

March 29, 1966

W. R. WILSON

3,243,560

ELECTRICAL APPARATUS USING PRESSURIZED AIR AS A DIELECTRIC
AND HAVING AIR DRYING MEANS INCORPORATED THEREIN

Filed July 16, 1963

FIG. 1.

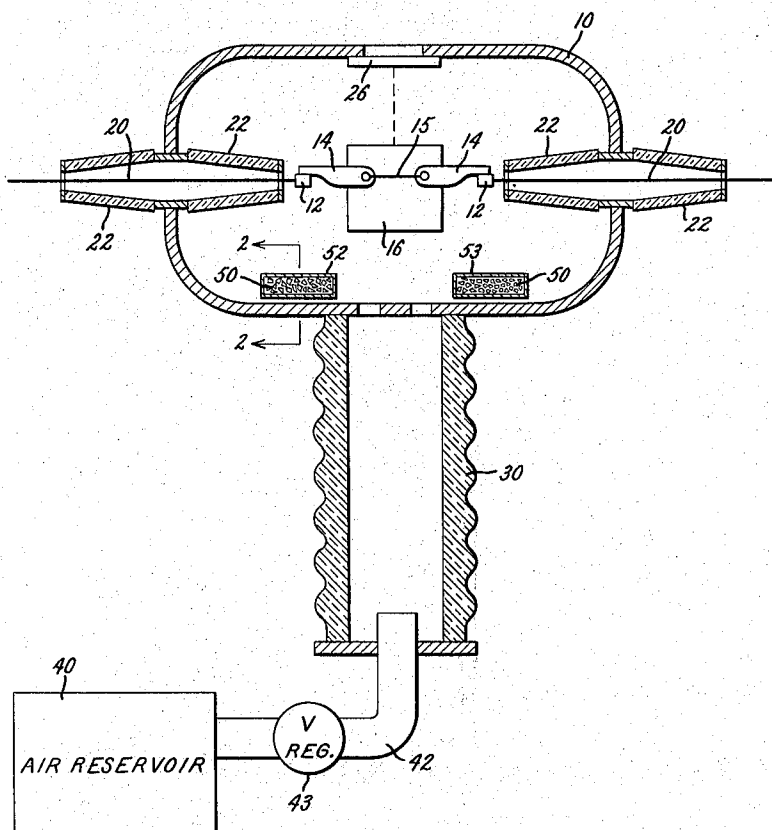
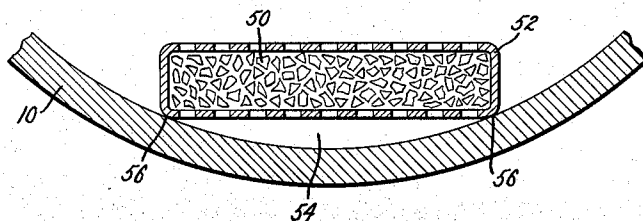


FIG. 2.



INVENTOR:
WALTER R. WILSON,
BY *William Freedman*
ATTORNEY.

1

3,243,560

ELECTRICAL APPARATUS USING PRESSURIZED AIR AS A DIELECTRIC AND HAVING AIR DRYING MEANS INCORPORATED THEREIN

Walter R. Wilson, Wallingford, Pa., assignor to General Electric Company, a corporation of New York
Filed July 16, 1963, Ser. No. 295,385
4 Claims. (Cl. 200—148)

This invention relates to electrical apparatus that uses pressurized air as a dielectric and relates, more specifically, to drying means for maintaining the relative humidity of the air low enough to prevent moisture-condensation on the surfaces of said apparatus that are under high electric stress.

A problem that is often present in electrical apparatus that uses a gaseous dielectric such as air is that the dielectric strength across electrically stressed regions of the apparatus can be impaired by the condensation of moisture contained in the dielectric. Typically, this moisture condensation results from sudden temperature drops. A decrease in temperature increases the relative humidity of the gas; and if the temperature drop is great enough, it will increase the relative humidity to 100%, at which point the water vapor in the gas will begin condensing out. If this condensation is on a surface that is under high electrical stress, there will be a greatly increased likelihood of a flashover involving this surface.

This problem is a particularly troublesome one in the non-sealed type of electrical apparatus, i.e., the type in which air, usually from the surrounding atmosphere, is introduced into the space inside the apparatus to make up for leaks or operations which release air to the atmosphere. In this respect, the air from the surrounding atmosphere contains appreciable, and frequently large, amounts of water vapor; and each quantity of air introduced carries with it added quantities of water vapor that can present condensation problems.

Various drying schemes have been proposed to remove this water vapor from the air that is brought in from the surrounding atmosphere, but these schemes have generally been quite complicated and expensive. Perhaps the simplest of these drying schemes is the type which employs a desiccant to adsorb the water vapor in the air. Merely through contact with the moist air, the desiccant extracts water from the air. But even such schemes tend to be quite complicated and expensive because they ordinarily require some means for reactivating the desiccant to remove the water that accumulates therein after repeated exposures to each new inflow of moist air.

An object of my invention is to provide for non-sealed electrical apparatus a desiccant-type drying scheme that is able to prevent moisture-condensation on the surfaces of the apparatus under high electrical stress for an indefinitely long period without requiring reactivation of the desiccant.

Another object is to achieve this freedom from moisture condensation despite wide and sudden temperature changes that might occur.

In carrying out my invention in one form, I provide an air blast circuit breaker that comprises a tank containing air at a high normal operating pressure. Within this tank are metallic parts and insulating parts that have surfaces that are under high electric stress in comparison to the electric stress adjacent the internal surface of the tank. The circuit breaker further comprises means for releasing pressurized air from the tank upon operation of the circuit breaker and means for supplying air to the tank to compensate for air released therefrom. Means is provided for limiting the relative humidity of the air entering the tank to a value less than 50%. Disposed within the tank is a quantity of desiccant that is of such character that it releases absorbed moisture to a surround-

2

ing gas when the vapor pressure of the absorbed water exceeds the partial pressure of the water in the gas. The desiccant material has saturation characteristics at room temperature that maintain the desiccant unsaturated when the equilibrium relative humidity of air surrounding the desiccant is maintained as high as 50 percent. The desiccant has the additional characteristic of maintaining an approximately constant relative humidity at equilibrium temperatures of between 30° F. and 200° F. when its water content is fixed. An example of a desiccant material with these characteristics is silica gel. The weight of desiccant provided in the tank is so high that the desiccant can adsorb the maximum amount of moisture contained in a tankful of air at said high normal pressures and at the highest equilibrium operating temperature of the circuit breaker without more than a few percent increase in the desiccant weight. The surface area of the desiccant exposed to the air in the tank is so large that the desiccant adsorbs water quickly enough to prevent moisture-condensation on said surfaces under high electric stress even when the external ambient temperature drops by as much as 50 degrees F. in one hour.

For a better understanding of my invention, reference may be had to the following description taken in conjunction with the accompanying drawing; wherein:

FIG. 1 is a diagrammatic view partially in section showing an electric circuit breaker embodying one form of my invention.

FIG. 2 is a cross sectional view taken along the line 2—2 of FIG. 1.

Referring now to FIG. 1, there is schematically shown an electric circuit breaker that comprises a metal tank 10 at high voltage which contains pressurized air. Disposed within the tank are two pairs of contacts connected in series-circuit relationship. Each pair of contacts comprises a stationary contact 12 and a movable contact 14 movable into and out of engagement with the stationary contact. The movable contacts 14, which are electrically connected together by a conductor schematically shown at 15, are adapted to be simultaneously opened by means of an operating mechanism 16 suitably coupled to the movable contacts. This operating mechanism 16, which is schematically shown in block form, is supported on the tank 10 by suitable metallic structure (not shown) which provides an electrical connection between the tank 10 and the operating mechanism to hold these parts at the same electrical potential. Each of the stationary contacts 12 is electrically connected to the inner end of a rigid conductor 20 that projects through one end of the tank 10. These conductors 20 are supported on the tank 10 and electrically isolated therefrom by means of insulating sleeves 22 surrounding each conductor 20. In a preferred embodiment of my invention, these sleeves 22 define a sealed housing about the conductor, and the interior of this housing is isolated from the space within the tank 10.

It will thus be apparent that when the breaker is closed as shown in FIG. 1, current flows therethrough via one conductor 20, the two series-connected sets of contacts 12, 14, and the other conductor 20.

When the movable contacts 14 are separated from their respective stationary contacts 12 to open the circuit, arcs are established at each set of contacts. These arcs are extinguished by blasts of air from the tank that are directed from the interior of the tank through the arcing region. These blasts of air are controlled by a suitable blast valve 26 shown in its normally-closed position. The blast valve 26 is opened when the contacts are opened to establish the air blasts. When the arcs have been extinguished, the blast valve 26 is closed to terminate the air blasts.

3

The above-described operation of blast valve 26 and the movable contacts 14 is controlled by means of the operating mechanism 16, which is mechanically coupled to these components. The details of this operating mechanism form no part of the present invention, but if more information is desired, reference may be had to U.S. Patent 2,783,338, Beatty, assigned to the assignee of the present invention, for a full description of a suitable operating mechanism.

The tank 10 is supported on a hollow insulating column 30, which electrically isolates the tank from ground. The column 30 also serves to convey pressurized air to the tank 10 so as to compensate for leakage and other losses therefrom, as would occur when the valve 26 is opened.

This pressurized air for tank 10 is obtained from a reservoir 40 which is at a pressure much higher than the pressure of the air in the tank 10. For example, in a typical embodiment of my invention, the reservoir pressure is 2,000 p.s.i. and the normal tank pressure is 500 p.s.i. Preferably, the air in the reservoir 40 is obtained from the surrounding atmosphere and is suitably compressed to the desired pressure before entering the reservoir. A conduit 42 connects the reservoir 40 and the lower end of the column 30; and a pressure responsive regulating valve 43 is located in this conduit to control the flow of pressurized air therethrough from the reservoir to the hollow column 30. This regulating valve, which is of a conventional design, automatically opens when the pressure in the tank 10 falls below a predetermined value and recloses when the tank pressure exceeds a higher predetermined value. For example, in a typical embodiment of my invention, the pressure responsive valve 43 opens when the tank pressure falls below 450 p.s.i. and recloses when sufficient air has passed through the conduit 42 to restore the tank pressure to 500 p.s.i. Since the air in the reservoir 40 is at a much higher pressure than the air in tank 10, the air is expanded in passing through the regulating valve 40 and this lowers its relative humidity. Assuming that the air in the reservoir is at a pressure of 2,000 p.s.i. and a relative humidity of 100 percent, its relative humidity after expanding through the valve to a pressure of 500 p.s.i. would be about 33 percent.

The primary problem that the present invention is concerned with is maintaining the relative humidity of the air in the tank 10 low enough to preclude water vapor from condensing out on any surfaces within the tank 10 that are under significantly high electrical stress. Examples of such surfaces are the surfaces of insulators 22 and of the contacts 12, 14 at least when the movable contacts 14 are in the open position. Moisture on these electrically stressed parts can seriously reduce the dielectric strength available to prevent flashovers involving these parts.

For limiting the relative humidity sufficiently to preclude such condensation, we provide within the tank 10 a quantity of desiccant shown at 50. In the illustrated embodiment, this desiccant 50 is located in two separate containers 52 and 53. Each of these containers 52 and 53 is preferably in the form of a shallow box. The top and bottom walls of the box are of a generally planar configuration and contain a large number of perforations that afford free communication between the air in the tank and the desiccant in the containers 52 and 53. The bottom edges 56 of each container rest on the curved walls of the tank to provide an open space 54 beneath each container that communicates freely with the remainder of the tank interior.

The desiccant 50 is of a type that can remove water vapor from the air by adsorption and can return water to the air when the vapor pressure of the adsorbed water exceeds the partial pressure of the water in the air. The desiccant material is also the type that will maintain an essentially constant relative humidity in a closed chamber at equilibrium temperatures of between 30° F. and

4

200° F., assuming a substantially fixed amount of water in the desiccant. An example of a desiccant of this type is silica gel, which is the desiccant that I prefer to use.

When used in the manner and quantities described hereinafter, the silica gel is capable not only of maintaining the relative humidity of the air in the tank 10 low enough to prevent moisture-condensation on the surfaces within the tank that are under high electric stress but can perform this function for an indefinitely long period without requiring reactivation. There are a number of factors responsible for these abilities of the silica gel. One such factor is that the equilibrium relative humidity in the tank 10 is maintained at a lower value than the relative humidity at which silica gel becomes saturated. In this regard, silica gel, at the temperatures under consideration, remains unsaturated at equilibrium relative humidities up to about 70 or 80 percent, but the equilibrium relative humidity in the typical embodiment heretofore described is only 33 percent, well under the saturation point of the silica gel. Thus, the silica gel does not become saturated with water while the circuit breaker remains in its equilibrium condition and is therefore always prepared to remove water vapor from the air in the tank should the relative humidity increase from its equilibrium value.

Assuming that the silica gel is relatively free of moisture when placed in the tank, it will eventually adsorb water to the point at which the adsorbed water has a vapor pressure equal to the partial pressure of the water vapor in the surrounding air. No further increases in the moisture content of the silica gel will then occur, assuming that the relative humidity in the tank does not rise further and the temperature of the silica gel remains essentially constant. The moisture content of the silica gel, in effect, reaches a certain equilibrium value where it remains constant so long as the temperature stays essentially constant and the relative humidity in the tank remains at its equilibrium value, assumed to be 33 percent in the described embodiment.

Should there be an increase in the relative humidity in the air in the tank from the equilibrium value, such as would result, for example, from a sudden drop in ambient temperature outside the tank, then the silica gel will adsorb more water vapor. The adsorption of this added water vapor increases the total moisture content of the silica gel by only a small percentage, however, because, in practicing the present invention, I use an unusually large quantity of silica gel in the tank 10. In this respect, I use a quantity of silica gel so large that it can adsorb the maximum amount of water vapor that will be contained in a tank full of air at 500 p.s.i. and the highest equilibrium operating temperature of the circuit breaker without increasing its weight more than a few percent. This assures that a sudden, large increase in relative humidity, as from a sudden and extreme temperature drop in the air, will not cause the silica gel to become saturated and unable to effectively continue its drying function.

The total water content of the silica gel does not cumulatively build up as a result of repetitive temperature drops, such as described above, because a new supply of air with a relatively low relative humidity periodically enters the tank 10 and relieves the silica gel of the excess moisture acquired from the preceding tankful. The periodic entry of this relatively low relative humidity air into the tank coupled with the ability of the silica gel to give up its excess moisture to this air makes it unnecessary to reactivate the silica gel.

Assume now that a large temperature drop has caused the relative humidity of the air in the tank to abruptly increase from its equilibrium value. A finite period of time is required for the silica gel to adsorb the moisture responsible for that portion of the relative humidity in excess of equilibrium relative humidity. By reducing this time, I can reduce the chances that the highly stressed parts will cool sufficiently to produce condensation thereon. I reduce this time by providing an unusually large

area of silica gel that is exposed to the air in the tank. This exposed area is so large that even the most extreme temperature drops encountered in the field cannot increase the relative humidity of the air adjacent the surfaces that are under high electrical stress fast enough to cause water vapor to condense thereon. The most extreme temperature drop ordinarily encountered in the field is about 50 degrees F. in one hour.

The internal surface of the tank is subject to some electrical stress, but, in view of its large rounded configuration, this stress is very minor in comparison to that adjacent parts 12, 14 and 22. Thus, the internal surface of the tank is not considered to be under significantly high electric stress.

Another factor that accelerates the speed at which the silica gel removes the excess moisture when the temperature drops is the location of the silica gel at the bottom of the tank 10 and in a position where air can readily pass through it. In this regard, the bottom of the tank is normally the coolest part of the tank since the heat resulting from current flow through the electric circuit breaker tends to produce the highest temperature at the highest point on the tank. By locating the silica gel in the coolest part of the tank, it can be kept relatively cool, and this increases its moisture adsorption capacity. Still further, when the silica gel adsorbs water vapor, heat, commonly referred to as the heat of adsorption, is liberated and this heat raises the temperature of the immediately surrounding air. The heated air rises toward the top of the tank 10 through convection, and cooler air moves in to replace it. This cool air approaches the silica gel through the space 54 at the bottom of the containers 52 and 53 and rises through the silica gel 50. Thus, the heat of adsorption induces a circulation of air by convection through the silica gel, and this accelerates the drying process.

Silica gel containing a given quantity of water has the property of being able to maintain an approximately constant relative humidity in a closed space at equilibrium temperatures ranging from the maximum operating temperature of my circuit breaker (around 200 degrees F.) down to about 30 degrees F. Thus, changes in the temperature of the silica gel between these limits will not impair the ability of the silica gel to maintain an approximately constant relative humidity. At temperatures lower than about 30 degrees F., the silica gel will maintain a somewhat lower relative humidity, but this is not undesirable since it results in even less chance of moisture-condensation.

While I have shown and described a particular embodiment of my invention, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from my invention in its broader aspects, and I, therefore, intend in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An air blast electric circuit breaker comprising:
 - (a) a tank containing air at a high normal operating pressure of at least several hundred p.s.i.,
 - (b) metallic parts and insulating parts within said tank having surfaces that are under high electric stress in comparison to the electric stress adjacent the internal surface of the tank,
 - (c) means for releasing pressurized air from said tank upon operation of said circuit breaker,
 - (d) supply means for supplying air to said tank to compensate for air released therefrom,
 - (d') said supply means comprising: a source of substantially saturated air at a pressure higher than said normal operating pressure, means connecting said

source to said tank, a normally-closed regulator valve controlling the flow of air through said connecting means, and means for opening said valve in response to a drop of pressure inside said tank to a predetermined level,

- (e) means comprising said regulator valve for reducing the relative humidity of air passing through said connecting means and for limiting the relative humidity of the air entering said tank to a value less than 50 percent,
 - (e') said regulator valve effecting said reduction in relative humidity by expanding air therethrough upon valve-opening,
 - (f) a quantity of desiccant material within said tank that is of such character that it releases adsorbed moisture to surrounding air when the vapor pressure of the adsorbed moisture exceeds the partial pressure of the moisture in the air,
 - (g) the saturation characteristics of said desiccant material at room temperature being such that the desiccant is unsaturated when the equilibrium relative humidity of air surrounding it is maintained as high as 50 percent,
 - (h) said desiccant material having the additional characteristic of maintaining an approximately constant relative humidity at equilibrium temperatures of between 30 degrees F. and 200 degrees F. when its water content is fixed,
 - (i) the weight of desiccant present in said tank being so high that the desiccant can adsorb the maximum amount of moisture contained in one tankful of air at said high normal operating pressure and at the highest equilibrium operating temperature of said circuit breaker without more than a few percent increase in said desiccant weight,
 - (j) the surface area of said desiccant exposed to the air in said tank being so large that the desiccant adsorbs moisture quickly enough to prevent moisture-condensation on said surfaces under high stress even when the ambient temperature external to said tank drops by as much as 50 degrees F. in one hour.
2. The circuit breaker of claim 1 in which said desiccant is located adjacent the bottom of said tank.
 3. The circuit breaker of claim 1 in which said desiccant is located adjacent the bottom of said tank but is spaced therefrom to provide an air space beneath said desiccant, said air space freely communicating with the air in said tank to permit air to enter said space and pass upwardly through the desiccant in response to heat emission by said desiccant during moisture-adsorption.
 4. The air blast circuit breaker of claim 1 in which said desiccant material is silica gel.

References Cited by the Examiner

UNITED STATES PATENTS

2,414,642	1/1947	Gary	34—77
2,505,581	4/1950	Unger	174—14
2,584,889	2/1952	Latour	200—148
2,783,337	2/1957	Beatty et al.	200—148
2,943,169	1/1960	Rice	200—87

OTHER REFERENCES

Technical Information On Drying Gases and Liquids, Linde Co., Div. of Union Carbide Corp.

ROBERT S. MACON, *Acting Primary Examiner.*

BERNARD A. GILHEANY, KATHLEEN H. CLAFFY, *Examiners.*

P. E. CRAWFORD, *Assistant Examiner.*