

[54] **ELECTRICAL CROWBAR SYSTEM
WITH NOVEL TRIGGERED SPARK
GAP DEVICES**

[75] Inventors: **Michael S. McDermott**, San Jose;
Carl A. Pederson, Los Altos, both of
Calif.

[73] Assignee: **The United States of America** as
represented by the Secretary of the
Army

[22] Filed: **Oct. 29, 1971**

[21] Appl. No.: **193,847**

[52] U.S. Cl.**315/75, 307/100, 313/205,**
313/308, 315/125, 317/16

[51] Int. Cl.**H01t 1/00, H02h 3/00**

[58] Field of Search.....315/35, 36, 74, 75, 119, 125,
315/189; 313/205, 325, 306, 308; 307/100;
317/16, 62; 337/29, 34

[56] **References Cited**

UNITED STATES PATENTS

3,211,940 10/1965 Hueschen313/325 X
3,275,891 9/1966 Swanson.....317/16

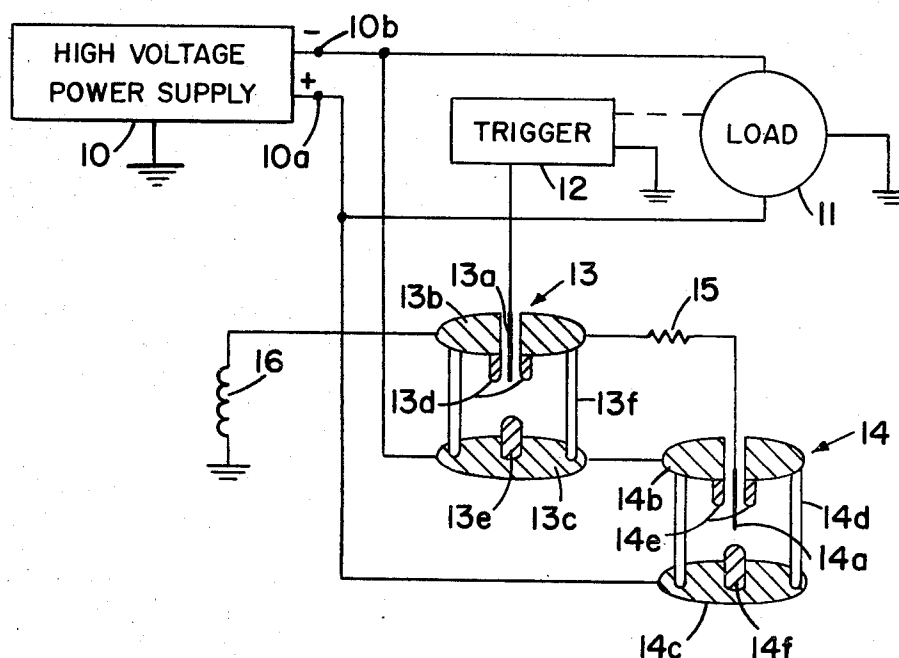
3,317,777 5/1967 Algar et al.313/306 X
3,339,111 8/1967 Possner, Jr.317/16
3,418,530 12/1968 Cheever317/16

Primary Examiner—Roy Lake
Assistant Examiner—Siegfried H. Grimm
Attorney—Charles K. Wright et al.

[57] **ABSTRACT**

Spark gap devices including removable and adjustable electrodes are shown. These devices are usable in an electrical crowbar circuit. The devices include a master gap device and a slave gap device, each of which includes a tubular insular with metal end caps, and with electrodes attached to the end caps. One of the caps of each device and one of the corresponding electrodes have an axial perforation, with a trigger electrode extending through the perforation. In the master gap device, the trigger electrode extends to the end of the electrode through which it extends; in the slave gap the trigger electrode extends beyond the electrode through which it extends and adjacent the other electrode of the device. All of the electrodes may be easily replaced by disassembling the devices, and may be easily adjusted.

4 Claims, 3 Drawing Figures



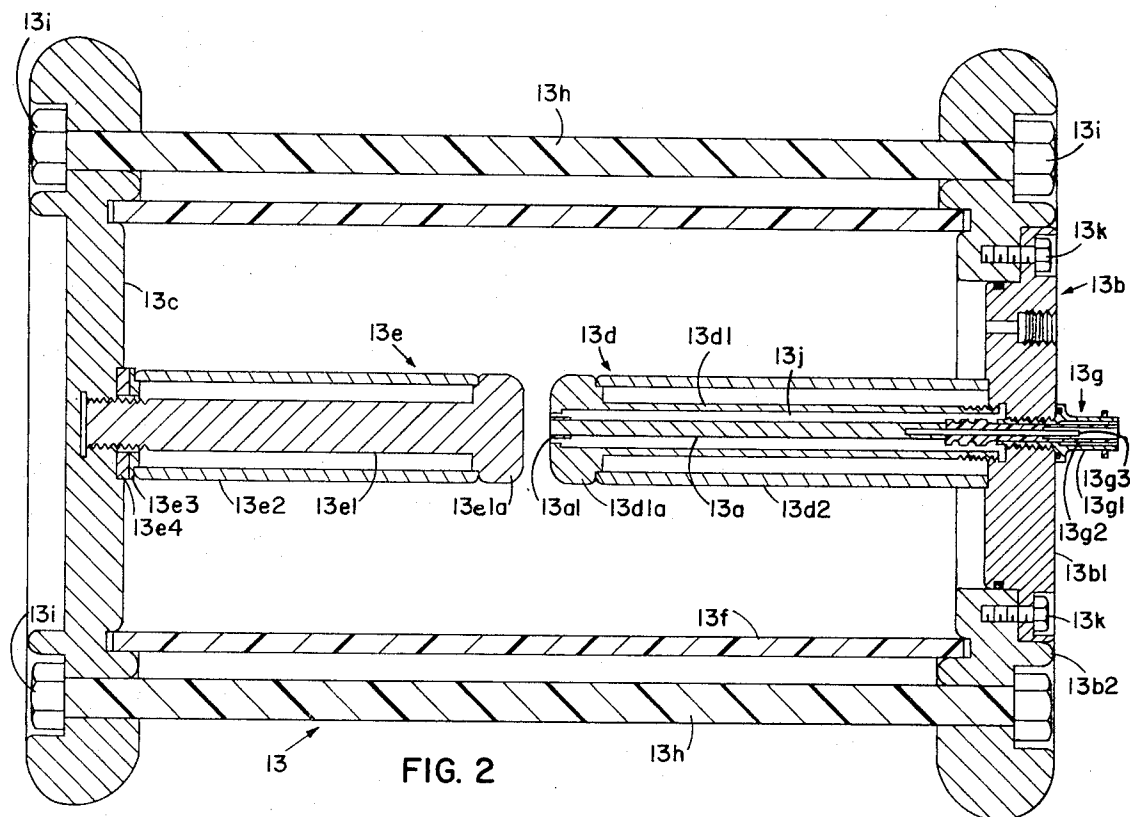


FIG. 2

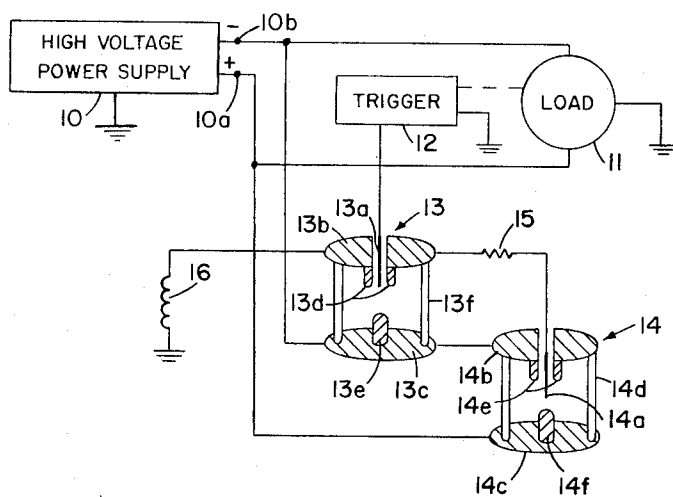


FIG. 1

Michael S. McDermott
Carl A. Pederson,
INVENTORS.

Jack W. Voigt
Aubrey J. Dunn
BY

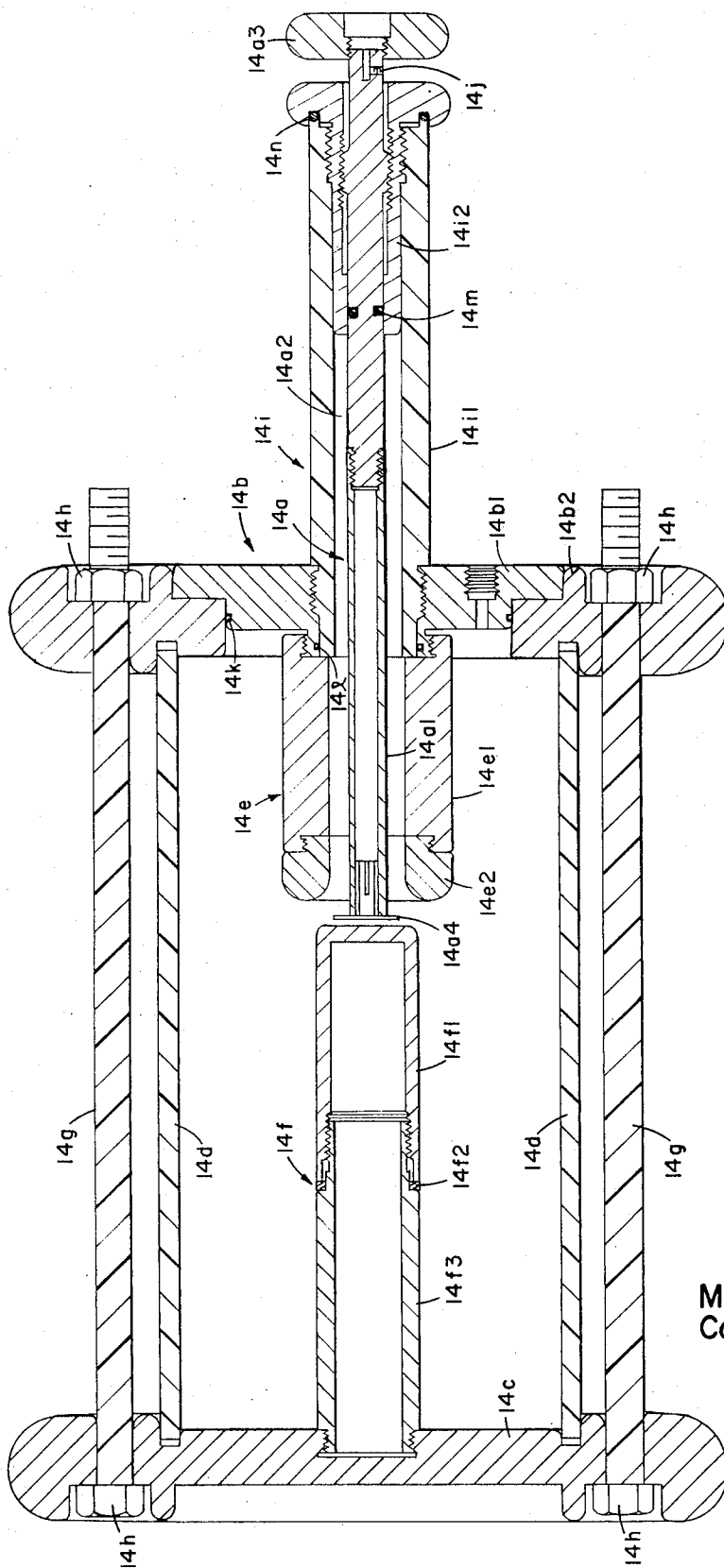


FIG. 3

Michael S. McDermott
Carl A. Pederson,
INVENTORS.

Jack W. Voigt
Audrey L. Dunn

ELECTRICAL CROWBAR SYSTEM WITH NOVEL TRIGGERED SPARK GAP DEVICES

BACKGROUND OF THE INVENTION

There are various types of spark gap devices known and used in electrical crowbars. These devices are usually made to accommodate certain voltage and current conditions and are not readily adjustable for different conditions. The instant invention is so adjustable.

SUMMARY OF THE INVENTION

The invention is a combination of novel spark gap devices in an electrical crowbar system. These devices each include a tubular insulator supporting metal end caps. One end cap of each device has a perforation through which a trigger electrode axially extends. Each trigger electrode is surrounded by a tubular electrode connected to the end cap through which the trigger electrode extends. A cylindrical electrode is attached to the other end cap of each device and extends towards its corresponding tubular electrode.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a schematic diagram of an electrical system employing the inventive spark gap devices.

FIG. 2 shows a detailed cross-section of the inventive master spark gap device.

FIG. 3 shows a detailed cross-section of the inventive slave spark gap device.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. 1, an electrical system is shown including a high voltage supply 10 having respective positive and negative terminals 10a and 10b and a ground terminal. Connected to terminals 10a and 10b is load 11. The load is also grounded. A trigger 12 is responsive to fault conditions, such as shorts, opens, etc. in load 11 and provides a high voltage pulse to ground trigger electrode 13a of master spark gap device 13 through inductor 16, end cap 12b, and electrode 13d via a spark between 13a and 13d. The particular contents of boxes 10, 11, and 12 are well known in the art and the invention is not dependent on the particular contents of 10, 11, 12. Device 13 includes metal end caps 13b and 13c and main electrodes 13d and 13e. The end caps are supported and separated by tubular insulator 13f. As can be seen in FIG. 1, end cap 13c is connected to negative terminal 10b of supply 10. Electrode 13c is in the general form of a right circular cylinder, electrode 13d is a circular tube through which trigger electrode 13a extends. The adjacent ends of 13c and 13d are chamfered. The end of 13a within 13d extends only to the end of 13d adjacent 13c. End cap 13b is maintained at DC ground potential through high frequency isolation inductor 16 and is connected to trigger electrode 14a of spark gap device 14 through current limiting resistor 15. Device 14 further includes end caps 14b and 14c mounted on tubular insulator 14d, and main electrodes 14e and 14f respectively mounted on end caps 14b and 14c. Electrode 14f is in the form of a right circular cylinder and electrode 14e is a round tube through which electrode 14a extends, with the end of 14a extending through 14e and adjacent to 14b. Electrodes 13a and 14a are generally right cir-

cular cylinders. End cap 14c of device 14 is connected to the positive terminal of supply 10.

OPERATION

The circuit of FIG. 1 operates in the usual manner for circuits of this type. Specifically, when a fault occurs in load 11, trigger 12 impulses electrode 13a of device 13. An arc is established between 13a and 13d and provides a plasma through which an arc can become established between main electrodes 13d and 13e. When this latter arc is established, the high frequency of the discharge causes inductor 16 to isolate 13b from ground and places device 13 at negative potential. Trigger electrode 14a then initiates an arc to electrode 14f. This arc provides a plasma through which an arc can become established between main electrode 14e and 14f. Power supply 10, which usually includes a storage or filter capacitor (not shown) connected between its electrodes 10a and 10b, is rapidly discharged through spark gap device 14, in order to prevent damage to load 11 because of its fault condition.

MASTER GAP DEVICE

Referring now to FIG. 2 the master spark gap device 13 is shown in great detail. End cap 13b is composed of removable portion 13b1 and fixed portion 13b2. Electrode 13d includes a portion 13d1 terminating in an end portion 13d1a and an outer tubular portion 13d2. As can be seen, the small end of 13d1 is threaded into a tapped hole in 13b1. Electrode 13a is supported by connector 13g including a generally tubular metal portion 13g1 threaded into a tapped hole in 13b1 with a generally tubular insulator 13g2 inside 12g1. Connector 13g further includes center electrode 13g3 having a reduced end onto which 13a is pushed fitted by inserting into a slotted blind hole in 13a. Terminal 13a includes a collar 13a1 brazed onto 13a to allow the proper surface gap spacing across 13j at its plain end. Trigger insulator insert 13j is concentric to 13a and 13d1a. Elements 13a and 13g of FIG. 2 together can be considered the equivalent of 13a as shown in FIG. 1. End caps 13b and 13c are mounted on tubular insulator 13f (which may be made of an acrylic plastic) and held on 13b by nylon bolts 13h and nuts 13i. Electrode 13e includes element 13e1 with end portion 13e1a, and tubular element 13e2. The end of 13e1 opposite 13e1a is threaded into a tapped hole in end cap 13c. 13e2 is supported on 13c by metal washers 13e3 and 13e4. Rubber O-ring 13j lies in a groove in 13b1 and provides a seal between 13b1 and 13b2. 13b1 is affixed to 13b2 by six cap screws 13k.

As can be seen, device 13 is so constructed that it can readily be disassembled for replacement of parts, for cleaning, or for adjustment. Any one of 13a, 13d1, 13d2, 13g, 13e1, 13e2, 13e3 or 13e4 can readily be replaced by removing 13b from device 13. The gap between 13d1a and 13e1a may readily be adjusted for different voltages by removing washers 13e3 and/or 13e4 or by inserting other washers in their places.

SLAVE GAP DEVICE

The slave gap device 14 of FIG. 3 includes nylon bolts 14g with nuts 14h on the ends thereof, to hold

together tubular insulator 14d and end caps 14b and 14c. Electrode 14e consists of a tubular portion 14e1 threaded to screw onto portion 14b1 of end cap 14b and anode ring 14e2 threaded into 14e opposite 14b1. Cap 14b includes a portion 14b2 as well as portion 14b1. Trigger electrode 14a includes metal portions 14a1, 14a2, 14a3, and 14a4 and is supported by trigger electrode holder 14i consisting of insulated portion 14i1 and metal 14i2. Portion 14a1 is a tube with one end screwed onto rod portion 14a2 and the other end extend beyond ring electrode 14e2. The said other end terminates in portion 14a4. Portion 14a4 has a disk part parallel to the end of electrode 14f and a tubular part inserted in 14a1. The tubular part of 14a4 is normally held in 14a1 by friction, but can be readily removed from 14a1. Rod portion 14a2 has a sliding fit in one end of portion 14i2 of 14i and has a raised portion having threads mating with the threads of a threaded hole in 14i2. The end of 14a2 outside of 14i has adjusting knob 14a3 tightly screwed thereon. Knob 14a3 has an axial opening therethrough, and 14a2 has an axial hole communicating with the opening through 14a3. Set screw 14j extends through a tapped hole in 14a2. The electrical conductor in FIG. 1 (no reference numeral) between 13b and 14a is inserted into the hole in 14a2 and set screw 14j is tightened to hold the conductor. Metal electrode 14f consists of anode 14f1, spacer ring 14f2 and extension 14f3. Extension 14f3 is threaded on both ends, with one end screwed into a threaded hole in 14c and with 14f1 screwed on the other end. Anode 14f1 may be readily adjusted in its spacing from 14a4 and 14e2 by removing cap 14band the elements it supports and replacing 14f2 by a different thickness ring. Obviously, it would be necessary to remove 14f1 from 14f3 to replace 14f2; 14f1 would be screwed back on 14f3 to zero clearance on either side of 14f2. Portion 14a4 is easily replaceable when 14b1 is removed from 14b2. The spacing between 14a4 and 14f1 may be adjusted without disassembling device 14 merely by turning knob 14a3. O-rings 14k, 14l, 14m, and 14n provide seals between the various parts of 14. In accordance with well known practices, insulators 13f and 14d may have bedding compound between their ends and end caps 13b, 13c and 14b, 14c. If desired, a retaining ring might be affixed to 14a2 to limit its adjustment range. It should be understood that the various electrodes reach their described shapes of tubular and cylindrical as described in FIG. 1 only when they are assembled. For example, electrode 14f is a closed cylinder when assembled, although its component parts are not closed cylinders.

In order for the invention to be usable at voltages as high as +200,000 volts a typical dimension of FIG. 2 would be 11 inches between nearest portions of the end caps. On FIG. 3 this dimension would be 17 3/8 inches for the full 400,000 volts. So far as materials are concerned, stainless steel may be used for parts 13d1a, 13e1a, 13e3, 13e4, 14a1, 14a2, 14a4, 14e2, and 14f1

and mild steel for the remaining metal parts. Obviously other metals could be used, as desired. If current limiting is desired for main gap current, extension 14f3 may be replaced by a resistive extension. This resistive extension could take the form of an insulated tube with metal threaded ends corresponding to the ends of 14f3. The tube would be filled with a resistive solution such as a CuSO₄ solution.

It is understood these are adjustable pressure devices and have the appropriate gas line fittings in 13b1 and 14b1.

We claim:

1. An electrical system including a high voltage power supply having a ground terminal and respective positive and negative high voltage terminals, a load having terminals connected to respective terminals of said power supply, and an electronic crowbar having terminals connected to respective terminals of said power supply and including a trigger responsive to fault conditions of said load, the improvement comprising: a master spark gap device and a slave spark gap device in said crowbar, with each of said devices including a tubular insulator having a longitudinal axis; first and second metal end caps on each insulator, with each of said first end caps having an axial perforation therethrough; each device further including a cylindrical electrode and a tubular electrode, with each of said electrodes being within and coaxial with a respective insulator, said tubular electrodes being mounted on said first end caps, said cylindrical electrodes being mounted on said second end caps; each of said devices further including first and second trigger electrodes, one each mounted within and coaxial with a respective tubular electrode; wherein said first trigger electrode is in said master spark gap device with one end coplanar with the end of said tubular electrode not attached to said respective first end cap, said second trigger electrode is in said slave gap device and extends through said tubular electrode and adjacent to the end of said cylindrical electrode not attached to said second respective end cap; and resistance means connected between said second trigger electrode and said first end cap of said master gap device; wherein said first trigger electrode is connected to said trigger, said second end cap of said master gap and said first end cap of said slave gap are connected to said negative terminal, and said second end cap of said slave gap device is connected to said positive terminal.

2. The system of claim 1 in which said cylindrical electrodes of each of said spark gap devices each include means for adjusting said electrodes along said longitudinal axis.

3. The system of claim 1 in which said trigger electrode of said slave gap device includes means for adjusting said trigger electrode along said longitudinal axis.

4. The system of claim 3 wherein the cylindrical electrode of said slave gap includes a resistive portion.

* * * * *