Sept. 14, 1965 H. E. SPINDLE 3,206,644

MULTIPLY TRIGGERED SPARK GAP

Filed Oct. 16, 1961

Fig. 1

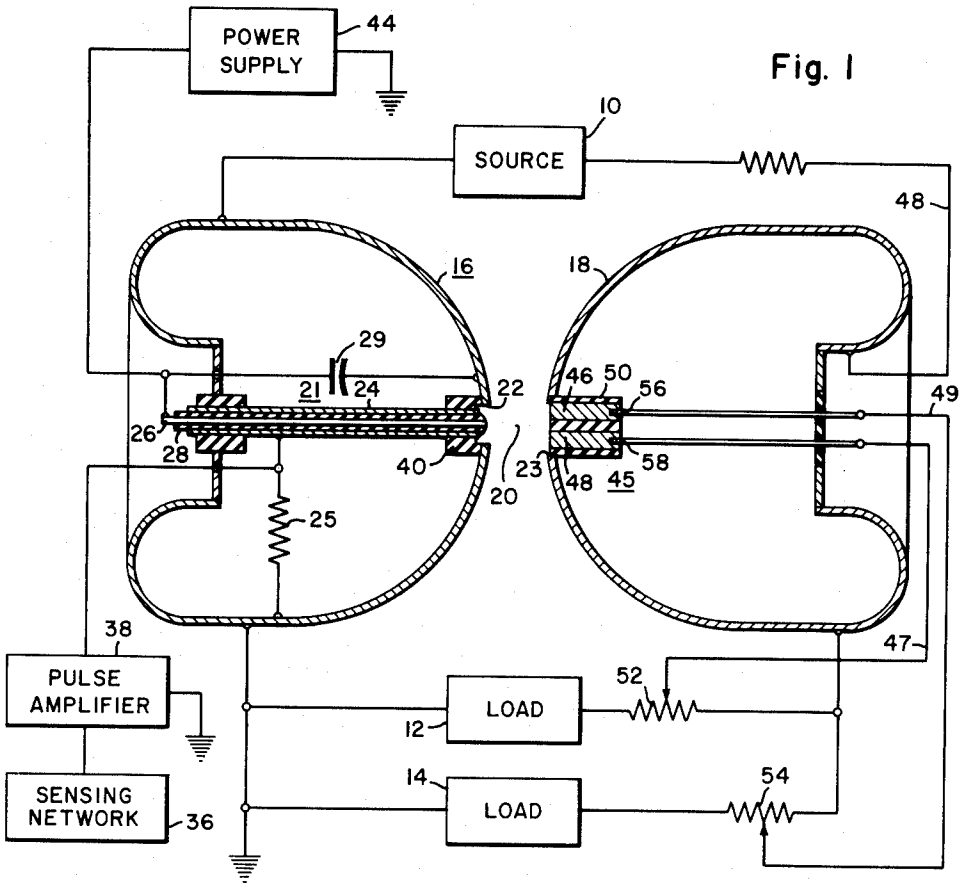


Fig. 2

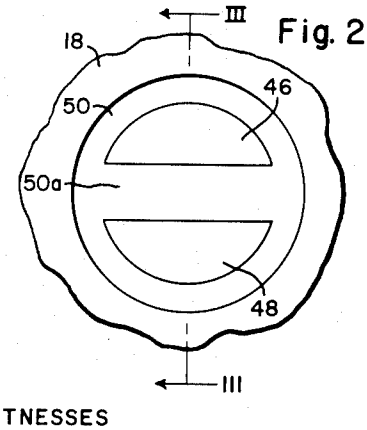
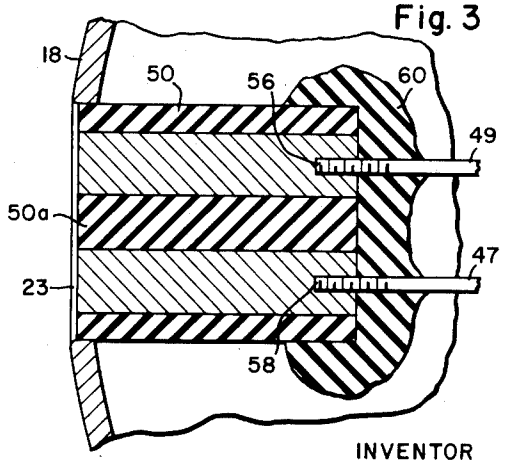


Fig. 3



WITNESSES

John E. Hensley, Jr.

Robert A. Baird

INVENTOR

Harvey E. Spindle

BY E. H. Liss

ATTORNEY

United States Patent Office 3,206,644 Patented Sept. 14, 1965

3,206,644

MULTIPLY TRIGGERED SPARK GAP

Harvey E. Spindle, Pittsburgh, Pa., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Filed Oct. 16, 1961, Ser. No. 145,403
2 Claims. (Cl. 317—46)

The present invention relates to spark gap devices and more particularly to an improved trigger gap arrangement for protecting a load in electrical apparatus.

High voltage discharge gaps employing auxiliary or trigger electrodes mounted adjacent the face of one of the main electrodes of the discharge gap have been known in the art for some time. The so-called trigger electrode is provided to reduce the working voltage of the main gap. For example, if the spacing of the main gap electrodes is such as to cause the breakdown or sparkover voltage at some fixed voltage, as for example, 100 kv., it can be triggered by a small spark between the trigger electrode and one of the main gap electrodes so that it will break down at some lower voltage as for example, 80 kv. The function of the trigger gap is to ionize the main discharge gap. Increasing the current increases ionization. Therefore, if the current in the trigger gap is increased, the voltage at which the main gap will break down is lower. These discharge gaps or spark gap devices are often employed to protect either a load or a power source in case of failure such as, for example, internal short-circuiting in the load.

In the conventional use of this type of spark gap device for preventing or protecting against internal faults in the load, as for example short-circuited electronic tubes, the gap is connected across the load and is subjected to the full voltage applied to the load. In case of a short circuit in the load, a means is employed to fire the trigger electrode thereby lowering the sparkover voltage in the main gap structure to a value lower than the applied voltage. Sparkover of the gap shunts the load and prevents further current from flowing therethrough. As is often the case, a single power source supplies a plurality of parallel loads. In the past, a separate discharge gap was needed to protect each load. It is sought to improve the prior art of protective spark gap devices by this invention in that a single spark gap device can be employed to protect a plurality of loads supplied from a single source.

The principal object of the present invention is to provide an improved protective discharge gap for electrical equipment by which a plurality of parallel loads can be protected with a single gap device.

Another object of the present invention is to provide a circuit for triggering a protective discharge gap which can initiate sparkover of the gap and bypass a plurality of parallel loads upon occurrence of a fault in any single one of the parallel loads.

Another object of the present invention is to provide a protective discharge gap which can be triggered to fire at a voltage lower than its normal sparkover by a fault in any one or more of a plurality of loads being protected by the gap.

Other objects and advantages of the invention will be apparent from the following detailed description, taken in connection with the accompanying drawings, in which:

FIGURE 1 is a circuit diagram including a diagrammatic sectional view of the discharge gap embodying the invention;

FIG. 2 is a partial front elevational view of a main electrode of a discharge gap embodying the invention; and

FIG. 3 is a partial sectional view on line III—III of FIG. 2.

Briefly, there is herein illustrated and described a circuit including two loads, as for example, high voltage electron tubes, operating in parallel from a direct-current power source. The loads are protected from internal short circuits by having a spark gap comprising a pair of electrodes spaced apart and connected across the loads. Upon the occurrence of a short circuit or other fault in the load, the gap will sparkover and shunt the load. Two separate trigger electrodes are provided in one of the main electrodes of the protective discharge gap and are operated from the taps of two similar resistors each in series with one of the loads, so that when a fault develops in either load, the voltage across the tap of the appropriate resistor will produce the trigger spark to fire the main discharge gap.

Referring now to the drawings, there is shown a power source **10** supplying loads **12** and **14** connected in parallel. Shunted across the voltage source **10** are a pair of main discharge electrodes **16** and **18**, respectively, forming a discharge gap **20**. The main discharge electrodes **16** and **18** may be, preferably, of spherical configuration having smooth, polished surfaces of conducting material.

Openings **22** and **23** are provided centrally in each main discharge electrode **16** and **18**, respectively. The electrode **16** may be of any suitable construction according to the broader aspects of this invention, but in its more specific aspects it may be constructed as more fully described in application Serial No. 110,699 by Harvey E. Spindle, filed May 17, 1961, now Patent No. 3,114,077, issued December 10, 1963, and assigned to the assignee of the present invention.

As described in more detail in the above-mentioned copending application, the main discharge gap **16** may include a tickler electrode **24** of cylindrical configuration which extends longitudinally through the electrode to a point adjacent the periphery of the opening **22**, and a trigger electrode **26** which may be a solid rod disposed within the tickler electrode **24**. A current discharge means, as for example, capacitor **29** is electrically connected between the main discharge electrode **16** and the trigger electrode **26**. The tickler electrode **24** is connected to the main discharge electrode **16** through a resistor **25**. The electrode assembly **21** formed by the tickler electrode **24**, the trigger electrode **26** and insulation **28** therebetween is supported adjacent the end of the electrode assembly by an insulating member **40**. The insulating member **40** adjacent the opening **22** may be an insulation disc having a central opening for receiving the electrode assembly **21**.

A sensing network **36** of any suitable type may be provided to sense faults or other undesirable characteristics in the voltage source or the load. When sensing network **36** detects a fault, it supplies a relatively low voltage signal to a pulse amplifier **38**. The pulse amplifier in turn amplifies and applies its output to the tickler electrode **24**. A voltage stress between the trigger electrode **26** and the main discharge electrode **16** is maintained by power supply **44**. When a low voltage pulse from the pulse amplifier is applied to the tickler electrode **24**, sparkover occurs between tickler electrode **24** and the main electrode **16**. This sparkover ionizes the air in the trigger gap. The ionized air in this region reduces the sparkover potential of the trigger gap causing it to sparkover at its normal bias potential. The capacitor **29** which is a low inductance capacitor, discharges at high current relative to the tickler gap current causing a high current discharge in the trigger gap. This high current discharge is sufficient to ionize the air in the main discharge gap, thereby sufficiently reducing the sparkover potential of the main discharge gap **20** to cause it to sparkover at between 50% and 80% of the normal sparkover potential of the main discharge gap. The sparkover of the main discharge gap

shunts the load thereby removing the source voltage. It should be noted, however, that the discharge gap **20** will continue to conduct until some external equipment is actuated to open the source voltage circuit.

As can be seen in FIG. 1, the loads **12** and **14** operate in parallel from the power source **10**. A triggering device **45** is provided in electrode **18** to initiate sparkover of the main gap **20** in case of an internal short circuit or other failure in the parallel loads **12** and **14**. As illustrated in FIG. 1 and hereinafter described, this circuit is unique in that a single main gap can be employed to protect two or more loads. In this circuit the two devices or loads **12** and **14** are to be protected from destruction due to internal short circuits by having the main gap **20** short circuit the source. As illustrated, a pair of trigger electrodes **46** and **48** are provided and extend parallel to the axis of the semi-spherical electrode **18** and are received in an insulator **50** which is in turn received in the opening **23** of the electrode **18**. Although only two trigger electrodes **46** and **48** are illustrated, it will of course be understood that any number of trigger electrodes may be provided and that at least one electrode for each load to be protected by the gap **20** is essential.

In series with each load **12** and **14**, there is a resistor **52** and **54**, respectively. The electrodes **46** and **48** are connected by leads **47** and **49** to taps on the resistors **52** and **54**, respectively. Thus, the electrodes **46** and **48** are maintained at a potential different from the potential of the main electrode **18**. When the increase of current to either load **12** or **14** is sufficient to provide a voltage across the resistor **52** or **54** in series with that load which exceeds the sparkover potential between either electrode **46** or electrode **48** and the main discharge electrode **18**, the trigger gap will sparkover. The sparkover between one of trigger electrodes **46** or **48** and the main discharge electrode **18** will produce ionized air in the gap space **20**, thereby reducing the sparkover potential between electrodes **16** and **18** and resulting in sparkover of the main discharge gap. Sparkover of this gap will shunt the source **10** thereby protecting the load from damage due to over-current.

The construction of the insulator **50** in the trigger electrode assembly **45** is a critical factor in achieving the objectives of this device. As can be seen clearly in FIGS. 2 and 3, insulator **50** is a cylindrical tube of suitable insulating material. The tube **50** includes an electrode separator **50***a* which is a dividing wall extending diametrically across the tube and extending for the length of the insulating tube **50**. A single electrode separator is shown in the embodiment illustrated, for illustrative purposes, and it will be understood that where more than two trigger electrodes are employed with more than two loads additional walls or electrode separators **50***a* will be provided. The separator **50***a* is of greater width than the cylinder wall. This is essential in order that the insulation level between the trigger electrodes **46** and **48** be higher than the insulation level between either electrode **46** or electrode **48** and the main discharge electrode **18**. In this arrangement the trigger spark will be between the appropriate trigger electrode **46** or **48** and the main discharge electrode **18**. The two trigger electrodes **46** and **48** will be isolated from each other under normal operating conditions and up to the time that the gap **20** is triggered. The insulation between the main discharge electrode **18** and the electrodes **46** and **48** should be good enough to withstand the normal voltage drop to the tap of either resistance **52** or resistance **54** and the insulation between electrodes **46** and **48** should be approximately twice this. The electrodes **46** and **48** are each received in the tubular semicylindrical openings in the insulator **50** formed by the wall **50***a* and the portion of the cylindrical wall **50**. Conductors **47** and **49** may be secured in the electrodes **46** and **48** in any suitable manner, as for example by a threaded connection as shown in FIG. 3 at **56** and **58**, respectively. As shown in the drawings, an insulating compound is molded around the leads **47** and **49** as shown at **60**. The leads pass through the semispherical main discharge electrode **18** and are connected in the structure as shown.

The operation of the protective discharge gap should be apparent from the above description. The main discharge gap **20** formed by electrodes **16** and **18** is connected across the source which supplies parallel connected loads **12** and **14**. Parallel connected loads **12** and **14** have in series, resistors **52** and **54**, respectively. Conductors **47** and **49** are tapped into resistors **52** and **54**, respectively, and are secured and electrically connected to trigger electrodes **46** and **48**. When an internal short or other failure which may cause over-current in the loads occurs, the voltage across the resistors **52** and **54** increases thereby increasing the voltage drop between either electrode **46** or **48** and the main discharge electrode **18** depending upon where the fault occurs. The resistors **52** and **54** are normally of such value as to permit the trigger electrodes to withstand the normal voltage drop to the tap. When the voltage drop across either resistance **52** or resistance **54** increases due to over-current in the load, the corresponding electrode **46** or **48** sparks over to the main discharge electrode **18**. This discharge ionizes the air in the gap space **20** and the main discharge electrode **16** and **18** spark over, thereby short circuiting the source and effectively removing the voltage from the load. Thus, a rapidly acting protective gap is provided which is sensitive to internal shorts and other failures resulting in over-current in either one or both of the loads connected in parallel.

It should now be apparent that a high voltage protective gap has been provided which has many advantages. The new protective gap and its associated trigger electrode arrangement is of simple and economical construction. It is so constructed that a plurality of loads supplied by a single source may be protected by a single spark gap device. While a particular embodiment of the invention has been shown and described for the purpose of illustration, it will be apparent that various other embodiments are possible within the scope of the invention. Thus, for example, more than two parallel loads supplied by a single source may be protected by a single gap which utilizes at least as many trigger electrodes as there are loads. While the resistances **52** and **54** are shown in series with the load, other impedance means may be employed. Inductive impedance may be employed in which case the trigger electrodes will respond to the rate of rise of current in the loads. Similarly, numerous other modifications and embodiments will be apparent to those skilled in the art and all such modifications and embodiments are within the scope of the invention.

I claim as my invention:

1. Electrical apparatus including a source of power, a plurality of loads supplied by said source, a pair of main discharge electrodes spaced apart to form a protective discharge gap connected in parallel with said loads, one of said main discharge electrodes having a plurality of trigger electrodes disposed adjacent the discharge path of said protective discharge gap, each of said trigger electrodes including means for connecting to a load to be protected, impedance means in series with each load intermediate said one main discharge electrode and the load, one of said trigger electrodes being connected intermediate said impedance means and the load whereby the potential difference between the trigger electrode and said one main discharge electrode varies directly with the current through the load.

2. A spark gap device for protecting electrical apparatus including a power source and a plurality of load devices supplied by said source, said spark gap device comprising a pair of main electrodes spaced apart to form a single protective discharge gap connected across

said load devices, one of said main electrodes having a central opening therein, an insulating member received in said opening, a plurality of trigger electrodes supported in said insulating member and insulated thereby from each other and from said one main electrode, the trigger electrodes being disposed to form trigger gaps with said one main electrode and being spaced from each other a greater distance than the spacing between each trigger electrode and the main electrode, and means for connecting each trigger electrode to respond to a predetermined abnormal condition of one of said load devices to independently initiate spark-over of the protective discharge gap.

References Cited by the Examiner

UNITED STATES PATENTS

1,300,127	4/19	Creighton	313—217 X
2,508,954	5/50	Latour et al.	313—198 X
2,593,429	4/52	Foulkes	313—198 X
2,946,923	7/60	Fitch	315—173 X
3,030,547	4/62	Dike et al.	315—234 X

FOREIGN PATENTS

825,899	12/59	Great Britain.

GEORGE N. WESTBY, *Primary Examiner.*

ARTHUR GAUSS, *Examiner.*