

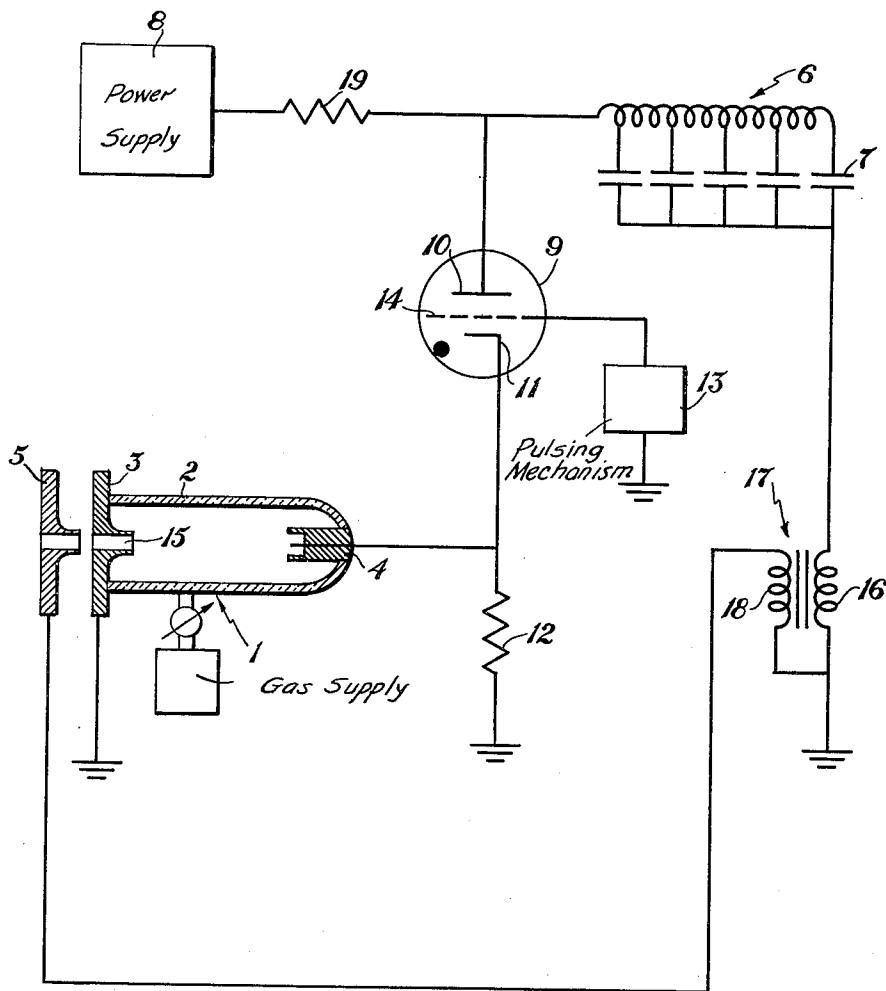
June 16, 1964

G. C. McFARLAND

3,137,820

HIGH-CURRENT PULSED ION SOURCE

Filed May 1, 1958



1

3,137,820

HIGH-CURRENT PULSED ION SOURCE

George C. McFarland, Berkeley, Calif., assignor to High Voltage Engineering Corporation, Burlington, Mass., a corporation of Massachusetts

Filed May 1, 1958, Ser. No. 732,360

4 Claims. (Cl. 328—258)

This invention relates to the production of ions and in particular to a novel ion source adapted to produce large ion currents suitable for use in particle accelerators and for other purposes.

The invention may best be understood from the following detailed description thereof, having reference to the accompanying drawing in which the single figure is a somewhat diagrammatic view showing the ion source of the invention in longitudinal central section and including a diagram of the associated circuit.

Referring to the drawing, ions are produced within a chamber 1 the lateral wall 2 whereof preferably is made of glass or other insulator. A grounded flange 3 is supported at one end of the lateral wall 2 and an anode 4 is supported at the opposite end thereof. A suitable gas to be ionized is admitted into the chamber 1 in accordance with techniques well known in the art. High-voltage pulses are produced by means to be described in detail hereinafter and are applied between the grounded flange 3 and the anode 4 so that the anode 4 is periodically raised to high positive voltage. As a result of this, a high voltage discharge is initiated periodically within the chamber 1, and the positive ions in this discharge are extracted by an extractor 5 to which negative voltage is applied by means to be described in detail hereinafter.

In order to produce the various voltages hereinbefore referred to, a high-voltage pulse-forming network 6, including several condensers 7 connected in parallel, is charged by a high-voltage power supply 8 to which it is connected through a current limiting resistor 19. The pulse-forming network 6 may, for example, have its components so designed as to provide a substantially square-wave pulse of 10 microseconds duration. The condensers 7 of the pulse-forming network 6 are discharged through a suitable switch mechanism, such as a 5C22 hydrogen thyatron 9 whose plate 10 is connected to the high-voltage end of the pulse-forming network 6 and whose cathode 11 is connected to the anode 4 of the ion-source chamber 1. The thyatron cathode 11 is also connected to ground through a blocking resistor 12. The hydrogen thyatron 9 is fired at suitable intervals by any conventional pulsing mechanism 13 connected to the grid 14 of the thyatron.

Just before the thyatron is fired, the anode 4 of the ion-source chamber 1 is at ground potential since it is connected to ground through the blocking resistor 12. When the thyatron 9 is fired, the anode 4 of the ion-source chamber 1 is immediately raised to high positive voltage, since it is now connected through the thyatron 9 to the high voltage end of the pulse-forming network 6. An intense electric field is thus generated within the chamber 1 between the anode 4 and the grounded flange 3, so that a discharge is initiated within the chamber 1. With this discharge there is associated a large flow of current within the chamber 1 between the anode 4 and the grounded flange 3, and this current is supplied from the charge stored in the condensers 7 of the pulse-forming network 6. When the condensers 7 of the pulse-forming network 6 have been discharged, the gas-discharges cease in the chamber 1 and in the thyatron 9, so that the thyatron 9 is again non-conducting and the anode 4 is at ground potential. The condensers 7 of the pulse-forming network 6 are then recharged by the high-voltage power supply 8, and the cycle is repeated.

2

During the discharge within the chamber 1 a negative pulse is applied to the ion extractor 5, thereby creating an electric field which extends from the ion extractor 5 to within the aperture 15 in the grounded flange 3, so as to pull positive ions out of the chamber 1. In order to produce the required negative voltage at the extractor 5, the low voltage end of the pulse-forming network 6 is connected to ground through the primary 16 of a pulse transformer 17. The secondary 18 of the pulse transformer 17 is connected to the ion extractor 5, so that during the discharge of the pulse-forming network 6 a voltage pulse of about 50 to 250 kilovolts negative is applied to the ion extractor 5. Because of the high currents involved during the pulse, very high ion beam currents are possible.

While the invention has been described with particular reference to the production of positive ions, the invention is not limited thereto, but is equally applicable to the production of negative ions by means of appropriate reversals of potentials in the apparatus hereinbefore described.

Summarizing then, in order to provide high currents of ions, positive and negative, the invention uses an ion discharge tube conducting 100 to 1000 amperes with high voltage extraction as described hereinbefore.

Having thus described the principles of the invention together with an illustrative embodiment thereof, it is to be understood that although specific terms are employed they are used in a generic and descriptive sense and not for purposes of limitation, the scope of the invention being set forth in the following claims.

I claim:

1. An ion source for the production of high currents of ions, consisting of an ion discharge tube having an apertured electrode and an anode, means for introducing a suitable gas to be ionized into said ion discharge tube, means for applying high-voltage pulses between said apertured electrode and said anode so that said anode is periodically raised to a positive voltage sufficiently high to initiate an ionization discharge within said ion discharge tube, a pulse-forming network adapted to deliver high current to said anode during said pulses to support said ionization discharge, an extractor electrode adapted to extract ions of one polarity from said ion discharge tube upon application of high voltage of opposite polarity to said extractor electrode and means for applying high-voltage pulses of said opposite polarity to said extractor electrode during delivery of said high-current pulses to said ion discharge tube.

2. An ion source for the production of ion currents of the order of amperes, consisting of an ion discharge tube having an apertured electrode and an anode, means for introducing a suitable gas to be ionized into said ion discharge tube, means for applying high-voltage pulses between said apertured electrode and said anode so that said anode is periodically raised to a positive voltage sufficiently high to initiate an ionization discharge within said ion discharge tube, a pulse-forming network for delivering current of the order of 10^2 to 10^3 amperes to said anode during said pulses to support said ionization discharge, an extractor electrode adapted to extract ions of one polarity from said ion discharge tube upon application of high voltage of opposite polarity to said extractor electrode and means for applying voltage of the order of 10^5 volts of said opposite polarity to said extractor electrode during delivery of said high-current pulses to said ion discharge tube.

3. An ion source for the production of high currents of ions, consisting essentially of an ion discharge tube having an apertured electrode and an anode, means for introducing a suitable gas to be ionized into said ion discharge tube, a high-voltage pulse-forming network, having a high-voltage power supply and a switching device as-

3

sociated therewith, for applying high-voltage pulses between said apertured electrode and said anode so that said anode is periodically raised to a positive voltage sufficiently high to initiate an ionization discharge within said ion discharge tube, and including an LC circuit adapted to deliver high current to support said ionization discharge, an extractor electrode adapted to extract ions of one polarity from said ion discharge tube upon application of high voltage of opposite polarity to said extractor electrode and means, energized by the flow of current upon discharge of said pulse-forming network by said switching mechanism, for applying high voltage of said opposite polarity to said extractor electrode.

4. An ion source for the production of high currents of ions, comprising an ion discharge tube having a grounded apertured electrode and an anode, the aperture in said grounded electrode being adapted to effect the egress of ions generated in said ion discharge tube, means for introducing a suitable gas to be ionized into said ion discharge tube, a high-voltage pulse-forming network, having a high-voltage power supply and a switching device associated therewith, for applying high-voltage pulses between said apertured electrode and said anode so that said anode is periodically raised to a positive voltage sufficiently high to initiate an ionization discharge within said ion dis-

4

charge tube, including an LC circuit adapted to deliver high current to support said ionization discharge, an extractor electrode disposed externally of said tube and proximate to said apertured electrode such that the electric field thereof extends through said aperture to extract ions of one polarity from said ion discharge tube upon application of high voltage of opposite polarity to said extractor electrode, and a pulse transformer of which the primary is so connected that the discharge current from said pulse-forming network flows therethrough, whereby a high-voltage pulse is produced by the secondary of said pulse transformer, and means for applying said high-voltage pulse to said extractor electrode.

References Cited in the file of this patent

UNITED STATES PATENTS

2,214,608	Bull	Sept. 10, 1940
2,444,921	Dawson et al.	July 13, 1948
2,820,142	Kelliher	Jan. 14, 1958
2,856,532	Martina	Oct. 14, 1958

OTHER REFERENCES

"Electronics Applied to the Betatron" (Dietze and Dickinson). Reprinted from the Proceedings of the I.R.E., vol. 37, No. 10, October 1949, pages 1171-1178.