Nov. 3, 1942. A. F. PFEIFFER 2,301,140

FORMING BLADE HOLDING CORE SEGMENTS

Filed Nov. 24, 1941 8 Sheets-Sheet 1

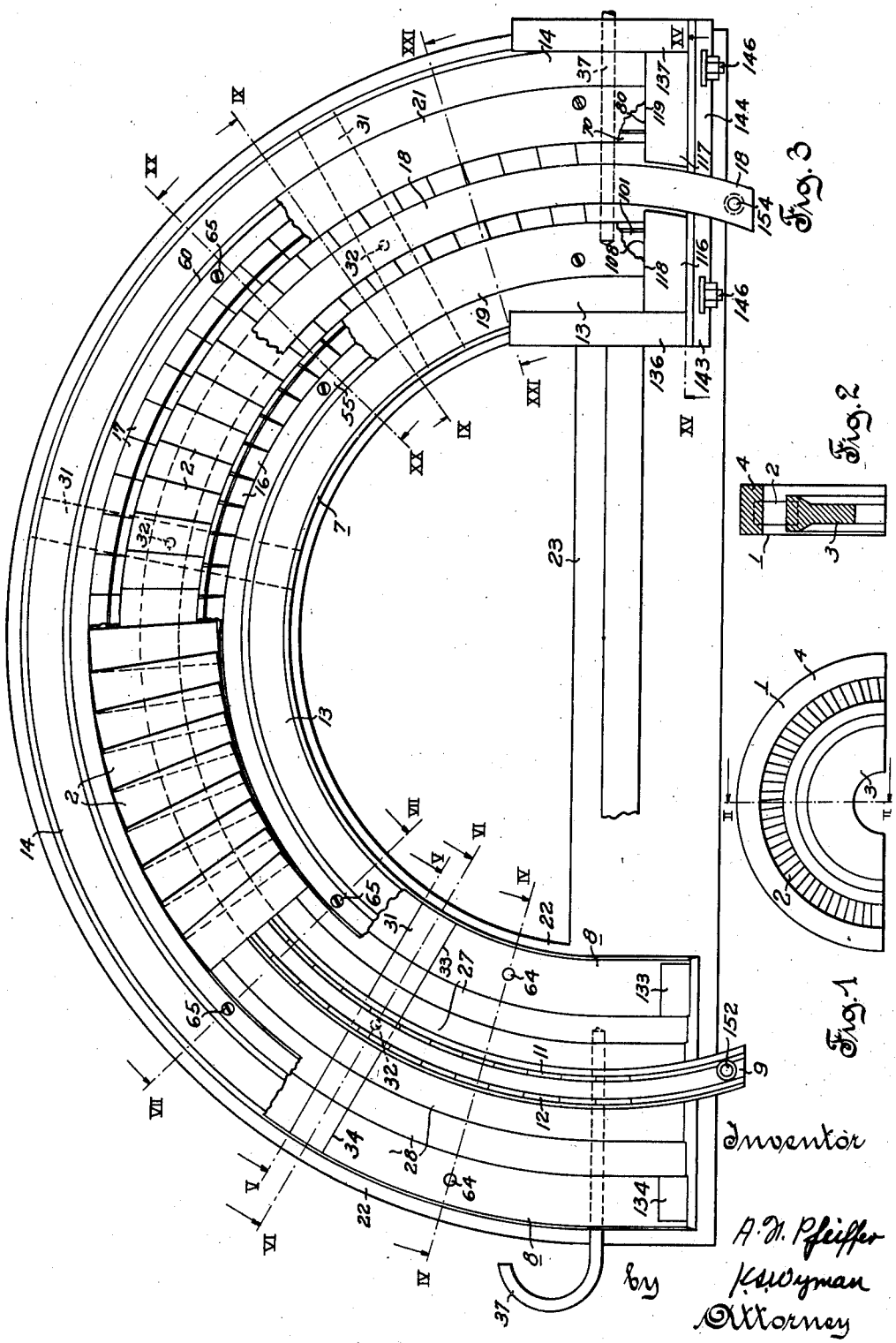

Fig. 3

Fig. 2

Fig. 1

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Nov. 3, 1942. A. F. PFEIFFER 2,301,140

FORMING BLADE HOLDING CORE SEGMENTS

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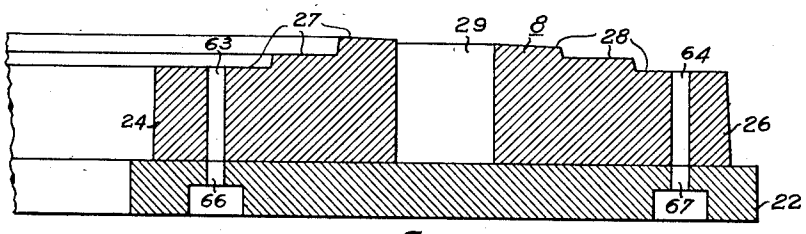

Fig. 4

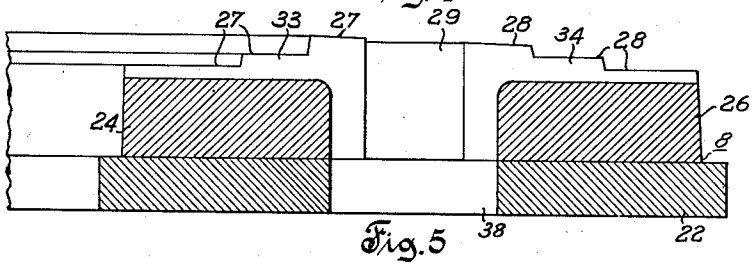

Fig. 5

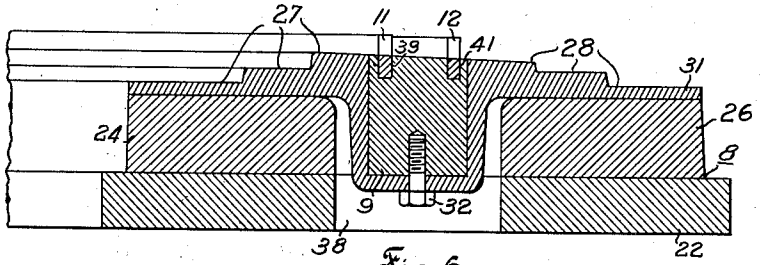

Fig. 6

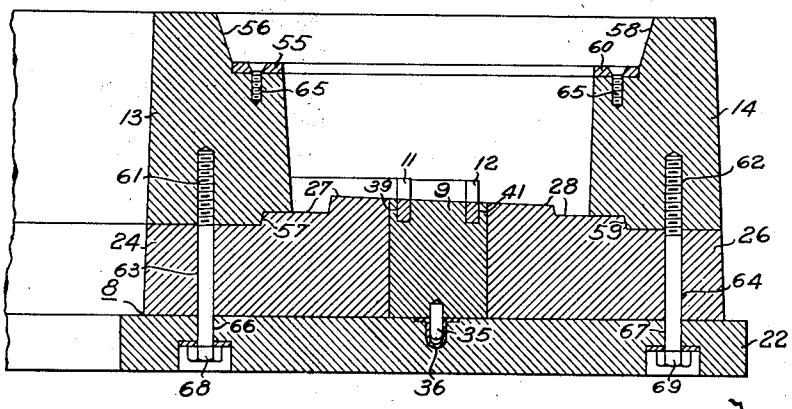

Fig. 7

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FORMING BLADE HOLDING CORE SEGMENTS

Filed Nov. 24, 1941 8 Sheets-Sheet 3

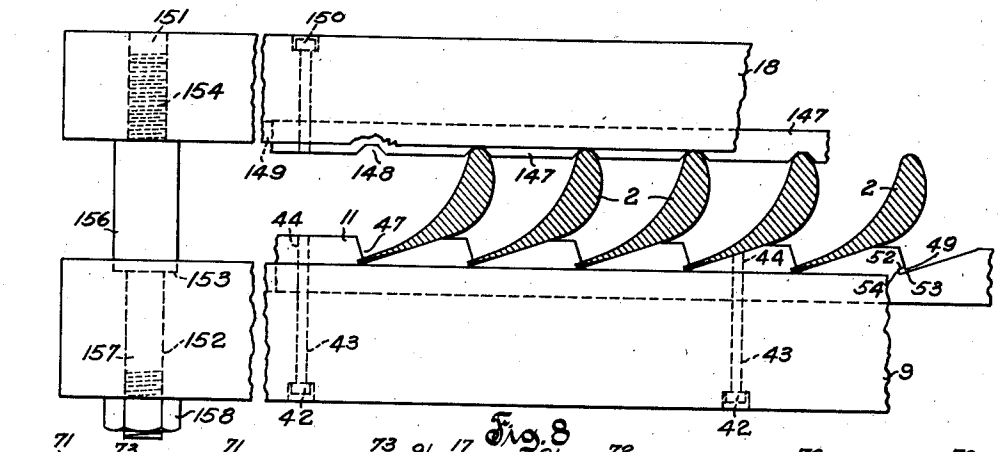

Fig. 8

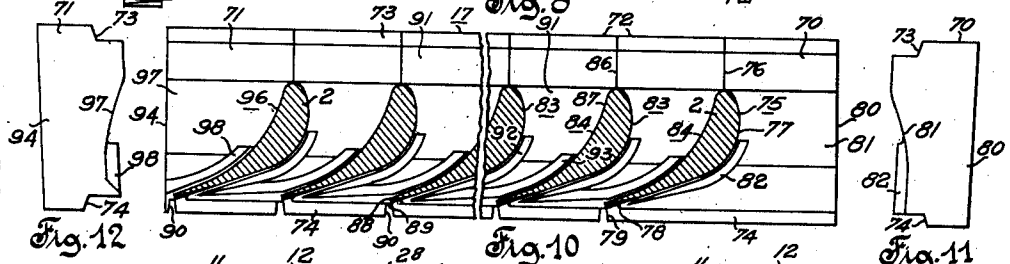

Fig. 12 Fig. 10 Fig. 11

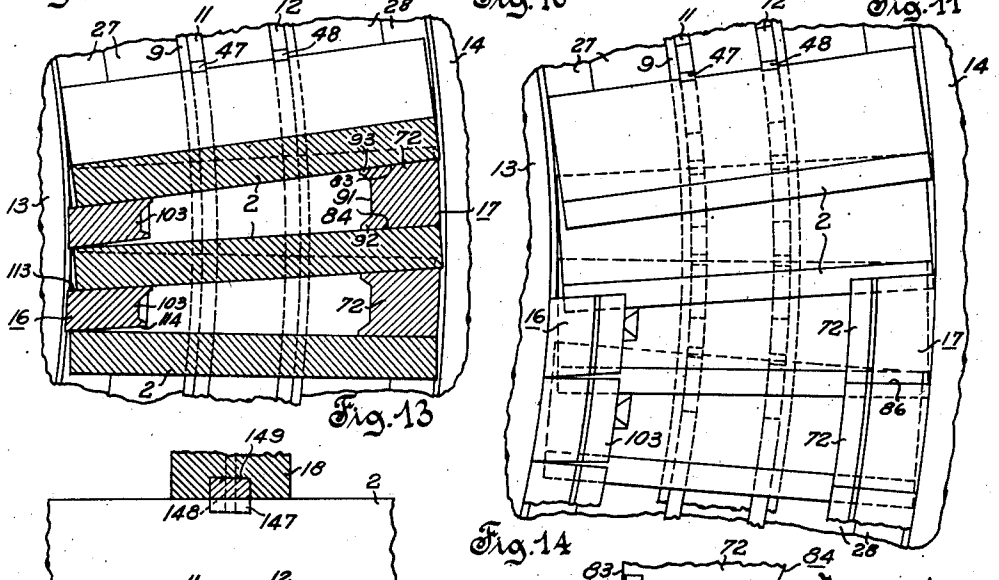

Fig. 13 Fig. 14

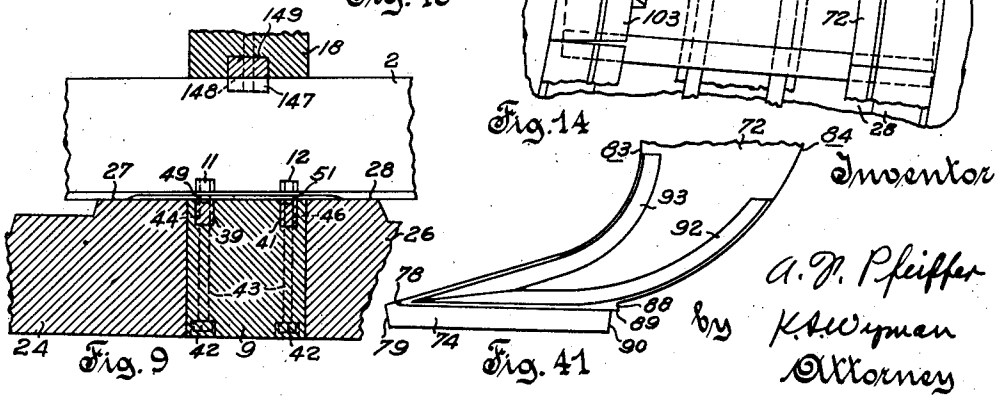

Fig. 9 Fig. 41

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FORMING BLADE HOLDING CORE SEGMENTS

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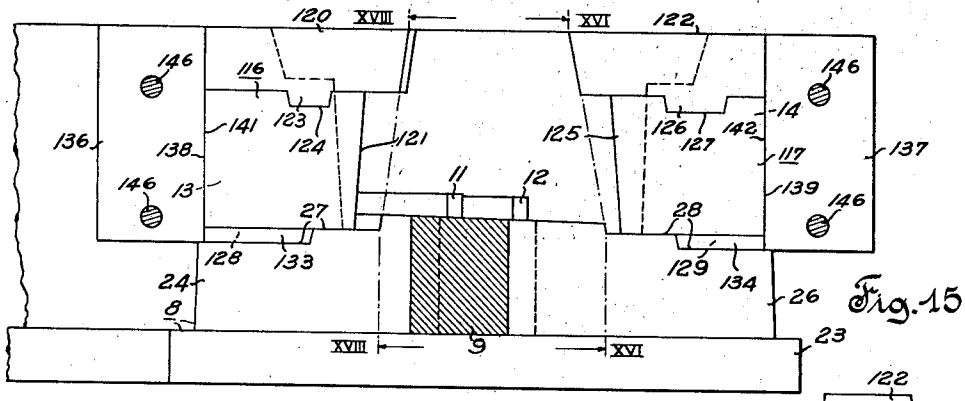

Fig. 15

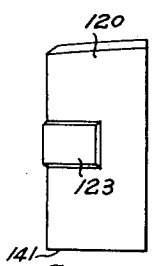

Fig. 19

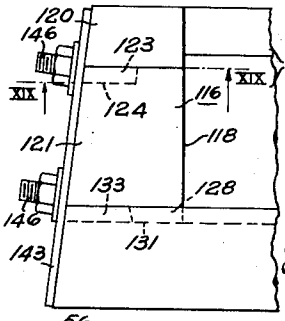

Fig. 18

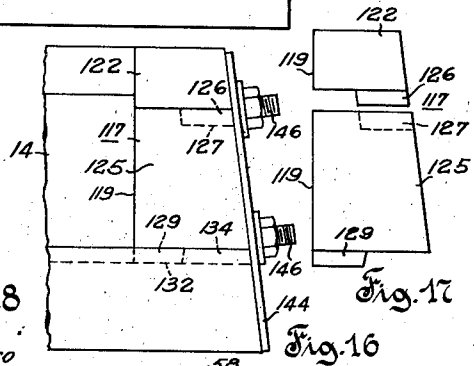

Fig. 17

Fig. 16

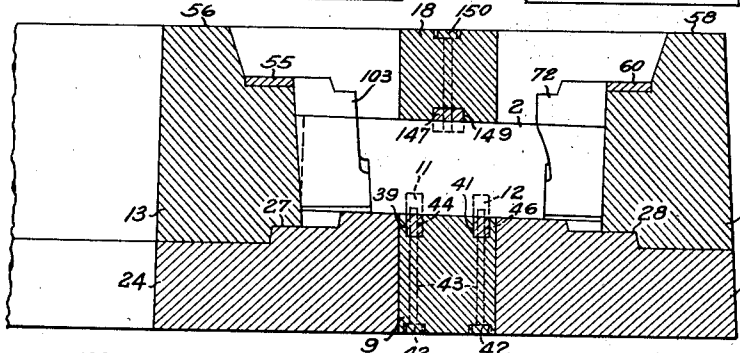

Fig. 20

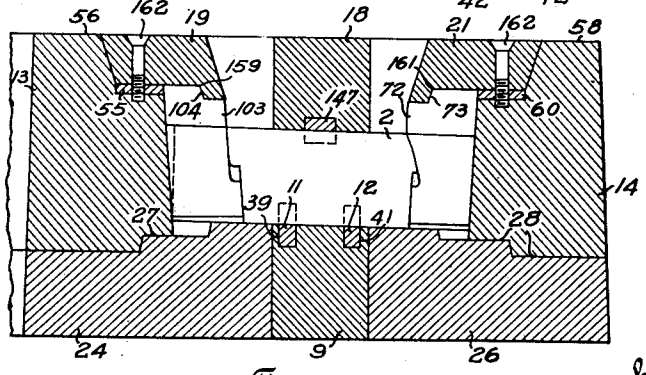

Fig. 21

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Nov. 3, 1942. A. F. PFEIFFER 2,301,140

FORMING BLADE HOLDING CORE SEGMENTS

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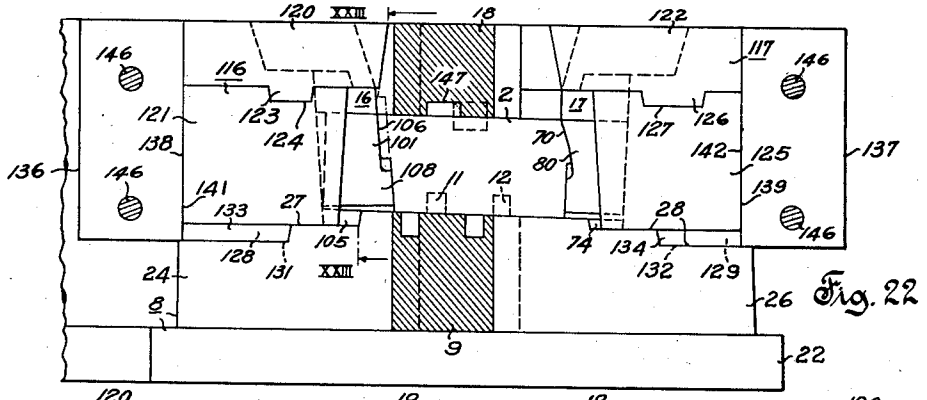

Fig. 22

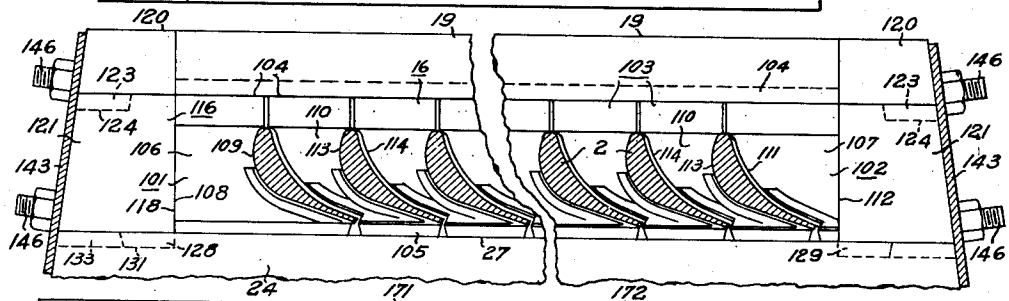

Fig. 23

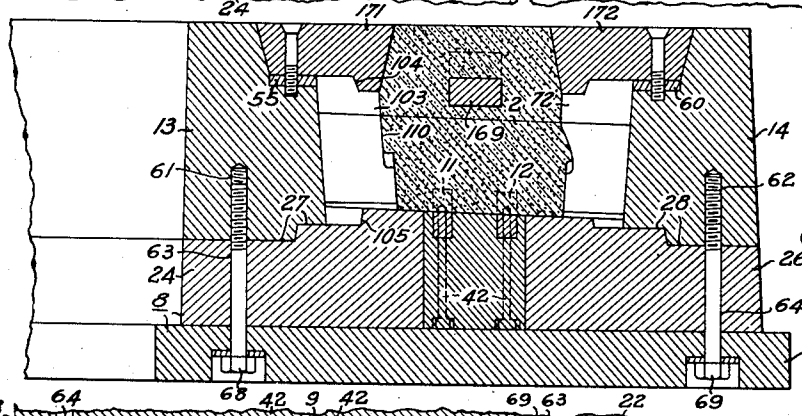

Fig. 24

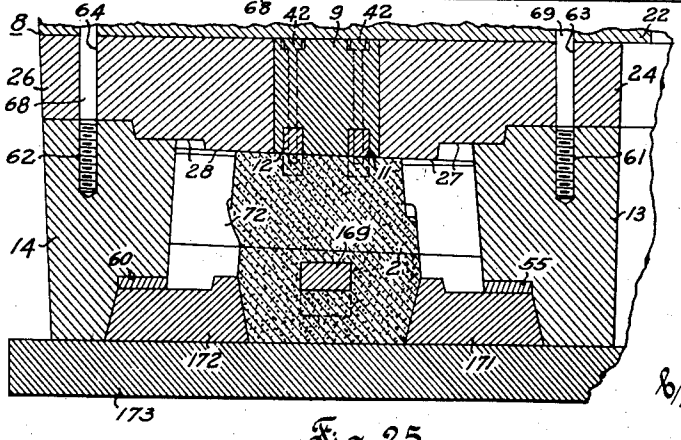

Fig. 25

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FORMING BLADE HOLDING CORE SEGMENTS

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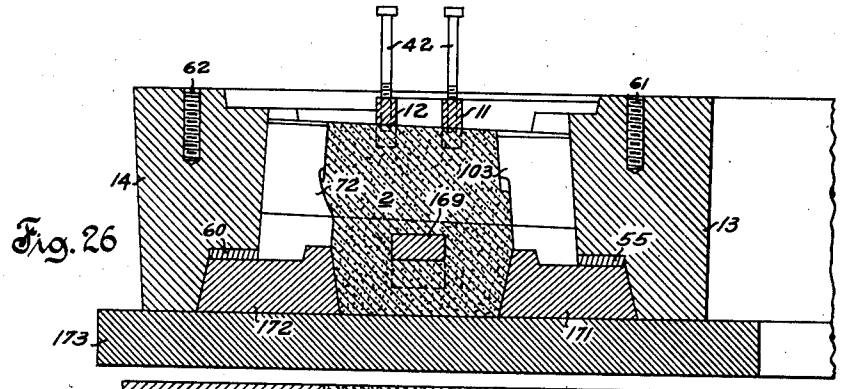

Fig. 26

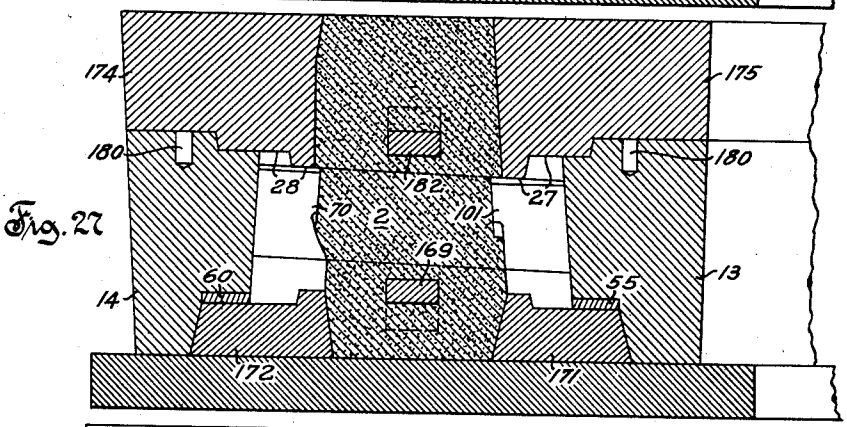

Fig. 27

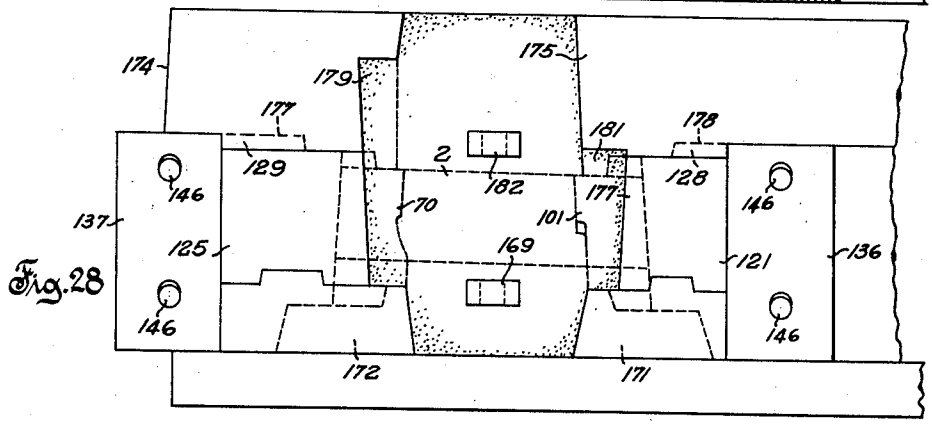

Fig. 28

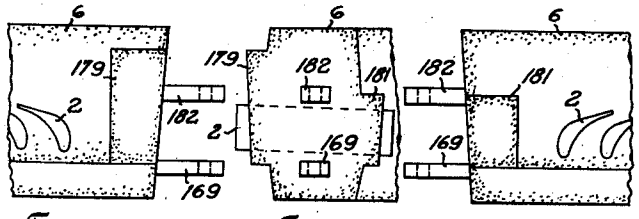

Fig. 31 Fig. 29 Fig. 30

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Nov. 3, 1942. A. F. PFEIFFER 2,301,140

FORMING BLADE HOLDING CORE SEGMENTS

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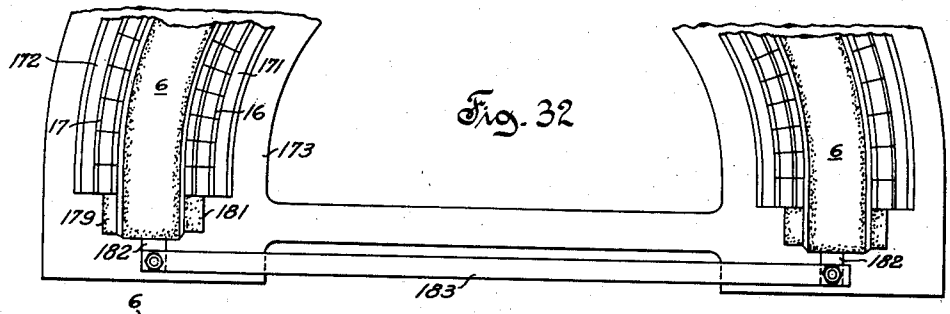

Fig. 32

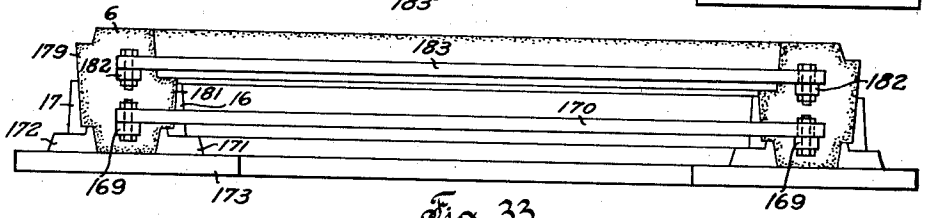

Fig. 33

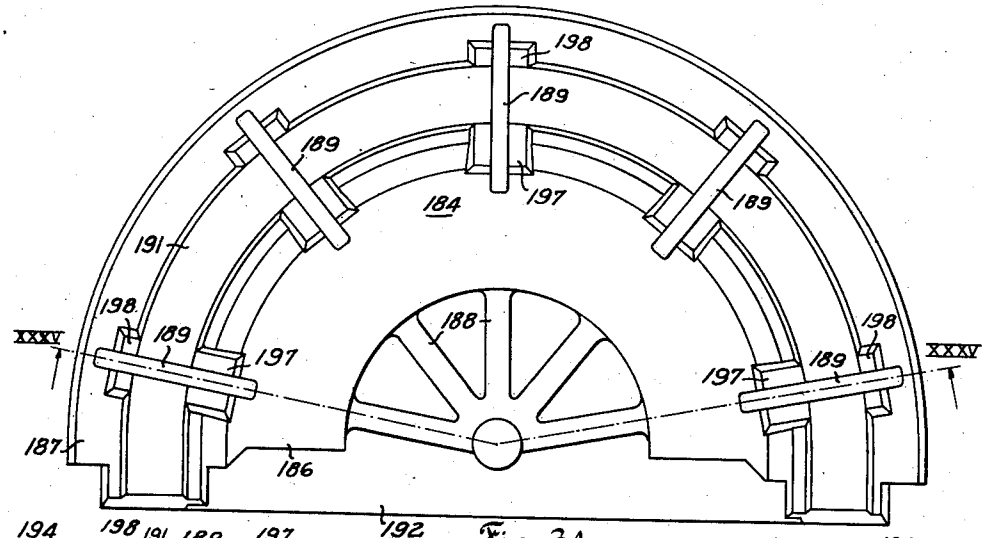

Fig. 34

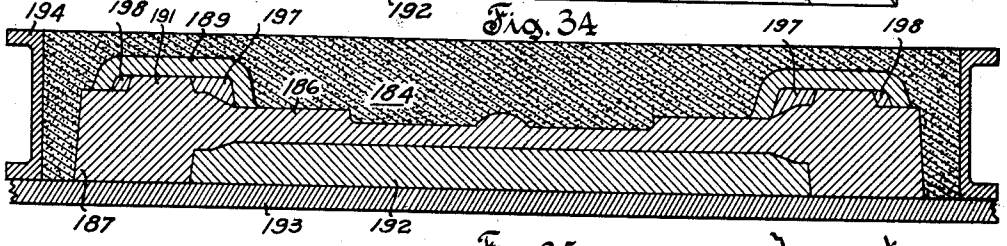

Fig. 35

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Nov. 3, 1942. A. F. PFEIFFER 2,301,140

FORMING BLADE HOLDING CORE SEGMENTS

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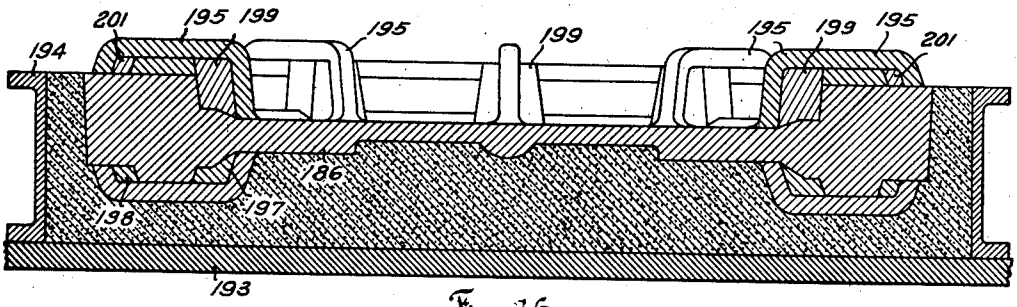

Fig. 36

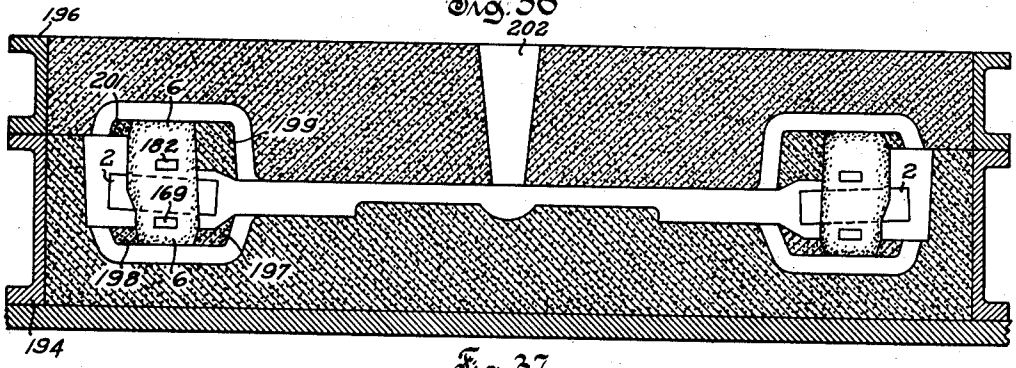

Fig. 37

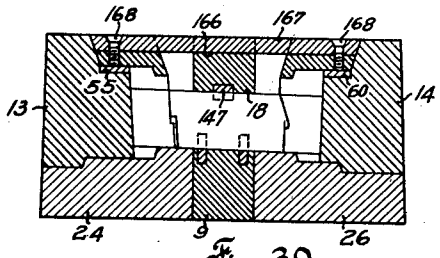

Fig. 39

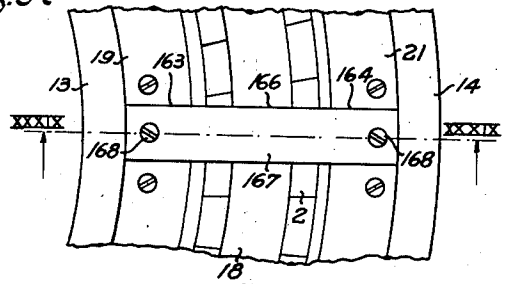

Fig. 38

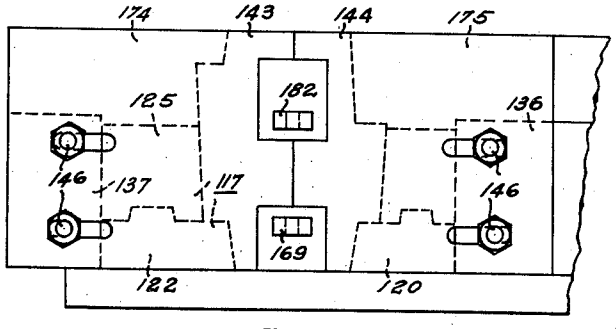

Fig. 40

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Patented Nov. 3, 1942

2,301,140

UNITED STATES PATENT OFFICE

2,301,140

FORMING BLADE HOLDING CORE SEGMENTS

Albert F. Pfeiffer, West Allis, Wis., assignor to Allis-Chalmers Manufacturing Company, Milwaukee, Wis., a corporation of Delaware

Application November 24, 1941, Serial No. 420,263

26 Claims. (Cl. 22—13)

This invention relates generally to elastic fluid turbine wheels, diaphragms and the like formed by embodying the buckets or fluid passage defining elements in a suitable core and by casting inner and outer diaphragm ring segment forming members integrally about the free end portions of the buckets or fluid passage defining elements which project from said core and more particularly to an improved core construction therefor.

In the construction of elastic fluid turbine diaphragm ring segments, for example, there are two known and accepted constructions which have heretofore been employed for correctly positioning and maintaining the partition or passage defining elements in their proper assembled relation within the core box during the ramming operation, namely: (1) indestructible metal filler blocks which are disposed between the free inner and outer end portions of adjacent blades and which may be removed either before or after the core is baked, and (2) destructible fiber side walls which are removable from the core only after the baking of the core is completed and which have formed therein exactly fitted alined openings through which the end portions of the partition or fluid defining elements extend.

The construction designated (1) above is time consuming and extremely costly since each filler block has to be accurately made and hand fitted to exact dimensions, since the filler blocks and partition elements have to be carefully assembled and the assembly accurately checked, and since all of these operations must be performed by persons having a high degree of skill. Moreover, as soon as a filler block becomes slightly worn, warped or otherwise deformed, it must be replaced and since deformation of the accurately fitted filler blocks frequently occurs, the cost of this type of construction is further increased. Furthermore, any error arising from the use of deformed or improperly fitted blocks or from the inclusion of foreign particles between the abutting surfaces on adjacent blocks and/or between the abutting surfaces on the blocks and the partition elements held therebetween is cumulative, thereby frequently requiring a completed or nearly completed assembly to be taken apart, the difficulty corrected, and the parts reassembled.

The construction designated (2) above is also time consuming and extremely costly. For example, each fiber side wall must be accurately shaped to the requisite curvature and punch guides (one for each of the openings through which a partition element extends) must be hand filed therein and carefully checked before the partition element retaining openings can be punched therein. Moreover, the fiber side walls (two are required for each core) must be left in place to support the partition elements when the core is being baked and the application of heat during the baking operation renders the fiber side walls sufficiently brittle to prevent their removal without destruction, thereby necessitating making a complete new set of fiber side walls for each core. Furthermore, after the fiber side walls have been removed from the core, fillet recesses must be cut by hand around both ends of each partition element.

Therefore, the primary object of this invention is to provide an improved construction for core segments embodying angularly spaced fluid passage defining elements which permit the core segments to be constructed with a minimum of skilled labor, which materially decreases the time required to form a core segment, and which insures a high degree of accuracy heretofore unexcelled by highly skilled labor.

Another object of this invention is to provide an improved core box structure embodying means permitting unskilled labor to rapidly and accurately position and secure in a core box an assembly comprising the fluid passage defining elements of a turbine diaphragm or wheel segment and the filler blocks adapted to be disposed in abutting relation between the end portions of adjacent elements.

Still another object of this invention is to provide an improved core box structure embodying means, which permits unskilled labor to rapidly and accurately position and secure in a core box, an assembly comprising the fluid passage defining elements of a turbine diaphragm or wheel segment and the filler blocks adapted to be disposed in abutting relation between the end portions of adjacent elements, which permits the box including said assembly to be readily rammed with core sand, and which permits the positioning and securing means to be readily removed from the box when the ramming operation is nearing completion without disturbing said assembly.

Still another object of this invention is to provide an improved ring segment core embodying the fluid passage defining elements of a turbine diaphragm or wheel in that the core is provided with means operative to prevent a radial deformation of the core during the baking operation and to permit the baked core to be readily picked up and bodily moved without danger of breaking same.

The invention accordingly consists of the various methods, features of construction, combinations of elements and arrangements of parts as fully set forth in the appended claims and in the detailed description, in which:

Fig. 1 shows a turbine diaphragm segment which was cast with the aid of a core constructed in accordance with this invention;

Fig. 2 is a section taken on line II—II of Fig. 1;

Fig. 3 is a top plan view of a core box embody-

ing the invention with parts removed or broken away to better show the construction;

Fig. 4 is a transverse section taken on line IV—IV of Fig. 3;

Fig. 5 is a transverse section taken on line V—V of Fig. 3 with the lower jig holding ring segment and its transversely extending supporting strap removed;

Fig. 6 is a transverse section taken on line VI—VI of Fig. 3;

Fig. 7 is a transverse section taken on line VII—VII of Fig. 3;

Fig. 8 is a developed side view of the means for positioning and maintaining the blades in the core box;

Fig. 9 is a partial section taken on line IX—IX of Fig. 3 with the filler block clamping segments, the drag ring segments, and the filler blocks removed;

Fig. 10 is a developed side view illustrating the outer series of filler blocks in assembled relation with respect to each other and with respect to the end portions of the blades;

Fig. 11 is an end view of the right-hand end block shown in Fig. 10;

Fig. 12 is an end view of the left-hand end block shown in Fig. 10;

Fig. 13 is a top view of a fragment of the channel portion of the core box with blades and filler blocks therein shown in section;

Fig. 14 is a view similar to that shown in Fig. 13 with the blades and filler blocks shown in plan;

Fig. 15 is a section taken on line XV—XV of Fig. 3 with the filler block clamping segments, the upper jig ring, and the blades and filler blocks removed;

Fig. 16 is a partial section taken on line XVI—XVI of Fig. 15;

Fig. 17 is an exploded view of the end block structure of Fig. 16 to better show the arrangement of the coacting projections and recesses;

Fig. 18 is a partial section taken on line XVIII—XVIII of Fig. 15;

Fig. 19 is a bottom view of the top portion of the end block structure taken on line XIX—XIX of Fig. 18;

Fig. 20 is a section taken on line XX—XX of Fig. 3;

Fig. 21 is a section taken on line XXI—XXI of Fig. 3;

Fig. 22 is a complete section taken on line XV—XV of Fig. 3;

Fig. 23 is a development of a section of the inner portion of the core box taken on line XXIII—XXIII of Fig. 22;

Fig. 24 is a section similar to Fig. 21 showing the box partially rammed with the upper jig holding ring removed and the core arbor and the substitute filler block clamping segments in place;

Fig. 25 shows the structure of Fig. 24 inverted on a mold board;

Fig. 26 shows the inverted structure of Fig. 25 with the base ring segment and the lower jig holding segment removed;

Fig. 27 shows the structure of Fig. 26 with the with the blade holding and spacing jigs removed and with the second core arbor and the cope segments in place;

Fig. 28 is an end view of the left-hand end of the inverted core box with the end plates removed;

Fig. 29 is an end view of the left-hand end of the finished core;

Fig. 30 is a side view of the inner side surface of the finished core;

Fig. 31 is a side view of the outer side surface of the finished core;

Fig. 32 is a partial plan view of the unbaked core;

Fig. 33 is an end view of the core shown in Fig. 32;

Fig. 34 is a plan view of the drag portion of the pattern used in forming a mold adapted to receive the core;

Fig. 35 illustrates a section of the drag portion of the pattern taken along the line XXXV—XXXV of Fig. 34 as it appears in a mold flask rammed with sand;

Fig. 36 is a sectional view showing the completed pattern supported in the drag flask;

Fig. 37 is a sectional view showing the completed mold with the core disposed therein;

Fig. 38 is a partial top view of the core box showing the manner in which the upper jig holding ring segment is secured in the core box;

Fig. 39 is a sectional view taken on line XXXIX—XXXIX of Fig. 38;

Fig. 40 is an end view of the left-hand end of the core box showing the end plates in place; and

Fig. 41 is an enlarged view of the bottom portion of an intermediate filler block.

Referring to the drawings, Fig. 1 shows a 180° turbine diaphragm segment 1 which was cast with the aid of a core structure embodying features constituting the invention. The diaphragm segment 1, of which a transverse section is shown in Fig. 2, comprises a series of spaced curved passage defining elements 2 (hereinafter referred to as blades), an inner ring segment 3 and an outer ring segment 4. The diaphragm segment 1 is constructed by forming a core 6 (see Figs. 29, 30, 31 and 37) in which the blades 2 are accurately held in predetermined spaced angular relation with the inner and outer end portions of the blades extending freely beyond the inner and outer side surfaces of the core and by casting integrally thereto, i. e., to the free end portions of the blades, the inner and outer ring segments designated 3 and 4, respectively. A complete diaphragm is usually made by casting two oversize segments which are then machined to provide two 180° segments having the requisite dimensions. However, neither the number of segments employed in forming a complete diaphragm nor the nature of the blades employed in forming the segments are essential features of this invention and a further description in this connection is believed unnecessary for a complete understanding of the core box structure 7 used in forming the core 6.

Referring particularly to Fig. 3, it is seen that the core box structure 7 comprises a base ring segment 8, a lower jig holding ring segment 9 disposed on said base ring segment in spaced concentric relation with respect to the side edges thereof, a pair of inner and outer blade positioning and holding jig segments 11 and 12, respectively, which are disposed on the jig holding ring segment 9 in spaced concentric relation with respect to the side edges of the said base segment and with respect to each other, a pair of inner and outer drag ring segments 13 and 14, respectively, which are disposed on said base ring segment in spaced concentric relation with respect to said pair of jig segments and with respect to each other, the blades 2 which are positioned and held in predetermined spaced angular relation by the inner and outer jig segments 11 and 12, respec-

tively, with a portion of the opposite end of each blade abutting the opposed channel forming side surfaces presented by the pair of inner and outer drag ring segments 13 and 14, respectively, the inner and outer series of filler blocks 16 and 17, respectively, which are disposed in spaced concentric relation between the inner and outer end portions of adjacent blades, the upper jig holding ring segment 18 which is disposed in spaced concentric relation between the opposed channel forming side surfaces presented by the inner and outer drag ring segments 13 and 14, and the inner and outer filler block clamping ring segments 19 and 21, respectively, which are secured to the top portions of the inner and outer drag ring segments 13 and 14 in spaced concentric relation with respect to the upper jig holding ring segment 18 and with respect to each other.

Referring also to Figures 4 and 5, it is seen that the base ring segment 8 may comprise a flat ring segment bottom member 22 having its ends rigidly connected by a cross member 23, and a pair of inner and outer base members 24 and 26 having similarly shaped top surfaces 27 and 28, respectively. Base members 24 and 26 are positioned on and secured to the bottom member 22 by any suitable means (not shown) and in spaced concentric relation with respect to the side edges thereof and with respect to each other so as to form therebetween a channel 29 adapted to snugly receive therein the lower jig holding ring segment 9. The jig holding segment 9 is properly positioned in the channel 29 with its top surface substantially flush with the surfaces of the uppermost steps on the base members 24 and 26. Referring also to Figs. 3, 5, 6 and 7, it is seen that the positioning means comprises a plurality of transversely extending straps 31 each of which is secured to the underside of the jig holding segment 9 by a cap screw 32 and each of which is disposed within a pair of radially extending alined grooves 33 and 34 provided in the stepped top surfaces of the base members 24 and 26, respectively, a plurality of pins 35 (see Fig. 7) which extend downward from the underside of the jig holding segment 9 and into the sockets 36 provided in the bottom member 22, and a pair of removable rods 37 which extend through alined openings in the base members 24 and 26 and the jig holding segment 9 as is shown in Fig. 3. The bottom member 22 is provided, as shown in Fig. 6, with openings 38 into which the strap 31 and the head of the cap screw 32 project. The top surface of the inner and outer radially extending portions of the strap 31 which lie in the alined grooves 33 and 34 are stepped to form continuations of the stepped top surfaces 27 and 28 presented by the base members 24 and 26, respectively, as is best shown in Figs. 3 and 6.

The lower jig holding ring segment 9 is provided in its top surface with a pair of inner and outer channels 39 and 41, respectively, which are preferably of rectangular shape when viewed in transverse cross section and which are disposed adjacent the inner and outer edges of the jig holding segment 9 and in spaced concentric relation with respect to each other and with respect to the concentric surfaces provided by the stepped top surfaces of base segments 24 and 26, respectively. The lower portions of the blade positioning and holding jigs 11 and 12 fit snugly within the inner and outer channels 39 and 41, respectively, as is clearly shown in Figs. 6 and 7 and are removably secured therein by means of a plurality of pairs of screws 42 which extend through pairs of bores 43 provided in the jig holding segment 9 and into the alined and internally threaded bores 44 and 46 provided in the bottom side of the inner and outer jig segments 11 and 12, respectively, as is shown in Figs. 9 and 20. The portions of the inner and outer jig segments 11 and 12 which extend above the top surface of the jig holding segment 9 are provided with pairs of alined transverse notches 47 and 48 which terminate in identical undercut portions 49 and 51, respectively, adapted to receive therein longitudinally spaced intermediate portions of the outlet edge of a curved blade as is best shown in Figs. 8, 9, 13 and 14.

In this connection, it should be particularly noted (see Fig. 8) that the undercut portions 49 and 51 are each defined by downwardly inclined opposed surfaces 52 and 53 and by an end surface 54; that the opposed portions of the surfaces 52 and 53 are substantially parallel and spaced apart a distance only slightly greater than the thickness of that portion of the outlet edge of the blade which is inserted therein; that the undercut portions of the pairs of notches are in radial alinement (see Figs. 3, 13 and 14); and that when the outlet edge portion of a curved blade is inserted therein, the weight of the blade acts to hold (1) spaced intermediate portions of the outlet edge in engagement with the end surfaces 54, (2) spaced portions of the concave surface which are immediately adjacent said outlet edge portions, in engagement with the upper surface 52, and (3) spaced portions of the convex surface, which are remote from the said outlet edge portions, in engagement with the lower surface 53 as is clearly shown in Fig. 8. In addition, it should also be particularly noted (see Fig. 9) that the blades 2 have an intermediate outlet edge portion of reduced thickness, and that therefore only relatively small portions of the outlet edge of each blade on either side of the jig holding segment 9 are shown as actually engaging the top steps of the surfaces 27 and 28. However, when blades are employed which have an outlet edge of substantially uniform thickness, it should be apparent that the entire width of the said top steps would be engaged by the overlying edge portions of each blade. The arrangement is preferably such that the top surfaces of the top steps are substantially flush with the top surface of the jig holding segment 9 and that the lowermost edges of the undercut portions 49 and 51, i. e., the edges formed by the junction of the lower surface 53 and the end surface 54, are also substantially flush with the top surface of the jig holding segment 9 and with the top surfaces of the said top steps. Consequently, when the thickness of the outlet edge of each blade is equal to the width of the end surface 54, portions of the outlet edge of each blade will engage the top surfaces of the said top steps in the manner just described. Obviously, if the thickness of the outlet edge of the blade is made greater than the width of the end surface 54, the outlet edge of the blade cannot be inserted into the undercut portions of the notches without deforming the notch or blade or both, and the preferred procedure in order to allow for reasonable manufacturing tolerances is to make the outlet edge of the blade just equal to or slightly less than the width of said end surface. Therefore, in actual practice, the outlet edge of the blade may be spaced above the top surfaces of the said top steps a distance equal to the maximum permissible tolerance.

Referring particularly to Fig. 7, it is seen that the inner and outer drag ring segments 13 and 14 are provided with stepped top and bottom surfaces 56, 57 and 58, 59, respectively, and that the bottom surfaces of the segments 13 and 14 are provided with internally threaded bores 61 and 62, respectively, arranged for alinement with the bores 63 and 64 in the base members 24 and 26 which bores are in turn alined with the bores 66 and 67 provided in the bottom member 22. Bolts 68 and 69 removably secure the drag ring segments 13 and 14 in spaced concentric relation on inner and outer concentric portions of the stepped top surfaces 27 and 28 which are presented by the base members 24 and 26, respectively. The radial width of the drag ring segments is less than that of the base members 24 and 26 and the opposed channel forming side surfaces of the segments 13 and 14 coact and form with exposed portions of the stepped top surfaces 27 and 28 spaced concentric surfaces adapted to position and retain thereagainst, the inner and outer series of filler blocks 16 and 17, respectively, which are to be assembled in spaced concentric relation between the inner and outer end portions of adjacent blades. The length of the blades 2 and the spacing of the drag ring segments 13 and 14 are such that when the outlet edges of the blades are inserted in the pairs of alined notches 47 and 48 which act to correctly position and hold the blades in a predetermined spaced angular relation, a portion of each end of each blade abuts the adjacent channel forming side surface presented by said drag ring segments as is best shown in Figs. 13 and 14. The lower step of the top surfaces 56 and 58 of the drag rings 13 and 14, respectively, are provided with metal facing ring segments 55 and 60, respectively, which are preferably removably secured thereon by any suitable means such as the countersunk screws 65.

Referring to Figs. 10–14, inclusive, and 41, it is seen that the outer series of filler blocks 17 comprises the end blocks 70 and 71 and a plurality of identical intermediate blocks 72. Each of the blocks 70, 71 and 72 has stepped top and bottom surfaces 73 and 74, respectively, which are similar, i. e., all steps on the top surfaces are identical and all steps on the bottom surfaces are identical, and the outer side surfaces of these blocks are preferably made to conform with the curvature of the inner side surface of the outer drag ring segment 14 as is best seen in Figs. 13 and 14. The end block 70 has a plane outer end surface 80 and an oppositely facing inner end surface 75 comprising a plane radially extending top portion 76, a concave radially extending intermediate portion 77 which conforms with and is adapted to engage the convex surface of a blade 2, and a bottom portion including a radially extending edge 78 and a plane radially extending surface 79. The edge 78 is formed by the intersection of the concave surface portion 77 and that portion of the stepped bottom surface 74 which is adapted to engage the top step of the surface 28 on the bottom member 26. The top portion of the block 70 is of greater radial thickness than the bottom portion thereof and its inner side surface 81 is preferably formed by upper and lower plane surfaces being connected by a portion of compound curvature as shown in Fig. 11. The lower portion of the concave surface 77 is extended inwardly a slight distance beyond the lower portion of the inner side surface 81 so as to form therewith a fillet forming projection 82. Each of the intermediate blocks 72 has an inner end surface 83 which is identical to the surface 75 on the end block 70 and an outer end surface 84 comprising a plane radially extending top portion 86 which is complementary to the similar surface 76 on the end block 70, a convex radially extending intermediate portion 87 which conforms with and is adapted to engage the concave surface of a blade 2, and a bottom portion including the plane radially extending surfaces 88, 89 and 90 as best seen in Fig. 41. The top portions of each block 72 are also of greater radial thickness than the bottom portions thereof and its inner side surface 91, which is formed in the same manner as the side surface 81 on the block 70, is provided with a pair of inwardly extending fillet forming projections 92 and 93 which merge into a single projection at the toe of the block as is clearly shown in Fig. 10 and Fig. 41. The fillet projection 92 conforms with the similar projection 82 on the end block 70. The end block 71 has a plane outer end surface 94 and an oppositely facing inner end surface 96. The surfaces 94 and 96 are identical to the outer end surfaces 80 and 84 on the end and intermediate blocks 70 and 72, respectively, and a repetition of the detailed description of such surfaces is believed unnecessary for a complete understanding of the invention. In addition, the top portion of each block 71 is of greater radial thickness than the bottom portion thereof and its inner side surface 97 is provided with an inwardly extending fillet forming projection 98 corresponding to the fillet forming projections 93 on the intermediate blocks 72. The side surface 97 is also formed by plane and curved surfaces as set forth in the description of end block 70.

The inner series of filler blocks 16 comprises, as best shown in Figs. 13, 14 and 23, the end blocks 101 and 102 and a plurality of intermediate blocks 103. Each of the blocks 101, 102 and 103 has identically stepped top surfaces 104 and identically stepped bottom surfaces 105 which are adapted to engage the exposed portion of the stepped surface 27 on the base member 24. The blocks 101, 102 and 103 have inner side surfaces which are made to conform with the outer side surface of the inner drag ring segment 13 and have outer side surfaces 106, 107 and 110 which are similar to the inner side surfaces 81, 92 and 97, respectively, on the outer blocks 70, 71 and 72. The end block 101 has a plane end surface 108 and an oppositely facing inner end surface 109 which end surfaces are similar to the outer and inner end surfaces 80 and 75, respectively, on the end block 70. The end block 102 has oppositely facing inner and outer end surfaces 111 and 112 of which the surface 112 is similar to the corresponding end surface 94 on the outer end block 71. However, the end surface 111, which is somewhat similar to the end surface 96 on the end block 71, differs therefrom in that the plane and convex portions thereof are made to extend parallel to the plane and concave portions of the surface 83 on the intermediate block 72 as is best shown in Fig. 13. The intermediate blocks 103 have oppositely facing end surfaces 113 and 114 with respect to which the surface 113 is identical to the surface 109 on the end block 101 and the surface 114 is identical to the surface 111 on the end block 102. In other words, the surface 111 on the end block 102 is made to extend parallel to the surface 113 on the adjacent intermediate block 103. This construction which permits the inner filler blocks to be withdrawn

from between the blades by an inward radial movement thereof is clearly shown in Figs. 13, 14 and 23.

Referring to Figs. 3, 15, 16, 17, 18, 22 and 23, it is seen that the end filler blocks 70 and 101 are held from being pushed out the end of the core box by means of inner and outer end blocks 116 and 117 having plane inner end surfaces 118 and 119, respectively. The arrangement is such that the plane end surface 118 of block 116 is disposed in abutting relation against the plane end surface of the inner clamping ring 19, the inner drag ring segment 13 and against a portion of the plane end surface 108 of the end filler block 101, and that the plane end surface 119 of block 117 is disposed in abutting relation against the plane end surface of the outer clamping ring 21, the outer drag ring segment 14 and against a portion of the plane end surface 80 of the end filler block 70. Each of the blocks 116 and 117 comprises separable top and bottom portions 120, 121 and 122, 125, respectively. The top portion 120 is provided on its underside with a projection 123 adapted to fit within the recess 124 provided in the top surface of the bottom portion 121 and the top portion 122 is provided on its underside with a projection 126 adapted to fit within the recess 127 provided in the top surface of the bottom portion 125. The underside of the bottom portions 121 and 125 are provided with projections 128 and 129 adapted to fit within recesses 131 and 132, respectively, which are formed by blocks 133 and 134 being secured on the lowermost step of the surfaces 27 and 28 in spaced opposed relation with respect to the adjacent end of the drag ring segments 13 and 14, respectively, as is best shown in Figs. 15 and 16. Each end of the drag ring segments 13 and 14 is provided with extensions 136 and 137, respectively, which present plane opposed side surfaces 138 and 139 adapted to engage the plane side surfaces 141 and 142 on the end blocks 116 and 117, respectively, and prevent a transverse movement of said end blocks relative to the drag ring segments and the end filler blocks 13, 14 and 70, 102, respectively. The extensions 136 and 137 terminate flush with the plane outer end surfaces of the blocks 116 and 117 and with the plane end surfaces presented by the base members 24 and 26 as is best shown in Figs. 3, 15, 16, 18 and 22, and a pair of coacting end plates 143 and 144 (see Fig. 40) are adapted to be removably secured in abutting relation against said surfaces by means of the stud bolts 146.

Assuming that the core box has been completed to the extent indicated in Figs. 7 and 15; i. e., that the lower jig holding segment 9 including the jigs 11 and 12 has been inserted in the base ring segment 8, that the drag ring segments have been positioned on and secured to the base ring segment 8, and that the end blocks 116 and 117 are in place; the next step is to position the end filler blocks 70 and 101 in the core box with their stepped bottom surfaces 74 and 105 engaging the exposed portions of the stepped surfaces 28 and 27, respectively, on the base members 26 and 24, with their outer and inner side surfaces abutting the inner and outer side surfaces, respectively, of the drag ring segments 14 and 13, and with their plane end surfaces 80 and 108 abutting the exposed portions of the plane inner end surfaces 119 and 118 on the end blocks 117 and 116 as is best shown in Figs. 22 and 23. The next step is to insert the outlet edge of a blade 2 into the adjacent pair of alined notches 47, 48 and the arrangement of the jigs 11 and 12 and the end filler blocks 70 and 101 is such that when a blade 2 is positioned and held by the said adjacent pair of notches, the end portions of the convex surface of the blade abut the entire concave portions of the inner end surfaces 75 and 109 on the end filler blocks 70 and 101, respectively, as is clearly shown in Figs. 10 and 23. An outer intermediate filler block 72 is then positioned in the box with its outer side surface abutting the inner side surface of the drag ring segment 14 and with its stepped bottom surface 74 engaging the exposed portion of the stepped surface 28 on base member 26 and so that the outer end surface 84, which comprises the plane surface 86, the convex surface 87, and the plane surface 88, abuts the plane surface 76 on the end filler block 70, the outer concave end portion of the blade 2, and the outer end portion of the outlet edge surface of the blade 2, respectively, as is clearly shown in Figs. 10, 13 and 14. An inner intermediate filler block 103 is then positioned in the core box with its bottom surface 105, its inner side surface, and its end surface 114, which includes plane and convex surfaces corresponding to the surface portions 86, 87, 88, 89 and 90 on the outer filler block 72, abutting the exposed portion of the stepped surface 27, the outer side surface of the drag ring segment 13, the inner margin of the plane top portion of the surface 109 on the end block 101, the inner end margin of the concave surface of the blade 2, and the inner end margin of the outlet edge surface of the blade 2, respectively, as is clearly shown in Figs. 13, 14 and 23. In actual practice, an inner and an outer filler block are placed simultaneously within the core box in the positions just described and the blade and filler block assembly is continued by alternately inserting a blade and a pair of inner and outer intermediate filler blocks. When the requisite number of blades has been inserted as just described, the assembly is completed by inserting the inner and outer end filler blocks 102 and 71 which are held in place in the core box by a retaining end block assembly which is identical to that described for the end filler blocks 70 and 101. Consequently, a further description in this connection is believed unnecessary for a complete understanding of the invention.

When the filler block, the blades and the retaining end block assemblies have been completed as just described, the blades 2 are securely locked in their assembled relation by placing thereon, i. e., on their inlet edges, the upper jig holding segment 18 which has secured in its underside, a projecting jig segment 147 provided with notches 148 arranged to engage the inlet edges of the blades 2 in the manner best shown in Figs. 8 and 9. The jig 147 is preferably positioned on the underside of the jig holding segment 18 by means of a channel 149 which is formed midway between the side edges of the segment 18 and which is adapted to snugly receive therein, a portion of the jig segment 147. The jig segment may be removably secured in the channel 149 by any suitable means, such as one or more of the screws 150 shown in Figs. 8 and 20. The upper jig holding segment 18 is positioned directly above the lower jig holding segment 9 and each end is rigidly connected to the underlying end of the segment 9. The connecting means (see Fig. 8) comprises an internally threaded bore 151 which extends

through the segment 18, a non-threaded bore 152 which extends through the segment 9 in alinement with the bore 151 and which terminates in an upper counterbored portion 153, a stud having an upper threaded portion 154 extending within the bore 151, an enlarged intermediate portion 156 which fits within the counterbore 153 and which abuts the underside of the segment 18, and an externally threaded reduced portion 157 which extends through the bore 152 and is engaged by a nut 158. It should be particularly noted that the jig 147 engages the inlet edge of each blade 2 at a point which is midway between the ends of the blade and which is also midway between the longitudinally spaced portions of the outlet edge of the blade engaged by a pair of the alined notches 47 and 48 in the jig segments 11 and 12 as is clearly shown in Figs. 9 and 20.

The core box structure is now completed to the extent shown in Fig. 20, and the next step is to place and secure the inner and outer filler block clamping segments 19 and 21, which are provided with stepped bottom surfaces 159 and 161, respectively, on the inner and outer drag ring segments with the stepped bottom surfaces 159 and 161 engaging the complementary stepped top surfaces 104 and 73 presented by the inner and outer series of filler blocks 16 and 17, respectively, as shown in Fig. 21. The top surfaces of the clamping ring segments 19 and 21 are substantially flush with the plane surfaces presented by top steps of the surfaces 56 and 58 on the drag rings 13 and 14, respectively, and the clamping segments are preferably secured to the drag ring segments by means of the countersunk screws 162 which extend through the metal facing segments 55 and 60. The opposed side surfaces on the filler block clamping segments 19 and 21 diverge upwardly with respect to each other and with respect to the adjacent sides of the upper jig holding segment 18 so as to facilitate the ramming operation. Referring to Figs. 38 and 39, it is seen that the upper surfaces of the filler block clamping segments 19 and 21 are provided with a pair of radially alined grooves 163 and 164 and the top surface of the upper jig holding segment 18 is provided with a similar groove 166 arranged for alinement with the grooves 163 and 164. A metal strap 167 is inserted in said grooves and is removably secured to the filler block clamping segments 19 and 21 by any suitable means such as the screws 168 so as to prevent the intermediate portion of the jig holding segment 18 from springing upward relative to the inlet edges of the blades. The end plates 143 and 144 are now secured to the ends of the box (see Fig. 40), thus rendering the box ready for the initial ramming operation.

Sand or other suitable core forming material, hereafter referred to as sand, is now rammed by hand or blown into the space between the blades until the box is filled with sand to a point slightly above the inlet edges of the blades, i. e., the edges engaged by the jig 147, whereupon the end plates 143 and 144 are partially removed which permits the upper jig holding segment 18 and the jig 147 to be removed as a unit. Additional sand is then rammed or blown into the box until the inlet edges of the blades are uniformly covered to a depth sufficient to support the metallic ring segment arbor 169 out of contact with the inlet edges of the blades as shown in Fig. 24. Usually a depth of approximately one-quarter of an inch is sufficient. The ends of the arbor 169 are removably connected together by a tie rod 170. It should also be noted, particular reference being had to Fig. 24, that the filler block clamping segments, which were removed either when the upper jig holding segment 18 was removed or after the arbor 169 was placed in the box, have been replaced by a new set of clamping segments 171 and 172 which differ from segments 19 and 21 only in that their opposed side surfaces converge upwardly with respect to each other. The ramming of the core box is then continued until the box is filled with sand to a point substantially flush with the top surfaces of the clamping segments 171 and 172 and the mold board 173 is placed over the core box and the entire structure is then inverted to the position shown in Fig. 25.

The next step in completing the core is to remove the base segment 8 which includes the bottom member 22 and the inner and outer base members 24 and 26 from the drag ring segments 13 and 14 and from the lower jig holding segment 9 and the straps 31 which are secured thereto. This step is readily accomplished by first removing the bolts 66 and 69 (see Fig. 7) and then lifting the entire base segment. Next, the lower jig hold segment 9 is removed from the jigs 11 and 12 which is readily accomplished by first removing the screws 42 and then bodily lifting the jig holding segment 9 together with the straps 31 which are secured thereto. When this has been done, the screws 42 are then inserted in the jigs 11 and 12. The resulting structure conforms with that shown in Fig. 26. The jigs 11 and 12 can now be readily removed from the outlet edges of the blades 2 and without affecting a movement thereof simply by grasping or tapping the screws 42 to effect a movement of the jigs circumferentially and upward with respect to the outlet edges of the blades (the necessary direction of movement is apparent from a consideration of Fig. 8 when inverted) a sufficient distance to free the undercut portions of the pairs of notches 47 and 48 from the outlet edges of the blades.

The core box is then completed preparatory to the final ramming operation, by placing on the drag ring segments, the inner and outer cope segments 174 and 175, respectively, which have the underside of their end portions provided with recesses 177 and 178, respectively, adapted to receive therein the projections 129 and 128 on the bottom end block portions 125 and 121, respectively. The bottom surfaces of the cope segments 174 and 175 are identical to the stepped surfaces 27 and 28 presented by the base members 24 and 26, respectively, and the cope segments are positioned and removably held with their bottom surfaces engaging the drag ring segments 13 and 14 and the inner and outer series of filler blocks 16 and 17 by any suitable means such as the dowel pins 180 shown in Fig. 27. The opposite end portions of the cope segment 174 coact with the ends of the drag ring segment 14, the bottom end block portions 125 (there being one such block portion at each end of the box), the plane end surfaces on the filler blocks 70 and 71, and with the inner surfaces of the end plates and forms therewith a space (see Fig. 28) into which sand is rammed to form the laterally extending projection 179 adjacent the ends of the core 6 as shown in Figs. 29, 30, 31 and 33. The opposite ends of the cope segment 175 coact with the ends of the drag ring segment 13, the bottom end block portions 121 (there being

one such block portion at each end of the box), the plane end surfaces on the filler blocks 101 and 102, and with the inner surfaces of the end plates and forms therewith a space (see Fig. 28) into which sand is rammed to form the laterally extending projection 181 adjacent the ends of the core 6 as shown in Figs. 29, 30, 31 and 33.

The outlet edges of the blades are now covered with sand (the end plates 143 and 144 having been partially removed to permit the removal of the jig holding segment 9 and the jigs 11 and 12) and ring segment arbor 182, which is similar to the arbor 169, is placed thereon and the ends of the arbor are removably connected together by a tie rod 183 which is also similar to tie rod 170. The core box structure shown in Figs. 27 and 28, is now dismantled except for the inner and outer series of filler blocks 16 and 17 and the filler block clamping segments 171 and 172 which are preferably made of metal, such as aluminum, so as to also function as drying segments, by removing, in the order named, the end plates 143 and 144, the cope segments 174 and 175, the drag ring segments 13 and 14, and the portions of the end blocks designated 121 and 125. The core together with the remaining portions of the core box is shown in Figs. 32 and 33. The core is now ready for baking and this is accomplished by placing the structure shown in Figs. 32 and 33 in a suitable oven (not shown) wherein the core is heated to and maintained at the requisite temperature for a predetermined time. Prior to the insertion of the core structure within the baking oven, the filler blocks, which are also made of metal such as aluminum to facilitate drying, are preferably withdrawn from the core a slight distance in the radial direction in order to prevent the expansion of the blocks from exerting a force on the blades tending to move same. Withdrawal of the inner series of blocks in the radial direction is permitted by forming the end surface 114 substantially parallel to the surface 113 as is best shown in Figs. 13 and 23. In addition, the connections between the ends of the arbors 169 and 182 and the ends of the tie rods 170 and 183 are loosened in order to permit the free expansion thereof during the baking operation to thereby prevent damage to the core. After the core has been baked and cooled, the inner and outer series of filler blocks 16 and 17 are entirely removed and the connections between the ends of the arbors 169, 182 and the ends of the tie rods 170, 183 are again made secure in order to aid in preventing deformation of the core while it is being removed from the mold board and placed in the mold. The filler block clamping and drying segments 171 and 172, which also function as a support for the filler blocks and the core as shown in Fig. 33, remain on the mold board 173 when the core is removed.

The dismantled core box structure including the previously used filler blocks and a new set of blades can be readily reassembled and a new core segment quickly formed in the manner just described. Obviously, no particular skill is required in this connection, and as a result the core segments can be rapidly formed with a minimum of expense, thereby materially reducing the cost of making cast diaphragm segments. In addition, the accuracy of diaphragm segments cast with the aid of cores made in accordance with this invention has in all cases been equal or superior to those made with cores constructed by highly skilled mechanics in accordance with the methods heretofore employed.

Referring to Figs. 34 and 35, it is seen that the drag portion 184 of the pattern, which is preferably used in forming a mold adapted to receive the core 6 preparatory to casting the diaphragm segment 1 shown in Figs. 1 and 2, comprises the inner and outer segments 186 and 187 for producing in the mold spaces corresponding to the portions of the diaphragm segment designated 3 and 4, respectively, a plurality of gate forming portions 188 which extend radially outward from the point at which the metal is to be introduced to the inner periphery of the segment 186, a plurality of radially extending gate forming bridging members 189 arranged to connect outer portions of the inner segment 186 with the outer segment 187 across the core space forming portion 191, and the match board 192. The first step in forming the mold is to place the drag portion 184 on a mold board 193, then place a flask 194 therearound and ram the same with sand to produce the structure shown in Fig. 35. When this has been done, the flask is inverted on the mold board, the match board 193 removed from the drag portion 184, and the cope portion 195 of the pattern is added to produce the structure shown in Fig. 36. The next step is to place the cope flask 196 on the flask 194, ram the same with sand, lift the flask 196 from the flask 194, remove the pattern from the flask 194, place the core blocks 197 and 198 in the space adapted to receive the core 6, place the core 6 in said core receiving space, insert the core blocks 199 and 201, and place the flask 196 on the flask 194 which completes the mold as shown in Fig. 37. The metal is poured into the mold through the central sprue 202 and after the casting operation has been completed and the casting cleaned, all that remains to be done is to machine finish the casting to the desired dimensions.

The pattern structure and the manner in which the mold is formed are merely illustrative of a practical construction for using a core formed in accordance with this invention, and it should therefore be understood that it is not desired to limit the invention to the exact methods and details of construction herein shown and described as various modifications within the scope of the appended claims may occur to persons skilled in the art.

It is claimed and desired to secure by Letters Patent:

1. In a core box for use in forming turbine blade holding core segments embodying spaced curved blades extending transversely therethrough and presenting inner and outer free end portions adapted to have inner and outer ring segments cast integrally thereto, a bottom and drag ring construction comprising a base ring segment, a pair of inner and outer drag ring segments disposed on said base ring segment adjacent the edges thereof and in spaced concentric relation with respect to each other, and a pair of inner and outer jigs disposed on said base ring segment between and in spaced concentric relation with respect to said pair of drag ring segments and in spaced concentric relation with respect to each other, said pair of jigs being shaped to engage longitudinally spaced intermediate edge portions of blades inserted therein and to thereby position and firmly hold the blades in a predetermined angular relation.

2. In a core box for use in forming turbine blade holding core segments embodying spaced curved blades extending transversely therethrough and presenting inner and outer free end

portions adapted to have inner and outer ring segments cast integrally thereto, a bottom and drag ring construction comprising a base ring segment, a pair of inner and outer drag ring segments disposed on said base ring segment adjacent the edges thereof and in spaced concentric relation with respect to each other, said drag ring segments coacting and forming with said base ring segment spaced concentric surfaces shaped to position and retain thereagainst inner and outer series of filler blocks, and a pair of inner and outer jigs disposed on said base ring segment between and in spaced concentric relation with respect to said inner and outer filler block positioning and retaining surfaces and in spaced concentric relation with respect to each other, said pair of jigs being shaped to engage longitudinally spaced intermediate edge portions of blades inserted therein and to thereby position and firmly hold the blades in a predetermined angular relation.

3. In a core box for use in forming turbine blade holding core segments embodying spaced curved blades extending transversely therethrough and presenting inner and outer free end portions adapted to have inner and outer ring segments cast integrally thereto, a bottom and drag ring construction comprising a base ring segment, a pair of inner and outer drag ring segments disposed on said base ring segment adjacent the edges thereof and in spaced concentric relation with respect to each other, said drag ring segments coacting and forming with said base ring segment spaced concentric surfaces shaped to position and retain thereagainst inner and outer series of filler blocks, and a pair of inner and outer jigs disposed on said base ring segment between and in spaced concentric relation with respect to said inner and outer filler block positioning and retaining surfaces and in spaced concentric relation with respect to each other, said pair of jigs being shaped to engage longitudinally spaced intermediate edge portions of blades inserted therein and to thereby position and firmly hold the blades in a predetermined angular relation, and said pair of drag ring segments being spaced apart a distance commensurate with the length of the blades to be positioned and held in said pair of jigs so as to form with the exposed top portion of said base ring segment and with said jigs a channel in which the blades and filler blocks can be quickly and accurately assembled simply by alternately placing in abutting relation, on said concentric positioning and retaining surfaces and in said pair of jigs, a pair of inner and outer filler blocks and a blade, respectively.

4. In a core box for use in forming turbine blade holding core segments embodying spaced curved blades extending transversely therethrough and presenting inner and outer free end portions adapted to have inner and outer ring segments cast integrally thereto, a bottom construction comprising inner and outer base members disposed in spaced concentric relation, a jig holding ring segment disposed in and substantially closing the space between said base members, and a pair of inner and outer jigs disposed in spaced concentric relation on the top portion of said jig holding ring segment, said pair of jigs being shaped to engage longitudinally spaced intermediate edge portions of blades inserted therein to thereby position and firmly hold the blades in a predetermined angular relation.

5. In a core box for use in forming turbine blade holding core segments embodying spaced curved blades extending transversely therethrough and presenting inner and outer free end portions adapted to have inner and outer ring segments cast integrally thereto, a bottom and drag ring construction comprising inner and outer base members disposed in spaced concentric relation, a jig holding ring segment disposed between said base members, a pair of inner and outer jigs disposed in spaced concentric relation on the top portion of said jig holding ring segment, said pair of jigs being shaped to engage longitudinally spaced intermediate edge portions of blades inserted therein to thereby position and firmly hold the blades in a predetermined angular relation, and a pair of inner and outer drag ring segments disposed in spaced concentric relation and coacting with said base members to form therewith spaced concentric surfaces shaped to position and retain thereagainst inner and outer series of filler blocks adapted to be assembled between the inner and outer end portions of blades held in said pair of jigs.

6. In a core box for use in forming turbine blade holding core segments embodying spaced curved blades extending transversely therethrough and presenting inner and outer free end portions adapted to have inner and outer ring segments cast integrally thereto, a bottom and drag ring construction comprising inner and outer base members disposed in spaced concentric relation, a jig holding ring segment disposed between said base members, a pair of inner and outer jigs disposed in spaced concentric relation on the top portion of said jig holding ring segment, said pair of jigs being shaped to engage longitudinally spaced intermediate edge portions of blades inserted therein to thereby position and firmly hold the blades in a predetermined angular relation, and a pair of inner and outer drag ring segments disposed in spaced concentric relation and coacting with said base members to form therewith spaced concentric surfaces shaped to position and retain thereagainst inner and outer series of filler blocks adapted to be assembled between the inner and outer end portions of blades held in said pair of jigs, said jigs being removably secured to said jig holding ring segment, said jig holding ring segment being removably secured to said base members, and said base members being removably secured relative to said pair of drag ring segments so that when the core box is inverted said base members can be removed from said jig holding ring segment and from their coacting relation with said drag segments, said jig holding ring segment can then be removed from said pair of jigs, and said pair of jigs can then be removed from the blades inserted therein.

7. In a core box for use in forming turbine blade holding core segments embodying spaced curved blades extending transversely therethrough and presenting inner and outer free end portions adapted to have inner and outer ring segments cast integrally thereto, a bottom and drag ring construction comprising inner and outer base members disposed in spaced concentric relation, a jig holding ring segment disposed between said base members, a pair of inner and outer jigs disposed in spaced concentric relation on the top portion of said jig holding ring segment, said pair of jigs being shaped to engage longitudinally spaced intermediate edge

portions of blades inserted therein to thereby position and firmly hold the blades in a predetermined angular relation, a pair of inner and outer drag ring segments disposed in spaced concentric relation and coacting with said base members to form therewith spaced concentric surfaces shaped to position and retain thereagainst inner and outer series of filler blocks adapted to be assembled between the inner and outer end portions of blades held in said pair of jigs, and said pair of drag rings being spaced apart a distance commensurate with the length of the blades to be positioned and held in said pair of jigs so as to form with the exposed top portions of said base members and with said jig holding ring segment and jigs a channel in which the blades and filler blocks can be quickly and accurately assembled simply by alternately placing in abutting relation on said concentric positioning and retaining surfaces and in said pair of jigs a pair of inner and outer filler blocks and a blade, respectively.

8. In a core box for use in forming turbine blade holding core segments embodying spaced curved blades extending transversely therethrough and presenting inner and outer free end portions adapted to have inner and outer ring segments cast integrally thereto, a bottom and drag ring construction comprising inner and outer base members disposed in spaced concentric relation, a jig holding ring segment disposed between said base members, a pair of inner and outer jigs disposed in spaced concentric relation on the top portion of said jig holding ring segment, said pair of jigs being shaped to engage longitudinally spaced intermediate edge portions of blades inserted therein to thereby position and firmly hold the blades in a predetermined angular relation, a pair of inner and outer drag ring segments superimposed in spaced concentric relation on portions of the tops of said base members and forming with the exposed portions of the tops of said base members spaced concentric surfaces shaped to position and retain thereagainst inner and outer series of filler blocks adapted to be assembled between the inner and outer end portions of blades held in said pair of jigs, and said pair of drag rings being spaced apart a distance commensurate with the length of the blades to be positioned and held in said pair of jigs so as to form with the exposed top portions of said base members and with said jig holding ring segment and jigs a channel in which the blades and filler blocks can be quickly and accurately assembled simply by alternately placing in abutting relation on said concentric positioning and retaining surfaces and in said pair of jigs a pair of inner and outer filler blocks and a blade, respectively.

9. In a core box for use in forming turbine blade holding core segments embodying spaced curved blades extending transversely therethrough and presenting inner and outer free end portions adapted to have inner and outer ring segments cast integrally thereto, a bottom and drag ring construction comprising a base ring segment, a pair of inner and outer jigs disposed in spaced concentric relation on said base ring segment, said pair of jigs being shaped to engage longitudinally spaced intermediate edge portions of blades inserted therein to thereby position and firmly hold the blades in a predetermined angular relation, a pair of inner and outer drag ring segments disposed in spaced concentric relation on and forming with the top portion of said base ring segment spaced concentric surfaces shaped to position and retain thereagainst inner and outer series of filler blocks adapted to be assembled between the inner and outer end portions of blades held in said pair of jigs, blades held in said pair of jigs and inner and outer series of filler blocks disposed on said positioning and retaining surfaces and between the inner and outer end portions of said blades, removable clamping means superimposed on said series of filler blocks in spaced concentric relation, and a jig ring segment removably secured in spaced concentric relation between said clamping means and the upper portions of said drag rings and in engagement with an intermediate portion of the adjacent edge of each of the blades held in said pair of jigs.

10. In a core box for use in forming turbine blade holding core segments embodying spaced curved blades extending transversely therethrough and presenting inner and outer free end portions adapted to have inner and outer ring segments cast integrally thereto, a bottom and drag ring construction comprising inner and outer base members disposed in spaced concentric relation, a jig holding ring segment disposed between said base members, a pair of inner and outer jigs disposed in spaced concentric relation on the top portion of said jig holding ring segment, said pair of jigs being shaped to engage longitudinally spaced intermediate edge portions of blades inserted therein to thereby position and firmly hold the blades in a predetermined angular relation, a pair of inner and outer drag ring segments disposed in spaced concentric relation and coacting with said bottom members to form therewith spaced concentric surfaces shaped to position and retain thereagainst inner and outer series of filler blocks adapted to be assembled between the inner and outer end portions of blades held in said pair of jigs, blades held in said pair of jigs and inner and outer series of filler blocks disposed on said positioning and retaining surfaces and between the inner and outer end portions of said blades, removable clamping means superimposed on said series of filler blocks in spaced concentric relation, and a jig ring segment removably secured in spaced concentric relation between said clamping means and the upper portions of said drag rings and in engagement with the adjacent edge of each blade at a point intermediate the longitudinally spaced opposite edge portions thereof which are engaged by said pair of jigs.

11. In a core box for use in forming turbine blade holding core segments embodying spaced curved blades extending transversely therethrough and presenting inner and outer free end portions adapted to have inner and outer ring segments cast integrally thereto, a bottom and drag ring construction comprising inner and outer base members disposed in spaced concentric relation, a jig holding ring segment disposed between said base members, a pair of inner and outer jigs disposed in spaced concentric relation on the top portion of said jig holding ring segment, said pair of jigs being shaped to engage longitudinally spaced intermediate edge portions of blades inserted therein to thereby position and firmly hold the blades in a predetermined angular relation, a pair of inner and outer drag ring segments superimposed in spaced concentric relation on portions of the tops of said base members and forming with the exposed portions of the tops of said base members spaced con-

centric surfaces shaped to position and retain thereagainst inner and outer series of filler blocks adapted to be assembled between the inner and outer end portions of blades held in said pair of jigs, said pair of drag rings being spaced apart a distance commensurate with the length of the blades to be positioned and held in said pair of jigs so as to form with the exposed top portions of said base members and with said jig holding ring segment and jigs a channel in which the blades and filler blocks can be quickly and accurately assembled simply by alternately placing in abutting relation on said concentric positioning and retaining surfaces and in said pair of jigs a pair of inner and outer filler blocks and a blade, respectively, blades held in said pair of jigs and inner and outer series of filler blocks disposed on said positioning and retaining surfaces and between the inner and outer end portions of said blades, removable clamping means superimposed on said series of filler blocks in spaced concentric relation, and a jig ring segment removably secured in spaced concentric relation between said clamping means and the upper portions of said drag rings and in engagement with an intermediate portion of the adjacent edge of each of the blades held in said pair of jigs.

12. In a core box for use in forming turbine blade holding core segments embodying spaced curved blades extending transversely therethrough and presenting inner and outer free end portions adapted to have inner and outer ring segments cast integrally thereto, a bottom and drag ring construction comprising inner and outer base members disposed in spaced concentric relation, a jig holding ring segment disposed between said base members, a pair of inner and outer jigs disposed in spaced concentric relation on the top portion of said jig holding ring segment and presenting pairs of downwardly inclined and transversely extending alined notches terminating in undercut portions providing pairs of transversely extending alined grooves adapted to receive snugly therein longitudinally spaced portions of the outlet edge of a curved blade, said pairs of notches being shaped to guide the outlet edge of a curved blade downward into the grooved portions thereof and to retain the blade inserted therein in a predetermined angular relation, a pair of inner and outer drag ring segments disposed in spaced concentric relation and coacting with said base members to form therewith spaced concentric surfaces shaped to position and retain thereagainst inner and outer series of filler blocks adapted to be assembled between the inner and outer end portions of blades inserted and held in said pairs of notches, blades disposed in each pair of said notches and inner and outer series of filler blocks disposed on said positioning and retaining surfaces and between the inner and outer end portions of said blades, removable clamping means superimposed on said series of filler blocks in spaced concentric relation, and a jig ring segment removably secured in spaced concentric relation between said clamping means and the upper portions of said drag ring segments and in engagement with the inlet edge of said blade at a point intermediate the longitudinally spaced outlet edge portions thereof which are inserted in said pair of notches.

13. In a core box for use in forming turbine blade holding core segments embodying angularly spaced curved blades extending transversely therethrough and presenting inner and outer free end portions adapted to have inner and outer ring segments cast integrally thereto, a bottom and drag ring construction comprising inner and outer base members secured in spaced concentric relation, a jig holding ring segment disposed in and substantially closing the space between said base members, a pair of inner and outer blade holding jigs removably secured in spaced concentric relation on the top portion of said jig holding ring segment and presenting pairs of downwardly inclined and transversely extending notches terminating in undercut portions providing pairs of transversely extending alined grooves adapted to receive snugly therein longitudinally spaced portions of the outlet edge of a curved blade, said pairs of notches being shaped to guide the outer edge of a curved blade downward into the grooved portions thereof and to retain the blade inserted therein in a predetermined angular relation, said base members having portions of the tops thereof shaped to concentrically position and support thereon a pair of inner and outer drag ring segments, a pair of inner and outer drag ring segments superimposed on said portions of the tops of said base members and forming with the exposed portions thereof concentric surfaces shaped to position and retain thereagainst inner and outer series of filler blocks adapted to be disposed between the free inner and outer end portions of blades disposed in said pairs of notches, blades disposed in each pair of said notches and inner and outer series of filler blocks disposed on said positioning and supporting surfaces and between the inner and outer end portions of said blades, removable clamping means superimposed on said filler blocks, and a removable jig ring segment disposed in spaced concentric relation between said clamping means and the upper portion of said drag rings and engaging the inlet edge of each blade at a point intermediate the longitudinally spaced outlet edge portions thereof which are disposed in a pair of said notches.

14. In a core box for use in forming turbine blade holding core segments embodying angularly spaced curved blades extending transversely therethrough and presenting inner and outer free end portions adapted to have inner and outer ring segments cast integrally thereto, a bottom construction comprising inner and outer base members positioned in spaced concentric relation, a jig holding ring segment disposed between and substantially closing the space between said base members, a pair of inner and outer blade holding jigs secured in spaced concentric relation on the top portion of said jig holding ring segment and presenting pairs of downwardly inclined and transversely extending notches terminating in undercut portions providing transversely extending alined grooves adapted to receive snugly therein longitudinally spaced portions of the outlet edge of a curved blade, said pairs of notches being shaped to guide the outlet edge of a curved blade downward into the grooved portions thereof and to retain the blade inserted therein in a predetermined angular relation, said jigs being removably secured to said jig holding ring segment, and said jig holding ring segment being removably supported between said bottom members so that when the core box has been partially rammed and inverted, said bottom members can be removed from said jig holding ring segment, said jig holding ring segment can then be removed from said pair of jigs, and said pair of jigs can then be removed from the outlet edges of the blades inserted in said pairs of notches.

15. In a core box for use in forming turbine

blade holding core segments embodying angularly spaced curved blades extending transversely therethrough and presenting inner and outer free end portions adapted to have inner and outer ring segments cast integrally thereto, a bottom construction comprising inner and outer base members disposed in spaced concentric relation, a jig holding ring segment disposed between said base members, a pair of inner and outer blade holding jigs disposed in spaced concentric relation on the top portion of said jig holding ring segment and presenting pairs of downwardly inclined and transversely extending alined notches terminating in undercut portions providing transversely extending grooves adapted to receive snugly therein longitudinally spaced portions of the outlet edge of a curved blade, said pairs of notches being shaped to guide the outlet edge of a curved blade downward into the grooved portions thereof and to retain the blade inserted therein in a predetermined angular relation, said jig holding ring being removable from said pair of jigs when the core box is inverted, and said pair of jigs being then removable from the outlet edges of the blades inserted in said pairs of notches.

16. In a core box for use in forming turbine blade holding core segments embodying angularly spaced curved blades extending transversely therethrough and presenting inner and outer free end portions adapted to have inner and outer ring segments cast integrally thereto, a bottom construction comprising a base ring segment and a pair of inner and outer blade holding jigs disposed in spaced concentric relation on the top portion of said base ring segment and presenting upwardly facing pairs of downwardly inclined and transversely extending alined notches terminating in undercut portions providing transversely extending grooves adapted to receive snugly therein longitudinally spaced portions of the outlet edge of a curved blade, said pairs of notches being shaped to guide the outlet edge of a curved blade downward into the grooved portions thereof and to retain the blade inserted therein in a predetermined angular relation.

17. In a method of forming turbine blade holding core segments embodying spaced curved blades extending transversely therethrough and presenting inner and outer free end portions adapted to have inner and outer ring segments cast integrally thereto, the steps comprising forming a core box having a bottom portion including inner and outer filler block positioning and retaining surfaces disposed in spaced concentric relation with respect to each other and with respect to the sides of said box and including a pair of blade positioning and holding jigs disposed between and in spaced concentric relation with respect to said inner and outer surfaces and in spaced concentric relation with respect to each other, alternately placing a pair of inner and outer filler blocks on said inner and outer surfaces and a blade in said pair of jigs with the inner and end portion of each blade abutting the proximate portions of said pair of filler blocks to thereby form a series of angularly spaced blades having the inner and outer end portions of each blade disposed between and enclosed by adjacent pairs of said filler blocks, clamping said filler blocks and blades in said box, ramming said box with a core forming material to a depth sufficient to cover said blades, removing said clamping means and placing a metallic ring segment arbor on said core forming material and in spaced concentric relation with respect to the sides of said box, completing the ramming of said box with core forming material, inverting said box and removing said bottom portion, placing cope ring segments in spaced concentric relation on the top portions of the sides of the inverted box and ramming sufficient core forming material between said cope segments to cover the adjacent edges of the blades, placing a metallic ring segment arbor on said core forming material and in spaced concentric relation with respect to the sides of said cope segments, completing the ramming of the space between said cope segments with the core forming material, removing the remaining portions of the box from the core formed therein, and removably securing a tie rod between the free exposed end portions of each arbor.

18. In a method of forming turbine blade holding core segments embodying spaced curved blades extending transversely therethrough and presenting inner and outer free end portions adapted to have inner and outer ring segments cast integrally thereto, the steps comprising forming a core box having a bottom portion including inner and outer filler block positioning and retaining surfaces disposed in spaced concentric relation with respect to each other and with respect to the sides of said box and including a pair of blade positioning and holding jigs disposed between and in spaced concentric relation with respect to said inner and outer surfaces and in spaced concentric relation with respect to each other, alternately placing a pair of inner and outer filler blocks on said inner and outer surfaces and a blade in said pair of jigs with the inner and outer end portion of each blade abutting the proximate portions of said pair of filler blocks to thereby form a series of angularly spaced blades having the inner and outer end portions of each blade disposed between and enclosed by adjacent pairs of said filler blocks, clamping said filler blocks and blades in said box, ramming said box with a core forming material to a depth sufficient to cover said blades, removing said clamping means and placing a metallic ring segment arbor on said core forming material and in spaced concentric relation with respect to the sides of said box, completing the ramming of said box with core forming material, inverting said box and removing said bottom portion, placing cope ring segments in spaced concentric relation on the top portions of the sides of the inverted box and ramming sufficient core forming material between said cope segments to cover the adjacent edges of the blades, placing a metallic ring segment arbor on said core forming material and in spaced concentric relation with respect to the sides of said cope segments, and completing the ramming of the space between said cope segments with the core forming material.

19. In a method of forming turbine blade holding core segments embodying spaced curved blades extending transversely therethrough and presenting inner and outer free end portions adapted to have inner and outer ring segments cast integrally thereto, the steps comprising forming a core box having a bottom portion including inner and outer filler block positioning and retaining surfaces disposed in spaced concentric relation with respect to each other and with respect to the sides of said box and including a pair of blade positioning and holding jigs disposed between and in spaced concentric

relation with respect to said inner and outer surfaces and in spaced concentric relation with respect to each other, alternately placing a pair of inner and outer filler blocks on said inner and outer surfaces and a blade in said pair of jigs with the inner and outer end portions of each blade abutting the proximate portions of said pair of filler blocks to thereby form a series of angularly spaced blades having the inner and outer end portions of each blade disposed between and enclosed by adjacent pairs of said filler blocks, clamping said filler blocks and blades in said box, and ramming said box with a core forming material.

20. In a core for use in forming turbine blade holding core segments embodying a series of spaced blades extending transversely therethrough and presenting inner and outer free end portions adapted to have inner and outer ring segments cast integrally thereto, a core reinforcing construction comprising a pair of metallic ring segment arbors extending throughout the length of the core on either side of and in close proximity with respect to the inlet and outlet edges of the spaced blades extending transversely therethrough and terminating in exposed free end portions, and a tie rod connecting the free end portions of each arbor.

21. In a core box for use in forming blade holding core segments embodying spaced blades extending transversely therethrough and presenting inner and outer free end portions adapted to have inner and outer ring segments cast integrally thereto, a bottom construction comprising a base ring segment presenting inner and outer concentric drag ring segment positioning and supporting surfaces and inner and outer concentric filler block positioning and supporting surfaces disposed between and in proximity to said inner and outer drag ring segment surfaces respectively, and a pair of blade positioning and holding jig segments disposed on said base ring segment in spaced concentric relation between said filler block positioning and supporting surfaces.

22. In a core box for use in forming blade holding core segments embodying spaced blades extending transversely therethrough and presenting inner and outer free end portions adapted to have inner and outer ring segments cast integrally thereto, a bottom construction comprising a base ring segment presenting inner and outer concentric drag ring segment positioning and supporting surfaces and inner and outer concentric filler block positioning and supporting surfaces disposed between and in proximity to said inner and outer drag ring segment surfaces respectively, and a pair of blade positioning and holding jig segments disposed on said base ring segment between said filler block positioning and supporting surfaces in spaced concentric relation with respect to each other and with respect to said filler block positioning and supporting surfaces.

23. In a core box for use in forming blade holding core segments embodying spaced blades extending transversely therethrough and presenting inner and outer free end portions adapted to have inner and outer ring segments cast integrally thereto, a bottom construction comprising a base ring segment presenting inner and outer concentric drag ring segment supporting surfaces embodying drag ring segment positioning means thereon and presenting between and in proximity to said inner and outer drag ring segment surfaces inner and outer concentric filler block supporting surfaces embodying filler block positioning means thereon, and a pair of blade positioning and holding jib segments disposed on said base ring segment in spaced concentric relation between said filler block supporting surfaces.

24. In a core box for use in forming blade holding core segments embodying spaced blades extending transversely therethrough and presenting inner and outer free end portions adapted to have inner and outer ring segments cast integrally thereto, a base ring segment presenting inner and outer concentric drag ring segment positioning and supporting surfaces and inner and outer concentric filler block positioning and supporting surfaces disposed between and in proximity to said inner and outer drag ring segment surfaces respectively, and a pair of blade positioning and holding jig segments disposed on said base ring segment in spaced concentric relation between said filler block positioning and supporting surfaces and presenting pairs of alined upwardly opening notches arranged to engage longitudinally spaced edge portions of blades inserted therein intermediate the free end portions thereof.

25. In a core box for use in forming blade holding core segments embodying spaced blades extending transversely therethrough and presenting inner and outer free end portions adapted to have inner and outer ring segments cast integrally thereto, a base ring segment presenting inner and outer concentric drag ring segment positioning and supporting surfaces and inner and outer concentric filler block positioning and supporting surfaces disposed between and in proximity to said inner and outer drag ring segment surfaces respectively, a pair of blade positioning and holding jig segments disposed on said base ring segment in spaced concentric relation between said filler block positioning and supporting surfaces and presenting pairs of alined upwardly opening notches arranged to engage longitudinally spaced edge portions of blades inserted therein intermediate the free end portions thereof, a pair of inner and outer drag ring segments mounted on said inner and outer drag ring supporting surfaces, respectively, and blades mounted in said jig segments with their ends abutting the opposed inner side surfaces of said drag ring segments.

26. In a core box for use in forming blade holding core segments embodying spaced blades extending transversely therethrough and presenting inner and outer free end portions adapted to have inner and outer ring segments cast integrally thereto, a base segment embodying a pair of concentric blade positioning and holding jig segments presenting pairs of alined upwardly opening notches arranged to engage longitudinally spaced edge portions of blades inserted therein intermediate the free end portions thereof, a pair of inner and outer drag ring segments coacting with said base segment to form a channel adapted to have blades positioned transversely therein by inserting an intermediate edge portion of each blade in a pair of said notches, blades positioned in said pairs of notches, and a superposed jig carrying ring segment engaging the opposite edge portion of each blade at a point intermediate the longitudinally spaced edge portions thereof which are disposed in a pair of said notches.

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