generation thereby interrupting the current supply to the electric compressor, and closes the contact at the recovery temperature lower than the first temperature and higher than 0°C, and the second bimetal contact piece opens the contact at the temperature equal to or more than the second temperature higher than the first temperature as a result of the heat generation thereby interrupting the current supply to the electric compressor, and closes the contact at the temperature lower than 0°C, even if the first bimetal contract is welded to the fixed contact, the heat generation by the heater as a result of an over current opens the second bimetal contact, thereby interrupting the current supply, and the over current will not continue to flow through the electric compressor, preventing the electric compressor from burning out. Thus, the invention according to the first aspect can solve the above fatal defects and very important problems of the conventional technologies. In other words, since the serial circuit of the two bimetal contact pieces to be activated at the different temperatures is further serially connected with the heater thermally coupled to the two bimetal contact pieces, and thus provides a double fail safe feature, thereby preventing the electric compressor from burning out, the invention can solve the above fatal defects and very important problems of the conventional technologies.

[0022] In other words, the invention according to the first aspect further serially connects the serial circuit of the first movable contact, which opens/closes the current supply circuit to the electric compressor upon the ordinary over current, and the second movable contact, which continuously opens the current supply circuit to the electric compressor when the first movable contact is welded, to the heater. The invention simultaneously realizes an over current protection device, by realizing the double fail safe feature with this configuration, thereby solving the above fatal defects and very important problems of the conventional technologies, promoting design of operation conditions, and providing a simple structure, and a reusable over current protection device. In other words, the invention according to the first aspect solves the above fatal defects and very important problems of the conventional technologies, and simultaneously have the great advantages which the conventional technologies do not provide, resulting in great effects.

[0023] Moreover, since the invention according to the first aspect has the above characteristics, the second bimetal contact piece interrupts the current supply to the electric compressor at a temperature equal to or more

than the second temperature higher than the first temperature at which the first bimetal contact warps, and thus opens the contact of the first bimetal contact, and recovers only at a temperature lower than 0°C. Thus, once the second bimetal contact piece warps, since the second bimetal contact piece will not recover unless it is intentionally cooled down to a temperature lower than 0°C, as long as the second bimetal contact piece is not cooled, the protection for preventing the electric compressor from burning out continues after the second bimetal contact piece warps. When the second bimetal contact piece is cooled down to a temperature lower than 0°C, the over current protection device becomes usable again. In this way, since the invention does not employ the method of forcedly detaching a welded movable contact, which is the problem of the conventional technologies, even if the welding is hard, the power supply to the electric compressor can be stably interrupted. Further, once the second bimetal contact piece is activated, when it is cooled down to a temperature lower than the recovery temperature, the second bimetal contact piece becomes reusable, which is economical.

[0024] Further, since the invention according to the first aspect can realize an intended over current protection device, the structure is simple, the design of the operation conditions is easy, and the assembly is easy. Moreover, since the heat generation of the heater generated by the over current supplied to the electric compressor warps the first bimetal contact piece or the second bimetal contact piece, the over current protection device is preferable for one which is sensitive both to temperature and over current.

[0025] According to the invention of the second aspect, since the over current protection device is stored in a single heat-resistant insulation case, the first bimetal contact piece and the second bimetal contact piece are mutually arranged at the angle of approximately 90 degrees, and the heater is the signal heater, and can generate heat so as to provide a temperature equal to or more than the second temperature, the second aspect can realize an over current protection device having the operations and effects according to the invention of the first aspect, and since the one heater and the two bimetal contact pieces are stored in the one case and the two bimetal contact pieces are mutually arranged at the angle of approximately 90 degrees, the over current protection device is even simpler in structure, the design of the operation conditions is easy, the size is decreased, and the assembly is easy.

[0026] According to the invention of the third aspect, since the heater includes the first heater that heats the first bimetal contact piece, and the second heater that is serially connected to the first heater, and heats the second bimetal contact piece, in addition to the operations and effects of the invention according to the first aspect, and compared with the case in which one heater warps the first bimetal contact piece and the second bimetal contact piece, the invention of the third aspect can adapt to various warp action temperatures and various over currents by changing the type of the bimetallic strip and the wire diameter of the heater. Thus, the activation points of the first bimetal contact piece and the second bimetal contact piece can be set more easily, the degree of freedom in design increases, a stable over current protection action is provided, and an over current protection device suitable for the electric compressor can be more easily produced. Moreover, when the recovery temperature of the second bimetal contact piece is set to a low temperature of -50°C, for example, which cannot be reached in an ordinary operation state, the second bimetal contact piece can maintain the state after it is once activated, and thus, the states of the power supply to the electric compressor and the interruption of the current supply can be stably maintained. In this way, since the invention does not employ the method of forcedly detaching a welded movable contact, which is the problem of the conventional technologies, even if the welding is hard, the power supply to the electric compressor can be stably interrupted. Further, once the second bimetal contact piece is activated, when it is cooled down to a temperature of lower than the recovery temperature, the second bimetal contact piece becomes reusable, which is economical. Moreover, the invention of the third aspect can realize an over current protection device constituting a first over current relay storing the first bimetal contact piece and the first heater heating the first bimetal contact piece in a first heat-resistant insulation case and a second over current relay storing the second bimetal contact piece and the second heater serially connected to the first heater and heating the second bimetal contact piece in a second heat-resistant insulation case, and hence the over current protection device can adapt to various warp action temperatures and various over currents. As a result, the invention have great advantages that the activation points of the first over current relay and the second over current relay can be set more easily, the degree of freedom in design increases, a stable over current protection action is provided, an over current protection device suitable for an electric compressor can be more easily produced, and further, by combining multiple over current relays, multi-tuple fail safe feature is provided, and the invention can adapt to many types of electric compressors. Moreover, only an over current relay the bimetal contact piece of which is welded can be replaced, the repair and maintenance are easy, and a great advantage of reductions in costs in the repair and maintenance is provided.

[0027] According to the invention of the fourth aspect, since the first heater can generate heat to provide a temperature equal to or more than the first temperature as a result of an over current supplied to the electric compressor, and the second heater can generate heat to provide a temperature equal to or more than the second temperature as a result of an over current supplied to the electric compressor, in addition to the operations and effects of the invention according to the first aspect, the

invention of the fourth aspect can adapt to various warp action temperatures and various over currents by changing the type of the bimetallic strip and the wire diameter of the heater. Thus, the activation points of the first bimetal contact piece and the second bimetal contact piece can be set more easily, the degree of freedom in design increases, a stable over current protection action is provided, and an over current protection device suitable for the electric compressor can be more easily produced. Further, since the over current protection device surely detects an over current flowing through an electric compressor, and warps the first bimetal contact piece and the second bimetal contact piece respectively, the interrupted state of the power supply to the electric compressor can be stably maintained.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028]

Fig. 1 is a circuit diagram in which a first over current relay unit and a second over current relay unit constituting a first embodiment of an over current protection device according to the present invention are serially connected;
Fig. 2 is a side view showing an exterior of the first embodiment of the over current protection device according to the present invention;
Fig. 3 shows an exterior on a terminal portion side of the over current protection device shown in Fig. 2;
Fig. 4 is an internal configuration diagram viewed from an opening surface of the over current protection device shown in Fig. 2.
Fig. 5 shows a state in which the over current protection device according to the first embodiment of the present invention is stored in a cover, and is attached to a top surface of a sealed case of an electric compressor;
Fig. 6 is a specific exploded perspective view showing a part storing the over current protection device according to the first embodiment of the present invention in the cover, and attached to the top surface of the sealed case of the electric compressor;
Fig. 7 is a cross sectional view along A-A in Fig. 4;
Fig. 8 is a cross sectional view along B-B in Fig. 4;
Fig. 9 is a circuit diagram in which a first over current relay and a second over current relay constituting a second embodiment of the over current protection device according to the present invention are serially connected;
Fig. 10 is a side view showing an exterior of the first over current relay and the second over current relay constituting the second embodiment of the over current protection device according to the present invention;
Fig. 11 shows an exterior on a terminal portion side of the first over current relay and the second over current relay shown in Fig. 10;
Fig. 12 is an internal configuration diagram viewed from an opening surface of the first over current relay and the second over current relay shown in Fig. 10;
Fig. 13 shows a state in which the over current protection device according to the second embodiment of the present invention is attached to a top surface of the sealed case of the electric compressor;
Fig. 14 is a specific perspective view of a part of attaching the over current protection device in Fig. 13 according to the second embodiment to the top surface of the sealed cased of the electric compressor;
Fig. 15 is a schematic lengthwise cross sectional view showing a state in which a terminal protection member for the electric compressor for storing the over current protection device according to the present invention is attached; and
Fig. 16(a) is a schematic lengthwise cross sectional view showing a protrusion of a terminal cover of the terminal protection member of the electric compressor for storing the over current protection device according to the present invention, and Fig. 16(b) is a schematic lengthwise cross sectional view showing a fitted state between the protrusion of the terminal cover and an engagement hole of a lock piece of a terminal fence.

DESCRIPTION OF THE PREFERRED EMBDODIMENTS

[0029] A description will now be given of an over current protection device according to the present invention with reference to accompanying drawings.

[First embodiment]

[0030] Fig. 1 is a circuit diagram in which a first over current relay unit and a second over current relay unit constituting the over current protection device according to the present invention are serially connected, Fig. 2 is a side view showing an exterior of the over current protection device according to the present invention, Fig. 3 shows an exterior on a terminal portion side of the over current protection device shown in Fig. 2, Fig. 4 is an internal configuration diagram viewed from an opening surface of the over current protection device shown in Fig. 2, Fig. 5 shows a state in which the over current protection device according to the present invention is stored in a cover, and is attached to a top surface of a sealed case of an electric compressor, Fig. 6 is a specific exploded perspective view showing a part storing the over current protection device according to the present invention in the cover, and attached to the top surface of the sealed case of the electric compressor, Fig. 7 is a cross sectional view along A-A in Fig. 4, and Fig. 8 is a cross sectional view along B-B in Fig. 4.

[0031] The over current protection device 1 according to the present invention is, for protecting an electric com-

pressor 50 from its over current state, closely attached to a main body case 51 of the electric compressor 50 used for refrigerating devices such as a refrigerator and a small air conditioner, detects a temperature, and interrupts a power supply to a motor 52 according to an over current flowing to the motor 52 of the electric compressor 50. The electric compressor 50 is in a widely known form in which the motor 52 and a refrigerant compressor unit 53 are stored in the main body case 51 constituting a sealed case, and the refrigerant compressor unit 53 is driven by the motor 52 to compress a refrigerant.

[0032] The over current protection device 1 is configured such that it is serially connected to the motor 52 of the electric compressor 50 in the current supply circuit to the motor 52, and the first over current relay unit 2 and the second over current relay unit 3 are electrically serially connected with each other, and are stored in a heat-resistant insulation case 1K made of a synthetic resin.

[0033] The over current protection device 1 includes, in the one heat-resistant insulation case 1K made of the synthetic resin, the first over current relay unit 2 constructed by a first bimetal contact piece 2A provided with first movable contacts 2E which carry out opening/closing operations with respect to first fixed contacts 2G so as to interrupt a current supply to the motor 52 of the electric compressor 50 at a temperature equal to or higher than a first temperature T1 (°C), and recover at a recovery temperature lower than the first temperature T1 and higher than 0°C, and the second over current relay unit 3 constructed by a second bimetal contact piece 3A provided with second movable contacts 3E which carry out opening/closing operations with respect to second fixed contacts 3G so as to interrupt a current supply circuit to the motor 52 of the electric compressor 50 at a temperature equal to or higher than a second temperature T2 (°C) higher than the first temperature T1, and recover only at a temperature T3 (°C) lower than 0°C, and the first over current relay unit 2 and the second over current relay unit 3 are arranged at an angle of approximately 90 degrees to constitute the electrically serial circuit. Therefore, the first bimetal contact piece 2A and the second bimetal contact piece 3A electrically constitute the serial circuit while the first fixed contacts 2G and the second fixed contacts 3G are arranged at the angle of approximately 90 degrees.

[0034] A specific description will now be given of this configuration. As shown in Figs. 1 to 4, the heat-resistant insulation case 1K made of the synthetic resin in a cylindrical shape with a bottom having an opening 1K1 on one surface (lower side surface in Fig. 2) serves as a main body, and the first bimetal contact piece 2A and the second bimetal contact piece 3A are supported by a support shaft 2C fixed by a nut 2D to a center portion of a bottom wall 1K2 (upper side wall in Fig. 2) of the case 1K, in a state separated from an inner surface of the case 1K, with a gap in a stacked state. A configuration is preferable in which the first bimetal contact piece 2A and the second bimetal contact piece 3A are electrically insulated from each other, and thus, in the present embodiment, in order to prevent a mutual electrical conduction between the first bimetal contact piece 2A and the second bimetal contact piece 3A via the support shaft 2C, the support shaft 2C is formed by an electrical insulator such as a synthetic resin.

[0035] The bimetal contact piece 2A is provided with the movable contacts 2E at protruded portions on both the left and right sides of a bimetallic plate in a circular shape. Moreover, the bimetal contact piece 3A is provided with the movable contacts 3E at protruded portions on both the left and right sides of a bimetallic plate in a circular shape. Two external terminals A and B are attached to the bottom wall 1K2 (upper side wall in Fig. 2) of the case 1K and the external terminals A and B are exposed to the inside of the case 1K.

[0036] Inside of the bottom wall 1K2 (upper side wall in Fig. 2) of the case 1K, a terminal C is provided, and on an inner surface of the bottom wall 1K2 (upper side wall in Fig. 2), the first fixed contacts 2G respectively corresponding to the left and right movable contacts 2E of the bimetal contact piece 2A, and the second fixed contacts 3G respectively corresponding to the left and right movable contacts 3E of the bimetal contact piece 3A are provided. On an inner end of the external terminal A is formed one of the fixed contacts 2G, and, on the terminal C is formed one of the fixed contacts 3G.

[0037] In the case 1K, the first over current relay unit 2 and the second over current relay unit 3 are arranged at the angle of approximately 90 degrees, and the first over current relay unit 2 and the second over current relay unit 3 constitute the electrical serial circuit. Therefore, the first bimetal contact piece 2A and the second bimetal contact piece 3A electrically constitute the serial circuit while the first fixed contacts 2G and the second fixed contacts 3G are arranged at the angle of approximately 90 degrees.

[0038] Moreover, in the case 1K of the over current protection device 1, an electric heater 1B having a predetermined electric resistance is disposed to form thermal coupling to the bimetal contact pieces 2A and 3A between the terminals B and C (the one of the fixed contacts 3G) along the inner surface of the bottom wall 1K2 (upper side wall in Fig. 2).

[0039] A specific example of the arrangement/configuration of the first bimetal contact piece 2A and the second bimetal contact piece 3A is shown in Figs. 4, 7 and 8. As shown in Fig. 4, the pair of fixed contacts 2G are arranged on an axis in the horizontal direction, the pair of fixed contacts 3G are arranged on an axis in the vertical direction, and, in order to oppose the respective movable contacts 2E and 3E to them, the bimetal contact pieces 2A and 3A are arranged on the support shaft 2C while the space therebetween is kept by spacers S1 and S2 which are electrical insulators. As shown in Figs. 7 and 8, from the opening 1K1 side of the case 1K toward the bottom wall 1K2 (upper side wall in Fig. 2) of the case 1K, the bimetal contact piece 2A, the bimetal contact

piece 3A, and the electric heater 1B are sequentially arranged while they are spaced from each other. The opening 1K1 is covered by a heat conduction plate 1P.

[0040] In an ordinary state, which is not an over current state, the bimetal contact piece 2A is in a state in which the left and right movable contacts 2E are in contact with the left and right fixed contacts 2G as shown by solid lines in Fig. 1, and the bimetal contact piece 3A is in a state in which the left and right movable contacts 3E are in contact with the left and right fixed contacts 3G.

[0041] The over current protection device 1 has a configuration that, in the state in which the first bimetal contact piece 2A, the second bimetal contact piece 3A, and the electric heater 1B are arranged in the case 1K, as shown in Figs. 5 and 6, the over current protection device 1 is stored in a predetermined cover KS while the opening 1K1 is directed downward, the cover KS is attached on an upper surface of the main body case 51 of the electric compressor 50, an external terminal 57 for power supply stored in the cover KS is connected to terminals 54A, 54B, and 54C protruding from the upper surface of the main body case 51, and the bimetal contact pieces 2A and 3A are positioned in a state to detect the temperature of the main body case 51. In this attached state, the bimetal contact piece 2Ais positioned on the lower side of the bimetal contact piece 3A, thereby promoting the detection of the temperature of the main body case 51.

[0042] In the cover KS, the over current protection device 1 is stored on one side, and the external terminal 57 is stored on the opposite side. In the configuration that the cover KS is attached to the upper surface of the main body case 51, lock holes 60A and 60B are formed on left and right lock pieces of a metallic support base 59 attached to the upper surface of the main body case 51, left and right pawls 58A and 58B of the cover KS are locked to the corresponding lock holes 60A and 60B by elasticity of the cover KS. As a result, the opening 1K1 of the case 1K comes in contact with the support base 59.

[0043] In the over current protection device 1 configured as described above, as shown in Fig. 1, the first bimetal contact piece 2A, the second bimetal contact piece 3A, and the electric heater 1B electrically constitute the serial circuit, and the serial circuit is serially connected to the motor 52 of the electric compressor 50. Moreover, in a type of the over current protection device 1 without the electric heater 1B, the first bimetal contact piece 2A and the second bimetal contact piece 3A electrically constitute a serial circuit, and the serial circuit is serially connected to the motor 52 of the electric compressor 50.

[0044] A description will now be given of one specific circuit connection. The motor 52 shown in Fig. 1 represents an AC motor, and a power supply 55 is also an AC power supply. If the motor 52 is inverter-controlled according to the frequency conversion for a variable rotation speed, the power supply 55 is an inverter-controlled power supply.

[0045] One terminal 54C of the motor 52 is connected to the power supply 55, and the terminal A (corresponding to the fixed contacts 2G of the first over current relay unit 2) of the over current protection device 1 is connected to the other terminal 54A of the motor 52. Then, the bimetal contact piece 2A in the state in which the movable contacts 2E are in contact with the fixed contacts 2G, the bimetal contact piece 3A in the state in which the movable contacts 3E are in contact with the fixed contacts 3G, and the electric heater 3B constitute the electrically serial circuit, and the terminal B is connected to a terminal 54B which is connected to the power supply 55. Thus, the serial circuit constituted by the first over current relay unit 2 and the second over current relay unit 3 is serially connected to the motor 52.

[0046] With this configuration, during an ordinary operation of the electric compressor 50, since the current flowing through the motor 52 is equal to or less than a set value, the heat generation quantity from the electric heater 1B is not large enough to warp the bimetal contact piece 2A as shown by dotted lines in Fig. 1, and the heat generation quantity from the electric heater 1B is not large enough to warp the bimetal contact piece 3A as shown by dotted lines in Fig. 1. Further, since the temperature of the main body case 51 does not warp the bimetal contact pieces 2A and 3A as shown by dotted lines in Fig. 1, the movable contacts 2E maintain in contact with the fixed contacts 2G, and the movable contacts 3E maintain in contact with the fixed contacts 3G, while the motor 52 is in the power supply state from the power supply 55, and the electric compressor 50 continues the ordinary operation state.

[0047] However, if the electric compressor 50 is brought into an overload state, a failed startup state, or a locked state, heat reception quantities of the bimetal contact pieces 2A and 3A increase due to a rise in temperature of the electric compressor 50. Moreover, as a result of the over current more than the set value, the heat generation quantity of the electric heater 1B increases, and the heat reception quantities of the bimetal contact pieces 2A and 3A increase. As a result, first, the bimetal contact piece 2A is heated to a temperature equal to or more than the first temperature T1 such as 120°C, which is the activation temperature, the bimetal contact piece 2A warps as shown by the dotted lines in Fig. 1, and the movable contacts 2E are separated from the fixed contacts 2G, thereby interrupting the current supply circuit to the motor 52. Since the warp action temperature of the bimetal contact piece 3A is set considerably higher than the first temperature T1, the bimetal contact piece 3A does not present the warp action, and the movable contacts 3E remain in contact with the fixed contacts 3G.

[0048] Due to the stop of operation of the electric compressor 50, the power supply to the electric heater 1B no longer exists, and as a result of natural cooling, when the bimetal contact piece 2A reaches the recovery temperature such as 100°C which is lower than the first temperature T1 such as 120°C and higher than 0°C, the bimetal contact piece 2A warps backward (recovers) as shown by the solid lines in Fig. 1, the movable contacts 2E again

come in contact with the fixed contacts 2G, the motor 52 starts again, and the electric compressor 50 recovers to the operation state. Upon the recovery, if the over load state, the failed startup state, or the locked state of the electric compressor 50 has been resolved, the current flowing through the motor 52 is equal to or less than the set value, and therefore, the electric compressor 50 continues the ordinary operation state as described above. However, upon the recovery, if the over load state, the failed startup state, or the locked state of the electric compressor 50 has not been resolved, the bimetal contact piece 2A is to be heated again to the first temperature T1 which is the activation temperature of the bimetal contact piece 2A, the bimetal contact piece 2A warps as the dotted lines in Fig. 1, and the movable contacts 2E are separated from the fixed contacts 2G, thereby interrupting the current supply circuit to the motor 52. In this way, the electric compressor 50 is protected from burnout caused by an overload state, a failed startup state, or a locked state of the electric compressor 50.

[0049] However, when the movable contacts 2E opens/closes with respect to the fixed contacts 2G caused by the warp and recovery of the bimetal contact piece 2A for a long period, or when the number of opening/closing of the movable contacts 2E with respect to the fixed contacts 2G increases due to the operation of the electric compressor 50 for a long period, the life of the forward and backward warp of the bimetal contact piece 2A expires, the movable contacts 2E cannot be opened with respect to the fixed contacts 2G, and the movable contacts 2E are welded to the fixed contacts 2G, the motor 52 of the electric compressor 50 remains in the over current state, and, if this state continues, the motor 52 burns out.

[0050] In this way, when the movable contacts 2E are welded to the fixed contacts 2G, since the power supply to the electric heater 1B continues, the heat generation of the electric heater 1B increases, and the heat reception quantity of the bimetal contact piece 3A increases. As a result, the bimetal contact piece 3A is heated to a temperature equal to or more than the second temperature T2 such as 150°C, which is the activation temperature, the bimetal contact piece 3A warps as shown by the dotted lines in Fig. 1, and the movable contacts 3E are separated from the fixed contacts 3G, thereby interrupting the current supply circuit to the motor 52, and preventing the motor 52 from burning out.

[0051] Since the second temperature T2 of the activation temperature at which the bimetal contact piece 3A warps, and the movable contacts 3E are separated from the fixed contacts 3G is set to the temperature such as 150°C considerably higher than the first temperature T1 such as 120°C which is the activation temperature at which the bimetal contact piece 2A warps, and the movable contacts 2E are separated from the fixed contacts 2G, the bimetal contact piece 3A does not warp before the warp of the bimetal contact piece 2A.

[0052] The recovery temperature at which the bimetal contact piece 3A warps backward (recovers) as the solid lines shown in Fig. 1, and the movable contacts 3E again come in contact with the fixed contacts 3G is a temperature T3 sufficiently lower than 0°C, and this temperature is a subzero temperature T3 sufficiently lower than a low temperature generated in a temperature state in which the electric compressor 50 is used in the ordinary condition. T3 (°C) is several tens of subzero degrees, for example approximately -50°C, and after the bimetal contact piece 3A once warps as shown by the dotted lines in Fig. 1, the bimetal contact piece 3A does not recover unless it is intentionally cooled down to the recovery temperature. Therefore, as long as the second bimetal contact piece is not cooled, after the bimetal contact piece 3A once warps as shown by the dotted lines in Fig. 1, it does not practically permanently recover, and the protection for preventing the electric compressor 50 from burning out continues. As a method of cooling the bimetal contact piece 3A to the recovery temperature, when the bimetal contact piece 3A is cooled by liquefied nitrogen and a low-temperature refrigerating device, the bimetal contact piece 3A becomes usable again.

[0053] In the above configuration, since the electric resistances of the bimetal contact pieces 2A and 3A are considerably smaller than the electric resistance of the electric heater 1B, self heat generation of the bimetal contact pieces 2A and 3A is small in the state in which an over current is flowing, and the warp action upon an over current is practically caused by the heat generation of the electric heater 1B.

[0054] As described above, the first over current relay unit 2 and the second over current relay unit 3 have approximately the same configuration, and are arranged at the angle of approximately 90 degrees, thereby achieving the intended over current protection device 1, which is simple in structure, easy in designing operation conditions, and easy in assembly.

[0055] Though Fig. 1 shows the circuit connection in the sequence of the power supply 55, the motor 52, the first over current relay unit 2, the second over current relay unit 3, and the electric heater, the positions of the first over current relay unit 2, the second over current relay unit 3, and the electric heater may be switched, thereby constituting the serial circuit attaining the functions as described above.

[0056] Moreover, in the above description, though the bimetal contact piece 2A of the first over current relay unit 2 and the bimetal contact piece 3A of the second over current relay unit 3 warp by the detection of the temperature of the main body case 51 of the electric compressor 1 as well as the heat generation quantity of the electric heater 1B, the electric heater 1B may be eliminated, and warp action may be caused only by the temperature detection of the main body case 51.

[0057] Moreover, in the above configuration, though the bimetal contact piece 2A of the first over current relay unit 2 and the bimetal contact piece 3A of the second over current relay unit 3 are to detect the temperature of

the main body case 51 of the electric compressor 1, the bimetal contact pieces 2A and 3A may act to warp only by the heat generation quantity of the electric heater 1B.

[Second embodiment]

[0058] Fig. 9 is a circuit diagram in which a first over current relay and a second over current relay constituting the over current protection device according to the present invention are serially connected, Fig. 10 is a side view showing an exterior of the first over current relay and the second over current relay according to the present invention, Fig. 11 shows an exterior on the terminal portion side of the first over current relay and the second over current relay shown in Fig. 10, Fig. 12 is an internal configuration diagram viewed from an opening surface of the first over current relay and the second over current relay shown in Fig. 10, Fig. 13 shows a state in which the over current protection device according to the present invention is attached to a top surface of the sealed case of the electric compressor, and Fig. 14 is a specific perspective view of a portion for attaching the over current protection device in Fig. 13 to the top surface of the sealed case of the electric compressor.

[0059] The over current protection device 10 according to the present invention is, for protecting an electric compressor 50 from its over current state, closely attached to a main body case 51 of the electric compressor 50 used for refrigerating devices such as a refrigerator and a small air conditioner, detects a temperature, and interrupts a power supply to a motor 52 according to an over current flowing to the motor 52 of the electric compressor 50. The electric compressor 50 is in a widely known form in which the motor 52 and a refrigerant compressor unit 53 are stored in the main body case 51 constituting a sealed case, and the refrigerant compressor unit 53 is driven by the motor 52 to compress a refrigerant.

[0060] The over current protection device 10 is configured such that it is serially connected to the motor 52 of the electric compressor 50 in the current supply circuit to the motor 52, and includes a first over current relay 20 storing, in a heat-resistant insulation case 2K made of the synthetic resin, the first bimetal contact piece 2A which interrupts the current supply circuit to the motor 52 of the electric compressor 50 at the temperature equal to or higher than the first temperature T1, and recovers at the recovery temperature lower than the first temperature T1 and higher than 0°C, and a second over current relay 30 storing, in a heat-resistant insulation case 3K made of the synthetic resin, the second bimetal contact piece 3A which interrupts the current supply circuit to the motor 52 of the electric compressor 50 at the temperature equal to or higher than the second temperature T2 higher than the first temperature T1, and recovers only at the temperature T3 lower than 0°C.

[0061] A specific description will now be given of this configuration. The first over current relay 20, as shown in Figs. 9 to 12, includes the heat-resistant insulation case 2K made of the synthetic resin in a cylindrical shape with a bottom having an opening 2K1 on one surface (lower side surface in Fig. 10) as a main body, and, the first bimetal contact piece 2A is supported by the support shaft 2C fixed by the nut 2D to a center portion of a bottom wall 2K2 (upper side wall in Fig. 10) of the case 2K, in a state separated from an inner surface of the case 2K. The bimetal contact piece 2A is provided with the movable contacts 2E at protruded portions on both the left and right sides of a bimetallic plate in a circular shape. To the bottom wall 2K2 (upper side wall in Fig. 10) of the case 2K, the two external terminals A and B are attached, and the external terminals A and B are exposed to the inside of the case 2K.

[0062] Inside the bottom wall 2K2 (upper side wall in Fig. 10), the terminal C is provided, the end of the terminal A inside the case 2K and the terminal C respectively form the fixed contacts 2G respectively corresponding to the movable contacts 2E of the bimetal contact piece 2A, to an end of the terminal B inside the case 2K, one end of a first electric heater 2B is connected, and, to the terminal C, the other end of the electric heater 2B is connected. In an ordinary state, which is not an over current state, the bimetal contact piece 2A is in a state in which the left and right movable contacts 2E are in contact with the left and right fixed contacts 2G as shown by solid lines in Fig. 9. The first electric heater 2B having a predetermined electric resistance is disposed to form thermal coupling to the bimetal contact piece 2A between the terminals B and C in correspondence with the circular portion of the bimetal contact piece 2A.

[0063] The second over current relay 30 is structurally the same as the first over current relay 20. Therefore, in Figs. 9 to 12, the same portions as the first over current relay 20 are denoted by reference numerals in parentheses. In other words, the second over current relay 30, as shown in Figs. 9 to 12, includes the heat-resistant insulation case 3K made of the synthetic resin in a cylindrical shape with a bottom having an opening 3K1 on one surface (lower side surface in Fig. 10) as a main body, and, the first bimetal contact piece 3A is supported by a support shaft 3C fixed by a nut 3D to a center portion of a bottom wall 3K2 (upper side wall in Fig. 10) of the case 3K, in a state separated from an inner surface of the case 3K. The bimetal contact piece 3A is provided with the movable contacts 3E at protruded portions on both the left and right sides of a bimetallic plate in a circular shape. To the bottom wall 3K2 (upper side wall in Fig. 10) of the case 3K, the two external terminals A and B are attached, and the terminals A and B are exposed to the inside of the case 3K.

[0064] Inside of the bottom wall 3K2 (upper side wall in Fig. 10), a terminal C is provided, an end of the terminal A inside the case 3K and the terminal C respectively form the fixed contacts 3G respectively corresponding to the movable contacts 3E of the bimetal contact piece 3A, to an end of the terminal B inside the case 3K, one end of the second electric heater 3B is connected, and, to the

terminal C, the other end of the electric heater 3B is connected. In an ordinary state, which is not an over current state, the bimetal contact piece 3A is in a state in which the left and right movable contacts 3E are in contact with the left and right fixed contacts 3G as shown by solid lines in Fig. 9. The second electric heater 3B having a predetermined electric resistance is disposed to form thermal coupling to the bimetal contact piece 3A between the terminals B and C in correspondence with the circular portion of the bimetal contact piece 3A.

[0065] As shown in Figs. 13 and 14, the over current protection device 10 has a configuration that the first over current relay 20 and the second over current relay 30 configured as described above are combined and stored in the predetermined cover KS, the cover KS is attached on the upper surface of the main body case 51 of the electric compressor 50, the external terminals 57 for power supply stored in the cover KS are connected to terminals 54A, 54B and 54C protruding from the upper surface of the main body case 51, and the bimetal contact pieces 2A and 3A are positioned in a state to detect the temperature of the main body case 51.

[0066] In the cover KS, on one side, the first over current relay 20 and the second over current relay 30 are provided along with each other, and, on the opposite side, the external terminal 57 is stored. In the configuration that the cover KS is attached to the upper surface of the main body case 51, the lock holes 60A and 60B are formed on left and right lock pieces of the metallic support base 59 attached on the upper surface of the main body case 51, the left and right pawls 58A and 58B of the cover KS are locked to the corresponding lock holes 60A and 60B by elasticity of the cover KS. As a result, the openings 2K1 and 3K1 of the cases 2K and 3K come in contact with the support base 59.

[0067] The serial circuit of the first over current relay 20 and the second over current relay 30 configured as described above is serially connected to the motor 52 of the electric compressor 50. While the movable contacts 2E of the first over current relay 20 are in contact with the fixed contacts 2G, the bimetal contact piece 2A and the electric heater 2B form a first serial circuit. Moreover, while the movable contacts 3E of the second over current relay 30 are in contact with the fixed contacts 3G, the bimetal contact piece 3A and the electric heater 3B form a second serial circuit. Both the first and second serial circuits are serially connected, and are serially connected to the motor 52.

[0068] A description will now be given of one specific circuit connection. The motor 52 shown in Fig. 9 represents an AC motor, and a power supply 55 is also an AC power supply. If the motor 52 is inverter-controlled according to the frequency conversion for a variable rotation speed, the power supply 55 is an inverter-controlled power supply.

[0069] One terminal of the motor 52 is connected to the power supply 55, and the terminal A of the first over current relay 20 is connected to the other terminal 54A of the motor 52. Then, the bimetal contact piece 2A in which the movable contacts 2E are in contact with the fixed contacts 2G and the electric heater 2B form the first serial circuit. The terminal B of the first over current relay 20 is connected to the terminal A of the second over current relay 30. In the second over current relay 30, the bimetal contact piece 3A in which the movable contacts 3E are in contact with the fixed contacts 3G and the electric heater 3B form the second serial circuit, and the terminal B is connected to the terminal 54B connected to the power supply 55. As a result, both the first and second serial circuits are serially connected, and form the serial circuit along with the motor 52.

[0070] With this configuration, during an ordinary operation of the electric compressor 50, since the current flowing through the motor 52 is equal to or less than a set value, the heat generation quantity from the electric heater 2B is not large enough to warp the bimetal contact piece 2A as shown by dotted lines in Fig. 9, and the heat generation quantity from the electric heater 3B is not large enough to warp the bimetal contact piece 3A as shown by dotted lines in Fig. 9. Further, since the temperature of the main body case 51 does not warp the bimetal contact pieces 2A and 3A as shown by dotted lines in Fig. 9, the movable contacts 2E maintain in contact with the fixed contacts 2G, and the movable contacts 3E maintain in contact with the fixed contacts 3G, while the motor 52 is in the power supply state from the power supply 55, and the electric compressor 50 continues the ordinary operation state.

[0071] However, if the electric compressor 50 is brought into an overload state, a failed startup state, or a locked state, heat reception quantities of the bimetal contact pieces 2A and 3A increase due to a rise in temperature of the electric compressor 50. Moreover, as a result of the over current more than the set value, the heat generation quantities of the electric heaters 2B and 3B increase, and the heat reception quantities of the bimetal contact pieces 2A and 3A increase. As a result, first, the bimetal contact piece 2A is heated to a temperature equal to or more than the first temperature T1 such as 120°C, which is the activation temperature, the bimetal contact piece 2A warps as shown by the dotted lines in Fig. 9, and the movable contacts 2E are separated from the fixed contacts 2G, thereby interrupting the current supply circuit to the motor 52. Since the warp action temperature of the bimetal contact piece 3A is set considerably higher than the first temperature T1, the bimetal contact piece 3A does not present the warp action, and the movable contacts 3E remains in contact with the fixed contacts 3G.

[0072] Due to the stop of operation of the electric compressor 50, the power supply to the electric heater 2B no longer exists, and as a result of natural cooling, when the bimetal contact piece 2A reaches the recovery temperature (such as 100°C) which is lower than the first temperature T1 such as 120°C and higher than 0°C, the bimetal contact piece 2A warps backward (recovers) as

shown by the solid lines in Fig. 9, the movable contacts 2E again come in contact with the fixed contacts 2G, the motor 52 starts again, and the electric compressor 50 recovers to the operation state. Upon the recovery, if the over load state, the failed startup state, or the locked state of the electric compressor 50 has been resolved, the current flowing through the motor 52 is equal to or less than the set value, and therefore, the electric compressor 50 continues the ordinary operation state as described above. However, upon the recovery, if the over load state, the failed startup state, or the locked state of the electric compressor 50 has not been resolved, the bimetal contact piece 2A is to be heated again to the first temperature T1 which is the activation temperature of the bimetal contact piece 2A, the bimetal contact piece 2A warps as the dotted lines in Fig. 9, and the movable contacts 2E are separated from the fixed contacts 2G, thereby interrupting the current supply circuit to the motor 52. In this way, the electric compressor 50 is protected from burnout caused by the overload state, the failed startup state, or the locked state of the electric compressor 50.

[0073] However, when the movable contacts 2E opens/closes with respect to the fixed contacts 2G caused by the warp and recovery of the bimetal contact piece 2A for a long period, or when the number of opening/closing of the movable contacts 2E with respect to the fixed contacts 2G increases due to the operation of the electric compressor 50 for a long period, the life of the forward and backward warp of the bimetal contact piece 2A expires, the movable contacts 2E cannot be opened with respect to the fixed contacts 2G, and the movable contacts 2E are welded to the fixed contacts 2G, the motor 52 of the electric compressor 50 remains in the over current state, and, if this state continues, the motor 52 burns out.

[0074] In this way, when the movable contacts 2E are welded to the fixed contacts 2G, since the power supply to the electric heater 3B continues, the heat generation of the electric heater 3B increases, and the heat reception quantity of the bimetal contact piece 3A increases. As a result, the bimetal contact piece 3A is heated to a temperature equal to or more than the second temperature T2, which is the activation temperature, the bimetal contact piece 3A warps as shown by the dotted lines in Fig. 9, and the movable contacts 3E are separated from the fixed contacts 3G, thereby interrupting the current supply circuit to the motor 52, and preventing the motor 52 from burning out.

[0075] Since the second temperature T2 of the activation temperature at which the bimetal contact piece 3A warps, and the movable contacts 3E are separated from the fixed contacts 3G is set to the temperature such as 150°C considerably higher than the first temperature T1 such as 120°C which is the activation temperature at which the bimetal contact piece 2A warps, and the movable contacts 2E are separated from the fixed contacts 2G, the bimetal contact piece 3A does not warp before the warp of the bimetal contact piece 2A.

[0076] The recovery temperature at which the bimetal contact piece 3A warps backward (recovers) as the solid lines shown in Fig. 9, and the movable contacts 3E again come in contact with the fixed contacts 3G is a temperature T3 sufficiently lower than 0°C, and this temperature is a subzero temperature T3 sufficiently lower than a low temperature generated in a temperature state in which the electric compressor 50 is used in the ordinary condition. T3 (°C) is several tens of subzero degrees, for example approximately -50°C, and after the bimetal contact piece 3A once warps as shown by the dotted lines in Fig. 9, the bimetal contact piece 3A does not recover unless it is intentionally cooled down to the recovery temperature. Therefore, as long as the second bimetal contact piece is not cooled, after the bimetal contact piece 3A once warps as shown by the dotted lines in Fig. 9, it does not practically permanently recover, and the protection for preventing the electric compressor 50 from burning out continues. As a method of cooling the bimetal contact piece 3A to the recovery temperature, when the bimetal contact piece 3A is cooled by liquefied nitrogen and a low-temperature refrigerating device, the bimetal contact piece 3A becomes usable again.

[0077] As described above, for the type causing the warp action by the heat generation of the electric heater, since the electric resistances of the bimetal contact pieces 2A and 3A are considerably smaller than the electric resistances of the electric heaters 2B and 3B, self heat generation of the bimetal contact pieces 2A and 3A is small in the state in which an over current is flowing, and the warp action upon an over current is practically caused by the heat generations of the electric heaters 2B and 3B.

[0078] By the configuration of the serial circuit of the first over current relay 20 and the second over current relay 30 as described above, and by changing the type of the bimetal contact pieces 2A and 3A and the wire diameter of the electric heaters 2B and 3B, the first over current relay 20 and the second over current relay 30 which can adapt to various warp action temperatures and various over currents can be produced, the warp activation points of the first over current relay 20 and the second over current relay 30 can be set more easily, the degree of freedom in design increases, a stable over current protection action is provided, and an over current protection device suitable for the electric compressor can be more easily produced.

[0079] Though Fig. 9 shows the circuit connection in the sequence of the power supply 55, the motor 52, the first over current relay 20, the second over current relay 30, and the power supply 55, the positions of the first over current relay 20 and the second over current relay 30 may be switched to provide the connection in a sequence of the power supply 55, the motor 52, the second over current relay 30, the first over current relay 20, and the power supply 55.

[0080] Moreover, in the above description, though the bimetal contact piece 2A of the first over current relay 20

and the bimetal contact piece 3A of the second over current relay 30 warp by the detection of the temperature of the main body case 51 of the electric compressor 1 as well as the heat generation quantity of the corresponding electric heaters 2B and 3B, the electric heaters 2B and 3B may be eliminated, and, the warp action may be caused only by the temperature detection of the main body case 51.

[0081] Moreover, in the above configuration, though the bimetal contact piece 2A of the first over current relay 20 and the bimetal contact piece 3A of the second over current relay 30 are to detect the temperature of the main body case 51 of the electric compressor 1, the bimetal contact pieces 2A and 3A may respectively act to warp only by the heat generation quantities of the corresponding electric heaters 2B and 3B.

[0082] A description will now be given of a terminal protection member for storing the over current protection device according to the present invention. The terminal protection member attached to the electric compressor includes terminals which are attached to a sealed container storing an electrically-driven mechanism unit and a compressing mechanism unit operated by the electrically-driven mechanism unit, and supplying a power to the electrically-driven mechanism unit, a terminal fence for protecting external electrical connection portions of the terminals, and a terminal cover to be dropped into, and to be fitted and attached to the terminal fence, and on protrusions formed on the terminal cover so as to fit engagement holes on lock pieces formed on the terminal fence, a top end portion is formed into a tilted surface tilting downward, and a bottom end portion is formed into a tilted surface tilting upward. A detailed description will now be given of the terminal protection member for storing the over current protection device according to the present invention with reference to accompanying drawings.

[0083] Fig. 6 is a schematic exploded perspective view showing an embodiment of the terminal protection member for storing the over current protection device according to the present invention. In Fig. 6, reference numeral 1 denotes the over current protection device; 11, a terminal protection member; and 51, the sealed container, and terminals 103 passing through and fixed to a top portion of a cover body 51a of the sealed container 51. To external electrodes 54A of the terminals 103, the connector 57 attached to ends of multiple codes 116 on a power supply side is electrically connected, and, to an internal electrodes, which are not shown, located in the sealed container 51, lead wires are electrically connected for supplying a power to stators of an electrically-driven mechanism unit stored in the sealed container 51. It should be noted that the over current protection device 1 is stored in the terminal cover KS. In other words, the over current protection device 1 is stored in the terminal protection member 11.

[0084] Reference numeral 101 denotes a terminal fence made of a rigid plate, on side portions of a base plate 59 thereof, reception pieces 104, 105 and 106 are erected, on terminal portions of the base plate 59, lock pieces 107 and 108 are erected, and, on the lock pieces 107 and 108, engagement holes 60A and 60B are respectively formed.

[0085] The terminal cover KS made of a synthetic resin has an approximately box shape opening downward, and is dropped into and fitted detachably to the terminal fence 101 to form the protection member 11 (Fig. 15), and this terminal protection member 11 covers and protects the external electric connection portions of the terminals 103.

[0086] On side wall portions of the terminal cover KS which are engaged with and locked to insides of the multiple reception pieces 104, 105 and 106 of the terminal fence 101, protruded portions 112a are respectively formed on the outside, and on bottom portions of the protruded portions 112a, tilted surfaces 112b are formed inward. In this case, the protruded portions 112a are also formed into tilted surface tilting inward further as the location approaches downward. This is to cause the side wall portions of the terminal cover KS to easily fit the inside of the reception pieces 104, 105 and 106 of the terminal fence 101, and to prevent gaps to the reception pieces 104, 105 and 106 from being generated.

[0087] Moreover, on outer bottom portions of the opposing end walls of the terminal cover KS, the protrusions 58A and 58B which respectively engage with the respective engagement holes 60A and 60B of the lock pieces 107 and 108 are provided. The protrusions 58A and 58B, as shown in Fig. 16(a), are formed, at top end portions, into tilted surfaces 59a tilting downward, and at bottom end portions into tilted surfaces 59b tilted upward which is the same as a conventional case.

[0088] Further, as shown in Fig. 6, on one side portion of the terminal cover KS, a code lead out hole 111 is provided, a code reception piece 115 is provided so as to protrude in approximately an L shape opposing to the code lead out hole 111, and a recessed portion 115a is formed on an top end edge of the code reception piece 115.

[0089] A protrusion 125 in a visor shape is provided on a peripheral portion of the code lead out hole 111, and a curved portion 125 is formed at a bottom end portion opposing an end portion 115b of the code reception piece 115 of the protrusion 125 by cutout for promoting routing of the codes 116 and the like. Moreover, the end portion 115b of the code reception piece 115 is also formed into a curved shape thereby eliminating angled portions for promoting the routing of the codes 116 and the like.

[0090] The terminal protection member 11 is formed as described above, when the terminal cover KS is dropped into and fitted to the terminal fence 101, as shown in Fig. 16(b), the respective tilted surfaces 59b on the bottom end portions of the protrusions 58A and 58B are locked to bottom edges of the respective engagement holes 60A and 60B of the lock pieces 107 and 108, and the respective tilted surfaces 59a of the top end portions of the protrusions 58A and 58B are locked to top edges

of the respective engagement holes 60A and 60B. As a result, even if a dimensional error C as described before is generated, the dimensional error C is absorbed by the tilted surfaces 59a on the top end portions of the protrusions 58A and 58B, thereby surely fitting the protrusions 58A and 58B to the engagement holes 60A and 60B.

[0091] As a result, such a conventional defect that, due to the dimensional error C, the protrusions 58A and 58B do not fit the engagement holes 60A and 60B of the lock pieces 107 and 108 does not occur. Moreover, bottom edges of the terminal cover KS come in contact with a top surface of the base plate 59 of the terminal fence 101, or only a slight gap is formed to the top surface, and thus, after the terminal cover KS is fitted, a large backlash does not occur.

[0092] After the terminal cover KS is fitted, while three codes 116 on the power supply side and the two codes 119 connected to the over current protection device 1 are assembled into a bundle, a cord group 120 led out from the code lead out hole 111 is routed over the end portion 115b of the code reception piece 115, and is received by the recessed portion 115a at the top end edge. This is to avoid a contact between the code group 120 and the cover body 51a of the sealed container 51. When the electric compressor is in use, the sealed container 51 is at a high temperature, and the code group 120 needs to be protected.

[0093] According to the present invention, the configurations of the over current protection devices 1 and 10, the configurations of the first over current relay portion 2, the second over current relay portion 3, the first over current relay 20, the second over current relay 30, and the like are not limited to the above embodiments, various changes can be conceived without departing from the technical scope of the present invention, and the present invention includes various embodiments.

Claims

1. An over current protection device (1) comprising at least one heater (1B, 2B or 3B) and a plurality of bimetal contact pieces (2A or 3A) serially connected to an electrically-driven element (52) in an electric compressor (50), the bimetal contact piece (2A or 3A) interrupting a current supply as a result of heat generation by the heater,
   wherein the plurality of bimetal contact pieces (2A or 3A) comprises a first bimetal contact piece (2A) and a second bimetal contact piece (3A) each serially connected to the at least one heater (1B, 2B or 3B), and the first bimetal contact piece (2A) interrupts the current supply to the electrically-driven element (52) by opening a first movable contact (2E) at a temperature equal to or more than a first temperature (T1) as the result of the heat generation, and closes the first movable contact (2E) at a recovery temperature lower than the first temperature (T1) and higher than 0°C, and the second bimetal contact piece (3A) interrupts the current supply to the electrically-driven element (52) by opening a second movable contact (3E) at a temperature equal to or more than a second temperature (T2) higher than the first temperature (T1) as the result of the heat generation, and closes the second movable contact (3E) at a temperature lower than 0°C.

2. The over current protection device (1) according to claim 1, wherein:

   the over current protection device (1) is stored in a single heat-resistant insulation case (1K);
   the first bimetal contact piece (2A) and the second bimetal contact piece (3A) are mutually arranged at an angle of approximately 90 degrees; and
   the at least one heater (1B, 2B or 3B) is a signal heater (1B), and can generate heat so as to provide a temperature equal to or more than the second temperature (T2).

3. The over current protection device (1) according to claim 1, wherein the at least one heater (1B, 2B or 3B) comprises a first heater (2B) that heats the first bimetal contact piece (2A), and a second heater (3B) that is serially connected to the first heater (2B), and heats the second bimetal contact piece (3A).

4. The over current protection device (1) according to claim 3, wherein:

   the first heater (2B) can generate heat to provide a temperature equal to or more than the first temperature (T1) as a result of an over current supplied to the electric compressor; and
   the second heater (3B) can generate heat to provide a temperature equal to or more than the second temperature (T2) as a result of the over current supplied to the electrically-driven element (52).

FIG. 1

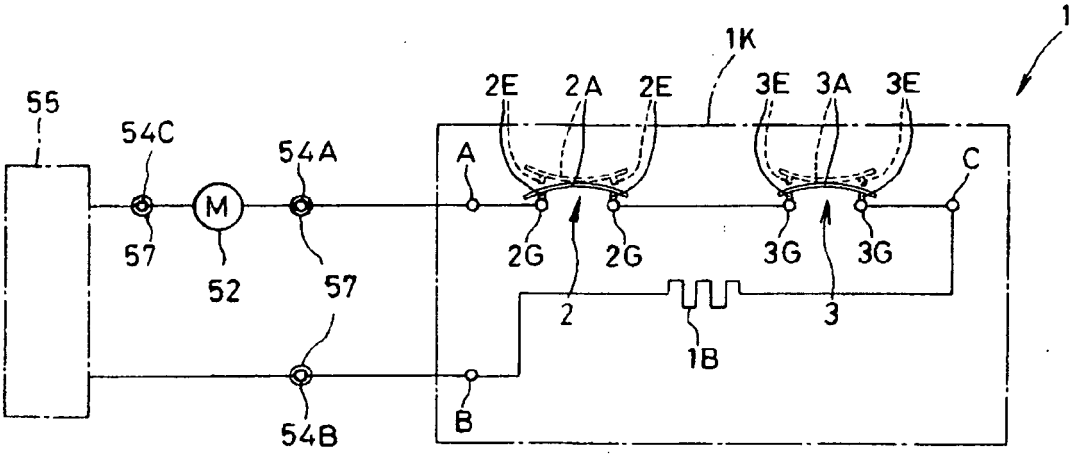

1
1K
55
54C
54A
2E
2A
2E
3E
3A
3E
A
C
M
57
52
57
2G
2G
3G
3G
2
3
1B
57
54B
B

FIG. 2

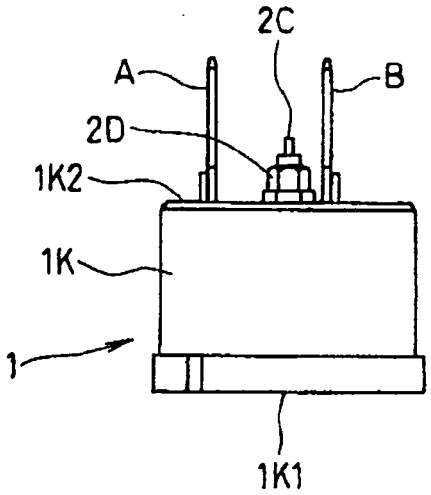

2C
A
B
2D
1K2
1K
1
1K1

FIG. 3

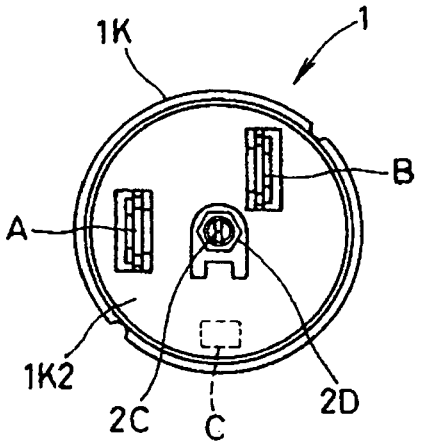
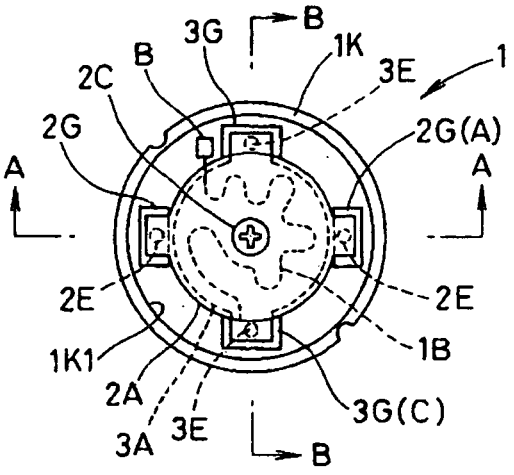
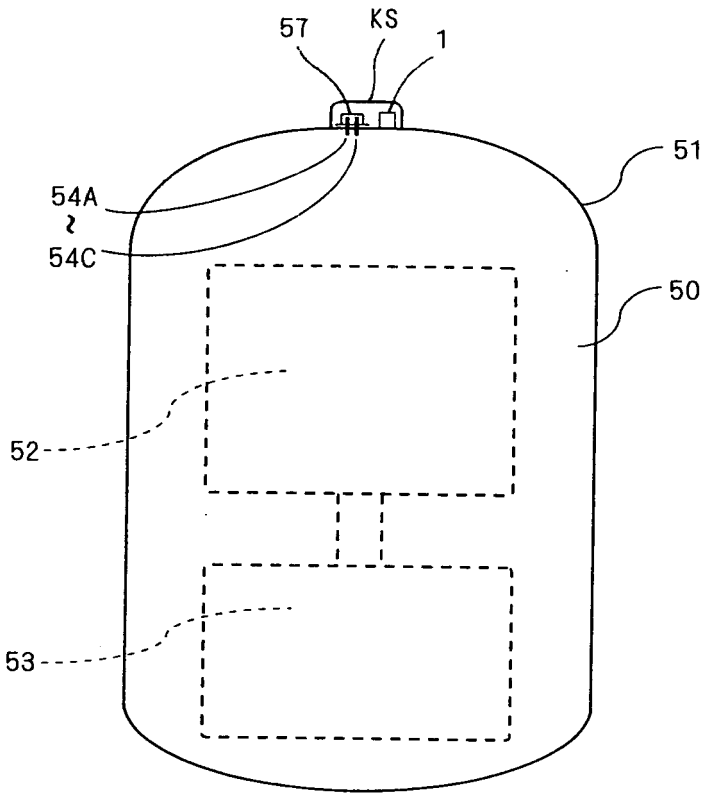

1K
1
B
A
1K2
2C
C
2D

FIG. 4


3G
B
1K
3E
1
2C
B
2G
2G(A)
A
A
2E
2E
1B
1K1
2A
3A
3E
3G(C)
B

F I G. 5



F I G. 6

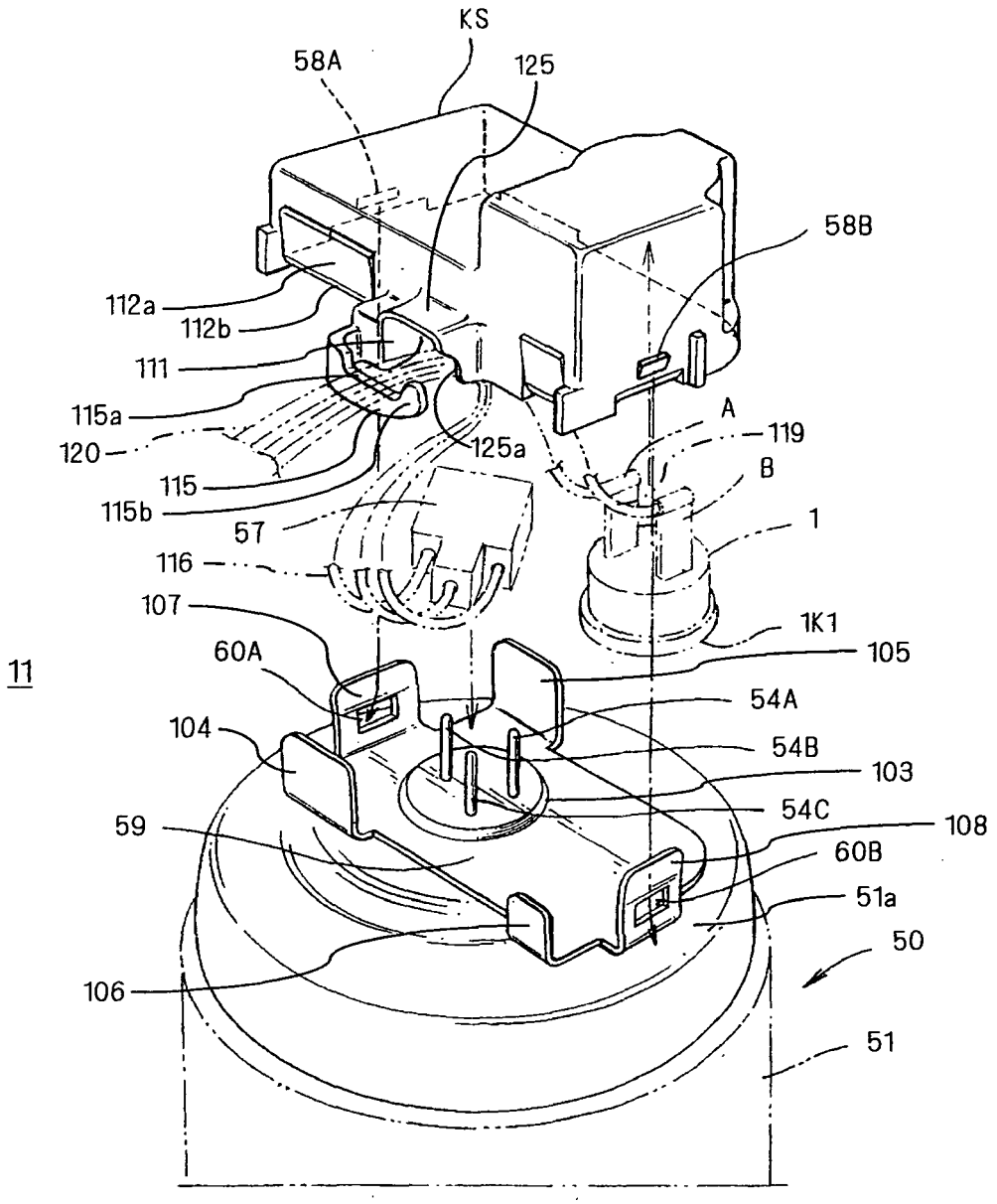

KS
58A
125
58B
112a
112b
111
115a
120
115
115b
57
116
107
60A
104
59
106
125a
A
119
B
1
1K1
105
54A
54B
103
54C
108
60B
51a
50
51
11

FIG. 7

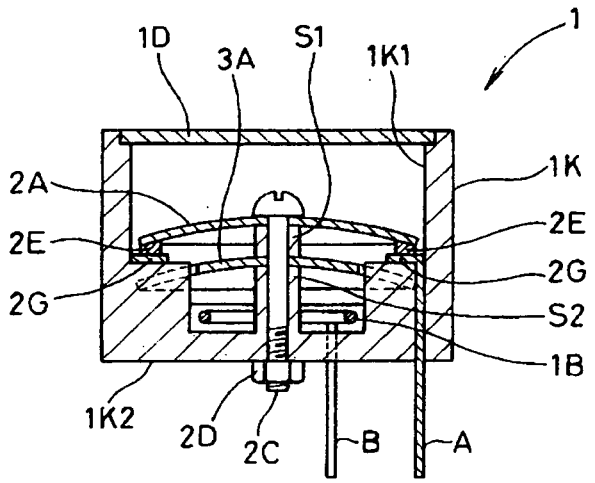

1
1D
3A
S1
1K1
1K
2A
2E
2G
2E
2G
S2
1B
1K2
2D
2C
B
A

FIG. 8

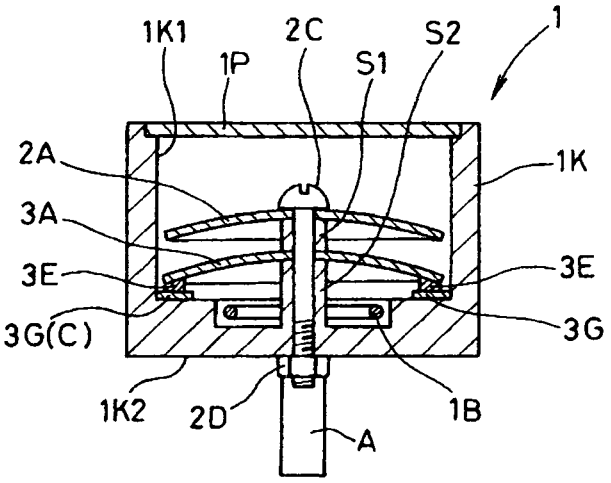

1
1K1
2C
S2
1P
S1
2A
1K
3A
3E
3E
3G(C)
3G
1K2
2D
1B
A

FIG. 9

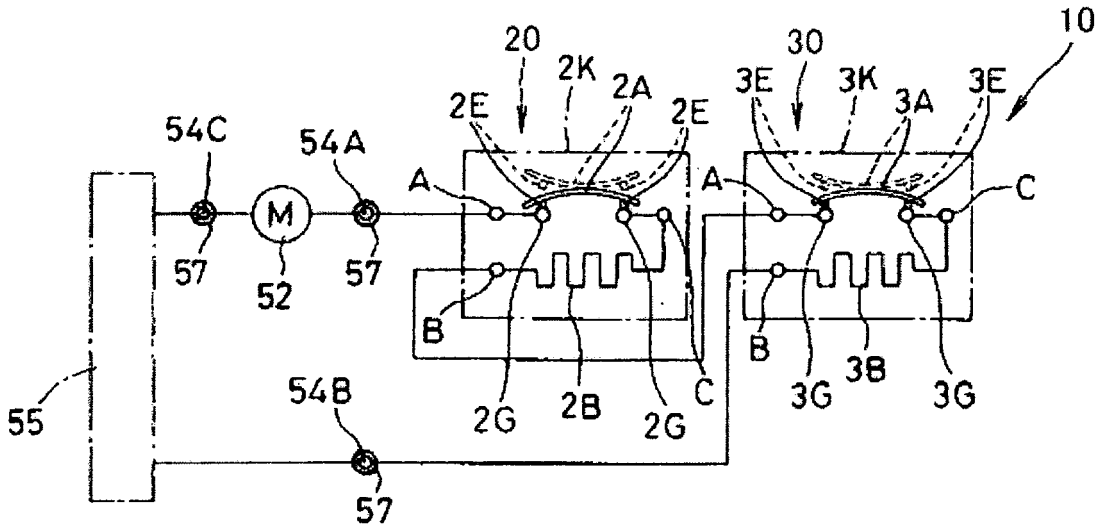

10
20
30
2K
2A
2E
2E
3E
3K
3A
3E
54C
54A
A
A
C
M
57
52
57
B
B
55
54B
2G
2B
2G
C
3G
3B
3G
57

FIG. 10

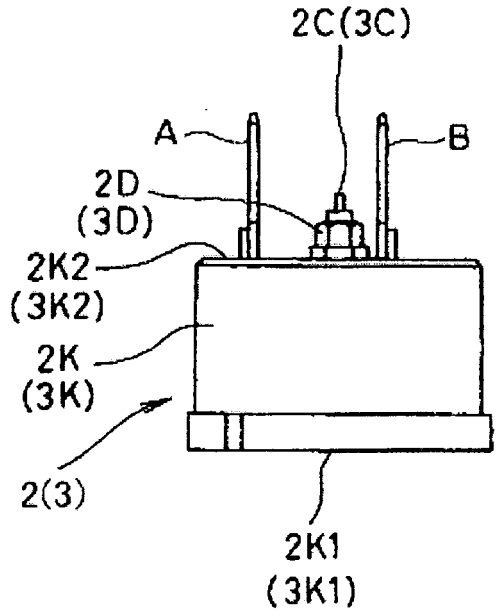

2C(3C)
A
B
2D
(3D)
2K2
(3K2)
2K
(3K)
2(3)
2K1
(3K1)

FIG. 11

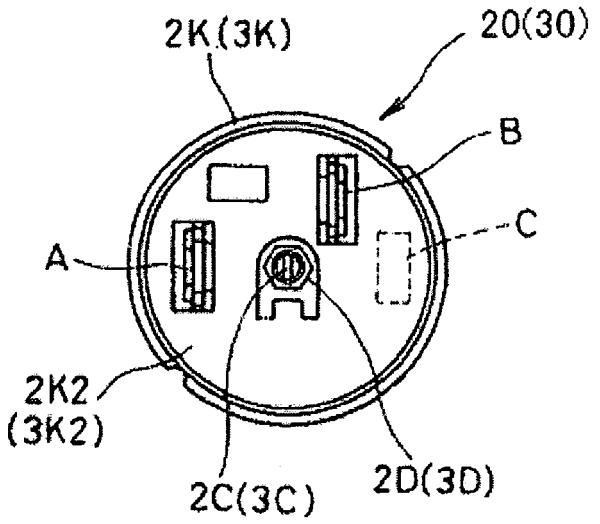

2K(3K)
20(30)
B
C
A
2K2
(3K2)
2C(3C)
2D(3D)

FIG. 12

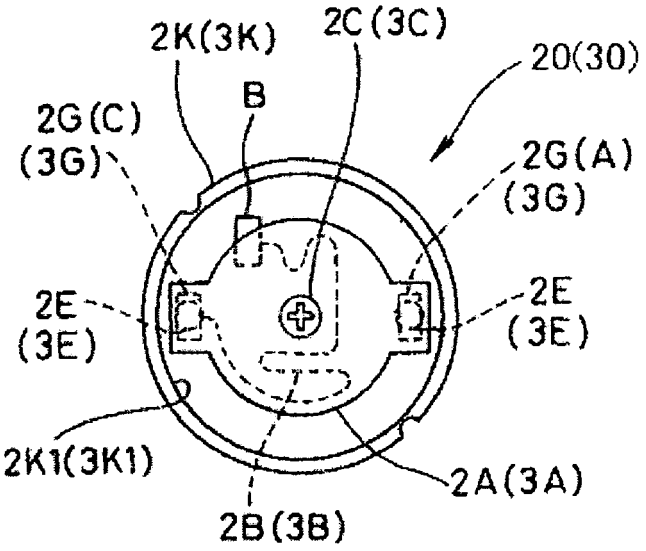

2K(3K)
2C(3C)
20(30)
B
2G(C)
(3G)
2G(A)
(3G)
2E
(3E)
2E
(3E)
2K1(3K1)
2A(3A)
2B(3B)

FIG. 13

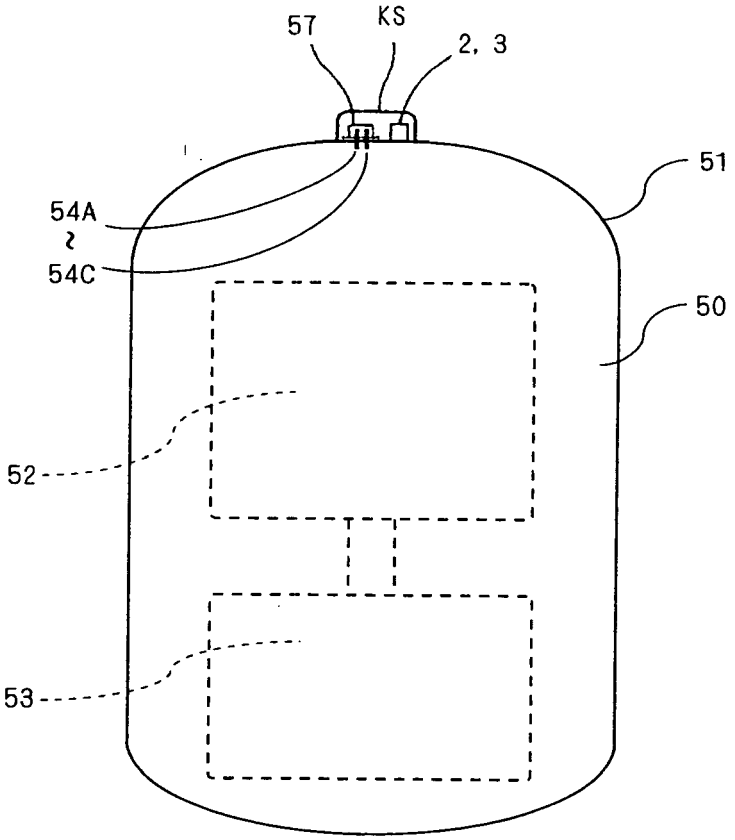


FIG. 14

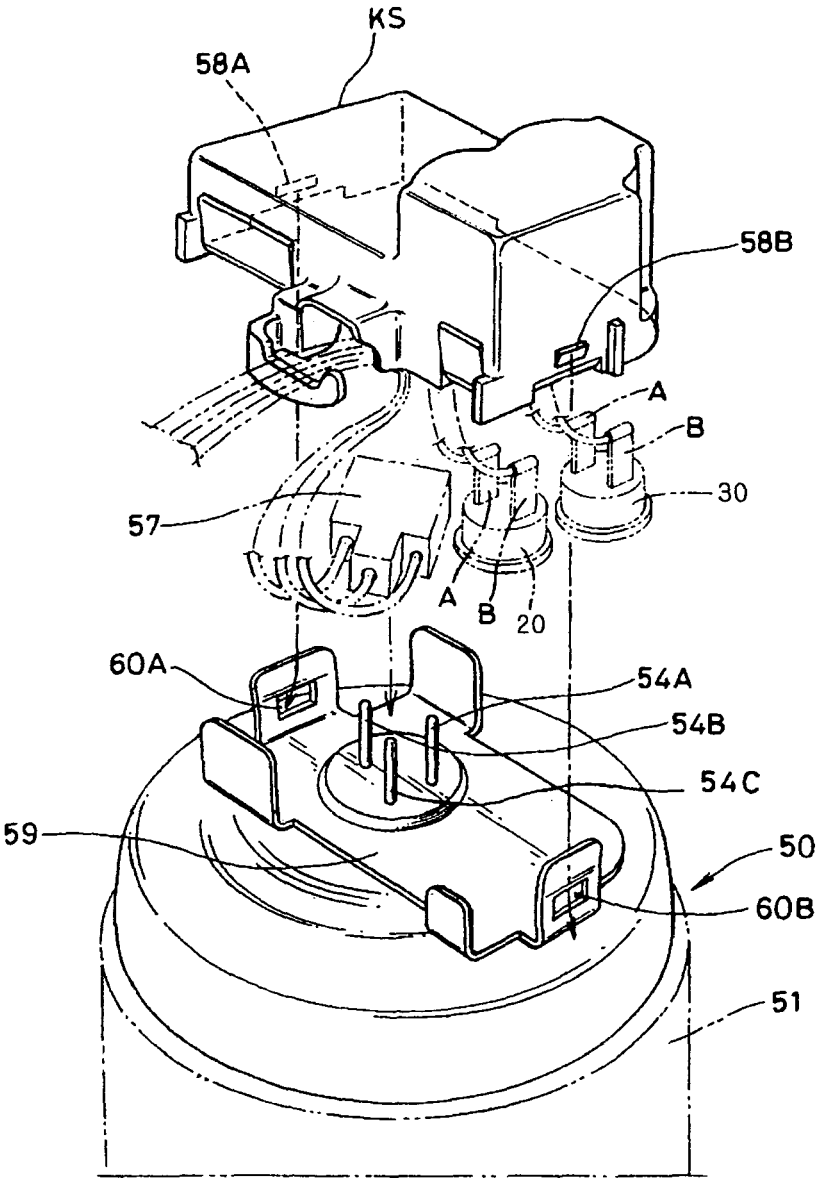


FIG. 15

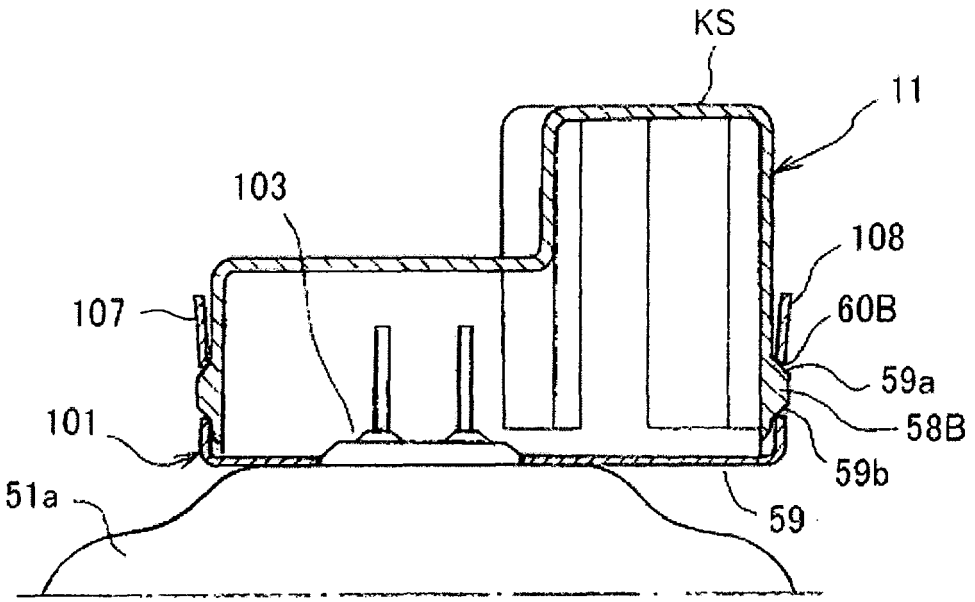


FIG. 16 (a)

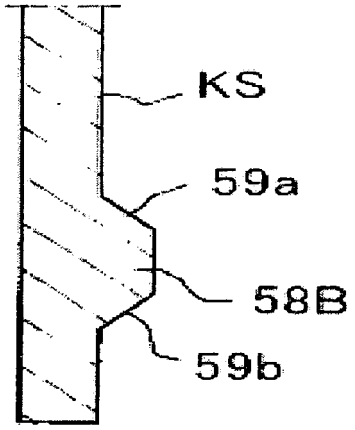
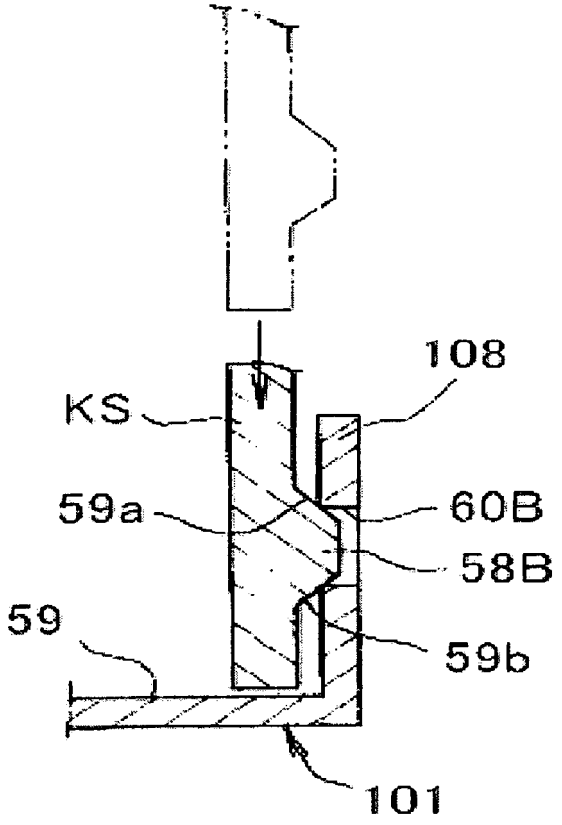


FIG. 16 (b)



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EUROPEAN SEARCH REPORT

Application Number
EP 09 01 0821

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	EP 0 858 091 A (THERMIK GERAETEBAU GMBH [DE]) 12 August 1998 (1998-08-12) * column 7, line 20 - column 8, line 27; figures 1,3 *	1,3,4 2	INV. H01H37/00 H01H37/54
Y	FR 2 698 963 A (JAEGER [FR]) 10 June 1994 (1994-06-10) * abstract; figure 7 *	2	
A	US 6 252 492 B1 (FRANK JAMES P [US] ET AL) 26 June 2001 (2001-06-26) * column 5, lines 14-53; figures 6,7 *	1	
D,A	JP 07 201262 A (SANYO ELECTRIC CO) 4 August 1995 (1995-08-04) * abstract *	1	

TECHNICAL FIELDS SEARCHED (IPC)

H01H
F25B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	24 November 2009	Findeli, Luc

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24-11-2009

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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- JP H07201262 B **[0004] [0007] [0010]**
- JP H09180612 B **[0005] [0006] [0007] [0008] [0010]**