Dec. 17, 1946. J. T. MULLER 2,412,644

METHOD OF MANUFACTURING COATED ARTICLES

Filed May 11, 1944

FIG. 1

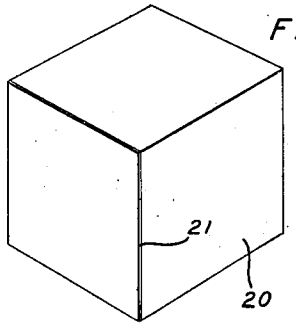


FIG. 2

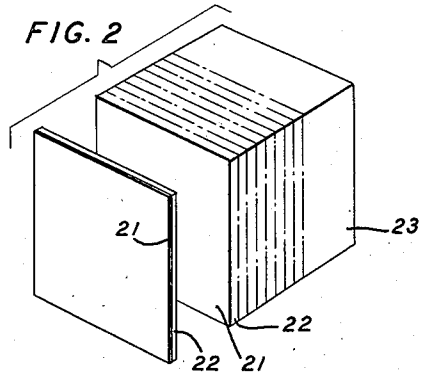


FIG. 3

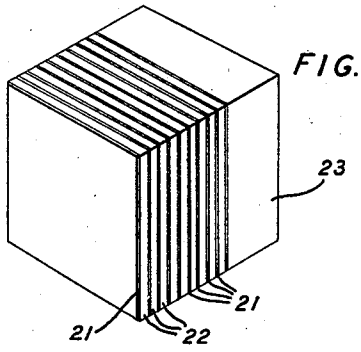


FIG. 4

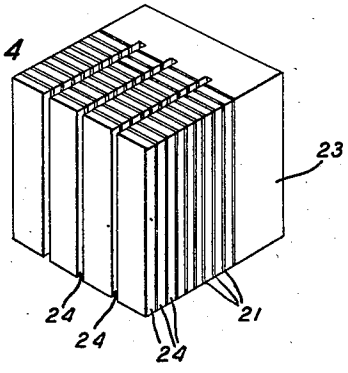


FIG. 5

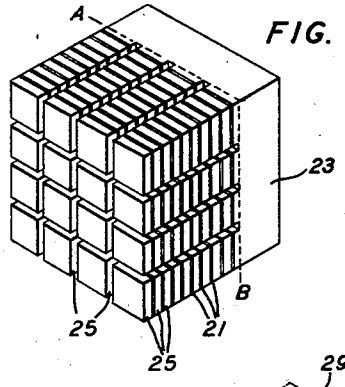


FIG. 6

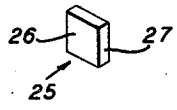


FIG. 7

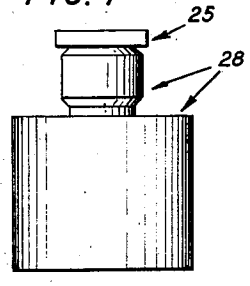


FIG. 9

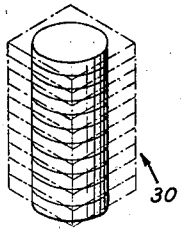
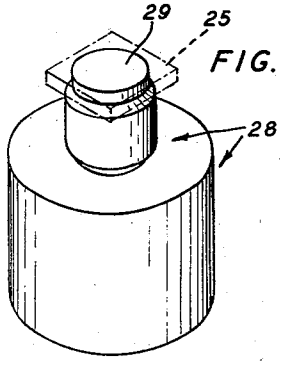


FIG. 8



INVENTOR
J. T. MULLER

BY
E. R. Nowlan
ATTORNEY

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METHOD OF MANUFACTURING COATED ARTICLES

John T. Muller, Livingston, N. J., assignor to Western Electric Company, Incorporated, New York, N. Y., a corporation of New York

Application May 11, 1944, Serial No. 535,169

4 Claims. (Cl. 125—12)

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This invention relates to a method of manufacturing coated articles, and more particularly to a method of manufacturing laminar members of brittle crystalline material and coated on one side for use in electrical apparatus.

The applications of slices, disks, chequers, wafers and the like usually laminar members of crystalline material such as quartz, silicon, graphite, carbon and the like macrocrystalline or microcrystalline substances coated on one flat face with metal, in electrical arts are too varied and too well known to require enumeration here.

An object of the present invention is to provide a simple, reliable method of producing from hard and brittle material which must be shaped by abrasive agents coated laminar members particularly adapted for electrical use, by steps which will reduce chipping and breakage to a minimum.

With the above and other objects in view, the invention may be embodied in a method of making laminar articles having a coating on one face thereof from material shapable by abrasives which comprises steps of forming a flat smooth face on a body of the material, coating the face so formed, cutting off a coated slice of the material by a cut parallel to the said face, coating the face of the body thus formed, a second coated slice by a cut parallel to the new coated face, cementing the coated slices together to substantially reconstitute the body, making a plurality of mutually parallel cuts in but not completely through the reconstituted body across the slices to sever these into separate stacks of cemented bars, making a second plurality of mutually parallel cuts in but not completely through the reconstituted body across the bars to sever these into separate stacks of cemented chequers, and treating the aggregate of chequers so formed to release the same from the cement.

Other objects and features will appear from the following detailed description of one embodiment thereof taken in connection with the accompanying drawing, in which the same reference numerals are applied to identical parts in the several figures and in which

Fig. 1 is a view in perspective of a parallelopipedal block of material after the first step;

Fig. 2 is a similar view showing the result of the second step of the method applied once;

Fig. 3 is a similar view showing the result of the third step of the method;

Fig. 4 is a similar view showing the result of the fourth step of the method;

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Fig. 5 is a similar view showing the result of the fifth step of the method;

Fig. 6 is a similar view showing a single chequer as thus made;

Fig. 7 is a side elevation of the chequer mounted for trimming;

Fig. 8 is a perspective of the mounted chequer as trimmed to form a wafer; and

Fig. 9 is a perspective of a stack of chequers in a modified form of the invention.

As herein illustratively disclosed, the invention is embodied in a method for manufacturing circular disks of homogeneously microcrystalline silicon, each disk having a metallic coating on one flat face. In carrying out the method it is assumed that the silicon is at hand in parallelopipedal pieces. The first step of the process comprises grinding one face of the silicon block **20** flat and smooth, etching this flat smooth face lightly to ensure its cleanliness, and coating the smoothed and etched face electrolytically with nickel as shown at **21**. A slab **22** of predetermined thickness is sawed from the block by a cut parallel to the plated face. The new face thus created on the block is smoothed, etched and plated as before, and a second slab **22** is sawed off. This procedure is repeated until all the usable portion of the block has been converted into slabs **22** each coated on one face with the nickel. The blocks of silicon at present available usually have a non-homogeneous portion **23** from the bottom of the melt from which they were made. These are then re-assembled, as shown in Fig. 3, to reconstitute the original block approximately, the slabs being cemented together with shellac. A series of parallel cuts is made into the reconstituted block, perpendicular to the plurality of parallel coated faces of the slabs **22**, which are thus converted into similarly coated flat bars **24** as shown in Fig. 4, and still held together by the shellac cement. A second plurality of mutually parallel cuts is made perpendicular to the cuts of Fig. 4 and also to the broad, coated faces of the bars **24**, thus converting the bars **24** into similarly coated, flat, square "chequers" **25**, as in Fig. 5. The aggregated unit shown in Fig. 5, still held together by the shellac, is then separated into its component parts by dissolving away the shellac cement, e. g., with alcohol. The cull stub **23** is disposed of. The product thus made is a plurality of chequers **25** like the one illustrated in Fig. 6, a parallelopipedal, small, flat body **27** of microcrystalline silicon with a nickel coating **26** on one of its broad faces. This product may itself be a

desired one, in which case the method terminates here. For other uses the chequers **25** may be cemented to a suitable holder **28** as shown in Fig. 7 and ground peripherally to produce the circular wafer shown at **29** in Fig. 8.

In the most important phase, the invention is typified by the sequence of operations illustrated in Figs. 2, 3, 4 and 5, both the particular steps and the order in which they are taken being important. The important feature of the steps and their sequence, is that after the slabs or slices **22** of Fig. 2 have been made and re-assembled with cement as shown in Fig. 3, the object worked on as shown in Figs. 4 and 5 remains a unitary solid aggregated block. The cemented slabs of the aggregate of Fig. 3 help to support each other while the cuts shown in Fig. 4 are being made; and so also the cemented bars of Fig. 4 support each other while the cuts shown in Fig. 5 are being made.

The crystalline materials usually in question are hard and brittle. Hence, if a single slab **22** be sawed transversely into bars **24** and if a single bar **24** be sawed transversely into chequers **25**, great care must be taken and the sawing done at relatively low speed and under relatively light pressure, lest the material chip at the corners and edges or crack through the body. The same general consideration holds in respect of other step sequences and methods of the prior art.

By the particular steps and sequence of the invention, not only are all cuts taken when the elements being cut are mutually supporting each other, but also the cement employed to hold them together is soft and resilient in comparison with the crystal substance, which appears to be an importantly useful feature in that the cement cushions the tiny but continuous and sharp jarring occasioned by the cutting grains of the abrasive powder or molded abrasive wheel used for the cutting. Whatever the true theory may be, the fact is, that the method characterized by the particular steps and sequence of steps described, reduces very materially the spoilage and waste from chipping and cracking, besides enabling the cutting to be done at materially greater speed and under materially heavier pressure than heretofore.

In a modification and extension of the method above described, the steps and their sequence are as before until the doubly sawed block of Fig. 5 is produced. This may then be cut along the plane indicated by the dotted angular line A—B in Fig. 5 to saw loose from the cull **23** stacks of superimposed cemented chequers, such as the single stack generally indicated at **30** in Fig. 9. Such a stack may be converted into a similar stack of circular wafers such as **29** in Fig. 8 by grinding off the corners, and the wafers then separated and cleaned by dissolving away the cement.

The invention has been illustrated as applied in the manufacture of silicon wafers coated on one face with nickel. Obviously the character of the body as silicon specifically or of the coating as nickel specifically, is not a limitation of the invention, which is applicable to the case of any relatively hard and brittle material which is best formed by cutting with abrasive agents and to any coating material both unaffected by the cement or the cement solvent selected. The specific use of shellac selected here as an illustrative cement, is also not a limitation. The manner in which the coating is applied also is irrelevant to the invention.

If the entire body **20** be of usable material to begin with, an artificial cull may be provided by cementing the block to another similar black or to a piece of glass or other suitable material.

Suitable apparatus to make the cuts shown in Figs. 2, 4 and 5 is described in detail in copending application Serial No. 535,172, filed by the present inventor of even date herewith and which matured as Patent No. 2,382,897, August 14, 1945; and suitable apparatus to face and edge trim the chequer **25** of Fig. 7 to make the wafer **29** of Fig. 8 is described in detail in copending application Serial No. 535,173, also filed by the present inventor of even date herewith and which matured as Patent No. 2,398,387, April 16, 1946. Apparatus to convert the prism **30** of Fig. 9 into a cylinder may be an ordinary lathe to hold and rotate the prism while a grinding wheel is reciprocated lengthwise of the prism.

What is claimed is:

1. A method of making laminar articles having a coating on one face thereof from hard and brittle material shapable by abrasives which comprises steps of forming a flat smooth face on a body of the material, coating the face so formed, cutting off a coated slice of the material by a cut parallel to the said face, coating the face of the body thus formed with tough and fracture resisting substance, cutting off a second coated slice by a cut parallel to the new coated face, repeating the steps of coating a new face and cutting off an additional coated slice until a desired part of the original body has been converted into coated slices, cementing the coated slices together to substantially reconstitute the body, making a plurality of mutually parallel cuts in but not completely through the reconstituted body across the slices to sever these into separate stacks of cemented bars, making a second plurality of mutually parallel cuts in but not completely through the reconstituted body across the bars to sever these into separate stacks of cemented chequers, and treating the aggregate of chequers so formed to release the same from the cement.

2. A method of making laminar articles having a coating on one face thereof from hard and brittle electrically conductive material shapable by abrasives which comprises steps of forming a flat smooth face on a body of the material, coating the face so formed with metal by electrolytic deposition, cutting off a coated slice of the material by a cut parallel to the said face, coating the face of the body thus formed with tough and fracture resisting metal by electrolytic deposition, cutting off a second coated slice by a cut parallel to the new coated face, repeating the steps of coating a new face and cutting off an additional coated slice until a desired part of the original body has been converted into coated slices, cementing the coated slices together to substantially reconstitute the body, making a plurality of mutually parallel cuts in but not completely through the reconstituted body across the slices to sever these into separate stacks of cemented bars, making a second plurality of mutually parallel cuts in but not completely through the reconstituted body across the bars to sever these into separate stacks of cemented chequers, and treating the aggregate of chequers so formed to release the same from the cement.

3. A method of making laminar articles having a coating on one face thereof from hard and brittle material shapable by abrasives which comprises steps of securing an artificial cull to a body of the material, forming a flat smooth face on the body, coating the face so formed,

cutting off a coated slice of the material by a cut parallel to the said face, coating the face of the body thus formed, with tough and fracture resisting substance, cutting off a second coated slice by a cut parallel to the new coated face, repeating the steps of coating a new face and cutting off an additional coated slice until substantially all of the original body has been converted into coated slices, cementing the coated slices and the cull together to substantially reconstitute the body, making a plurality of mutually parallel cuts through the reconstituted body but not completely through the cull across the slices to sever these into separate stacks of cemented bars, making a second plurality of mutually parallel cuts through the reconstituted body but not completely through the cull across the bars to sever these into separate stacks of cemented chequers, and treating the aggregate of chequers so formed to release the same from the cement.

4. A method of making laminar articles having a coating on one face thereof from hard and brittle electrically conductive material shapable by abrasives which comprises steps of securing

an artificial cull to a body of the material, forming a flat smooth face on the body, coating the face so formed with metal by electrolytic deposition, cutting off a coated slice of the material by a cut parallel to the said face, coating the face of the body thus formed with metal by electrolytic deposition, cutting off a second coated slice by a cut parallel to the new coated face, repeating the steps of coating a new face and cutting off an additional coated slice until substantially all of the original body has been converted into coated slices, cementing the coated slices and the cull together to substantially reconstitute the body, making a plurality of mutually parallel cuts through the reconstituted body but not completely through the cull across the slices to sever these into separate stacks of cemented bars, making a second plurality of mutually parallel cuts through the body but not completely through the cull across the bars to sever these into separate stacks of cemented chequers, and treating the aggregate of chequers so formed to release the same from the cement.

JOHN T. MULLER.