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ELECTRICAL SPARK PRODUCING APPARATUS

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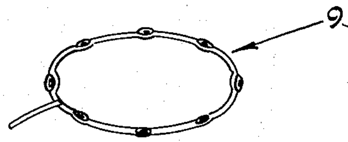

FIG. 2.

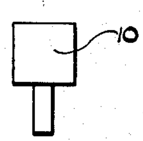

FIG. 3

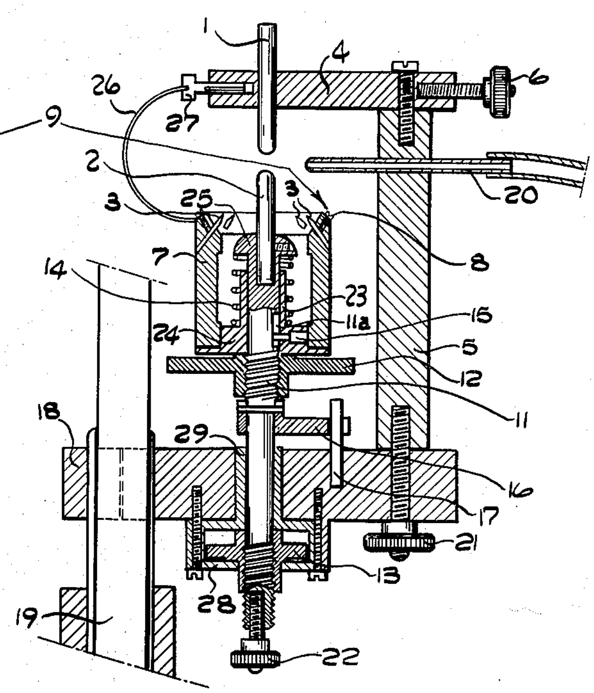

FIG. 1.

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ELECTRICAL SPARK PRODUCING APPARATUS

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8 Claims. (Cl. 313—146)

This invention relates to apparatus for producing an electrical spark in a spark gap between two opposed axially aligned electrodes.

In such apparatus it is often important to ensure that the commencement of the spark can be accurately timed.

It is an object of this invention to provide means which assist in such accurate timing of the commencement of the spark.

According to this invention there is provided apparatus for producing an electrical spark in a spark gap between two opposed axially aligned electrodes in which at least six needle-shaped members of electrically conducting material are arranged so that their points are directed towards the spark gap between the electrodes and so that their points lie at equal intervals on the circumference of a circle around the common axis of the electrodes in a plane at right angles to such axis the diameter and position of the circle being such that the said points are in close proximity to the spark gap but sufficiently spaced therefrom so as to be free of the spark, electrical connections for applying a sparking voltage to the electrodes, and electrical connections adapted to apply to such needle-shaped members a voltage not less than that applied to the electrode operating at the higher voltage.

The needle-shaped members may conveniently be arranged around the electrode operating at the lower voltage with the axes of their needle points at an acute angle to the axis of such electrode. Furthermore an electrical conductor may be provided connecting the needle-shaped members to each other and to the electrode operating at the higher voltage.

In the apparatus according to this invention, there may be provided needle adjustable mounting means for adjustably mounting the needle-shaped members so that the diameter of the circle on the circumference of which their points lie can be varied. Axial adjustment means may be provided for supporting the needle adjustable mounting means for varying the position relative to the electrodes of the circle on the circumference of which the needle points lie. Electrode spacing adjustment means may be provided whereby the axial spacing between the electrodes can be varied to vary the spark gap.

Gas flow means may also be provided for directing a flow of gas at the spark gap for removing therefrom electrically charged particles resulting from one spark before the commencement of the next spark.

It is preferred to use eight needle-shaped members in the apparatus of this invention.

The apparatus of this invention assists in reducing the statistical time lag in the spark gap thereby assisting in the accurate timing of the commencement of the spark.

The other well known factors which also assist in controlling the statistical time lag in the spark gap must of course be suitably adjusted in the conventional manner. Such other factors include the voltage across the spark gap, the width of the spark gap, the electrical field intensity in the spark gap as controlled, e.g. by the shape of the electrode, the electrode material and the gas condition of the spark gap.

Thus it is well known that the higher the voltage across

the gap becomes the shorter will be the statistical time lag for a given gap width. The width of the spark gap is also known to have an influence such that the smaller the gap for a given voltage the smaller will be the statistical time lag. Similarly it is well known that the shape of the electrodes affects the electrical field intensity in the spark gap which in turn affects the statistical time lag. Generally, cylindrical electrodes with dome-shaped ends are preferred. The material from which the electrodes are made should also be chosen appropriately in known manner. Thus materials with a low work function but not too high a rate of evaporation have been found suitable. Aluminum is the preferred material. The gas condition in the spark gap is also known to affect the statistical time lag. Thus for accurately timed repetitive sparks it is known to be desirable to ensure as far as possible that there will be identical gas conditions obtaining in the spark gap just prior to the commencement of each spark. It is therefore preferred to blow electrically charged particles produced by one spark out of the spark gap before the commencement of the next spark, by means of a suitable blast of gas.

The needle-shaped members provided in the apparatus of the present invention are believed to assist in the reduction of the statistical time lag by providing a corona discharge effect from their needle points producing sufficient ultra-violet radiation to cause the appearance of high energy electrons in the spark gap. So also for repetitive sparks the needle-shaped members are believed to mask changes in the electrical field conditions in the spark gap arising from haphazard cratering of the electrodes by the spark, thereby providing more nearly identical electrical field conditions for each spark.

The adjustable features of the preferred form of the apparatus according to this invention enable the setting of the needle-shaped members in optimum position causing minimum spark jitter, for each of a number of different operating conditions, e.g. applied voltage, spark gap width, electrode materials, etc.

In view of the fact that in the apparatus of this invention the needle points are spaced sufficiently from the spark gap so as to be free of the spark, i.e. so that the spark does not strike the needle points, it is possible to use the apparatus for a considerable time before readjustments are required, and the needles have a comparatively long life.

The apparatus of this invention finds a particularly useful application in time resolved spectrochemical analysis using a control gap with one or more analytical gaps in any conventional electrical circuit arrangement. As is well known in such analysis the control spark gap is employed to control as accurately as possible the time of commencement of the repetitive sparks in the analytical spark gap where the material to be analyzed is rendered luminous by the sparks and viewed through spectral analyzing equipment. It is therefore desirable that the commencement of the spark in the control gap should be controlled as accurately as possible and that the spark in the analytical gap should commence as nearly as possible at the same time as the spark in the control gap. This may to a large measure be achieved by using the apparatus of the present invention as the control gap and disposing the analytical gap(s) in close proximity to such control gap with an optical path for ultra-violet radiation between them.

As pointed out above the apparatus of the present invention enables the commencement of the spark in the control gap to be controlled to a high degree of accuracy and the ultra-violet radiation produced by the spark in the control gap can be made to trigger the spark in the analytical gap. As ultra-violet radiation travels with the speed of light and as the analytical gap is disposed in close proximity to the control gap it follows that the spark in the analytical gap will commence virtually at the same time as the spark in the control gap. The analytical gap must not be so close to the control gap as to be contaminated by the spark products of the control gap. Furthermore the optical path between the control gap and the analytical gap must be such as to pass ultra-violet radiation. Thus while a quartz window would be permissible in such optical path a glass window would not, as ultraviolet radiation cannot pass therethrough.

An arrangement such as described above allows greater freedom of adjustment in the analytical gap which facilitates the whole process of analysis. Thus a greater variation in electrode material or shape and in gap width will be permissible without affecting the accurately timed commencement of the spark in the analytical gap.

By way of example the invention will now be described with reference to the accompanying drawings in which:

FIGURE 1 is a cross-sectional elevation of one embodiment of this invention;

FIGURE 2 is a perspective view of a connecting ring; and

FIGURE 3 is a side elevation of a needle point adjustment former.

Referring to FIGURE 1, the spark gap is defined between the cylindrical aluminum electrode **1** operating at the higher voltage and cylindrical aluminum electrode **2** operating at the lower voltage. Electrode **1** is mounted in a brass holder **4** all supported by an insulating column **5** of polymethyl methacrylate (perspex) on an insulating base **18** of similar material which is clamped to the side support of any suitable arc stand **19**. The electrical connection to electrode **1** is made at terminal **6**. Electrode **2** is mounted removably in metal control support **11** passing through base **18** and having at the other end thereof terminal **22** by which the electrical connection for electrode **2** is made. Mounted on control support **11** are two adjustment discs **12** and **13**.

Adjustment disc **12** is made of electrically insulating material and has internal screw threads cooperating with external screw threads on control support **11**. Mounted slidably on control support **11** is a metal sleeve **23** with a circular shouldered flange **24** at its lower end. Rotation of the metal sleeve **23** is prevented by the key **15** in the shouldered flange thereof engaging slidably in the key way **11*a*** provided therefor in control support **11**. Spring **14** bears on the top of the shouldered flange **24** of metal sleeve **23** and against the bottom shoulder provided on head **25** of control support **11**.

Mounted on the shouldered flange **24** of metal sleeve **23** is a perspex tube **7** in the top end of which are provided eight steel needles **3** with their points directed towards the spark gap between the electrodes **1** and **2**. These steel needles are spaced equally around the perspex tube **7** and their axes are at an angle of 60° to the common axis of the electrodes **1** and **2**. The set screws **8** and the tube **7** form part of needle adjustable mounting means for adjusting the diameter of the circle defined by the points of the needles **3**. The needles **3** can be set at variable positions in their mountings by set screws **8** all passing through connecting ring **9** made of steel. This connecting ring **9** is mounted on the top edge of perspex tube **7** and serves as an electrical connection to all the needles **3**. Flexible conductor **26** connects connecting ring **9** to terminal **27** in brass holder **4**.

Adjustment disc **12**, and tube **7** form part of axial adjustment means for varying the axial position of the circle defined by the points of the needles **3**, relative to the electrodes **1** and **2**. By rotating adjustment disc **12** in one direction metal sleeve **23** is raised so as to compress spring **14** and to raise perspex tube **7** and with it needles **3** relative to electrode **2**. By rotating adjustment disc **12** in the opposite direction spring **14** forces metal sleeve **23** down and with it perspex tube **7** and needles **3** are lowered relative to electrode **2**.

Adjustment disc **13** is made of electrically insulating material and has internal screw threads cooperating with external screw threads on control support **11**. Adjustment disc **13** abuts on the one side against the inside of metal bracket **28** mounted with screws against the bottom of perspex base **18** and on the other side against metal sleeve **29** passing through perspex base **18** and slidably surrounding control support **11**. Rotation of adjustment disc **13** in one direction raises control support **11** and with it adjustment disc **12**, metal sleeve **23**, perspex tube **7** and electrode **2** thereby decreasing the spark gap. Similarly rotation of adjustment disc **13** in the opposite direction increases the spark gap. Adjustment disc **13**, metal bracket **28**, and metal sleeve **29** form part of electrode spacing adjustment means whereby the spacing between electrodes **1** and **2** and hence the spark gap may be varied.

Metal arm **16** is non-rotatably mounted on control support **11** and has a forked end slidably engaging pin **17** fixed in base **18**. This metal arm prevents rotation of control support **11** when adjustment discs **12** and **13** are rotated.

Perspex tube **20** is mounted on column **5** so as to direct an airstream (e.g. supplied at 3 to 5 lbs. pressure when tube **20** has a diameter of ¼ inch) at the spark gap. Clamping screw **21** clamps column **5** to base **18** and when released allows column **5** and brass holder **4** to be swung out to one side to facilitate removal, replacement or adjustment of electrodes **1** and **2** and tube **7** with needles.

The points of needles **3** are all set on the circumference of a circle around the axis of the electrodes and in a plane at right angles to such axis. This can conveniently be achieved by means of a needle point adjustment former **10**. Electrode **2** is removed, former **10** inserted in its place and the needles **3** set by set screws **8** with their points in contact with the cylindrical surface of the former. A set of formers with different diameters can be provided to allow for a number of different adjustments of the needle points.

When operating this apparatus as the control gap in conventional spectrochemical analysis using one analytical gap, with 6.00 mm. diameter electrodes, a spark gap of 4.5 mm., an applied voltage of 17 kilovolts across the spark gap and applying repetitive sparks of 50, 100 up to say 400 sparks per second it has been found that the optimum diameter of the circle on which the needle points lie is 3 cm. and that this circle should be positioned 2½ cm. below the centre of the spark gap. A capacitance of about 100 picofarads is connected between the two leads to the analytical gap to avoid small changes in the setting of the electrodes causing a significant change in the capacitance leading to the spark.

Under such conditions the spark jitter can be reduced to less than 10 millimicro seconds, i.e. the commencement of each spark can be timed with an error of less than 10 millimicro seconds. Where the analytical gap is arranged, as described above, to be triggered by the ultra-violet radiation of the control gap (e.g. about 10 to 15 cm. from the control gap), it is clear that greatly improved analytical conditions are obtained by virtue of the great accuracy with which the commencement of the spark in the analytical gap can be timed. Furthermore it was found that under such operating conditions the width of the analytical gap could be varied from 3 to 12 millimetres with varied electrode materials and shapes which greatly facilitates the analytical operations.

In known high precision high voltage electronical control spark apparatus, a special type of high voltage transformer must be used. This invention allows the use of standard conventional high voltage transformers used for building spectro-chemical spark light sources.

For different operating conditions the optimum setting of the various variable adjustments of the apparatus described above can be readily determined.

Wherever in this specification and claims it is stated that the points of the needle-shaped members are "directed towards the spark gap between the electrodes" it must be understood that it does not necessarily mean that they must be directed to the centre of the spark gap but includes the cases where they are directed slightly above or below the spark gap.

What we claim is:

1. Apparatus for producing an electrical spark in a spark gap between two opposed elongated electrodes arranged with their longitudinal axes in alignment, in which at least six needle shaped members of electrically conducting material are arranged so that their points are directed towards the spark gap between the electrodes and so that their points lie at equal intervals on the circumference of a circle around the common axis of the electrodes and in a plane at right angles to such axis the diameter and position of the circle being such that the said points are in close proximity to the spark gap but suffiicently spaced therefrom so as to be free of the spark, electrical connections for applying a sparking voltage to the electrodes, and electrical connections adapted to apply to such needle shaped members a voltage at least equal to that applied to the electrode operating at the higher voltage.

2. Apparatus according to claim **1** in which the needle-shaped members are arranged around the electrode operating at the lower voltage with their needle points disposed in a circle around the external circumference of the electrode and with the axes of their needle points at an acute angle to the axis of such electrode.

3. Apparatus according to claim **1** which includes an electrical conductor connecting the needle-shaped members to each other and to the electrode operating at the higher voltage.

4. Apparatus according to claim **1** in which there is provided needle adjustable mounting means for adjustably mounting the needle-shaped members so that the diameter of the circle on the circumference of which their points lie can be varied.

5. Apparatus according to claim **1** in which there is provided axial adjustment means supporting the needle adjustable mounting means for varying the position relative to the electrodes of the circle on the circumference of which the needle points lie.

6. Apparatus according to claim **5** in which there is provided electrode spacing adjustment means; whereby the axial spacing between the electrodes can be varied to vary the spark gap.

7. Apparatus according to claim **1** in which gas flow means are provided for directing a flow of gas at the spark gap for removing therefrom electrically charged particles resulting from one spark before the commencement of the next spark.

8. Apparatus according to claim **1** arranged as the control gap with at least one analytical gap for time resolved spectrochemical analysis in which the analytical gap is disposed in close proximity to the control gap with an optical path for ultra-violet radiation between the control gap and the analytical gap.

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