

[54] **SWITCHGEAR HAVING HEAT PIPES INCORPORATED IN THE DISCONNECTING STRUCTURES AND POWER CONDUCTORS**

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[52] U.S. Cl. .... **200/166 K**, 165/105  
 [51] Int. Cl. .... **H01h 1/62**  
 [58] Field of Search ..... 174/15 BH; 165/105; 200/166 K; 317/100

[56] **References Cited**

**UNITED STATES PATENTS**

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[57] **ABSTRACT**

The primary disconnecting contacts of a metal-clad switchgear unit has at least one, and preferably two, heat pipes incorporated in the structure thereof. The use of one or more heat pipes conducts the heat generated adjacent the point of contact separations, and removes it to a remote area, at which heat sinks may be readily provided to more easily dissipate the heat generated at the separable contact structure. The advantage results that a cheaper material, such as aluminum, of small cross-sectional area, may be utilized instead of a solid copper disconnecting contact structure or higher currents may be carried where large conductors are restricted by available space.

Suitable finned structures may be associated with the one or more heat pipes to serve as heat-sink structures.

Also, where power conductors pass through locations, where radial heat flow is impeded, a heat pipe may advantageously be incorporated therein.

**8 Claims, 11 Drawing Figures**

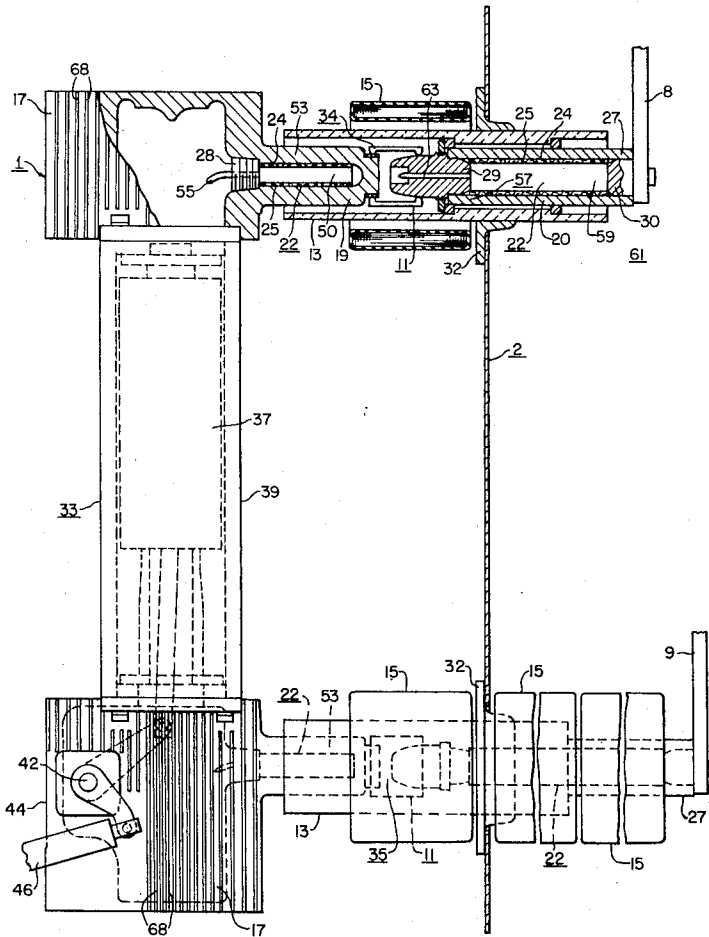
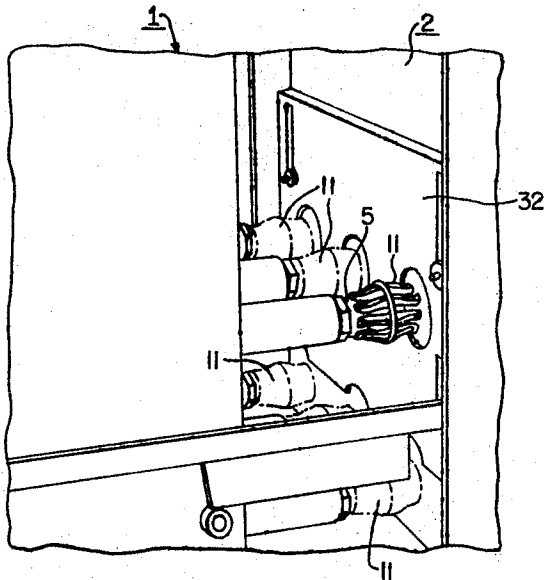
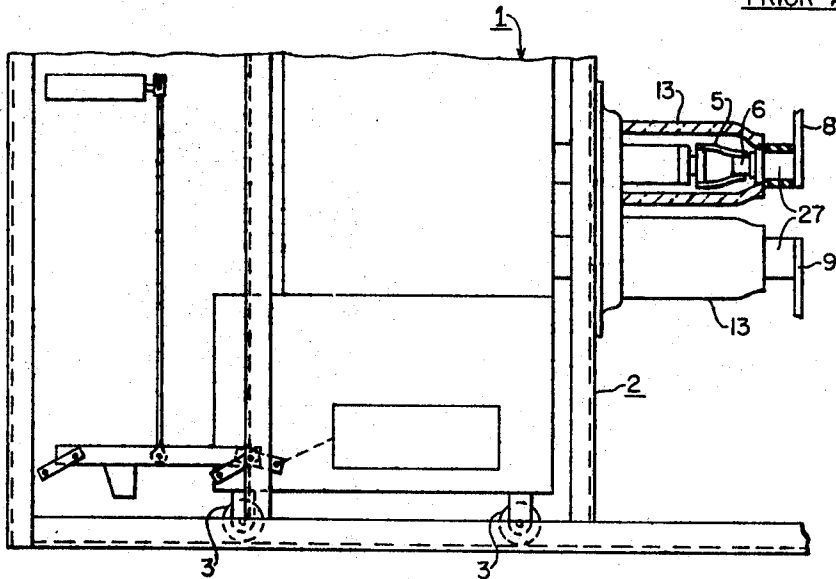


FIG. 1.

PRIOR ART

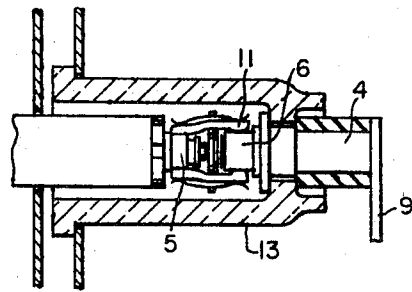


PRIOR ART

FIG. 2.

WITNESSES

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PRIOR ART

FIG. 3.

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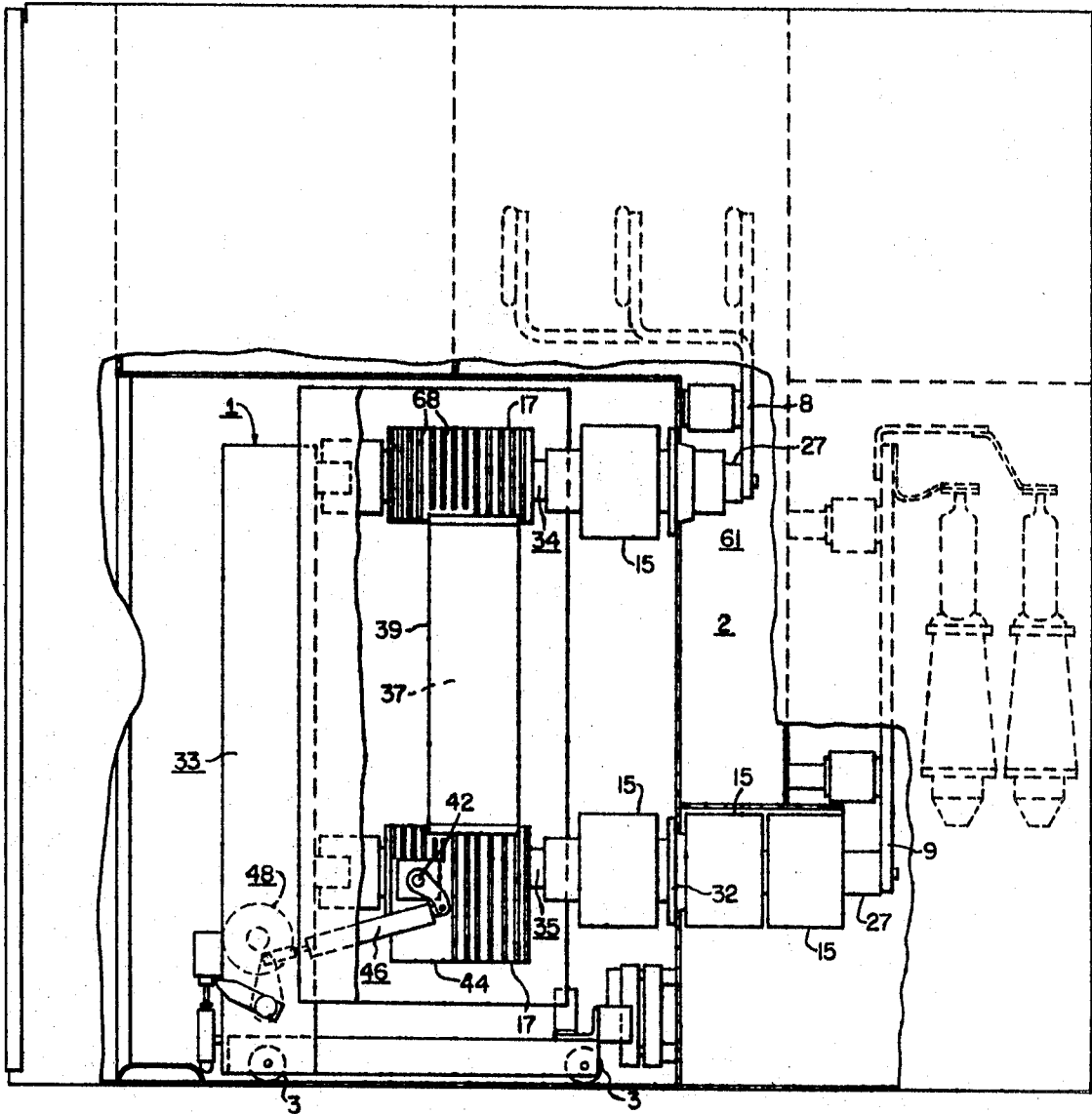


FIG. 4.

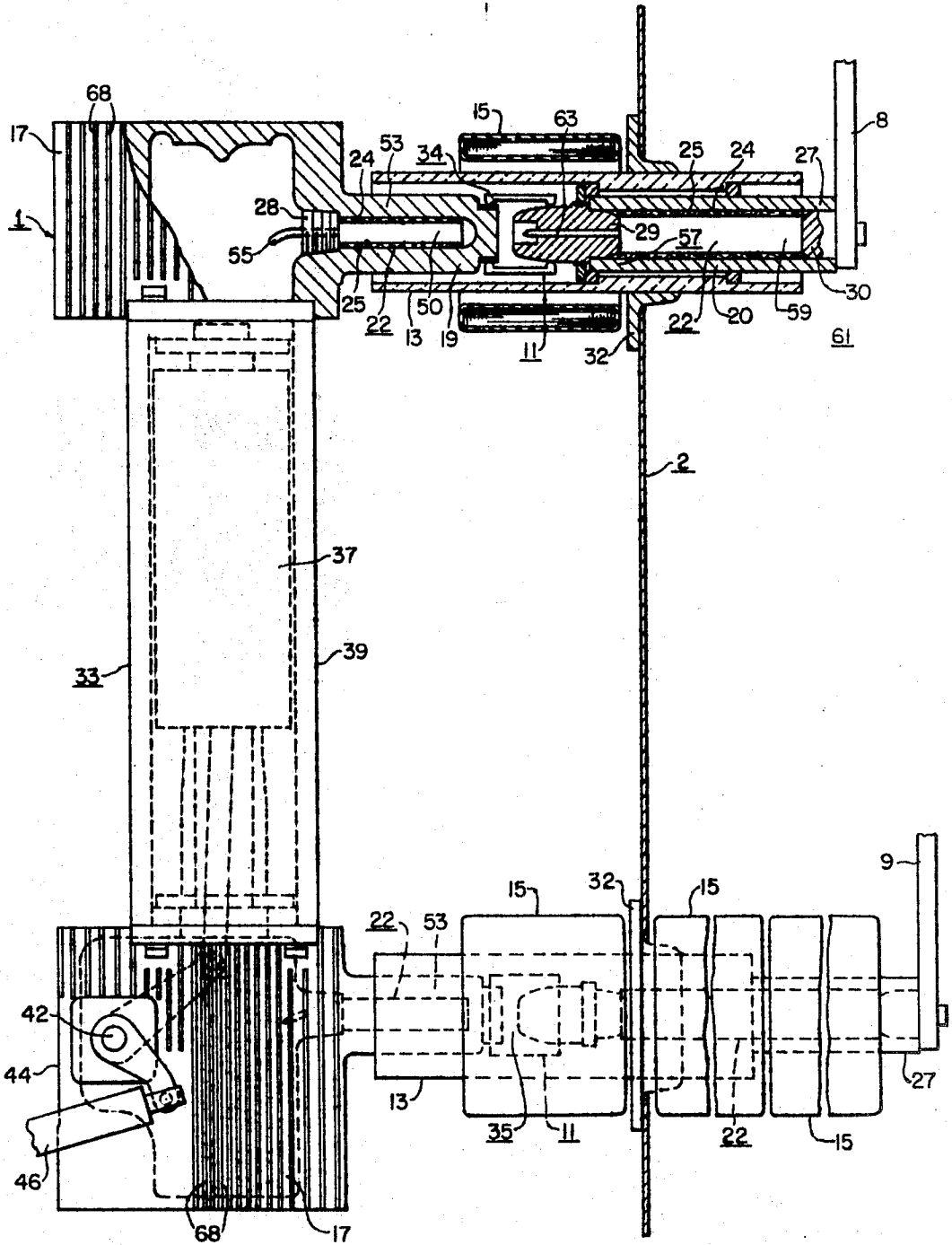


FIG. 5.

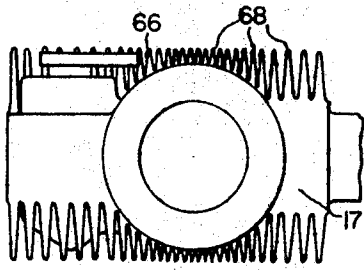


FIG. 6.

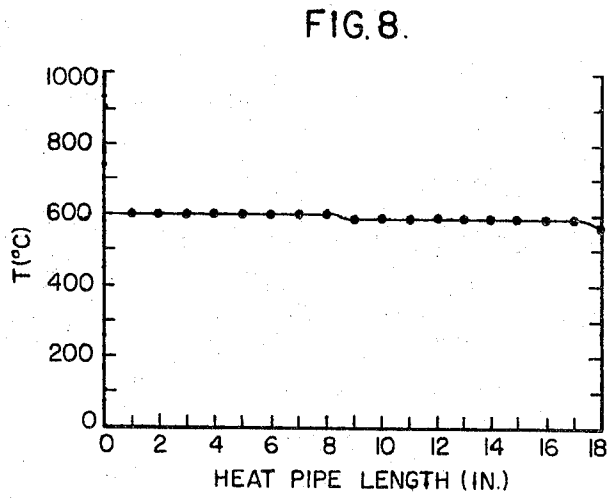


FIG. 8.

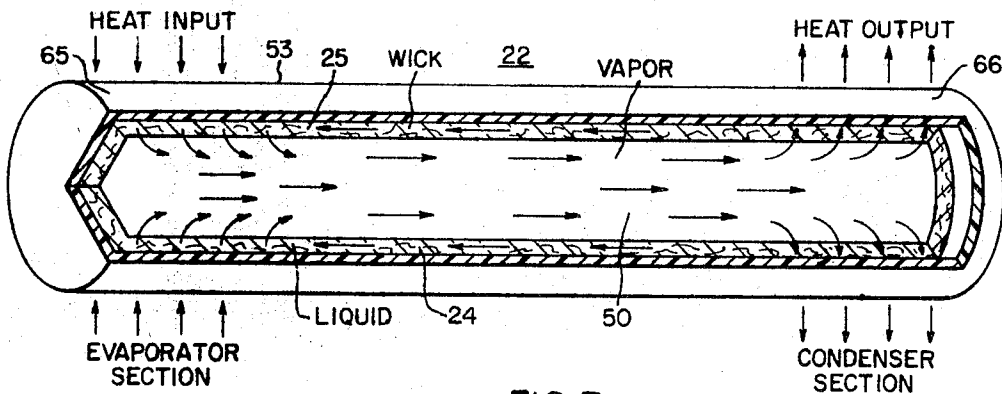


FIG. 7.

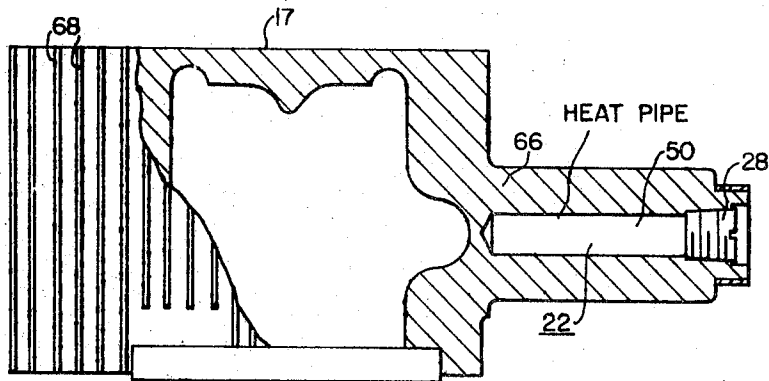


FIG. 9.

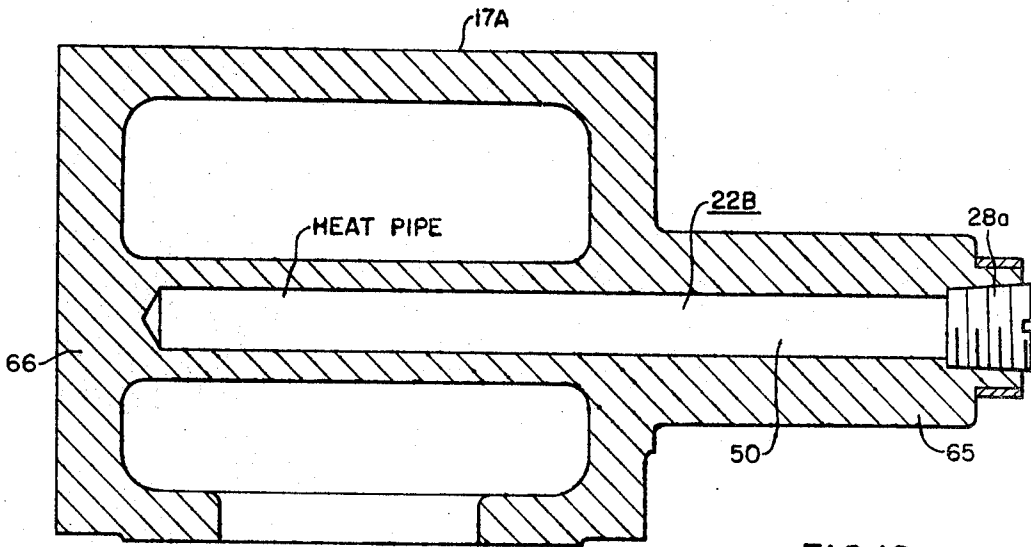


FIG. 10.

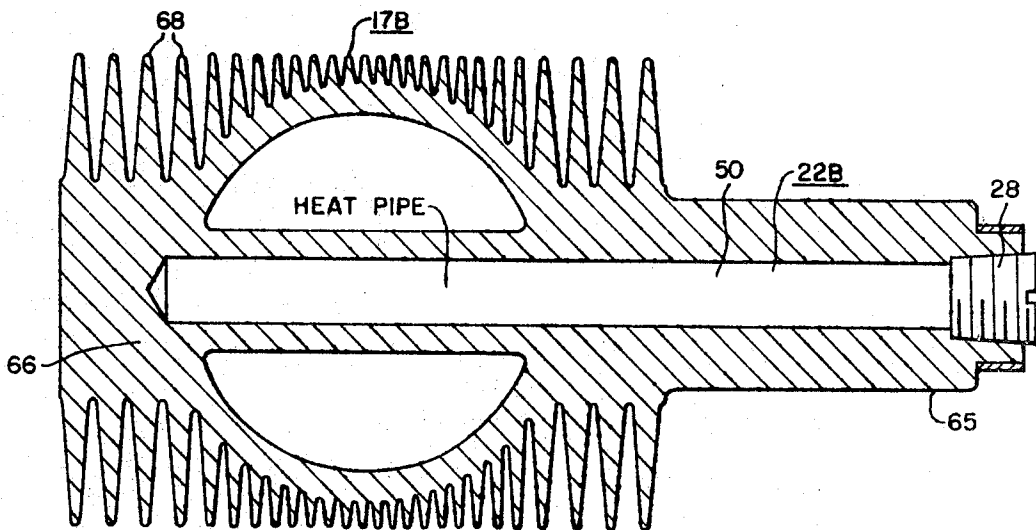


FIG. 11.

## SWITCHGEAR HAVING HEAT PIPES INCORPORATED IN THE DISCONNECTING STRUCTURES AND POWER CONDUCTORS

### CROSS-REFERENCES TO RELATED APPLICATIONS

Applicant is not aware of any related applications pertinent to the present invention. However, U.S. Pat. application filed Nov. 18, 1968, Ser. No. 776,518, now U.S. Pat. 3,541,487, issued Nov. 17, 1970 to Merrill G. Leonard, entitled "Electrical Winding Having Heat Exchangers Between Layers of the Winding for Cooling the Windings," illustrates a heat-pipe application to a transformer winding structure. In addition, attention is directed to case filed Sept. 30, 1969, Ser. No. 862,281 by Frank G. Arcella and Russell Brumm, entitled "Battery Heater," and also assigned to the assignee of the instant application. Also, attention is directed to patent application, filed Jan. 21, 1970 Ser. No. 4,493 by Charles M. Cleaveland directed to somewhat similar subject matter.

### BACKGROUND OF THE INVENTION

Getting the heat out of the finger clusters and the relatively small power conductors associated with the primary disconnecting contact structure of circuit breakers, particularly metal-clad circuit breakers, is particularly difficult in view of the fact that, generally, a surrounding porcelain bushing, commonly known as a "bottle," or other insulating bushing structure, together with the surrounding current transformer, limits the radial heat flow. As a result, according to prior art structures, the mode of heat transfer reaches its limit when the terminal studs, or power conductors, associated with the aforesaid primary disconnecting contact structure, are formed of solid copper and are as large in diameter as possible.

It is, therefore, a difficult problem encountered by designers to provide a suitable structure for dissipating the considerable amounts of heat, which are generated at the separable contact structure of a primary disconnecting switch associated with metal-clad switchgear.

Also, where a power conductor passes through a restricted location, where lateral heat flow is impeded, its temperature will be raised considerably. This has necessitated the use of heavy expensive large cross-sectional conductors.

### SUMMARY OF THE INVENTION

According to a preferred embodiment of the present invention, there is associated with either one or both separable contact structures of a primary disconnecting switch, associated with metal-clad switchgear, a single heat pipe, or more preferably, two heat pipes, which serve to rapidly transmit the heat generated adjacent the separable contact structure to a remote part, where suitable heat sinks may be provided, in the form of finned castings, or bus-bar risers, to permit rapid dissipation of the heat generated at the separable contact structure.

The invention also contemplates the use of a heat pipe disposed interiorly of a power conductor passing through a location, where lateral heat flow is impeded.

Accordingly, a general object of the present invention is to provide an improved switchgear unit with improved means for heat dissipation.

A more specific object of the present invention is to provide an improved disconnecting switch structure for a circuit breaker incorporating at least one heat pipe interiorly thereof.

Still a further object of the present invention is to provide cooperable, separable primary disconnecting contact structures for a metal-clad switchgear unit in which each of the contact structures has incorporated therewith a heat pipe to transmit the flow of heat from the point of generation at the separable contact structure to a remote point, where it can be rapidly dissipated at a suitably-provided heat sink.

Another object is to associate a heat pipe with a power conductor.

Further objects and advantages will readily become apparent upon reading the following specification, taken in conjunction with the drawings.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a semi-diagrammatic side elevational view of a circuit-breaker structure, of the metal-clad type, indicating generally the location and use of the primary disconnecting contact structure, and the power conductors leading thereto;

FIG. 2 is a perspective view of three finger clusters associated with prior art primary disconnecting contact structure of metal-clad switchgear units;

FIG. 3 is a fragmentary vertical sectional view taken through a typical primary disconnecting contact structure of the type set forth in FIGS. 1 and 2, and illustrating the power conductor locations;

FIG. 4 illustrates a metal-clad switchgear unit incorporating the improved primary disconnecting contact structures and power conductors of the present invention;

FIG. 5 illustrates, fragmentarily, in an enlarged fashion, a vertical sectional view taken through the upper primary disconnecting contact structure and power conductor of the present invention, illustrating the two heat pipes involved;

FIG. 6 is a bottom end view of the lower end of the drawout interrupter unit, illustrating the finned heat sink construction associated with the lower heat pipe of the lower movable primary disconnecting switch;

FIG. 7 is a partial sectional view illustrating the details of the heat exchanger, or heat pipe, utilized in the present invention;

FIG. 8 illustrates a graph of a typical heat-pipe temperature profile with a transfer of 3,000 watts ( $t$ ) at 600° C using sodium fluid in a 1-inch diameter stainless steel heat pipe;

FIG. 9 is an enlarged detailed view of the casting construction of FIG. 6; and,

FIGS. 10 and 11 illustrate, respectively, side and top plan views of a modified finned casting construction serving as the heat sink of a modified-type of heat-pipe construction.

### DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings, and more particularly to FIGS. 1-3 thereof, the reference numeral 1 illustrates a draw-out type of circuit-breaker unit associated with the cell, or housing structure 2 of a metal-clad switchgear installation. As well known by those skilled in the art, the switchgear unit 1 is adapted for draw-out operation, being mounted upon wheels 3; and the movable primary disconnecting contacts 5 are engageable and disengageable from a pair of vertically-spaced relatively stationary primary disconnecting contacts 6, the latter being connected to bus-bar structures, illustrated in FIG. 1, and designated by the reference numerals 8 and 9.

FIG. 2 illustrates, in perspective, a phase draw-out type circuit breaker unit 1 of the prior art illustrating the radially inwardly-biased clusters of finger contacts 11, which are secured to, and movable with the movable primary disconnecting contacts 5. FIG. 3 illustrates, in vertical section, the finger cluster construction of one of the primary disconnecting contact structures of FIG. 2 and the enclosed power conductor 4, which tends to heat up considerably.

As well known by those skilled in the art, a difficult problem has been to remove the heat from the finger clusters 11 and the relatively small conductors 4 associated with primary disconnecting contact structures. This is particularly true since enclosing the relatively stationary primary disconnecting contact structure 6 and power conductor 4 is an enveloping, or encompassing "bottle" structure 13, generally formed of ceramic, or porcelain material, and serving to prevent radial outward flow of heat from the power conductor 4. In addition to the enveloping "bottle" structure 13, the particular location of the current transformers 15 (FIG. 4) additionally prevents the radial transmission of heat flow from power conductor 4.

Consequently, getting the heat out of the finger clusters 11 and the relatively small conductors 4 inside the ceramic "bottle" 13 to the finned heads 17 of the interrupter units 1, and out to the risers 8, 9, has been a limiting factor in the current rating of present day switchgear. As mentioned, the porcelain

"bottles" 13, and the current transformers 15 generally impede the heat flow radially outwardly, so that conduction through the studs on each side of the finger cluster 11 becomes the best way to get rid of heat. Of course, this mode of heat transfer reaches its limit when the studs are solid copper, for example.

I have discovered, however, that if a heat pipe 22 is associated with one of the disconnecting contact structures, or preferably, two heat pipes 22 are associated with each of the separable contact structures 5, 6 and power conductors, there arises a considerably increased heat flow capability, as shown in FIG. 5. A heat pipe 22 generally utilizes a wick 24 and a vaporizable fluid 25, such as water, which may be put inside the tubes 19, 20 before the end plugs 28, 29, 30 (FIG. 5) of the primary disconnecting contact structure are pressed into place, and thereby results a vastly increased heat transfer, as compared with a solid-stud construction. As a result of the aforesaid modification, there is a potential of, for example, 5,000 amperes current-carrying capability in a physical space, which, according to prior art constructions, only carried 2,000 amperes.

FIG. 4 generally illustrates an application of the principles of the present invention in which a draw-out breaker unit 33 has associated therewith a pair of primary disconnecting contact structures 34, 35, each of which is of the type illustrated in FIG. 5 of the drawings. In more detail, the interrupter unit 33 is set forth and described in U.S. patent application filed Jan. 8, 1968, Ser. No. 696,415, (now abandoned), and filed July 1, 1970 as a continuation-in-part patent application Ser. No. 51,709, by Stanislaw A. Milianowicz, entitled "Fluid-Blast Circuit Interrupter with Insulating Arc Shield," and assigned to the assignee of the instant application. Reference may be made to the aforesaid U.S. Pat. application Ser. No. 696,415 for an understanding of the manner of arc interruption within the interrupter unit 37 (FIG. 4).

Generally, it may be observed that a piston structure (not shown) reciprocates within the interior of the interrupter tube 39, and effects gas flow against the established arc to effect extinction thereof. The piston structure (not shown) is actuated, together with the separable contact structure, interiorly of the interrupter tube 39 by a crank-arm mechanism disposed interiorly of the lower operating housing casting by a transversely extending operating shaft 42, the latter extending exteriorly of the housing 44, and operated by a linkage 46 connected to the operating mechanism 48 of the draw-out switchgear unit 33.

According to the present invention, the movable primary disconnecting contact 34 has a heat pipe 22 associated therewith, which transmits the heat generated in the conductor 34 (or 53 or 19) and in the fingers 11, and forces it to flow to the finned top and bottom castings 17 of the interrupter unit 37. FIG. 5 illustrates how the cylindrical screen wick 24 and water 25 are enclosed within a horizontally-extending cavity 50, or tube provided interiorly of the movable terminal-stud portion 53. A pipe plug 28 is screwed into place, and the region 50 evacuated. The screen 24 and water 25 are placed within the tube 53 and the end plug 28 pressed in, whereupon a rough vacuum is pulled, and the "pinch-off tube" 55 is brazed into one of the end plugs 28.

Similarly, the relatively stationary contact portion 57 of the primary disconnecting contact structure 34 also has a heat pipe 22 associated therewith. Again, this assumes the form of a wick 24 and water 25 enclosed within a cavity 59, the ends of which are closed by a pair of end plugs 29, 30, one of the end plugs being associated with a vertical bus-bar riser 8, which serves to transmit the heat flow from the power conductor 27 into the rear compartment 61 of the cell structure 2. The pinch-off tube 63 may be incorporated in the front conducting plug 29, which also serves as a seat for the cluster of radially biased-inwardly contact fingers 11. FIG. 5 illustrates the contact fingers 11 in the engaged position. As well known by those skilled in the art, the entire switchgear unit 33, being mounted upon wheels 3 (FIG. 4), may be moved laterally to

effect a disengagement between the finger clusters 11 and the relatively stationary terminal portions 29 for removal, or testing of the circuit breaker unit 33.

For details of the heat exchanger 22 reference is made to FIG. 7 which shows a sectional view of a heat exchanger 22 of the type used in this invention. The heat exchanger 22 comprises an outside container 53, which is completely closed and evacuated. A hollow cylindrical wick 24 lines the inside of the container 53, and the hollow space 50 inside the hollow wick 24 contains a liquid, such as a liquid fluoridated hydrocarbon material, or even water.

The operation of this heat exchanger 22 is as follows. The application of heat to the heat input end 65 of the container 53 causes the fluoridated hydrocarbon material 25, or other working liquid, such as water, to evaporate from the wick 24 and also increases the vapor pressure at the heat input end 65. As a result of this increased vapor pressure at the heat input end 65, the vapor due to the vaporization of the water material 25, or other working liquid, moves through the inside of the container 53, carrying heat energy toward the heat output end 66 of the container 53. Heat is removed from the container at the heat output end 66 of the container 53 by any of the means which will be described hereinafter, and the vapor condenses and goes back into the wick 24. The condensed vapor returns as liquid fluoridated hydrocarbon 25, or water, to the heat input end 65 of the heat exchanger 22 by capillary action. A wick return for the liquid fluoridated hydrocarbon 25, or water is more efficient and is preferred where there is no gravity force to return the liquid 25; however, where there is gravity force to return the liquid, the wick 24 may be eliminated.

The working fluid will boil and condense at roughly the same temperature if it is held at the correct pressure causing the temperature along the entire length of the container 53 to be uniform. The heat exchanger 22, shown in FIG. 7, may be constructed entirely of insulating materials, if desired; for example, the container 53 may be made of ceramic material, the wick 24 may be made of fiber glass and the insulating liquid 25 may be fluoridated hydrocarbon material, or even water. This heat exchanger 22 provides a very rapid efficient means for conveying heat from the inside of the disconnecting switch to the exterior, where the heat may be rapidly and economically dissipated from the heat output end 66 of the heat exchanger 32 by means of some convenient heat sink, such as risers 8, 9, which will absorb and dissipate a large amount of heat in a very short time. A detailed discussion of the type of heat exchanger 22, as shown in FIG. 7, is disclosed in "Scientific American," May 1968 pages 38 through 46.

The power conductors 27 and 53 (FIG. 5) may be provided with their own heat pipes 22 to thereby run cooler. The surrounding structure, such as the insulating "bottle" 13, current transformers 15, framework 32 all contribute to prevent the lateral dissipation of heat from the power conductors 27 and 53. The associated heat pipe 22 assists in the rapid dissipation of heat to the rear risers 8, 9, and the finned castings 17 and thus permits a smaller cross-sectional area for the power conductors 27 and 53.

FIG. 7 illustrates the working of a typical heat pipe 22. The heat pipe 22 is a closed evacuated chamber with a wire mesh wick 24 around its inner surface. The wick 24 is saturated with a working fluid 25 such as water, for example. Heat applied to one end 65 of the pipe causes the working fluid to vaporize, increasing the vapor pressure at that end. As a result, the vapor moves through the core of the pipe and carries heat energy to the other end 66. As the vapor condenses, it releases its heat of vaporization, returns as a liquid by way of the wick, and is drawn back to the evaporator end 65 by the capillary action of the wick 24.

It will be apparent that in utilizing a heat pipe 22, it is desirable to afford a highly efficient heat sink, which may assume the form of a finned upper and lower castings 17, as illustrated in FIGS. 5 and 6 of the drawings. FIG. 6 illustrates the disposition of the laterally extending fins 68, which are preferably formed with the upper and lower castings 17.

FIGS. 10 and 11 illustrate a modified type of heat sink with different arrangements for the extension of the heat pipes 22 through the upper ends of the interrupter-head castings 17A, 17B. FIGS. 10 and 11 illustrate a construction in which the heat pipe 22B extends entirely through the upper and lower head casting 17B, the latter having the laterally extending fins 68, as was the case with FIG. 6 of the construction set forth in FIG. 5.

The isothermal profile of a typical heat pipe 22 is illustrated in FIG. 8 of the drawings, which shows the conditions for the transfer of 3,000 watts (*t*) at 600° C, using sodium fluid in a 1-inch diameter stainless steel heat pipe. However, various vaporizable fluids 25, such as water, may be utilized, as well known by those skilled in the art.

The advantages of a heat pipe 22 are that it is self-pumping, and the fluid water 25 circulates without external assistance. A heat pipe 22 can transmit over 500 times more heat than a solid copper rod of the same cross-section. Moreover, a heat pipe 22 provides an enclosed durable tested safe heat transfer system, which operates equally well over a wide temperature range.

It is to be clearly understood that the heat pipe 22 may be used without a capillary wicking structure 24 for certain applications; however, for other applications, the use of a wicking structure 24, which may be either of a metal screen construction, or a suitable felt or sponge, may be desirable. As stated hereinbefore, the heat, upon entering one area 65 of the heat pipe 22, causes the fluid water within that area to evaporate. The vapor traversing the chamber and condensing at the heat sink areas 66 gives up a large heat of vaporization. The fluid water 25 is then drawn back to the evaporator sections 65 by capillary forces within the wick structure 24.

From the foregoing description, it will be apparent that there has been provided an improved disconnecting contact structure 34, 35, and power conductor arrangement, for a circuit interrupter, assuming, in the particular disclosed form, an improved primary disconnecting contact structure, and cooled power lead for draw-out type metal-clad switchgear. The use of such heat pipes, associated with one or more of the separable contact structures, and power conductors 27 and 53, rapidly removes the heat from the point of generation at the finger clusters and power conductors, and transmits it to a remote region, where suitable heat sinks, either in the form of finned casting structures 17, or bus-bar risers 8, 9 may be utilized to dissipate the heat to the ambient atmosphere.

Although there has been illustrated and described specific

structures, it is to be clearly understood that the same were merely for the purpose of illustration, and that changes and modifications may be readily made by those skilled in the art without departing from the spirit and scope of the invention.

I claim:

1. A disconnecting separable contact structure for circuit breakers, particularly those of the draw-out type, comprising, in combination:

- a. a movable disconnecting contact and a relatively stationary disconnecting contact separable therefrom;
- b. at least one of said separable disconnecting contacts having incorporated therewith a heat pipe;
- c. whereby heat generated in proximity to the point of separable engagement of the contact structure may be removed to a remote point for facilitated cooling.

2. The disconnecting separable contact structure of claim 1, wherein both of the cooperable contact structures incorporate heat pipes.

3. The combination of claim 1, wherein the stationary contact structure has an incorporated heat pipe and additionally a surrounding bottle-shaped enclosing insulator.

4. The combination of claim 3, wherein a current transformer encircles the enclosing insulator.

5. A disconnecting switch comprising a pair of separable contacts, a heat exchanger comprising a volatile liquid and having a heat-input portion and a heat-output portion, the heat-input portion of said heat exchanger being positioned closely adjacent the point of contact separation, and the heat output portion of said heat exchanger extending an appreciable distance away from the point of contact separation to dissipate heat generated at the point of contact separation.

6. The apparatus of claim 5, wherein said heat exchanger comprises a closed container, a wick inside said closed container and adjacent the inside walls thereof, the space inside said wick comprising a cavity, a volatile liquid in said cavity, the heat input portion of said heat exchanger being in close thermal proximity to the point of contact separation to permit the generated heat to vaporize said volatile liquid, which vapor passes through said cavity to the heat-output portion of said heat exchanger where said vapor is condensed to a liquid, which liquid passes through said wick back to the heat input portion of said heat exchanger.

7. The disconnecting switch of claim 5, wherein each separable contact encloses its own heat exchanger.

8. The combination of claim 6, wherein each separable contact encloses its own heat exchanger.

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