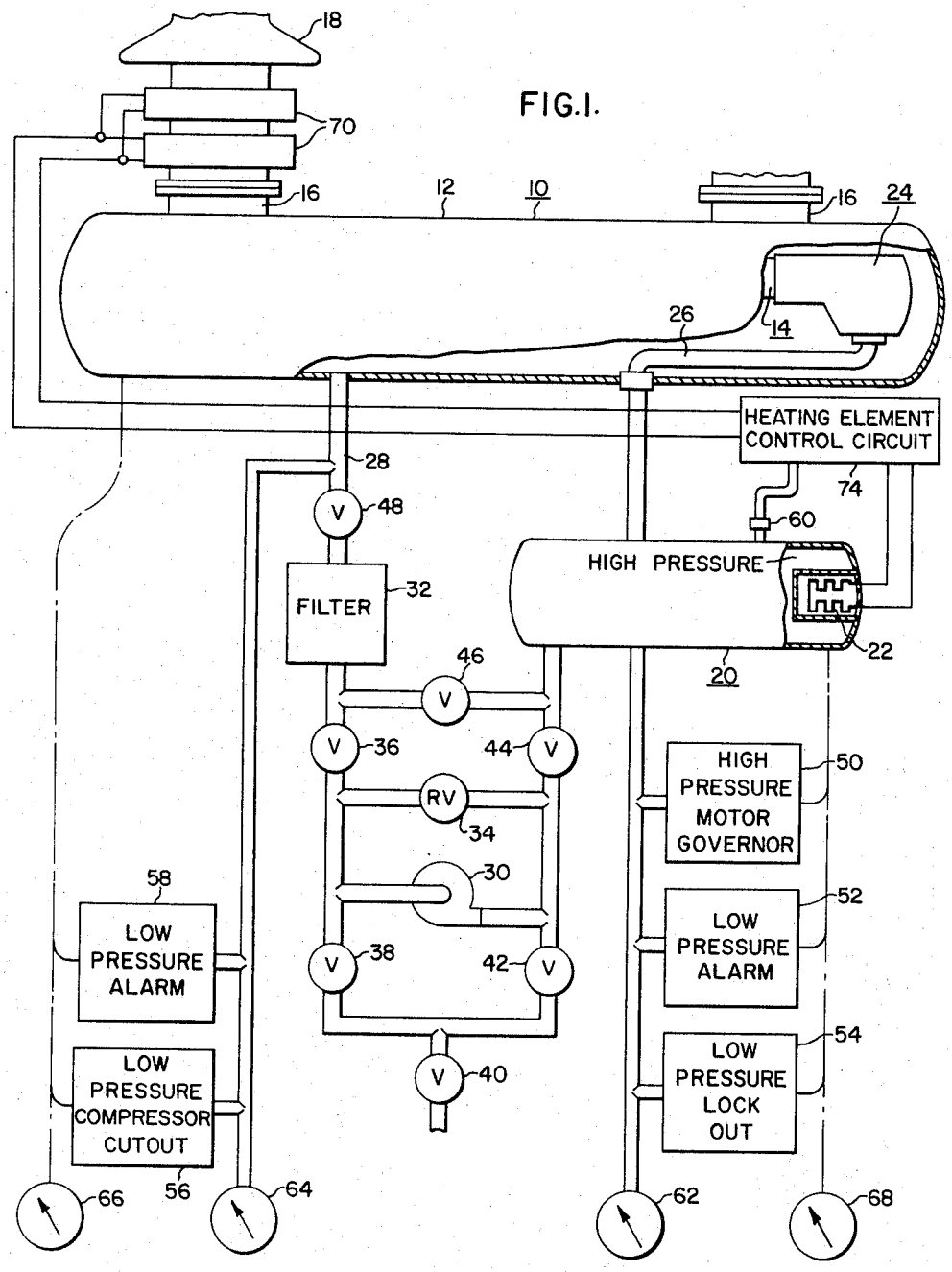
Dec. 12, 1967 C. F. CROMER ETAL 3,358,104

HEATING MEANS FOR COMPRESSED-GAS CIRCUIT INTERRUPTERS

Filed Oct. 29, 1964 3 Sheets-Sheet 1

FIG. 1.



WITNESSES

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HEATING MEANS FOR COMPRESSED-GAS CIRCUIT INTERRUPTERS

Filed Oct. 29, 1964 3 Sheets-Sheet 2

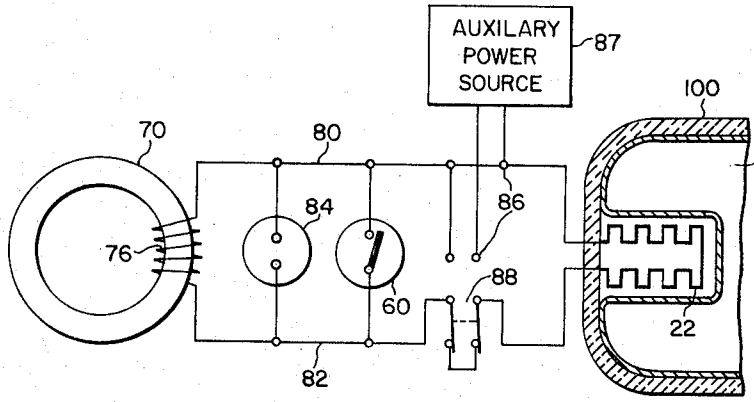


FIG.2.

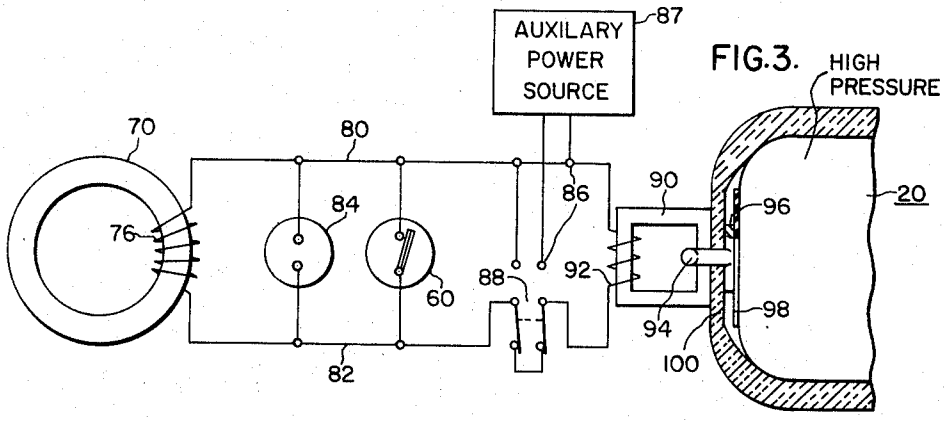


FIG.3.

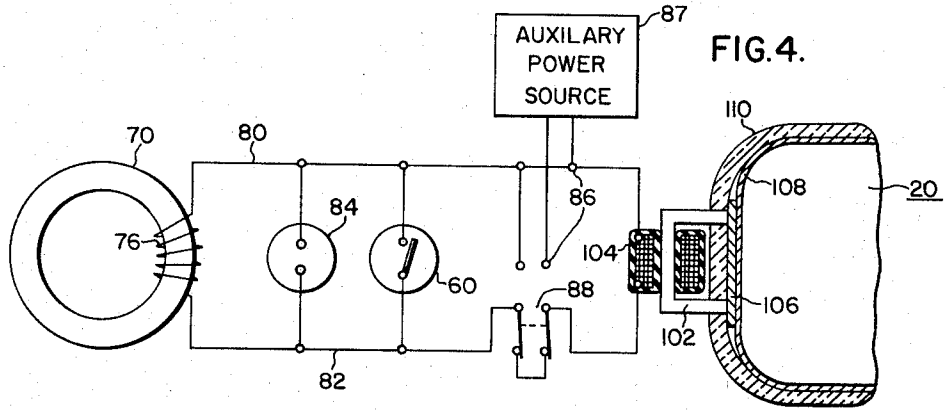


FIG.4.

Dec. 12, 1967 C. F. CROMER ETAL 3,358,104

HEATING MEANS FOR COMPRESSED-GAS CIRCUIT INTERRUPTERS

Filed Oct. 29, 1964 3 Sheets-Sheet 3

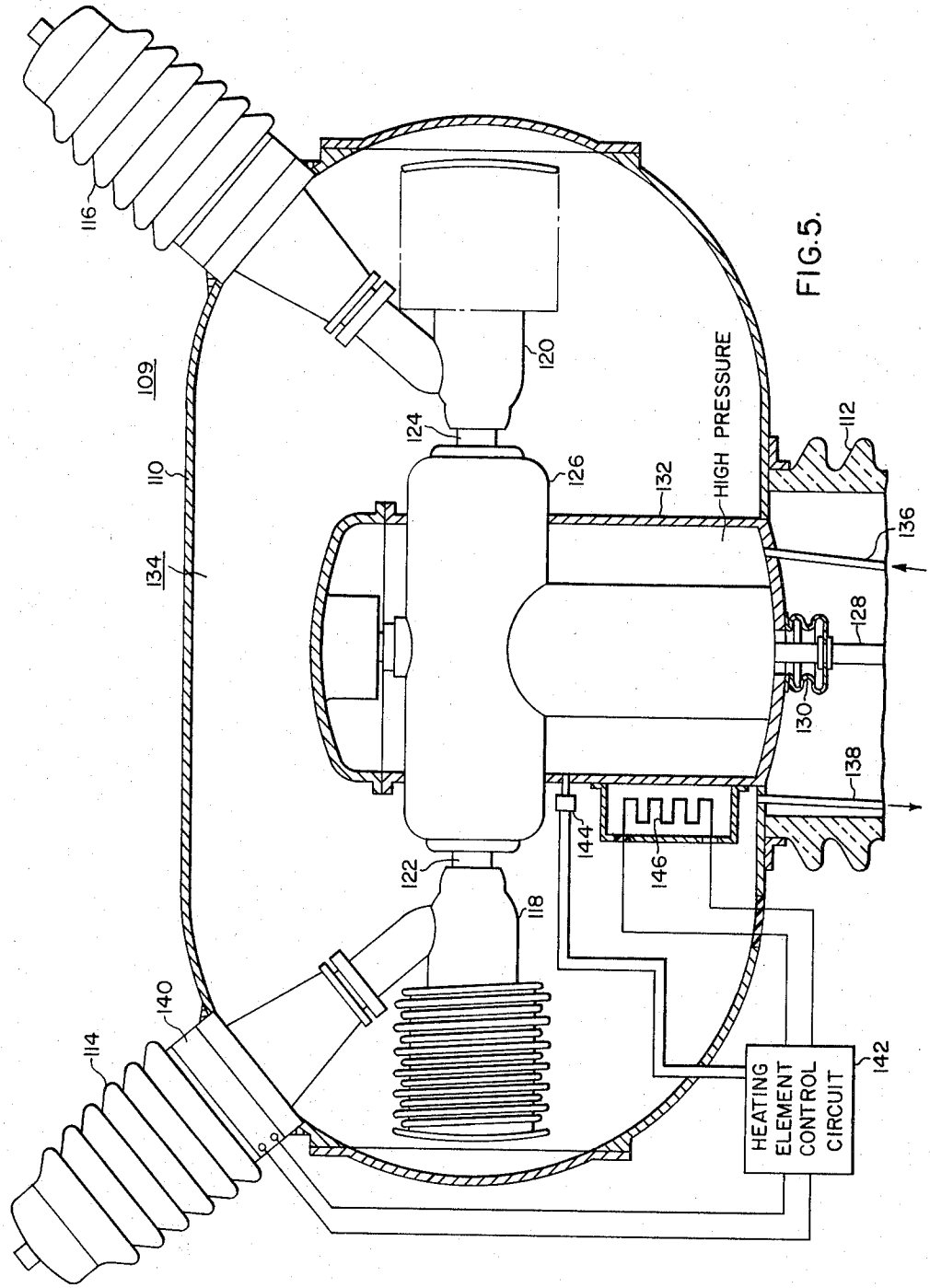


FIG. 5.

United States Patent Office 3,358,104 Patented Dec. 12, 1967

3,358,104

HEATING MEANS FOR COMPRESSED-GAS CIRCUIT INTERRUPTERS

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Filed Oct. 29, 1964, Ser. No. 407,293
9 Claims. (Cl. 200—148)

ABSTRACT OF THE DISCLOSURE

To provide adequate heating of the high-pressure gas in a compressed-gas circuit interrupter to prevent liquefaction, a current transformer inductively coupled to one of the terminal bushings of the circuit breaker is utilized to provide energy to be supplied to the heating means.

This invention relates to compressed-gas circuit breakers in general and, more particularly, to novel heating means for maintaining the gas fed into such circuit interrupters above a predetermined minimum temperature level.

Although not limited thereto, the present invention is particularly adapted for use with compressed-gas circuit breakers of the double-pressure type, wherein gas in a high-pressure storage chamber is discharged into a low-pressure chamber, which houses the separable contacts of the circuit breaker. In such apparatus, the gas, such as sulfur hexafluoride (SF_6) gas, in the high-pressure chamber must be maintained above a predetermined minimum temperature in order to prevent condensation of the SF_6 gas, which would otherwise result in a lowering of the pressure and density in this chamber. Consequently, heaters must be provided with temperature-sensitive controls to prevent the temperature of the high-pressure chamber from falling below the aforesaid predetermined minimum temperature which, in the case of sulfur hexafluoride (SF_6) gas is 40° F.

In circuit interrupters commonly in use, the high-pressure chamber is usually heated by resistors supplied by an auxiliary circuit. This arrangement, however, is not entirely satisfactory since the resistors may burn out, leaving the breaker unprotected. Furthermore, the power supply for the auxiliary circuits may also fail, and these auxiliary circuits are limited to supplying power at ground potential. Therefore, more reliable heating elements and other methods of heating the high-pressure chamber are highly desirable.

A general object of the present invention is to provide a compressed-gas circuit interrupter incorporating improved means for maintaining the gas in a high-pressure chamber above a predetermined minimum temperature to prevent the liquefaction thereof.

A more specific object of the invention is to provide electrical heating means for the gas used in a compressed-gas circuit breaker wherein the electrical energy supplying the heating means is derived from the current flowing through the circuit breaker itself.

Another object of the invention is to provide electrical heating means for a compressed-gas circuit breaker wherein current transformers, energized by current flowing through the circuit breaker, are utilized to supply electrical energy to heaters for the gas in a high-pressure chamber. As will be seen, this arrangement guarantees the availability of power as long as the circuit breaker is energized, and eliminates problems encountered in the case of circuit breakers at high potential, where the high-pressure gas reservoir is also at high potential and cannot be heated by auxiliary circuits at low potential.

Still another object of the invention is to provide improved heating element means for the gas in the high-pressure chamber of a compressed-gas circuit breaker to prevent the liquefaction thereof.

In accordance with the invention, a current transformer is inductively coupled to at least one of the terminal bushings of the circuit breaker whereby alternating current flowing through the bushing will induce current in the transformer. The transformer, in turn, is connected through a control circuit to the heating means disposed within, or adjacent to, the high-pressure tank of the circuit breaker. The current transformer is preferably designed to saturate at a power level above that required by the heating means, thereby insuring adequate power at all times. Also, the control circuit preferably includes an overvoltage protective device together with a switch responsive to the temperature of the gas within the high-pressure reservoir, which latter switch serves to short out the current transformer when the gas temperature reaches the desired level.

Various types of heating elements may be employed in accordance with the invention, one of which comprises a heating resistor designed for low-voltage usage. Such a resistor is more sturdy than the usual higher-voltage type, and may be readily utilized by reducing the number of turns on the current-transformer secondary winding to give a lower voltage, without affecting the watt output. Another heating element utilized in accordance with the invention employs an auxiliary laminated iron core at the point where the heat is to be applied, this core being energized by a coil fed from the current-transformer secondary. Still a third possible embodiment of the heating element involves the use of a U-shaped laminated iron core provided with a coil energized from the current-transformer secondary. The U-core is preferably inverted and clamped to a sheet of steel which forms the magnetic return path of the U-core. This sheet is mounted on a sheet of copper, and the combination clamped on the tank wall whereby the heat is generated by eddy currents in the sheet steel forming the return magnetic path of the U-core.

The above, and other objects and features of the invention will become apparent from the following detailed description, taken in connection with the accompanying drawings which form a part of this specification, and in which:

FIGURE 1 is a schematic diagram of one embodiment of the invention as applied to a dead-tank circuit breaker;

FIG. 2 is a schematic circuit diagram of one type of heating system in accordance with the principles of the invention utilizing an electrical resistance coil as the heating element;

FIG. 3 is a schematic circuit diagram of another embodiment of the invention utilizing an auxiliary laminated iron core;

FIG. 4 is a schematic circuit diagram of still a further embodiment of the invention utilizing a modified form of a U-shaped laminated iron core at the point where the heat is applied to the high-pressure tank of the circuit breaker; and

FIG. 5 is a schematic illustration of another embodiment of the invention, as applied to a compressed-gas circuit breaker operated at high potential.

Referring now to the drawings, and particularly to FIG. 1, the circuit breaker shown is designed generally by the reference numeral **10**, and is of the general type shown in U.S. Patent No. 3,057,983, issued to R. N. Yeckley et al. on October 9, 1962, and assigned to the assignee of the present application. The specific circuit breaker shown in FIG. 1 is of the dead-tank type, and is utilized for one phase of a three-phase alternating-current system. In this respect, it will be appreciated that the complete circuit-breaker assembly includes three circuit

breakers, only one of which is shown herein for purposes of simplicity. The mechanism includes an elongated tank **12**, which serves as a housing for an arc-extinguishing assemblage **14**, the details of which are fully shown in the aforesaid U.S. Patent No. 3,057,983. Extending upwardly from the tank structure **12** is a pair of upstanding cylindrical steel positioning supports **16**, which carry a pair of terminal bushings only one of which is shown, and designated by the reference numeral **18**.

The gas system for the circuit interrupter shown in FIG. 1 is a dual-pressure, closed-cycle system utilizing sulfur hexafluoride gas (SF_6). The high-pressure gas is provided to perform the arc-interrupting function, while the function of the low-pressure gas is to provide the necessary dielectric strength between the energized parts within the grounded tank **12**. The high-pressure system consists of a thermally-insulated high-pressure reservoir **20** at ground potential, provided with a heater **22**, and a high-pressure gas chamber **24** inside the tank **12** at high potential. The high-pressure chamber **24** is an integral part of the arc-extinguishing assemblage **14**, as can be fully appreciated by reference to the aforesaid U.S. Patent No. 3,057,983. The gas in the high-pressure chamber **24** is connected to the ground potential reservoir **20** through electrically insulating tubing **26**.

The low-pressure system consists of the tank **12** with piping **28** to a compressor **30** used to maintain the pressure difference between the two systems. Dual pressures are maintained by auxiliary equipment consisting of a filter **32**, the compressor **30**, a relief valve **34**, hand valves **36–46**, and various control and indicating instruments.

In the normal operation of the closed-cycle gas system, valves **48**, **36** and **44** are open, and valves **38**, **40**, **42** and **46** are closed. During an opening operation of the circuit interrupter, a blast valve to the high pressure chamber **24** is opened, and the gas flows into the arc-extinguishing assemblage **14**, thereby performing the interrupting function. At the completion of the interrupting operation, the high-pressure system will be at reduced pressure, and the low-pressure system will have increased pressure due to the fact that the gas from the high-pressure reservoir **24** has flowed into the tank **12** comprising part of the low-pressure system. Initial conditions of the gas system will then be restored by operation of the compressor **30**, which takes low-pressure gas from the tank **12** through conduit **28**, valve **48** and filter **32**, and then compresses it into the high-pressure reservoir **20** and high-pressure storage chamber **24**.

The instruments included in the auxiliary control equipment for the gas system may be incorporated into two groups, namely control instruments and indicating instruments. The control instruments consist of the motor-governor switch **50**, the high-pressure system, low-pressure alarm switch **52**, the high-pressure system, low-pressure lock out switch **54**, a low-pressure system, low-pressure compressor cutout switch **56**, a high-pressure system, low-temperature alarm switch **58**, and a thermostat **60**. Because of the constant-volume type of gas system, the first five control instruments **50–56** are special temperature-compensated pressure switches. In effect, these switches **50–56** are sensitive to density changes. In a closed volume, any change in the system temperature will cause a proportional change in the pressure. However, the density of the gas in the low- or high-pressure system is not affected by temperature changes. Only the gain or loss of gas in a system can cause a change in density. Since pressure alone does not give a reliable measure of system conditions, temperature-compensated pressure switches are employed.

The indicating instruments consist of two pressure gages **62** and **64** and two temperature gages **66** and **68**. Other equipment includes the relief valve **34** and the filter **32**.

The temperature-compensated pressure switch **50** regulates the pressure in the high-pressure system. In other words, this governor switch **50** operates to start the compressor **30** as soon as the density in the high-pressure system has reached a predetermined value. For this system, a 10 p.s.i. drop in pressure below the normal pressure required for a particular temperature will start the compressor **30**, and return the pressure to normal before stopping of the compressor **30**. The operation of this switch could be the result of either a breaker operation, or leakage of gas from the high-pressure system.

The temperature-compensated pressure switch **52** will operate an alarm in the event of low pressure in the high-pressure system, which is approaching a condition in which an operation may not be successful. This switch provides a warning should the compressor **30** fail to restore normal operating pressure.

To insure against the breaker attempting to operate when there is insufficient gas in the high-pressure system to perform a successful operation, a temperature-compensated low-pressure cutout switch **54** is located in the high-pressure reservoir **20**, and has its electrical contacts connected in the control circuit to provide either of two protecting schemes. In the first scheme, the breaker is prevented from being closed, if it is in the open position or from being tripped, if it is in the closed position upon the event of low reservoir pressure. In the second scheme, the breaker is either held in, or tripped to, the open position. This condition of low pressure in reservoir **20** could result in failure of the compressor **30** to restore the proper operating condition or malfunctioning of the relief valve **34** or blast valve, not shown, within the high-pressure chamber **24**. A temperature-compensated pressure switch **58**, responsive to the low-pressure system, will operate an alarm in the event of loss of gas to the atmosphere at a point at which dielectric strength may be impaired. However, even with a loss of gas to a pressure of one atmosphere, the breaker will still be capable of withstanding twice line-to-ground voltage.

A temperature-compensated, low-pressure system, low-pressure compressor cutout switch **56** is provided. Its function is to prevent operation of the compressor **30** in the event of loss of gas, and subsequent low pressure, in the low-pressure system. This prevents further depletion of the gas in the low-pressure system in this eventuality.

The pressure gages **62** and **64** and the temperature gages **66** and **68** indicate conditions in the high- and low-pressure systems, and provide a quick visual inspection of the entire gas system.

The heating element **22** in the high-pressure reservoir **20** is provided to prevent liquefaction of the high-pressure SF_6 gas and a consequent drop in pressure; and in accordance with the present invention, the electrical power for the heating element **22** is supplied by means of a pair of current transformers **70** surrounding one of the terminal bushings **18**, and adapted to be energized by current flowing through the terminal bushing. In the particular embodiment of the invention shown in FIG. 1, the two current transformers **70** are connected in parallel to a control circuit **74**, to which the thermostat **60**, responsive to the temperature of the gas within high-pressure reservoir **20**, is connected. The output of the control circuit is connected directly to the heating element **22**, as shown.

With reference, now, to FIGS. 2, 3 and 4, three different types of heating arrangements are shown. A typical 1200/5 current transformer can deliver about 3600 volt amperes at rated current before saturation begins. This will supply more than enough energy to heat the high-pressure chamber **20**, which requires only about 750 watts. A current transformer **70** of only one half as much iron as the standard current transformer would be sufficient, although it would be generally desirable to use a standard current transformer. In the system shown in FIG. 2, the transformer secondary winding **76** is connected directly to the heating resistor **22** through leads **80** and **82**. In this particular case, it is preferable to employ a transformer **70** which saturates at somewhat less than one-half the rated current of the circuit breaker, with

an output of about 750 to 1000 watts, so that for higher currents, the watt output is limited by saturation of the transformer. For example, if a transformer core is chosen that saturates at 1.5 volts per turn, a resistance of the heating element can be chosen which, when connected to the secondary winding **76**, will give 1.5 volts per turn at a particular current. If this current is, for example, 500 amperes in the primary, then the output would be 750 watts. As the current, and hence saturation, increases, the watts will rise; but the maximum watts will be held by saturation to about twice 750 watts for an increase of current to 1500 amperes, which occurs at 125% of the circuit-breaker rating.

To control the circuit of FIG. 2, the thermostat **60** is employed which may, for example, comprise a bimetal device responsive to the temperature of the gas within the high-pressure reservoir **20**, and connected across the secondary winding **76**. If the temperature of the SF_6 gas within the high-pressure reservoir **20** exceeds a predetermined maximum value, say 40° F., the bimetal **60** closes the circuit, thereby shorting out the heating resistor **22** and taking the load off of the current transformer **70**. An overvoltage protective device **84**, similar to those used in series lighting circuits, is also provided to short circuit the current transformer **70** in case an opening were to develop in the resistor. In case the circuit breaker is disconnected from the line, heat may be supplied to the high-pressure reservoir **20** by simply closing double-pole double-throw switch **88**, which is normally closed downwardly, to its upper position, thereby connecting terminals **86** to the heating resistor **78**. The terminals **86**, in turn, are connected to a source of auxiliary power **87**, not shown.

In FIG. 3, elements corresponding to those shown in FIG. 2 are identified by like reference numerals. This system, however, utilizes an auxiliary laminated iron core **90** having its primary winding **92** connected across the output leads of windings **76** on the current transformer **70**. The auxiliary core **90** is preferably relatively small with only about half the iron cross-sectional area of the current transformer **70**. A single-turn secondary **94** on the auxiliary core **90** feeds a plate-type resistor **96**, which has a large surface area. This plate **96**, which, for example, could be of Nichrome, is mounted directly on the surface of the high-pressure tank **20**, separated only by a thin sheet of mica insulation **98**.

With an auxiliary core **90** of 1.5 square inches cross-sectional area having primary turns in its winding **92** equal to those in winding **76** on the current transformer **70**, 750 watts can be transmitted to the plate-type resistor **96** at 500 amperes line current. By providing the mica insulation **98**, the 750 watts can be transmitted to the high-pressure reservoir tank **20** with only approximately a 35° rise of temperature in the resistor **96**. The energy input to the resistor **96** is limited at higher currents by saturation of the current transformer **70** as explained above, and would rise to approximately 1500 watts at 125% full rated current of the circuit breaker. This, however, would not overheat the resistor. The assembly is completed by thermal insulation **100** disposed between the laminated core **90** and the resistor **96**.

In the system of FIG. 4, a U-shaped iron core **102** is provided with a winding **104** connected across the secondary winding **76** of the current transformer **70**, the remaining elements of the control circuit being the same as those shown in FIGS. 2 and 3 and identified by like reference numerals. The open end of the U-shaped core is clamped to an iron induction heating plate **106**, which abuts a copper heat conducting plate **108** in contact with the wall of the high-pressure reservoir **20**. Surrounding the plates **106** and **108** is thermal insulation **110**.

As will be understood, the plate **106** forms a magnetic return path for the U-core, and heat is generated by eddy currents in the plate **106**. The copper plate **108** between the iron plate **106** and the tank wall quickly conducts the heat into the tank wall and, hence, into the gas contained therein. In this arrangement, the cross-sectional area of the core **102** may, for example, be 1.5 square inches with the coil **104** having 1000 turns, supplied from a 1200:5 current transformer **70**. The steel plate **106** may, for example, be 7" x 6" by ¼" thick. Saturation of the core **102** will begin at approximately 700 line amperes, at which it is estimated that the input to the iron armature would be about 700 watts, and would approximately double at 125% full load on the circuit breaker. The system shown in FIG. 4 is, of course, superior to that shown in FIGS. 2 and 3 for the reason that the element in which the heat is generated is in direct metallic contact with the wall of the high-pressure reservoir **20**. Hence, the energy can be transferred to the gas within the reservoir **20** with a minimum temperature rise and low heat loss to the atmosphere.

A variation of the arrangement of FIG. 4 would be to have the U-core **102** clamped directly on the steel wall of the tank **20**. Thus, eddy currents generated in the tank wall would thus heat the tank **20** and hence the SF_6 gas.

FIG. 5 shows the application of the invention to a high-potential circuit interrupter **109**. The high-potential compressed-gas circuit interrupter **109** comprises a live metallic tank **110** supported at the upper end of an insulating column **112**. Extending downwardly interiorly within the live metallic tank **110** are a pair of terminal bushings **114**, **116**, which support stationary contact structures, generally designated by the reference numerals **118**, **120**, respectively. Engageable with the stationary contact structures **118**, **120** are a pair of movable contacts **122** and **124**, respectively. The movable contacts **122** and **124** are actuable by means of a mechanism, not shown, housed within an enclosure **126** and operated by means of an insulating operating rod **128**, which extends downwardly into the hollow insulating column **112** through a metallic bellows **130**, the bellows **130** serving to hermetically seal the enclosure **126**. Means, not shown herein, are connected to the actuating rod **128** for causing separation or engagement, as the case may be, of the movable contacts **122** and **124** with the stationary contact structures **118** and **120**, respectively. Reference may be had to United States patent application filed October 12, 1961, S.N. 144,720, now U.S. Patent 3,214,546 issued October 26, 1965 to Winthrop M. Leeds, for a detailed description of the operation of the circuit interrupter **109**.

Disposed substantially centrally within the outer tank structure **110** is a high-pressure reservoir **132** containing a high-pressure gas, such as sulfur hexafluoride (SF_6) at a pressure of about 100 to 200 p.s.i. Preferably, the high-pressure reservoir **132** assumes the form of an upstanding cylindrically-shaped tank surrounding the enclosure **126**, which houses the operating mechanism for the movable contacts **122** and **124**. Gas at high pressure is stored within the chamber formed by reservoir **132**; while low pressure is contained within chamber **134** formed between the inner periphery of the live metallic tank **110** and the outer periphery of the reservoir **132**. To replenish the gas which is used from the pressurized reservoir **132** during an arc-extinguishing operation, there is provided an insulating supply conduit **136**, which passes upwardly through the interior of the hollow insulating column **112** from a grounded pressure tank not shown. Gas exhausted from the chamber **134** is conveyed through an exhaust pipe line **138** to a compressor, not shown, which compresses the exhaust gas from line **138** and feeds it into the aforesaid grounded pressure tank connected to the supply conduit **136**.

In the operation of the device, gas under high pressure in enclosure **132** is discharged over the movable contacts **122**, **124** during a contact-separation operation, and thence into the enclosure **134** where it is discharged through the exhaust pipe line **138**. From line **138**, the gas is again compressed for use in the high-pressure reservoir **132**.

In accordance with the present invention, a current transformer **140** surrounds one of the terminal bushings **114**, as in the embodiment shown in FIG. 1, and is connected to a control circuit **142** having connected thereto a thermostat **144** responsive to the temperature of the high-pressure gas within reservoir **132**. The control circuit **142**, in turn, is connected to a heating element **146** which, in the particular embodiment shown in FIG. 5, is of the resistive type.

The control arrangements **141** for the circuit breaker shown in FIG. 5 may be any of those shown in FIGS. 2, 3 or 4. However, the use of the system of the invention on a high-potential circuit breaker, such as that shown in FIG. 5, has unique advantages, since the current transformer **140** is at the same potential as the interrupter tank **110**. Auxiliary circuits at low potential cannot be used for this purpose.

Although the invention has been shown in connection with certain specific embodiments, it will be readily apparent to those skilled in the art that various changes in form and arrangement of parts may be made to suit requirements without departing from the spirit and scope of the invention.

We claim as our invention:

1. In a compressed-gas circuit interrupter of the type having a metallic tank, a pair of terminal bushings extending into said tank and connected to separable contact structures within the tank, and a high-pressure reservoir for storing high-pressure fluid to be fed into said tank; the combination of means for maintaining the temperature of gas stored in said high-pressure reservoir above a predetermined minimum temperature, comprising transformer winding means inductively coupled to at least one of said terminal bushings, whereby alternating current flowing through said terminal bushing will induce a current in said winding means, electrically-energized heating means for the gas stored in said high-pressure reservoir, circuit means connecting the winding means to the heating means whereby current induced in said winding means is adapted to energize said heating means, and a temperature-sensitive switch device responsive to the temperature of the gas within said high-pressure reservoir connected in shunt with said winding means, whereby the winding means will be shorted to prevent energization of the heating means when the temperature of the gas within the high-pressure reservoir exceeds a predetermined maximum temperature.

2. The combination claimed in claim **1**, wherein said temperature-sensitive switch device comprises a bimetal element connected in shunt with said winding means.

3. The combination of claim **1** and including an overvoltage protective device adapted to close and short out said winding means to prevent energization of the heating means when the voltage across the winding means exceeds a predetermined maximum value.

4. The combination claimed in claim **1** and including an auxiliary source of voltage connected to said heating means for energizing the same upon failure of current supplied from said winding means.

5. In a compressed-gas circuit interrupter of the type having a metallic tank, a pair of terminal bushings extending into said tank and connected to separable contact structures within the tank, and a high-pressure reservoir for storing high-pressure fluid to be fed into said tank; the combination of means for maintaining the temperature of gas stored in said high-pressure reservoir above a predetermined minimum temperature, comprising transformer-winding means inductively coupled to at least one of said terminal bushings, whereby alternating current flowing through said terminal bushing will induce a current in said winding means, electrically-energized heating means for the gas stored in said high-pressure reservoir and including a plate-type resistor, transformer means for supplying electrical energy to said plate-type resistor and including a primary winding connected in series with said first-mentioned winding means, and a single-turn secondary winding for said latter-mentioned transformer means which includes as a part thereof said plate-type resistor.

6. The combination of claim **5**, wherein the plate-type resistor is in snug, abutting relationship with a sheet of insulation which abuts the outer wall of said high-pressure reservoir, whereby the heat generated by the plate-type resistor will be transferred to the gas within the reservoir by radiation.

7. In a compressed-gas circuit interrupter of the type having a metallic tank, a pair of terminal bushings extending into said tank and connected to separable contact structures within the tank, and a high-pressure reservoir for storing high-pressure fluid to be fed into said tank; the combination of means for maintaining the temperature of gas stored in said high-pressure reservoir above a predetermined minimum temperature, comprising transformer-winding means inductively coupled to at least one of said terminal bushings, whereby alternating current flowing through said terminal bushing will induce a current in said winding means, electrically-energized heating means for the gas stored in said high-pressure reservoir, said heating means including a U-shaped laminated iron core, a winding surrounding said U-shaped core and connected across said first-mentioned winding means to be energized thereby, a sheet of magnetically permeable material connected across the legs of said U-shaped laminated iron core, and means including a sheet of high-heat-conductive metal connecting said sheet of magnetically permeable material to the wall of said high-pressure reservoir, whereby heat generated by eddy currents in the magnetically-permeable material will be transferred through said sheet of high-heat-conductive metal and the wall of the high-pressure reservoir to the gas within the reservoir.

8. The combination claimed in claim **7**, wherein said sheet of magnetically-permeable material is steel and wherein the sheet of high-heat-conductive metal is copper.

9. In a compressed-gas circuit interrupter of the type having a metallic tank, a pair of terminal bushings extending into said tank and connected to separable contact structures within the tank, and a high-pressure reservoir for storing high-pressure fluid to be fed into said tank; the combination of means for maintaining the temperature of gas stored in said high-pressure reservoir above a predetermined minimum temperature comprising transformer-winding means inductively coupled to at least one of said terminal bushings, whereby alternating current flowing through said terminal bushing will induce a current in said winding means, electrically-energized heating means for the gas fed into said tank, said electrically-energized heating means comprising a U-shaped laminated core clamped to a magnetically-permeable wall of said high-pressure reservoir, whereby flux will flow through the wall and eddy currents generated in the wall will heat the tank and the gas stored therein, and a winding inductively coupled to said U-shaped core and connected across said first-mentioned winding means to be energized thereby.

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ROBERT S. MACON, *Primary Examiner.*