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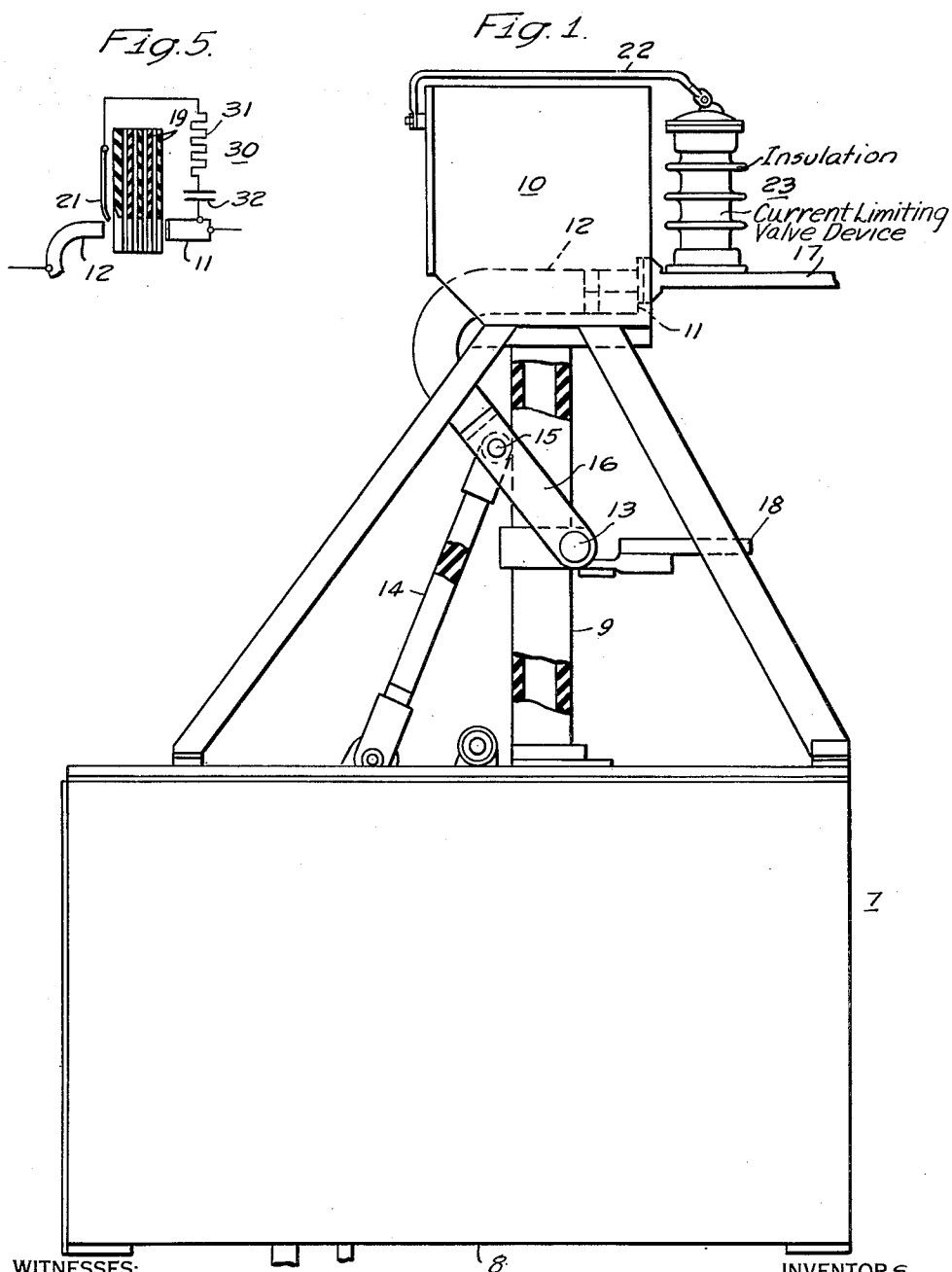
B. P. BAKER ET AL

2,586,290

CIRCUIT INTERRUPTER

Filed Nov. 1, 1947

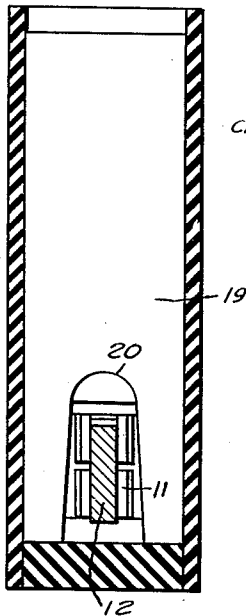
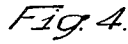
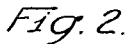
2 SHEETS—SHEET 1



Filed Nov. 1, 1947

CIRCUIT INTERRUPTER

2 SHEETS--SHEET 2



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UNITED STATES PATENT OFFICE

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CIRCUIT INTERRUPTER

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3 Claims. (Cl. 200—146)

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This invention relates to circuit interrupters in general, and more particularly to arc-extinguishing structures therefor.

A general object of our invention is to provide an improved circuit interrupter, particularly of the gas-blast type, in which arc extinction is more readily effected than heretofore and in which trouble due to high surge voltages is avoided during opening of the connected circuit.

A more specific object is to provide an improved circuit interrupter of the gas-blast type in which a shunt including a current limiting valve device of the voltage or frequency sensitive type is employed. Preferably, an auxiliary electrode disposed adjacent to the path of movement of the movable contact is utilized so that the current limiting valve device may be inserted into series circuit during the opening operation.

Still a further object is to provide an improved gas-blast circuit interrupter of the splitter cross-blast type in which a probe is utilized in the extinguishing structure, adjacent to which the movable contact moves during the opening operation. Preferably, a current limiting valve device is connected between the probe and the stationary contact to limit voltage surges during the opening operation.

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

Figure 1 is a side elevational view, partially in section, of an improved gas-blast type of circuit interrupter embodying our invention and shown in the closed circuit position;

Fig. 2 is a vertical sectional view through the arc-extinguishing structure of the interrupter shown in Fig. 1, the contacts being shown in the closed circuit position;

Fig. 3 is a vertical sectional view taken along the line III—III of Fig. 2;

Fig. 4 is a graph indicating the circuit voltage, arc voltage and arc current in a circuit of the type to be interrupted; and

Fig. 5 illustrates diagrammatically an arrangement similar to that of Fig. 2, except that a different current limiting valve shunt is employed.

Trouble is sometimes experienced with circuit breakers when opening low or moderate currents in highly inductive circuits due to abnormally high voltage surges which sometimes occur. These abnormal transient over-voltages are caused by too early extinction of the arc formed between the breaker contacts on opening and are generally of the form shown in Fig. 4. Fluid

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blast breakers in which the blast is independent of the interrupted current magnitude are particularly prone to cause such over-voltages, which may cause failure of the breaker to interrupt the circuit or failure of the insulation of connected apparatus.

Referring to Fig. 4, the reference numeral 1 indicates the circuit voltage which alternates in sinusoidal fashion, 2 designates the arc current which passes to zero at the point 3, and 4 indicates the magnitude of the arc voltage, the latter being initially low before the arc is interrupted and upon interruption of the arc oscillating about the circuit voltage in a manner designated by the reference numeral 5. The oscillating voltage transient 5 finally settles down to the circuit voltage at 6, whereafter the voltage across the open contacts is merely the normal open circuit voltage.

We have found that abnormally high voltage surges indicated by the reference numeral 5 in Fig. 4 not only tend to break down the arc gap to cause reignition of the extinguished arc but also subject the connected apparatus to severe electrical strain.

We have discovered that the use of a voltage limiting device including a plurality of non-linear resistance blocks such as are used in lightning arresters, may be successfully employed in reducing such over-voltages. These valve blocks may, for example, be composed of silicon carbide with sodium silicate as a binder. Such valve type circuit elements have the property of discharging large currents at nearly constant voltage near their upper voltage limit, but passing only very small currents at lower voltages. These voltage limiting shunts are so related to the circuit being interrupted by the breaker that they will pass only small currents at normal circuit voltage but at abnormally high voltage, pass sufficient additional current to absorb the excess energy associated with the abnormal transient and so limit the voltage to prevent its further rise.

Referring to Fig. 1, there is illustrated a gas-blast type of circuit interrupter generally designated by the reference numeral 7. The interrupter 7 includes an operating mechanism and a gas storage tank enclosed within the housing 8, the latter also serving as a base for supporting an insulating blast tube 9 of tubular form which extends between the reservoir tank and the arc chute 10 employed for interrupting the arc drawn between the stationary contact 11 and the movable contact 12. Preferably, opening motion of

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the C-shaped movable contact 12 is provided by pivotally mounting it at a fixed pivot 13 and employing an operating rod 14 pneumatically operated in desired sequence. The upper end of the operating rod 14 is pivotally connected at 15 to the bifurcated portion 16 of the movable contact 12. Thus downward or opening motion of the operating rod 14 causes counterclockwise rotation of the C-shaped movable contact 12 about its stationary pivot 13 to thereby cause a separation between the movable contact 12 and the stationary contact 11.

Since the line terminals 17, 18 are respectively connected electrically to the stationary contact 11 and the movable contact 12, an arc is established between the separating contacts 11, 12, within the arc chute 10.

Extinction of this arc is readily effected by a cross-blast of compressed gas, preferably air, passing upwardly through the insulating tube 9 and transversely across the arc gap between the stationary contact 11 and the movable contact 12. Preferably, a plurality of slotted spaced insulating plates 19 (Fig. 3) having slots 20 formed therein are provided to permit the arc to be forced laterally by the gas blast against the apices of the slots 20. The cross-blast of compressed gas causes the arc to be attenuated between the spaced insulating plates 19 to readily effect its extinction. Preferably, such an arc chute construction follows the teachings set forth in United States Patent 2,272,380 which issued February 10, 1942, to Leon R. Ludwig, Herbert L. Rawlins and Benjamin P. Baker, and assigned to the assignee of the instant application.

In accordance with our invention, we employ a probe or auxiliary electrode 21 disposed immediately adjacent to or actually rubbing against the upper side of the movable contact 12, as shown in Fig. 2. In the particular form illustrated, the gap between the probe 21 and the upper side of the movable contact 12 is $\frac{1}{4}$ ". The probe 21 is electrically connected by a connector 22 to the current limiting valve device, generally designated by the reference numeral 23, and mounted upon the plate forming the line terminal 17.

The current limiting valve device 23, in this instance, includes a plurality of non-linear resistance blocks 24 of the type employed in lightning arresters. As mentioned previously, these non-linear resistance blocks 24 have the property of discharging large currents at nearly constant voltage near their upper voltage limit, but passing only very small currents at low voltages. To provide a weatherproof construction, a ceramic tube 25 is utilized having at its upper end a metallic cap 26 suitably secured thereto as by cementing at 27.

As the tip of the moving contact 12 moves toward the left, as viewed in Fig. 2, past the probe or auxiliary electrode 21, the current through the main arc transfers to the current limiting valve device 23 so that the main arc between the contacts 11, 12 is extinguished, and only a residual current arc remains to be extinguished, the latter extending between the probe 21 and the tip of the movable contact 12. The blast of compressed gas passing upwardly through the blast tube 9 passes partly out of the opening 23 of the arc chute 10 to readily effect extinction of the residual current arc of smaller magnitude.

Thus in Figs. 1-3, we have shown a voltage limiting shunt 23 applied to a cross-blast or insulating splitter type of air-blast interrupter. The shunt is connected between the stationary

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contact 11 of the breaker and an auxiliary electrode 21 at the other end of the arc chute 10 so positioned as to make connection with the moving contact either directly or through a short spark, while the moving contact 12 is within the arc chute 10. The residual current to the shunt 23 is easily interrupted as the tip of the moving contact 12 pulls past the auxiliary electrode 21 to its fully open position outside of the chute 10 and separated from it by several inches of air space. This additional air space is normally designed alone to be able to withstand full circuit voltage with an adequate factor of safety. Even though the shunt 23, so connected, short-circuits a portion of the contact separation distance in the fully open position, it still enables the breaker to interrupt circuits of higher voltage than could be interrupted without its presence. This arises because the shunt 23 serves to reduce the maximum "overshoot" 29 (Fig. 4) of the voltage applied to the interrupting portion of the space by many times. For example, if the space "shorted" by the shunt 23 constitutes as much as one-half of the total fully open dielectric strength of the breaker, and if the peak voltage 29 applied to this space is limited to one-fourth or less of the peak voltage which would be applied without the shunt 23, then the voltage interrupting ability of the breaker as a whole should be at least doubled.

Such a voltage limiting shunt 23 also serves to protect the breaker and associated insulation from voltage surges occurring during circuit opening but originating in connected apparatus, such as when the interrupter load is or includes an arc furnace. It would also prevent over-voltages due to the cascading effect of restrikes when opening a capacitive circuit.

We have found that the utilization of such a current limiting valve shunt 23 results in an improvement of 2 to 1 or better in voltage interrupting ability by using such a voltage limiting shunt.

Fig. 5 illustrates a modification of our invention in which the current limiting valve device 30, in this instance, includes a resistance 31 and a serially connected capacitance 32. The higher-than-normal current produced in this shunt by transient over-voltages results from the higher-than-normal frequency of the transient over-voltage. The operation and the transfer of the main current to the shunting device 30 is the same as described heretofore. Again, the residual current arc between the moving contact 12 and the probe 21 is interrupted by the gas blast. Since the current magnitude of the residual current arc is small and of small leading power factor, the extinction thereof is readily effected.

The foregoing description of two embodiments of our invention shows that we have improved the interrupting ability of gas-blast circuit interrupters of the cross-blast splitter type by employing a current limiting valve device 23, 30 shunted between the stationary contact 11 and the auxiliary electrode or probe 21. The shunts 23, 30 serve to have a current valve action permitting appreciable flow of current at high voltage but reducing it to a very small value as the voltage decreases. The ohmic resistance of the device 23 is, therefore, variable and non-linear as a function of applied voltage. As a result of the decrease in resistance, the applied voltage is prevented from rising higher than a safe value. Should the recovery voltage continue to rise in

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magnitude, the effective resistance of the shunt 23 decreases to limit such a rise in applied voltage.

By an application of our invention, we have increased the interrupting ability of cross-blast compressed gas circuit interrupters by a factor of two or more. Further, the connected apparatus and the breaker itself are not subjected to severe electrical strain; consequently, the operational life is increased and maintenance costs are considerably reduced.

Although we have shown specific structures, it is to be clearly understood that the same were merely for the purpose of illustration, and that changes and modifications may readily be made therein without departing from the spirit and scope of the appended claims.

We claim as our invention:

1. A circuit interrupter including a relatively stationary contact, a movable contact separable from the stationary contact to establish a main current arc, a probe disposed adjacent the path of movement of the movable contact, a resistance, a condenser, means electrically connecting the resistance and condenser in electrical series between the probe and stationary contact, and a residual current arc being established between the probe and the movable contact near the end of the opening operation, the main current arc being extinguished prior to the extinction of the residual current arc, and the residual current arc being thereafter extinguished to finally interrupt the electrical circuit.

2. A circuit interrupter of the cross-blast type including a plurality of spaced insulating plates, a relatively stationary contact disposed adjacent one end of the plates, a movable contact separable from the stationary contact to establish a main current arc substantially transversely of the plates, means for forcing a blast of gas across the main current arc laterally thereof to effect the extinction thereof, a conducting probe disposed adjacent the path of movement of the

movable contact, a resistance, a capacitance, means electrically connecting the resistance and capacitance in series electrically between the stationary contact and the probe, the current passing through the resistance and capacitance after extinction of the main current arc, and means for forcing a blast of gas against the residual current arc established between the probe and the movable contact to effect the extinction thereof.

3. A circuit interrupter including means for establishing a main current arc, a resistance and a serially connected condenser, means for electrically connecting the resistance and the serially connected condenser in parallel with the main current arc to more readily effect the extinction of the latter, and means for causing the extinction of the residual current through the resistance and the serially connected condenser following extinction of the main current arc to thereby effect the interruption of the circuit.

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