Oct. 21, 1969 S. SCHMIDT 3,474,288

ROTATABLE SPARK GAP PRINTING DEVICE HAVING A FIXED IGNITION ELECTRODE

Filed Nov. 23, 1966 4 Sheets-Sheet 1

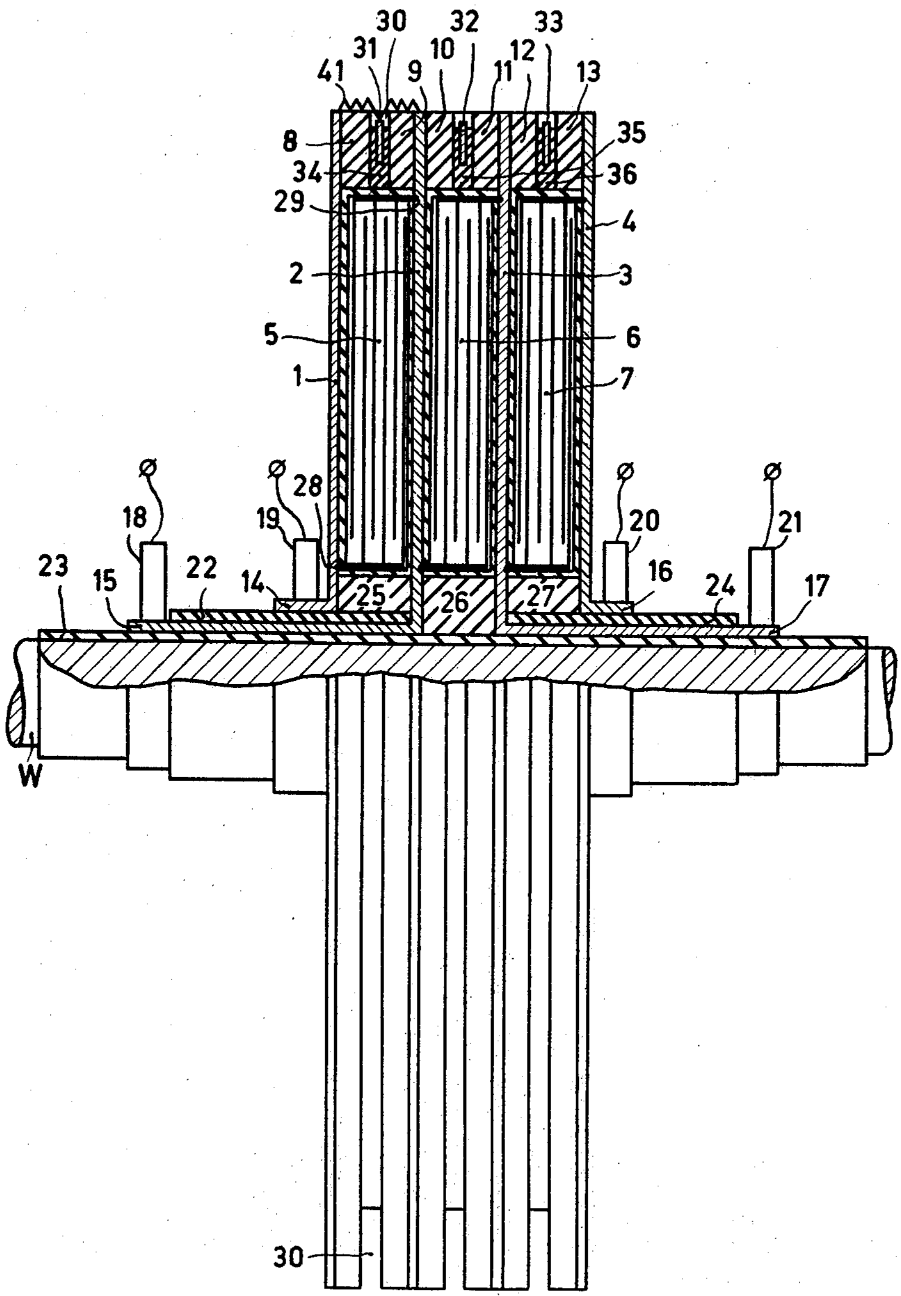

FIG.1

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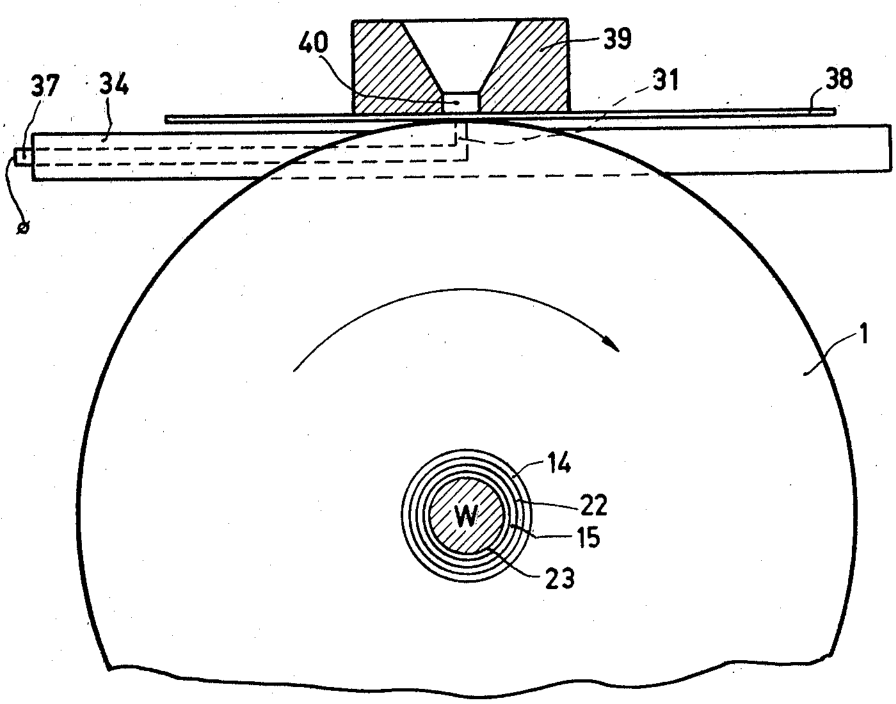

FIG.2

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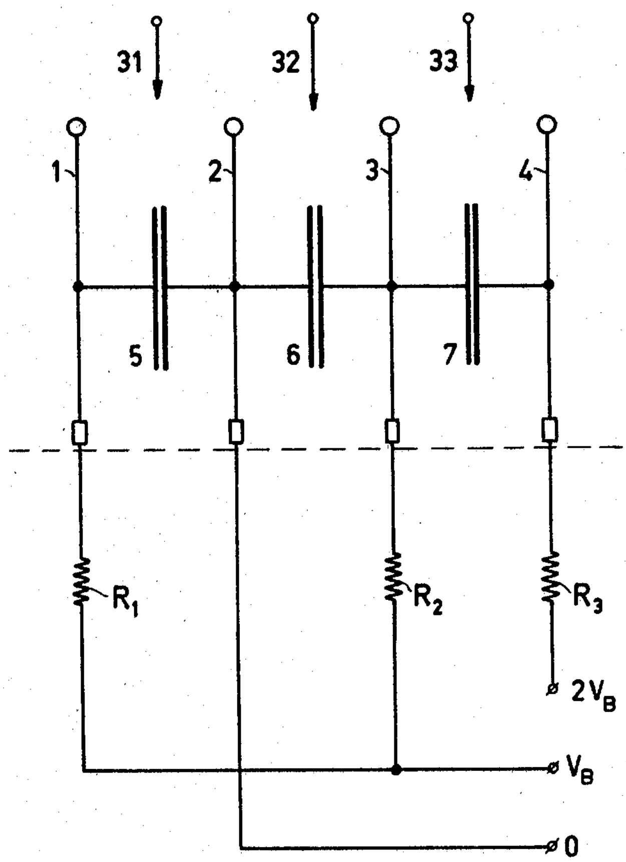

FIG.3

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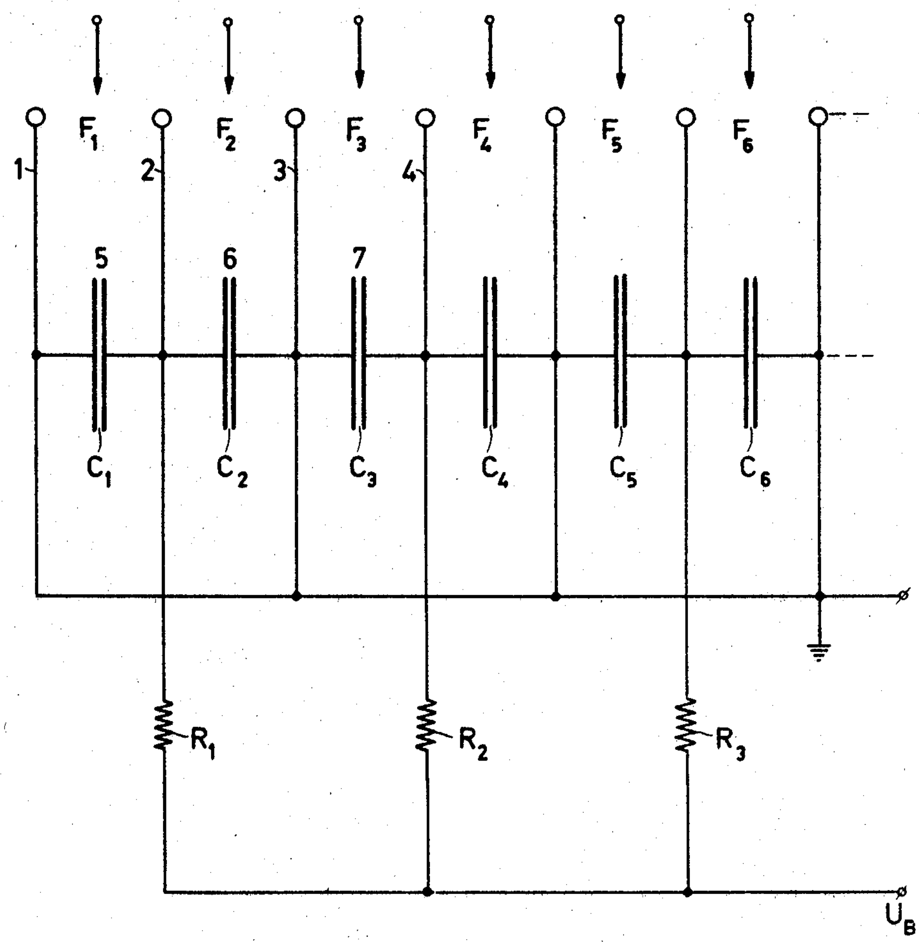

FIG.4

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United States Patent Office

3,474,288
Patented Oct. 21, 1969

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3,474,288

ROTATABLE SPARK GAP PRINTING DEVICE HAVING A FIXED IGNITION ELECTRODE

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Filed Nov. 23, 1966, Ser. No. 596,606
Claims priority, application Germany, Nov. 26, 1965, P 38,223
Int. Cl. H01j 7/44
U.S. Cl. 315—36 12 Claims

ABSTRACT OF THE DISCLOSURE

A spark gap printing device that includes a plurality of disc electrodes axially mounted on a rotatable shaft with annular insulating rings therebetween. A fixed ignition electrode is mounted between each adjacent pair of electrodes near the surface of the annular rings to initiate and fix the location of the spark discharge.

The present invention relates to a spark gap device comprising disc-shaped electrodes mounted on a rotatable shaft wherein a spark track extends between the electrode which is bounded on one side by an insulating surface.

A device of this type may be employed for producing pressure waves for punching perforations or printing legible characters on a carrier. The spark discharge produces a great deal of wear on the electrodes and also on the insulating material bounding the spark track. Therefore, both the electrode and the bounding insulating material have been arranged rotatably so that it is possible to insert each time a different portion of said elements in the range of the spark track. In a known device of the kind set forth, disc-shaped elements arranged in the same plane are countersunk in the upper face of an insulating plate. The elements extend by the proximal peripheral portions across an opening in the plate which is closed on the rear side by part of the conical end of a thick-walled, hollow cylinder, which is adapted to rotate about an axis at an angle to the plane of the insulating plate.

An object of the invention is to provide a device of the kind set forth comprising geometrically simple elements which can be easily assembled and dismounted and arranged so that it is possible to obtain a plurality of adjacent spark tracks within a relatively compact space.

The device according to the invention comprises an annular or disc-shaped insulating material of substantially the same outer diameter as the electrodes and interposed between the electrodes on the same rotatable shaft, in combination with a fixedly mounted ignition electrode for fixing the place of spark discharge between adjacent electrodes independently of the angular position of the shaft.

The supply of the high discharge currents to the movable electrodes via wear-subjected slip rings is avoided by providing discharge capacitors fixedly connected with the electrodes so that the capacitors rotate with the electrodes. It is advantageous to join the discharge capacitors and the electrodes in a structural unit. It is then only necessary to pass the low charging currents via the slip rings, which does not present any technical problems. The resultant unit consisting of a discharge capacitor and a discharge track can be mounted so as to have a low inductance, which is, in general, very advantageous.

However, if the construction is such that the capacitors are not rotated with the electrodes, the discharge current may be conducted via non-touching contacts forming preliminary spark tracks, for example, similar to the ignition distributor in an Otto motor.

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Although the movable electrodes are to be rotated, the spark discharge should invariably occur at the same predetermined place. This may be obtained by means of an additional stationary ignition electrode arranged at the place where the electric discharge is to take place. Thus the place of discharge is determined since the discharge is initiated by a trigger pulse on the ignition electrode at the desired spot.

A further possibility consists in arranging the movable electrodes in an insulating liquid so that the electrodes emerge from the liquid only at the desired place of discharge. It is structurally simpler to use compressed gas (for example, compressed air) instead of an insulating liquid. At the place of discharge the compressed gas reservoir is provided with an aperture through which the movable electrodes emerge. The gas flows out of this comparatively small aperture so that the pressure is reduced. In this case the location of the discharge between the electrodes is fixed by the reduced gas pressure at the outlet aperture. The emerging gas simultaneously provides an intensive cooling of the spark track so that deionisation is accelerated, while developed metal vapour from the electrodes is carried away. Further possibilities for fixing the location of the discharge include the preionisation of the gas at the relevant place by means of a radio-active preparation or a "corona" discharge.

In the last-mentioned cases, the initiation of the discharge may also be obtained by an additional ignition electrode. In these cases the ignition electrode may also be movable. A subdivision of the ignition electrode may be conductive to the fixation of the location of discharge. In order to obtain a uniform wear of the main electrodes, the ignition electrode now must be moved at a speed differing from that of the main electrodes. If, in the last mentioned cases, an ignition electrode is not present the discharge may be initiated by controlled charge of the relevant capacitor to the discharge voltage.

If it is desired to have several spark gaps closely adjacent one another, it may be necessary for a movable electrode to be associated with two discharge circuits and hence to be connected to two discharge capacitors. In order to avoid the discharge of a capacitor that is not associated with the ignited spark gap, the capacitors are charged in series if there are more than two closely adjacent discharge circuits. The conditions are quite simple when the discharge circuits are operative sequentially, that is each at a different moment, for instance in order of succession (series operation). It is then sufficient, in known manner, to use one discharge capacitor, while all spark tracks have their corresponding main electrodes connected in parallel.

One embodiment of the invention will be described hereinafter in connection with the accompanying drawings, in which:

FIG. 1 shows a side view of a preferred embodiment of the invention;

FIG. 2 shows an axial view of the device shown in FIG. 1; and

FIGS. 3 and 4 show two different circuit arrangements of the capacitors.

FIGURE 1 shows, in a partly developed side view, the basic construction of three closely adjacent spark tracks each having a stationary ignition electrode. In this case the whole assembly is arranged symmetrically upon rotation. A shaft W, which is caused to rotate, in operation, by a drive (not shown), is provided with four electrode discs **1**, **2**, **3** and **4**, three discharge capacitors **5**, **6** and **7**. The shaft also supports the insulators **8** to **13** of the three spark tracks and the associated current supply conductors in the form of slip rings **14** to **17**, as well as the required insulating members. The electrode discs **1** to **4** are conductively connected with the tubes **14** to **17**, which serve for the supply of current. The current supply is performed through the sliding contacts **18** to **21**, which are shown diagrammatically. The tubes **14** to **17** are electrically separated from each other by insulating tubes **22** to **24**. The insulating rings **25** to **27** provide the correct axial distance between the electrode discs. The major portion of the space between the electrode discs is occupied by the discharge capacitors **5**, **6** and **7**.

The embodiment shown comprises annular stacked capacitors having disc-shaped conductive coatings which are alternately connected to the inner and outer surfaces. Each of the capacitors are connected between two electrode discs, for example, the capacitor **5** is connected at the places **28** and **29** to the electrode discs **1** and **2**, respectively, in an annular fashion. A still simpler construction is achieved when the discs **1** to **4** are so large that the capacitance between them is adequate to provide the required discharge capacitance. By the choice of a suitable dielectric material of high dielectric constant, appropriate dimensions may be obtained in practice.

At the outer edge, between the electrode discs, the insulating rings **8** to **13** are arranged so that between each pair of discs (for example, **1** and **2**) at the center, a groove **30** is left for accommodating the ignition electrode **31** at the desired discharge spot. The stationary ignition electrodes **31**, **32**, **33** are held by the insulations **34**, **35**, **36**, in which the supply conductors (for example, the strips **31**, **32**, **33**) also are provided. It is advantageous to manufacture the ignition unit by casting a synthetic resin around the ignition electrodes **31**, **32**, **33** with their supply conductors. The insulators **34**, **35**, **36** may, as an alternative, be formed from two halves, in which case the supply conductors are arranged between said insulator halves in the form of thin foils or thin conductive layers on the insulators themselves. The insulators ensure that a spark-discharge will occur only at the location of the ignition electrodes proper. The broken line **41** indicates the location of the spark discharge. At the place of the spark ignition, the electrode discs may be made of a suitable electrode material (for example, tungsten).

FIGURE 2 shows the same arrangement viewed in the direction of the axis. It shows the rotatable electrode disc **1** and the stationary insulator **34**, inside which the supply conductor **37** for the ignition electrode **31** is provided. FIGURE 2 also shows, by way of example, the use of the spark for perforating paper. The paper **38** is located between the spark track and the mould **39**, shown in a sectional view. Upon a spark-discharge being initiated between the electrode discs **1** and **2** at the place of the ignition electrode **31**, the resultant pressure urges the paper so hard against the mould that a hole is punched in the paper. The shape of the punched hole is determined by the shape of the hole **40** is the mould **39**.

For a good understanding of the function of the electrode array, FIGURE 3 shows the circuit arrangement. The part above the broken line shows the arrangement of the rotatable part, whereas the stationary arrangement is indicated beneath said line. The capacitor **5** is connected to the electrodes **1** and **2** and the capacitors **6** and **7** are similarly connected to the electrodes **2** and **3** and **3**, **4** respectively. The electrodes **1** to **4** are supplied from the outside via the sliding contacts **18** to **21**. In the embodiment shown the electrode **2** is at zero potential. The capacitors **5** and **6** are charged via the resistors R_1 and R_2 from a source of voltage U_B. The capacitor **7** receives a charge via the resistors R_2 and R_3 from a source of voltage **2**U_B to zero potential.

If a capacitor is discharged by the ignition of a spark, this capacitor is recharged via the associated resistors without appreciably affecting the further capacitors. In principle, the charge may be obtained by using corresponding, known arrangements including inductors or control elements. A direct mutual action of the spark tracks upon the occurrence of a spark discharge is prevented by the decoupling charging circuit elements (for example, the resistors R_1 to R_3).

If further similar electrode discs are to be arranged close to each other, the best solution is to avoid a direct through-connection of an electrode plate to zero potential. This can be accomplished by inserting in the supply conductor to that electrode a charging circuit element (for example, a resistor). Then it is sufficient to use one voltage source U_B, so that the aforesaid series charging may be dispensed with. The charging circuit elements are in that case alternately connected to one and to the other terminal of the voltage source.

FIGURE 4 also shows a circuit arrangement in which an arbitrary number of spark tracks may be located close to each other. In this case, however, every second electrode E_1, E_2 is at zero potential. There are shown six spark tracks F_1 to F_6 with the associated capacitors C_1 to C_6 and the three charging resistors R_1 to R_3. In this arrangement every two adjacent spark tracks (for example, F_1 and F_2) are not independent of each other since they are connected in parallel with the associated capacitors (for example, C_1 and C_2). The capacitors C_1 and C_2 can therefore be discharged in common at the same time only across one spark track F_1 or F_2. The two spark tracks can only be operated in sequence. In spite of this restriction, this arrangement is suitable for many uses, for example, for a high-speed printer in which two adjacent positions are printed in order of succession.

Structurally some advantages are obtained from the reduction of the number of slip rings. If the charging resistors also are included in the rotating part, only two slip rings are required. The electrical connections may also be established by a hollow shaft.

In principle, the invention is not restricted to the embodiment described above. It is possible, for example, to exchange permanently the loaded insulator **8**, **9** in the form of narrow strips and to cause only the electrodes to rotate as a wheel. It is also possible to coat the insulator with a quantity of electrode material such that the erosion of the insulator and of the electrodes is the same. Then only one part is subjected to wear, which part can always be replaced.

What is claimed is:

1. A spark gap printing device comprising a plurality of disc-shaped electrodes coaxially mounted in spaced apart relationship on a rotatable shaft, an annular body of insulating material of substantially the same outer diameter as the electrodes coaxially mounted on said rotatable shaft between adjacent pairs of electrodes so that the outer surface of said insulating body provides a spark track between adjacent electrodes, and an ignition electrode fixedly mounted between each set of two adjacent electrodes for fixing the place of spark discharge between adjacent electrodes independently of the angular position of the shaft, said ignition electrode having one end located between adjacent ones of said disc-shaped electrodes near the outer surface of said insulating material.

2. A spark gap device as claimed in claim **1** wherein the body of insulating material between adjacent electrodes is provided at its periphery with a groove concentric to the shaft for accommodating said ignition electrode.

3. A device as claimed in claim **1** further comprising a stacked capacitor coaxially mounted on the shaft between adjacent electrodes, said capacitor having a plurality of conductive coatings connected alternately to one and to the other of said adjacent electrodes.

4. A device as claimed in claim **1** wherein the shaft with the set of electrodes and the body of insulating material is immersed in an insulating liquid to a level such that only a small portion of the cylindrical surface formed by the periphery of the electrodes and the insulating material extends out of said liquid.

5. A device as claimed in claim **1** further comprising a reservoir of compressed gas in which the shaft with the set of electrodes and the body of insulating material is arranged, said reservoir having an outlet aperture at the place of the desired spark track between adjacent electrodes.

6. A device as claimed in claim 1 having more than two electrodes and including a common charging circuit for the capacitors connected between each pair of adjacent electrodes comprising, a first supply conductor directly connected to a first set of alternately mechanically interconnected electrodes and a second supply conductor connected through a plurality of separate charging resistors to each of the other electrodes.

7. A spark gap printing device comprising a plurality of disc electrodes mounted in spaced apart relationship on a rotatable shaft, a circular body of insulating material mounted on said shaft between each pair of adjacent electrodes so that the outer surface of said insulating body defines a spark guiding surface between said adjacent electrodes, means for charging adjacent electrodes to a given voltage level, and an ignition electrode having one end fixedly mounted adjacent said insulating body outer surface and between each pair of adjacent disc electrodes for initiating a spark discharge therebetween and along said spark guiding surface.

8. A device as claimed in claim 7 wherein each circular insulating body comprises a pair of annular members axially spaced to provide a gap therebetween, and each ignition electrode comprises a thin elongated electrode mounted within said gap with one end extending close to the outer surface of said pair of annular insulating members.

9. A device as claimed in claim 8 wherein the outer diameter of said annular members is equal to the outer diameter of the disc electrodes so that together they form a substantially continuous cylindrical surface.

10. A device as claimed in claim 8 wherein each ignition electrode includes a portion that extends linearly between adjacent disc electrodes and parallel to the confronting surfaces thereof, said electrode portion being adapted to receive electric trigger pulses for selectively initiating a spark discharge between adjacent disc electrodes.

11. A device as claimed in claim 9 further comprising a body mounted adjacent said cylindrical surface to provide a gap therebetween and having a hole therein in the vicinity of each ignition electrode.

12. A device as claimed in claim 7 wherein said shaft includes at least three disc electrodes, said device further comprising a first supply conductor directly connected to alternate ones of said disc electrodes, a plurality of resistors, a second supply conductor, means connecting said second supply conductor to the other alternate ones of said disc electrodes by means of individual ones of said resistors, and a source of voltage connected to the terminals of said first and second supply conductors.

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U.S. Cl. X.R.

313—149, 297, 325; 317—35