April 5, 1966 SAMPEI KAMEYAMA ETAL 3,244,842

CIRCUIT INTERRUPTER

Filed June 7, 1963

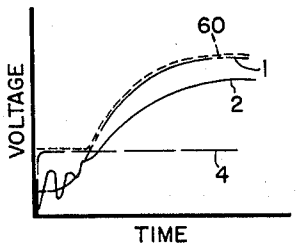

Fig. 1.

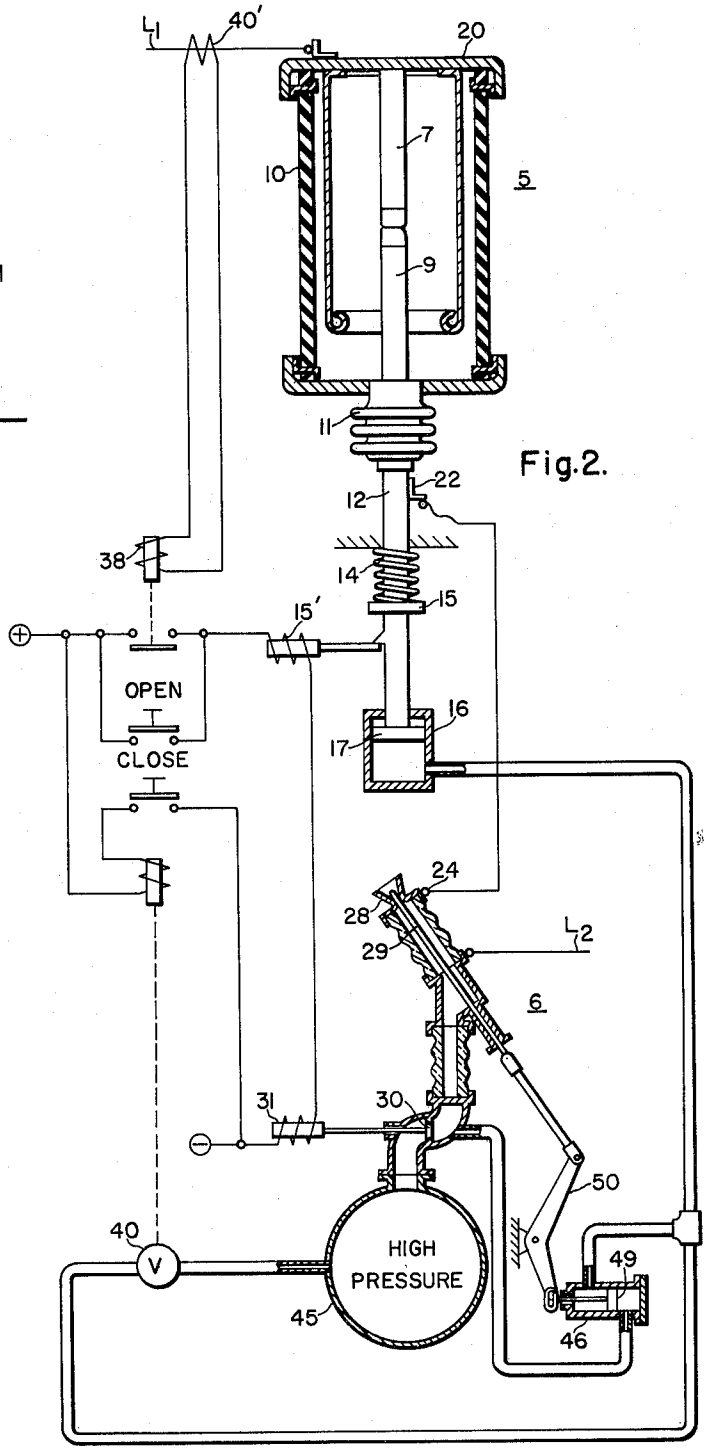

Fig. 2.

United States Patent Office 3,244,842 Patented Apr. 5, 1966

3,244,842

CIRCUIT INTERRUPTER

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Filed June 7, 1963, Ser. No. 286,328
Claims priority, application Japan, July 30, 1962, 37/32,110
3 Claims. (Cl. 200—144)

This invention relates to circuit interrupters in general and, more particularly, to improved circuit-interrupting structures adaptable for interrupting circuits having relatively high rates of rise of recovery voltage transient.

A general object of the invention is to provide an improved interrupting device incorporating a pair of serially related circuit breakers having different voltage withstanding characteristics. Preferably, one of said circuit breakers has an immediate extremely high rate of rise of impressed voltage withstanding characteristics, to become thereby immediately effective to prevent reignition of fault conditions having very high rates of rise of recovery voltage transients; and the other serially related circuit breaker has the characteristic of withstanding impressed voltage in the region of the peak amplitude of the recovery voltage transient. Hence, the combined characteristics of both serially related breakers result in effective and successful interruption of faults of extremely high rates of rise of recovery voltage.

Another object of the present invention is to provide an improved circuit interrupter in which the combined operating characteristics of a vacuum-type circuit interrupter and a compressed-gas circuit interrupter are utilized to the best advantage for minimizing, or substantially preventing restriking of the recovery voltage across the breaker during high rates of rise of the recovery voltage transient, such as produced by kilometric faults.

Still a further object of the present invention is to provide an improved circuit interrupter embodying two different types of circuit-interrupting structures whose voltage withstanding characteristics upon interruption are utilized to the maximum extent.

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

FIGURE 1 illustrates a graph showing the voltage-withstanding characteristics of different types of circuit interrupters, and the recovery voltage to be encountered during a kilometric fault; and,

FIG. 2 is a circuit-interrupting structure embodying features of the present invention, the contact structure being illustrated in the closed-circuit position.

As electrical power systems are constantly increased in their power capacity, short-circuit currents flowing through them rapidly increase in magnitude, and the so-called kilometric faults have become such as to impose very severe requirements upon air, or gas-blast circuit interrupters. The reason for this is that the air-blast circuit interrupter has a so-called insulation-recovery characteristic, such as illustrated by the reference numeral **1** in FIG. 1, whereas in any kilometric fault, a restriking voltage having a wave form, such as shown by curve **2** in FIG. 1, appears immediately after interruption at the current zero as a result of super-imposing upon the restriking voltage a high-frequency oscillation caused by a reciprocal reflection along the line. This leads generally to failure of the interrupting units of the prior art.

To solve the foregoing problem, circuit interrupters have recently been manufactured having a complicated structure and including three interrupting points, two of which include inserted therein low resistances for suppressing the impressed voltages.

The present invention contemplates the elimination of the aforementioned disadvantages of conventional air-blast or gas-blast circuit interrupters by utilizing the special insulating characteristics of a vacuum switch. Any vacuum switch has a high resistance to both the slope of a current flowing therethrough, and a rapidly rising insulation rate for a restriking voltage (rate of rise of recovery voltage) across the same near to the current zero interruption point, which imposes severe requirements upon a conventional type of air-blast circuit interrupter. Taking, as an example, a small vacuum switch including tungsten electrodes, experiments have proved that the same withstands a current slope of 10^8 amperes/microsecond and a voltage rate of rise of 20 kv./microsecond or more. However, such a vacuum switch has the disadvantage that it is inferior to an air-blast circuit interrupter in the range of the peak of the restriking voltage. The insulation recovery characteristics of a vacuum switch may be represented by the curve **4** in FIG. 1.

As a result, the present invention contemplates the provision of a circuit interrupter of high interrupting performance comprising a high-pressure circuit interrupter, such as an air-blast circuit interrupter, and a vacuum switch connected in series thereto, whereby the vacuum switch bears a high rate at which a restriking voltage is imposed immediately after a current interruption, whereas the high-pressure circuit interrupter resists the peak amplitude of the restriking voltage.

With reference to FIG. 2 of the drawings, it will be apparent that there is provided a vacuum switch **5** disposed in series relation with an air, or gas-blast type of circuit interrupting structure **6**. The vacuum switch **5** comprises a stationary contact **7**, a movable contact **9**, the latter entering the evacuated envelope **10** through means of a Sylphon bellows **11**. The extension **12** of the movable contact **9** is biased by a spring **14** to the open-circuit position. As shown, the accelerating spring **14** has a spring seat, a flange portion **15** fixedly secured to and movable with the operating rod portion **12** of the movable contact **9**. The movable contact **9**, as shown, is latched in the closed-circuit position by a latching device **15'**, which may be electrically released in a manner hereinafter described.

To effect closing of the vacuum circuit interrupter **5**, pressure may be fed to an operating cylinder **16**, within which reciprocally moves a piston **17** attached to the lower extremity of the operating rod **12**.

A line connection L_1 is secured to an upper conducting plate **20**, to which the upper relatively stationary electrode **7** is affixed. The circuit extends by way of a sliding connection **22** to a terminal **24** of the gas-blast breaker **6**.

The gas-blast breaker **6**, as shown, comprises a nozzle-shaped stationary contact **28**, and a movable rod-shaped contact **29**, which is actuated during the opening operation by the opening of a blast valve **30**. The blast valve **30**, in turn, is electrically actuated by a solenoid device **31**, which, as shown, is responsive either to the pressing of an "open" button, or to a relay **38** responsive to a current transformer **40'** monitoring the current conditions in the line L_1.

To effect closure of the compressed-gas circuit interrupter **6** as well as closure of the vacuum switch **5**, a suitable closing valve **40** is provided, which controls the admission of air from the reservoir **45** to the operating cylinders **16**, **46** to effect closing movement of the respective pistons **17**, **49** therein. Closing movement of the piston **49** within the operating cylinder **46** of the compressed-gas breaker **6** is effective through the linkage **50** to force

the movable rod-shaped contact **29** toward its closed-circuit position, as shown in FIG. 2.

It will be apparent from the foregoing description of the circuit interrupter of FIG. 2 that when an opening signal is fed to the device, the vacuum switch **5** and the high-pressure circuit interrupter **6** are opened at the same time, so that the characteristic of the circuit-interrupting device, as a whole, is that of each of the individual interrupters **5**, **6** in combination, so that a resulting voltage-withstanding curve, such as indicated by the reference numeral **60** in FIG. 1, is the result.

It will be apparent that by combining the characteristics of the individual breakers **5**, **6**, as indicated by the reference numeral **60** of FIG. 1, interruption may be successfully achieved even though high rates of rise of recovery voltage during fault conditions are encountered.

As well known by those skilled in the art, a kilometric fault condition is encountered when the fault occurs relatively closely to the circuit interrupter under consideration, and, for many instances, this is considered to be one-half mile by those skilled in the art. The result is a very high rate of rise of recovery voltage imposed upon the breaker.

From the foregoing description of the invention, it will be apparent that there is provided an improved circuit-interrupting structure comprising a vacuum switch **5** in series with a cooperating gas-blast breaker **6**, the combined voltage-withstanding characteristics of both breakers having the result, such as illustrated by the curve **60** in FIG. 1. By such a combination, high rates of rise of the recovery voltage may be withstood and successful interruptions achieved.

Although there has been illustrated and described a specific structure, it is to be clearly understood that the same was merely for the purpose of illustration and that changes and modifications may readily be made therein by those skilled in the art without departing from the spirit and scope of the invention.

We claim as our invention:

1. A circuit interrupting arrangement for interrupting relatively high rates of rise of recovery voltage comprising, in combination, a vacuum-type circuit interrupter having a high rate of rise of voltage withstanding characteristic, another circuit interrupter having the characteristic of withstanding impressed voltage in the region of peak amplitude of the recovery voltage transient, means for electrically connecting the two circuit interrupters in series to achieve their combined voltage-withstanding characteristics, and means for effecting substantially simultaneous contact opening movement of both circuit interrupters during circuit interruption.

2. A circuit interrupting arrangement for interrupting relatively high rates of rise of recovery voltage comprising, in combination, a vacuum-type circuit interrupter having a high rate of rise of voltage withstanding characteristic, a serally-related gas-blast circuit interrupter having the characteristic of withstanding impressed voltage in the region of peak amplitude of the recovery voltage transient, means for electrically connecting the two circuit interrupters in series to achieve their combined voltage-withstanding characteristics, and means for effecting substantially simultaneous contact opening movement of both circuit interrupters during circuit interrupton.

3. The combination according to claim **2**, wherein means are provided to effect the simultaneous closing operation of both serially-related circuit interrupters.

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