Dec. 28, 1965 R. D. CRAIG ET AL 3,226,542
MASS SPECTROMETER ARC-TYPE ION SOURCE
HAVING ELECTRODE COOLING MEANS
Filed Dec. 10, 1962

FIG. 3

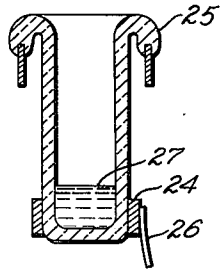


FIG. 1

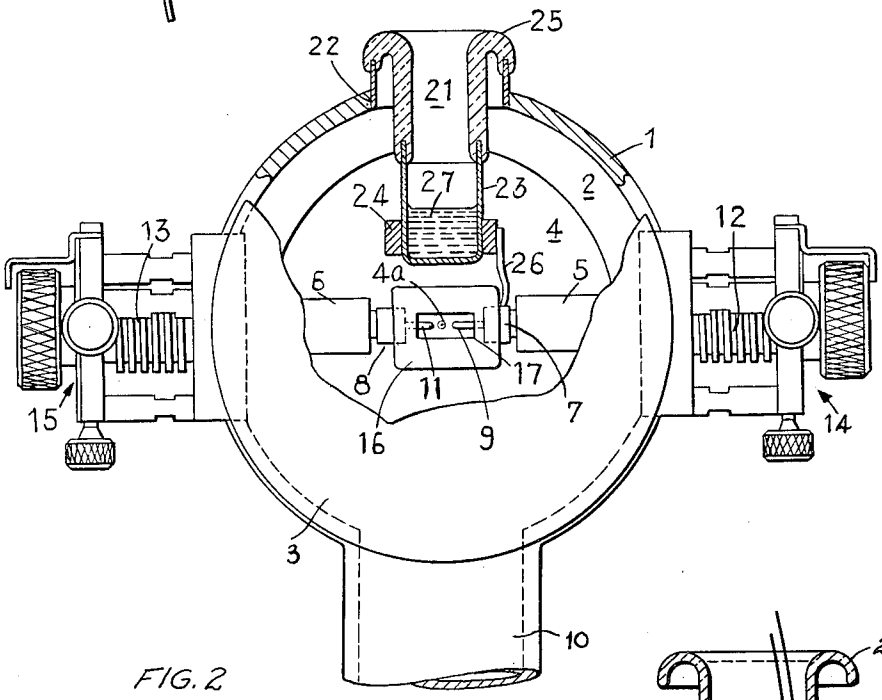
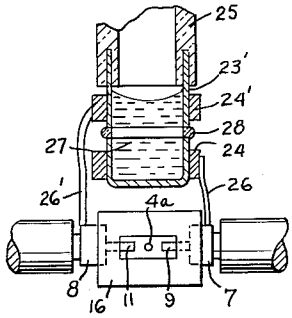


FIG. 2



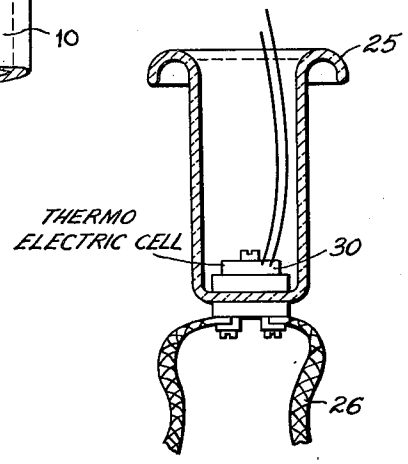


FIG. 4

United States Patent Office 3,226,542 Patented Dec. 28, 1965

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MASS SPECTROMETER ARC-TYPE ION SOURCE HAVING ELECTRODE COOLING MEANS

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Filed Dec. 10, 1962, Ser. No. 243,501
10 Claims. (Cl. 250—41.9)

The present invention relates to mass spectrometers and more particularly to ion sources for mass spectrometers.

In certain types of ion source the sample to be analysed is in the form of two electrodes supported in a vacuum with their ends adjacent and when a voltage is applied between the two ends of the electrodes an electrical discharge is formed and the sample is ionised. The passage of current and the discharge generate heat and this causes the electrodes to heat up. In an alternative method only one of the electrodes is of the material to be analysed while the other electrode has a known composition.

If the electrodes are made from a material having a low melting point, such as gallium for example, at least the ends of the electrodes may melt when the arc is formed. This is an undesirable characteristic and may cause selective volatization of impurities or even complete collapse of the sample electrodes.

The object of the present invention is to provide an improved mass spectrometer ion source of the type described which tends to prevent melting of at least one of the sample electrodes.

According to the present invention a mass spectrometer ion source comprises a chamber adapted to be evacuated, two electrically insulating supports extending within said chamber and supporting respectively two electrodes at least one of which is of the material to be analysed, so that surfaces of the electrodes are located adjacent to each other and an electrical discharge may be produced between said two electrodes, a heat absorbing member, and a connector of a material having a good thermal conductivity connecting said heat absorbing member with one of said electrodes.

The heat-absorbing member is conveniently a flask containing a cooling medium such as liquid nitrogen for example.

If the connector is not made from an electrically insulating material means are normally provided for electrically insulating the heat-absorbing member.

The ion source may comprise a second connector providing a good thermally conducting path between the second support and the heat-absorbing member or another heat-absorbing member.

In order that the invention may be more readily understood reference will now be made to the accompanying drawing in which the FIGURE 1 is a view of a mass spectrometer ion source embodying the invention, and FIGURES 2, 3 and 4 are fragmentary views showing modifications.

With reference to FIGURE 1 the ion source comprises a chamber having a cylindrical wall 1 with an end wall 2 and cover 3, shown partly cut away. The end wall 2 is formed with an axial channel which connects with the remaining components of the mass spectrometer. An ion gun, of which only the first plate 4 with aperture 4*a* is shown, is situated adjacent the channel through end wall 2. This ion gun accelerates and focuses ions formed in the ion source thus providing a well defined ion beam which passes through said channel in wall 2 into the analyser region of the mass spectrometer which lies beyond. The chamber is adapted to be evacuated through a duct 10.

Two supporting pillars 5, 6 extend through the wall 1 and are formed with clamps 7, 8 of good thermally conducting material and adapted to hold electrodes 9, 11 respectively, at least one of which is of the material to be analysed. The pillars are made of an electrically insulating material and are sealed as they pass through the wall 1 by means of bellows 12, 13. Two mechanisms 14, 15 are provided for moving the pillars so that the ends of the electrodes 9, 11 may be located accurately relative to each other and to the aperture 4*a*. Electrical conductors are also provided, but not illustrated, for connecting the electrodes 9, 11 to suitable sources of potential so that an electrical discharge may be formed between the adjacent ends of the electrodes, and an electric field is provided so that the ions produced in the discharge may be accelerated through aperture 4*a*.

Typical operating conditions are for items 4, 7, 9 and 16 to be at +20 kv. D.C. with items 8 and 11 connected to these through an air core transformer generating up to 100 kv. pulses. Other components are all at earth potential.

A shield 16 covers the adjacent ends of the electrodes and is formed with an aperture 17 through which the ends of the electrodes may be viewed. The shield 16 prevents material emitted from the electrodes when the electrical discharge is formed from being deposited on all the other components of the ion source. The shield 16 is conveniently mounted on the clamp 7.

A flask 21 is located in an aperture 22 in the wall 1 in a gas-tight manner. The flask comprises a metal portion 23 surrounded by a metal band 24 and a glass portion 25 which supports the metal portion 23 and provides an electrically insulating path between the metal portion and the wall of the ion source. The glass portion of the flask conveniently has a re-entrant configuration as illustrated. A flexible connector strip 26 of good thermally conducting material connects the metal band 24 to the clamp 7.

The flask is adapted to contain a cold liquid 27, such as liquid air, liquid nitrogen or liquid helium, for example, and this absorbs heat from the clamp 7 and the electrode 9 by conduction through the connector 26. The materials of the flask and of the connector are chosen so that there is good thermal conductivity between the coolant 27 and the electrode 9 and good thermal insulation between the coolant 27 and the wall of the ion source. In an alternative arrangement shown in FIGURE 3 the metal portion 23 is replaced by a glass portion 29 which may be an extension of the glass portion 25.

The liquid in the flask cools both the electrode 9 and the shield 16 by direct conduction. The second electrode 11 is cooled by radiation from the surrounding components 9 and 16. A second connector may be provided to connect the second electrode 11 either to flask 21 or to a second similar flask also containing a cooling medium. It would be necessary to electrically insulate these two connectors from each other in order to avoid forming a short circuit between the electrodes. It would therefore not be possible to attach both the connectors directly to the metal portion 23 illustrated in FIGURE 1. A practical arrangement could utilise a glass portion in place of the metal portion 23 to which both connectors would be secured by bands such as the metal bands 24. An alternative practical arrangement, and as shown in FIGURE 2, could incorporate a glass ring, as 28, forming part of the metal portion, here indicated as 23′ so as to separate portion 23 into two parts which are electrically insulated from each other because of the glass ring 28 and to which the two connectors 26 and 26′ could be respectively attached via the metal bands 24 and 24′.

A shield may be placed round the flask **21** in order to reduce the rate of heat absorption by the flask from the surrounding atmosphere and hence reduce the rate of evaporation of the fluid in the flask.

In a further alternative arrangement shown in FIGURE 4 the coolant **27** is replaced by a thermoelectric device **30** which provides a heat absorbing member in a well known way, so as to cool the sample electrodes. The thermoelectric device may alternatively be encapsulated and inserted within the ion source chamber **1** and connected directly to one or both of the sample electrodes.

The cooling arrangements described above cool the sample electrodes **9**, **11** and therefore tend to prevent the electrodes from melting when an electrical discharge is formed between their adjacent ends.

What we claim is:

1. A mass spectrometer ion source comprising a chamber adapted to be evacuated, two relatively movable electrically insulating supports extending within said chamber and supporting respectively two electrodes, at least one of which is of the material to be analysed, so that surfaces of the electrodes may be located adjacent to each other and an electrical discharge may be produced between said two electrodes, a heat absorbing member, and a flexible connector of a material having a good thermal conductivity connecting said heat absorbing member with one of said electrodes whereby to permit movement of the insulating support on which that electrode is supported.

2. A mass spectrometer ion source comprising a chamber adapted to be evacuated, two relatively movable electrically insulating supports extending within said chamber and supporting respectively two electrodes, at least one of which is of the material to be analysed, so that surfaces of the electrodes may be located adjacent to each other and an electrical discharge may be produced between said two electrodes, a container for a mass of fluid at a low temperature, and a flexible connector of a material having a good thermal conductivity connecting said container with one of said electrodes whereby to permit movement of the insulating support on which that electrode is supported.

3. A mass spectrometer ion source comprising a chamber adapted to be evacuated, two relatively movable electrically insulating supports extending within said chamber and supporting respectively two electrodes, at least one of which is of the material to be analysed, so that surface of the electrodes may be located adjacent to each other and an electrical discharge may be produced between said two electrodes, a thermoelectric device including a member adapted to be maintained at a low temperature, and a flexible connector of a material having a good thermal conductivity connecting said low temperature member with one of said electrodes whereby to permit movement of the insulating support on which that electrode is supported.

4. A mass spectrometer ion source comprising a chamber adapted to be evacuated, two relatively movable electrically insulating supports extending within said chamber and supporting respectively two electrodes, at least one of which is of the material to be analysed, so that surfaces of the electrodes may be located adjacent to each other and an electrical discharge may be produced between said two electrodes, a heat absorbing member, and two flexible connectors of a material having a good thermal conductivity connecting said heat absorbing member to said two electrodes respectively whereby to permit movement of the two insulating supports.

5. A mass spectrometer ion source comprising a chamber adapted to be evacuated, two relatively movable electrically insulating supports extending within said chamber and supporting respectively two electrodes, at least one of which is of the material to be analysed, so that surfaces of the electrodes may be located adjacent to each other and an electrical discharge may be produced between said two electrodes, two heat absorbing members, and two flexible connectors of a material having a good thermal conductivity connecting said two heat absorbing members to said two electrodes in one to one correspondence whereby to permit movement of the two insulating supports.

6. A mass spectrometer ion source comprising an evacuated chamber, two electrically insulating supports extending within said chamber and supporting respectively two electrodes, at least one of which is of the material to be analyzed, so that surfaces of the electrodes are located adjacent to each other and an electrical discharge may be produced between said two electrodes, a flask supported by said chamber extending within the chamber and insulated therefrom, a coolant fluid in the bottom of said flask, and heat conducting strip material interconnecting the lower end of said flask with at least one of said electrodes for conducting heat from said electrode to the flask of the coolant within the flask.

7. The structure of claim **6** wherein the lower portion of said flask is made of metal.

8. The structure of claim **7** wherein a metallic band contacts the metal portion of the flask and is thermally connected to said strip material.

9. The structure of claim **6** wherein the lower portion of the flask is provided with two metallic portions insulated from one another, each metallic portion being thermally connected to respective ones of said electrodes.

10. A mass spectrometer ion source comprising a chamber adapted to be evacuated, two relatively movable electrically insulating supports extending within said chamber and supporting respectively two electrodes, at least one of which is of the material to be analyzed, so that surfaces of said electrodes may be located adjacent to each other and an electrical discharge may be produced between said two electrodes, a heat absorbing member at a low temperature, electrically insulating means for supporting said heat absorbing member from said chamber and a flexible connector of a material having a good thermal conductivity connecting said heat absorbing member with one of said electrodes and permitting movement of the insulating support on which that one of said electrodes is supported.

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