AN ARC TYPE WATER-COOLED ION SOURCE FOR POSITIVE IONS*

S. Z. R. HASHMI

NUCLEAR PHYSICS SECTION, HYDERABAD SCIENCE SOCIETY ASIFNAGAR HYDERABAD DN.

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ABSTRACT An arc type water-cooled ion source for positive ions of simple construction and reliable operation is described in which the anode-filament assembly can be readily changed. The characteristic curves of the source are given Operating at an arc current of 0.4 amp a total beam current of 500 micro-amperes is produced with a probe potential of about 3000 volts.

INTRODUCTION

A low voltage arc type ion source was installed in 1955 in connection with a 500 Kv Van de Graaff accelerator to provide positive ions for nuclear disintegration experiments. The ion source described here is the third one to be tried out. The first ion source was based on a design of Allen (1938)

The second ion source and the third, the present one incorporated improvements and simplifications on the original design Attempts have been made to incorporate desirable features found in previous designs of various types of ion sources (Crane 1937 Timoshenko, 1938; Smith and Scott 1939 Livingston Holloway & Baker 1939; Getting Fisk & Vogt, 1939, Finkelstein, 1940, Allison 1948, Swann and Swingle, 1952, Goodwin 1953 and Barnett, Steir and Evans, 1953), e.g., reliability, long filament life, easy accessibility of parts etc. The source has been constructed of materials readily available in the laboratory

DESCRIPTION

The source is pictorially represented in Fig. 1 The construction of the source can be understood from Fig 2 The body of the source is made of brass. The filament-anode assembly is mounted on a single plate (A) which can be readily replaced with a similarly constructed assembly *a*, *b* and *c* are machine screws which hold the filament and anode sassembly. They also serve as electric leads through the porcelain insulators, which are made vacuum tight by using lead gaskets. The hard glass envelope *D* confines the discharge, otherwise the arc spreads out and little current can be drawn by the probe voltage. During the experiment it was found that occasionally discharges would take place between

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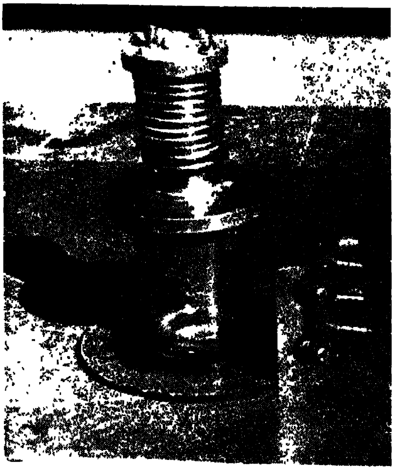

Fig. 1

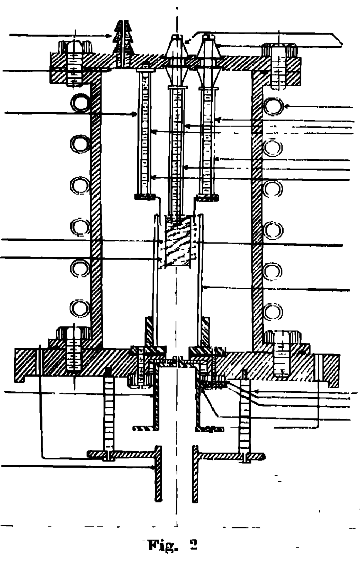
A
B
Mica guides
Anode
Probe
Focus electrode
Porcelain insulator
Cooling coil
Glass tubes
a
b
c
Filament
D
d
B

Fig. 2

the screws *a*, *b* and *c*, therefore, they have been covered with glass tubes to eliminate undesirable discharges. *B* is a Mycalex piece which holds the probe, which can be aligned by means of the screw *d*. The probe is made of steel and its front hole is drilled by No. 56 drill.

After considerable experience with tunsten-nickel combinations coated with alkaline earth oxides, we have decided on pure tungsten wire filaments. In the original design of Allen (1938) the distance between the anode and the filament was kept very small for easy starting of arc. Our experiments with close tungsten-nickel filaments coated with strontium and barium oxides have shown that although the arc would strike easily, sometimes the wire would break and would touch the anode thereby short-circuiting the power. Apart from this, unguided filaments are difficult to align with the result that the ion beam goes out of focus, as pointed out by Fulton and Gabrich (1952). In the new filaments, provision has been made to guide the helical form of the filament with three mica pieces. By using such guides the distance between the filament and the anode has been made uniformly as low as 3/32″. The filament is a helix of ½ mm thick tungsten wire. It requires a current of 8-12 amps at about 8-12 volts. The striking voltage for the arc is about 250 volts, which is supplied from a 866A mercury vapour rectifier set.

The disappointing results with the oxide-coated tungsten-nickel filaments might be due to traces of oxygen present in hydrogen or vacuum system or due to non-trapping of organic vapours. However, pure tungsten filaments seem to be satisfactory except for heavy current consumption.

PERFORMANCE

The accelerator is operated with the ion source at ground potential, the accelerating tube being separate from the Van de Graaff generator. The usual electrical operating conditions of the ion source are given in Table 1.

TABLE 1

1.	Arc current	400 mA
2.	Starting voltage for arc.	250 volts
3.	Voltage drop; anode to filament	88 volts
4.	Filament current	_11 amps
5.	Filament voltage	9 5 volts
6.	Probe voltage	3.2 Kv
7.	Beam current	500 Micro-amp
8.	Focus voltage*	10.4 KV

* Applied while working the accelerator.

The curves of Fig. 3 show the beam current put out by the arc, and the current to the probe face, as a function of the probe voltage at various arc currents The beam current is the current at the first electrode of the accelerating tube, next to the focus electrode (not shown here). There was no focussing voltage across the first gap during these measurements and the arc was operating on hydrogen gas.

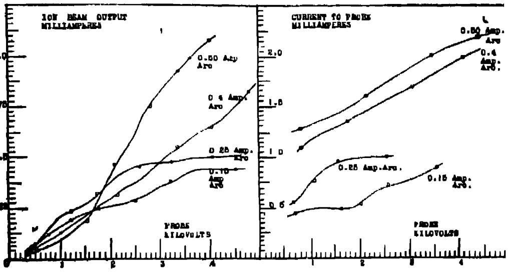

Fig. 3

Rough studies were made of the rate of consumption of the gas and the pressure when it was operating. The practice that has been followed is to adjust the leak till the pressure in the ion source rises to 1 5×10^{-3} mm of Hg, when measured with a gauge The rate of consumption of the gas is then about 25 c.c at atmospheric pressure per hour. The pumping speed on our accelerator as given by the manufacturers of the pumps and estimated from pump orifice dimensions is 40 litres per second.

We have two duplicate assemblies of the filaments made on another arc port plate In order to change the filament assemblies, the diffusion pump is allowed to cool. With the fore pump in operation the entire plate is removed and the new plate inserted and tightened The whole operation takes less than two minutes and the pressure rises a little through the probe canal. On the whole, the trouble due to any faults in the design has been negligible.

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