

[54] MOLD PATTERN

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[58] Field of Search.....164/247, 248, 215, 216, 133, 164/333, 332, 334, 240; 249/63, 64, 59, 84, 90, 60; 18/DIG. 58

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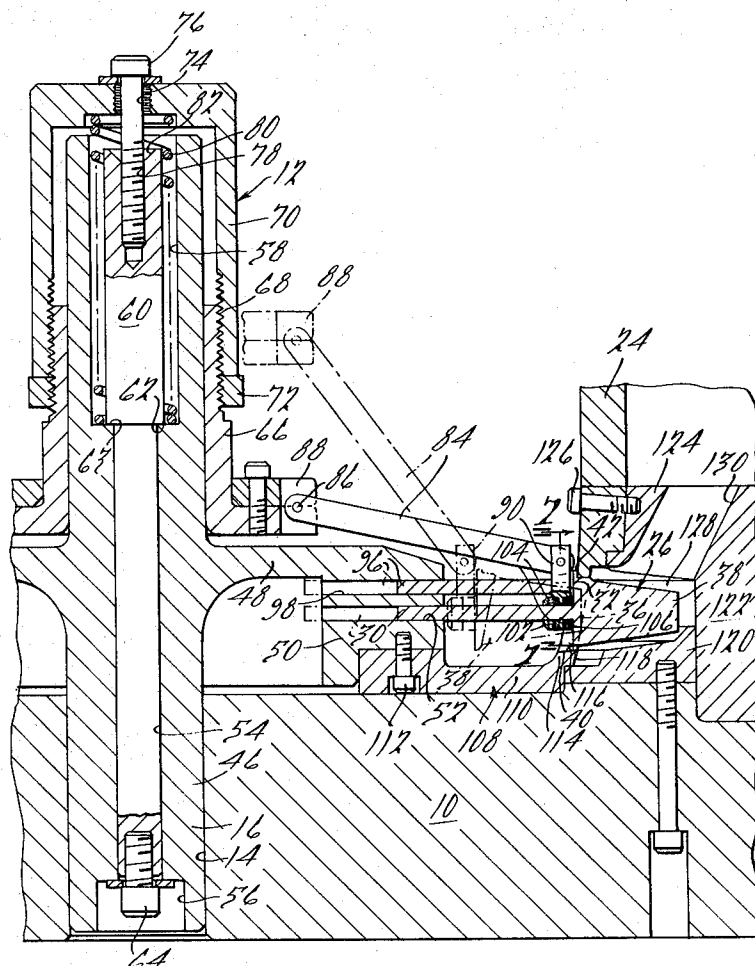
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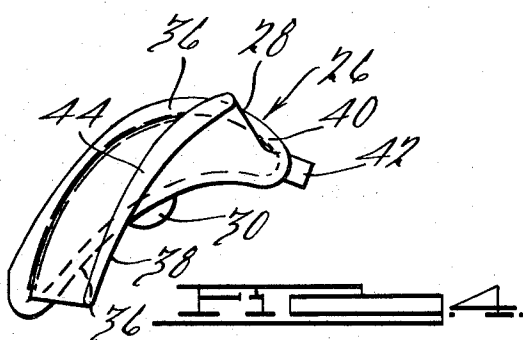
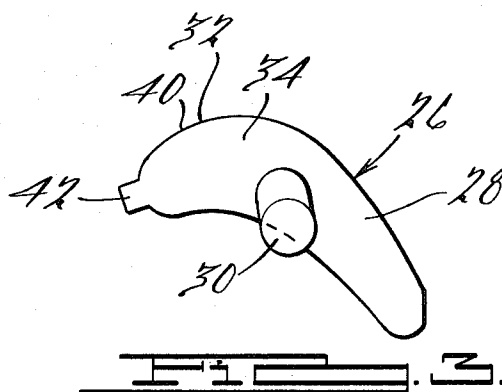
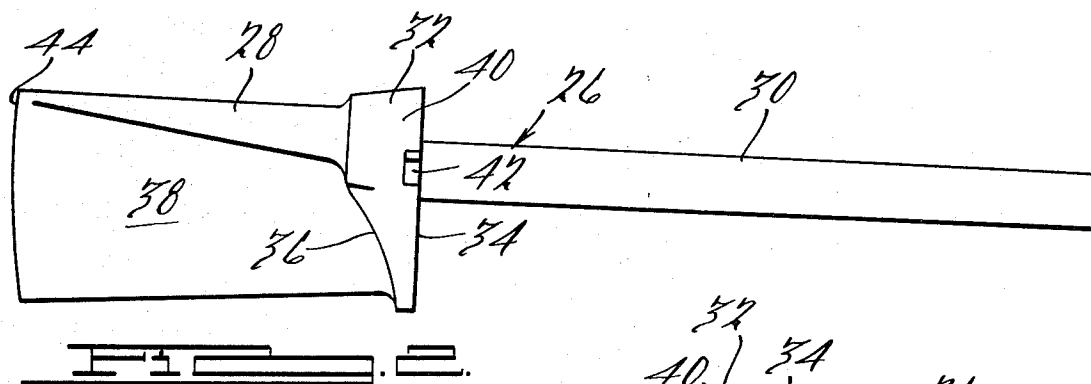
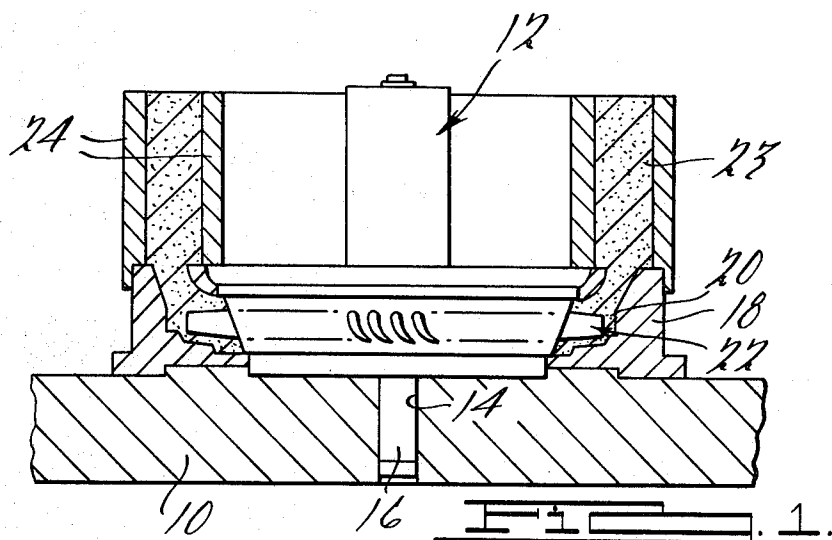
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[57] ABSTRACT

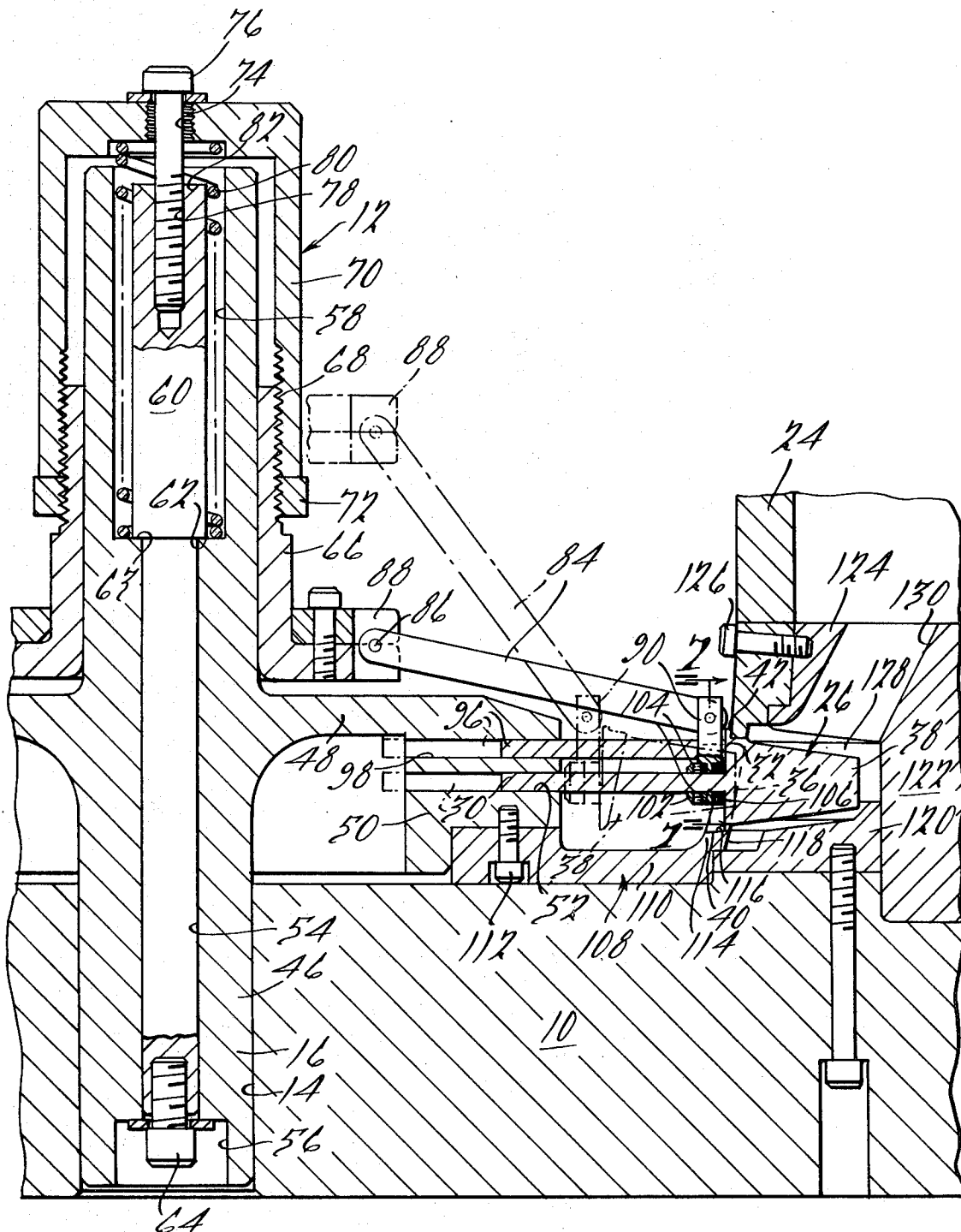
A permanent type non-expendable pattern for making refractory molds in which portions of the pattern are retractable from a projected position in which they are disposed in the cavity to be filled with the refractory molding material and a retracted position in clearance relationship relative to the refractory mold material, enabling an extraction of the pattern from the refractory mold produced. The retractable pattern sections, when in the projected position, are locked in accurate registration with the frame of the pattern, but upon initiation of retraction, are unlocked so as to enable pivoting movement of the sections, whereby they can be withdrawn from the mold cavities formed without damaging the mold surfaces.

10 Claims, 7 Drawing Figures

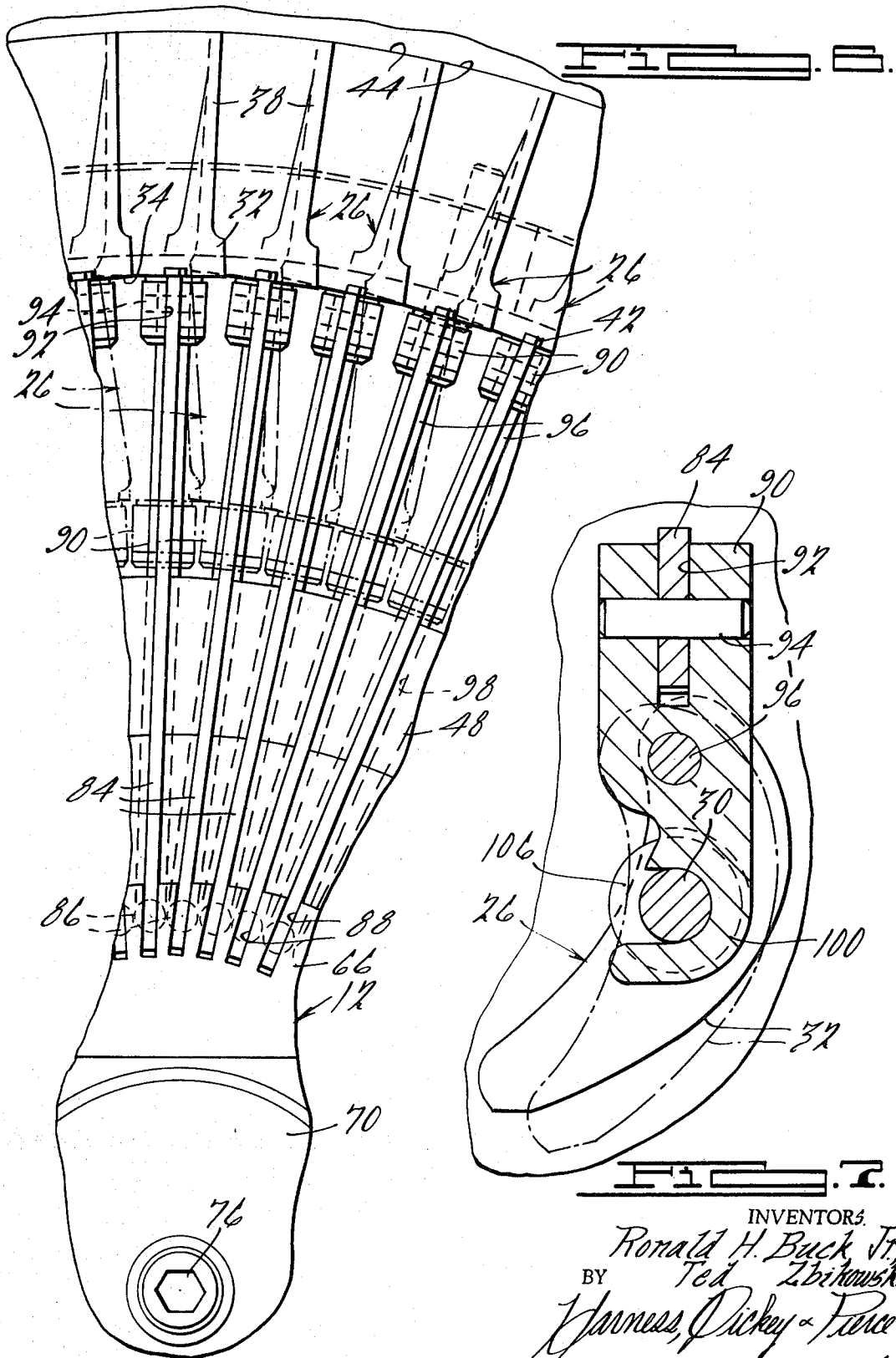




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MOLD PATTERN

BACKGROUND OF THE INVENTION

The use of refractory-type molds composed of silica or ceramic particles bonded by organic or inorganic binding agents is in widespread commercial use for making precision-type castings, requiring only minimal final machining operations. Typical of such techniques is the so-called "lost wax" or "investment casting" process which employs expendable patterns that are composed of waxes or plastic materials. The expendable patterns are conventionally formed in metal dies and are assembled to form a composite pattern of the desired configuration. The resultant expendable patterns are thereafter employed for making the refractory mold in which the embedded pattern corresponds to the mold cavity which subsequently is to be filled with molten metal. The removal of the expendable pattern after the refractory mold has solidified or cured is achieved by the application of heat, effecting a melting, vaporization or thermal degradation of the pattern, leaving a cavity of the desired configuration.

A continuing problem associated with such expendable patterns is their susceptibility to distortion and breakage during handling and forming of refractory molds, which in turn results in mold cavities which are of inaccurate size and configuration. In addition, in the formation of expendable patterns of relatively complicated shape, a plurality of individual sections are conventionally used that must be manually assembled and accurately secured together. This practice constitutes a costly and time consuming operation.

The increasing use of gas turbines as a source of power has placed renewed emphasis on the need for economical manufacturing processes for making turbine wheels and similar components that are of accurate dimensions and balance as is required due to the high speed and centrifugal stresses to which such parts are subjected during use. It has been necessary in the past to form such turbine wheels by individually machining and assembling each blade or bucket to a hub which constitutes a costly manufacturing operation and has detracted from a more widespread use of such engines. Alternatively, investment casting processes employing expendable patterns have been used or proposed for use, but the complexity of the part and the fragile nature of the patterns produced has resulted in relatively high costs in fabricating the patterns, as well as a relatively high scrap rate due to inadvertent warpage or distortion of the patterns during the formation of the refractory molds.

The foregoing and other problems and disadvantages of investment-type casting processes for making turbine wheels and like components of complicated configuration are overcome in accordance with the permanent non-expendable pattern of the present invention which is of high strength and extremely accurate final dimensions, enabling its repeated reuse for making successive refractory molds, each having accurately-sized and shaped mold cavities therein.

SUMMARY OF THE INVENTION

The benefits and advantages of the present invention are achieved by a non-expendable pattern suitable for making refractory-type molds which is composed of a high strength, abrasion-resistant material and consists of a frame of which a portion thereof is provided with a pattern surface which is of a preselected configuration and which is formed with one or more apertures therethrough that are disposed in communication with the pattern surface. A pattern section is movably and guidably mounted on the frame and is disposed in each of the apertures thereof for movement between a projected position in which the section projects outwardly of the pattern surface and a retracted position in which the section is withdrawn inwardly of the pattern surface. Coacting means are provided on the frame and each section for fixedly positioning the section in precise registration relative to the pattern surface when the section is in the projected position and for disengaging the section during its retraction, enabling movement of the section so

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as to permit its withdrawal from the mold cavity formed without damaging or otherwise disturbing the surface of the mold cavity.

Additional benefits and advantages of the present invention will become apparent upon a reading of the description of the preferred embodiments taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic elevation view partly in section illustrating a typical assembly of the non-expendable pattern and molding components for making a refractory-type mold;

FIG. 2 is a plan view of an individual turbine blade pattern assembly comprising a movable section of the permanent pattern;

FIG. 3 is an end view of the individual blade pattern shown in FIG. 2 as viewed from the base end of the turbine blade;

FIG. 4 is an end view of the individual blade pattern shown in FIG. 2, as viewed from the tip end of the turbine blade;

FIG. 5 is a fragmentary vertical transverse sectional view through the non-expendable pattern with the turbine blades disposed in a projected position;

FIG. 6 is a fragmentary plan view with portions broken away for clarity of the non-expendable pattern shown in FIG. 5; and

FIG. 7 is a vertical sectional view taken through the linkage connecting the individual blade patterns as shown in FIG. 5, and taken substantially along the line 7-7 thereof.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now in detail to the drawings and as is best illustrated in FIG. 1, a typical assembly is shown for making refractory-type molds for casting turbine wheels comprising a base 10 on which a permanent non-expendable pattern 12 is accurately positioned. The base 10 is formed with a central aperture 14 extending inwardly of the upper surface thereof into which an aligning pin 16 of the pattern 12 is adapted to be slidably disposed for maintaining these two components in proper registration. An annular back-up mold 18 is positioned on the base and encircles the periphery of the pattern 12 defining therebetween an annular mold cavity 20, into which retractable pattern sections, such as turbine blades 22, project. A suitable particulated molding material 23, containing a bonding agent, is introduced into the mold cavity 20 by means of an annular tubular member 24, removably disposed on the upper surfaces of the back-up mold 18 and the pattern 12. After a setting of the molding material 23, in which it attains sufficient strength to retain dimensional accuracy, the blades 22 are withdrawn inwardly of the pattern 12 and the entire pattern is lifted upwardly, leaving a composite mold consisting of the back-up mold 18 having a lining around its inner surface incorporating a plurality of circumferentially spaced cavities which conform to the configuration of the turbine blades 22. It will be noted that the periphery of the pattern is of a configuration to provide satisfactory draft angles so as to enable upward withdrawal of the pattern from the mold after the blades have been retracted. The resultant composite mold is thereafter assembled with appropriate cores for receiving the molten metal to form a turbine wheel of the requisite configuration.

The details of the construction of the permanent non-expendable pattern 12 will now be described with specific reference to FIGS. 2-7 of the drawings. The movable or retractable mold sections comprise a plurality of individual blade assemblies 26, as best seen in FIGS. 2-4, each of which comprises a blade portion 28 and a supporting pin 30 integrally connected thereto. Each blade assembly may be composed of a high-strength injection molded plastic material such as polystyrene, for example, or of a suitable metal or metal alloy. The supporting pin 30 is of a cylindrical configuration and is provided with a smooth surface finish. The blade portion 28 is composed of a root section 32, which is provided with an air foil shaped cross section. The root section extends

from a rear surface 34 to an arcuate face surface 36, from which a blade 38 projects. The root section 32, as best seen in FIGS. 2 and 4, is formed with a tapered peripheral surface 40 being of progressively decreasing cross sectional area on moving from the rear surface 34 to the face surface 36. In addition, a tab 42 is integrally formed on the root section 32, which serves as a stop for establishing the outermost travel of the blade assembly when it attains the fully projected position.

The blade 38, which is integrally formed with the root section 32, is provided with an air foil shaped cross section and is of a variable pitch on moving from the face surface of the root section to the tip 44 of the blade. The variation in the pitch of the blade being greatest at the tip 44 forms two warped surfaces having a gradual twist or helical configuration. The thickness of the blade 38 itself increases on moving from the tip 44 toward the root section 32.

It will be apparent from the configuration of the blade 38 that the twist of the blade, due to the variation in pitch thereof, prevents an axial withdrawal of the blade from a mold cavity as defined by molding material disposed therearound without incurring distortion and damage to the mold cavity surfaces. In accordance with the permanent non-expendable pattern of the present invention, each of the blade assemblies undergoes a rotation about the axis of its supporting pin 30 during retraction thereof, whereby the surfaces of the blade follow the surface contour of the molding cavity formed, providing a resultant mold having accurate and smooth surfaces for receiving the molten metal to be cast.

A typical embodiment of the supporting arrangement and retracting mechanism for each of the blade assemblies will now be described with particular reference to FIGS. 5-7 of the drawings. The framework of the pattern comprises a central shaft 46, which is formed with a radially extending flange 48 disposed intermediate the ends thereof. The radial flange 48 is provided with an integrally formed annular flange 50 along its lower peripheral surface which is provided with a first plurality of substantially radially extending guide bores 52 in which the supporting pins 30 of the blade assemblies 26 are slidably disposed. The lower portion of the shaft 46 is of a preselected diameter so as to serve as the aligning pin 16, as previously described in connection with FIG. 1, and is adapted to be removably received in the aligning bore 14 extending centrally through the base 10 for accurately positioning the pattern 12 on the mold base.

The shaft 46 is formed with a centrally extending bore 54 which is provided with a recess 56 at the lower end thereof and a counterbore 58 of enlarged diameter extending inwardly and concentrically of the bore 54 at the upper end thereof, as best seen in FIG. 5. A stepped pin 60 is disposed with its lower shank in the bore 54 and with its shoulder 62 seated on a shoulder 63 formed at the intersection of the bore 54 and counterbore 58. The stepped pin is secured in the bore 54 by means of a socket head cap screw 64 which is disposed in threaded engagement in the lower end thereof with its head portion positioned within the recess 56. The upper peripheral portion of the shaft 46 disposed upwardly of the radially extending flange 48 is of a uniform and smooth circular cross section and a flanged sleeve 66 is disposed in sliding encircling relationship therearound. The upper portion of the flanged sleeve 66 is formed with exterior threads 68 on which a cylindrical cap 70 is threadably engaged and retained in appropriate axial disposition thereon by means of a lock nut 72. The end of the cap 70 is formed with a central threaded bore 74, through which the shank of a locking screw 76 is adapted to extend and to be disposed in threaded engagement within a threaded bore 78, extending axially and inwardly of the upper end of the stepped pin 60.

The locking screw 76 is adapted to clamp the cap and the flanged sleeve 66 in the position as shown in solid lines in FIG. 5, which corresponds to the position in which the blade assemblies are disposed in the projected position. Movement of the flanged sleeve and cap upwardly from the position as shown in solid lines in FIG. 5 to effect a retraction of the blade assem-

blies is achieved in response to the removal of the locking screw 76 which is assisted by a coil spring 80 disposed in encircling relationship around the upper end of the stepped pin 60 having its ends seated, respectively, against the underside of the end wall of the cap 70 and the shoulder 63 formed between the bore 54 and counterbore 58.

To further facilitate upward movement of the flanged sleeve and cap during a retraction of the blade assemblies, an extracting screw (not shown) can be inserted in threaded engagement in the threaded bore 74 provided in the end wall of the cap and turning the extractor screw inwardly until its shank end is disposed in bearing engagement against a concave seat 82 formed in the upper end of the stepped pin 60. Rotation of the extractor screw effects an axial extracting movement of the cap and flanged sleeve, effecting a retraction of the blade assemblies through a linkage arrangement as hereinafter described.

Each blade assembly 26 is individually retracted by means of a pivotally connected link arm 84 having its inner end pivotally secured about a steel ball 86 secured within a spherical opening in a radially extending slot 88 formed in the periphery of the flanged sleeve 66 and its opposite outer end pivotally secured to a guide yoke 90. The guide yoke 90, as best seen in FIGS. 5 and 7, is formed with a slot 92 through its upper end for receiving the end of the link arm which is pivotally secured therein by means of a pivot pin 94. The guide yoke is securely fastened to a guide pin 96, which is slidably disposed in a second series of guide bores 98, which extend in a substantially radial direction through the upper portion of the annular flange 50. The lower portion of the guide yoke 90, as shown in FIG. 7, is formed with a hook-shaped portion 100 that is adapted to partially overlie the periphery of the supporting pin 30 of a blade assembly.

The rearward surface of the hook-shaped portion 100 is disposed in bearing relationship against a collar 102 secured such as by means of set screws 104 to the supporting pin 30 of each blade assembly. The forward face of the hook-shaped portion 100 is disposed in bearing contact against a spring washer 106 overlying the rear surface 34 of the root section of a blade assembly.

In accordance with this arrangement, upward movement of the flanged sleeve 66 and the cap 70 affixed thereto from the position as shown in solid lines in FIG. 5 effects an angular pivoting movement of each of the link arms 84 from the position as shown in solid lines to the positions as shown in phantom, effecting thereby a retraction of each of the blade assemblies wherein the tips of the blades are withdrawn inwardly of the pattern framework. Projecting movement of the blade assemblies is achieved by a reversal of the foregoing steps in which the flanged sleeve 66 is moved downwardly wherein the link arms assume the positions as shown in solid lines in FIG. 5, whereby the blades are retained in the fully projected position in response to the outward force exerted by the hook-shaped portions 100 of the guide yokes positioned against the spring washers 106.

As will be noted, the peripheral portion of the non-expendable pattern is defined by an annular rim 108 including a radial flange 110 which is securely fastened, such as by means of socket head screws 112, to the underside of the annular flange 50, as shown in FIG. 5. The upwardly and outwardly tapered circular flange 114 of the annular rim 108 is formed with a plurality of apertures 116 at circumferentially spaced intervals therealong, which are of a configuration corresponding to the cross sectional configuration of the root section 32 of the blade assemblies. The apertures 116 have correspondingly inwardly tapered surfaces for receiving the tapered peripheral surfaces 40 of each blade portion, effecting appropriate registration therebetween, wherein the blade 38 is disposed at the proper pitch. The stop tab 42 on the root section 32 is adapted to engage and overlie the rear surface of the circular flange 114, assuring that the blade portion is in the appropriate projected position.

The coaction between the inwardly tapered surfaces of the apertures 116 and the tapered peripheral surface 40 of each blade assembly serves to lock each blade when it attains the fully projected position in appropriate angular disposition relative to the pattern framework. Upon the initiation of retraction of the blade assemblies, a disengagement occurs between the tapered peripheral surface 40 of the blade portions and the conforming surfaces of the apertures 116, whereby the blade assemblies are free to rotate about the axes of the supporting pins 30, enabling rotation of the blade to conform with the helical configuration of the mold cavity formed. As will be noted in FIG. 6, the axes of the supporting pins are angularly offset from a true radial position such that the blades during retraction are withdrawn from the mold cavities without interference with the mold surfaces. The particular angle of retraction can be varied in accordance with the specific geometry of the turbine blades.

As shown in FIG. 5, the face surface 36 of the root section 32 of the blade assembly is contoured so as to conform exactly with the configuration of the outer surface of the circular flange 114, which itself is contoured, adjacent to the apertures 116 to form a pattern surface against which the molding material is adapted to be disposed. The exterior or pattern surface 118 of the circular flange 114, the upper surface of an annular mold ring 120, the inner surface of an annular back-up mold ring 122 and the lower surface of an upper mold ring 124, which is secured by means of screws 126 to the upper edge of the circular flange 114, define therebetween an annular mold cavity 128, into which the blades 38 project. A suitable molding material is poured into the mold cavity 128 such as by means of a series of angular chutes 130 formed in the upper mold ring 124. The close tolerance between the tapered peripheral surface 40 of the blade assemblies and the tapered apertures 116 form a seal, preventing leakage of any molding material inwardly of the pattern assembly.

While the description of the present invention is made with respect to a permanent pattern for making turbine wheels of a type having a central hub from which a plurality of blades extend in a substantially radial direction, it will be appreciated that the present invention is also applicable for forming stators and like components including an annular rim having a plurality of blades projecting radially inwardly therefrom. The principle of operation of the permanent non-expendable pattern as herein described is also applicable for forming molds of any one of a variety of types and compositions where precision castings are required and wherein selected sections of the pattern must be retracted in order to enable separation of the mold and pattern.

We claim:

1. A pattern for producing a mold having a bladelike cavity of twisted configuration, said pattern comprising: a frame defining a mold cavity; a pattern section having a twisted configuration; guide means connected to said pattern section and in sliding engagement with said frame, said guide means being

adapted to move said pattern section a given distance into said mold cavity and to move said pattern section out of said mold cavity, said pattern section being free to rotate relative to said guide means; and locking means to retain said pattern section in a predetermined position relative to said mold cavity when said pattern section is at said given distance into said mold cavity.

2. The pattern as defined in claim 1, wherein said mold cavity is of a circular configuration having a central axis, said frame includes a plurality of apertures communicating with said mold cavity and disposed at circumferentially spaced intervals along said circular configuration and a pattern section is adapted to be moved through each aperture into and out of said mold cavity.

3. The pattern as defined in claim 1, wherein said locking means comprises a tapered surface against which a conforming surface on said pattern section is adapted to be disposed in bearing relationship when said pattern section is at said given distance into said mold cavity.

4. The pattern as defined in claim 1, wherein said pattern section includes stop means adapted to coact with said frame for limiting the travel of said pattern section at said given distance into said mold cavity.

5. The pattern as defined in claim 2, including linkage means connected to each pattern section to effect movement of all of the pattern sections in unison into and out of said mold cavity.

6. The pattern as defined in claim 6, including means connected to said linkage means for retaining said pattern sections at said given distance into said mold cavity.

7. The pattern as defined in claim 2 wherein: a shaft extends axially through said central axis; a cap is adapted to be slid axially along said shaft; a link arm connects each of said pattern sections to said cap; and said guide means are movable normal to said shaft.

8. The pattern as defined in claim 7 wherein: said frame includes a plurality of passages extending in a direction normal to said shaft; and said guide means includes a guide pin slideably engaged in one of said passages and rigidly secured at one end to a guide yoke, said guide yoke being pivotally connected to one of said link arms, said guide means further includes a pin support slideably engaged in another of said passages and supported by said guide yoke, said pin support being adapted to rotate relative to said guide yoke and being connected to said pattern section.

9. The pattern as defined in claim 8 wherein resilient means is interposed between said guide yoke and said pattern section to exert a force on said pattern section to retain said pattern section in a given position.

10. The pattern as defined in claim 7 wherein said cap includes a plurality of radially extending slots, a ball is secured in each of said slots and one end of a link arm is pivotally secured about each of said balls.

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