

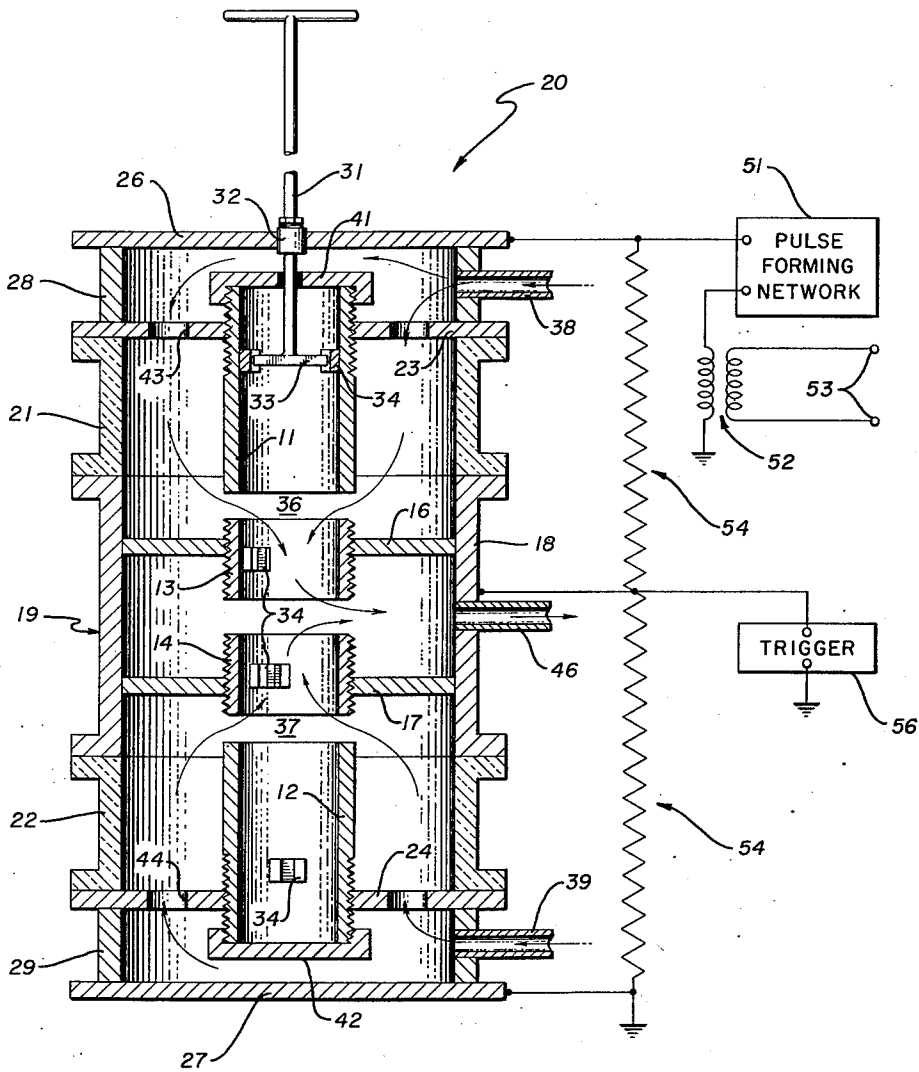
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SPARK GAP SWITCH

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SPARK GAP SWITCH

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The present invention relates to an improved triggered spark gap switch particularly adapted for the switching of very large amounts of power with precise time control.

For high power circuits, there have been developed certain gaseous discharge devices such as thyatrons for controlling the time of circuit switching; however, even these devices are limited in power capacity so that for the switching of even greater power the spark gap appears best adapted. A long-standing limitation of spark gaps has been the inability to precisely control discharge as to time and to prevent spurious discharge where large amounts of power are to be switched. A further limitation on conventional spark gap switches is the very narrow voltage variation allowed in the operation of any single switch construction.

The present invention provides a spark gap switch that overcomes the above-noted and other limitations of the prior art through the accomplishment of the following objects.

It is an object of the present invention to provide a spark gap switch having precisely controllable firing time while switching very large amounts of power.

It is a further object of the present invention to provide an improved triggered spark gap switch with externally adjustable gaps.

It is yet another object of the present invention to provide an improved spark gap switch having structure precluding spurious arcing.

It is a still further object of the present invention to provide an improved double-gap spark gap switch with ion removal away from both gaps for improved control.

It is another object of the present invention to provide an improved spark gap switch having a substantial voltage range.

Numerous other advantages and possible objects of the invention will become apparent to those skilled in the art from the following description of a preferred embodiment of the invention taken together with the accompanying drawing, wherein the sole figure is a longitudinal sectional view of the switch with a suitable circuit shown connected thereto.

The invention in general comprises three electrodes adjustably spaced and adapted to have a large potential impressed between the outer electrodes. The central electrode, which is normally maintained at a potential intermediate the outer electrodes, is adapted to receive a pulsed trigger voltage whereby spark discharge occurs between same and one end electrode followed substantially instantaneously by spark discharge to the other end electrode. Gas flow is channeled across the two spark gaps in opposition so as not to carry ions from one into the other.

Considering now the invention in some detail and referring to the drawing, the illustrated spark discharge switch will be seen to include a pair of cylindrical electrodes 11 and 12 spaced apart and axially aligned. Intermediate these electrodes are situated a second pair of metal cylinders 13 and 14 disposed in spaced relation

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and in axial alignment with each other and with the end electrodes. The second pair of cylinders 13 and 14 are adjustably mounted on metal plates 16 and 17, respectively, as by threaded engagement through central plate openings, and the plates 16 and 17 are fixed transversely in a metal envelope cylinder 18 surrounding the second pair of cylinders. As the intermediate cylinders are electrically connected through the conducting plates 16 and 17 and envelope cylinder 18, they may be considered as a single central or intermediate electrode 19, and the metal cylinder 18 serves further to prevent the accumulation of bound charges in the vicinity of sparking as occurs on insulators with possible subsequent spurious discharge.

A switch housing 20 surrounding the aforementioned electrode elements includes in addition to the central metal envelope cylinder 18 a pair of cylindrical insulators 21 and 22 secured one to each end of the central envelope cylinder 18 and terminating at transverse metal plates 23 and 24, respectively. The plates 23 and 24 are centrally apertured for threaded engagement by end electrodes 11 and 12, respectively, whereby the latter are supported coaxially with the insulating cylinders and are adjustable axially of the switch housing 20. The switch housing is completed by end plates 26 and 27 mounted on cylinders 28 and 29, respectively, and secured coaxially with the insulating cylinders as upon the plates 23 and 24, respectively. The housing will thus be seen to include metal end sections insulated from a metal center section by insulators and generally defining a hollow cylinder. The various portions of the housing may be secured together in any desired manner as by clamping, fastening devices, or welding between metal elements, and appropriate flanges or the like may be provided to this end. The housing 20 is assembled in sealing relation to prohibit the flow of fluids through the joints thereof and suitable gaskets may be inserted in the latter as required to accomplish same.

Provision is made for adjusting the axial spacing between electrodes of the switch from a position outside the switch housing 20 and may include an elongated rod 31 extending axially of the housing through an end plate 26 via bearing and sealing means 32 thereat. The adjusting rod 31 is provided with a handle exteriorly of the switch housing and a cross bar 33 at the end thereof within the housing, this bar being disposed within the cylindrical end electrode 11 and the rod being slidably mounted in the housing for moving the bar 33 into the element to be adjusted. Within each of the cylinders 11, 12, 13, and 14 there are provided diametrically opposed catches 34 with each having slots therein radially of the cylinder for admitting the bar 33 whereby the bar locks with the cylinder catch to rotate the cylinder with rotation of the rod 31. As previously noted, the cylindrical electrode elements are all threaded into their respective mounting plates so that rotation of the cylinders serves to adjust the axial disposition thereof for varying the gap or spacing between adjacent cylindrical elements. Of particular importance is the gap 36 between the upper end electrode 11 and adjacent cylinder 13 of the central electrode 19 and the gap 37 between the lower end electrode 12 and adjacent cylinder 14 of the central electrode 19, for these constitute the spark gaps of the switch and variation of the extent thereof affects the voltage range of the switch.

There is additionally provided as a portion of the switch a gas flow system including a pair of gas inlet tubes 38 and 39 connected through the housing at the end cylinders 28 and 29, respectively. These inlet tubes are connected to a blower or other source of gas, such as air, whereby gas flows into the housing at both ends thereof under a nominal pressure, as for example two pounds per square inch. Gas flow control within the

housing is accomplished by the provision of caps 41 and 42 on the outer ends of the end cylindrical electrodes 11 and 12, respectively, to prevent gas flow therethrough and the provision of apertures 43 and 44 in the end electrode supporting plates 11 and 12, respectively. Gas is thus forced through these apertures to flow about the end electrodes and as the central electrode plates 16 and 17 extend solidly between the outer cylinder 18 and the inner cylinders 13 and 14 they form gas barriers so that the gas flows at one end between the end electrode 11 and adjacent central electrode element 13 into the latter and similarly at the other end between the end electrode 12 and the adjacent central electrode element 14 into the latter. A gas outlet tube 46 is provided in the housing through the central conducting cylinder 18 between the plates 16 and 17 so that the gas flows through the cylindrical electrode elements 13 and 14 to join flow at the center of the housing and flow out of the outlet pipe 46. It will be seen from the foregoing that gas flows in opposite directions in the housing from both ends toward the center and that the gas flows across the gaps 36 and 37 noted above. Of importance is the fact that gas flowing across one gap does not flow across or near the other gap so that ions being swept away from one gap cannot enter the other.

Operation of the improved spark gap switch of the present invention may be best understood in connection with circuit operation, and there is illustrated in the drawing an exemplary circuit with which the switch may be employed. As shown in the drawing, this circuit includes a pulse forming network 51 which may conventionally include capacitive means charged by a direct current power supply. The network 51 is connected with the positive terminal joined to the switch at one end thereof as at the end plate 26 or other external element electrically connected to an end electrode 11. The negative terminal of the network is connected to the primary winding of a pulse transformer 52 which is in turn connected as by ground connection to the other end electrode 12 of the switch, as at the end plate 27. The transformer secondary is connected across a pair of output terminals 53 to which a load, such as a klystron or the like, may be connected. Across the switch from one end electrode to the other is connected a voltage divider 54 and the center tap thereof is connected to the central switch electrode 19, as at the cylinder 18. A trigger voltage supply 56 is provided for actuating the switch in timed control and connection is made from the positive terminal thereof to the voltage divider center tap, and thus to the central switch electrode 19, and from the negative terminal thereof to the negatively connected switch electrode 12, as by a ground line.

In operation of the switch with the illustrated electrical circuit, the pulse forming network builds up a charge as across a capacitor from a direct current power supply and the voltage thereof appears across the voltage divider 54 connected across the switch. At a desired time, controlled for example by the magnitude of the voltage applied across the switch, the trigger circuit produces a sharp voltage pulse, in this case a positive pulse, which is applied across the lower half of the voltage divider 54. This trigger pulse is thus applied between central electrode 19 and end electrode 12 of the switch and produces a potential gradient increase between switch elements 12 and 14 so that an arc is struck therebetween across the gap 37. As this arc occurs in parallel with the lower half of the voltage divider 54, the center thereof is effectively grounded so that almost the entire voltage of the network 51 appears between cylinders 11 and 13 to likewise produce an arc therebetween across the gap 36. Two arcs are thus established almost simultaneously within the switch, one across the gap 36 and one across gap 37. These gaps are electrically connected in series through the central electrode

cylinder 18 across the pulse forming network so that the network discharges therethrough. This discharge passes through the primary of the transformer 52 to induce a pulse between the output terminals 53 connected across the transformer secondary. It will be appreciated that the switch is capable of carrying very large currents at substantial voltages, as for example, some thousands of amperes at 15-20 kilovolts.

Switch conduction ceases when applied voltage falls to a predetermined value insufficient to maintain arc discharge across the gaps thereof and the gas flow through the switch across the gaps 36 and 37 immediately removes all ions from the gaps to preclude spurious arcing thereacross. The gas flow will be noted not to sweep ions from one gap through the other, but instead to separately remove ions from each gap whereby danger of after arcing is substantially precluded.

The trigger controlled switch provides precise timing of switch conduction without the variation in time of conduction which is unavoidable in spark gap devices having no spark initiation control. The externally controlled electrode spacing allows switch insulation as by oil immersion while providing an adjustable voltage at which the switch will best operate. The annular electrode surfaces defining the spark gaps insure long life of the switch, particularly as contrasted to such as spherical surfaces, and the opposed gas flow passing each gap separately provides maximum insurance against misfire. Additionally, note that both spark gaps are surrounded by metal walls so as to prevent the accumulation of bound charges as occur upon insulators, sometimes triggering spurious discharges.

While the salient features of the present invention have been described in detail with respect to a single preferred embodiment it will be apparent that numerous modifications may be made within the spirit and scope of the invention and it is therefore not desired to limit the invention to the exact details shown except insofar as they may be defined in the following claims.

What is claimed is:

1. A spark gap switch comprising a sealed envelope, a pair of end electrodes disposed at opposite ends of said envelope, a central electrode disposed within said envelope intermediate said end electrodes and including two separate elements electrically connected with one facing each of said end electrodes to define a pair of spark gaps between end electrodes and central electrode, and means operable exteriorly of said envelope for displacing said end electrodes and the elements of said central electrode independently to vary the size of said gaps.

2. A spark gap switch comprising a pair of end electrodes, a hollow central electrode disposed intermediate said end electrodes and defining a pair of spark gaps therewith, means directing a flow of gas transversely across said gaps into said central electrode, and gas exit means communicating with the interior of said central electrode.

3. A spark gap switch comprising three aligned electrodes defining a pair of spark gaps between adjacent electrodes, control means for independently adjusting the position of each electrode relative to the adjacent electrode for controlling the extent of said spark gaps, and means directing a flow of gas transversely across said spark gaps for removing ions therefrom.

4. A spark gap switch comprising an envelope, a pair of axially aligned cylindrical end electrodes spaced apart within said envelope, a central electrode including a pair of electrically connected cylindrical elements axially aligned with said end electrodes intermediate same and defining therewith a pair of annular spark gaps, and control means operable exteriorly of said envelope for axially displacing each of said end electrodes and the cylindrical elements of said central electrode for varying the length of said spark gap.

5. A spark gap switch as defined in claim 4 further

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characterized by gas flow inlet and outlet means communicating with the interior of said envelope, and means directing the flow of gas oppositely past said end electrodes transversely across said spark gaps and oppositely through the elements of said central electrode for removing residual ions from said spark gaps.

6. A spark gap switch as defined in claim 4 further characterized by the end electrodes and the elements of said central electrode each being threadably connected to said envelope, said control means comprising a rod extending into said envelope axially of the electrodes therein in slidable and rotatable relation to the envelope and having an enlarged end interiorly of said envelope, and said end electrodes and elements of said central electrodes each having internally thereof catches removably attachable to the enlarged end of said rod to rotate therewith for axial electrode displacement within the envelope.

7. A spark gap switch as defined in claim 4 further characterized by said envelope including insulation between connection thereto of said end electrodes and the elements of said central electrode for insulation of potentials adapted to be impressed therebetween, and a metallic

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surface surrounding said spark gaps for precluding the accumulation of bound charges thereat.

8. A spark gap switch comprising an envelope including a central metal cylinder with insulating cylinders attached to each end thereof, a pair of end electrodes threadably mounted coaxially with separate insulating cylinders, a central electrode having a pair of cylindrical elements separately threadably mounted in solid support plates secured to said metal cylinder and disposed coaxially with said end electrodes in spaced relation thereto for defining a pair of spark gaps therewith, and gas flow means communicating with the interior of each of said insulating cylinders and with said metal cylinder intermediate the central element support plates for passing gas separately across said spark gaps to remove residual ions therefrom.

References Cited in the file of this patent

UNITED STATES PATENTS

2,182,751	Reithman	Dec. 5, 1939
2,213,226	Marshall	Sept. 3, 1940