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ION-SOURCE WITH COMBINED CATHODE AND TRANSFER LINE HEATING

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ABSTRACT

The plasma-discharge ion-source concept used in connection with the high temperature thick targets at the CERN-ISOLDE facility is described. Derived from the construction of the tubular surface ionizer, the same current which heats the transfer line between the target and the ion source is also used to heat the disc shaped cathode. This construction has the advantage that the less volatile nuclear reaction products are transferred to the center of the source by diffusion along a rising temperature gradient so that adsorption losses on the walls are minimized. The design which exists in several versions dependent on the element to be ionized and the coupling between the target and ion source is discussed and examples of the measured efficiencies are given.

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1. Introduction

The plasma-discharge ion-source concept used in conjunction with the high temperature thick targets at the CERN ISOLDE facility is described. The ion source construction is based on the principle of the FEBIAD ion source [1].

In several applications it is important to keep the transfer line from the target to the ion source at high temperature to avoid adsorption losses on the walls. Derived from the tubular surface ionizer a new cathode was designed permitting a simultaneous heating of both the transfer line and the cathode with a common power supply. This construction allows the nuclear reaction products to pass through the center of the cathode into the ion source discharge chamber. As the cathode turned out to be very reliable with a life time of several hundred hours it was also used in other variants of the ion source, where a high temperature transfer line was not needed.

A description of the cathode construction and the application in several versions of the ion-source as well as the transfer lines from the target to the ion source is given.

The target ion source assembly including the vacuum chamber and valve is shown in Fig. 1.

2. Cathode

The cathode (Fig. 2) is made from Tantalum. It consists of 3 parts welded together by means of electron beam welding and press fit into the transfer tube. When a temperature controlled transfer tube is used there is no hole drilled in the electron emitting surface of the cathode and a short Ta tube is attached as connection for the heating current. The cathode is heated by a 350-400 A DC current.

3. Ion sources

The ion source exists in 3 different versions:

1. High temperature Mk5 Max. 1900^{o} C
2. Medium temperature Mk6 Max. 1400^{o} C
3. Water cooled Mk7 Max. 500^{o} C

3.1 High Temperature Mk 5

The discharge chamber and the anode assembly are made from Molybdenum and screwed into a graphite cylinder rigidly fixed to the main target base onto which also the source magnet is mounted as shown in Fig. 3. The anode is insulated by means of three BeO_2 insulators. The anode grid consists of a graphite disc with holes drilled to permit electrons to be accelerated into the discharge chamber. The source is surrounded by a minimum of three heat screens made out of Molybdenum. The electrical circuit for the cathode and source heating is shown in Fig. 4. A DC-current is flowing through the transfer line via the cathode, the anode cylinder, the external graphite tube and back through the main target flange. The advantage of this design is that only one power supply is needed for heating of the line, cathode and ion source. The same power supply can also be used for heating of the tubular surface ionizers [2]. This ion source has been used for the production of elements with low vapor pressure [2].

3.2 Medium temperature Mk 6

In this version, shown in Fig. 5, the discharge chamber, the outlet plate and the support cylinder are made of graphite, the anode may be made of Molybdenum or graphite. The anode insulator is made from Boron Nitride. It has to be pointed out that the BN can not be used in the Mk 5 source since the temperature is too high. This source is used in connection with a temperature controlled line as shown in Fig. 5. The cathode is therefore of the type with a closed end. The maximum line temperature is 400^{o} C. The temperature controlled transfer line consists of a stainless steel block with reduced cross section between the cooled and the heated part. The heater is a 0.8 mm Ta wire inserted in the lower part of the stainless steel body. The temperature can be varied from 200 to 400°C. This ion source has been used for the production of elements with intermediate to low vapor pressures [2].

3.3 *Low temperature Mk 7*

This ion source shown in Fig. 6, is dedicated to noble gases. To be able to keep the temperature as low as possible it is water cooled. The discharge chamber and the outlet plate are made from stainless steel and the anode from Molybdenum. A water cooled Copper block acts as source holder and transfer line. The temperature of the discharge chamber is 500° C and the temperature of the transfer line about 50° C thus effectively stopping elements wich may be condensed. Contrary to Mk5 and Mk6 the cathode heating current does not flow through the ion source discharge chamber but directly to the Copper block.

4. Performance

The different versions of the ion source have been used to ionize the the elements listed in table 1 where also some measured ionization efficiencies are quoted. The performance in terms of radioactive beam intensities are found in ref. [3, 4, 5]

Figure captions

Fig. 1 Target and Ion source assembly with plasma ion source Mk5. The vacuum valve and the extraction electrode is part of the assembly.

Fig. 2 Cathode, which consists of 3 parts welded together by means of electron bombardment welding.

Fig. 3 High temperature plasma ion source, Mk5, with target container.

Fig. 4 Principle of cathode and source heating.

Fig. 5 Medium temperature plasma ion source, Mk6, with heated transfer line.

Fig. 6 Low temperature, watercooled plasma ion source, Mk7.

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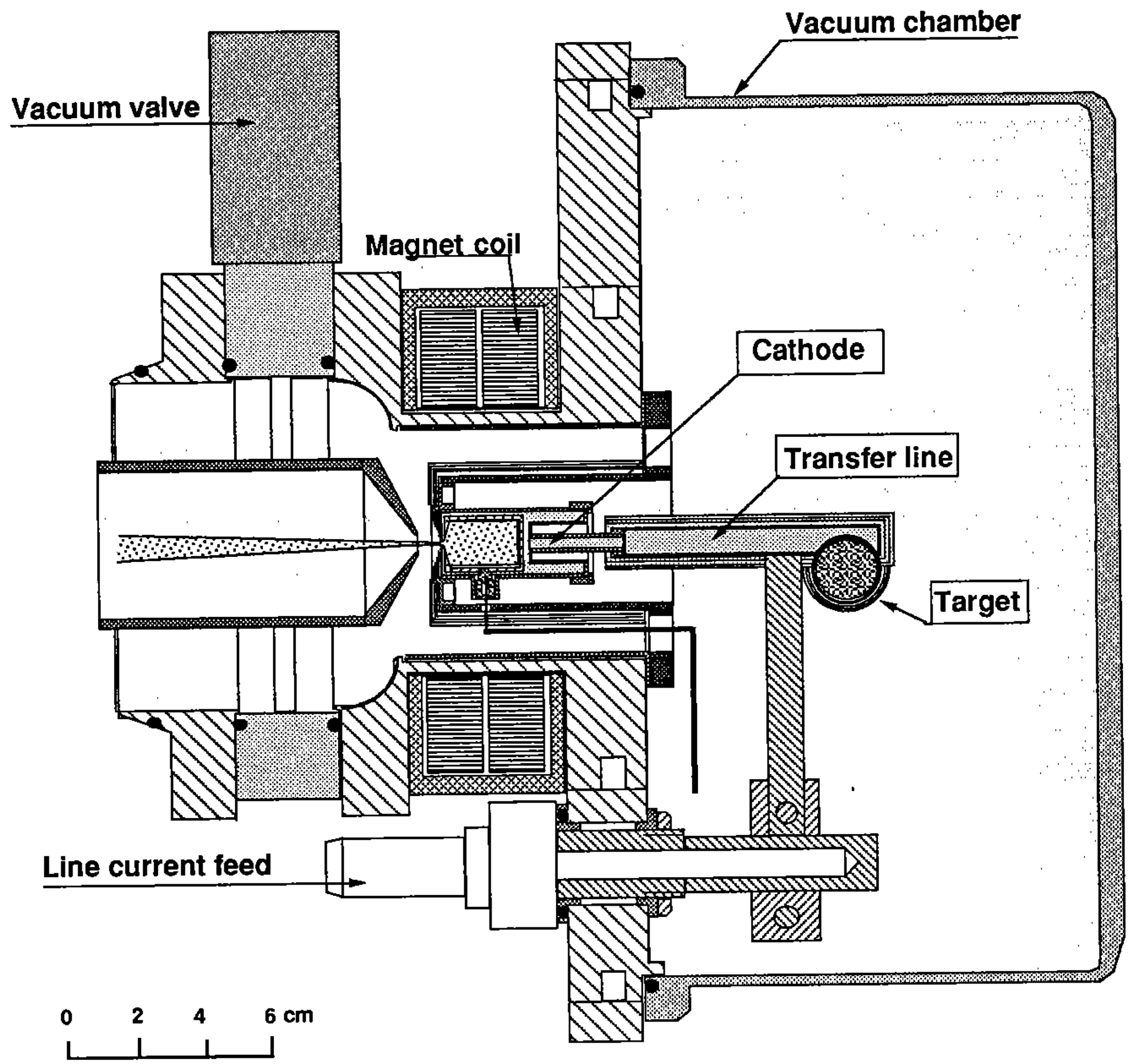
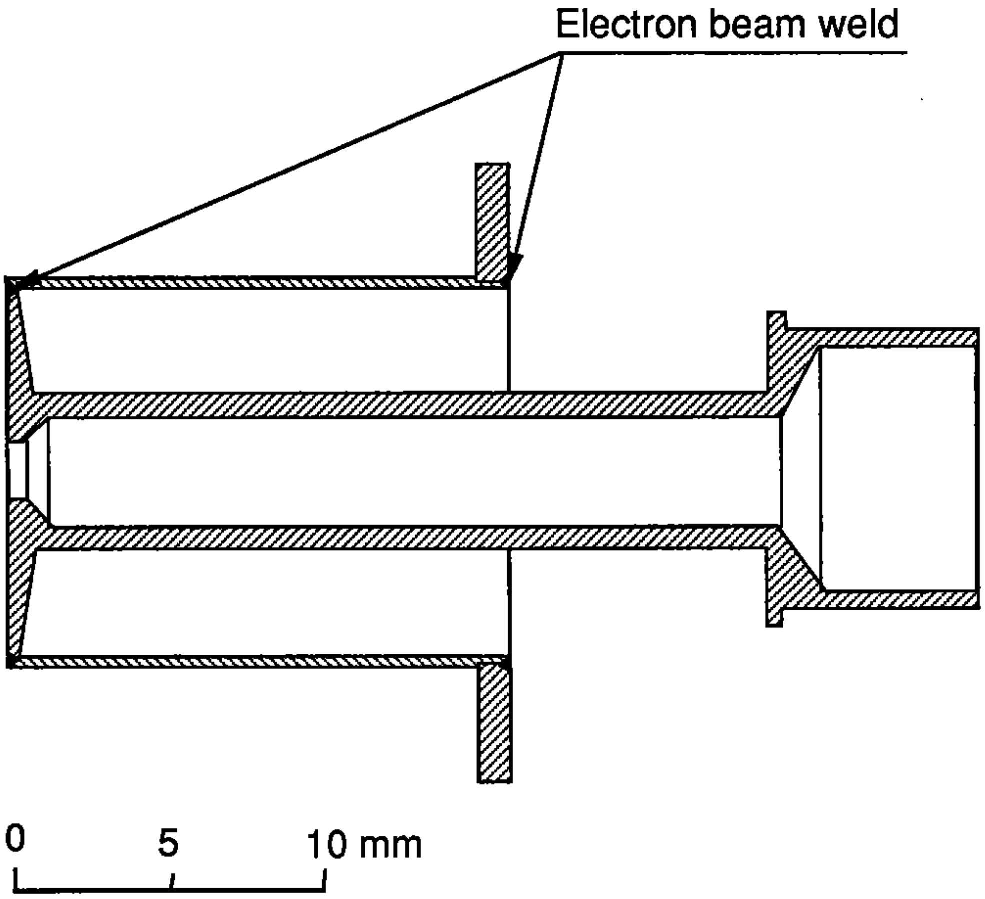
Table 1: Ion source and line combination for different elements

Element	Ion source	Type	Special techniques	Efficiency
He	Watercooled	Mk7	Cold line	0.5%
C	Plasma	Mk6	Cold line as CO^+	0,1%
N	Plasma	Mk7	Cold line as CO^+	0,1%
O	Watercooled	Mk7	Cold line as CO^+	0,1%
F	Hot plasma	Mk5	as AlF or BaF^+	1%
Ne	Watercooled	Mk7	Cold line	1%
Mg	Hot plasma	Mk5		
Ar	Watercooled	Mk7	Cold line	10%
V	Plasma	Mk6	CF4-addition	
Mn	Plasma	Mk6		
Cu	Hot plasma	Mk5		
Zn	Plasma	Mk6	Cold line	
As	Hot plasma	Mk5		
Se	Hot plasma	Mk5		
Kr	Watercooled	Mk7	Cold line	20%
Zr	Hot plasma	Mk5	CF4-addition	
Pd	Hot plasma	Mk5		
Ag	Hot plasma	Mk5		
Cd	Plasma	Mk6	Cold line	
Sn	Hot plasma	Mk5		
Sb	Hot plasma	Mk5		
Te	Hot plasma	Mk5		
Xe	Watercooled	Mk7	Cold line	40%
Hf	Hot plasma	Mk5	CF4-addition	
Au	Hot plasma	Mk5		
Hg	Plasma	Mk6		60%
Pb	Hot plasma	Mk5		
Bi	Hot plasma	Mk5		
Po	Hot plasma	Mk5		
Rn	Watercooled	Mk7	Cold line	



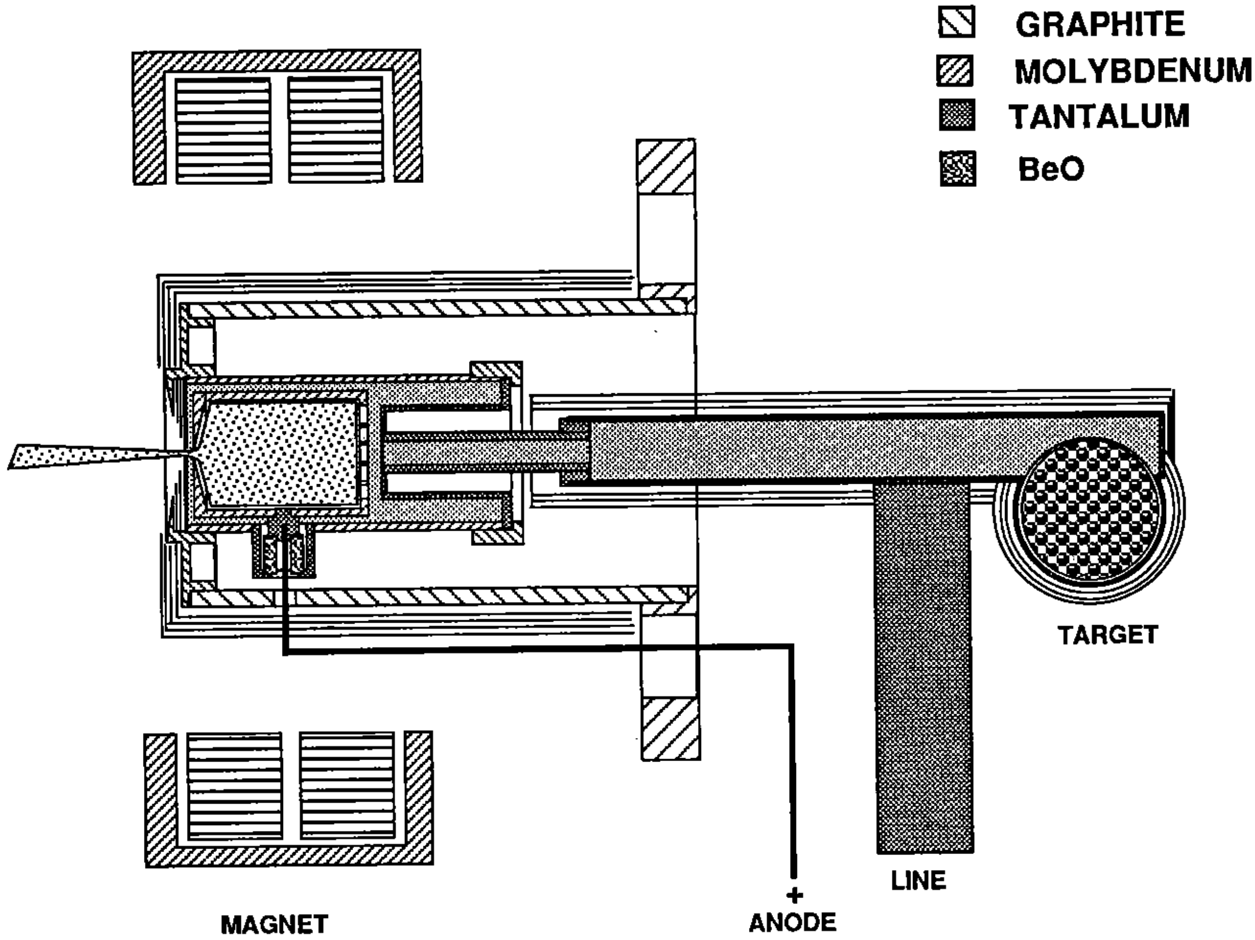
TARGET ION SOURCE ASSEMBLY

Fig. 1



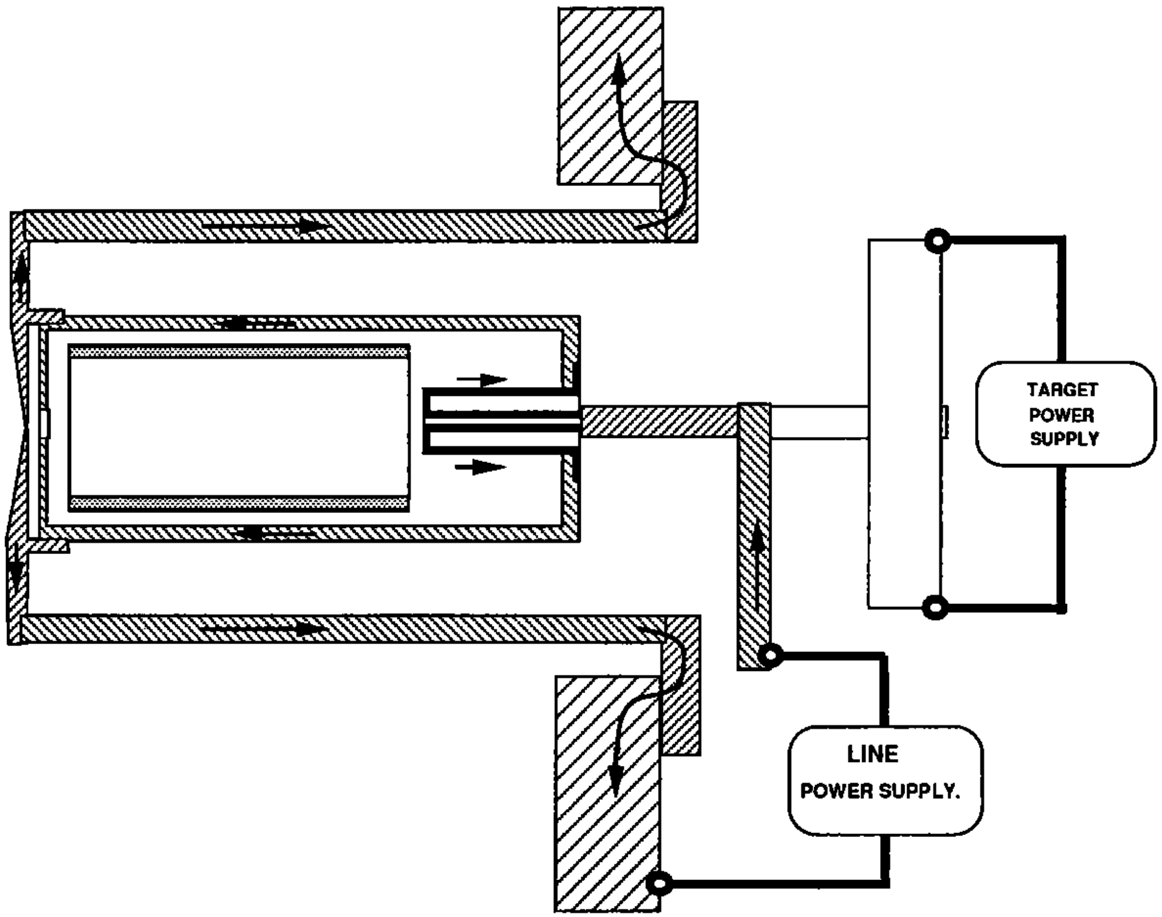
CATHODE

Fig. 2



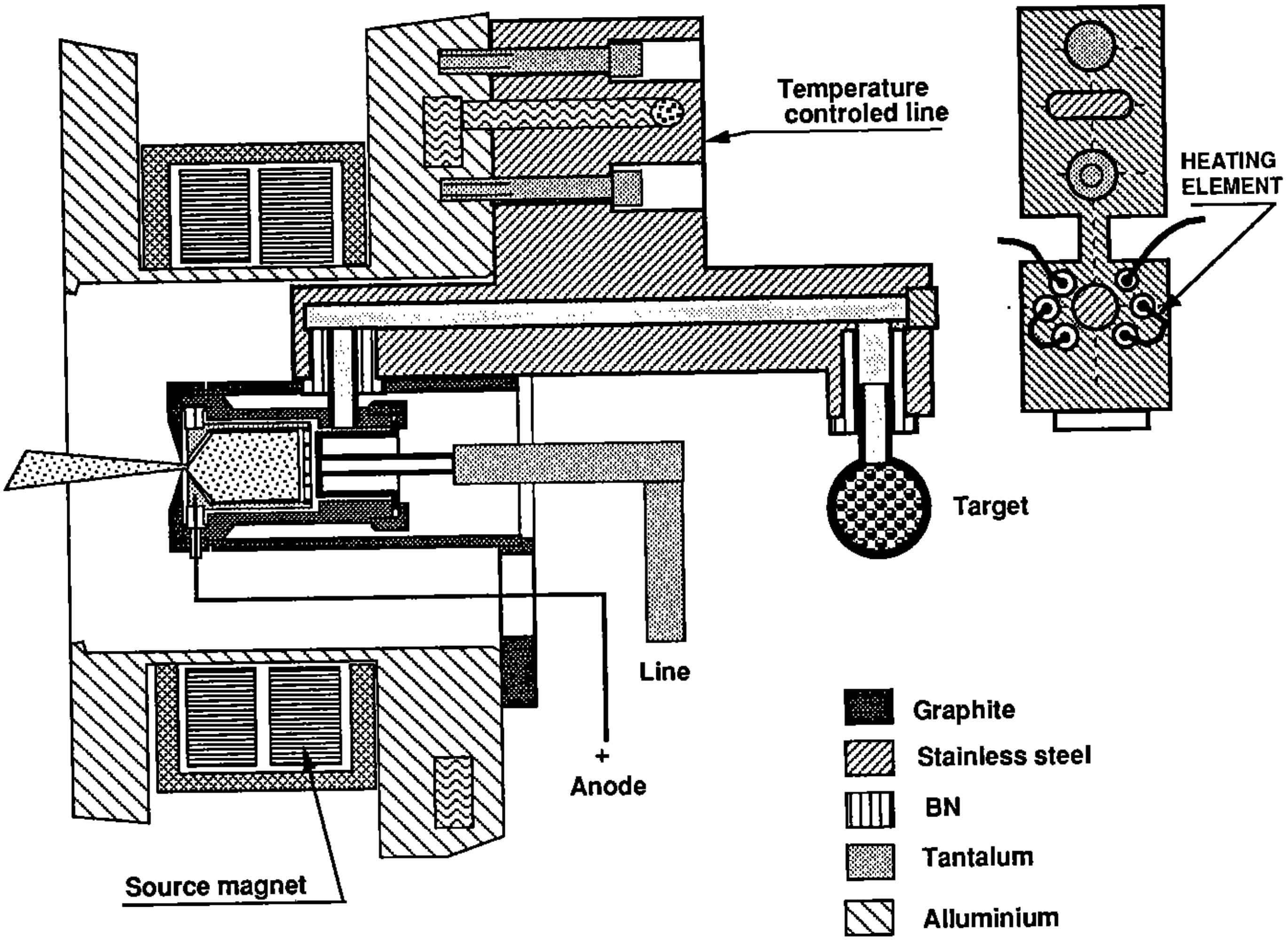
HIGH TEMPERATURE ION SOURCE Mk 5A

Fig. 3



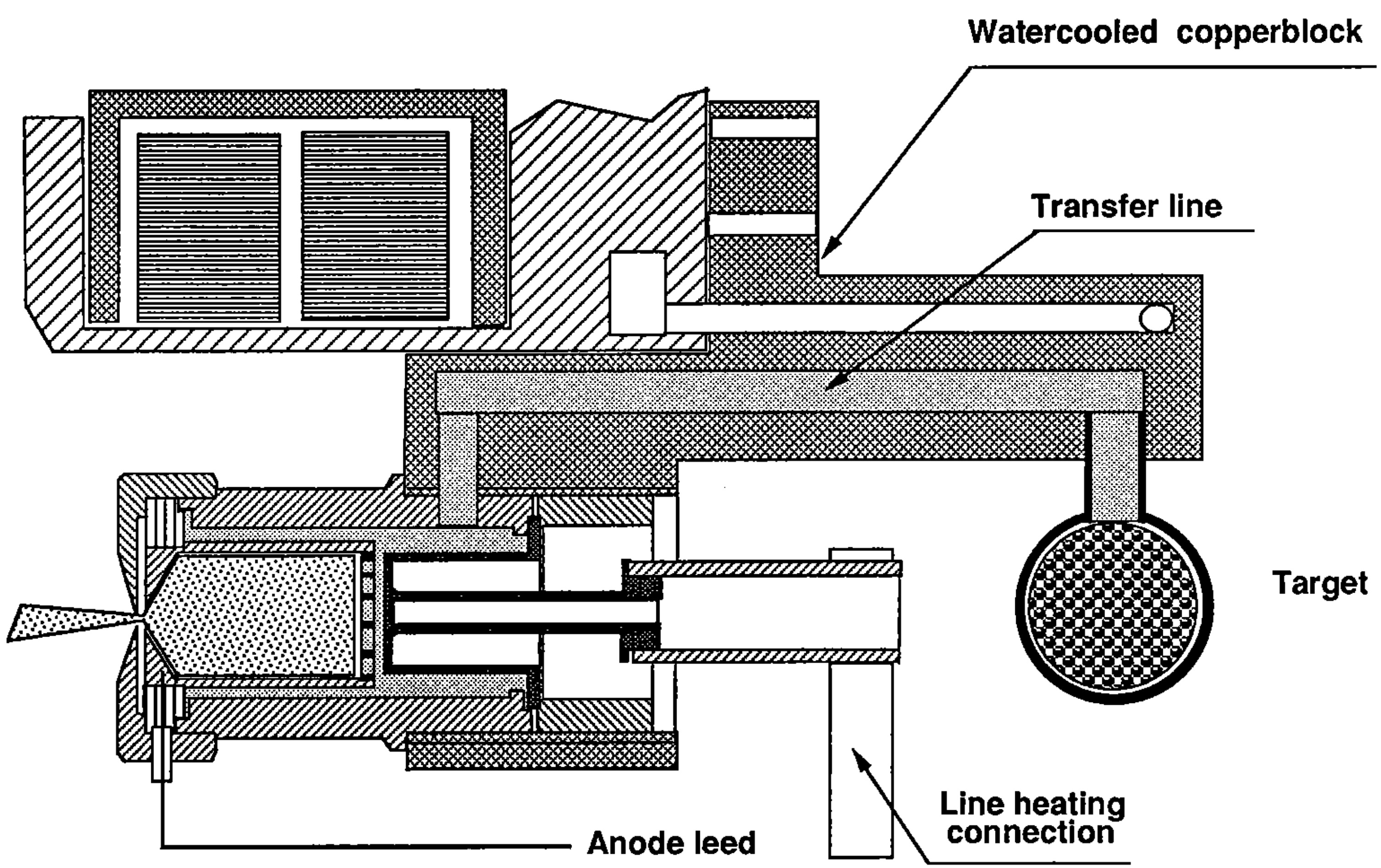
PRINCIPLE OF CATHODE AND SOURCE HEATING

Fig. 4



**ION SOURCE Mk 6 WITH
TEMPERATURE CONTROLLED LINE**

Fig. 5



IONSOURCE Mk 7. Watercooled.

Fig. 6

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