(12) UK Patent Application (19) GB (11) 2 150 737 A

(43) Application published 3 Jul 1985

(21) Application No 8429285

(22) Date of filing 20 Nov 1984

(30) Priority data
(31) 8331912 (32) 30 Nov 1983 (33) GB

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(51) INT CL[4]
G21G 4/02

(52) Domestic classification
G6P 5E1A 5E2D 5E4A 5E4B
U1S 1247 1266 1605 2159 G6P

(56) Documents cited
None

(58) Field of search
G6P

(54) Lithium target

(57) A target for generating fast neutrons by the reaction ${}^{7}_{3}Li\,(p,\,n)\,{}^{7}_{4}Be$ consists of a thin layer 12 of lithium coated onto a water-cooled plate 14 of hydrogen porous material eg niobium or copper. No significant degree of alloying occurs at the interface, and hydrogen diffuses fast enough through the plate 14 for bubbles not to form at the interface when the layer 12 is bombarded by protons.

Fig.2.

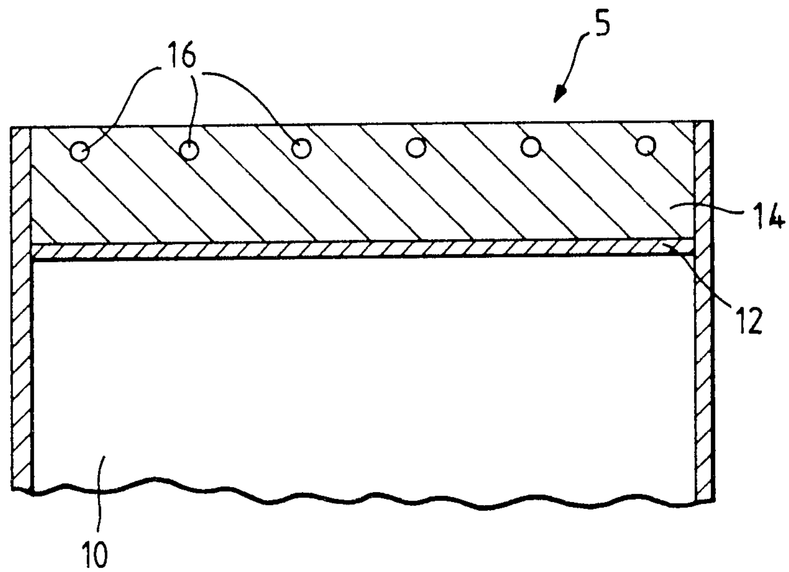

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Fig. 1.

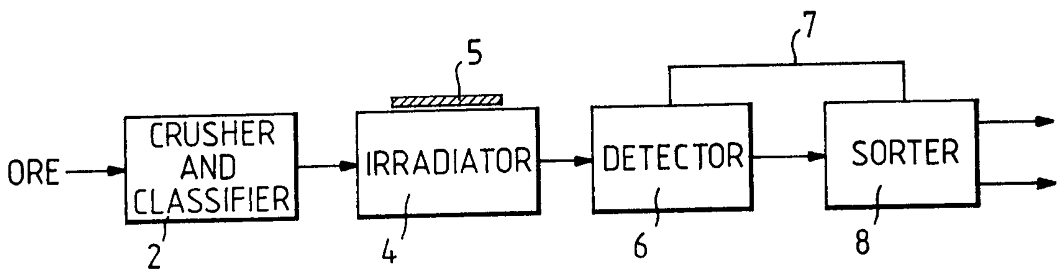
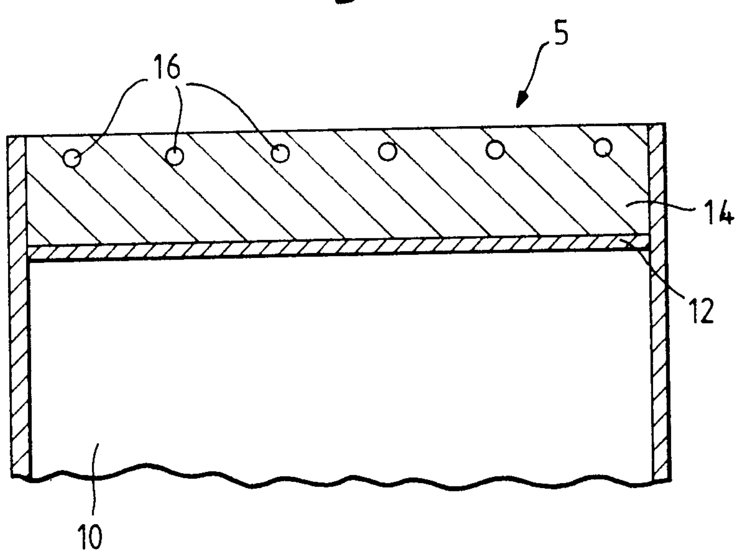

ORE
CRUSHER AND CLASSIFIER
IRRADIATOR
DETECTOR
SORTER
2
4
5
6
7
8

Fig. 2.


5
16
14
12
10

SPECIFICATION

Lithium target

This invention relates to a lithium target for bombardment by protons to generate neutrons by the reaction $^{7}_{3}$Li (p, n) $^{7}_{4}$Be, and to apparatus for detecting the presence of a selected substance in ores by neutron activation analysis, for example the gold content of gold-bearing ores.

A practical gold ore sorting plant needs to be able to process several tens of tonnes of ore an hour, and hence must use a rapid analytical technique. A suitable technique is neutron activation analysis using the reaction ^{197}Au (n, n' γ) ^{197m}Au to activate gold present in a lump of ore, the ^{197m}Au nuclides so produced decaying with a half-life of about 7.8 seconds, with the emission of γ-rays of energy 279 keV. British Patent Specifications Nos 2 055 465B and 2 101 304A (US Patent No. 4 340 443, and US Serial No 383 686 filed 27 May 1982, respectively) which are incorporated by reference herein, describe apparatus for sorting gold bearing ores in which lumps of ore are activated by the above reaction, the γ-rays emitted subsequently being detected and analysed to assess the gold content of the ores.

Such an ore-sorting plant requires an intense source of fast neutrons to bring about the activation, and one possible source is a target consisting of a lithium layer, coated onto a silver backing plate, and bombarded by protons. However the effect of the bombardment is to generate heat and hydrogen in the target, which can be detrimental to the target structure. In the above target, for example, hydrogen bubbles tend to form at the interface between the lithium and the silver.

According to a first aspect of the present invention there is provided a lithium target comprising a relatively thin layer of lithium coated onto one side of a backing plate of a metal which does not form an alloy layer at the interface, and through which hydrogen diffuses at such a rate that bubbles do not form at the interface.

Preferably the backing plate is niobium. Desirably channels for the passage of a cooling fluid are provided in thermal contact with the other side of the backing plate.

The target of the invention thus provides a source of high energy neutrons which can be expected to suffer less damage than known targets, and which provides neutrons of a relatively well-defined energy range since the thickness of the lithium is well-defined, because no significant thickness of the alloy layers is formed.

In a second aspect, the invention provides an irradiator for irradiating lumps of ore for detecting the presence of a selected substance in the lumps, the irradiator including as a neutron source the lithium target defined above.

The invention will now be further described by way of example only and with reference to the accompanying drawings, in which:

Figure 1 is a flow diagram of a gold ore sorting apparatus including a lithium target according to the invention; and

Figure 2 is a sectional view of the lithium target of Fig. 1.

Referring to Fig. 1, a gold ore sorting apparatus comprises a rock crusher and classifier 2 to which mined ore is supplied, in which the ore is crushed into lumps, and from which emerges a stream of lumps corresponding to mesh size of about 75 mm, while lumps smaller than mesh size about 35 mm are rejected. The stream of lumps is passed through an irradiation chamber 4 adjacent to a lithium target 5 to be described in more detail later, and then all the lumps are caused to pass a γ-ray detector assembly 6 arranged to detect ξ-rays having an energy of 279 keV arising from the decay of ^{197m}Au nuclides and so signiying the presence of gold in the lumps of ore. Each lump of ore is interrogated individually by the detector assembly 6 to establish whether its gold content lies above or below some predetermined concentration. The critical concentration is typically in the range 0.5 to 5 parts per million (ppm), and might for example be set at 1 ppm. Each lump of ore is then passed into a sorter 8 arranged by means of a cable 7 to respond to signals from the detector assembly 6, and to sort each lump of ore into one of two outlet streams depending on whether the gold concentration in the lump lies above or below the predetermined concentration.

The crusher and classifier 2 and the sorter 8 may be of types well known in the art, while the detector assembly 6 may be as described more fully in the aforementioned specifications to which reference may be made, the crusher and classifier 2, the sorter 8 and the detector assembly 6 not being the subject of the invention.

Referring to Fig. 2, the lithium target 5 forms one end of an evacuated beam tube 10 along which a 1 mA beam of protons of energy 4.5 MeV is passed during operation of the apparatus of Fig. 1. The target 5 comprises a layer 12 of lithium 0.3 mm thick coated onto one side of a circular niobium plate 14, the lithium layer 12 being on the side onto which the proton beam is incident. A number of ducts 16 are defined through the plate 14 near the other side thereof.

In operation of the apparatus of Fig. 1, the proton beam is accelerated down the beam tube 10 onto the target 5, and a coolant liquid such as water is passed through the ducts 16 to remove heat from the plate 14. The temperature of the target 5 is monitored to ensure it remains below 186°C, the melting point of lithium, and the beam is moved over the surface of the layer 12 to avoid localized overheating.

As a result of the reaction $^{7}_{3}$Li (p, n) $^{7}_{4}$Be, an intense flux of fast neutrons of energy between about 0.6 MeV and 2.8 MeV emerges from the target 5, to irradiate the lumps of ore passing through the adjacent irradiation chamber 4 (see Fig. 1). The range of energies of the neutrons is determined by the energy of the incident protons and the thickness of lithium layer 12. The cross-section for activating gold nuclei, ^{197}Au, is a maximum for neutrons of energy about 2.5 MeV, and neutrons of energy between 0.6 MeV and 2.8 MeV can bring about this activation, but have insufficient energy to bring about activation by (n, p) reactions of other elements which are likely to be present in the ore, such as aluminium and silicon. Neutrons of energy below about 0.6 MeV are unlikely to activate the gold nuclei but may bring about activation by (n, γ) reactions of for example aluminium. The thickness is well-defined because no significant degree of alloying takes place at the interface between the niobium plate 14 and the lithium layer 12, and is chosen so that neutrons of energy less than 0.6 MeV are unlikely to be generated.

Those protons which do not undergo the above reaction with lithium atoms emerge from the lithium layer 12 into the niobium plate 14 with an energy of about 3.3 MeV, and this energy is then dissipated to heat by collisions with the niobium lattice. Hydrogen atoms are thus generated with the niobium plate 14 (i.e. protons which have been slowed down), and diffuse through the plate 14 to emerge from the side remote from the incident proton beam. Thus there is no tendency for hydrogen to accumulate at the interface between the niobium plate 14 and the lithium layer 12.

The target 5 has been described as being cooled by passing a coolant liquid through ducts 16 defined through the plate 14. It will be appreciated that alternatively grooves (not shown) might be defined on the side of the plate remote from the lithium layer 12, the grooves being covered by a copper cover plate (not shown) so as to define ducts for the passage of a coolant fluid. Yet again, copper ridges (not shown) might be brazed to that side of the plate 14 and covered with a copper cover plate (not shown) so as to define ducts for the passage of a coolant fluid.

It will also be understood that although the preferred material for the plate 14 is niobium, an alternative material, such as copper, might be used as long as it does not form an alloy layer at the interface, and that hydrogen diffuses sufficiently fast through it at the temperature of operation, for hydrogen not to accumulate at the interface to form bubbles.

CLAIMS

1. A lithium target comprising a relatively thin layer of lithium coated onto one side of a backing plate of a metal which does not form an alloy layer at the interface, and through which hydrogen diffuses at such a rate that, when the lithium layer is bombarded by a proton beam, hydrogen bubbles do not form at the interface.

2. A lithium target as claimed in Claim 1 wherein the backing plate comprises niobium.

3. A lithium target as claimed in Claim 1 or Claim 2 wherein channels for the passage of a cooling fluid are provided in thermal contact with the other side of the backing plate.

4. A lithium target substantially as hereinbefore described with reference to, and as shown in, Fig. 2 of the accompanying drawings.

5. An irradiator for irradiating lumps of ore for detecting the pesence of a selected substance in the lumps, the irradiator including as a neutron source a lithium target as claimed in any one of the preceding Claims.

Printed in the United Kingdom for
Her Majesty's Stationery Office, Dd 8818935, 1985, 4235.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.