

July 5, 1966

H. SCHIERHOLT
METHOD OF OPERATING A SPARK EROSION MACHINE AND A CIRCUIT
FOR PERFORMING THE METHOD
Filed Aug. 6, 1962

3,259,795

Fig. 1

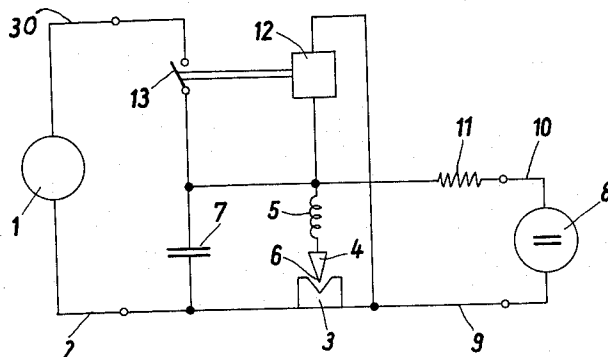


Fig. 2

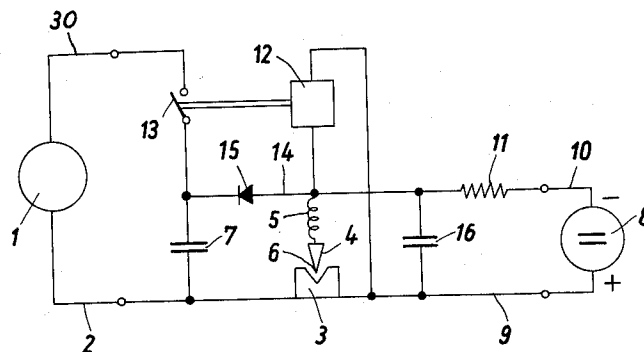
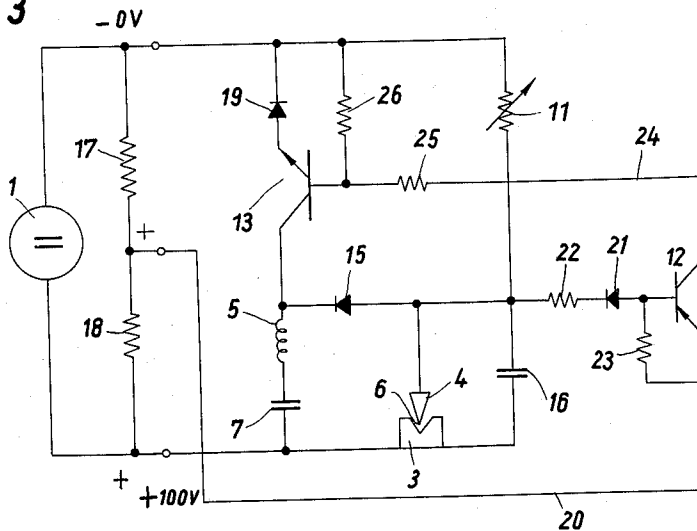


Fig. 3



Inventor:
Hans Schierholt
By Cushman, Darby & Cushman
Attorneys

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METHOD OF OPERATING A SPARK EROSION MACHINE AND A CIRCUIT FOR PERFORMING THE METHOD

Hans Schierholt, Iserlohn, Germany, assignor to Deutsche Edelstahlwerke Aktiengesellschaft, Krefeld, and Allgemeine Elektrizitäts-Gesellschaft, Berlin - Grunewald, Germany

Filed Aug. 6, 1962, Ser. No. 215,133

Claims priority, application Germany, Aug. 12, 1961, D 36,792

5 Claims. (Cl. 315-173)

The invention relates to spark erosion machines in which a storage condenser is charged through controllable switch means by a source of potential and then discharged across the working gap between electrode and work when flashover potential is reached. Spark erosion machines in which a condenser is thus controllably charged are known devices which are conventionally used.

The charging operation in these machines is controlled by a timing element which delays the charging of the storage condenser for a given period after a previous discharge. The purpose of this delay is to prevent flashover potential from being attained before the working gap has been sufficiently deionized and desirable working conditions re-established therein. Although a timing element of this kind can usually be adjusted to provide the necessary delay for deionization it is generally impossible to ensure with any degree of certainty that the physical conditions in the gap will be as desired when the potential has built up to flashover level. For instance, the dielectric may be contaminated or deposits may still be present inside the gap which can carry the current without the generation of an erosive discharge. Moreover, contamination of the working gap may even delay deionization beyond the preadjusted time of delay. Also, if a short circuit should have been formed in the working gap which is not due to contamination but to mechanical contact between the electrode and the work, it is possible for a current to flow continuously without having any erosive effect though causing an undesirable and harmful degree of heating in the environment of the contact point.

It is the object of the present invention to provide a method whereby these difficulties can be overcome. More particularly, it is intended that release of the stored energy shall not depend upon a predetermined time of delay but rather upon the conditions actually prevailing in the working gap. For solving this problem the invention proposes permanently to connect across the working gap a source supplying a reference potential and having a high internal resistance but incapable as such of maintaining an electric discharge. When, after discharge of the energy storage means, the gap is progressively deionized and cleaned of deposits and so forth, the resistance across the gap between the electrode and the work steadily rises to a very high value. The voltage across the internal resistance of the source of reference potential in relation to that across the resistance of the gap therefore changes and the voltage drop across the working gap rises. When this voltage drop across the gap reaches a given prescribed value which characterises the desired physical conditions in the working gap, say 40 volts, then this voltage through a measuring and switch means initiates the charging of the storage condenser to flashover voltage.

The proposed method therefore effectively prevents the storage condenser from being discharged before the physical conditions existing in the working gap are such as will ensure the generation of a spark discharge with an erosive action.

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The low current supplied by the source of reference potential thus tests the conditions obtaining in the working gap and automatically controls the charging of the storage condenser as soon as the required physical conditions in the gap have been established. The storage condenser which is connected across the working gap in conjunction with the internal resistance of the source of reference potential prevent the potential drop across the working gap from reaching the predetermined value until a given time has elapsed after deionization. The magnitude of this period of delay depends upon the product of the capacity of the storage condenser and the internal resistance of the source of reference potential. It may be advisable to disconnect the storage condenser from the working gap during the period the conditions in the working gap are subject to test. This period can thus be curtailed.

For performing the method the invention proposes circuit arrangements of which illustrative embodiments will be hereinafter described.

In FIG. 1 an electric connection 2 leads from a source of current 1 to the work 3 and a second connection 30 leads to the electrode 4, an inductance 5 possibly being included in this line. Parallel to the working gap 6 is the storage condenser 7. This is the arrangement which is at present conventional in spark erosion machines.

According to the embodiment of the invention shown in FIG. 1 there is provided a second source of current 8 which supplies a direct current, and which is connected by leads 9 and 10 across the working gap 6. Line 10 contains a resistor 11. The value of this resistor is suitably selected to prevent the current flowing in line 10 from being high enough to maintain a discharge across the working gap 6.

Parallel with the working gap 6 is a measuring element 12. The measuring element is arranged to operate a switch means 13 in line 30, which in the illustrated example is shown to be a mechanical switch in order to make the principle of operation clear. In actual practice this switch means would take the form of an electronic switching device. The measuring element 12 would in practice generally be a transistor or valve assembly designed to respond to particular voltage.

The circuit arrangement shown in FIG. 1 operates as follows: It is assumed that a spark discharge across the working gap has just taken place. Consequently the gap is still ionized and some deposits of material will have been formed and not yet flushed away. The low current from the reference source 8 therefore flows through resistor 11 and across the working gap 6 which at this instant still offers a low resistance. As deionization in the gap proceeds and the deposits are removed the resistance of gap 6 increases and a potential difference builds up across the gap, controlled by the rate at which the current deriving from the reference source 8, which is now unable to flow through the gap, charges condenser 7.

The voltage build-up across the gap affects the measuring element 12. This element is preset to respond to a particular voltage, say 40 volts. Therefore, when the voltage drop across the gap has built up to 40 volts the measuring element 12 will respond and operate switch 13 which thus completes the circuit through line 30. The condenser can therefore now be charged by source 1, preferably a source of D.C., to the high voltage at which a spark discharge across the working gap 6 will occur and produce the desired erosive effect.

The method and circuit proposed by the invention, as will be readily understood from the description, therefore has the effect of preventing the energy storage means from being charged until the requisite physical conditions have been re-established in working gap 6 for an effective

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erosive spark discharge to take place. Any undesirable flow of current across the working gap due to accumulation of material or arcing is thus positively suppressed. Moreover, since the sequence of spark discharges is independent of a timing member, the voltage automatically builds up to the maximum level permitted by the conditions obtaining in the working gap.

FIG. 2 illustrates the same kind of circuit modified by the provision of a valve 15 in the line 14 between the storage condenser 7 and the electrode 4. This valve is orientated to prevent current from the reference source from flowing to condenser 7. Consequently the voltage build-up across the working gap 6 after deionization will not depend upon the charging time of condenser 7 by the current derived from the reference source. The time required for testing the conditions obtaining in the working gap is thus reduced. In order to prevent this time from becoming too short it may be advisable to provide a second relatively small condenser 16 across the working gap 6. By suitably selecting the capacity of this condenser 16 in relation to the resistance of resistor 11 the time needed for testing the conditions in the working gap can be controlled as desired.

FIG. 3 illustrates a preferred embodiment of a circuit for performing the method according to the invention. In this circuit the control member 13 is a transistor. Instead of providing a transistor, a high vacuum valve might be included in the charging circuit of the condenser in a similar circuit arrangement. In detail the connections are as follows: The D.C. source 1 is connected with a potential divider comprising resistors 17 and 18 in such manner that in addition to a voltage of say 100 volts a potential of say 60 volts can be tapped from source 1. The positive pole of source 1 is connected with the work 3, condenser 7 and condenser 16. The negative pole of source 1 is connected through a valve 19, a transistor 13 of npn-type and an inductance 5 with condenser 7. On the other hand, condenser 7 is electrically connected through the inductance 5 and valve 15 with the working electrode 4.

In the illustrated embodiment source 1 simultaneously provides the reference potential. The negative pole is connected through an adjustably variable resistor 11 with the working electrode and can charge the second small capacity condenser 16 which lies across the working gap 6 so long as no current can flow across the gap.

The measuring element is embodied in a transistor 12 of pnp-type. The emitter of this transistor is connected by a lead 20 with the intermediate tap of source 1 (60 volts). Its base is connected through a valve 21 and a protective resistor 22 to the working electrode 4. A leak 23 is connected between base and emitter. The collector of transistor 12 is connected by a lead 24 and a resistor 25 with the base of the switching transistor 13. A leak 26 connects emitter and base of transistor 13.

This circuit functions as follows: It is assumed that a spark discharge has just taken place across the working gap 6. The gap is not yet fully deionized and it is assumed that deposits of eroded particles are still present in the gap. So long as these conditions endure a current from source 1 will flow through resistor 11 across the working gap 6. However, this current is too small to interfere with the process of deionization. When deionization and cleaning of the gap has proceeded sufficiently, the flow of current across gap 6 will cease and

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condenser 16 will begin to be charged. When the condenser voltage has reached a predetermined value, in the present case 40 volts, the base of transistor 12 becomes negative in relation to the emitter. Consequently a current will flow through lead 24 to the base of transistor 13 which now becomes conductive, permitting condenser 7 to be charged by source 1 until the flashover potential across gap 6 as determined by the feed, say 90 volts, has been reached and the next spark discharge can take place.

The valves 19 and 21 are merely protective. They could be dispensed with. Valve 19 has the effect of ensuring that no current will pass through transistor 13 and valve 21 protects the base of transistor 12 from too high a blocking potential.

The method according to the invention is not limited to the use of the particular circuit arrangements illustrated in FIGS. 1, 2 and 3. For instance, in place of transistors or high vacuum tubes, controlled semiconductor rectifying devices with a characteristic similar to that of a thyatron or gas-filled discharge tubes could be used.

What I claim is:

1. Means for controlling discharge across a spark-eroding gap between a workpiece and a working electrode in a spark erosion machine, comprising a charging circuit including switch means and storage condenser means and means to create energy for storing by said latter means and discharge across the said gap, further circuit means connected across the said gap for supplying a reference potential and incapable itself of maintaining a discharge across said gap, said further circuit means including voltage measuring means and being operative in such a way that during deionization and cleaning out of the said gap and the establishment of a suitable distance between the working electrode and the workpiece the build-up of voltage across the gap by said further circuit means is used through said measuring and switch means and when the voltage has reached a predetermined value less than the sparking voltage to trigger the charging of the said storage means to sparking potential.

2. A circuit arrangement as claimed in claim 1, in which the switch means in the charging circuit is a high vacuum valve.

3. A circuit arrangement as claimed in claim 1, in which the switch means in the charging circuit is a transistor.

4. A circuit arrangement as claimed in claim 1, in which the switch means in the charging circuit is a controllable gas filled discharge tube, such as a thyatron.

5. A circuit arrangement as claimed in claim 1, in which the switch means in the charging circuit is a controllable semiconductor rectifier device with a characteristic similar to that of a thyatron.

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JOHN W. HUCKERT, *Primary Examiner.*

JAMES D. KALLAM, *Examiner.*

R. F. POLISSACK, *Assistant Examiner.*