Nov. 3, 1970 W. M. LEEDS 3,538,276

HIGH-VOLTAGE CIRCUIT BREAKER HAVING TWO-STEP CLOSING RESISTANCE

Filed Nov. 24, 1967 3 Sheets-Sheet 1

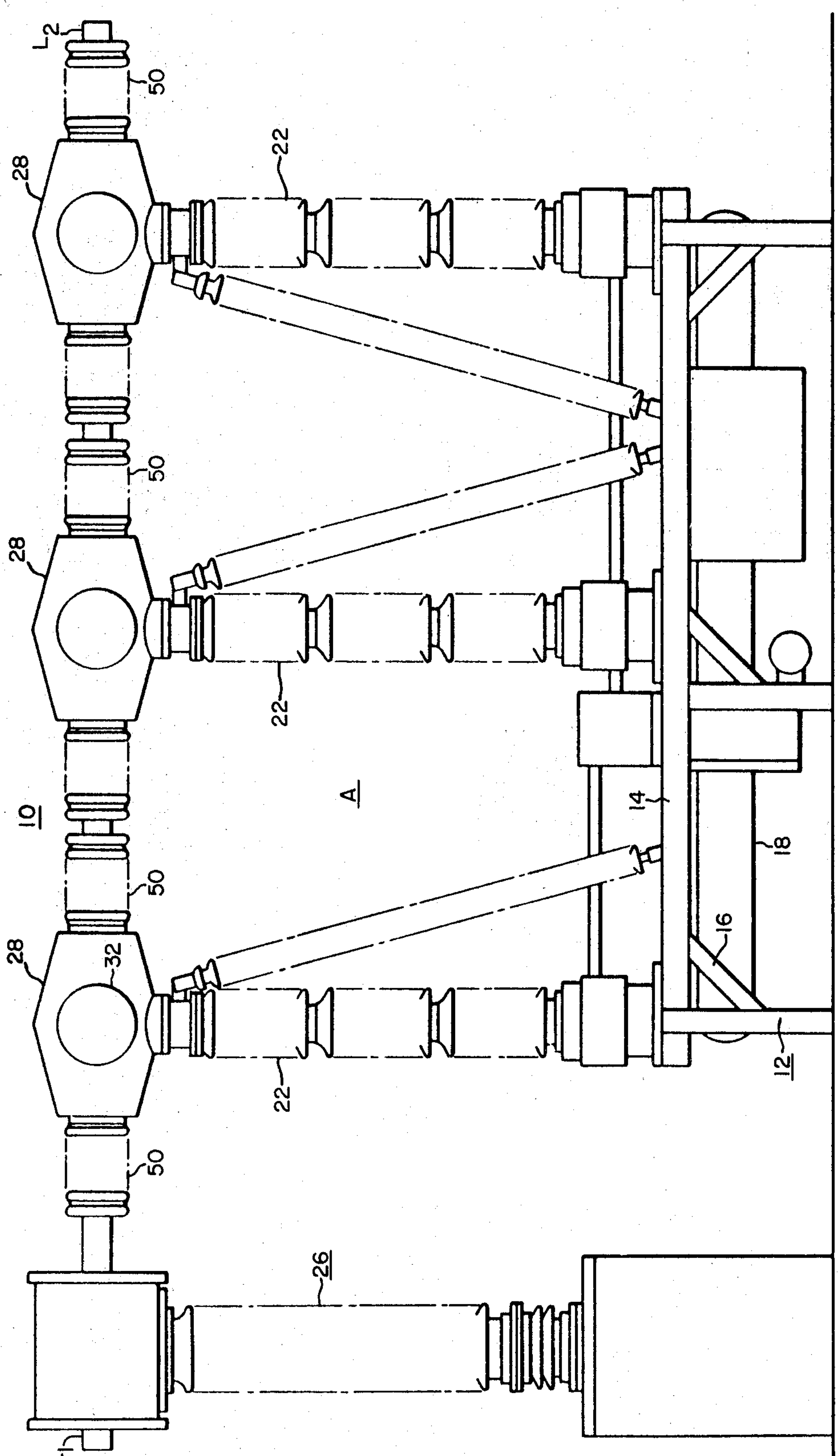

FIG. 1.

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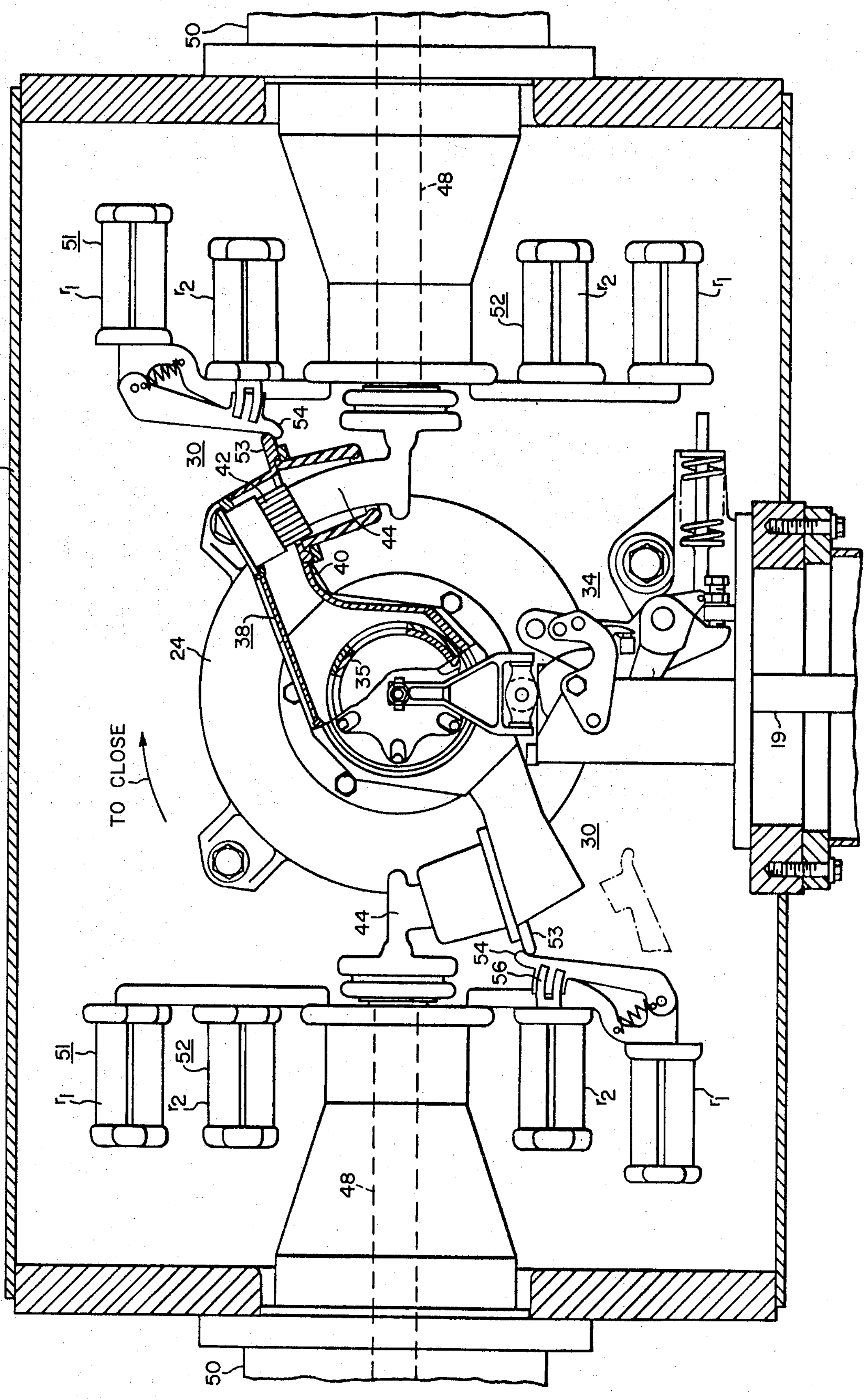

FIG. 2.

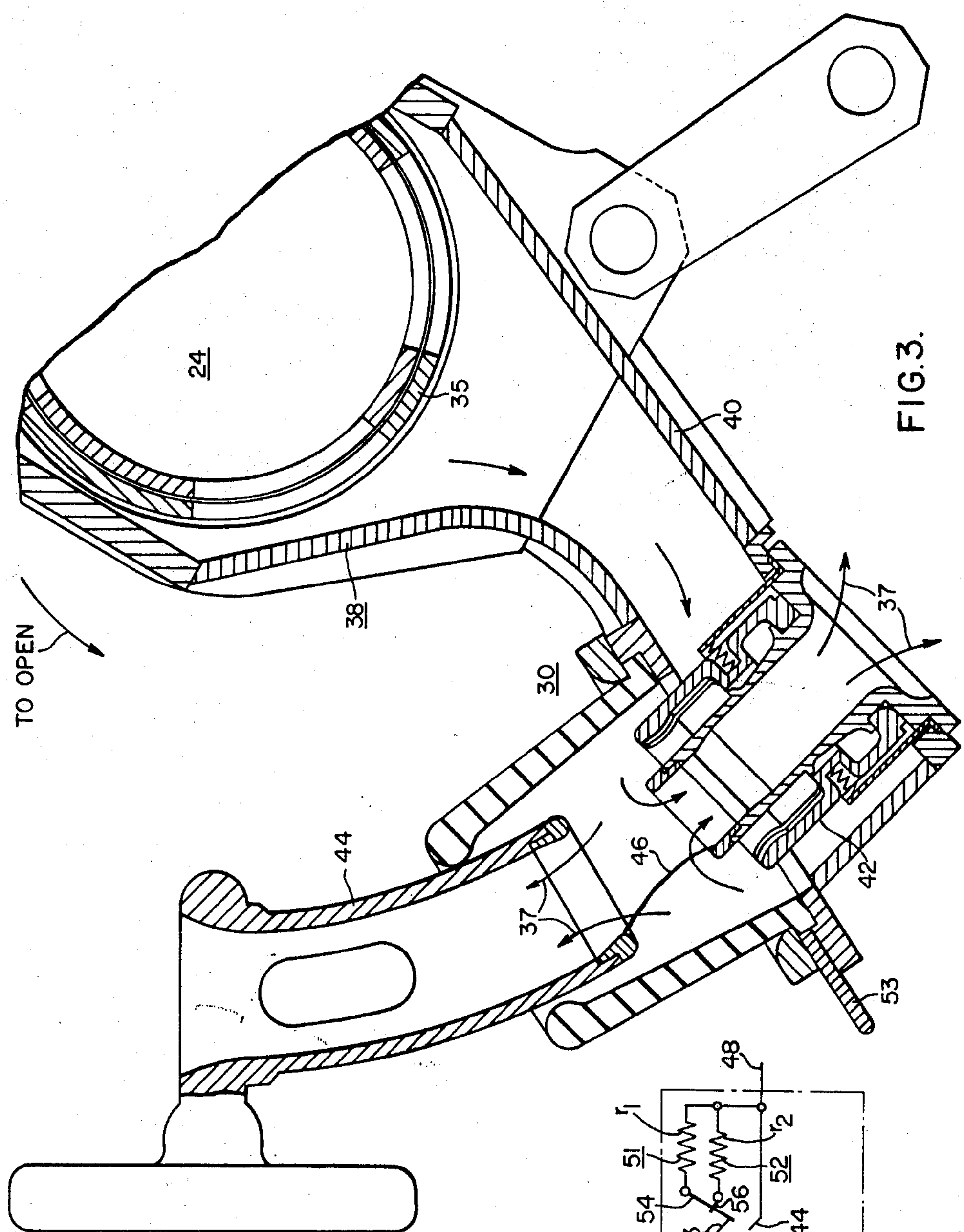

FIG.3.

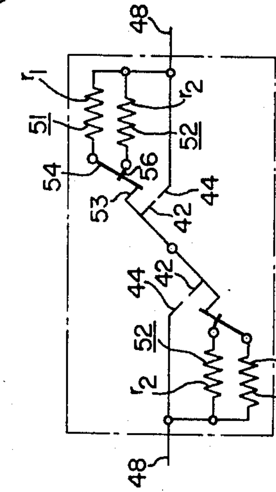

FIG.4.

United States Patent Office

3,538,276

Patented Nov. 3, 1970

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3,538,276

HIGH-VOLTAGE CIRCUIT BREAKER HAVING TWO-STEP CLOSING RESISTANCE

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Filed Nov. 24, 1967, Ser. No. 685,572
Int. Cl. H01h 9/42
U.S. Cl. 200—144 9 Claims

ABSTRACT OF THE DISCLOSURE

A high-voltage circuit breaker has a two-step closing resistance whereby during the closing or reclosing operation one resistance value is picked up and, by the closing of resistance contacts, a second resistor assembly is put in parallel electrically with the first inserted resistor assembly to thereby reduce the value of inserted resistance. In the fully closed-circuit position of the interrupter, the main contacts are in engagement and both resistor assemblies are shorted out. Preferably, the resistances have particular values in terms of the surge impedance of the line being connected.

During the opening operation, the construction of the resistor contacts is such that no resistance is inserted during the opening operation of the breaker.

CROSS-REFERENCES TO RELATED APPLICATIONS

Applicant is not aware of any related application which is pertinent to the present invention.

BACKGROUND OF THE INVENTION

In United States Pat. 3,291,947, issued Dec. 13, 1966 to Roswell C. Van Sickle, and assigned to the assignee of the instant application, there is taught the concept of inserting resistance of certain desired values during the closing stroke of a high-voltage circuit interrupter. Curves are contained in the aforesaid patent, which indicate that the surge voltage magnitude is a function of closing resistance values. Values of .9 to 1.5 times the surge impedance of the energized line were suggested to limit the surge voltages during the closing operation.

Anacom computer studies of switching surge overvoltages on EHV transmission lines have shown that limiting the overvoltage to 2.0 per unit under the worst conditions of reclosing with 1.0 per unit crest voltage on the line requires the insertion of resistance equal to 200 to 600 ohms per phase. Even with optimum resistance values equal to the surge impedance of the line, the overvoltage cannot be held to less than approximately 1.8 per unit. Some utility engineers believe that if switching surges could be held to a limit not exceeding 1.5 per unit on 500 kv. and 700 kv. lines, that very substantial savings in line insulation could be made. The present invention is particularly concerned with a high-voltage circuit breaker in which the individual modules may be modified to include a double step of resistor insertion on the closing or reclosing operation, whereby during the initial portion of the closing stroke one resistance assembly is picked up and inserted electrically into the circuit, and subsequently a second resistance assembly is picked up by resistance contacts and put in parallel electrically with the first resistor assembly. The result is a lower resistance value inserted during the final portion of the closing operation, which effects a further reduction in overvoltages.

SUMMARY OF THE INVENTION

According to a preferred embodiment of the invention, a high-voltage compressed-gas circuit interrupter of

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the rotating contact arm type has a two-step resistor assemblage, which is inserted during the closing operation. The arrangement is such that the rotating main contact arms pick up a first step of the resistance during the closing operation. Subsequently, due to resistance-contact closing, a second step of resistance is placed in parallel electrically with the first step so as to reduce the inserted resistance value. Preferably, the resistances have particular values in terms of the surge impedance of the line.

A general object of the present invention is to provide an improved high-voltage circuit breaker which reduces the overvoltages occurring during the closing or reclosing operation of the circuit interrupter.

A further object of the present invention is the provision of an improved high-voltage circuit interrupter in which an impedance means, such as a resistor, is inserted by a two-step arrangement only during the closing or reclosing operation of the circuit interrupter to damp the accompanying voltage surges on the line. This has the important advantage that voltage surges on the line are damped on closing, but yet a fast interrupting time, such as two-cycle operation for complete clearing of the circuit, is achieved by the elimination of a two-step opening operation with a resistor.

Still a further object of the present invention is the provision of an improved construction arrangement for a two-step resistance assemblage, which is inserted into the circuit only during the closing or reclosing operation, with one step being initially inserted during the closing stroke, whereas the second step is subsequently put in parallel electrically with the first resistance step to reduce thereby the magntiude of the resistance being inserted into the circuit during such a closing operation.

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

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of a three-phase high-voltage compressed-gas circuit interrupter embodying the principles of the present invention;

FIG. 2 is a vertical sectional view taken through one of the modular interrupting heads of one of the pole-units of the circuit interrupter of FIG. 1 with the separable contact structure being illustrated in the closed-circuit position;

FIG. 3 is an enlarged fragmentary vertical sectional view showing the disposition of the several contact parts in the partially open position; and,

FIG. 4 is a diagrammatic view of the circuit being connected with the two-step resistance assembly diagrammatically indicated.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to FIG. 1 it will be noted that there is shown a side view of one pole of a high-voltage three-phase compressed-gas circuit breaker **10** which is comprised of three pole-units A, B and C, although only the end pole-unit A is shown. The pole-units are alike except for the interpole electrical control wiring, gas lines and air lines and for the house on the middle pole, which contains the common parts of the air and gas systems. Reference may be had to U.S. Pat. 3,291,947. Each pole unit A, B or C is mounted upon a heavy grounded supporting frame **12** comprising longitudinally extending beam members **14** and angularly-braced supports **16**. In addition, each supporting frame **12** preferably has a longitudinally extending high-pressure main reservoir tank **18** associated therewith, extending in generally parallel relationship, having individual supply pipes **19** (FIG. 2) extending upwardly therefrom into several (in this case three) insulating upstanding hollow column structures **22** to supply high-pressure gas to auxiliary high-pressure reservoir chambers **24** (FIG. 2) at high potential, as more particularly described hereinafter.

Associated with each pole-unit A, B or C, is an upstanding current transformer assembly or structure **26**, which is utilized to measure the current flow through the pole-unit. Since the current transformer structure **26** constitutes no part of the present invention, and the internal structure thereof is well understood by those skilled in the art, it will not be described. Reference may, however, be made to U.S. Pat. 2,504,647 for a description of a typical gas-filled type of current transformer, which could be used.

As shown in FIG. 1, surmounted upon the insulating hollow column structures **22** are live metallic exhaust housings, or interrupting head units **28** at high potential, interiorly of each of which is a pair of serially-related gas-flow arc-extinguishing units **30**, more particularly illustrated in FIGS. 2 and 3 of the drawings. An inspection door **32**, pivotally supported upon hinge pins, may be secured by bolts, to form a gas-tight closure for the head unit **28**.

With respect to FIG. 2 of the drawings, it will be noted that each interrupting head unit **28** comprises a rotating bridging contact cross-arm assembly, generally designated by the reference numeral **38**, and including a pair of radially outwardly extending gas-conducting arms **40** carrying movable contacts **42**. Each movable contact **42** separates from a relatively stationary contact structure **44** to establish an arc **46** (FIG. 3), which is extinguished by an intensive double-orifice gas flow, as more fully described hereinafter. The stationary contacts **44** are supported and clamped to terminal studs **48** extending through terminal bushings **50**, the latter protruding through the ends of the interrupting head units **28**. Generally, the circuit-interrupting structure **10** operates, during the opening and closing operations, so as to effect rotation of the several cross-arm assemblies **38** to consequently bring about a closing, or alternatively, an interruption of the electrical circuit L_1L_2 through the circuit interrupter **10**. On opening, a blast-valve assembly **34** operates a blast-valve in synchronism with the operating mechanism to permit an outflow of high-pressure gas from the horizontal blast tube **35** and radially outwardly, as illustrated by the arrows **37**, and as described in U.S. Pat. 3,291,947.

With reference to FIG. 2 of the drawings, it will be observed that surrounding the inner ends of each of the two terminal bushings **50** extending within the casing **28** are two annular resistor assemblages **51, 52** constituting a two-step resistor arrangement. The construction is such that when the moving contact arm **40** closes, it closes the resistor contacts **53, 54** inserting thereby the outer annular resistor assembly **51**. A short time later, the movable resistor contact **54** puts the inner resistor assemblage **52** in parallel electrically with the outer resistor assemblage **51**, thereby reducing the magnitude of the resistance being inserted during the closing operation. When the main contacts **42, 44** touch, as shown in FIG. 2 of the drawings, both resistor assemblages **51, 52** are shorted out.

During the opening operation, the time delay associated with the movable pivotal resistor contact **54** is such that it remains in engagement with the inner resistance contact **56** and parts company with the moving resistor contact **53** disposed at the extermity of the rotating main contact arm **40**. As a result, the resistance **51, 52** is not in the circuit during the opening operation. This leads to high-speed two cycle operation.

Anacom computer studies of switching surge overvoltages on EHV transmission lines have shown that limiting the overvoltage to 2.0 per unit under the worst conditions of reclosing with 1.0 per unit crest voltage on the line requires the insertion of resistance equal to 200 to 600 ohms per phase. Even with optimum resistance values equal to the surge impedance of the line, the overvoltage cannot be held to less than approximately 1.8 per unit.

Some utility engineers believe that if switching surges could be held to a limit not exceeding 1.5 per unit on 500 kv. and 700 kv. lines, that very substantial savings in line insulation can be made.

This invention shows how the SF_6 gas-flow EHV breaker modules **28** might be modified to produce this result by a double step of resistor insertion on closing.

It is desirable to make the resistance value "R" (summation of all resistance "r_1" of assemblies **51** for all the modules **28**) fall within the following range.

$$Z<R<2Z$$

where Z is the surge impedance of the line being electrically connected.

Moreover, it is preferable to make the resistances r_2 of the inner resistance assemblages **52** substantially equal to the resistance value r_1 of the outer resistance assemblage **51**. As well known by those skilled in the art, the paralleling electrically of the two resistance assemblages **51, 52** will half their resistance values so that shortly before the closing of the main contact structures **42, 44** the summation of all of these electrically paralleled resistance assemblies per pole will total a value approximately as follows:

$$\tfrac{1}{2}Z<(\text{inserted resistance per pole})<Z$$

where Z is again the surge impedence of the line being electrically connected.

TYPICAL EHV LINE SURGE IMPEDANCES Z

Number of bundled conductors:	Surge impedance range ohms
1	450–500
2	350–400
3 or 4	300–350

From the foregoing description it will be apparent that there is provided an improved high-voltage circuit breaker **10** particularly adaptable for minimizing switching surge overvoltages during the closing operation by being provided with a two-step closing resistance **51, 52** in which the one step **51** is initially inserted during the closing operation, and subsequently the second step **52** is placed in parallel electrically with the first step so as to reduce the closing resistance value to one half a short time before all of the resistance is shorted out by the closing of the main contacts **42, 44**.

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.

I claim as my invention:

1. A high-voltage circuit breaker including a pair of separable contacts, means defining a two-step resistance assemblage, contact means interposed in the path of closing travel only of said pair of separable contacts, the arrangement being such that during the closing operation only one of said separable contacts electrically inserts a resistance (r_1) and later inserts the second step of resistance in electrical parallel with the first resistance during such closing operation and finally at the end of the closing operation the said separable contacts make engagement and short out all of the resistances, and means preventing the insertion of said two-step resistance assemblage during the opening operation.

2. The combination according to claim **1**, wherein a rotating movable contact assembly carries a pair of movable contacts at the outer ends thereof, which engage a pair of spaced stationary contacts, and each pair of separable contacts has the aforesaid resistance arrangement associated therewith.

3. The combination according to claim **2**, wherein the rotating contact assembly has a pair of gas-conducting hollow contact arms associated therewith to assist in arc interruption.

4. The combination according to claim **3**, wherein a metal tank has a pair of terminal bushings extending therein, which support the spaced pair of stationary contacts, and the movable rotating contact assembly is disposed generally centrally of said tank.

5. A high-voltage compressed-gas circuit interrupter including an upstanding hollow insulating column structure, a metallic tank module surmounted on top of said hollow insulating column, a pair of laterally-extending terminal bushings extending laterally into the ends of said tank, the inner ends of said terminal bushings supporting a pair of spaced stationary contacts, a two-step closing resistance assemblage disposed adjacent each stationary contact structure, a rotating movable contact assembly carrying a pair of radially outwardly-extending gas-conducting contact arms carrying movable contacts therewith, resistance contact means associated with each closing resistance assemblage, and the arrangement operating to pick up the two resistance assemblages sequentially during the closing operation, but preventing its insertion during the opening operation for high-speed breaker operation.

6. The combination according to claim **5**, wherein the total value "R" of the first step of resistances totals a value between the surge impedance "Z" and twice the surge impedance according to the following relation:

$$Z<R<2Z$$

where "Z" is the surge impedance of the line being electrically connected.

7. The combination according to claim **5**, wherein the two-steps of resistance are substantially equal.

8. The combination according to claim **1**, wherein the total value of the first step of resistance falls within a range between the surge impedance of the line and twice the surge impedance of the line.

9. The combination according to claim **8**, wherein the second step of resistance is substantially equal to the first step of resistance.

References Cited

UNITED STATES PATENTS

3,235,694	2/1966	Thallner.
3,291,947	12/1966	Van Sickle.
3,393,285	7/1968	Harper.

ROBERT S. MACON, Primary Examiner

U.S. Cl. X.R.

200—148; 317—11; 307—136