

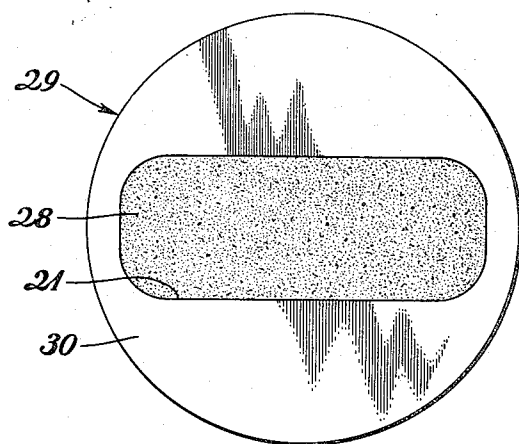
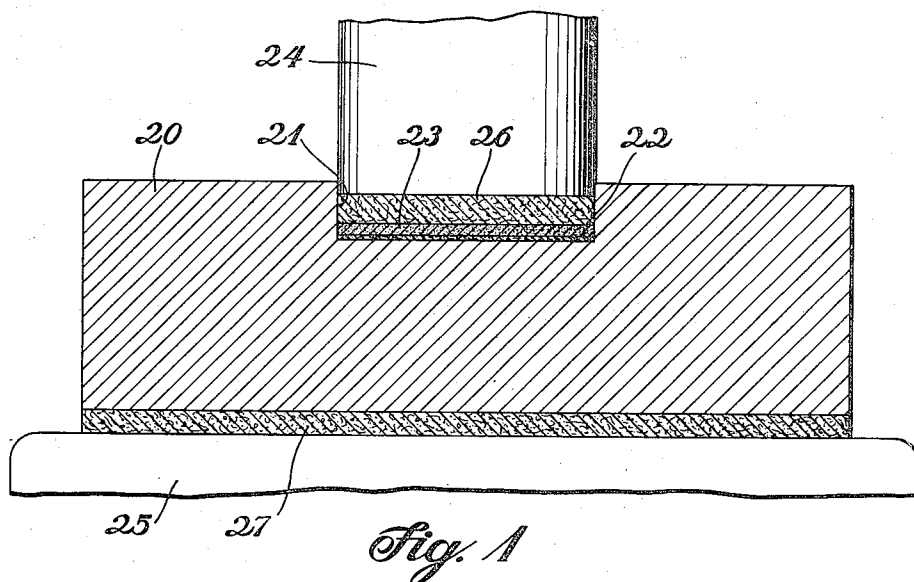
April 17, 1951

J. G. HAMILTON ET AL.

2,549,596

BERYLLIUM TARGET AND METHOD OF MANUFACTURE

Filed Oct. 8, 1946



INVENTORS.

JOSEPH G. HAMILTON.

THOMAS M. PUTNAM.

JACOB H. WIENS.

BY

Robert A. Saunders

ATTORNEY

UNITED STATES PATENT OFFICE

2,549,596

BERYLLIUM TARGET AND METHOD OF MANUFACTURE

Joseph G. Hamilton, San Francisco, Thomas M. Putnam, Oakland, and Jacob H. Wiens, Redwood City, Calif., assignors to the United States of America as represented by the United States Atomic Energy Commission

Application October 8, 1946, Serial No. 701,907

7 Claims. (Cl. 313—330)

1

This invention relates to methods of producing a new and improved plate formed of different materials and to the plates thus formed. More particularly the invention relates to the production of copper-beryllium plates particularly useful as targets in cyclotrons.

It has hitherto been the practice in preparing copper-beryllium plates for cyclotron targets to unite to a plate copper, strips of beryllium secured thereto by "easy-flo" soldering under pressure. As these targets are designed to be bombarded with intense beams of deuterons it is important to insure the secure bonding of the beryllium to the copper in a good thermal junction, to the end that the heating of the beryllium target may be controlled by surface cooling of the copper plate by passing a stream of water thereon.

It has been discovered, however, that these targets have a short life due to the rapid failure of the bond resulting from severe thermal stresses induced by the unequal co-efficients of thermal expansion involved and the frequent heating and cooling attendant the turning on and off of the deuteron beam. The targets burn out for when the bond between the copper plate and the beryllium strips is broken the thermal conductivity of the bond becomes so poor that the beryllium becomes severely overheated and rapid target destruction follows. The result has often been that a run is continued long after the target has unknowingly been destroyed by the heat with a consequent loss of bombardment time as well as exposing the operating personnel to radiation by the deuterons which were no longer stopped by the beryllium target. The targets thus formed were destroyed after merely 20,000 microampere hours of bombardment.

The present invention contemplates the use of metallurgy in the production of a new and improved target. In accordance with the present invention a recess is milled in a thick copper plate and a thin layer of mixed copper and beryllium filings is placed therein. Over this layer is laid a second layer composed of beryllium filings and the layers are united and alloyed under the heat and pressure. Beryllium filings rather than powder are used in order to reduce oxidation. The targets produced by this method have proved to have lives in excess of 65,000 microampere hours notwithstanding the increase of the deuteron beam intensity to 250 microamperes.

Accordingly it is one object of this invention to improve the process of manufacturing plates composed of different materials.

2

It is another object of this invention to improve the bond and thermal junction of plates composed of different materials.

It is another object of this invention to provide an improved process for the manufacture of beryllium cyclotron targets.

It is a further object of this invention to provide an improved beryllium cyclotron target.

It is a further object of this invention to provide a process for manufacturing a new and improved target composed of beryllium bonded to copper.

Further objects and advantages will be apparent from the annexed specification in which:

Fig. 1 is a fragmentary elevation; partly in section of a target in the process of manufacture.

Fig. 2 is a plan view of a completed target.

Fig. 3 is a cross-section of the finished target shown in Fig. 2.

Referring particularly to Fig. 1, there is shown a target in the process of manufacture. A copper block 20 of cylindrical form and $3\frac{3}{8}$ inches in diameter by 1" thick had a target area 21 roughly rectangular in shape and $1\frac{1}{8}$ " by $2\frac{7}{8}$ " milled therein to a depth of $\frac{1}{4}$ ". A thin layer 22 of copper filings mixed with a small amount of beryllium filings is then placed in the target area 21 over which is laid a layer 23 of beryllium filings. Approximately 8 grams of beryllium filings is used, which provides in the finished target a layer of approximately 0.06" thick beryllium.

A 16 million electron volt deuteron beam such as generated by the 60" cyclotron employed has a range of 150 mg./cm.². The equivalent density of beryllium being about 1.85 gm./cm.³, 1 mm. of beryllium is equivalent to 185 mg./cm.² and $1\frac{1}{2}$ mm. (or 0.06") of beryllium therefore gives 275 mg./cm.² or 50% more absorber than is necessary to stop the beam. The targets thus produced therefore have a safety factor of 50%.

A plunger 24 having a face designed to fit the target area 21 is provided and the block 20 is placed on the bed 25 of a suitable press and the powder is compressed. About 25 tons pressure is used. The pressure is then released and an asbestos strip 26 is placed over the target area and another asbestos strip 27 is placed under the block 20 to protect the bed 25. The pressure is again applied and simultaneously heat is applied by heating the plunger 24 to a bright red heat until the copper-beryllium alloy begins to flow from under the plunger. The heat is then removed and the block is allowed to cool. During the heating, the pressure is reduced to 5 tons per square inch and maintained at that point.

After the assembly has cooled it is removed and milled down to form the finished target 29. As shown in Figures 2 and 3, the finished target is $\frac{7}{64}$ inch thick and has a target area 28 filled as above described $\frac{1}{8}$ inch deep.

In the event it is desired to provide a strip of beryllium bonded to the target, the asbestos strip 26 may be replaced by such a strip of beryllium which will also be heated to the flow point during the process, thus welding it to the mat of compressed beryllium filings.

From the foregoing description it will be apparent that the target 29 is composed of a plate of copper 30 containing a target area 28 the upper layer of which is largely beryllium while the lower layer thereof is a copper-beryllium alloy. This structure provides a greatly improved bond and insures a good thermal junction in the target.

It will also be apparent that the above described process results in the uniting of a strip of beryllium to a strip of copper in a simple, economical manner without resorting to the successive sintering steps hitherto employed.

While there is described what is at present considered a preferred embodiment of the present invention, it is apparent that various changes may be made without departing from the invention and it is intended to cover all such as come within the true scope and spirit of the appended claims.

What is claimed is:

1. In a method of forming a target for bombardment by a high energy beam and including a beryllium target material bonded to a body formed of copper, the steps which comprise positioning a body of said beryllium target material on a body of copper and separated therefrom by a granulated layer composed of an alloyable mixture of copper and beryllium, and bonding said two bodies together by applying high pressure to said bodies across said layer and heating said layer to the flow point of said mixture.

2. A cyclotron target comprising a copper plate, a solid layer of beryllium, and a solid layer of a beryllium copper alloy bonding said beryllium layer to said copper plate.

3. In a method of making a cyclotron target, the improvement which comprises placing a layer composed of a mixture of copper and beryllium powder in a recess formed in a copper plate, placing a layer of beryllium powder over the layer composed of said mixture, and pressing said layers against said copper plate under high temperature conditions, whereby the materials

in said layers fuse to form a solid layer of beryllium bonded to said copper plate by an intervening solid layer composed of beryllium and copper.

4. A cyclotron target comprising a copper block having a recess formed in one face thereof, a beryllium plate arranged in said recess, and a layer of copper and beryllium alloy bonded both to said block and to said plate.

5. The method of making a cyclotron target comprising placing a mixture of copper and beryllium filings in a recess formed in a copper block, placing a beryllium plate in said recess in engagement with said mixture, and subjecting said mixture to pressure between said block and said plate under high temperature, whereby said mixture is fused into a coherent layer bonded both to said block and to said plate.

6. In a process for the production of a cyclotron target, the steps comprising disposing a layer of a mixture of copper and beryllium filings in a recess formed in a copper block, disposing a layer of beryllium filings over said mixture layer, compacting said filing layers by the application of pressure, and bonding the assembly composed of said block and said compacted layers by the application of heat and pressure, thereby producing a target having a beryllium surface which is bonded to a copper block by a beryllium-copper alloy.

7. In a method for manufacturing a cyclotron target, the steps comprising disposing a layer comprising a mixture of beryllium and copper filings in a recess formed in a copper block, placing a beryllium body in said recess and above said layer, and applying heat and pressure simultaneously whereby said beryllium-copper filing layer fuses and flows to bond said beryllium body to said copper block.

JOSEPH G. HAMILTON.
THOMAS M. PUTNAM.
JACOB H. WIENS.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,948,384	Lawrence	Feb. 20, 1934
2,096,924	Schwarzkopf	Oct. 26, 1937
2,116,387	Driggs et al.	May 3, 1938
2,329,320	Atlee	Sept. 14, 1943
2,359,361	Gleszer et al.	Oct. 3, 1944
2,362,353	Cate	Nov. 7, 1944