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PRODUCTION OF HOLLOW METAL ARTICLES

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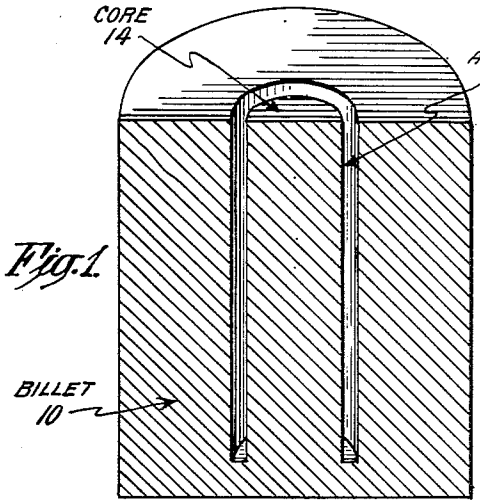


Fig. 1.

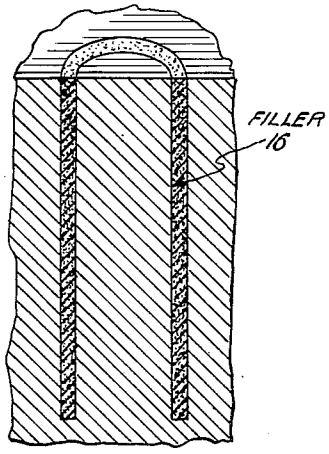


Fig. 1A.

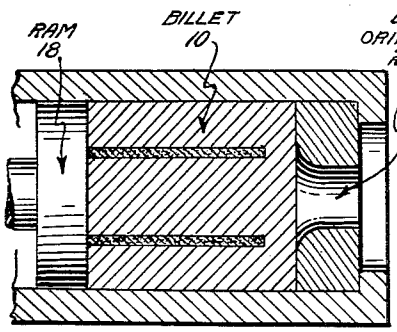


Fig. 2.

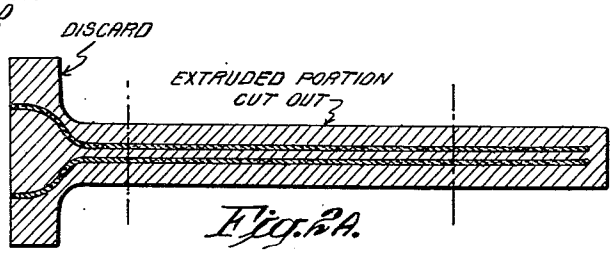


Fig. 2A.



Fig. 2B.

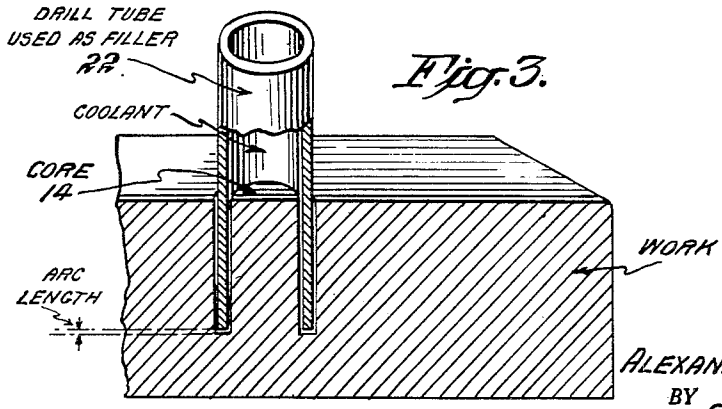


Fig. 3.

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PRODUCTION OF HOLLOW METAL ARTICLES

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3 Claims. (Cl. 29—423)

The present invention relates to a method for producing metal articles containing inner passages or cavities and, more particularly, to a special method which affords improved dimensional control in the production of said inner passages or cavities.

It is known that in the manufacture of special metal shapes, such as gas turbine blades or guide vanes employed in aircraft gas turbines, it is frequently desirable to provide inner passages or cavities in such blades or vanes. Thus, the gas turbine designer may wish to provide internal cooling for the blades and/or vanes used in the hot zone of a gas turbine and in such a case passages must be provided in the blades, etc., to carry the coolant, which is usually a gas. Again, it may be desired to reduce the weight of the rotating gas turbine members and this may be accomplished by hollowing out the blades, e. g., by providing internal passages therein.

Those skilled in the art know that the blades or vanes which are employed in the high temperature portions of a gas turbine are made of very refractory high temperature alloys, such as nickel-chromium alloys, nickel-chromium-iron alloys, nickel-chromium-cobalt alloys, etc. These alloys also may contain substantial amounts of other alloying or addition metals, including tungsten, vanadium, molybdenum, aluminum, titanium, columbium, etc. Because of the refractory nature of such alloys, it is a practical impossibility to drill the finished parts made therefrom, e. g., a gas turbine blade or vane, to provide internal passages or cavities therein, especially when such passages or cavities are of small diameter.

Accordingly, it has been proposed heretofore to provide inner passages or cavities in such articles by a process comprising drilling a metallic body or billet which is made of an appropriate metal for the desired service, filling the resulting holes with a filler material and then hot working the resulting metallic body by extrusion or otherwise. The resulting hot worked article can then be cut to desired size and the filler material can be removed to provide the desired inner passages or cavities therein. Usually, the passages or cavities extend longitudinally through the worked article.

It has been found in practice that the hot working characteristics of the filler material, in relation to the hot working characteristics of the billet metal, govern to a great extent the uniformity of dimension in the elongated holes resulting from the hot working of the initially filled billet. Thus, if the filler material is more readily deformable than the metal, the reduction in the cross-sectional area of the filled hole during hot working will be proportionately greater than that of the metal. In addition, the said cross-sectional area will vary along the length of the hole. On the other hand, if the filler is less readily deformable than the metal, it will act as a mandrel in the extrusion. In this manner, the filler will pass through the die before extrusion of the metal is complete and the trailing end of the extruded section will

contain no filler. In addition, the cross-sectional area of the hole formed will be irregular.

I have now discovered a method whereby the dimensional accuracy of internal passages or cavities produced during the hot working of billets containing filled holes can be achieved with a high degree of control over the dimensions of the final passages or cavities produced in the hot worked article.

It is an object of the present invention to provide a method wherein improved dimensional control is achieved in the production of hot worked metal articles containing internal passages or cavities.

Other objects and advantages will become apparent from the following description taken in conjunction with the accompanying drawings in which:

Fig. 1 is a sectional view of a billet illustrating a blind cored hole defining a concentric core of billet metal;

Fig. 1A depicts the cored hole of Fig. 1 filled with filler material;

Fig. 2 is illustrative of the billet in Fig. 1A in an extrusion press;

Fig. 2A depicts the extruded billet;

Fig. 2B shows the extruded billet with core and filler removed; and

Fig. 3 is illustrative of another embodiment carrying out the present invention.

According to this invention, the hole or each hole initially produced in the billet is of annular or other section such that a core is left inside it. Preferably, the holes are machined or cut by electric erosion into the billet or the like. It is also preferred that the erosion be stopped before the hole passes right through the billet or the like so that a closed end is left. A dissimilar filler is then inserted in each hole around the core, i. e., the space between each core and each corresponding wall in the billet is filled with the filler material, and the billet or the like is worked to the desired cross section. Thereafter, the closed end is removed. After the filler has been removed, by acid leaching or otherwise, the core in each hole is loose and can also be removed. Alternatively, the original hole can be made right through the billet or the like so that the core is freed, and this free core (or a like core of essentially the same composition) is used inside a filler to fill the hole before the billet or the like is worked.

The process of electric erosion is described, for instance, in "Aircraft Production" dated August 1952, pages 271 to 274.

The method according to the invention presents the advantages that the holes can be of any desired cross section, whereas only circular holes can be made by drilling and that, by the use of electric erosion, annular or other-sectioned cored holes of very small width can be made so that the total volume of filler required to fill them is small, with the result that the time taken to remove the filler subsequently is much reduced.

The removable filler should have the same deformation characteristics as the metal of the billet or other blank. It may advantageously be used as a preformed metal sleeve inserted into the hole around the core. It should, of course, be attacked by a leaching acid more easily than the metal of the blank or be otherwise capable of removal without damaging the blank. Thus, the filler material should, for example, be susceptible to a selective chemical or electrochemical attack as compared to the billet metal.

When the removable filler is a preformed sleeve, e. g., is a section cut from a length of extruded or cold drawn metal, it or a duplicate (e. g., another section cut from the same extruded or cold drawn length) may, when the

filler material is suitable, be used with advantage as the electrode in the erosion process.

It will be seen in accordance with the foregoing that the hole or holes which are machined into the initial billet have inner and outer walls defining a substantially concentric core and may conveniently be referred to as "cored holes" which may have any cross-sectional configuration. It is preferred in accordance with the invention to discontinue the drilling operation before the core becomes completely detached from the remainder of the billet, i. e., it is preferred to drill a "blind" cored hole. In this way, the core remains fastened in its place in the billet and the filling of the cored hole with the desired filler material is facilitated.

The required filler material may be selected from a number of suitable materials depending to some extent upon the nature of the particular heat-resisting alloy being worked. As an example, it can be pointed out that the iron-magnesia filler material disclosed in the Hignett U. S. application Serial No. 472,755, filed December 2, 1954, may be employed satisfactorily in accordance with this invention in the treatment of many of the common heat-resisting alloys used in manufacturing gas turbine blades and vanes. Another satisfactory filler material comprises a special alloy steel containing about 1% to 10% titanium, about 5% to 20% manganese and up to about 0.5% carbon and is the subject matter of a separate patent application Serial No. 509,380 in the name of Walter Betteridge.

For the purpose of giving those skilled in the art a better understanding of the invention, reference is now made to the drawing illustrating, by way of example, procedural steps by which the present invention can be carried into practice.

Referring to Fig. 1, there is illustrated a cylindrical billet **10** in which cored hole **12** has been provided, e. g., by electric erosion or other machining processes. The hole which is illustrated as of annular cross section can be of other suitable cross section. As referred to hereinbefore and as shown in Figs. 1 and 1A, it is desirable to discontinue the machining operation short of one end of the billet to thereby provide a "blind" cored hole having a substantially concentric integral core **14** of billet metal. A suitable filler material **16** fills the cored hole **12** and the billet can be then hot worked, e. g., by an extrusion operation. The filler material can be in compacted powder form or desirably in the form of metal sleeves, or in other suitable forms apparent to those skilled in the art. As shown in Fig. 2, the ram **18** forces the cored billet through die orifice **20** to thereby provide an extruded product of predetermined configuration such as illustrated in Fig. 2A. The extruded product can be then cut and the filler material removed therefrom by leaching or otherwise. The core is easily removed as shown in Fig. 2B.

In Fig. 3, there is depicted a modification for providing a cored hole in a billet and filling the same with a filler material. In this instance, a preformed metallic sleeve **22** is employed as the electrode or drill tube in the machining process, e. g., electric erosion. The sleeve after this operation then serves as the filler material. As will be readily understood by those skilled in the art, a suitable arc length is maintained and a suitable coolant can be employed during the eroding operation.

It will be seen that when the filled billet produced in accordance with the present invention is hot worked as by extrusion or hot rolling, the core and the filler in the hole flow in a similar way to the remainder of the billet. This factor contributes to improved dimensional accuracy and control in the production of the desired passages and/or cavities in the final hollow metal article.

Although the present invention has been described in conjunction with preferred embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention, as those skilled in the art will readily understand. Such modifications and variations are considered to be within the purview and scope of the invention and appended claims.

I claim:

1. The method for producing a hollow metal article having at least one internal passage or cavity comprising electrically eroding a metal billet to provide therein at least one longitudinally located, annular, blind hole having inner and outer walls defining a substantially concentric, integral core of billet metal, said electric erosion operation being performed while utilizing a preformed metal electrode sleeve; leaving said electrode sleeve in situ to thereby provide a filler material in said cored hole; hot working the resulting billet in a direction parallel to said filled, cored hole to change the cross section of said billet and said cored hole; and removing the filler material and core from each hole to provide a worked metal article having at least one passage or cavity therein.

2. The method for producing a hollow metal article which comprises electrically eroding a metal billet to provide therein at least one blind hole having inner and outer walls defining a substantially concentric, integral core of billet metal, said electric erosion operation being performed while utilizing a preformed electrode sleeve; leaving said electrode sleeve in situ to thereby provide a filler material in said cored hole; working the resulting billet to change the cross section thereof; and removing the sleeve and core from said hole to thereby provide a hollow metal article having at least one passage or cavity therein.

3. A method for producing a hollow metal article characterized by at least one internal passage of uniform cross-sectional area along the length thereof which comprises providing in a metal billet of refractory high temperature alloy at least one annular blind hole, said annular hole having an inner wall constituting the outer surface of a self-sustaining, unremoved and substantially concentric core of billet metal integral with said billet, filling the space between the self-sustaining integral core of billet metal and the outer wall of said blind hole with a dissimilar filler material having substantially the same deformation characteristics as the metal of the billet, working the resulting billet having said blind hole containing said self-sustaining integral core of billet metal and said filler material to alter the cross section thereof, cropping the end where the core is integral with the billet to separate the core from the connecting body of the formed billet, selectively removing the filler material, and then removing the core.

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