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ISOTHERMAL ELECTROMAGNETIC APPARATUS

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2 Sheets-Sheet 1

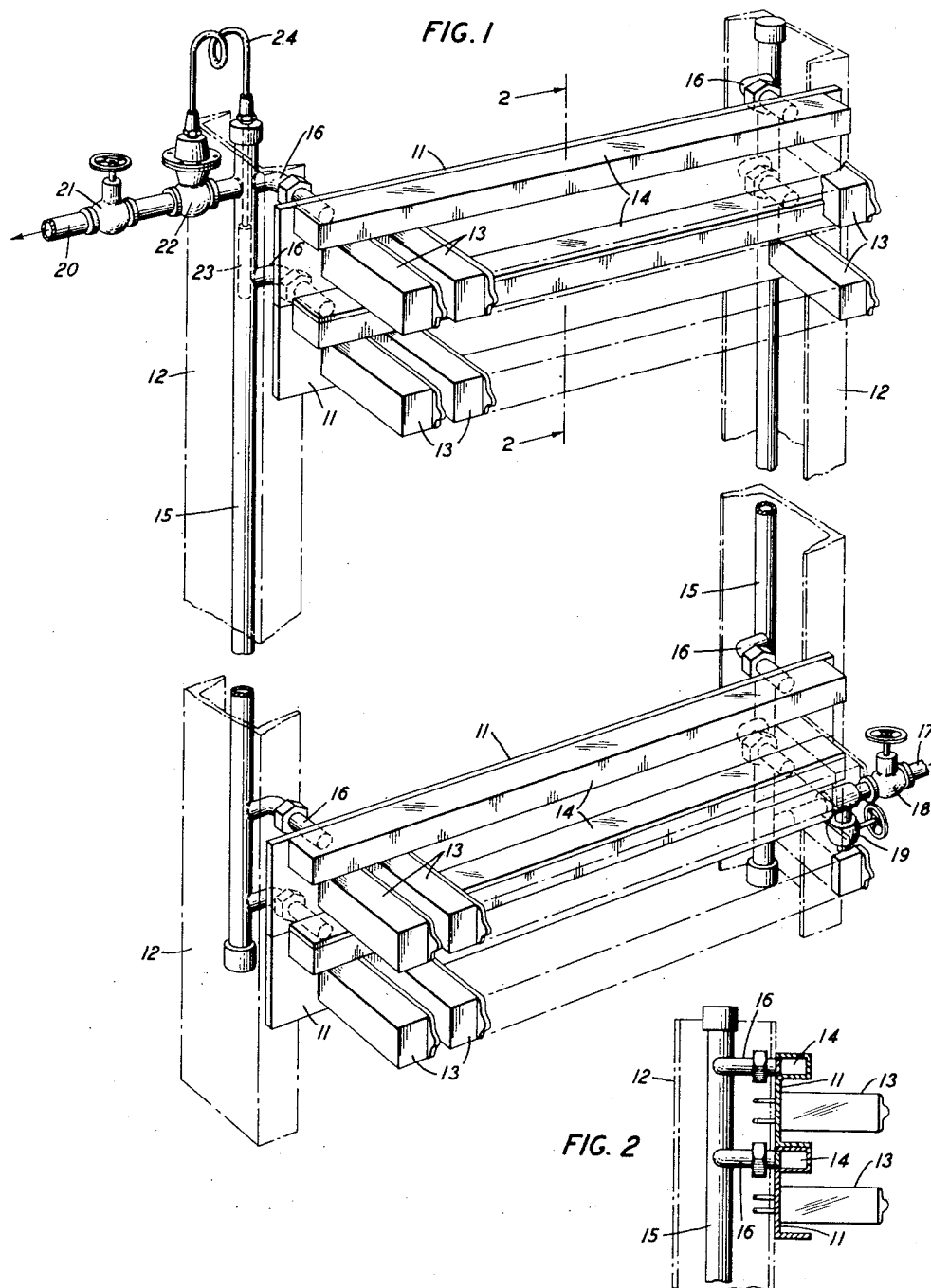


FIG. 2

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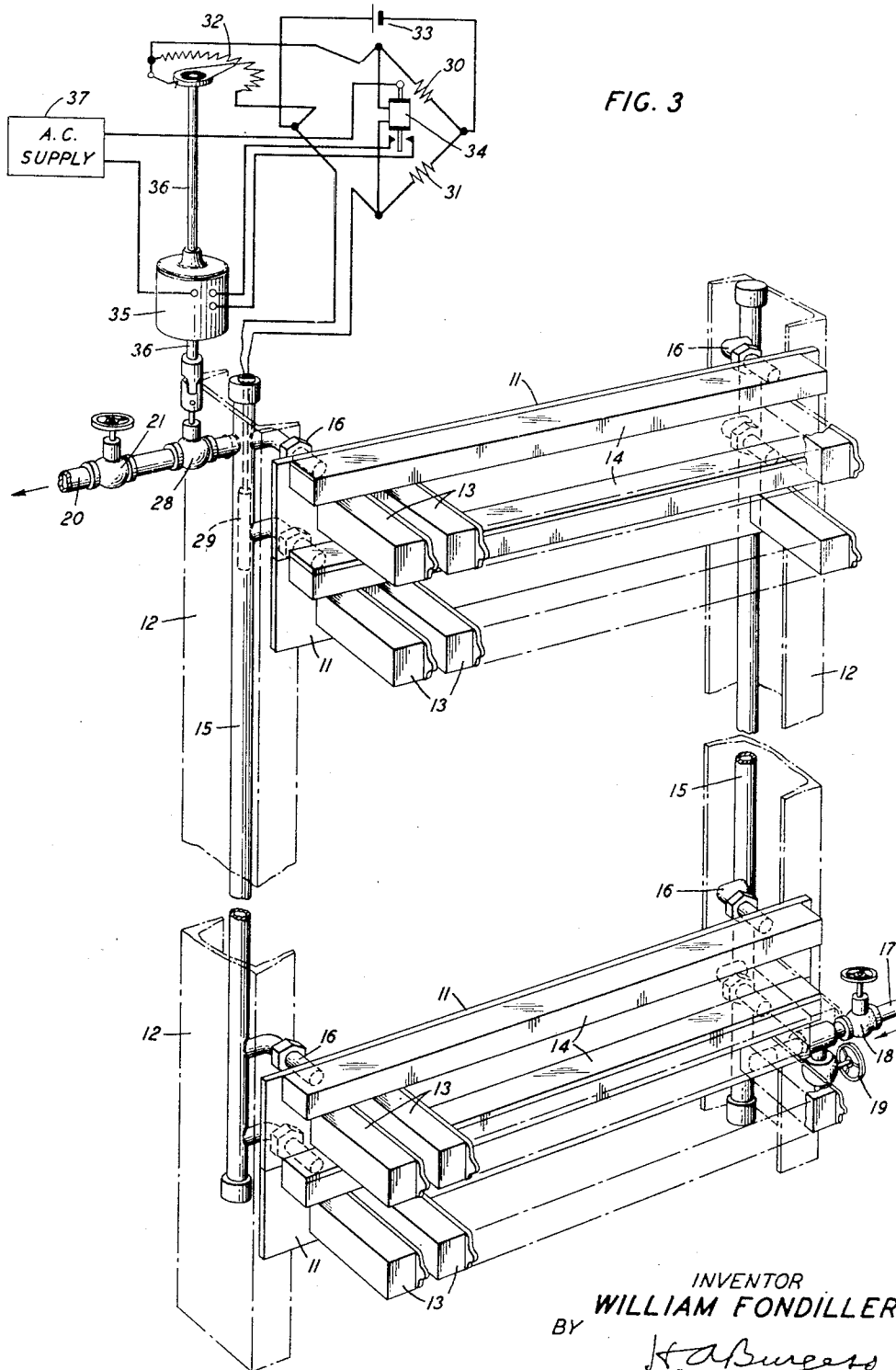
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## UNITED STATES PATENT OFFICE

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ISOTHERMAL ELECTROMAGNETIC  
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This invention relates generally to electromagnetic apparatus and more particularly to mounting structures therefor.

One object of the invention is to provide means for designing relays and other electromagnetically operated apparatus for improved performance.

Another object is to enable such apparatus to be designed for greater economy.

In the interest of both performance and economy, electromagnets for use in telephone central office equipment are usually made as small as practicable. There are, however, several considerations which usually require electromagnets to be made larger than they would be if performance and economy were the only considerations. In the first place, the temperature of the electromagnet due to heat generated in its operation should be limited so as not to make it difficult for a maintenance man to work on other equipment mounted nearby. In the second place, the temperature of the electromagnet under trouble conditions should be limited so that the electromagnet does not constitute a fire hazard. Finally, electromagnetically operated equipment in telephone central offices usually undergoes wide temperature variations which affect its performance adversely. The first two considerations have the effect of limiting the current which may be applied to the electromagnet windings to achieve the required magnetomotive force, while the third has the effect of requiring the electromagnets to be designed to produce sufficient magnetomotive force to assure successful operation under adverse conditions such as, for example, at elevated temperatures. All three have the effect of requiring more than the optimum number of turns in the electromagnet windings and, in order to provide an adequate heat radiating surface, relatively large electromagnets result.

In accordance with a principal feature of the present invention, the cores of the electromagnets of electromagnetically operated apparatus are maintained at a substantially constant low temperature. Heat is thereby conducted readily from the electromagnets themselves and they are thereby also maintained at a substantially constant low temperature. Thus, not only are winding current limitations relaxed but also the total number of ampere-turns necessary to assure successful operation under all circumstances is reduced. Smaller coils can be used and electromagnetically operated apparatus can be designed for optimum performance and economy.

In accordance with another feature of the invention, electromagnets are cooled by means of

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their mounting structure, which is composed principally of heat-conducting material and which includes conduits for a suitable cooling fluid located adjacent to the portions of the structure upon which the apparatus is mounted. The conduits are integral with the mounting structure to promote efficient cooling. The electromagnets are thereby refrigerated effectively without necessitating either a radical change in their design or the refrigeration of the entire room in which they are located, thus permitting optimum electromagnet design at a minimum of expense. Flexibility is also achieved, as different bays of equipment can readily be maintained at different fixed temperature levels.

In accordance with still another feature of the invention, a direct metallic heat-conducting path is provided between the core of each mounted electromagnet and a cooling fluid channel. Highly efficient heat conduction is thereby provided and the heat-generating electromagnets are cooled with a minimum effect on the surrounding air and apparatus.

Other objects and features of the invention will appear from a study of the following detailed description of several specific embodiments. In the drawings:

Fig. 1 shows a refrigerated relay rack the temperature of which is controlled by a diaphragm valve;

Fig. 2 is a cross-sectional detail of the rack shown in Fig. 1, taken along the line 2-2; and

Fig. 3 shows a refrigerated relay rack the temperature of which is controlled by a motor driven valve.

As has been noted, for purposes of both performance and economy it is desirable to make electromagnets for use in telephone central offices as well as those for power applications as small as practicable. Small relays, for example, are generally both faster and cheaper than larger relays and also take less mounting space. In order to design a relay of minimum size and cost and yet maintain the magnetomotive force required to operate the relay under the most adverse conditions, it is generally desirable to minimize the number of turns and the diameter of the wire with which the electromagnet coil is wound.

A number of factors enter into the design of such electromagnetic apparatus as relays which tend to increase the number of turns required in the electromagnet windings. As has been pointed out, two of these are temperature limits, above which the electromagnet and its associated apparatus should not be permitted to rise. In con-

tinuous operation, it is desirable that the maximum temperature of relays be such that a workman working on the mounting structure or framework will not be subjected to a temperature of more than about 150° F. It is thereby made certain that the framework can be worked on at all times without danger or serious discomfort to persons so employed. Translating frame temperature to coil temperature, it is generally found under existing mounting practices that this condition will obtain if the temperature of the winding does not go above 225° F.

The other temperature limitation in relay design is for trouble conditions, at which time it is essential that the electromagnet shall not constitute a fire hazard. In that connection, it is generally found that a relay will be safe if the temperature of the winding never exceeds 360° F. Above that temperature, insulation burns and more and more turns are short-circuited, causing both an operating failure and a fire hazard.

As has been noted briefly, top temperature limitations make it necessary to design electromagnets so that their operating currents never exceed the corresponding limits. In order to achieve the required magnetomotive force, the turns of the windings must be increased. The resulting relay is slower, more expensive, and more bulky than would otherwise be necessary.

The other factor in relay design which is of interest in connection with the present invention is the wide variation in temperatures to which the relays are likely to be subjected. In unattended telephone central offices, for example, the ambient temperature may reach as high as 120° F. and may go as low as 40° F. In continuously operated relays, the winding temperature may exceed the ambient temperature by as much as 125° F., with the mounting structure temperature at an intermediate value. Wide temperature variations are generally undesirable because of their adverse effect upon relay performance. As the winding temperature increases, the time required for the relay to operate also increases, until finally a point is reached where the relay will fail to operate. A relay must, therefore, generally be designed with a sufficient margin of magnetomotive force so that it will operate effectively not only at average operating temperatures but also at the highest temperatures to which it is likely to be subjected. Thus, more than the optimum number of ampere-turns must generally be provided, resulting both in a larger relay winding and in a larger operating current than would otherwise be necessary.

Tests have indicated that a large part of the heat generated in relay windings is conducted away through the magnetic cores to the supporting structure. In accordance with principal features of the present invention, as heretofore discussed, the relay and its mounting structure are both maintained at a substantially constant low temperature. A direct metallic heat-conducting path is provided between each winding core and a coolant channel. Heat is thereby readily conducted away from the relay windings, and the windings are maintained at a substantially constant temperature. The constant low temperature permits relays to be designed for optimum performance and economy and allowance for wide temperature variations is no longer required.

If, for example, the mounting plate temperature is reduced to about 40° F., and maintained within a few degrees of that value, substantial economies can be realized and more satisfactory operating conditions maintained. The upper cur-

rent limitations for relay windings are relaxed, since more heat can be dissipated in the windings without causing either the winding temperature or the frame temperature to exceed the predetermined limits. Smaller electromagnets can be employed, and relays will not only be cheaper and occupy less mounting space but also will require less magnetomotive force for operation, since the most adverse operating conditions have been ameliorated. Among the variables normally affecting electromagnet performance, there should be considered number of turns, winding resistance, battery voltage, length of circuit loop, and ambient temperature. All of these are allowed to vary within limits because of the cost of controlling all of them to exact values. Of these, the winding resistance experiences the most important change under extremes of operating conditions. If, for instance, the relay is designed to operate on the longest circuit loop, it is likely on short loops to receive an operating current which will heat it beyond the tolerable limit. The principles of the present invention permit the operation of the relay under the most adverse circuit and ambient temperature conditions to be as favorable as under the best conditions. In other words, the present temperature control method stabilizes relay performance and makes it independent of both operating and environmental conditions.

Magnetomotive force requirements for relays mounted in accordance with the present invention are also reduced by reason of the elimination of wide temperature variations. Since the relay temperature is held practically constant along with that of the mounting structure, there is no need for providing more ampere-turns than are required to operate the relay in the desired time interval. The reduction in magnetomotive force requirements made possible by the reduction and stabilization of the temperature of relay windings is advantageous in a number of respects. Not only are fewer turns required to achieve the required magnetomotive force, but also the reduction may, if desired, be turned into a saving in direct-current power through reduced operating currents. Since the alternating-current power required for refrigeration is much cheaper than direct-current power derived from storage batteries, a substantial reduction in cost can be realized in this manner. Other advantages made possible by the reduced magnetomotive force requirements can be realized to the greatest degree if a fairly large ampere-turn margin remains in the redesigned relay. The presence of a large margin of ampere-turns in excess of actual operating requirements makes operation faster and more reliable. Maintenance costs are reduced because very little readjustment of relays will be required.

In accordance with the features of the present invention, the above-noted improvements in electromagnet and relay design are made possible without introducing radical design requirements and without reducing the room temperature appreciably. As previously noted, conduits integral with the supporting structure are provided adjacent to the portions of the structure upon which the relays or other electromagnetically operated equipment are mounted. The conduits carry a suitable refrigerant and, in the cooling fluid circuit, temperature-sensitive means is provided to maintain both the mounting and the apparatus temperatures substantially constant by controlling the flow of the refrigerant. Pipes carrying

the refrigerant are heat-insulated at all points except where they come into contact with the mounting elements. The advantage of refrigerating only the mounting units instead of the entire equipment room is that a minimum amount of power is required, since the heat transfer from the relay core and mounting will take place at the point of maximum temperature difference and by the most effective heat transfer method, metallic conduction. Individual refrigerating units could be designed for each bay of equipment, making it possible to maintain different fixed temperatures for different units, depending on the results desired.

When a bay of relay or other electromagnetically operated equipment is cooled in accordance with the principles of the present invention, care should be taken to maintain the temperature of the refrigerated parts higher than a certain critical temperature, i. e., the dew point. The dew point is the temperature at which moisture will begin to condense at a given air temperature, barometric pressure, and relative humidity. From a study of psychrometric tables, it is apparent that lowering the temperature of an object appreciably below the ambient temperature will cause condensation unless the relative humidity is kept at a low figure. For example, at a room temperature of 80° F., a barometric pressure 30 inches of mercury, and a relative humidity of 80 per cent, the dew point is 73° F. This will not allow a material margin for the cooling of operating parts by refrigeration. However, if the relative humidity is reduced to 15 per cent, other conditions remaining the same, the dew point drops to 28° F. This will allow cooling approximately 50 degrees below room temperature without causing condensation.

The winding temperature will, in general, greatly exceed the ambient temperature and can be disregarded from the standpoint of condensation. The temperature of the equipment, which, in accordance with the present invention, is maintained substantially constant by thermostatic control of the refrigeration unit, should always be greater than the dew point. In practice, it need exceed the dew point by only 2 or 3° F. This can readily be accomplished with widely varying ambient temperatures by controlling the humidity. Since, in modern installations, electromagnets are enclosed for dust protection in a way which easily lends itself to chemical dessication of the air, the relative humidity can be kept at 15 per cent or less with little difficulty. Under enclosed conditions, the heat radiation from relays is impaired, tending to raise their operating temperatures and thus further enhancing the merit of cooling them in accordance with the teachings of the present invention.

Still another advantage which may be derived from the employment of features of the present invention is that a "solder-through" insulating enamel may be used on the relay windings. When such an enamel is used, it need not be scraped away for connections to be made to the windings. It has been found, however, that such enamel deteriorates at high temperatures, and the heat generated in relay windings usually prohibits its use thereon. If the winding temperatures are, in accordance with the present invention, maintained at a sufficiently low level, a suitable "solder-through" enamel may be used, with all the accompanying benefits of economy and simplicity.

A specific embodiment of the invention is illustrated in Fig. 1. Referring to Fig. 1, a refrigerated

relay rack is shown which comprises a large number of mounting plates 11 supported by a pair of vertical channels 12. Mounting plates 11 are mounted parallel to and in contact with each other and extend substantially horizontally. While only a few such plates 11 are shown for reasons of clarity, in practical installations they will normally extend from the bottom to the top of the bay of which they form a part. A large number of relays 13 are mounted in rows on mounting plates 11 and extend substantially perpendicularly thereto.

A refrigerant-carrying conduit 14 is provided in each mounting plate 11 parallel and closely adjacent to the row of relays mounted thereon. Each conduit 14 is shown, by way of example, as being rectangular in cross section and is preferably fabricated as part of the mounting plate 11 itself. At both ends of each conduit 14, openings are provided in the base of mounting plate 11 for the entry and exit of the coolant.

The conduits 14 are connected substantially in parallel by a pair of vertical pipes 15, which are located to the rear of mounting plates 11 within the respective channels 12. At regularly spaced intervals, the vertical pipes 15 are connected to conduits 14 by short connecting pipes 16. Connecting pipes 16 enter conduits 14 through the openings provided at each end in mounting plates 11. Vertical pipes 15 and connecting pipes 16 are provided with a suitable heat-insulating covering to avoid unnecessary cooling of the surrounding air, and each vertical pipe 15 is capped at both top and bottom.

A suitable refrigerant is applied to the piping-conduit system at the lower right-hand corner of the structure. An input pipe 17 is tapped into the right-hand vertical pipe 15 below the lowermost mounting plate 11. Included along input pipe 17 are a cut-off valve 18 and a drain valve 19, drain valve 19 being situated between cut-off valve 18 and vertical pipe 15. Egress for the refrigerant is provided by an output pipe 20 at the upper left-hand corner of the structure. Output pipe 20 is tapped into the left-hand vertical pipe 15 above the uppermost mounting plate 11. A cut-off valve 21 is provided in output pipe 20, which, along with cut-off valve 18, may be used to isolate the refrigerating system for the particular bay of equipment from those of the adjoining bays.

The refrigerant, which may, by way of example, be brine, is supplied under pressure and is thereby circulated through the conduits 14. A cross section of a portion of the Fig. 1 structure appears in Fig. 2, showing details of the structure of mounting plates 11 and conduits 14 and the mode of connection between vertical pipes 15 and conduits 14.

The entire relay mounting structure is maintained at a substantially constant temperature by controlling the flow of the cooling fluid. A thermostatically controlled diaphragm valve 22 is provided in output pipe 20 between cut-off valve 21 and vertical pipe 15. A temperature-sensitive element 23 is connected to diaphragm valve 22 by suitable tubing 24 and is situated within the top portion of the left-hand vertical pipe 15. Sensitive element 23 is filled with a volatile liquid, and as the temperature of the refrigerant surrounding element 23 rises, the liquid volatilizes, thus increasing the pressure through tube 24 and opening diaphragm valve 22. As the temperature of the refrigerant decreases, pressure in tube 24 is reduced and valve 22 is closed.

The positions of sensitive element 23 within the

uppermost portion of the left-hand vertical pipe 15 and of diaphragm valve at the output terminal of the system insure the most effective operation of the refrigerating system. The temperature of the refrigerant will be increased to the greatest extent at the output end of the system, and changes in the flow of the refrigerant will, therefore, accurately reflect changes in the refrigeration requirements imposed by the condition of the relays 13.

Another embodiment of the invention is illustrated in Fig. 3. The relay rack and the incorporated refrigeration equipment are substantially the same as in the Fig. 1 system and will not be redescribed. The principal difference resides in the thermostatic control mechanism, which may be used as one alternative to that shown in Fig. 1.

In Fig. 3, the flow of the refrigerant is controlled by a motor-driven valve 28, which is located in series with output pipe 20 between cut-off valve 21 and the left-hand vertical pipe 15. A temperature-sensitive element 29, corresponding to temperature-sensitive element 23 in Fig. 1, is located within the upper portion of the left-hand vertical pipe 15 and surrounded by the refrigerant. Sensitive element 29 differs from sensitive element 23 in Fig. 1, however, in that it contains a temperature-sensitive electrical resistance, i. e., a resistor the resistance of which either increases or decreases with temperature. Leads connected to the ends of the temperature-sensitive resistance are insulated and are brought out through the cap at the top of the left-hand pipe 15. From there, the leads are used to connect the temperature-sensitive resistance into a bridge circuit, the other three arms of which comprise two resistors 30 and 31 and the resistance arm of a slide-wire rheostat 32. A battery or other suitable direct-current source 33 is connected between two opposite corners of the bridge circuit, and a polarized relay 34 is connected between the other two.

A small series-type valve-operating motor 35 is provided with a shaft 36, which is, in turn, coupled both to valve 28 and the contact arm of rheostat 32. The resistance arm of rheostat is in the form of an arc, and the effective resistance presented by it to the bridge circuit is controlled by the rotation of shaft 36. Motor 35 is provided with a pair of field coils which are connected so that, when energized, each turns the armature in the opposite direction from the other. Current is supplied to motor 35 from an alternating-current source 37, one side of which is connected to one side of both field coils and the other side of which is connected to the other side of one coil or the other, depending on the direction of the unbalance of the bridge circuit.

Polarized relay 34 includes, as its principal operating part, a three-terminal switch. The center terminal is connected to a contact spring and to the previously-mentioned other side of alternating-current source 37. The other two terminals are connected to contacts and to respective field coils of motor 35.

When the temperature of the refrigerant surrounding sensitive element 29 departs from a predetermined value, the bridge circuit becomes unbalanced, causing relay 34 to operate. When the refrigerant temperature is too high, the direction of bridge unbalance causes relay 34 to complete the circuit of motor 35 which turns the armature and shaft 36 in the direction to open valve 33. The flow of cooling fluid is thus increased, and the bridge is balanced once more by the action of shaft 36 in adjusting the resistance presented by

rheostat 32. When the temperature of the refrigerant is too low, the operation is reversed. The outer contact of relay 34 is closed, and the armature of motor 35 is caused to turn in the opposite direction. Valve 28 is closed, and the action of rheostat 32 tends to rebalance the bridge when the correct valve opening is reached.

It will be observed that the advantages of the present invention insofar as improved relay performance is concerned may be secured by redesigning the relays themselves so that the cooling fluid passes through conduits in the core of each electromagnet. The mounting structures which have been disclosed are, however, preferable since they are relatively simple and inexpensive, and permit conventional relay design principles to be employed.

It is to be understood that the above-described arrangements are illustrative of the application of the principles of the invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. An isothermal relay rack which comprises, in combination, a pair of supporting members, a plurality of substantially parallel hollow heat-conducting cross-members extending between said supporting members, a plurality of substantially parallel heat-conducting mounting plates each secured between and in contact with a pair of successive hollow cross-members, means to secure a plurality of electrical relays to each of said mounting plates with a direct heat-conducting path between the core of each relay and the nearest one of said hollow cross-members, means to circulate cooling fluid through said hollow cross-members to reduce the temperature of said mounting plates to a predetermined level, and means to maintain the temperature of said mounting plates accurately at said predetermined level by regulating the flow of cooling fluid.

2. An isothermal relay rack which comprises, in combination, a pair of vertical supporting members, a plurality of horizontal hollow heat-conducting cross-members extending between said supporting members, a heat-conducting mounting plate facing at right angles to both said supporting members and said cross-members secured between and in contact with each successive pair of cross-members, means to secure a horizontal layer of electrical relays to the same side of each said mounting plate with a direct heat-conducting path between the core of each relay and at least one of said hollow cross-members, means to circulate cooling fluid through said hollow cross-members to reduce the temperature of said mounting plates to a predetermined level, and means to maintain the temperature of said mounting plates accurately at said predetermined level by regulating the flow of cooling fluid.

3. An isothermal relay rack which comprises, in combination, a pair of supporting members, a plurality of heat-conducting mounting plates mounted edge to edge, each of said mounting plates extending between said supporting members, a plurality of substantially parallel heat-conducting conduits extending between said supporting members, each of said conduits being secured to one side of a respective one of said mounting plates, means to secure a plurality of electrical relays to said mounting plates in substantially parallel rows with a direct heat-conducting path between the core of each relay and

at least one of said conduits, one row to each of said mounting plates, means to circulate cooling fluid through said conduits to reduce the temperature of said mounting plates to a predetermined level, and means to maintain the temperature of said mounting plates accurately at said predetermined level by regulating the flow of cooling fluid.

4. An isothermal relay rack in accordance with claim 3 in which all of said conduits are secured to the same side of said mounting plates and said relay securing means is adapted to secure the relays to the same side of said mounting plates as said conduits, with the terminals of the relays projecting through to the other side of said mounting plates.

5. An isothermal relay rack which comprises, in combination, a pair of supporting members, a plurality of substantially parallel hollow heat-conducting cross-members extending between said supporting members, a plurality of substantially parallel heat-conducting mounting plates each secured between and in contact with a pair of successive hollow cross-members, means to secure a plurality of electrical relays to each of said mounting plates with a direct heat-conducting path between the core of each relay and at least one of said hollow cross-members, means to circulate cooling fluid through said hollow cross-members to reduce the temperature of the rack to a predetermined level, and means including a temperature-sensitive element thermally coupled to said hollow cross-members to maintain the temperature of the rack accurately at said predetermined level by regulating the flow of cooling fluid.

6. An isothermal relay rack which comprises, in combination, a pair of supporting members, a plurality of substantially parallel hollow heat-conducting cross-members extending between said supporting members, a plurality of substantially parallel heat-conducting mounting plates each secured between and in contact with a pair of successive hollow cross-members, means to secure a plurality of electrical relays to each of said mounting plates with a direct heat-conducting path between the core of each relay and at least one of said hollow cross-members, a pair of conduits connecting said hollow cross-members substantially in parallel, means to circulate cooling fluid through said hollow cross-members and said conduits to reduce the temperature of the rack to a predetermined level, a valve at one side of said hollow cross-members to regulate the flow of cooling fluid, and means including a temperature-sensitive element thermally coupled to said hollow cross-members to maintain the temperature of the rack accurately at said predetermined level by controlling the opening in said valve.

7. An isothermal relay rack which comprises, in combination, a pair of supporting members, a plurality of substantially parallel hollow heat-conducting cross-members extending between said supporting members, a plurality of substantially parallel heat-conducting mounting plates each secured between and in contact with a pair of successive hollow cross-members, means to secure a plurality of electrical relays to each of said mounting plates with a direct heat-conducting path between the core of each relay and at least one of said hollow cross-members, a pair of conduits connecting said hollow cross-members substantially in parallel, means to circulate cooling fluid through said hollow cross-members and

said conduits to reduce the temperature of the rack to a predetermined level, and means including a temperature-sensitive element thermally coupled to said hollow cross-members to increase the flow of cooling fluid whenever the temperature of the rack rises above said predetermined level and to decrease the flow of cooling fluid whenever the temperature of the rack falls below said predetermined level.

8. An isothermal relay rack which comprises, in combination, a pair of supporting members, a plurality of substantially parallel hollow heat-conducting cross-members extending between said supporting members, a plurality of substantially parallel heat-conducting mounting plates each secured between and in contact with a pair of successive hollow cross-members, means to secure a plurality of electrical relays to each of said mounting plates with a direct heat-conducting path between the core of each relay and at least one of said hollow cross-members, a pair of conduits connecting said hollow cross-members substantially in parallel, means to circulate cooling fluid through said hollow cross-members and said conduits to reduce the temperature of the rack to a predetermined level, a diaphragm valve at one side of said hollow cross-members to regulate the flow of cooling fluid, and means to maintain the temperature of the rack accurately at said predetermined level by controlling the opening in said valve comprising a temperature-sensitive element in the form of a container of volatile liquid thermally coupled to said hollow cross-members and coupling means between said temperature-sensitive element and said valve, whereby the opening in said valve varies with the gas pressure produced by said temperature-sensitive element.

9. An isothermal relay rack which comprises, in combination, a pair of supporting members, a plurality of substantially parallel hollow heat-conducting cross-members extending between said supporting members, a plurality of substantially parallel heat-conducting mounting plates each secured between and in contact with a pair of successive hollow cross-members, means to secure a plurality of electrical relays to each of said mounting plates with a direct heat-conducting path between the core of each relay and at least one of said hollow cross-members, a pair of conduits connecting said hollow cross-members substantially in parallel, means to circulate cooling fluid through said hollow cross-members and said conduits to reduce the temperature of the rack to a predetermined level, a valve at one side of said hollow cross-members to regulate the flow of cooling fluid, and means to maintain the temperature of the rack accurately at said predetermined level by controlling the opening in said valve comprising a temperature-sensitive element in the form of an electrical resistor having a resistance which varies with temperature, an electric valve motor controlled by said temperature-sensitive element, and mechanical coupling means between said valve motor and said valve, whereby the opening in said valve varies with the resistance of said temperature-sensitive element.

10. An isothermal relay rack in accordance with claim 9 in which said temperature-sensitive element is connected as one of the resistance arms of a bridge circuit which is unbalanced in one direction when the temperature of the rack is above said predetermined level and is unbalanced in the other direction when the tem-

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perature of the rack is below said predetermined level.

11. An isothermal relay rack which comprises, in combination, a pair of supporting members, a plurality of substantially parallel flat rectangular heat-conducting mounting plates extending between said supporting members, each of said mounting plates having a hollow raised portion on one side thereof forming a conduit extending substantially the entire distance between said supporting members, means to secure a row of electrical relays to each of said mounting plates with a direct heat-conducting path between the core of each relay and the mounting plate to which it is secured, a pair of conduits extending along respective ones of said supporting members, separate connections from one end of the hollow raised portion of each of said mounting plates to one of said pair of conduits, separate connections from the other end of the hollow raised portion of each of said mounting plates to the other of said pair of conduits, means to circulate cooling fluid from one end of one of said pair of conduits to the correspondingly opposite end of the other of said pair of conduits,

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whereby cooling fluid is circulated through the hollow raised portion of each of said mounting plates and the temperature of said mounting plates is reduced to a predetermined value, and means to maintain the temperature of said mounting plates accurately to said predetermined level by regulating the flow of cooling fluid.

12. An isothermal relay rack in accordance with claim 11 in which all of the hollow raised portions of said mounting plates are on the opposite sides of said mounting plates from said pair of conduits.

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