Rutherford Laboratory

Technical leaflet

DUOPLASMATRON ION SOURCE

The 'duoplasmatron' type of arc discharge ion source was originally developed by von Ardenne in about 1948. It is widely used in particle accelerator applications because of its high gas efficiency and high current output.

Fig. 1 illustrates the basic principle of the device. A low pressure arc discharge of a few hundred volts (100-200V) is struck in hydrogen gas between a hot cathode and an anode plate. Between cathode and anode a magnetised intermediate electrode of mild steel, with a small aperture, is introduced. Further constriction is introduced by an inhomogeneous axial magnetic field in the anode region, having its maximum field at a point on the axis, near to or in the anode aperture. Since two constricting methods are used the device is called a 'duoplasmatron'. The charged particles tend to move in helical paths and follow the magnetic field lines. This creates a high concentration of ionising electrons in the anode region. Very high plasma densities (10^{14} ions/cc) are reached in the anode region, permitting the extraction of high current densities (several hundred mA/mm^2). The leak of neutral hydrogen gas can be kept low because of the small anode aperture and with high extraction currents the gas efficiency can be 80-90%.

The source exhibited is a modified duoplasmatron source, Fig. 2. An 'expansion cup' has been added to the downstream side of the anode aperture, and ions are drawn from a large area of relatively low density plasma. The addition of an expansion cup is intended to improve the beam quality. The source has been specially designed to fit into a 600 KeV single-gap D.C. accelerator exhibited in Building R25. Since the ion source is located in the high voltage (600 kV) electrode of the accelerator, the magnetic circuit had to be specially designed to reduce the size of the source. Ion currents of approximately 500 mA have been extracted from the source using a plane extraction grid held at a negative potential of 15 kV.

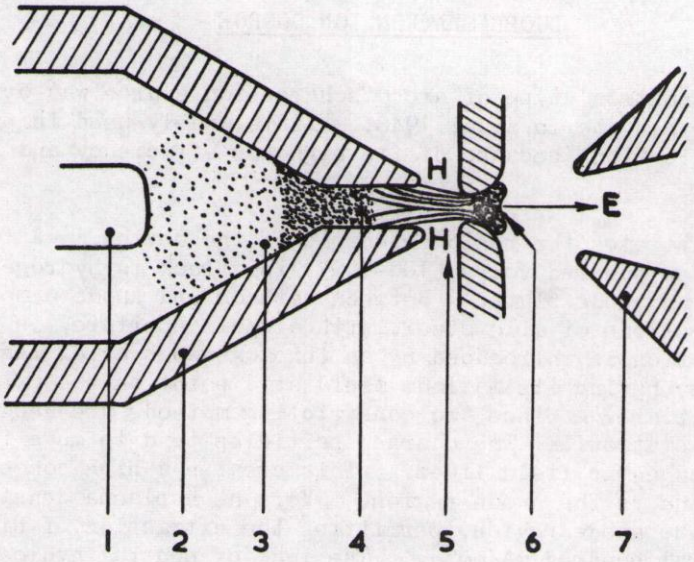
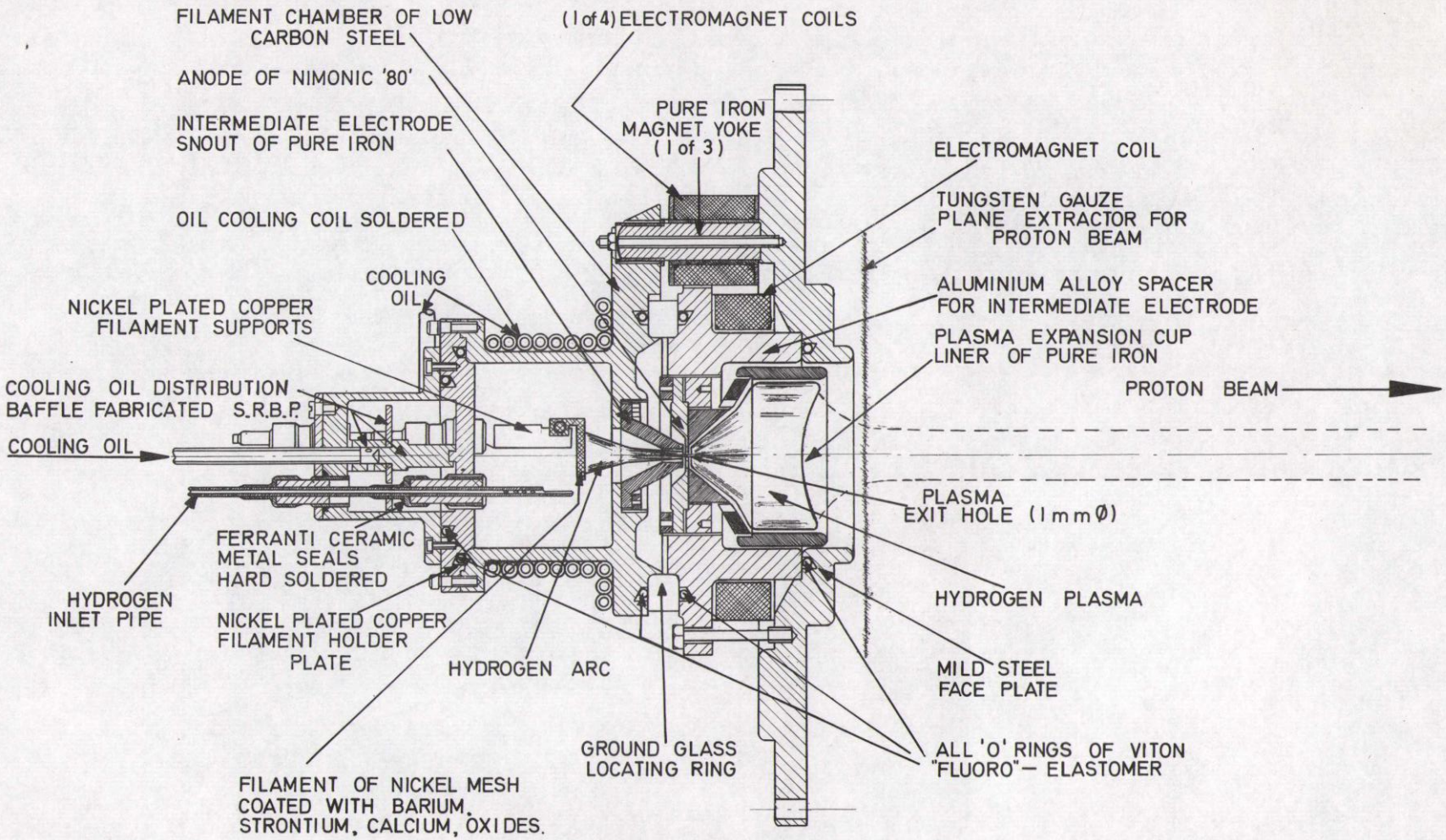


Fig. 1. Principle of a Duoplasmatron

1. Oxide coated filament.
2. Intermediate electrode-snout.
3. Dense plasma.
4. Canal.
5. Anode, with emission aperture.
6. Protruding plasma.
7. Extraction (acceleration) electrode.



DUOPLASMATRON FOR SINGLE GAP ION GUN EXPERIMENT

Figure 2. Duoplasmatron Mk.II