Jan. 22, 1957 C. C. CLARK 2,778,064

COINING METHOD AND APPARATUS

Filed Oct. 20, 1951

Fig. 1

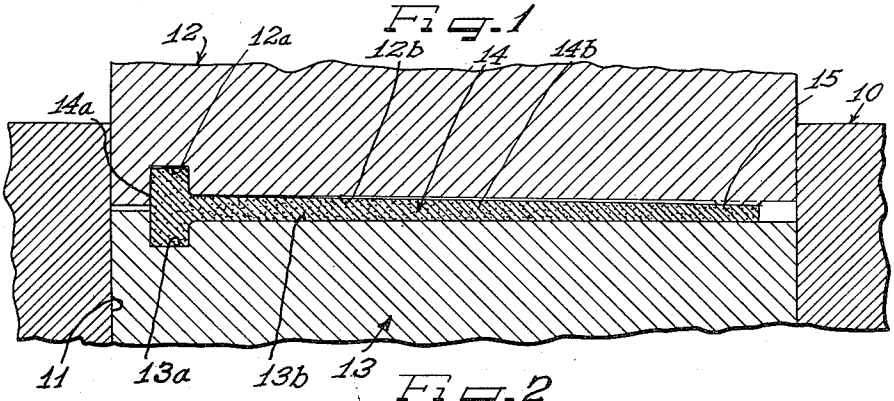


Fig. 2

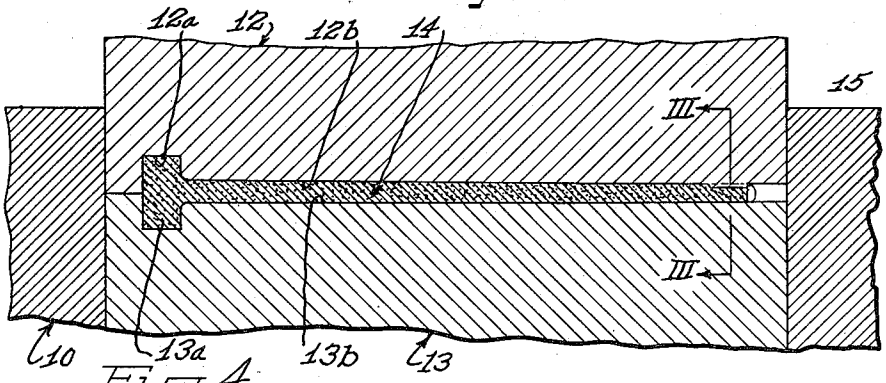


Fig. 4

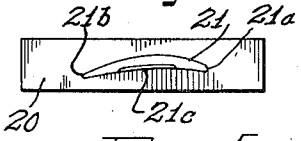


Fig. 5.

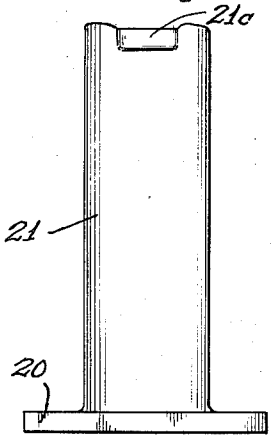
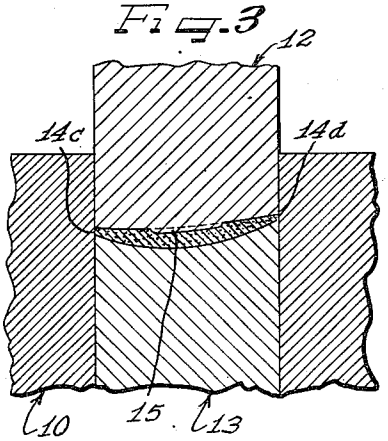


Fig. 3



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COINING METHOD AND APPARATUS

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3 Claims. (Cl. 18—59.3)

The present invention is concerned with the shaping and particularly the coining of powdered metal compacts.

One of the most difficult articles to coin satisfactorily is an article such as a compressor blade for a jet turbine engine. A blade of this type normally consists of a relatively massive root portion and an arcuate, twisted vane portion of varying thickness, including a leading edge, a relatively thick central portion, and a relatively thin tapered trailing edge. The problem of shaping such compressor blades from powdered metal compacts is complicated by the fact that such blades must have close dimensional tolerances in the twisted and arcuate vane portions to achieve optimum aerodynamic characteristics.

In the past, attempts have been made to coin a preformed powdered metal compact into the shape desired in the compressor blade while at the same time increasing the density of the powdered metal compact to the proper value for further metallurgical treatment, such as infiltration with a low melting metal such as copper.

In coining powdered metal compacts to produce the twisted shape required, while simultaneously increasing the density of the powdered metal compact for further metallurgical operations, the usual practice is to place the preformed powdered metal compact of iron or a similar metal in a cavity defined between two cooperating punch elements, the elements being slidably disposed within recess of a suitable die. The two punch elements are brought together under very substantial pressures, on the order of 5 to 50 tons per square inch to effect the shaping of the article and the substantial compression required to increase the density of the article from a value of about 65% characteristic of the preformed compact, to a value of about 80% of the theoretical density of iron. One of the more serious drawbacks in using this type of coining assembly is the fact that relatively thin edges are difficult to produce, as the powdered metal compact has a tendency to be compressed in a longitudinal direction rather than moving laterally to fill up the edges of the article to the proper density. The result is that in using conventional coining assemblies in the producton of articles such as compressor blades, the unequal compresson of the powdered metal compact between the punches fails to produce sharply defined edges on the coined compact.

In the present invention, I have provided an improved coining assembly for the purpose of shaping preformed powdered metal compacts into arcuate complex shapes such as compressor blades while producing edge portions on the blade of the required density and dimensions. In the punch assembly of the present invention, means are provided to restrain longitudinal movement or flow of the compact material during compression in the coining die, thereby facilitating lateral expansion or flow of the material toward the edges resulting in the production of arcuately shaped, twisted compressor blades having

the proper density and dimensions particularly in the edge portions.

An object of the present invention is to provide an improved coining assembly for the manufacture of articles having relatively thin edges of predetermined density.

Another object of the present invention is to provide an improved coining assembly for fabricating articles such as compressor blades in which elements are provided to facilitate lateral expansion of the preformed metal compact contained in the coining cavity.

Still another object of the present invention is to provide an improved coining assembly including a male punch member having a projection or lug thereon which compresses an end portion of an article being coined thereby to facilitate lateral expansion of the metal of the preformed compact toward the edges of the compact.

Still another object of the present invention is to provide an improved coining method for manufacturing articles of complex shape and having sharply defined edges.

Further objects and features of the present invention will be apparent to those skilled in the art from the following description of the attached sheet of drawings, which by way of preferred example, illustrate a preferred embodiment of the present invention.

In the drawings:

Figure 1 is a fragmentary cross-sectional view of the coining assembly illustrating the manner in which the two punch elements cooperate within the coining die to shape a preformed metal compact contained therein at the beginning of the compression step;

Figure 2 is a view similar to Figure 1 and illustrating the position of the members at the end of the compression step;

Figure 3 is a cross-sectional view taken substantially along the line III—III of Figure 2;

Figure 4 is a plan view of a compressor blade produced according to the process of the present invention;

Figure 5 is an elevational view of the compressor blade illustrated in Figure 4.

As shown on the drawings:

In Figure 1, reference numeral **10** denotes generally a coining die having an interal recess **11** receiving the slidable punch members. A male punch member **12** has forming surfaces **12***a* and **12***b* shaped to define one surface of the compressor blade, including a relatively massive root portion and an arcuate, twisted vane portion.

The male punch member **12** cooperates with a female punch member **13**, the latter having a generally rectangular relieved area **13***a* and an arcuately shaped relieved area **13***b* which, upon relative movement of the punch members **12** and **13** toward each other cooperate with the complementary forming surfaces on the male punch to compress a powdered metal compact **14** and coin the compact **14** into the desired shape.

The compact **14** is preferably composed of a preformed, compacted and sintered mass of iron particles having a shape approximating that of the compressor blade to be produced. The compact **14** is provided with a relatively massive rectangular base portion **14***a* which is arranged to be included between the relieved areas **12***a* and **13***a* of the respective punch members, and a relatively thinner vane portion **14***b* which is acted upon and compressed by the relieved areas **12***b* and **13***b* of the cooperating punch elements.

As best illustrated in the cross-sectional view of Figure 3, the compact **14** also has a relatively thin leading edge **14***c* and a thinner, tapered trailing edge **14***d*. As best seen in Figure 2, the maximum thickness or center of mass of the compact **14**, occurs near the center of the blade. Unless means are provided for facilitat-

ing lateral flow of the compact 14 toward the edges 14*c* and 14*d*, edge portions of unequal density, and lacking the fine detail required in the compressor blade, will be produced. To facilitate such lateral flow of the compacts 14 toward the edge portions, the male punch member 12 is provided with a projection or lug 15 extending into the coining cavity between the cooperating surfaces of the punch members 12 and 13. As best seen in Figure 3, the marginal edges of the lug 15 terminate short of the edges of the coining cavity. Further, it will be observed from Figure 1 that the lug 15 extends into the coining cavity farther than the other cooperating surfaces of the punch element so that the lug 15 strikes the compact 14 first during initial relative movement of the two punch elements 12 and 13 toward each other. As a result, the pressure of the lug 15 against the blade end of the compact 14 in the vicinity of its maximum thickness pinches the compacted metal powder in that area of the coining cavity, and as the rest of the punch elements progressively contact the compact from the root end to the blade end the powdered metal compact will expand laterally to obtain good edge characteristics.

In the improved punch assembly of the present invention, the punch progressively works on the compact, from the root end, that is, the first portions of the punch assembly to contact the compact after the initial compression made by the lug 15 are the root defining relieved areas 12*a* and 13*a*. Alternatively, the punch elements can be designed so that the root defining relieved areas 12*a* and 13*a* strike the compact simultaneously with the lug 15, as long as the lug 15 is urged against the compact prior to the time that the vane defining relieved areas 12*b* and 13*b* compress the vane portion 14*b* of the compact 14. Further, the vane defining relieved areas 12*b* and 13*b* are suitably tapered so that the portion of the vane nearest the root end is compressed first, followed by compression of portions of the vane further removed from the root end, and so on until the extreme end of the vane portion is compressed, as indicated in Figure 2.

As previously mentioned, the width of the lug is less than the width of the punch members to which it is attached, so that the lug pinches the longitudinal central portion of the compact where the vane portion has its maximum thickness. Restricting the area of the lug element results in a higher unit pressure in this area. It will be noted that the presence of the lug still permits some longitudinal flow of powdered metal beyond the edges of the lug, but longitudinal flow in this region is desirable to insure proper edge densities at the corners of the vane.

Relative movement of the punch elements 12 and 13 toward each other is accomplished by placing the coining die in a suitable high-pressure apparatus such as a knuckle press or a hydraulic press and forcing the two punch elements toward each other at substantial pressures on the order of 5 to 50 tons per square inch.

The coined compressor blade is illustrated in Figures 4 and 5 and is shown in these figures, the blade includes a relatively massive rectangular root portion 20 and a twisted, arcuately shaped vane portion 21 including a relatively rounded leading edge 21*a* and a thin, tapered trailing edge 21*b*. The extreme forward edge of the

vane portion 21 may also have a slight imprint 21*c* resulting from the compression of the lug 15 against the edge.

The shape of the lug 15 is not critical as long as the lug will exert substantial pressure on the forward end of the vane portion of the compact to block longitudinal flow in the thickest portion of the vane and facilitate lateral expansion of the powdered metal compact toward the edges.

From the foregoing, it will be appreciated that the present invention will provide an improved punch assembly for coining metal articles to complex shapes, particularly where such articles are to be provided with relatively thin edges of uniform density.

It will be understood that modifications and variations may be effected without departing from the scope of the novel concepts of the present invention.

I claim as my invention:

1. The method of coining a powdered metal compact having a relatively thick base portion and an arcuate, relatively thinner body portion having its maximum thickness in the region of its longitudinal center and having relatively thin edge portions which comprises inserting a preformed powdered metal compact havng a shape approximatlng that of the finished article between two relatively movable relieved punch members which define a coining cavity, compressing the body portion in the vicinity of its longitudinal center laterally spreading the powdered metal compact toward the thin edge portions, immediately thereafter compressing the relatively thick base portion of said compact, and then progressively compressing said body portion from said base portion toward the end of said body portion.

2. The method of coining a pre-formed compact having an elongate body of maximum thickness along a longitudinal center of mass and relatively thin lateral edge portions which includes the steps of, pinching a localized portion of the body at one end and at the longitudinal center of mass to block longitudinal flow in the thickest part of the body, and thereafter progressively compressing the compact from the opposite ends of the body to facilitate lateral expansion of a compact toward the edges.

3. A coining assembly for coining a pre-formed compact having an elongate body of maximum thickness along a longitudinal center of mass and thin lateral edge portions comprising, a die having an internal recess, male and female punch members slidably supported by said die and having an elongate shaping cavity formed therebetween, pinching means on one of said punch members at one end thereof at the longitudinal center of mass of said shaping cavity to block longitudinal flow after initial contact with the compact, and tapered compact-engaging surfaces on said punch members to progressively compress the compact from the opposite end thereof to facilitate lateral expansion of the compact toward the edges.

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