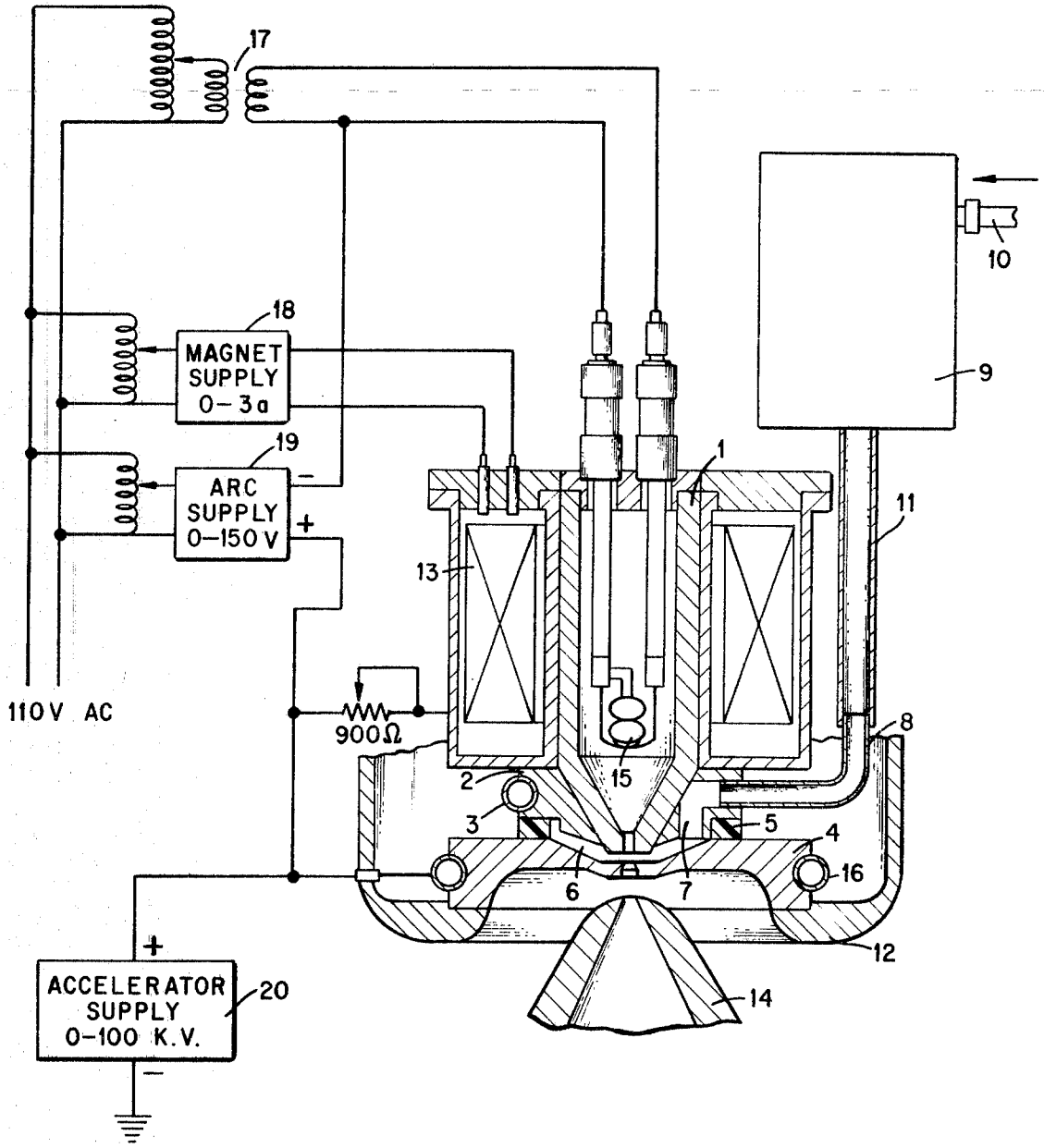
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DUOPLASMATRON-TYPE ION SOURCE INCLUDING A GAS RESERVOIR

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DUOPLASMATRON-TYPE ION SOURCE INCLUDING A GAS RESERVOIR

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ABSTRACT OF THE DISCLOSURE

The effective volume of the region between the intermediate electrode and the anode of a duoplasmatron-type ion source is made large compared to that of the prior art to reduce current transients caused by ion pumping of the arc passing therethrough. This is effectively accomplished by providing an external reservoir that communicates with that region and, furthermore, by introducing the source gas into that reservoir.

BACKGROUND OF THE INVENTION

This invention was made in the course of, or under, a contract with the U.S. Atomic Energy Commission.

An understanding of the state of the art of high current duoplasmatron-type ion sources may be obtained by considering the devices disclosed in U.S. Pat. No. 3,238,414, dated Mar. 1, 1966, to George G. Kelley et al., and in U.S. Pat. No. 3,340,425, dated Sept. 5, 1967, to George G. Kelley.

When the ion beams from those sources are pulsed by switching the arc voltage, as is often desired in the research related to the injection of ion beams into thermonuclear-type devices and similar devices, severe transients are experienced in the ion current. The initial current, for example, may be greater than twice the steady state value. The peak of this transient must be limited so as to prevent voltage breakdown in the accelerator tube and excessive heating in the beam duct. This limitation, in turn, may restrict steady state operation to a current value lower than that desired. The present invention was conceived to provide a means for substantially reducing the peak transient currents during startup of such ion sources or during pulsed operation thereof, thus permitting use of higher steady state currents.

SUMMARY OF THE INVENTION

It is the object of the present invention to provide an improved high current ion source that may be operated in a pulsed mode without the attendant large transients. This has been accomplished in the present invention by substantially increasing the effective volume of the region between the intermediate electrode and the anode of a duoplasmatron-type ion source. It has been determined that, when such a larger effective volume has been provided in an ion source, the peak transient currents are substantially reduced, thus permitting use of higher steady state currents in the operation of the ion source than was heretofore possible. Thus, by effecting a substantial reduction in the peak transient currents, as is accomplished in the present invention, the problems of voltage breakdown in the accelerator tube and the excessive heating in the beam duct, which are characteristic of prior art ion sources, have been substantially solved by the present invention.

BRIEF DESCRIPTION OF THE DRAWING

The single figure of the drawing is a cross-sectional view of the improved ion source of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As shown in the single figure of the drawing, an intermediate electrode **1** is provided with a tapered end portion with an ion exit aperture in alignment with an ion exit aperture in an anode electrode **4**. The intermediate electrode **1** encloses a heated cathode element **15** which is connected to a 0–40 ampere filament supply **17**. A cooling jacket **2** encompasses the tapered portion of electrode **1** and a coolant flows to this jacket through a cooling tube **3**. The jacket **2** is spaced from the anode electrode **4** by means of an insulator **5** to thus keep the electrode **1** at some prescribed distance from the anode electrode **4**. Thus, a definite volume **6** is established between the intermediate electrode **1** and the anode electrode **4**.

A grounded accelerating electrode **14** with an entrance aperture in alignment with the exit aperture of anode **4** is provided to serve in its conventional manner. A conventional source magnet **13** is provided and it encompasses the upper portion of the intermediate electrode **1** and is connected to a conventional magnet supply **18**. An arc supply **19** is connected between the cathode **15** and the anode **4**. A 0–100 kv. accelerator supply is connected between ground and the anode **4**. A housing **12**, partially shown, encompasses the major components of the ion source and is evacuated in a conventional manner. A cooling tube **16** is provided for cooling the anode electrode **4**.

In accordance with the above object of the present invention, the cooling jacket **2** is provided with a passageway **7** which communicates with the volume **6**. This passageway **7** is connected through a conduit **8** and a conduit **11** to an external volume or reservoir **9** mounted adjacent to the ion source. The capacity of the reservoir **9**, for example, is ½ liter, which is very large compared to the volume **6**. Provision is made to bring the ion source gas into the reservoir **9** by means of a supply pipe **10**, and then the source gas flows from the reservoir **9** through conduits **11** and **8** and passageway **7** into the arc discharge volume **6**. The feed gas to the ion source may be hydrogen, for example. The pressure in volume **6** is substantially stabilized by the addition of the reservoir **9** and by the continuous influx of source gas thereinto.

A separate reservoir is utilized in the present invention to effect a substantial increase in the arc-pumped volume since the volume **6** within the accelerating region cannot of itself be physically altered conveniently to greatly increase its size.

When beams are pulsed by switching the arc voltage in prior art devices, there is a large transient at turn-on. This transient limits the average value of output current from the prior sources, which is about 55 milliamperes, for example, and the transient peak currents are often as high as 200 ma. The transients limit the output currents in such prior devices because of voltage breakdown in the accelerator tube and heating in the beam duct. On the other hand, in the operation of the present device with the reservoir addition thereto, some transient exists when the electrode potential is applied, but the maximum value of current is only about 1.2 or 1.3 times the steady state value. Accordingly, average steady state output currents of molecular ions of 75 ma. are achieved with the present device without excessive transient peak currents.

It should be understood that the operation of the present device regarding the vacuum requirements and the function of the source solenoid **13** is the same as described in the above-mentioned patents. Also, it should be understood that the beneficial modifications set forth in the above patents such as the use of a plasma expansion cup associated with the anode with a solenoid coil encompassing the expansion cup, the use of electron dump fins,

and/or the use of beam stabilizing accelerating electrodes may be incorporated into the structure of the present device without departing from the spirit or scope of the present invention, if such is desired.

This invention has been described by way of illustration rather than by way of limitation and it should be apparent that it is equally applicable in fields other than those described.

What is claimed is:

1. In a duoplasmatron-type ion source including a heated cathode, an intermediate electrode enclosing said cathode and defining an exit aperture, an anode having a centrally disposed aperture and being in spaced alignment with said intermediate electrode to define an arc gap region therebetween, an ion source solenoid encompassing the major portion of said intermediate electrode, an ion extractor electrode in alignment with said anode in spaced relation thereto, means for energizing said cathode filament and said solenoid, an arc supply voltage connected between said cathode and anode, and an acceleration voltage connected between said anode and extractor electrode, the improvement comprising an external reservoir mounted adjacent to said ion source, tubing means connecting said reservoir to said arc gap region between said

intermediate electrode and said anode, and means for feeding a source gas into said reservoir and thus into said arc gap region, whereby the pressure in said region is substantially stabilized thereby substantially reducing current transients during pulsed operation of said ion source to thus effectively permit an increase in the average steady state output current from said ion source.

2. The ion source set forth in claim 1, wherein the capacity of said reservoir is ½ liter.

3. The ion source set forth in claim 1, wherein said source gas is hydrogen.

References Cited

UNITED STATES PATENTS

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