

June 6, 1972

R. L. HUNDSTAD
CONTACT STRUCTURES FOR VACUUM-TYPE CIRCUIT INTERRUPTERS
HAVING RADIALLY OUTWARDLY-EXTENDING SPOKES
Filed Feb. 10, 1969

3,667,871

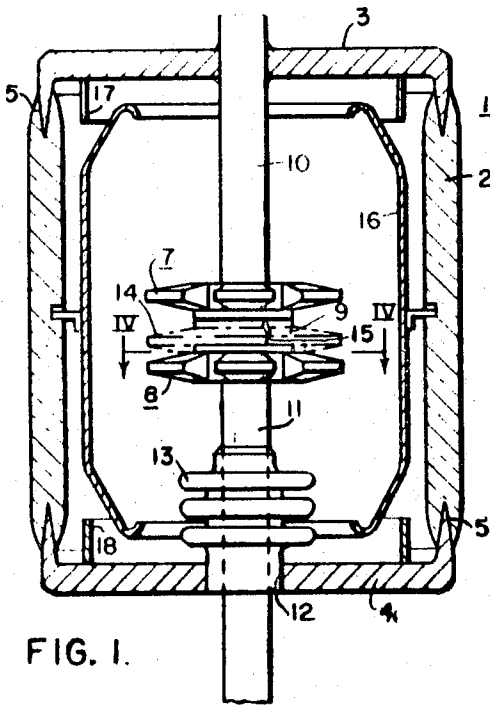


FIG. 1.

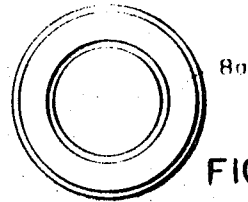


FIG. 6.

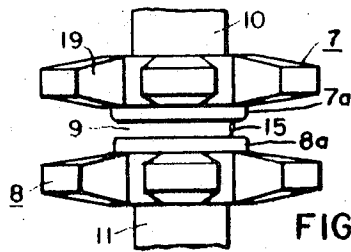


FIG. 2.

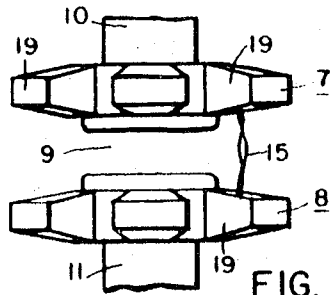


FIG. 3.

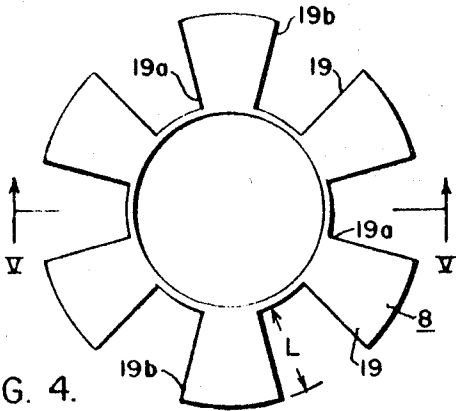


FIG. 4.

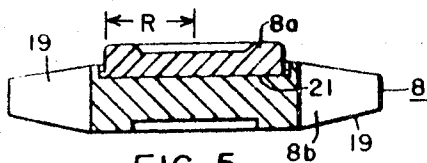


FIG. 5.

WITNESSES:

Leon M. Gorman
Robert C. Baird

INVENTOR
Richard L. Hundstad
BY
Willard R. Croitt
ATTORNEY

1

3,667,871

**CONTACT STRUCTURES FOR VACUUM-TYPE
CIRCUIT INTERRUPTERS HAVING RADIALY
OUTWARDLY-EXTENDING SPOKES**

Richard L. Hundstad, Pittsburgh, Pa., assignor to West-
inghouse Electric Corporation, Pittsburgh, Pa.

Filed Feb. 10, 1969, Ser. No. 797,930

Int. Cl. H01h 33/66

U.S. Cl. 200—144 B

12 Claims

ABSTRACT OF THE DISCLOSURE

The contact structure of a vacuum-type circuit inter-
rupter is provided with radially-outwardly extending
spokes, or contact bars, extending outwardly from a cen-
tral primary contact region. The arc is initiated at the
primary contacting surfaces adjacent the central point of
the separable contact structure, and, because of the
provision of the outwardly extending spokes, the arc is
moved outwardly to the arc-dissipation surfaces which
extend to the outer periphery of the contacts. The arc is
rapidly moved outwardly, and the primary arcing surfaces
are thereby prevented from becoming eroded.

**CROSS REFERENCES TO RELATED
APPLICATIONS**

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

BACKGROUND OF THE INVENTION

It has been customary in the design of vacuum-type
circuit interrupters to provide a primary arcing region
at which the arc is initially established, and a secondary
arcing region, or arc-dissipation surface at which the arc
is moved until extinction takes place. United States Pat.
3,182,156 issued May 4, 1965 to Lee et al. illustrates a
prior-art construction of this general nature.

The primary electrode contact surfaces of conventional
circuit interrupters, i.e., the surfaces which conduct the
current from one electrode to another during normal
steady state operation, are subjected to very intense heat
while performing their function during a current inter-
ruption. The electrode surface must support the arc from
its initiation at the time the electrodes open until its
extinction at approximately zero current. This arc energy
causes melting, erosion and general deterioration of the
surfaces. The construction set forth in the aforesaid
United States patent partially circumvents this problem
by providing primary surfaces for conducting the cur-
rent during normal steady-state operation, and additional
surfaces surrounding the primary surfaces for arc-energy
dissipation during an interruption. According to the ap-
parent theory of operation, the arc is driven from the
primary surfaces following initiation and then rotates on
the energy-dissipation surfaces until extinction takes place.
Spiral slots in the energy-dissipation surfaces cause the
arc to spiral radially outwardly under the influence of the
 $j \times B$ forces. The spiral slots also provide a cusp-type mag-
netic field, which causes the arc to rotate under the in-
fluence of the $j \times B$ forces. Many experimental tests of
vacuum switches embodying the foregoing construction
have shown that the design is only partially successful.
It appears that the spiral slots, although quite effective in
rotating the arc, do not confine the intense heat release
and resulting deterioration to the energy dissipation sur-
faces. General deterioration of all adjacent surfaces re-
sults.

Electrodes for vacuum-type circuit interrupters of the
construction set forth in the aforesaid patent are not
very effective in providing the necessary $j \times B$ forces to

2

move the arc radially outwardly and away from the con-
tact surfaces. The conically-shaped energy dissipation
portion of the electrodes, which extend radially outwardly
from the contact surfaces, have a large cross-sectional
area through which the current may flow radially out-
wardly. As a result, the current densities are low, and
the self-induced magnetic fields are small, distributed,
and ineffective in forcing the arc from the contact sur-
faces.

SUMMARY OF THE INVENTION

According to the present invention, the contact con-
struction for a vacuum-type circuit interrupter is provided
having primary and secondary, or arc-dissipation surfaces.
The arc is initially established at the primary contact sur-
faces, and then is moved radially outwardly to the arc-
dissipation surfaces, and arc extinction occurs at these
latter secondary surfaces.

The construction according to the present invention
has spokes, or radially-outwardly-extending contact bars
which extend from the primary contact surfaces, and
these spokes are purposely made small in cross-sectional
area adjacent to the primary contact button so as to con-
centrate the self-induced magnetic fields as well as the
arc columns and, thereby, effectively provide the neces-
sary $j \times B$ forces to move the arc radially outwardly and
away from the primary contact surfaces.

Accordingly, it is a general object of the present in-
vention to provide an improved contact construction for
a vacuum-type circuit interrupter.

A more specific object of the present invention is to
provide an improved contact, or electrode construction
for a vacuum-type circuit interrupter utilizing primary
contact surfaces and outwardly-extending spokes, or con-
tact bars, which move the initially established arc out-
wardly away from the primary contact surfaces.

Still a further object of the present invention is the
provision of an improved electrode or contact construc-
tion for a vacuum-type circuit interrupter in which pri-
mary contact surfaces are provided of one material, and
the secondary or arc-dissipation surfaces are provided
utilizing another contact material.

According to a preferred embodiment of the invention,
a vacuum-type circuit interrupter has separable contacts,
at least one of which uses, preferably, a generally disc-
shaped primary contact surface of one material, such as
a copper-bismuth alloy, and spokes or contact bars, which
extend radially outwardly from the primary contact sur-
faces, and the secondary contact surfaces are preferably
formed of a different contact material, such as pure
copper, for example.

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 vertical sectional view of a vacuum-type
circuit interrupter embodying the contact construction of
the present invention the contacts being shown in full
lines in the open-circuit position;

FIG. 2 is a detailed side elevational view taken of the
contact structure of FIG. 1 in an initial stage of the
opening operation;

FIG. 3 is a view similar to that of FIG. 2, but illus-
trating the arc position at a later point of time during the
opening operation;

FIG. 4 is a plan view of one of the contacts drawn to
an enlarged scale;

FIG. 5 is a sectional view taken along the line V—V
of FIG. IV; and,

FIG. 6 is a plan view of the primary contact button
prior to assembly.

3 DESCRIPTION OF THE PREFERRED EMBODIMENT

When the electrodes of a vacuum switch are opened at the beginning of a given interruption, a metallic arc initiates between the separating electrodes, and serves as a vehicle for current conduction until the normal alternating current cyclic variation of current drops the magnitude of the current below the chopping current. At this value of current, the mechanisms which cause the arc to extinguish predominate over those, which sustain the arc, and it goes out. Because of the high-power density impressed upon the electrodes during the conduction interval, substantial erosion takes place, and it is, therefore, desirable to move the established arc outwardly away from the primary contacting surfaces.

Referring now to the vacuum interrupter of FIG. 1, there is shown a highly-evacuated envelope 1 comprising a casing 2 of suitable insulating material, and a pair of metallic end caps 3 and 4 closing off the ends of the casing. Suitable seals 5 are provided between the end caps and the casing to render the envelope vacuum-tight. The normal pressure within the envelope 1 under static conditions is lower than 10^{-4} torr; so that reasonable assurance is had that the mean free path for electrons will be longer than the potential breakdown paths within the envelope.

Located within the envelope 2 is a pair of relatively movable disk-shaped contacts or electrodes 7 and 8 shown in full lines in their separated or open-circuit position. When the contacts are separated, there is an arcing gap 9 located therebetween. The upper contact 7 is a stationary contact suitably secured to a conductive rod 10, which at its upper end is united to the upper end cap 3. The lower contact 8 is a movable contact joined to a conductive operating rod 11, which is suitably mounted for movement. The operating rod 11 projects through an opening 12 in the lower end cap 4, and a flexible metallic bellows 13 provides a seal about the rod 11 to allow for movement of the rod without impairing the vacuum inside the envelope 2. As shown in FIG. 1, the bellows 13 is secured in sealing relationship at its respective opposite ends to the operating rod 11 and to the end cap 4.

Coupled to the lower end of the operating rod 11, suitable actuating means (not shown) is provided for driving the movable contact 8 upwardly into engagement with the stationary contact 7 so as to close the interrupter. The closed position of the movable contact is indicated by the dotted line 14. The actuating means is also capable of returning the contact 8 to its illustrated solid-line open position so as to open the interrupter. A circuit-opening operation will, for example, entail a typical gap length, when the contacts are fully separated, of perhaps $\frac{1}{2}$ inch.

The arc (indicated at 15) that is established across the gap 9 between the electrodes, as the electrodes are opened and also when they are closed, vaporizes some of the contact material, and these vapors are dispersed from the arcing gap 9 toward the envelope 2. In the illustrated interrupter, the internal insulating surfaces of the casing 2 are protected from the condensation of arc-generated metallic vapor and particles thereon by means of a tubular metallic shield 16 suitably supported on the casing 2 and preferably isolated from both end caps 3 and 4. This shield 16 acts to intercept and to condense arc-generated metallic vapors before they can reach the casing 2. To reduce the chances for vapor bypassing the shield 16, a pair of end shields 17 and 18 are provided at opposite ends of the central shield 16.

With particular attention being directed to FIG. 4 of the drawing, it will be observed that there is provided a contact, or electrode 8 which has radially-outwardly-extending spokes, or contact bars 19. With attention being directed to the plan view of FIG. 4 of one of the electrodes 8, it will be noticed that the cross-sectional area at the hub portion 19a is less than the cross-sectional

area of the spoke, or contact bar at its outward periphery 19b. Although only six spokes or contact bars 19 are shown, there may be more or less depending on the current rating of the vacuum-interrupting device.

It is particularly desirable to provide the contact area of a highly efficient conducting material, which has a relatively low weld strength, such as a copper-bismuth alloy, such as set forth in United States patent Lee et al. 2,975,256.

To facilitate the manufacture of a composite-type electrode or contact structure 7, 8, it is desirable to machine, or otherwise provide a recess 21 (FIG. 5) within the body of the secondary contact 8b to accommodate the primary contact surface 8a, which is shown separately in FIG. 6 of the drawings. The two parts 8a, 8b may be secured together, as by a brazing operation.

With reference to FIG. 2, it will be observed that the arc, which is initially established, is formed at the primary contact surfaces 7a, 8a, and is designated by the reference numeral 16. Soon thereafter, by virtue of the magnetic forces, the initially-established arc 15 is moved outwardly along the spoke, or contact bar surfaces 19 to the outer edges of the secondary contacts, where arc extinction takes place.

The construction proposed by the present invention alleviates the problem of general deterioration by effectively confining the arc and resultant melting to the energy-dissipation surfaces. The proposed construction has spokes extending from the contact surfaces, and these spokes are purposely made small in cross-sectional area adjacent to the primary contact surface so as to concentrate the self-induced magnetic fields as well as the arc columns, and thereby effectively provide the necessary $j \times B$ forces to move the arc radially outwardly and away from the primary contact surfaces.

Experimental tests have conclusively demonstrated that regardless of the phenomena utilized, that the initially-established arc is moved rapidly outwardly to the secondary arc dissipation surfaces because of the self-induced magnetic effects. The result is less erosion of the contact structures, and a greater operational life of the circuit-interrupting device as a whole.

For certain applications, the center primary contact button may be made of a copper-bismuth alloy, such as, for example, 99.7% copper and .3% bismuth by weight. In this event, it is desirable to have the outwardly extending spokes or contact bars made of pure copper.

Although it has been suggested that different materials be used for the primary and secondary contact surfaces, for certain applications this may not be absolutely essential, and, as a cost-reduction feature, the same material may be used for both the primary and secondary contact surfaces.

The spoke portions 19 of the two contacts need not be axially or longitudinally aligned, but better results are achieved if they are in longitudinal alignment as shown in the drawing.

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 vacuum-type circuit interrupter including, in combination:

- (a) means defining an evacuated envelope;
- (b) a pair of separable contacts disposed within the evacuated envelope separable to establish arcing;
- (c) at least one of the separable contacts including a central primary contact portion and a plurality of circumferentially spaced radially-outwardly-extending conducting spoke portions emanating only radially outwardly from said central primary contact portion and connected thereto,

5

(d) whereby upon separation of said contacts current flow through said central contact portion and said spokes, by virtue of magnetic forces, moves an arc established on said central portion exclusively radially outwardly onto one of said spoke portions whereby vaporized metal will be free to disperse radially and axially of said spoke portion.

2. The combination of claim 1, wherein the confronting surfaces of the spoke portions are displaced rearwardly from the confronting surfaces of the associated primary contact portion.

3. The combination of claim 1, wherein the cross-section of the individual spoke portions are rectangular.

4. The combination of claim 1, wherein the cross-sectional area of the inner portion of the spokes is less than the outer portions of the spoke portions.

6. The combinations of claim 1, wherein the primary contact portion and the spoke portions are made of different contact materials with the primary contact portion having a lower chopping current value.

6. The combination of claim 1, wherein the primary separable contacts each has a central primary contact portion and a plurality of radially-outwardly-extending conducting spoke portions emanating radially outwardly from said central primary contact portion and connected thereto.

7. The combination of claim 1, wherein the central

6

primary contact portion is disk-shaped and has a central recessed portion.

8. The combination of claim 3, wherein the cross-sectional area of the inner portion of the spokes is less than the outer portions of the spoke portions.

9. The combination of claim 1, wherein six (6) spoke portions are utilized, and the width of the inner ends of the spoke portions is substantially equal to the spacing between the inner ends of the spoke portions.

10. The combination of claim 1, wherein the length (L) of the spoke portions is substantially equal to the radius (R) of the central primary contact portion.

11. The combination according to claim 6, wherein the spoke portions are in longitudinal alignment.

12. The combination of claim 1, wherein the central primary contact region has a recess portion.

References Cited

UNITED STATES PATENTS

| | | | |
|-----------|---------|----------------|--------------|
| 3,218,426 | 11/1965 | Montoya et al. | 200—166 B |
| 3,462,572 | 8/1969 | Sofianek | 200—166 B8 X |

FOREIGN PATENTS

| | | | |
|-----------|--------|-------------|-----------|
| 1,456,423 | 9/1966 | France | 200—144.2 |
| 460,122 | 9/1968 | Switzerland | 200—144.2 |

ROBERT S. MACON, Primary Examiner