United States Patent

[11] 3,612,798

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[21] Appl. No. **15,631**
[22] Filed **Mar. 2, 1970**
[45] Patented **Oct. 12, 1971**
[73] Assignee **General Electric Company**

[54] **AIRBLAST CIRCUIT BREAKER WITH IMPROVED SEALING MEANS**
5 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** ..... **200/148 R,** 200/148 D, 174/14 BH
[51] **Int. Cl.** **H01h 33/82**
[50] **Field of Search** ..... 200/148 A, 148 B, 148 D, 148 R, 150 R; 174/14, 14 BH, 15, 15 BH, 16 BH

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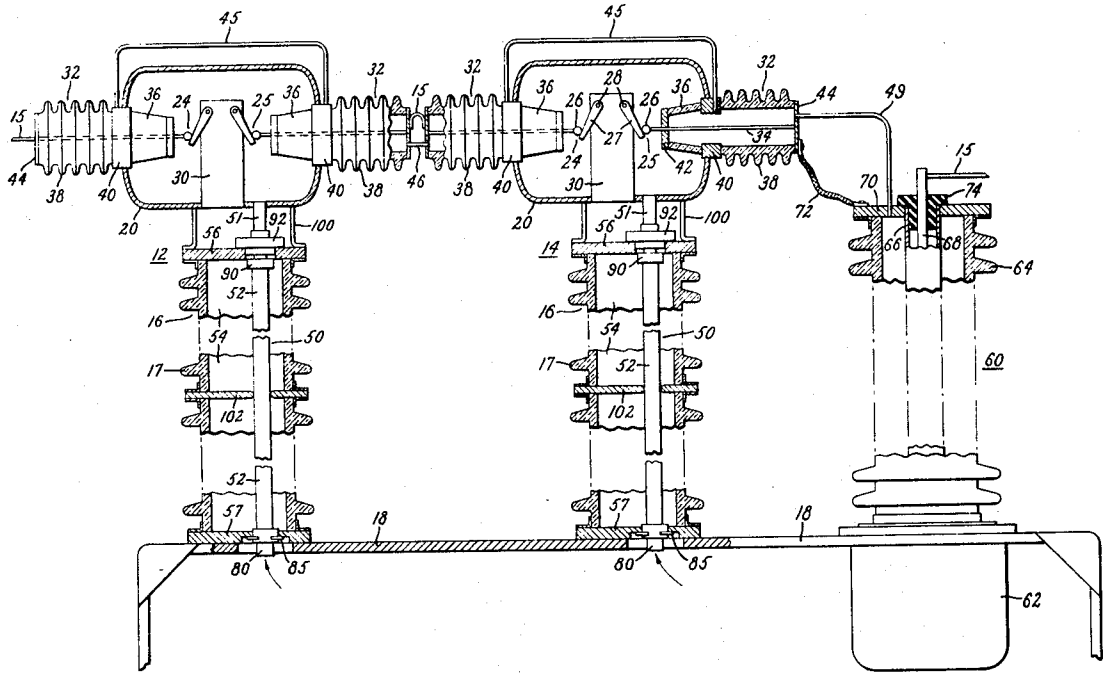
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ABSTRACT: Discloses an airblast circuit breaker comprising interrupter tanks at high voltage filled with high-pressure air and provided with terminal bushings filled with a dielectric gas other than air. The tanks are mounted on hollow insulating columns through which air lines of insulating material extend to supply high-pressure air to the tanks. A current transformer adjacent the columns has an insulating housing that is pneumatically interconnected with the bushings in the high-voltage region and is filled with dielectric gas of the same type as the bushings to serve as a reservoir for supplying the bushings with dielectric gas. Also discloses special means for mounting and sealing the high-pressure air line with respect to its column and tank.



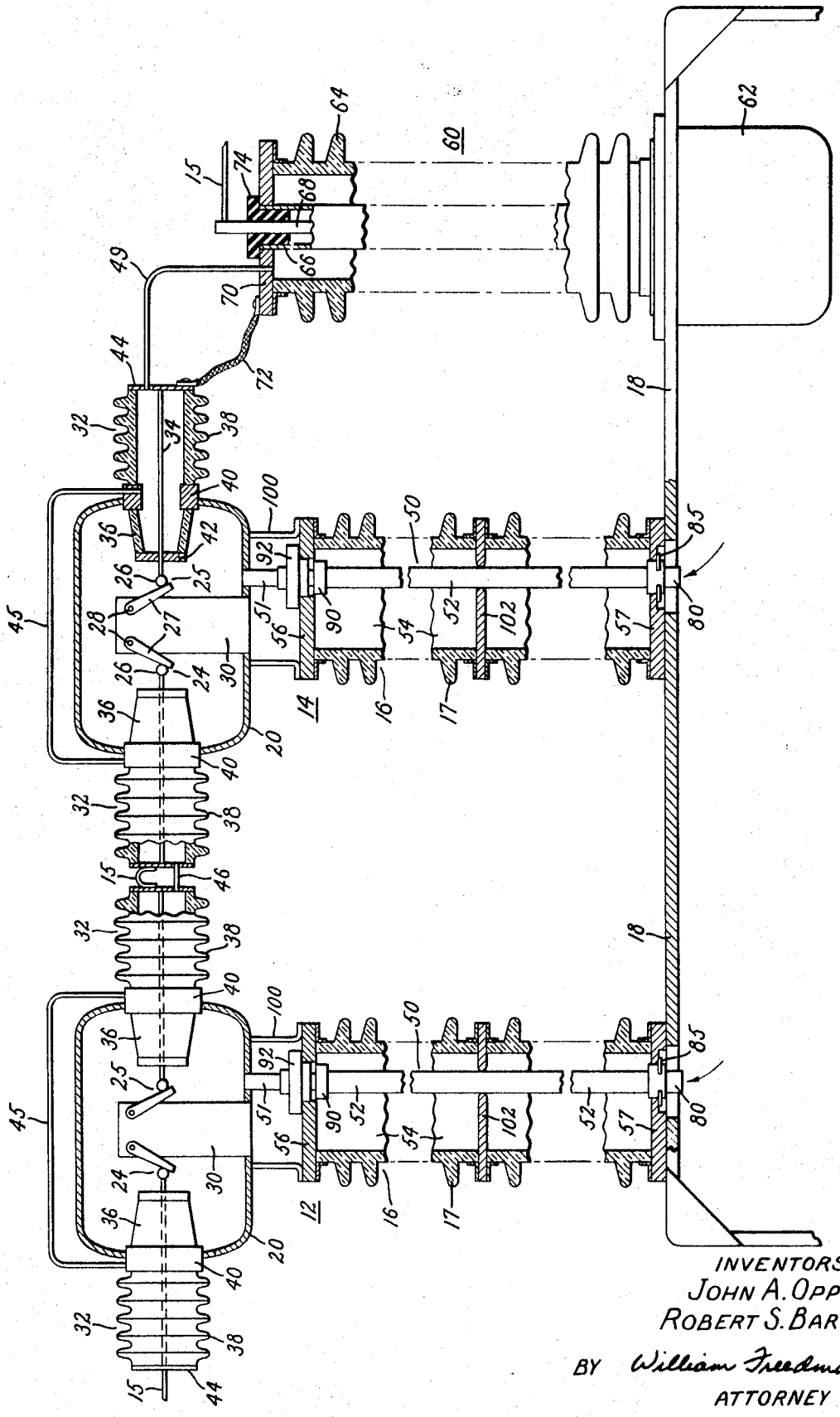


Fig. 1.

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Fig. 2.

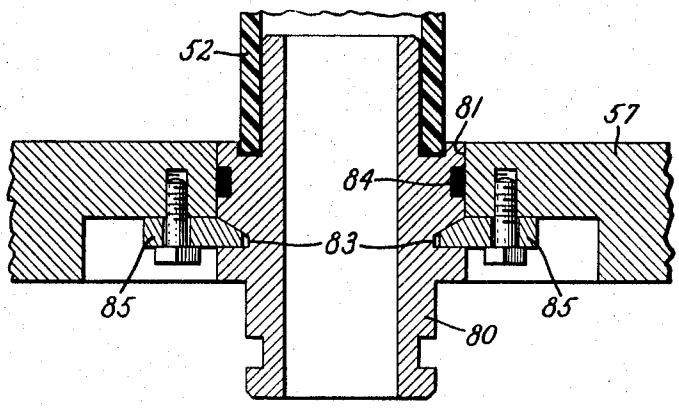


Fig. 3.

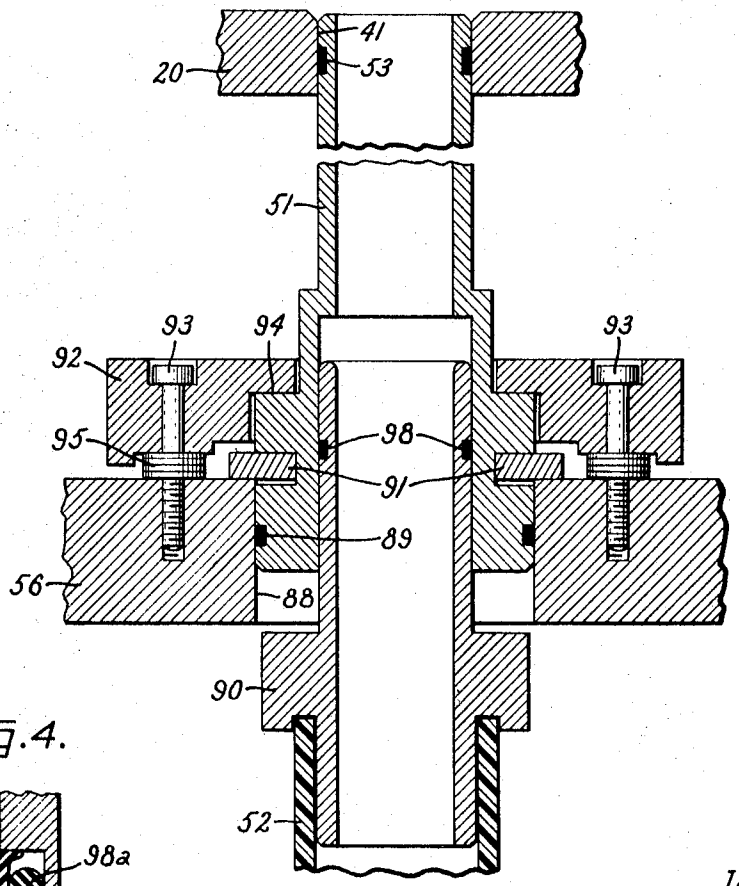
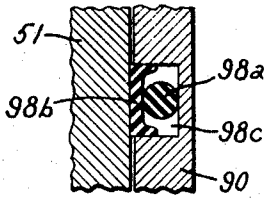


Fig. 4.



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AIRBLAST CIRCUIT BREAKER WITH IMPROVED SEALING MEANS

BACKGROUND

This invention relates to an airblast circuit breaker that comprises interrupter tanks at high voltage filled with high-pressure air and supported on hollow insulating columns and, more particularly, relates to a circuit breaker of this type that includes high-voltage bushings extending into the tanks and filled with a pressurized dielectric gas other than air. The invention is especially concerned with constructing a circuit breaker of this type in such a manner that a high-reliability seal is maintained between its air system and its dielectric gas system.

In a prior form of such circuit breaker, the hollow insulating support columns for the interrupter tanks have contained dielectric gas of the same type as the bushings and have served as reservoirs from which the bushings are supplied with dielectric gas. The high-pressure air contained in each interrupter tank has been supplied to the tank through an insulating air line extending through the interior of the dielectric gas-filled supporting column.

This prior type of circuit breaker construction has presented some difficult problems in maintaining good seals between the two gas systems. Expensive seal constructions, e.g., involving spaced O-rings with a vented space between them, have typically been required, and even these have not always performed as well as might be desired. One source of the problem is that the two media have been in juxtaposition and the O-ring seals for the two systems have been close to one another, increasing the change of mixing of the two media.

SUMMARY

An object of the present invention is to construct the circuit breaker in such a manner as to improve the seal between the two media and to make possible the use of simpler seal constructions in certain key locations in the circuit breaker.

Another object is to provide a ring-type seal for the upper end of such an air line which is resistant to damage resulting from sliding caused by temperature-induced expansion and contraction of the air line.

Another object is to reduce the number of locations along the length of the air line where the seals used must accommodate large amounts of sliding motion, thus reducing the likelihood that the seals will be damaged by wear or other forces.

Still another object is to provide an air line mounting arrangement for such a circuit breaker that facilitates replacement of the seals should this become necessary and, more specifically, does not require removal of the interrupter tank to effect such seal replacement.

In carrying out the invention in one form, we provide a plurality of series-connected interrupting assemblies, each comprising an insulating column, a high-voltage interrupter tank mounted atop the insulating column and filled with high-pressure air, and terminal bushings projecting into the tank and containing a dielectric gas other than air. Adjacent one of the interrupting assemblies, there is a freestanding current transformer that comprises a primary circuit and an insulating housing around a portion of the primary circuit. This insulating housing is pneumatically connected to the bushings of the interrupting assemblies by tubing located in the high-voltage region of the circuit breaker. The insulating housing contains a supply of dielectric gas of the same type as the bushings and is thus able to serve as a reservoir from which the bushings are supplied. The hollow insulating columns that support the interrupter tanks are filled wit relatively low-pressure air and are free of said dielectric gas.

Each high-pressure air line that extends through an insulating column into an interrupter tank atop the column comprises a long slender type of insulating material and a pair of tubular metal end fittings secured in sealed relationship to opposite ends of the tube. The lower end fitting is secured in sealed relationship to an end plate of the insulating column located at its lower end. Secured to an end plate of the insulating column located at its upper end, there is a metal pipe constituting a portion of the air line and projecting into the interrupter tank. This metal pipe has a bore in which the upper end fitting is slidably received. Ring-type sealing structure is provided between said bore and the outer surface of the upper end fitting to provide a seal therebetween that allows said sliding motion to occur.

BRIEF DESCRIPTION OFF DRAWINGS

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

FIG. 1 is a side elevational view partially in section and partially schematic showing a circuit breaker embodying one form of the present invention.

FIG. 2 is a sectional view of a portion of the circuit breaker of FIG. 1, which portion is located at the bottom of the air line.

FIG. 3 is a sectional view of another portion of the circuit breaker of FIG. 1, which portion is located at the top of the air line.

FIG. 4 is a more detailed sectional view of a portion of FIG. 3.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

Referring now to FIG. 1, there is shown a high-voltage electric circuit breaker comprising a pair of interrupting assemblies 12 and 14 electrically connected in series in a high-voltage power circuit 15. Since these interrupting assemblies are substantially identical, only one will be described, and identical reference numerals will be used for both assemblies to designate corresponding parts. Assembly 14 comprises a hollow insulating column 16 comprising a tubular casing 17, preferably of porcelain. At its lower end the insulating column 16 is mounted on and attached to a fixed base 18. At its upper end the insulating column 16 carries a metal tank 20 that is filled with compressed air and houses the interrupting elements of interrupter assembly 14. The details of these interrupting elements form no part of the present invention and may be of any suitable conventional form, such as disclosed and claimed, for example, U.S. Pat. No. 2,783,338-Beatty, assigned to the assignee of the present invention.

It is believed sufficient for the present application to point out that the interrupting elements within tank 20 comprise two sets of relatively movable contacts 24 and 25 electrically connected in series. Each set of contacts comprises a stationary contact 26 and a movable contact 27 mounted for pivotal motion on a stationary pivot 28. When movable contact 27 is pivoted away from is stationary contact 26, an electric arc is formed between the contacts, and this arc is soon extinguished in a known manner to interrupt the circuit. The two movable contacts 27 are operated simultaneously by means of an operating mechanism (not shown) within a centrally located metal casing 30. This operating mechanism is preferably of the type shown and claimed in the aforesaid Beatty patent. The two sets of contacts 24 and 25 are electrically connected in series through the metal casing 30. Since metal casing 30 is also connected to tank 20, the tank is at line potential when the circuit breaker is closed.

For extinguishing the arc that is formed when the contacts are separated, a blast valve (not shown) in the tank 20 is opened to direct a portion of the compressed air in the tank through the arcing region into the surrounding atmosphere via the open blast valve. When interruption is completed, the blast valve is closed in order to conserve compressed air in the tank 20. A typical normal pressure for the air in tank 20 is 800 p.s.i.

HIGH-PRESSURE AIR LINE

For replenishing the supply of compressed air in each of the tanks **20** in order to maintain the tank pressure above a predetermined level, a high-pressure air line **50** is provided for each tank. Each air line **50** extends vertically upward through hollow insulating column **16** from the base of the column into the metal tank **20**. At its bottom end, each air line **50** is connected to a high-pressure air supply (not shown) from which high-pressure air is admitted to the air line through a suitable regulator valve (not shown) when the tank pressure falls below said predetermined level. It is to be understood that the air line normally contains high-pressure air at the same pressure as the pressure in tank **20**. The major portion **52** of the length of each air line is of a high-strength insulating material such as fiber-glass-reinforced polyester resin. The uppermost portion of the air line is a metal pipe **51** that spans the space between the top of the insulating column **16** and the metal tank **20**. The top of metal pipe **51** enters the tank interior through an opening **41** in the lower tank wall, with a suitable O-ring seal **53** being provided between the opening and the outer periphery of pipe **51**.

HIGH-VOLGATE BUSHINGS

Each of the stationary contacts **26** of the interrupter is mounted on a high-voltage terminal bushing **32** which extends through one end wall of metal tank **20**. This high-voltage bushing is of a conventional design, preferably corresponding to that shown and claimed in U.S. Pat. No. 3,009,983, Oppel, assigned to the assignee of the present invention. The bushing **32** comprises a central conductive stud **34** and an insulating housing concentrically surrounding stud **34**. The insulating housing comprises a pair of aligned porcelain shells **36** and **38** and a metal spacing ring **40** therebetween. The parts **36**, **38** and **40** are suitably clamped between a pair of shoulders **42** and **44** on stud **34** at opposite ends of the insulating housing. Suitable gaskets (not shown) are provided between the adjacent abutting components of the bushing to seal the interior of the bushing from the surrounding media.

Each tank **20** is provided with two high-voltage bushings **32**, and all of these bushings are preferably substantially identical. These bushings serve not only to support the stationary contacts **26** of the interrupters but also to insulate these contacts and studs **34** from tank **20** when the breaker is open. To aid the bushings in preforming their insulating function, each is filled with a high-quality dielectric gas, such as sulfur hexafluoride. The interiors of all of the bushings are placed in communication with each other by metallic tubing **45** and **46**. Tubing **45** spans the metal tank **20** of each interrupter assembly and is connected at each end to an opening extending laterally through central spacer ring **40** of one of the bushings. Tubing **46** is connected between the outer ends of the two immediately adjacent bushings of the two interrupter assemblies. The dielectric gas that fills the bushings is supplied to the right-hand bushing **32** of interrupter assembly **14** via a tube **49** at the outer end of the bushing. The tubing **45** and **46** allows the gas entering the tube **49** to fill all the bushings.

CURRENT TRANSFORMER

For measuring the current in power line **15** to provide suitable signals for controlling the circuit breaker and for other relaying purposes, a current transformer **60** of a conventional design is provided at the right-hand side of interrupter assembly **14**, as seen in FIG. **1**. In certain circuit breakers embodying this invention, the current transformer will be located to the left of interrupter assembly **12**. In others, current transformers will be provided at both sides of the two assemblies. A preferred form of current transformer is shown and claimed in U.S. Pat. No. 3,456,220 Stewart, assigned to the assignee of the present invention. This current transformer will be described herein only in sufficient detail as to afford an understanding of the present invention. This current transformer comprises a grounded metal tank **62** and a vertically extending hollow insulating housing **64** mounted atop the tank. The primary winding of the transformer comprises two spaced-apart conductive arms **66** and **68**, which are mounted in coaxial relationship and are connected in series by means of a loop-shaped portion (not shown) of the primary winding located within tank **62**. Inner conductor **68** is electrically connected to an external portion of power circuit **15**, and outer conductor **66** is electrically connected to a metal plate **70** extending across the top of insulating housing **64**. Current entering the current transformer through inner arm **68** flows downwardly through arm **68** through the loop-shaped conductor portion (not shown) located in tank **62** and then upwardly through outer conductor **66** to top metal plate **70**. A suitable conductor **72** between top metal plate **70** and stud **34** of the right-hand bushing **32** carries current between the current transformer and the interrupter assembly **14**. Conducting arms **66** and **68** are locally insulated from each other by means comprising an insulating sleeve **74** near the top of the conductive arms.

UTILIZING THE CURRENT TRANSFORMER AS A GAS-SUPPLY RESERVOIR FOR THE BUSHINGS

The interior of current transformer **60** is filled with the same dielectric gas as contained in the bushings **32**. In accordance with one aspect of our invention, the current transformer housing serves as a reservoir for supplying the bushings with their dielectric gas filler. To this end, tube **49** communicates with the interior of the current transformer at the top of insulating column **64** and thus pneumatically connects the interior of right-hand bushing **32** with the interior of current transformer **60**. Thus, any dielectric gas lost from any of the bushings **32** can be made up by gas supplied from the interior of the current transformer, via tube **49**. The volume of free space in the current transformer **60** is very large compared to that in the bushings, e.g., about 25 times that of each bushing, and thus a bushing can be replenished from the current transformer volume with little effect on the pressure of the dielectric gas in the overall system. The pressure in the system is maintained above a predetermined level by supplying gas to the interior of current transformer tank **62** either manually or through a suitable regulator valve (not shown). A typical normal pressure of the dielectric gas is about 50 p.s.i. gauge.

Note that the tubes **45**, **46**, and **49**, being mounted atop insulating columns **16** and insulating housing **64**, are in regions that are normally at line voltage. Since they extend between zones of the same potential, they require no insulating ability and may, if desired, be made of metal. However, to facilitate electrical testing and to preclude significant current flow through the tubing, we prefer to use a suitable electrical insulating material for tubes **46** and **49**.

In a typical prior design of this general type circuit breaker, the insulating columns **16** that support the interrupter tanks **20** have been relied upon to serve as reservoirs from which the bushings **32** atop each column are supplied with dielectric gas. But by using the separate freestanding current transformer **60** as the reservoir from which all of the bushings **32** are supplied, as is described hereinabove, I can remove from the support columns **16** all of the special dielectric gas previously present. This is a significant advantage, as will soon appear more clearly.

INSULATING SUPPORT COLUMNS

To maintain good insulating properties of the parts that are located within the space **54** inside each column **16**, we keep this space filled with dry air at a relatively low pressure compared to that in tanks **20** and air lines **50**, e.g., about 50 p.s.i. For confining this low-pressure air within space **54**, top and bottom metal plates **56** and **57** are provided at the respective upper and lower ends of insulating casing **17** and are suitably sealed thereto. Using air instead of a special dielectric gas in space **54** is advantageous because should there be any leakage

from the air line **50** into the space **54**, there is no mixing of the special dielectric gas and the air. To minimize the possibility of such mixing, it has been typical practice to provide between the top plate **56** and the air line complex sealing structure, e.g., double O-ring seals with a vented space therebetween. But we can eliminate the need for such complex sealing structure since there is no special dielectric gas near the air line into which the high-pressure air might leak. We are thus able to provide a simple seal between the air line **50** and top plate **56**. This seal, which is schematically shown at **98** in FIG. **1**, will soon be described in more detail. A suitable pressure relief valve (not shown) provided for each column **16** limits the pressure rise therein in the remote event of high-pressure air leaking into the column.

Since the air line **50** is primarily of fiber-glass-reinforced polyester resin and the insulating casing **17** is primarily of porcelain, a given temperature change will produce an appreciably different expansion of these two parts. This is accentuated by the fact that typically these are both relatively long parts, e.g., 10 feet or more. To accommodate this differential expansion, we fix the lower end of the air line to the bottom metal plate **57** and allow the top end of the air line to slide relative to top plate **56**.

JOINTS BETWEEN AIR LINE AND SUPPORT COLUMN COMPONENTS

The joint between the lower end of the air line and the bottom plate **57** is depicted in greater detail in FIG. **2**. In this joint, the tubular metal fitting **80** on the lower end of the air line extends through an opening **81** in the end plate and has a peripheral groove **83** of generally V-form therein. A split ring **85** fits into this groove and is bolted to end plate **57**. An O-ring **84** between metal fitting **80** and end plate **57** provides a leakproof seal between these parts.

The joint between the upper end of the air line and the top plate **56** is depicted in detail in FIG. **3**. In this joint, a tubular metal fitting **90** is bonded to the top of the tubular resin portion **52** of the air line. This metal fitting **90** extends freely through an opening **88** in the top plate **56** and is slidably received in the bore of the metal pipe **51** which extends between top plate **56** and interrupter tank **20**. Metal pipe **51** is secured to the upper end plate **56** by means of a split ring **91** fitting into a groove in the outer periphery of the pipe **51** and bearing against the top of end plate **56**. A clamping ring **92** bears against an external shoulder **94** on pipe **51** and is clamped to top plate **56** by screws **93**. When screws **93** are tightened against the opposition of spring washers **95**, they force ring **91** against the top of end plate **56**, thereby clamping pipe **51** to plate **56**. Pipe **51** has a cylindrical portion fitting into the opening **88** in the top plate **56** and provided with an O-ring **89** that provides a leakproof seal between pipe **51** and top plate **56**. The space surrounding pipe **51** is at atmospheric pressure.

If the air line **50** increases its length relative to porcelain casing **17** in response to a temperature change, the metal fitting **90** on the upper end of the air line slides within the bore of metal pipe **51** to accommodate this differential expansion. Sealing structure **98** preferably of the O-ring type is carried in a groove in metal fitting **90** to provide a seal between fitting **90** and the bore of pipe **51** that allows such relative movement without permitting leakage between parts **51** and **90**.

A more detailed showing of a preferred form of sealing structure **98** is shown in FIG. **4**. This sealing structure comprises an O-ring element **98*a***, preferably of a silicone resin, and a surrounding sleeve **98*b***, sometimes referred to as a slipper seal, of a wear-resistant, low-friction material such as polytetrafluoroethylene. These parts fit in a groove **98*c*** in the outer periphery of the cylindrical fitting **90**. When the fitting **90** moves with respect to the pipe **51**, the outer surface of the slipper seal **98*b*** slides along the cylindrical bore of he pipe. Since this is a commercially available sealing structure, no further description of its details is believed necessary.

There is very little movement of metal pipe **51** with respect to the wall of tank **20**. This is the case because the tank **20** is supported on the top plate **56** by brackets **100** of a metal having substantially the same coefficient of thermal expansion as the metal of pipe **51**. Thus, the tank moves vertically in response to temperature changes by substantially the same amount as the upper end of the pipe, and little or no relative movement of these parts occurs, thereby reducing the duty on O-ring seal **53**.

Referring o FIG. **3**, a much greater amount of vertical movement takes place between the metal end fitting **90** and the bore of metal pipe **51**, but this can be accommodated without leakage by the simple O-ring type seal **98**. The fact that this O-ring seal **98** is disposed between two metal surfaces instead of between one metal and one insulating surface reduces its wear and its likelihood of being otherwise damaged by the appreciable sliding motion present. Our studies indicate that motion of an O-ring type seal on fiber-glass containing resin in the presence of very high fluid pressures is detrimental to the life of the seal, and we therefore eliminate any such motion on fiberglass resin from out construction.

The other O-ring seals used in or around our air line **50** are substantially free of sliding motion and are thus subject to very little wear. In this respect, note that the lower end of air line **50** is fixed with respect to the lower end plate **57**, as shown in FIG. **2**, and this substantially eliminates wear on O-ring seal **84** present in that location. Note also that the pipe **51** at the upper end of the air line is clamped to the top plate **56**, and thus its O-ring seal **89** is substantially free of sliding motion. This substantial freedom from sliding motion and wear contributes to high reliability and long life.

For guiding the long slender air line **50** during its expansion and contraction, a suitable guide plate **102** is provided intermediate its ends. This guide plate has an opening receiving the air line and may be provided with a suitable bearing for imparting added guidance to the air line. Additional guide plates at other locations along the length of the air line may be provided to impart additional guidance for the air line. This guidance helps to reduce the possibility of damage to sliding O-ring seal **98**.

REPLACEMENT OF SEALS

It is a simple matter to replace any of our O-ring seals should this be necessary. This can be done by first removing split ring **85** at the lower end of the air line and lowering the major portion **52** of the air line to expose the O-ring **84** in the lower joint for replacement. Then the clamping ring **92** of FIG. **3** can be detached from the upper end plate **56**, following which pipe **51** can be slid up part way into tank **20** to expose the O-ring seals **89** and **98** for replacement. Note that all of these steps can be preformed without removing the tank **20** from the insulating column **16**, which is a distinct advantage in terms of cost and time saving. The interrupting mechanism inside the tank and the pipe **51** are free of obstructions that would block the desired raising of pipe **51** into the tank **20**.

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

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

1. A high-voltage electric circuit breaker of the airblast type comprising:

a. a plurality of interrupter tanks at a high voltage, each containing high-pressure air and circuit-interrupting means disposed in said high-pressure air,

b. at least one high-voltage bushing for each tank projecting into said tank and containing an interior space filled with a pressurized gaseous dielectric other than air,

c. a plurality of generally vertically extending hollow insulating columns respectively supporting said tanks, each being filled with air at a pressure lower than the normal pressure in said tanks,

d. a plurality of air lines primarily of insulating material for respectively supplying high-pressure air to said interrupter tanks,

e. each of said air lines extending generally vertically through the hollow insulating column on which its associated tank is supported,

f. means for sealing the interior of each of said air lines from the interior of its associated insulating column in a manner that allows a portion of said air line to move relative to said insulating column in response to temperature changes,

g. a high-voltage current transformer mounted adjacent one of said supporting columns and comprising a generally vertically extending insulating housing filled with gaseous dielectric of the same type as in said bushings and further comprising a high-voltage primary winding extending through said insulating housing,

h. means located atop said insulating columns and said insulating housing for interconnecting said insulating housing and the interior spaces in said bushings to allow said insulating housing to act as a reservoir from which the gaseous dielectric supply in said bushings can be replenished, and

i. means for electrically connecting in series said interrupting means and said high-voltage primary winding.

2. The circuit breaker of claim 1 in which:

a. at least one of said insulating columns comprises a tubular casing primarily of insulating material and a pair of end plates respectively secured in sealed relationship to the upper and lower ends of said tubular casing,

b. the air line that extends through said one insulating column comprises a long slender tubular portion of insulating material and a pair of tubular metal fittings secured in sealed relationship to opposite ends of said tubular insulating portion,

c. means is provided for securing the lower one of said end fittings to the lower one of said end plates in sealed relationship thereto,

d. said air line further comprises a metal pipe fixed to said upper end plate and having a bore receiving said upper metal end fitting in sliding relationship and ring-type sealing structure between the outer surface of said metal fitting and said bore for providing a seal therebetween that allows sliding motion of said upper end fitting within said bore,

e. said metal pipe extends from said upper end plate to said tank.

3. The circuit breaker of claim 2 in which:

a. said metal pipe is fixed to said upper end plate by releasable fastening means which allows said metal pipe to be detached from said upper end plate,

b. said metal pipe is slidable within the wall of said tank so that following detachment from said upper end plate said pipe can be raised partially into said tank,

c. said interrupting means and said pipe are so constructed that the pipe, when detached from said upper end plate, can be raised sufficiently into said tank to expose said ring-type sealing structure and allow for its replacement without necessitating removal of said tank from said insulating column.

4. A high-voltage electric circuit breaker of the airblast type comprising:

a. an interrupter tank at a high voltage containing high-pressure air and circuit-interrupting means disposed in said high-pressure air,

b. a generally vertically extending hollow insulating column supporting said tank and filled with gas at a pressure lower than the normal pressure in said tank,

c. said insulating column comprising a tubular casing primarily of insulating material and a pair of end plates respectively secured in sealed relationship to the upper and lower ends of said tubular casing,

d. an air line for supplying high-pressure air to said interrupter tank, said air line extending generally vertically through said hollow insulating column,

e. said air line comprising a long slender tubular portion of insulating material and a pair of tubular metal fittings secured in sealed relationship to opposite ends of said insulating material portion,

f. means for securing the lower one of said end fittings to he lower one of said end plates in sealed relationship thereto,

g. said air line further comprising a metal pipe fixed to said upper end plate and having a bore receiving said upper end fitting in slidable relationship,

h. ring-type sealing structure between the outer surface of said metal fitting and said bore for providing a seal therebetween that allows sliding motion of said upper end fitting within said bore when said insulating material portion changes its length in response to temperature changes, and

i. said metal pipe extending from said upper end plate to said tank.

5. The circuit breaker of claim 4 in which:

a. said metal pipe is fixed to said upper end plate by releasable fastening means which allows said metal pipe to be detached from said upper end plate,

b. said metal pipe is slidable within the wall of said tank so that following detachment from said upper end plate said pipe can be released partially into said tank,

c. said interrupting means and said pipe are so constructed that the pipe, when detached from said upper end plate, can be raised sufficiently into said tank to expose said ring-type sealing structure and allow for its replacement without necessitating removal of said tank from said insulating column.