PATENT SPECIFICATION (11) 1 588 985

1 588 985

(21) Application No. 37764/77 (22) Filed 9 Sept. 1977

(31) Convention Application No. 2 641 275 (32) Filed 14 Sept. 1976 in

(33) Fed. Rep. of Germany (DE)

(44) Complete Specification published 7 May 1981

(51) INT. CL.³ B23P 1/08

(52) Index at acceptance B3V 4A1C

(54) A SPARK EROSION MACHINE CONTAINING AN ELECTRICAL POWER STORAGE DEVICE

(71) We, AEG-ELOTHERM GMBH, a German Company of Hammesberger Strasse 31, 563 Remscheid-Hasten, Federal Republic of Germany, do hereby declare

the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:–

This invention relates to a spark erosion machine in which working pulses are produced across the working gap when connected to a d.c. pulse source for working pulses with selective pulse intervals to form a signal voltage which is variable with the width of the working gap, which spark machine includes a storage device for connection across the said working gap to form a signal voltage which is variable with the width of the working gap, the said storage device comprising a storage capacitor which is charged by pulses of the working gap voltage to a signal voltage and which is discharged intermittently by means of a control device to extinguish the signal voltage, which signal voltage can then be reformed.

Such storage devices are needed on spark erosion machines to prepare a measuring signal which is used in conjunction with an associated desired value signal as an actual value signal at the input of a regulator to adjust the working electrode of the machine in relation to the surface of the workpiece to be processed in the sense of re-adjusting the electrode to bring about a constant width of the gap between the surface of the working electrode and the surface of the workpiece to be processed.

In known devices of this kind, the arrangement is such that the storage capacitor is completely discharged across a contact-break distance at the beginning of each spark voltage pulse in order to form the actual value voltage and only after that is charged to a voltage equal to or proportional to the spark voltage appearing at the working gap. The device is intended to store the voltage of the working pulses, which in practice are separated from one another by an interval of adjustable length, over a large proportion of the pulse interval and to hold it available for forming the control deviation. The storage capacitor is only discharged shortly before the end of the pulse interval and the signal voltage is formed afresh with the beginning of a fresh working pulse.

Such a known arrangement has the advantage that, with suitable construction of the associated control device components, which control the charging and discharging of the storage capacitor, the signal voltage at the storage capacitor can be formed independently of the length of the interval between two working pulses, i.e. independently of the pulse duty factor of the pulse train. However the said known devices have the disadvantage of relative insensitivity to fluctuations in the gap width as the voltage of the working pulses, which can be measured as operating voltage during the passage of the spark between the working electrode and the workpiece to be processed, depends on the width of the working gap but the dependence of the amplitude of the working voltage on the width of the working gap is relatively low.

It has been found according to the invention that in spark erosion machines of the kind referred to, the sensitivity in forming the signal voltage can be considerably improved by ensuring that the said storage capacitor is a component of an integrator for forming a signal voltage which is variable with the voltage-time area of a working pulse and of which the integration time constant is selected so as to be longer than the duration of the working pulse. Should the duration of the pulses be altered the integration time constant will be changed. For the rapid formation of the signal voltage, it is an advantage to evaluate every other pulse.

In the construction according to the invention, a signal voltage which varies with a time integral from the pulse voltage is formed by means of the storage capacitor or the associated integrator. It has been determined that this quantity depends more sensitively on the width of the working gap at the machine, so that a more sensitive regula-

tion of the working gap width and hence an improvement in the quality of the processing operation at the machine can be achieved.

The invention is hereinafter particularly described and illustrated in the accompanying drawing, of which

Figure 1 shows, diagrammatically, a circuit diagram of a device according to the invention on a spark-erosion machine.

Figure 2 shows a pulse diagram explaining the mode of operation of Figure 1.

In Figure 1, 1 designates a metal workpiece to be processed, 2 a vessel which can be adjusted by hand in the usual manner in the horizontal plane on a cross-table of the machine and in which the workpiece 1 is mounted, 3 a working electrode for processing the workpiece 1, the surface of which forms a gap 4 with the surface of the workpiece to be processed, and 5 a hydraulic piston motor which serves to adjust the height of the working electrode 3 and which is acted upon from both sides and can be controlled by means of an electrohydraulic regulator 6. The vessel 2 is filled in the usual manner with a dielectric liquid, for example petroleum, which fills the working gap 4 and renders possible the transfer of the spark between the working electrode 3 and the workpiece 1. For the spark operation, the working gap 4 is connected, via the electric leads 7, to the output of an electronic d.c. pulse generator 8 which produces d.c. working pulses with adjustable pulse spacing and of a selected duration. The means for setting the intervals between two working pulses at the generator 8 are designated by 9.

In the illustration of Figure 2, the axis a) shows the working pulses at the working gap depending on time, the duration of the working pulses being designated by *ti* and the width of the associated pulse intervals by *to*. The pulse interval *to* can be set by means of the setting means 9.

10 designates an electrical integrator, the input of which is connected, via the conductors 11, to the working gap 4. It contains the storage capacitor 12 serving as an integration capacitor and a resistor 13 which is connected in series therewith, and, as a result of appropriate selection of the adjustable resistor 13 and dimensioning of the capacitor 12, the construction is such that the integration time constant of the integrator is of the order of magnitude of $ti + to$. In any case, the integration time constant is selected greater than *ti* so that the signal voltage u, which can be tapped off at the storage capacitor 12 through the conductor 14 and supplied to the input of an amplifier 15, is proportional to the time integral over the pulse voltage.

The output voltage of the amplifier 15 is supplied, via the conductor 15A, to the input of the electrohydraulic regulator 6, as an actual-value signal, where this actual-value voltage is compared with a desired-value voltage which can be preset at the input of the regulator 6 by means of a desired-value setter 6A. The difference between the two voltages controls the regulator 6 as a control deviation, and hence controls the adjustment of the piston motor 5.

16 designates a short-circuiting device which is connected in parallel with the storage capacitor 12 and can be actuated by means of a control device 17. In order to prevent the discharge of the storage capacitor 12 on closing of the short-circuiting device 16, a blocking diode 18 is connected in series with the short-circuiting device and the capacitor and prevents the discharge of the capacitor.

19 designates a further short-circuiting device which is connected in parallel with the storage capacitor 12 and can be actuated by means of a control device 20. The short-circuiting device 19 serves to discharge the capacitor 12 and hence to extinguish the signal voltage 4.

The control devices 17 and 20 can be controlled by timing pulses by means of a control device 21 via pulse lines 22 and 23, which timing pulses are derived from the output pulses of the generator 8 via the line 7A. The construction is such that the control pulses of the line 22 actuate the short-circuiting device 16 through the control device 17 in such a manner that only every other working pulse of the line 11 is supplied to the integrator 10. For this purpose, the short-circuiting device 16 is opened shortly before the beginning of a working pulse so that the working pulse is supplied to the storage capacitor 12 for the formation of the signal voltage u. Then the short-circuiting device 16 is closed so that the following pulse is short-circuited for the integration capacitor. In the next following pulse interval *to*, the short-circuiting device 16 is opened again so that the following working pulse can again be supplied to the storage capacitor.

Independently of this operation, the short-circuiting device 19, actuated by corresponding control pulses from the timing circuit 23, serves for the rapid discharge of the storage capacitor 12 in such a manner that the short-circuiting device 19 is opened again after a discharge of the capacitor 12, whereupon the charging of the capacitor 12 is effected by the following working pulse. After formation of the signal voltage u, which is proportional to the time integral of the pulse voltage, the voltage at the capacitor 12 is stored for a period t' as a result of non-actuation of the short-circuiting device 19, the time t' (see the axis

b) of Figure 2) following on the end of the pulse, the time integral of which is formed at the storage capacitor 12. The period t' is selected so that the pulse interval initiated on the discharge of the storage capacitor 12 by the following actuation of the short-circuiting device 19 is short in comparison with the time during which the voltage u is available on the line 14. The time t' is therefore selected so that the short-circuiting device 19 is only actuated shortly before the supply of a fresh working pulse to the integrator 10 and is opened again immediately after the discharge of the capacitor. In order to synchronize the pulses of the timing circuit 23 with the duration of the pulse intervals *to* which are situated between the working pulses of the line 11, the setting means 9 for the length of these pulse intervals at the generator 8 are connected to the control pulse generator 21 through setting means 9A.

Apart from this, it comes within the scope of the invention to make the construction such that immediately successive pulses are supplied to the integrator 10 instead of every other pulse, to form the signal voltage. Every third, fourth or further pulse may also be used to form the signal voltage. Furthermore, it is possible to integrate a plurality of pulses in order to form the signal voltage. Appropriate means can be provided by appropriate construction of the control device 21.

WHAT WE CLAIM IS:–

1. A spark erosion machine in which working pulses are produced across the working gap when connected to a d.c. pulse source for working pulses with selective pulse intervals to form a signal voltage which is variable with the width of the working gap, which spark machine includes a storage device for connection across the said working gap to form a signal voltage which is variable with the width of the working gap, the said storage device comprising a storage capacitor which is charged by pulses of the working gap voltage to a signal voltage and which is discharged intermittently by means of a control device to extinguish the signal voltage, which signal voltage can then be reformed; characterized in that the said storage capacitor is a component of an integrator for forming a signal voltage which is variable with the voltage-time area of a working pulse and of which the integration time constant is selected so as to be longer than the duration of the working pulse.

2. A spark erosion machine as claimed in Claim 1, wherein in the said storage device every other pulse of the gap voltage is supplied to the integrator for the integration.

3. A spark erosion machine as claimed in Claim 1, substantially as hereinbefore described and illustrated in the accompanying drawing.

HYDE, HEIDE & O'DONNELL
2 Serjeants' Inn
London EC4Y 1LL
Chartered Patent Agents
Agents for Applicants

Printed for Her Majesty's Stationery Office by The Tweeddale Press Ltd., Berwick-upon-Tweed, 1981. Published at the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1588985 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

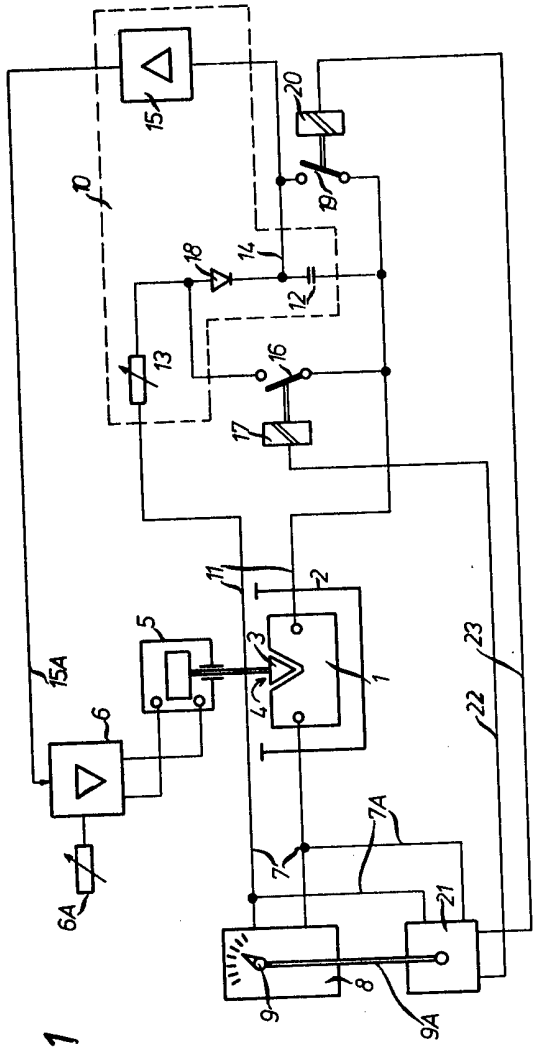

Fig.1

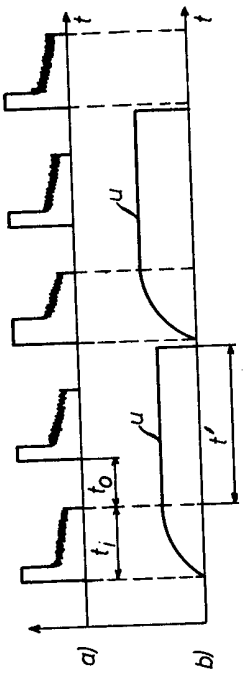

Fig.2