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M. S. ROUSH

2,807,437

METHOD FOR MAKING INTRICATE HOLLOW POWDER METAL PARTS

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FIG-1.

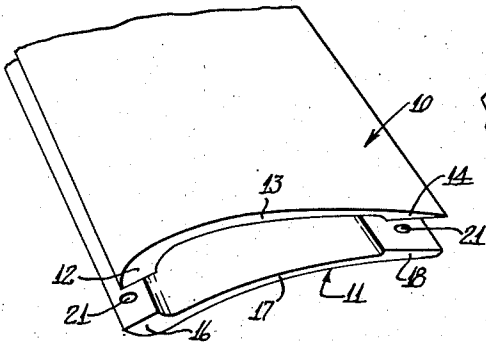


FIG-3

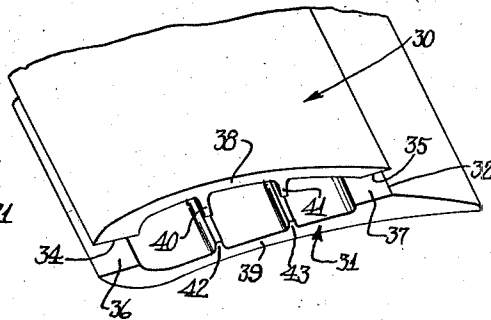


FIG-2

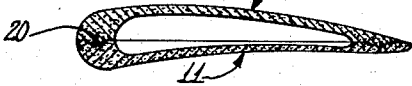


FIG-4

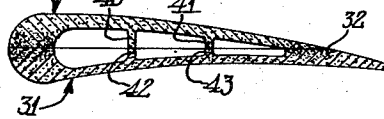
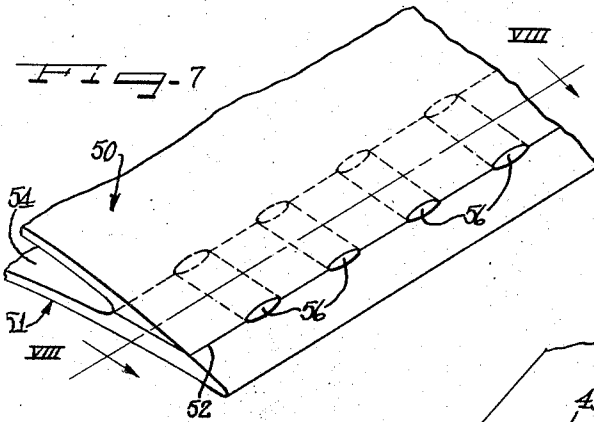


FIG-7



VIII

FIG-8

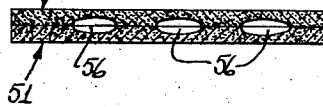


FIG-5

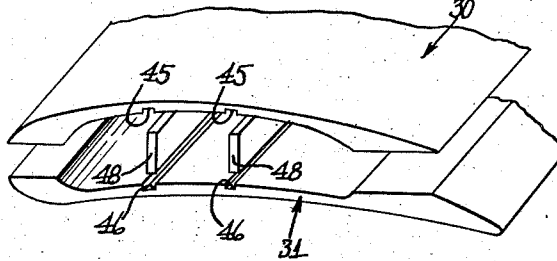
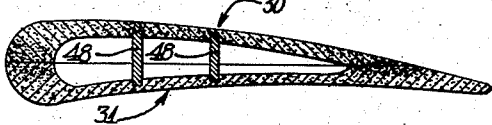


FIG-6



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2,807,437

METHOD FOR MAKING INTRICATE HOLLOW POWDER METAL PARTS

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9 Claims. (Cl. 253—77)

The present invention is concerned with the manufacture of fluid directing members from powdered metal, particularly fluid directing members for use in jet engines.

The present invention is particularly applicable to the manufacture of hollow fluid directing members such as inlet guide vanes, rotor blades and stator vanes of jet turbine engines and involves forming powdered metal compacts into segmental sections of the finished member, the interior of each of the segmental sections being suitably recessed to define the particular shape desired in the hollow section of the finished article when the segmental sections are assembled. Upon assembly of the sections, the segments are joined into an integral fluid directing member by infiltration of the powdered metal sections with a suitable infiltrant metal.

An object of the present invention is to provide an improved method of making intricate, hollow powder metal parts.

Another object of the present invention is to provide an improved method for assembling porous metal compacts, and joining the compacts together by a process of infiltration with metal.

Another object of the present invention is to provide an improved hollow fluid directing member composed of powdered metal segmental sections.

Another object of the present invention is to provide an improved fluid directing member in which selected areas of the member are provided with different porosities.

Still another object of the present invention is to provide a fluid directing member composed of segmental sections, each consisting of a powdered metal compact, the sections upon assembly defining a hollow interior and having cooling slots communicating the hollow interior of the fluid directing member with the surface of the member.

In making the fluid directing members of the present invention, powdered metal, such as powdered iron or a powdered heat resistant alloy composition is molded into a plurality of segmental sections which upon assembly define the shape of the ultimate fluid directing member. The segmental compacts are then sintered and coined prior to assembly. Upon assembly of the two segmental portions, the assembled compacts are bonded together by means of infiltration with a metal infiltrant network, thereby bonding together the porous metal skeletons of the segmental sections.

One of the advantages of using the above described method resides in the fact that the segmental sections are coined separately so that, if desired, each of the sections may be selectively coined to produce areas of differing density and porosity within the same section. For example, in the case of guide vanes, the portions of the segmental sections defining the leading and trailing edges of the vane may be coined to leave these areas with a porosity greater than the porosity of the central portion of the vane.

The control of porosity inherent in the presently de-

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scribed processes is very useful in the manufacture of inlet guide vanes, where a fluid is bled through the vanes for de-icing purposes, and for the manufacture of nozzle vanes where a liquid coolant is bled through the porous portions of the vane for evaporative cooling.

A further description of the present invention will be made in connection with the attached sheets of drawings which illustrate four types of fluid directing members produced according to the present invention.

In the drawings:

Figure 1 is a fragmentary view in perspective of two segmental powdered metal compacts used in the manufacture of an inlet guide vane, the two segments being shown prior to assembly thereof;

Figure 2 is a cross-sectional view of the inlet guide vane of Figure 1, with the segments thereof in assembled relation after infiltration;

Figure 3 is a fragmentary view in perspective of a modified form of the invention in which each of the segmental sections is provided with longitudinally extending ribs;

Figure 4 is a cross-sectional view of the fluid directing member of Figure 3, with the segments thereof in assembled relation after infiltration;

Figure 5 is a fragmentary view in perspective of still another modified form of the invention in which separate ribs are provided within the hollow interior of the vane;

Figure 6 is a cross-sectional view of the fluid directing member of Figure 5, after assembly and infiltration;

Figure 7 is a fragmentary view in perspective of another modified form of the present invention in which cooling slots are provided to communicate the hollow interior of the vane with the surface of the vanes; and

Figure 8 is a cross-sectional view taken substantially along the lines VIII—VIII of Figure 7.

As shown in the drawings:

Reference numerals 10 and 11 indicate generally two compacted metal hollow sections molded by conventional powder metallurgy techniques. Section 10 is generally of a convex configuration externally, while section 11 is generally concave externally, the two sections 10 and 11 upon assembly defining an arcuately shaped hollow fluid directing vane. Convex section 10 includes a longitudinally extending thickened marginal portion 12 having a flattened inner face, a recessed arcuate longitudinally intermediate portion 13, and a relatively flat faced longitudinally extending opposite marginal portion 14, while the concave section 11 includes a similar inner relatively flat longitudinally extending marginal portion 16, a generally arcuate recessed intermediate longitudinal portion 17, and an inner relatively flat longitudinally extending opposite marginal portion 18. In order to locate the sections 10 and 11 in proper alignment, the longitudinally extending marginal portions 12 and 14 of the section 10 may be provided with spaced conical locating pins or bosses 20 (Figure 2) which are received within complementary conically shaped recesses 21 provided in the longitudinally extending marginal portions 16 and 18 of section 11.

The sections 10 and 11 may be composed of any suitable metal such as iron, where the fluid directing member is to be used under relatively low operating temperatures, or may be composed of heat resisting alloys where the parts are to be employed in the hot zone of a jet engine. In a preferred embodiment of the present invention, the metal particles making up the sections 10 and 11 are separately molded, and sintered in a protective atmosphere of hydrogen, or the like, at a sintering temperature appropriate to the metal used. After sintering, the sintered compacts are then coined into final shape prior to assembly. In a preferred embodiment of the invention, the sections are selectively coined to make portions of the section more porous

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than other areas of the same section. For example, in the vane structure of Figure 1, it is preferable to make the areas of the sections adjacent to the leading and trailing edges more porous than the central portion of the vane structure.

After coining, the compacted metal sections 10 and 11 are assembled together with the locating pins 20 received within the recesses 21, and the sections 10 and 11 are then clamped together. The powdered metal sections are joined into an integral member by infiltrating the sections about their areas of contact with an infiltrant metal. For low temperature work, copper and copper base alloys form a suitable infiltrant for ferrous metal compacts, while for fluid directing members intended for very high temperature work, heat and oxidation-resistant alloys will be indicated for the infiltrant.

In infiltrating the assembled compacts, a rod of solid copper or copper alloy, or other infiltrant metal is placed over the areas of the assembled sections 10 and 11 at each end of the hollow intermediate chamber defined by the segmental sections. The resulting assembled compacts and the infiltrant metal are then introduced into a furnace maintained at a temperature above the melting point of the infiltrant metal, and retained therein for a time sufficient to permit diffusion of the molten infiltrant metal through the inter-particle voids in the powdered metal sections. After cooling and upon solidification of the infiltrant metal, the porous metal sections are joined together by means of a network of the infiltrant metal. Since the leading and trailing edge face portions of the assembled compacts are more porous than the central portion due to selective coining, there will be a greater quantity of infiltrant metal per unit area at these leading and trailing edge portions than at the portions intermediate the ends. This difference in infiltrant concentration has been indicated by heavier stippling in the drawings in the areas of greater infiltrant concentration. Further heat treatment of the infiltrated compact to improve the physical characteristics of the compact may then be carried out according to the process described in Goetzel Patent No. 2,456,779 issued December 21, 1948.

The modified form of the invention illustrated in Figures 3 and 4 provides longitudinally extending ribs through the hollow central portion of the vane. As seen in these drawings, the composite vane is built up from a pair of powdered metal sections, comprising a convex shaped upper section 30 and a concave shaped lower section 31. The lateral width of the upper section 30 is less than the width of the lower section 31, and the two sections merge together into a continuous airfoil contour along a parting line 32 spaced laterally from the extreme marginal edge of the lower section 31.

The two mating sections 30 and 31 have cooperating abutting surfaces, the upper section 30 having spaced longitudinally extending flat faces 34 and 35 at opposite margins thereof, while the lower section 31 has generally flat longitudinally extending faces 36 and 37 which cooperate with the faces 34 and 35 to define the airfoil contour of the vane. The sections 30 and 31 have recessed intermediate portions 38 and 39 respectively which upon alignment of the sections 30 and 31 define a generally hollow interior. The upper section 30 is provided with a pair of spaced longitudinally extending ribs 40 and 41 which abut correspondingly located ribs 42 and 43 in section 31 upon assembly of the two sections to provide longitudinally extending ribs intermediate the edges of the vane which divide the hollow interior of the vane into three spaced hollow compartments.

Infiltration of the assembled sections 30 and 31 can be accomplished in the same manner as that described for the form of the invention illustrated in Figures 1 and 2. In addition to supplying infiltrant metal along the abutting faces 34, 36, 35 and 37 additional amounts of infiltrant metal can be applied centrally of the vane along the ribs 40, 41, 42 and 43 to provide additional bonding between the assembled sections.

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The form of the invention illustrated in Figures 5 and 6 is similar to that shown in Figures 3 and 4 except that preshaped individual ribs are employed in place of the integral ribs of the previous form. In this form of the invention, the convex upper section 30 as well as the concave lower section 31 are provided with longitudinally extending grooves, the grooves or notches in the upper section 30 being identified at numeral 45, and those in the lower section 31 being identified at numeral 46. Upon assembly of the sections 30 and 31, the grooves or notches 45 and 46 are vertically aligned to receive a pair of elongated, rectangular ribs 48 therein. The ribs 48 are preferably composed of a powdered metal compact of the type employed in the body of the sections 30 and 31. The infiltration of the assembled sections with the ribs in place is carried out in the manner described for the previous forms of the invention.

The modified form of the invention illustrated in Figures 7 and 8 of the drawings is applicable to any of the previously described modifications. In this form of the invention, an upper section 50 composed of a powdered metal compact, and a lower section 51 of similar composition are assembled together in face contact along a parting line 52. The internal recesses in the sections 50 and 51 define an internal cavity 54. Each of the sections 50 and 51 is coined prior to assembly to provide laterally extending complementary notches in the mating face of each section which, upon assembly of the two components, define spaced cooling slots 56 which communicate the hollow cavity 54 with the surface of the finished vane. It will be appreciated that these cooling slots may be placed in both the leading and trailing edges of the vanes or blades, and that the provision of these laterally extending slots provide for more efficient cooling of the fluid directing member. Since the slots 56 are of substantial width compared to the size of the pores of the mating sections 50 and 51, infiltration of the assembled sections with the infiltrant metal does not fill up the slots.

It will be appreciated 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 making hollow powdered metal parts which comprises shaping a pair of powdered metal compacts into a pair of sections each having longitudinally extending marginal portions and an intermediately recessed portion between said marginal portions, coining said sections to provide the marginal portions thereof with a greater porosity than the intermediate portions thereof, assembling said pair of sections together with the longitudinally extending marginal portions of one of said pair of sections abutting the longitudinally extending marginal portions of the other of said sections, with the recessed portions of both of said sections cooperating to form a hollow central portion between the abutting portions, and infiltrating the assembled sections with an infiltrant metal along the greater porosity abutting portions to bond said abutting portions together.

2. The method of making hollow powdered metal parts which comprises molding powdered metal compacts into a pair of sections each having longitudinally extending face portions and an intermediately recessed portion between said face portions, sintering said sections, selectively coining said sections to produce a pair of porous sections each having longitudinally extending face portions and an intermediately recessed portion between said face portions, said longitudinally extending face portions having a higher degree of porosity than said intermediately recessed portion, assembling said pair of sections together with the longitudinally extending face portions of one of said pair of sections abutting the longitudinally extending face portions of the other of said sections, with the intermediately recessed portions of both of said sections cooperating to form a hollow central portion between the

abutting face portions, and infiltrating the assembled sec-

tions with an infiltrant metal along the relatively higher degree of porosity abutting face portions to bond said abutting face portions together.

3. A hollow fluid directing member comprising a pair of porous compacted powdered metal sections, said sections each including leading and trailing edge portions in face contact, with a recessed portion defining a substantially hollow portion included between the leading and trailing edge portion, said sections being joined together with an infiltrant metal and having a greater quantity of the infiltrant metal per unit area at the leading and trailing edge portions than at the portions of said member between said leading and trailing edge portions.

4. A hollow fluid directing member comprising a pair of porous compacted metal sections each having longitudinally extending face portions and a recessed intermediate portion extending therebetween, said sections being joined together with said longitudinally extending face portions in abutting contact, and said intermediate recessed portions cooperating to define a substantially hollow interior between said face portions, said sections being joined together with an infiltrant metal and having a greater quantity of infiltrant metal per unit area at the face portions than in said intermediate portions.

5. A hollow fluid directing member comprising a pair of porous compacted metal sections each having longitudinally extending face portions and an intermediate recessed central portion extending therebetween, said face portions having a greater porosity than said recessed portions, said sections being joined together with said longitudinally extending face portions in abutting contact and said recessed portions cooperating to define a generally hollow interior between said face portions, said sections being joined together with an infiltrant metal and having a greater quantity of infiltrant metal per unit area at the face portion than in said intermediate portions.

6. A hollow fluid directing member comprising a pair of porous compacted metal sections each having a pair of spaced longitudinally extending face portions and a recessed intermediate portion therebetween, one of said pair of sections having protuberances extending from its longitudinally extending face portion, the other of said pair of sections having apertures therein receiving said protuberances to position said sections in alignment with each other with the longitudinally extending face portions on the other of said sections, the recessed portion of each of said sections when in assembled position cooperating to define a substantially hollow interior, and an infiltrant metal network joining said sections together along the abutting longitudinally extending face portions of said sections and having a greater quantity of the infiltrant metal per unit area at the longitudinally extending face portions than in said intermediate portions.

7. A hollow fluid directing member comprising a pair of porous compacted metal sections each having a pair of spaced longitudinally extending face portions and a recessed intermediate portion therebetween, each of said sections having longitudinally extending ribs disposed be-

tween said longitudinally extending face portions, said sections being joined together with the longitudinally extending face portions and the ribs of one of said sections being in abutting contact with the longitudinally extending face portions and ribs of the other of said sections, the recessed portion of each of said sections when in assembled position cooperating to define a substantially hollow interior, and an infiltrant metal network joining together the abutting longitudinally extending face portions of said sections and having a greater quantity of the infiltrant metal per unit area at the longitudinally extending face portion than in said intermediate portions.

8. A hollow fluid directing member comprising a pair of porous compacted metal sections each having a pair of spaced longitudinally extending face portions and a recessed intermediate portion therebetween, said sections being assembled with the longitudinally extending face portion of said sections in face to face contact, each of said sections having at least one longitudinally extending notch between the longitudinally extending face portions thereof in alignment with a notch on the other of said sections, a rib received within the aligned notches, the recessed portions of said sections when in assembled position cooperating to define a substantially hollow interior, and an infiltrant metal network bonding the longitudinally extending face portions of said sections together and having a greater quantity of the infiltrant metal per unit area at the longitudinally extending face portions of said sections than in said intermediate portions.

9. A fluid flow directing member comprising a pair of porous powdered metal compacts defining an arcuate fluid directing vane, said compacts being separated in an intermediate portion thereof to provide a substantially hollow, longitudinally extending interior, both of said sections being slotted transversely of said vane to provide a plurality of open-ended slots communicating said hollow interior with the surface of said vane, said compacts being joined together along areas beyond said hollow interior with an infiltrant metal network and having a greater quantity of the infiltrant metal at said areas than in said intermediate portions.

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