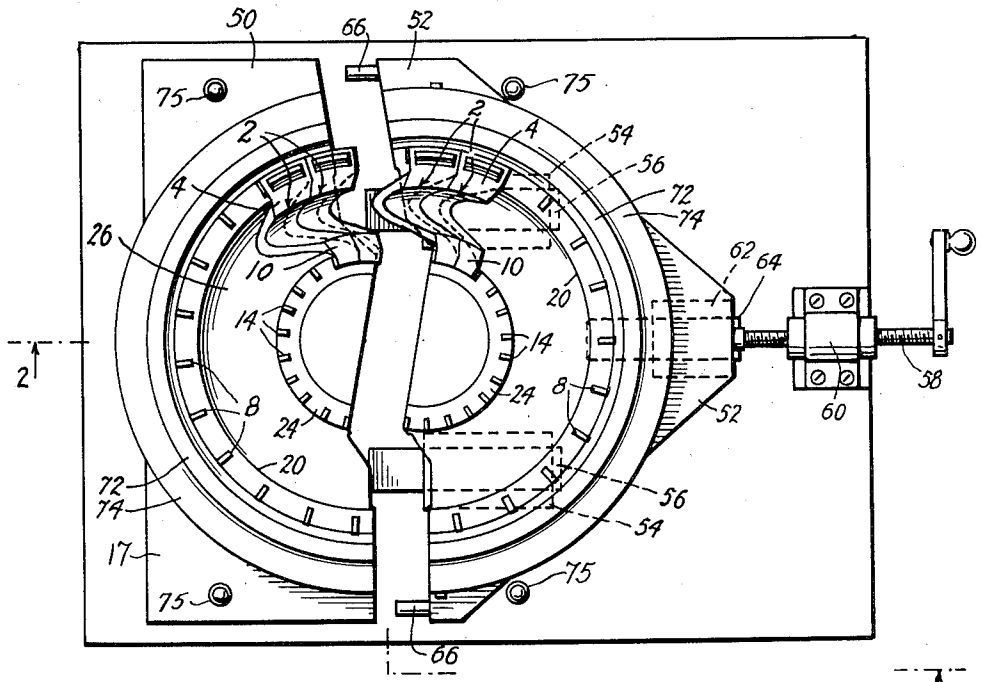
Feb. 26, 1957 M. M. BEAN ET AL 2,782,477

PRECISION CASTING MOLD AND METHOD OF MAKING

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Fig. 1.



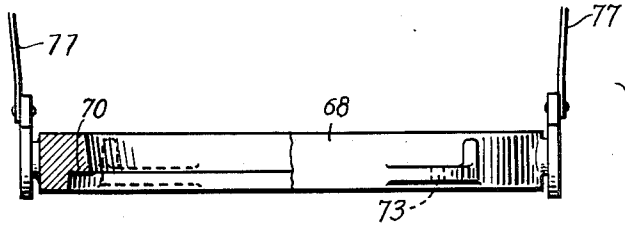
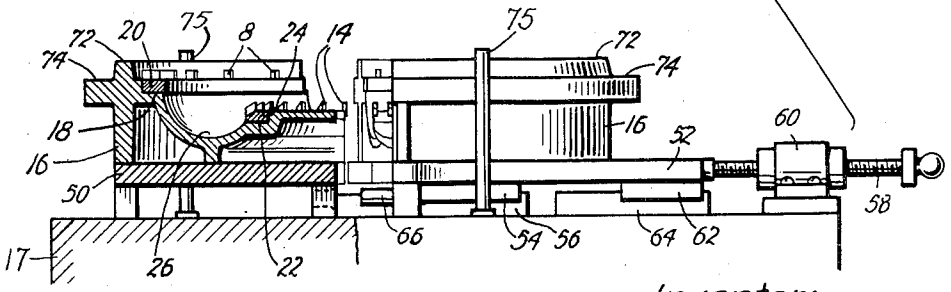


Fig. 2.



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PRECISION CASTING MOLD AND METHOD OF MAKING

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Fig. 3.

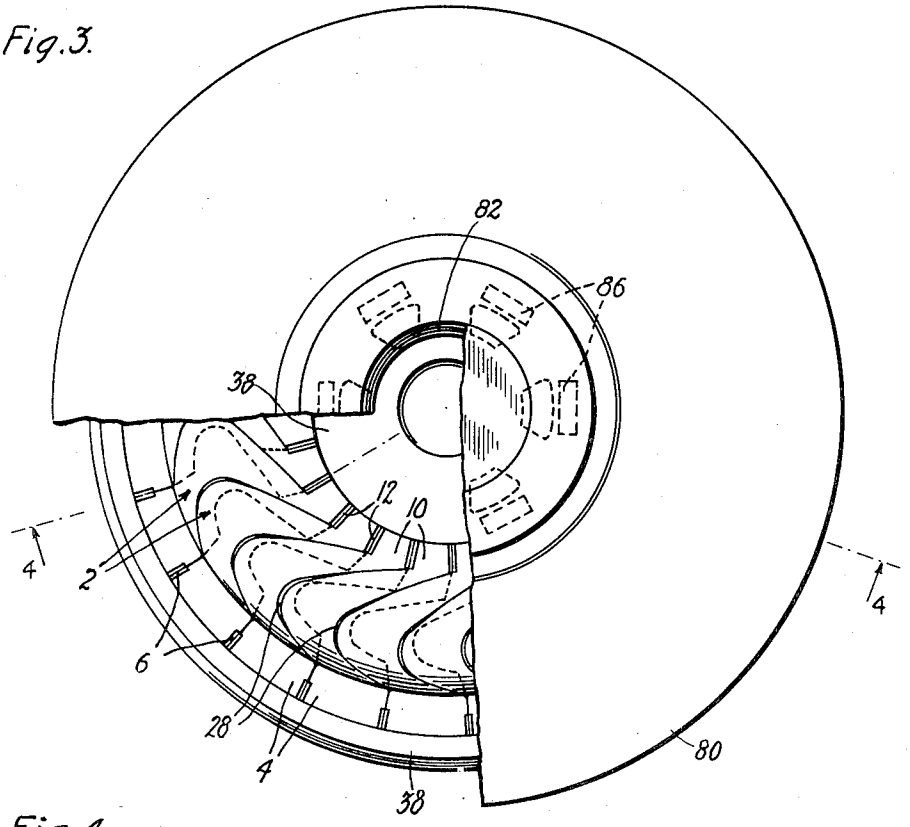
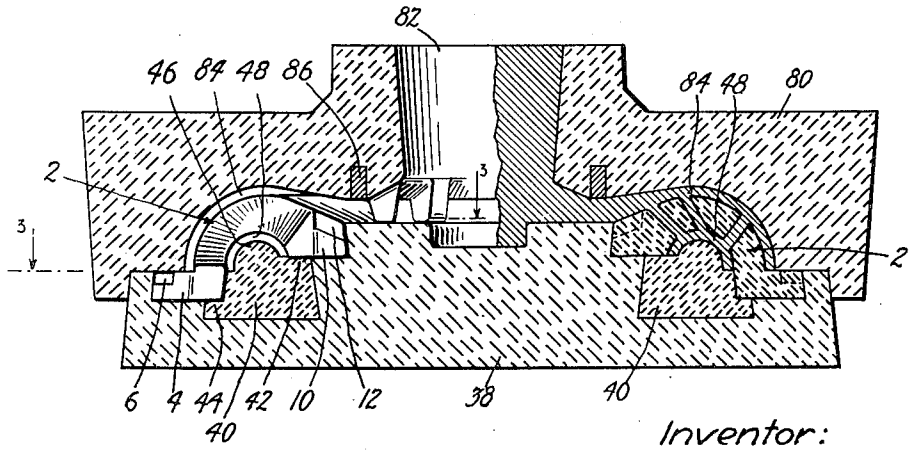


Fig. 4.



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PRECISION CASTING MOLD AND METHOD OF MAKING

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Fig. 5.

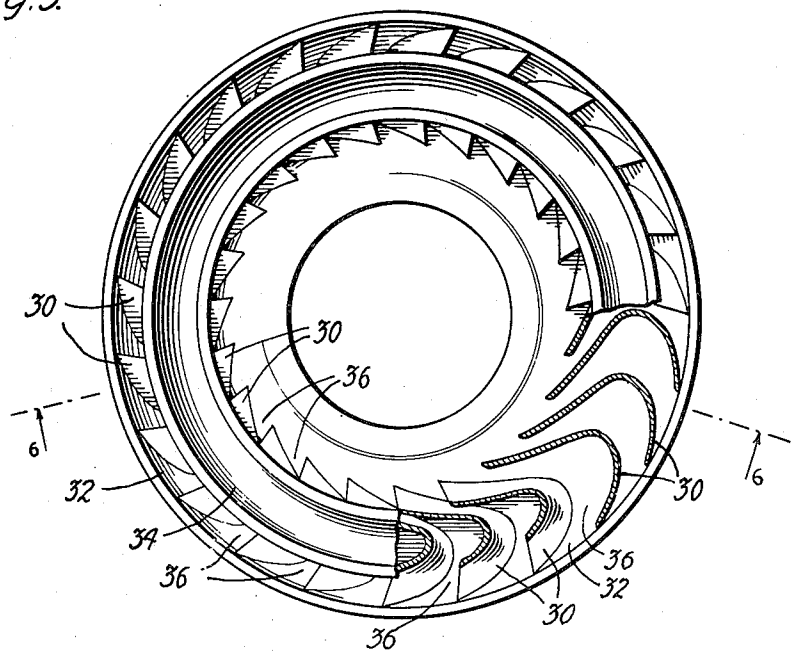
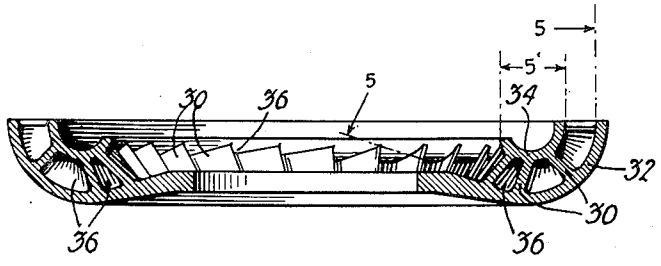


Fig. 6.



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PRECISION CASTING MOLD AND METHOD OF MAKING

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Fig. 7.

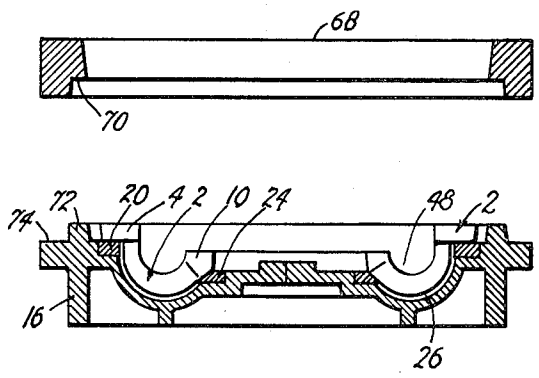


Fig. 8.

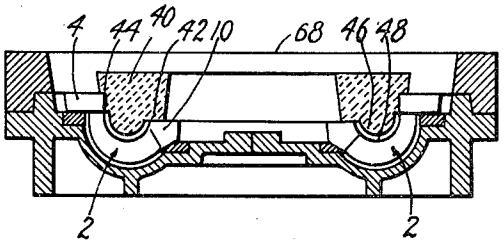


Fig. 9.

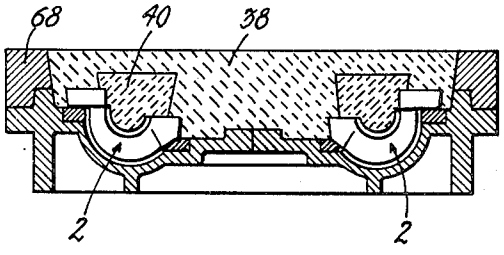
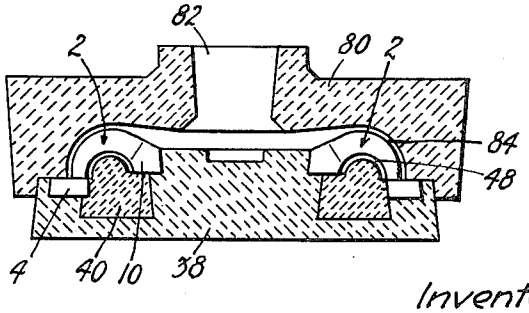


Fig. 10.



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2,782,477

PRECISION CASTING MOLD AND METHOD OF MAKING

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Application March 11, 1953, Serial No. 341,642

13 Claims. (Cl. 22—131)

This invention relates to the preparation of molds for the precision casting of devices or parts thereof which require for their formation a considerable number of cores fixed in accurate predetermined relation to each other and to the other mold parts in the completed mold. Examples of devices which, when they are to be made by casting, require for their accurate formation molds of the character aforementioned are turbine rings, impellers, inducers, turbine rotors and stators, torque converter parts, etc. for fluid flow applications.

Devices such as those for fluid flow applications ordinarily require complex curvatures and frequently follow a repetitive pattern having a symmetry about a central axis. It is important to the efficient and satisfactory performance of such devices that the vanes or blades and other flow controlling parts be accurate and uniform as to contour and dimensions, and particularly in respect to thickness, since the flow of the fluid is affected by the capacity and shape of the spaces between such parts.

One way of making devices having the aforementioned structural characteristics is by casting. This may be illustrated by a torque converter casting using a mold in which the entire casting including the vanes and other elements having axial symmetry, such as the hub and shrouds, are formed as one integral structure by casting the metal about cores located in molds. In this procedure the vanes or blades are formed by metal which runs between the cores, the passageways being formed by the cores, which are disintegrated and removed after the casting operation. The exterior of the casting is, of course, formed by the mold.

The dimensional accuracy and uniformity of the flow-controlling surfaces of such parts is determined both by the accuracy of the contours of the cores and by the location of the cores in respect to each other and to the mold surfaces. It has been common foundry practice to locate such cores by means of matching locating surfaces on the ends of the cores and in the bottom or "drag" part of the mold, and to locate them laterally by means of matching surfaces on the sides of the cores. All these locating surfaces are beyond the surfaces against which metal will be cast; and, in the case of the cores, are formed on extensions thereof termed core "prints." (Note that the "key" or registering part of the drag mold into which such extensions fit are also called "prints," but are distinguished as the "female prints.")

Although little difficulty is experienced in registering two cores accurately with respect to each other by the common foundry practice, a much more difficult problem is presented when it is attempted to apply the present foundry practice to the accurate assemblage of twenty or more such cores about a common center; and the difficulty is aggravated in casting devices of the type hereinabove referred to because of their complex and overlapping shapes. It will be obvious that a slight, possibly negligible, dimensional error in the location of the lateral matching face of a core print will be multiplied in an assembly of

twenty or thirty like cores until the accumulated error becomes too great to be negligible. For example, an error of .001" in a core print would probably be negligible in a two core assembly but would not be negligible in a thirty core assembly, where the accumulated error would amount to .030".

A further difficulty encountered when the common foundry practice of locating cores is employed is that it is not practicable to make cores with such close dimensional tolerances as even that given in the above illustration. Problems of core box construction and manipulation, variations and changes in dimension of foundry mold materials, etc. make such an approach to the problem of maintaining accuracy in a circular assembly of cores impracticable. In addition to the difficulty of making an accurate assembly to start with, there is the further difficulty of maintaining accuracy throughout all the steps necessary to making a casting, these steps often involving mold baking, etc. and always involving the movement of the mold from one place to another in the foundry and the pouring of the metal into the mold.

In making castings for structures of the kind hereinabove referred to, such, for example, as impellers, inducers, torque converter parts, etc., it is advantageous to use cores made of a composition in which plaster of Paris is the principal binder or cementing agent. When making such cores compositions containing plaster of Paris are gaged with the proper amount of water to form a pourable slurry. This is then poured into a core box and sets in approximately five minutes to a rigid and very accurate impression of the core box or cavity. As just suggested, the advantage of cores made out of such compositions is their accuracy and smoothness. These cores can be processed in various ways to prepare them for casting, but the method which is preferred in the practice of the present invention is that disclosed in U. S. Letters Patent to Morris Bean No. 2,220,703, granted November 5, 1940.

The present invention is directed particularly to a procedure, hereinafter more fully described, by which it is possible to take cores of the kind just described, made to the degree of accuracy which is usual for this type of core, and make fluid-flow-directing devices or parts thereof which have a degree of accuracy as to vane or blade thickness that has previously not been achieved in the production of such castings in commercial quantities. This procedure involves the utilization of an accurately constructed jig in which the cores may be indexed around the common axis by means of registering surfaces on the core prints which register with suitably situated projections or keys on the jig.

After the cores have thus been indexed in proper relation to each other about the common axis, they are secured in this position by flowing onto the registered core prints a settable material which when set fixes the cores in position so that they can be removed from the jig as a unit without disturbing their relation to each other. Where, for example, both the mold and the cores are to be formed of a hydraulic setting composition such as plaster of Paris, the jig can be of metal, advantageously stainless steel or aluminum, and a preformed plaster mold part can be fitted over the cores at suitable spacing therefrom to mold the part of the cast metal which flows around the cores. This mold part leaves the core prints exposed to the pouring thereon of a cementing material, but covers the molding surfaces of the cores so that the cementing material will not run onto them. A drag flask, or other enclosure, may be fitted around the area of the core prints and the mold part so that the locking of the cores in their proper relation to each other may be effected by pouring into it a hydraulic setting slurry. The resulting set material, in addition to locking the cores in position, may also serve as a part of the casting mold.

Obviously, as hereinafter pointed out, this step in the process does not necessarily require a hydraulic setting binder for its practice.

There is important advantage in the arrangement of the jig in respect to the flask for the core-fixing settable material such that the jig and flask can be removed from the assembly after the core-tying material has set. Another important advantage is to be found in the utilization of a preformed part of the mold to prevent the mold-tying material from entering between the cores into the vane-forming openings.

In practice it has been found desirable, particularly where the cores are formed with overlapping or interfitting parts, to construct the jig in a plurality of separable pieces with their parting lines such that the pieces can move together on a line along the direction of the overlap, so that the core assembly can be completed without serious interference between the cores or mold parts.

Although the novel process of the present invention will be described hereinafter in one of its more important applications, namely, to the accurate positioning of a comparatively large number of cores in circular arrangement about a central axis, it will be understood that the process has much wider applications and that it may be used to advantage in preparing core containing molds for the precision casting of many different structures. It will further be understood that the accurate location of the cores by means of a jig so positioned as to be removable, after the cores have been tied into the part of the mold of which they constitute a part, is not limited to use with the particular mold materials or binders therefor herein described.

In fact the teachings of the novel procedure of the present invention which make possible the quick and accurate location and fixing of a plurality of cores in a mold have, with such slight modifications of the procedure as may be required in special cases and which are well within the skill of experienced foundry workers, wide applicability in foundry practice.

Other important features, objects and advantages of the invention to which attention has not hereinabove specifically been directed will appear hereinatfer when the following description and claims are considered in connection with the accompanying drawings, in which

Figure 1 is a plan view of the core jig employed in practicing the process of the present invention, this view showing the parts of a two-part jig separated and a few cores already located. This figure also shows a device for moving the two parts of the jig together after the cores have been placed therein;

Figure 2 is a section on the line 2—2 of Figure 1, this view showing a removable ring, which forms the drag section of the flask, separated from the bottom part of the flask which also serves as the core jig; and with the two parts of the core jig still separated and ready to receive cores;

Figure 3 is a plan view of the assembled mold with parts broken away along the section line 3—3 of Figure 4;

Figure 4 is a section on the line 4—4 of Figure 3, this view showing, at the right, how the metal casting fills the mold cavity;

Figure 5 is an inverted plan view of a casting made in the mold shown in Figures 3 and 4, this casting being shown partly in section taken on the line 5—5 of Figure 6 and partly in section taken on line 5′ of Figure 6;

Figure 6 is a section on the line 6—6 of Figure 5;

Figure 7 is a vertical section through the core jig after the cores have been assembled therein and after the two parts of the jig have been brought together, this view also showing the flask ring, or drag, in separated relation to the jig;

Figure 8 is a section similar to Figure 7 but showing the drag ring in assembled relation on the jig and also showing the preformed annulus of the mold in position over the vane-forming cores for casting the inner shroud;

Figure 9 is a section similar to Figures 7 and 8 but with the drag flask filled with the settable mold material such, for example, as plaster of Paris slurry;

Figure 10 is a section through an assembled mold. It will be noted in this figure that the drag part of the mold, which has been shown as molded in inverted position in Figure 9, has now been turned right side up and provided with a suitable cope having therein a pouring gate.

The process of the present invention is herein illustrated as it is employed to make a mold for a torque converter part having curved fluid passages and curved vanes therebetween shaped to obtain reaction effects from the fluid flow. Each of the cores 2, which are shown assembled in proper relation to each other about a central axis in Figure 3, forms one of said passages and the spaces between adjacent cores form the vanes, when the metal is cast.

It will be noted that each of the cores 2 has a complex curvature in its body portion, which forms the reaction passage for the fluid, and has a print extension 4 at one end, provided with notches 6 for registering with keys 8 on the core jig, and has a print 10 at its other end, provided with notches 12 for registering with keys 14 on the core jig.

It will further be noted, from an inspection of Figures 3, 4, and 5 that the prints 4 of the cores 2 are so shaped that the side faces of adjacent prints substantially abut and that the notches 6 in the substantially abutting side faces of the prints 4 register with each other and together embrace one of the keys 8 of the core jig. In like manner the side faces of the prints 10 of adjacent cores 2 substantially abut when the cores are assembled and the notches 12 in the substantially abutting side faces register with each other and together embrace one of the keys 14 of the core jig.

As shown in plan in Figure 1 and in section in Figures 2, 7, 8 and 9, the core jig comprises a cast frame, advantageously divided into two sections along a line roughly corresponding to the edges of cores, as hereinabove suggested. The assembled frame has a cylindrical supporting skirt 16 which rests on flat plates 50 and 52 (Figures 1 and 2). A core locating and supporting structure within and integral with skirt 16 has an accurately formed and positioned key ring 20 of wear-resistant material such, for example, as bronze. This key ring provides exactly spaced core-locating projections 8, herein referred to as "keys," advantageously integral with the ring 20.

An inner ring 24 of the core-supporting structure is both nearer the center of the jig and lower than the outer ring 20. On it are located, in exactly spaced relation, the keys 14, hereinabove referred to.

Between the rings 20 and 24 the core-supporting structure of the jig has a transversely curved annular channel 26 into which the curved part of each core 2 may extend, there being preferably a slight clearance between the bottom of the channel and the curve of the core when the core is in assembled relation on the jig with its print 4 resting on the ring 20 and located by the keys 8 and its print 10 resting on the ring 24 and located by the keys 14.

The foregoing description applies particularly to the core jig in its assembled condition, that is, with the two parts brought together, at which time the key support 20 may be considered to be a continuous ring and likewise the key support 24. The same applies also to the channel 26. As shown in Figure 1, however, because of the peculiar shapes of the fluid passages of the device for which the mold herein shown is designed, it would be very difficult to assemble the cores initially in a full circle. Therefore the cores are assembled in the two sections respectively while they are separate and then the two sections, together with the cores, are brought together as shown in Figures 7 to 9 inclusive.

It will be seen that the core jig is so constructed that the cores are assembled therein with those faces down which will later be uppermost in the drag portion of the assembled mold and that, as assembled in the jig, the spaces 28 between adjacent cores, which are the vane-forming portions of the mold, will be open on the exposed sides of the cores when they have been assembled in the jig. Since the structure to be formed in this mold is of the type in which the vanes 30 are located between and are integral with outer and inner shrouds 32 and 34 and form with the shrouds the curved reaction passages 36 for the fluid, it is important, when preparing the drag portion of the mold, to prevent the settable mold-forming material 38 from getting into the spaces 28 between the cores and thus interfering with the formation of the vanes. It is also important that provision be made for casting the inner shroud 32 integral with the vanes.

As shown particularly in Figures 8 and 9 of the drawings, these advantages are attained by employing a ring 40, formed of mold material, which has an inner shoulder 42 shaped to rest on what is the under face of the print 10, as is shown in Figure 10, and having an outer shoulder 44 shaped to rest on what is the under face of the print 4. This ring core of mold material also has a curved face 46 which, when the ring 40 is in assembled relation to the cores 2, as shown in Figure 8, presents a face that is substantially concentric with the bottom of the annular channel 48 formed by the concave faces of the curved bodies of the cores 2, but spaced therefrom a distance equal to the desired thickness of the inner shroud 34.

Before the ring core 40, which is preferably formed in one piece, can be placed in position over the annular channel 48 the two parts or segments of the jig, in which the cores have been assembled must be brought together. This may be accomplished, as shown in Figure 2, by mounting the left hand segment of the jig on a stationary plate 50 and the right hand segment of the jig movable relative thereto on plate 52, which has a pair of grooved shoes 54 on its under side travelling on parallel tracks 56. The plate 52 may be moved toward the plate 50 by means of a jack screw 58 turning in a threaded stationary jack stand 60 mounted upon the molder's bench. A third shoe 62, on the under side of the plate 52 and travelling upon an intermediate track 64, serves to give further support to the right hand jig segment and to insure its movement in a horizontal plane.

Dowel pins 66 each fixed in one of the plates 50, 52 and guided in dowel sockets in the other plate, may be provided to insure accurate register of the two segments of the core jig with each other when they are brought together.

After the cores have been thus assembled upon the two segments of the core jig and the segments brought together to give a complete circle of cores with each core exactly located by their print recesses 6 and 12 registering with the keys 8 and 14, respectively, the ring 40 is put in position with its convex face projecting into the channel 48. The assembly is now ready for the bringing of the drag flask 68 into position preparatory to pouring the plaster slurry or other settable mold composition. This flask is in the form of a ring 68 having a half-lap joint or shoulder 70 shaped to rest upon the rim 72—74 of the core jig and having ears 73 with holes to receive pins 75 upstanding from base 17. The fixed half of the jig is positioned by holes in plate 50 into which pins 75 fit snugly. It will be seen that the ring 68 is thus readily positioned over the jig by pins 75, and then, when it is lowered onto the jig it fits readily at the half-lap joint 70 and thus holds the swo segments of the jig in accurately assembled relation. As shown the flask 68 is suspended by yoke 77 from a crane or hoist not shown.

The assembly just described is shown in Figure 8 of the drawings and is now ready to receive the liquid mold material. As hereinabove suggested a suitable material for tying the cores 2 together in their proper relation to each other and to the other parts of the mold and for completing the mold drag is a hydraulic setting slurry such, for example, as plaster of Paris with or without fillers, e. g. fine sand. It will be understood, however, that mold mixtures in which other binders are employed and/or other methods of causing the binders to set are employed may be used.

In Figure 9 the jig and drag flask are shown after the settable mold material has been poured or otherwise introduced thereinto.

It will be seen that the drag thus formed has both the cores 2 and the ring core 40 firmly embedded, and thus locked together, in the same relations as when they were assembled in the jig. It will also be seen that the parts of the jig are so constructed that, when the mold has been turned into the position which it will have when assembled with a cope for casting, the jig and flask can be lifted away leaving the mold drag in the form shown in Figure 10 and also in Figures 3 and 4.

The drag is now ready to be assembled with a suitable cope 80, shown in Figures 3, 4 and 10. The cope 80 has a pouring gate 82 and the inner face of the cope is so shaped and so spaced from the upper faces of the cores 2 as to provide an annular mold cavity 84 that will receive metal to form the outer shroud of the torque converter part. Chills 86 may be located in the cope 80 in accordance with usual foundry practice.

From the foregoing description it will be seen that among the advantages of the novel mold making process of the present invention is the accurate location of the cores in a jig and the fixation of these cores in their accurate relations to each other and to the other mold parts. Furthermore, errors in core prints are not accumulated, but are taken up in permissible clearance between cores, the location of each core being determined wholly by the accurately located keys of the jig.

It will further be seen that, once the cores are thus placed in their accurate relations to each other, they are then anchored by a very positive and accurate means so that they cannot move at any subsequent time up to and including the casting operation.

It will be apparent that the idea can be applied as well to vane wheel castings in which shrouds are not formed on both sides, e. g., consisting of a central hub and radiating vanes.

Other types of cores made by other molding methods and materials may be positioned and held by this improved process and mold construction to improve the accuracy of the results which they obtain. As above suggested, however, it is important that the cores, which are to be registered with the keys in the core jig, be formed with a fairly high degree of accuracy and, therefore, even when the improved process of the present invention is applied to ordinary foundry practice it will doubtless be advantageous to start with cores of the degree of accuracy obtainable with the use of gypsum bonded materials.

What is claimed as new is:

1. The process of making a casting mold having a plurality of cores fixed in accurate predetermined relation to each other and to the other mold parts, which comprises making said plurality of cores as separate parts with accurately formed core prints beyond the ends of the molding faces thereon, positioning said cores on a jig provided with precisely located keys, the core prints being positioned against said keys, flowing over exposed parts of the thus assembled core prints a settable fluent material which upon setting unites the core prints in fixed relation to each other but excluding said material from the molding faces of said cores and then assembling with the cooperating part of the casting mold.

2. The process according to claim 1 wherein a mold part is preformed to cover the cores between the core prints, said part is located on said cores with the core prints exposed beyond it, and the settable material is then flowed into the space over the exposed core prints and

beside said mold part and set, whereby the cores are anchored with respect to said mold part.

3. The process according to claim 2 wherein the mold part is designed to form, with the set material and the assembled cores, the drag part of the mold.

4. The process according to claim 3 in which the cores are assembled in the core jig in inverted relation to their positions in the finished drag, whereby, when the set drag is inverted, the jig form may be lifted away from the completed drag.

5. A process according to claim 1 for making a mold having a plurality of like cores fixed therein in a generally spokelike arrangement about a common axis, wherein each core print is formed with a bottom face in an annular surface and a recess to receive a locating key, and said cores are assembled with the prints at opposite ends thereof on radially spaced supporting ledges with corresponding radially spaced, concentric, annular surfaces, each ledge being provided with core-print-locating keys accurately positioned to index the respective core prints.

6. A process according to claim 5 in which the core prints are formed with complementary contiguous faces which, when assembled in the drag, form an annulus, and key embracing recesses are formed one-half in each of adjacent prints.

7. A process according to claim 5 wherein the assembled cores are laterally spaced to form vane molds therebetween and wherein, before the flowing on of the print-uniting mold mixture material, a preformed shroud defining ring of mold material is located in position over the vane-forming spaces and against said core prints whereby to exclude the print-uniting material from flowing into said vane-forming spaces, and said material is flowed onto said shroud as well as onto the core prints, whereby all are united into a drag mold unit.

8. A core jig including an annular channel member in which a mold may be formed, said channel member having near its inner and outer peripheries, respectively, inner and outer annular core-supporting ledges, a first and second plurality of core-print locating keys integrally secured to said inner and outer core-supporting ledges, respectively, and uniformly accurately spaced along each core-uniformly accurately spaced along each core-supporting ledge, each key providing side surfaces adapted to bear against the side faces of the core prints of adjacent cores in said jig, each pair of adjacent keys along each ledge being adapted to straddle a core print of a core in said jig, and said core jig being divided into at least two separable portions, whereby the cores can be assembled in separate groups in each portion thereof and said portions can thereafter be brought together and unified with the cores in said jig being accurately held spaced around said annular channel member without cumulative error, and whereby said cores can all be withdrawn simultaneously in an axial direction from said unified core jig while leaving said keys integrally secured to said inner and outer core-supporting ledges.

9. A mold-making device including a core jig divided into at least two separable portions, said core jig having first and second spaced core-supporting ledges, a first and second plurality of core-print locating keys integrally secured with respect to said first and second ledges, respectively, and spaced along each ledge, a plurality of cores each having core prints at opposite ends with accurately spaced side faces having a spacing therebetween equal to the spacing between respective pairs of adjacent keys along each ledge, each of said cores being spanned across between said ledges and having its core prints fitted between respective adjacent pairs of keys along each ledge with each pair of adjacent keys straddling a core print and bearing against the side faces thereof, whereby the cores in said jig are held accurately positioned along said ledges and can all simultaneously be removed from said ledges while leaving said keys in position integrally secured with respect to said ledges.

10. The process of making a mold having a plurality of cores fixed in accurate predetermined relation to each other and to the other mold parts, which comprises preparing cores with prints at the respective ends having accurately located key-registering recesses therein, registering said core print recesses with the appropriate keys positioned on a core jig, introducing over core prints a mixture comprising a settable fluent material to lock the core prints in fixed relation to each other and thus to form a mold unit, while blocking said material against flowing onto the molding faces of said cores, and then removing the jig and assembling the resulting mold unit with a cooperating mold part for casting.

11. A mold-making device which comprises a core jig according to claim 8 and a plurality of cores annularly arranged with prints at opposite ends of each core supported on said ledges, respectively, the print at each end of each core being provided with key registering recesses in its opposite side faces spaced to register with adjacent keys on said supporting ledges.

12. A mold-making device according to claim 11 in which the prints at the two ends of each core are offset in respect to each other both angularly about the annulus and axially thereof into different spaced planes, and the jig is separated in two segments during the assembling of the cores thereon, and brought together into a complete core assembly while the cores are located on said segments respectively.

13. The process of making a casting mold having a plurality of cores fixed in accurate predetermined relation to each other and to the other mold parts comprising the steps of making said plurality of cores as separate parts with accurately formed core prints beyond the limits of the molding faces and each core print having a pair of opposed accurately spaced side faces thereon, positioning said cores on a jig provided with precisely located keys, said keys respectively having spacing equal to the spacing between the side faces of the respective core prints, the side faces of each core print being positioned against a pair of said keys and straddled thereby, flowing over exposed parts of the thus assembled core prints a settable fluent material which upon setting unites the core prints in fixed relation to each other but exluding said fluent material from the molding faces of said cores, then removing the resultant core assembly from the jig, and assembling it with a cooperating part of the casting mold.

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