United States Patent

Abe et al.

[15] **3,670,395**

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[54] **METHOD OF MAKING A HONEYCOMB BLOCK COLLIMATOR**

[72] Inventors: **Isamu Abe,** Kawasaki; **Hideo Yashiro,** Tokyo; **Naoyuki Sori,** Tokyo; **Sotaro Hatano,** Tokyo; **Tomiyasu Katsumoto,** Tokyo; **Tadao Suzuki,** Ichikawa, all of Japan

[73] Assignee: **Tokyo Shibaura Electric Co., Ltd.,** Kawasaki-shi, Japan

[22] Filed: **Sept. 18, 1970**

[21] Appl. No.: **73,573**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 726,041, Sept. 18, 1970, abandoned.

[52] **U.S. Cl.** **29/471.1,** 250/105

[51] **Int. Cl.** **G21f 5/02,** H01j 35/16

[58] **Field of Search** .....29/455, 471.1, 472.3; 250/105, 250/71.5 R, 71.5 S

[56] **References Cited**

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Primary Examiner—Anthony L. Birch

Attorney—Flynn & Frishauf

[57] **ABSTRACT**

A honeycomb block is made by winding a tungsten metal wire compactly around a core and then removing the core, thereby fabricating a compactly wound coil member. The coil members are arranged side by side and are bonded together with a metal paste bonding agent to form the honeycomb block.

10 Claims, 3 Drawing Figures

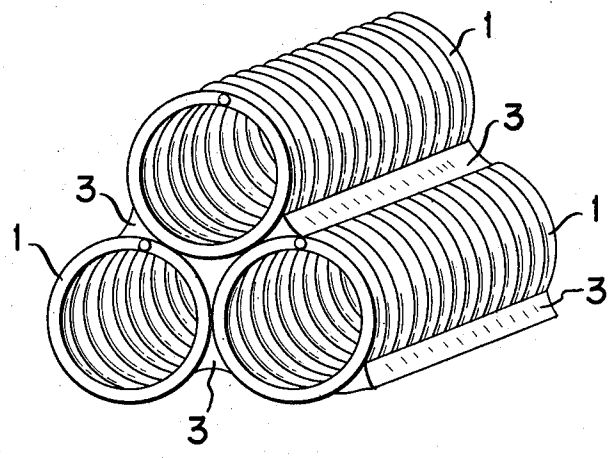


FIG. 1

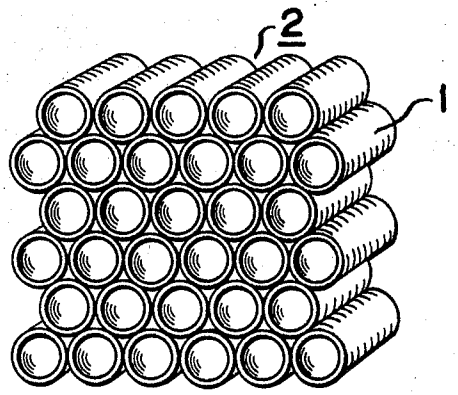


FIG. 2

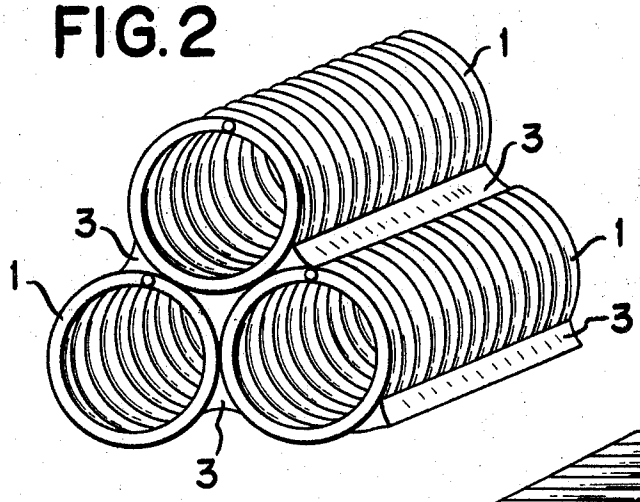
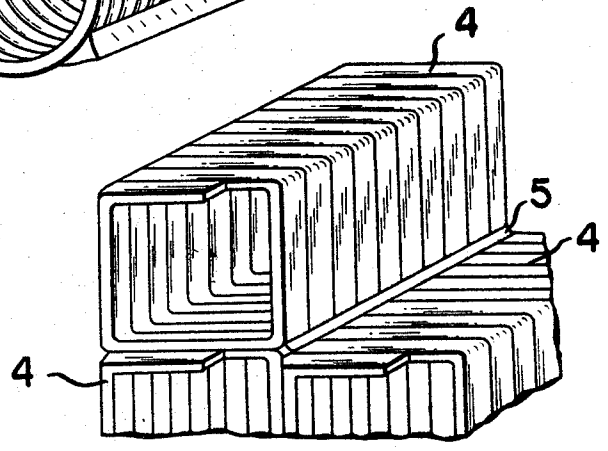


FIG. 3



ISAMU ABE,
HIDEO YASHIRO, NAOYUKI SORI,
SOTARO HATANO,
BY TOMIYASU KATSUMOTO
TADAO SUZUKI,
INVENTORS
by Stephen H. Frishauf
Atty

METHOD OF MAKING A HONEYCOMB BLOCK COLLIMATOR

This is a continuation-in-part of application Ser. No. 726,041, filed May 2, 1968, now abandoned.

This invention relates to honeycomb blocks, and more particularly to a method of making a honeycomb block for X-ray use.

Where medical treatment is conducted by photographing the interior of the human body using X-rays, or radiating said interior using a ^{60}Co source it is common practice to apply to the human body the X-rays generated by the source or diffused radiations such as gamma rays emitted from the ^{60}Co after being focused by a collimator. This collimator is in the form of a honeycomb block prepared by laminating a plurality of thin plates having a large number of apertures therein. Since these numerous apertures are arranged in registration with each other, the incoming radiations are allowed to pass through them in such a manner that they are collimated only within a specified range on the outlet side.

For convenience in description, there will now be described a prior art collimator or honeycomb block used in photographing the human body by means of X-rays. The thin plates forming the honeycomb block were made of materials capable of readily absorbing X-rays, namely, high density materials. These materials generally consisted of lead, gold, platinum, molybdenum, tungsten and tungsten alloys. The fabrication of the honeycomb block from the aforementioned thin plates required the steps of drilling a large number of apertures in the plates and laminating these perforated plates. The perforation of the thin plates was a difficult operation because the drilling of a large number of apertures through hard and yet brittle materials such as tungsten reduced the life of a drilling tool and required long hours of work. Conversely where apertures were perforated at close intervals in thin plates made of soft materials such as lead and gold, the portions of the plate between the apertures were often subject to deformation. Consequently there was the drawback that high precision could not be obtained for the apertures. Further for this reason, there were limits to the extent of reducing the aperture intervals of the honeycomb block, namely, the thickness of the portions of the plate intervening between the apertures in order to elevate the passage of X-rays.

SUMMARY OF THE INVENTION

The present invention is intended to provide a large number of apertures not by perforating a thin plate, but by compactly coiling metal wire made of, for example, molybdenum or tungsten into a tubular form, and bonding these compactly wound coil members close to each other, thereby fabricating a honeycomb-like multi-hole block. The aforementioned tubular compactly wound coil member is fabricated by closely coiling wires around a core and thereafter withdrawing the core from the coil. Thus, the adjacent wire turns are intimately attached to each other. It will be apparent that in this case, the shape of the aperture or inner hollow space of the compactly wound coil member may be not only circular, but also may take any desired polygonal form, for example, a triangle, square, rectangle or hexagon according to the shape of the core used. The word "tubular" is used herein to denote any of these various shapes. Where the hollow space assumes any of the latter forms, for example, a square or rectangle, the compactly would coil members will have increased contact areas when arranged together, thus enabling the honeycomb block composed of such members to have a greater assembled strength.

Also where the metal wire itself used in forming a compactly wound coil member has a polygonal, for example, a rectangular cross section rather than a circular one, namely, a ribbon-like form, there will be obtained larger contact areas between the wire turns, thus improving the mechanical strength of the compactly wound coil member.

To integrate a plurality of compactly wound coil members into a honeycomb block by close attachment side by side, there is used a metal paste bonding agent, such as copper paste, silver paste, copper alloy paste or silver alloy paste. Among copper alloy pastes, for example, there are Cu–Zn pastes, and among silver alloy pastes, there are Ag–Zn–Cu pastes. A metal paste is prepared by mixing together the metal powders and an organic solvent such as butyl acetate, vinyl acetate, and amyl acetate in the proportion of 1–2:1 by weight.

The apertures of a honeycomb block used as a radiation collimator are preferably arranged in a linear direction. However, where these apertures must have a nonlinear arrangement for use in other applications, the compactly wound coil members are purposely deformed and assembled by the use of a metal paste bonding agent into any desired type of honeycomb block so as to have a nonlinear aperture arrangement.

The honeycomb block prepared according to the present invention allows the apertures for passing radiations to have any desired cross sectional shape. Furthermore, all of the apertures will have a uniform dimensional precision and the honeycomb block as a whole will have precisely positioned apertures free from any distortion.

Referring to fabricating problems, the honeycomb block of the present invention eliminates the necessity of drilling apertures in a thin plate. Since the only requirement is to wind wiring about a core, there is the advantage that manufacturing process will become much easier even if wiring consists of materials such as tungsten which normally present difficulties in machining. Moreover, the crosswise and lengthwise intervals between the apertures can be reduced to about 40 to 60 microns, thus substantially increasing the radiation collimating capacity of the honeycomb block of the present invention over the prior art apparatus.

There will now be described the present invention by reference to the appended drawing in which:

FIG. 1 is a perspective of a honeycomb block according to an embodiment of the present invention;

FIG. 2 is a perspective of an enlarged part of the honeycomb block of FIG. 1, showing details of the compactly coiled wire turns; and

FIG. 3 is a perspective of assembled compactly wound coil members whose aperture or interior hollow space as well as the cross section of the component wire is of a different shape from those of FIG. 2.

EXAMPLE 1

Referring to FIG. 2, numeral 1 represents a substantially tubular compactly wound coil member prepared by winding a tungsten wire having a circular cross section so as to form a circular aperture, the adjacent wire turns being arranged intimately close to each other. The compactly wound coil member is prepared by heating a tungsten wire having a circular cross section 0.2 mm in diameter to about 800° C to soften it and winding it about a molybdenum core (not shown) in a manner to cause the adjacent wire turns to be wound intimately close to each other. When the coil is wound to a length of 20 mm the core is withdrawn to obtain a compactly wound coil member having an aperture diameter of 3.1 mm and an outer diameter of 3.5 mm.

Next there are piled in a rectangular form a large number of compactly wound coil members thus prepared in such a manner that the adjacent apertures are set apart approximately 3.5 mm from center to center, thereby to form as shown in FIG. 1 a honeycomb block 95 mm on each side and 20 mm in depth. In this case, as illustrated in FIG. 2, a metal paste bonding agent 3 is filled into the gaps between the respective compactly wound oil members 1. The bonding agents consists of a copper paste comprising electrolytic copper powders and a butyl acetate solution mixed, 1:1 by weight. The honeycomb block formed from the coil members thus assembled is heated to a temperature of 1,150° to 1,200° C in a hydrogen at-

mosphere for 30 minutes. The copper component included in the bonding agent is thermally melted to be carried into all the interstices between the respective coil members **1** and upon cooling, firmly bonds them together, thus integrally fabricating a honeycomb block **2**.

EXAMPLE 2

The coil material consists of a molybdenum wire having a cross section 1 mm × 0.2 mm as shown in FIG. **3**. The wire is compactly wound at normal room temperatures about a molybdenum core having a cross section 3.0 mm × 3.0 mm to a length of 20 mm. After completion of coiling, the core is drawn out to obtain a compactly wound coil member **4** having an aperture 3.1 mm × 3.1 mm and an external size 3.5 mm × 3.5 mm. Thereafter, over the circumferential surface of the compactly wound coil member thus formed is sprayed a solution of a bonding agent **5** comprising electrolytic copper powders and a vinyl acetate solution, mixed 1:1 by weight. After evaporation of the solvent, there are piled a large number of compactly wound coil members **4** in a rectangular form. These coil members are heated to a temperature of 1,150° to 1,200° C for 30 minutes and are bonded together by the molten copper. Upon cooling, there is obtained a honeycomb block of approximately the same overall shape as that shown in FIG. **1**.

EXAMPLE 3

Compactly wound coil members are formed fron tungsten wire as described in Example 1, and these coil members are then piled in a rectangular form, also as described in Example 1. In this case, a metal paste comprising silver powders and a butyl acetate solution, mixed 1:1 by weight, is filled into the gaps between respective coil members. The assembly is then heated to a temperature of 1,100°–1,150° C in a hydrogen atmosphere for 20 minutes. Thereafter, upon cooling, the silver component in the metal paste firmly bonds the coils together, thus integrally fabricating a honeycomb block. The use of the silver paste permits the fabrication of the honeycomb block to be effected at a lower temperature than in the case of a copper paste. Also, a shorter heating period is required.

EXAMPLE 4

Compactly wound coil members are formed from tungsten wire as described in Example 1, and these coil members are then piled in a rectangular form, also as described in Example 1. In this case, a metal paste comprising copper alloy powders of 65% Bu and 35% Zn (by weight) and a butyl acetate solution, the copper alloy powders and butyl acetate solution being mixed 1:1 by weight, is filled into the gaps between respective coil members. The assembly is then heated to a temperature of 950°–1,000° C in a hydrogen atmosphere for 20 minutes. Thereafter, upon cooling, the silver component in the metal paste firmly bonds the coils together, thus integrally fabricating a honeycomb block.

EXAMPLE 5

Compactly wound rectangularly shaped coil members are formed from molybdenum wire as described in Example 2, and these coil members are then piled in a rectangular form, also as described in Example 2. In this case, a silver alloy paste comprising silver alloy powders of 45% Ag, 25% Zn and 30% Cu (by weight) and an amyl acetate solution, the silver alloy powders and amyl acetate solution being mixed 1:1 by weight, is applied to the assembly, also as in Example 2. The assembly is then heated to a temperature of 800°–900° C in a hydrogen atmosphere for 20 minutes. Thereafter, upon cooling, the silver alloy components in the metal paste firmly bonds the boils together, thus integrally fabricating a honeycomb block.

Generally, there is a tendency for tungsten and molybdenum not to become intimately bonded to the other metal. However, it has been found that by using a metal paste of copper or silver alloy, this tendency not to bond is more easily overcome and the bonding operation can be effected at even lower temperatures.

While the invention has been described in connection with some preferred embodiments thereof, the invention is not limited thereto and includes any modifications and alterations which fall within the scope of the invention as defined in the appended claims.

We claim:

1. A method of making a honeycomb block used for collimation of electro-magnetic radiations in the frequency range of X-rays and gamma-rays comprising the steps of:

fabricating a number of coil members, each being fabricated by:

winding around a core with a high density metal wire selected from the group consisting of tungsten and molybdenum; and

thereafter drawing out said core to form a compactly wound coil member; and

firmly bonding together a plurality of said coil members side by side to thereby fabricate a honeycomb block by:

assembling a plurality of coil members in a predetermined arrangement;

filling a metal paste as a bonding agent among said plurality of coil members, said metal paste comprising powders of metal selected from the group consisting of copper, silver, copper alloy and silver alloy; and

heating the resultant assembly of coil members at a temperature of from 800°–1,200° C in a hydrogen atmosphere.

2. A method according to claim **1** wherein said metal wire is tungsten and further comprising the step of heating said tungsten wire to approximately 800° C prior to the winding step.

3. A method according to claim **1** wherein said assembling step is carried out prior to filling said metal paste among said plurality of coil members, and said heating step is thereafter carried out.

4. A method according to claim **3** wherein said metal wire is tungsten.

5. A method according to claim **1** wherein said metal paste is sprayed on said plurality of coil members prior to assembling same, and said heating step is thereafter carried out.

6. A method according to claim **5** wherein said metal wire is molybdenum.

7. A method according to claim **1** wherein said metal wire has a substantially circular cross section.

8. A method according to claim **1** wherein said metal wire has a substantially rectangular cross section.

9. A method according to claim **1** wherein each coil member is wound to have a polygonal aperture.

10. A method according to claim **1** wherein each coil member is wound to have a round aperture.

* * * * *

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(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,670,395 Dated June 20, 1972

Inventor(s) Isamu ABE, et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Page 1, In the heading add the following Priority data:

--[30] Foreign Application Priority Data

May 9, 1967 Japan.....28893/67--.

Signed and sealed this 5th day of December 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents