Feb. 18, 1969 S. SCHMIDT 3,428,782

ELECTRODE ASSEMBLIES WITH SEQUENTIALLY OPERATED, CLOSELY ADJACENT SPARK GAPS

Filed July 27, 1966 Sheet 1 of 4

FIG.1

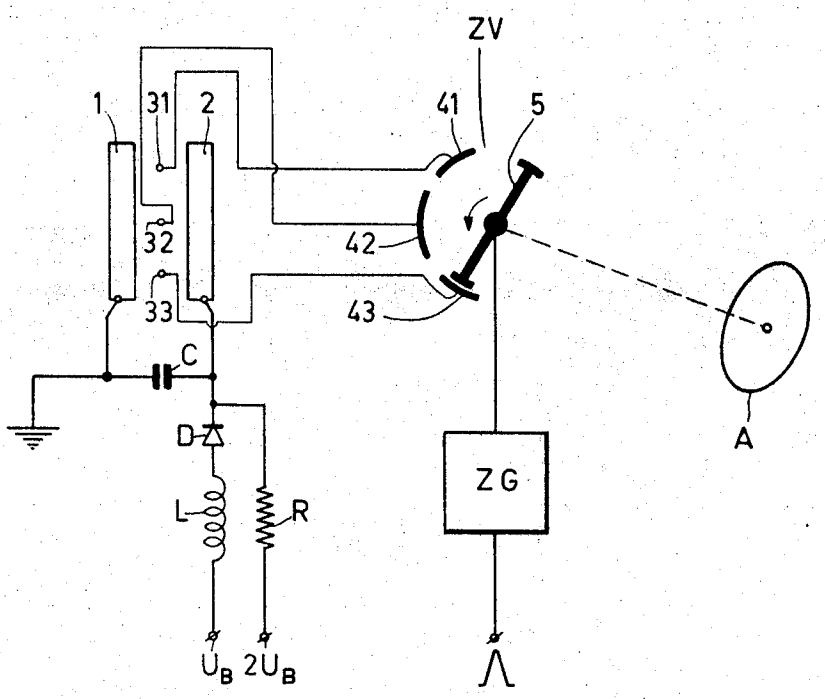
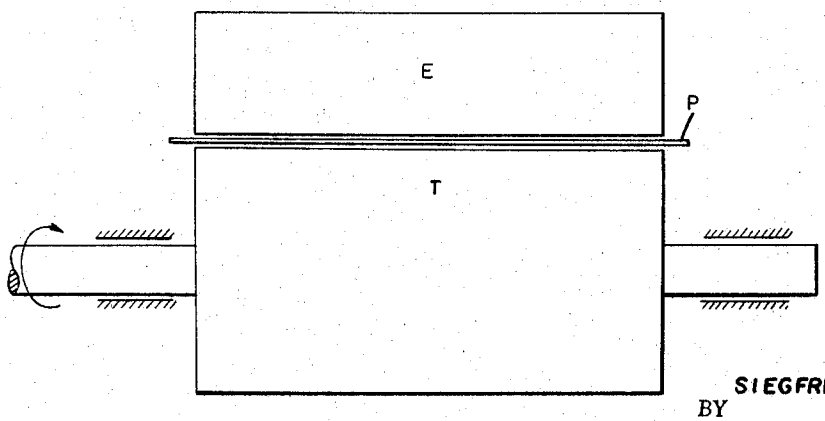


FIG.3



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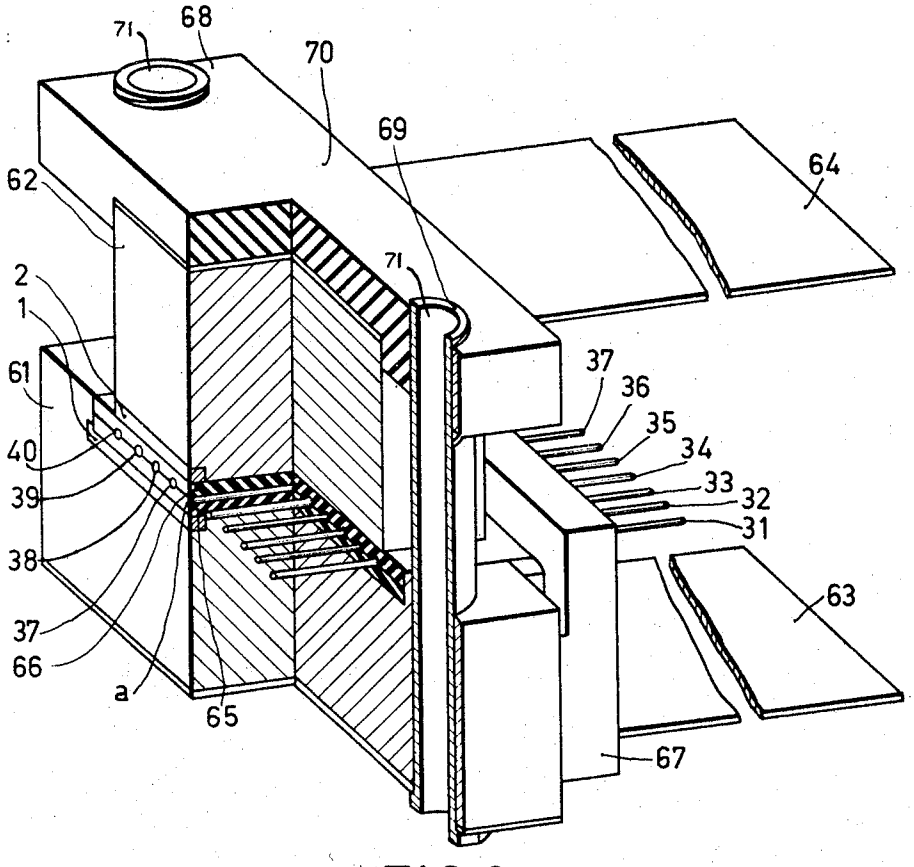

FIG.2

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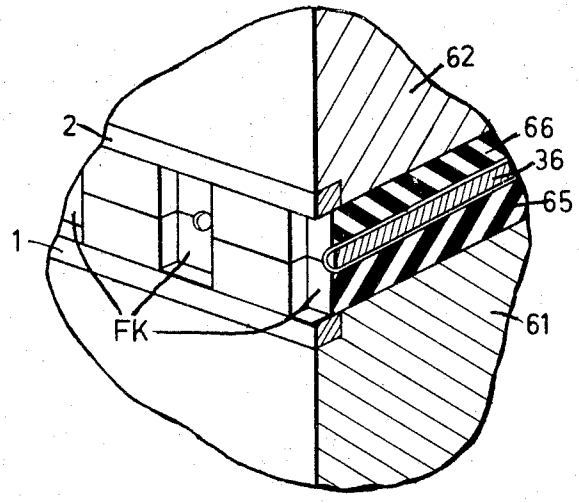

FIG. 4

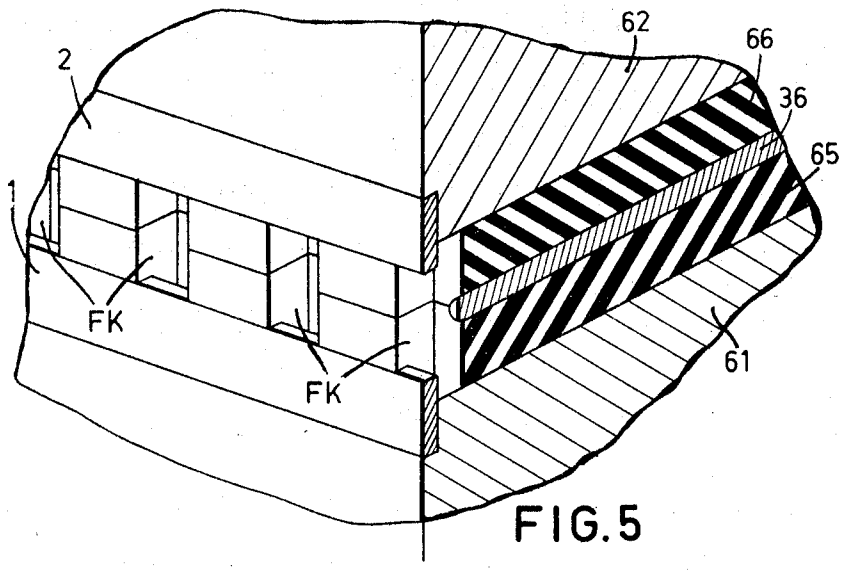

FIG. 5

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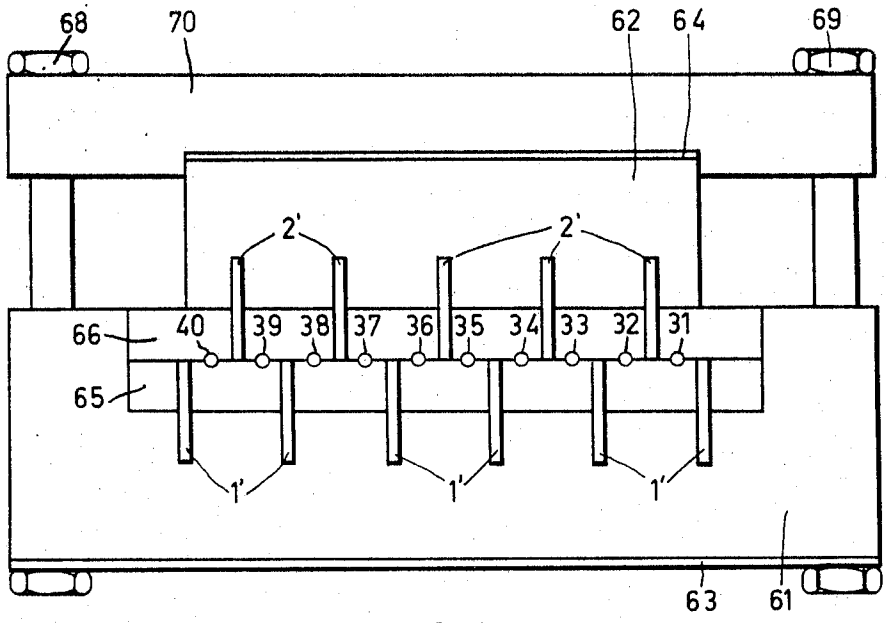

FIG.6

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ELECTRODE ASSEMBLIES WITH SEQUENTIALLY OPERATED, CLOSELY ADJACENT SPARK GAPS

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Claims priority, application Germany, July 31, 1965, P 37,370
U.S. Cl. 219—383 6 Claims
Int. Cl. H05b 7/18, 7/14; G01d 15/08

ABSTRACT OF THE DISCLOSURE

An electrode assembly for a spark gap printer where a DC electric field having an intensity below the ionization potential of the surrounding medium is produced between two adjacent main electrodes. Electric pulses having an intensity above the ionization potential are distributed to a plurality of closely spaced ignition electrodes positioned within the field produced by the main electrodes to discharge the main electrodes in the area of the energized ignition electrode.

The invention relates to an electrode assembly with sequentially operated, closely adjacent spark gaps. The use of spark generated pressure waves for perforating or printing in output devices of data-processing apparatus requires the closely adjacent arrangement of a plurality of spark gaps.

There has been proposed an arrangement for delivering data by means of controllable, electric discharges, in which use is made of a sequentially operated spark printer. In this arrangement a separate spark gap electrode with its own discharge circuit is provided for each area to be printed. The term sequentially operated is to be understood to mean herein that the perforations required for one character are punched consecutively or the characters of a line of characters are printed one after the other. For each place to be printed there is provided a separate spark gap electrode with its own discharge circuit. If no special precautions are taken, the ignition of one spark gap may bring about the unintentional ignition of an adjacent spark gap.

According to the invention an electrode assembly of the type indicated is characterized in that all spark gap electrodes are electrically connected in parallel and have a common discharge circuit, while sequentially controllable ignition electrodes for the individual spark gap electrodes are electrically and spacially separated and insulated from each other.

The ignition electrodes therefore not only determine the moment of occurrence of a spark discharge, but also determine the location thereof.

The assembly according to the invention may be comprised of a practically unlimited number of parallel-connected spark gaps, which are to be operated sequentially. A plurality of such spark gap assemblies, which are insulated from each other, may be arranged near each other. Whereas sequential operation of the spark gaps is visualized in the individual assemblies, the assemblies themselves may be operated in parallel that is simultaneously. Even in the case of highly different requirements, this possibility of combining sequential and parallel operation permits great flexibility in controlling the spark pattern. It is ensured that an undesirable or random ignition of adjacent spark gaps is avoided. Since only one discharge circuit is provided for each assembly, the arrangement is fairly simple. Since heat can now be conducted away satisfactorily without difficulties, blurring of the print and hence the risk of ghost prints, that is to say random printing of adjacent marks or random punching of adjacent perforations is reduced. The wear of electrodes and the insulator is reduced.

The drawing shows embodiments of the invention herein:

FIG. 1 shows a survey of the circuit arrangement.
FIG. 2 shows a spark gap assembly.
FIG. 3 shows diagramatically a high-speed printer.
FIG. 4 shows a detail of FIG. 2.
FIG. 5 shows a variant of FIG. 4.
FIG. 6 shows a variant of the main electrode arrangement.

FIG. 1 shows by way of example the basic diagram of the discharge and trigger circuit for three spark gaps. Between the parallel-connected main electrodes **1** and **2** there are disposed the ignition electrodes **31**, **32** and **33**. The main electrodes **1** and **2** are connected to the capacitor C. This capacitor C is charged immediately after a discharge through an inductor L and a diode D by the voltage source U_B to the voltage $2U_B$. The voltage $2U_B$ and the capacitance of the capacitor C are chosen such that the energy required for a spark discharge is stored in the capacitor. A current circuit of a voltage source $2U_B$ through a high-ohmic resistor R serves only to compensate the leakage losses during longer intervals between discharges. By the oscillatory charging a sequential frequency of discharges of more than 2.5 kc./s. is attained at the required energies without difficulty. If considerably higher sequential frequencies have to be attained, use may be made of a known manner of controlled charging of the capacitor.

The ignition electrodes **31**, **32** and **33** are connected to the contacts **41**, **42** and **43** of an ignition distributor ZV, the distributing contact **5** of which is connected to the output of the ignition pulse generator ZG. The ionized air between an energized ignition electrode and the common electrode **1** causes capacitor C to discharge through a spark between electrodes **1** and **2** in the area of the energized ignition electrode. Mechanically the distributing contact is connected with the scanning device A, required for the electronic coupling between the type cylinder or typechain and the printing device. In order to ensure satisfactory ignition it is advantageous to apply to the ignition electrodes by a known method a quiescent electric potential between that of the main electrodes **1** and **2** and corresponding to the potential at the location of said ignition electrodes.

FIG. 2 shows partly perspectively and partly in a sectional view an electrode assembly according to the invention for a 10-position sequential printer. The main electrodes **1** and **2** are not divided into separate electrodes for each spark gap, but they form a unit for the ten spark gaps. They are formed by tungsten wires of rectangular section and are held in the metal parts **61** and **62**. For obtaining a satisfactory drain of heat said parts **61** and **62** are made of copper.

For particularly high energy requirements these copper parts can be easily provided with cooling tubes. The plate-iron strips **63** and **64** establish the connection between the capacitor C of FIG. 1 and the electrodes. The ignition electrodes **31** to **40** are tungsten wires. They are arranged between flat insulating plates **65** and **66**, provided with grooves for accommodating the ignition pins and made, for example, of alumina ceramic. The insulating plates **65** and **66** are coplanar at the front with the electrodes **1** and **2**, whereas at the rear they protrude from the metal parts **61** and **62** to an extent such that electric sparking at the rear is avoided. The ignition pins **31** to **40** and the insulating plates **65** and **66** are held in the insulator **67**, so that they form a sub-assembly that can be easily re-

moved. The insulator **67** is attached to the metal block **61**. The assembly is held together by two hollow screw bolts **68** and **669**, which extend transversely through insulating substance **70**. The bores **71** of the screw bolts **68** and **69** form fastening holes.

The ignition electrodes are electrically connected at the rear to the ignition distributor ZV. If, for example, the ignition electrode **36** receives a high-voltage pulse, a spark discharge is generated between the main electrodes **1** and **2** just at the place *a*.

FIG. 3 shows diagrammatically the position of the electrode array E in a high-speed printer. The paper P to be printed is located with one face closely in front of the spark gaps and with the other face directly in front of the rotating, inked type cylinder T. Guide members for the paper P prevent the paper from coming into contact with the type cylinder in the rest position.

This embodiment does not possess a spark chamber proper. The spark is struck in the thin air layer between the electrode array E and the paper. In order to influence the printing distribution it is advantageous to form spark chambers FK by incisions of the insulating plates **65** and **66**, as is shown in FIG. 4 in a detail view. In order to ensure satisfactory ignition the ignition pin should not penetrate into the spark chamber. The ignition pins have therefore to be proportioned such that the wear due to the discharges equals that of the insulator.

Whereas in the embodiment of the spark gaps so far described the discharge has the form of a sliding spark along the surface of the insulator (**65** and **66**), FIG. 5 shows in a detailed view a spark gap array in which the discharge has the form of a spark through the air, the path between the main electrodes **1** and **2** through the air or the gas being considerably shorter than that along the surface of the insulator. The wear of the insulator (**65**, **66**) is thus considerably reduced. A small additional energy is then, however, required for obtaining the same printing effect. In the arrangement shown in FIG. 5 the distance between the metal parts **61** and **62** is larger than the distance between the main electrodes **1** and **2**. The insulating plates (**65**, **66**) are thicker than in the preceding embodiment and the main electrodes **1** and **2** protrude from the metal parts **61** and **62**. The ignition pin (here **36**) may protrude from the insulating plates **65** and **66**, but it should not extend wholly in the shortest path between the main electrodes in order to ensure a satisfactory ignition.

If, for example, for reducing ghost printing, the axes of the spark channels should extend in the direction of the sequence of separate spark gaps, the main electrodes are arranged as is shown diagrammatically in the plan view of FIG. 6. The main electrodes **1'** and **2'** are formed here by a plurality of separate electrode rods arranged (for example soldered) in the metal parts **61** and **62** in a direction at right angles to the sequence of the spark gaps.

In principle, also in these parallel-connected multiple spark gaps the wear of the insulator may be reduced by using liquids as the insulating means.

What is claimed is:

1. An electrode assembly for selectively producing sparks, comprising first electrode means, second electrode means adjacent said first electrode means, said first electrode means and said second electrode means defining a plurality of spaced spark gap areas connected in parallel, means connected to said first electrode means and to said second electrode means for providing across each said gap area an electric field having an intensity insufficient to cause a spark, at least two ignition electrodes spaced from said first electrode means and said second electrode means, each said ignition electrode extending within the electric field within one of said gaps, means for insulating said ignition electrodes from said first electrode means and from said second electrode means, and means operating independently of said field producing means for selectively raising each said ignition electrode to a potential sufficient to produce a spark between said first electrode means and said second electrode means in the gap area into which an excited ignition electrode extends.

2. An electrode assembly as claimed in claim **1** wherein said electric field providing means comprises a DC voltage source and means for connecting said source between said first electrode means and said second electrode means.

3. An electrode assembly as claimed in claim **2** wherein said connecting means for said DC source comprises a capacitor connected between said first electrode means and said second electrode means, an inductance connected to said DC source, a diode connected to said inductance, and means for connecting said DC source through said inductance and said diode to said capacitor.

4. An electrode assembly as claimed in claim **1** wherein said first electrode means and said second electrode means are elongated spaced parallel metal bars, and wherein said ignition electrodes are spaced adjacent the area between said bars.

5. An electrode assembly as claimed in claim **4** wherein said insulating means extends into the area between said bars adjacent each said ignition electrode.

6. An electrode assembly as claimed in claim **5** wherein said insulating means is spaced from said bars in an area adjacent each said ignition electrode and wherein said insulating means is spaced from the area between said bars adjacent each said ignition electrode.

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U.S. Cl. X.R.

315—325; 346—74