HYDRODYNAMIC BLADED WHEEL ASSEMBLIES

Filed Dec. 28, 1961 4 Sheets-Sheet 1

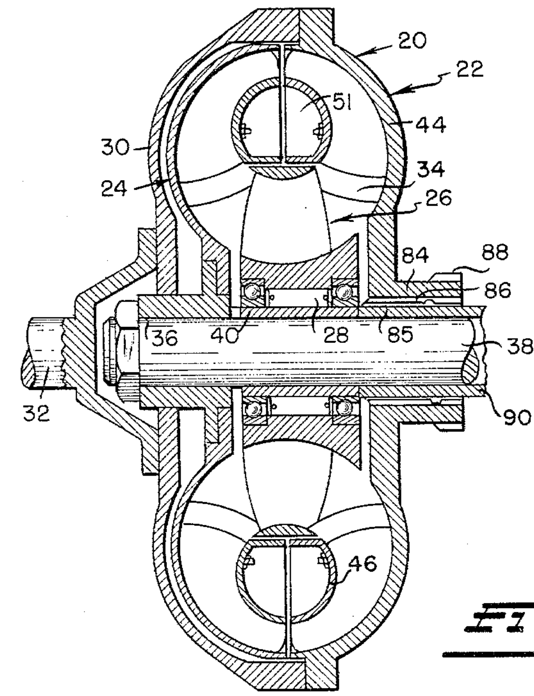


Fig. 1

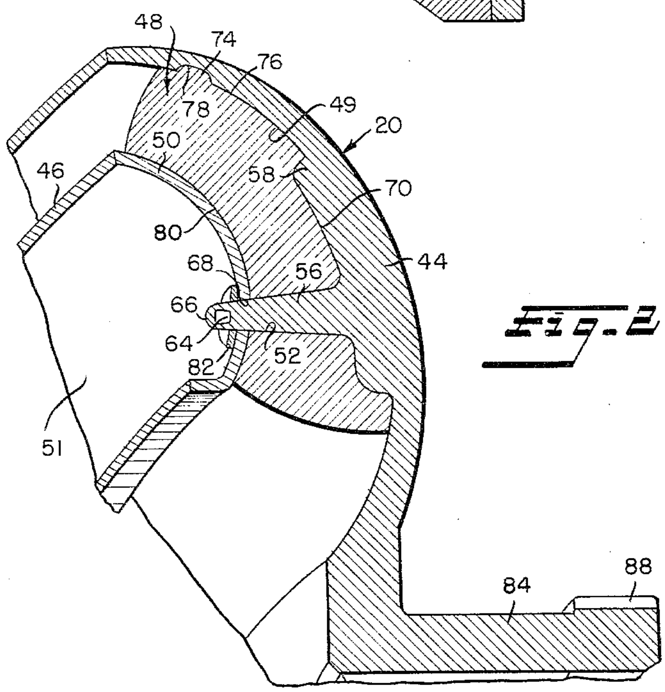


Fig. 2

INVENTOR
Carl N. Schrader

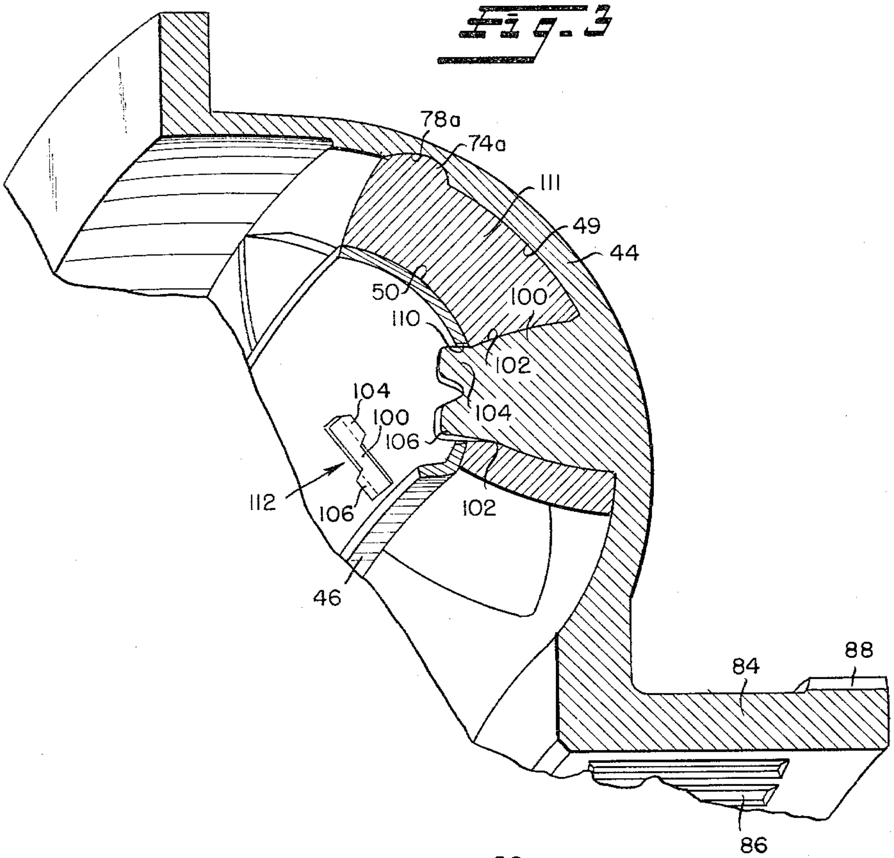
BY Strauch, Nolan & Neale
ATTORNEYS

March 15, 1966 C. N. SCHRADER 3,240,153

HYDRODYNAMIC BLADED WHEEL ASSEMBLIES

Filed Dec. 28, 1961 4 Sheets-Sheet 2

Fig. 3



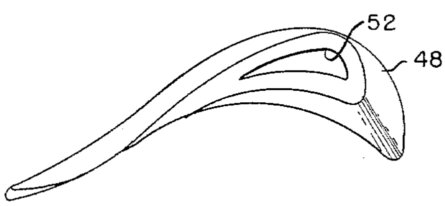


Fig. 4

INVENTOR
Carl N. Schrader

BY Strauch, Nolan & Neale
ATTORNEYS

March 15, 1966 C. N. SCHRADER 3,240,153

HYDRODYNAMIC BLADED WHEEL ASSEMBLIES

Filed Dec. 28. 1961 4 Sheets-Sheet 3

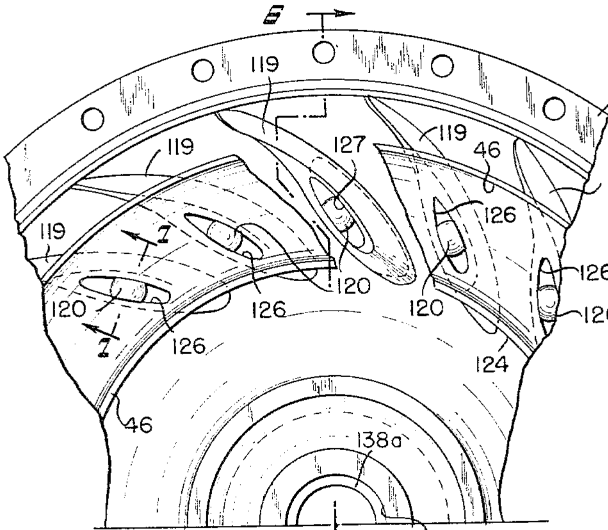


Fig. 5

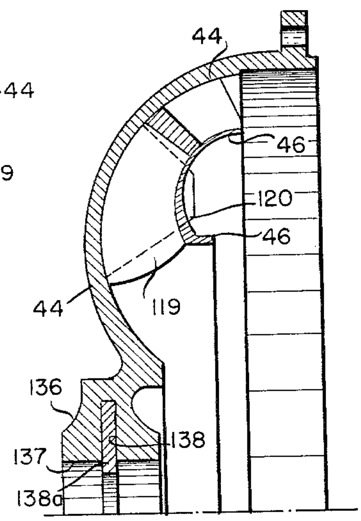


Fig. 6

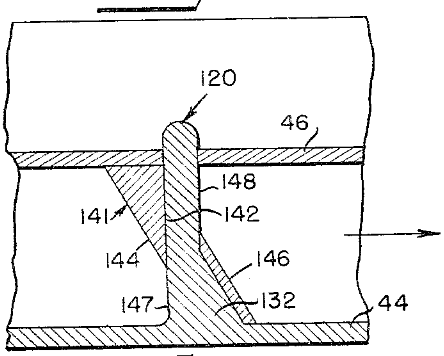


Fig. 9

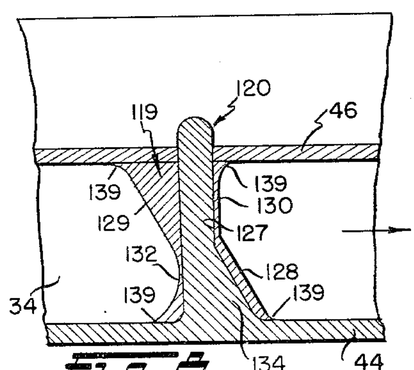


Fig. 8

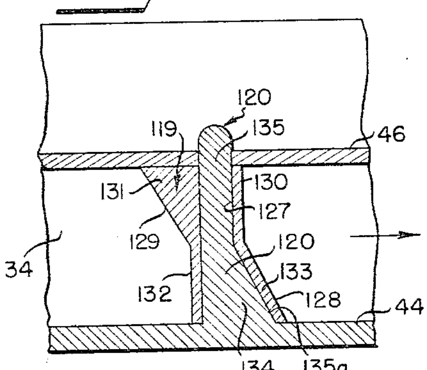


Fig. 7

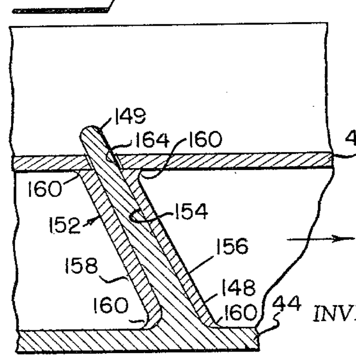


Fig. 10

INVENTOR

Carl N. Schrader

BY

ATTORNEYS

March 15, 1966 C. N. SCHRADER 3,240,153

HYDRODYNAMIC BLADED WHEEL ASSEMBLIES

Filed Dec. 28, 1961 4 Sheets-Sheet 4

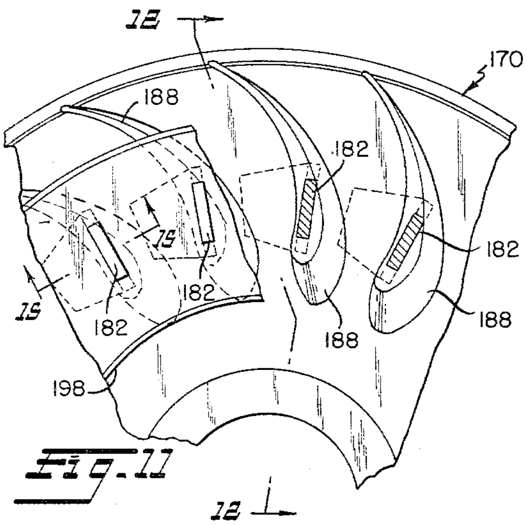


Fig. 11

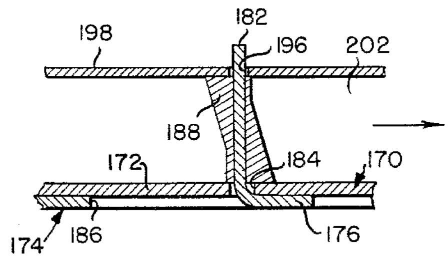


Fig. 15

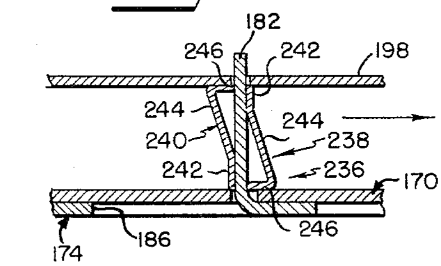


Fig. 16

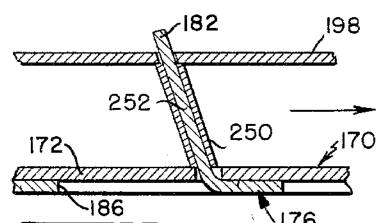


Fig. 17

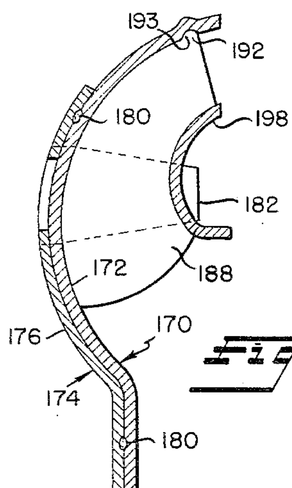


Fig. 12

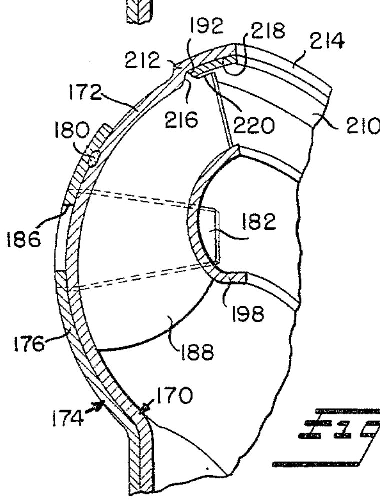


Fig. 13

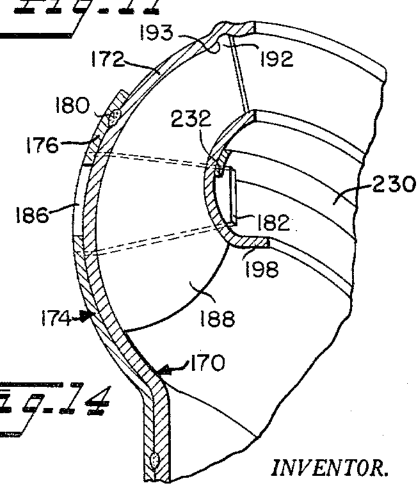


Fig. 14

INVENTOR.
Carl N. Schrader

BY

Strauch Nolan & Neale
Attorneys

United States Patent Office

3,240,153

Patented Mar. 15, 1966

1

3,240,153
HYDRODYNAMIC BLADED WHEEL ASSEMBLIES

Carl N. Schrader, Trenton, Mich., assignor, by mesne assignments, to Rockwell-Standard Corporation, a corporation of Delaware

Filed Dec. 28, 1961, Ser. No. 162,872
15 Claims. (Cl. 103—115)

This application is a continuation-in-part of my co-pending application Serial No. 79,040 filed December 9, 1960, now abandoned.

The present invention relates to hydrodynamic drives of the fluid coupling or torque converter type and more particularly to improved constructions of bladed fluid torque transmitting wheels in hydrodynamic drives and also to the method of making and assembling the components of such bladed wheels.

Bladed wheel assemblies of hydrodynamic devices are customarily constructed with an outer semi-toroidal annular shell, an inner semi-toroidal core ring, and a set of curved vanes or blades held in place between the outer shell and inner core ring to transmit a rotational force from one wheel to the other by means of a fluid medium.

Prior to the present invention, the manufacture and assembly of hydrodynamic bladed wheels was achieved in a variety of ways. In one of the more widely practiced prior art methods of manufacture, the core and shell are stamped or cast and the blades are assembled in position by means of tabs formed integral with the blades. The tabs are fitted into complementary slots formed in the core and the shell to locate the blades between the toroidal members in such position as to achieve the desired direction of fluid flow. By bending the tabs over on the outer side of either the shell or core, or both the core and shell, the blades are fixed in position. Such tabbed blades are generally fabricated from sheet metal to readily enable the tabs to be fitted into their respective securing slots and bent in locking position.

In another prior method of manufacturing bladed wheels, the blades are correctly located between the outer shell and core ring by holding the assembly in a fixture and spot welding or brazing the blades to the outer shell and core ring.

In other conventional methods of assembly and fabrication, the blades and outer shell or blades and core ring are formed as an integral unit as by die casting and the remaining toroidal member, whether it be the shell or core ring, is then welded, brazed or cast on to the sub-assembly. In torque converters, the impeller, turbine or reaction members have been made of a number of separate segments with each segment being die cast and having one or more blades cast integral with parts of the outer shell or inner core or both. The separate segments are assembled together by suitable well-known means such as lock rings.

In the hydrodynamic wheel assemblies embodying separate sheet metal blades having integral tabs for locating and securing the blades in place, several difficulties have been encountered. To this end, it will be appreciated that due to the inherent flexibility of the sheet metal, the blades are subjectable to distortion during assembly, especially when the tabs are bent over and lockingly secured to the shell or core. As a consequence, the critical blade curvature is change to correspondingly affect the torque multiplying characteristics or the torque transferring characteristics of the hydrodynamic drive, thus diminishing the efficiency of the drive.

2

Furthermore, a substantially large number of tabbed sheet metal blades are usually required in fluid wheel assemblies in order to absorb fluid impact loads and to effectively direct the flow of fluid. In addition, it was not possible to interchange one set of tabbed blades with blades having a different curvature because of the fixed tab and slot locations in the assembly.

Integral cast wheel assemblies, either cast as a whole or in segments, are quite expensive to make because of the intricate coring required to form the various parts. Die casting the fluid wheels as an integral unit has generally been found to be economically unacceptable and impractical because of the complex shapes of the curved blades which require several dies and cores, thus making the cost of manufacture prohibitive. Furthermore, in torque converters, either the turbine or impeller is usually drivingly attached to separate hub members or the like, thus requiring cost-consuming bolting or welding to secure the hub member to the shell of the turbine or the impeller.

From the above considerations, it is apparent that, heretofore, there have been no satisfactory hydrodynamic bladed wheel constructions in general use which are simple and economical to make and to assemble and which, at the same time, provide for a rigid vibration-proof bladed wheel structure. Accordingly, the present invention contemplates and has as its primary purpose a hydrodynamic bladed wheel of improved construction which satisfies these foregoing requirements and which is readily made and easily assembled.

This is essentially accomplished according to the present invention by providing for an outer shell having integral rigid posts on which hollowed blades are mounted and held in their proper oriented positions by securing an inner core ring to the mounting posts. The blades according to the present invention are tightly but non-interlockingly held between the core and shell with the blades engaging the core and shell only along separable abutment surfaces. In contrast to the commercially acceptable hydrodynamic drive constructions heretofore known, the blades of the present invention are not fixed or interlocked to either the shell or the core ring but rather engage the shell and the core ring only along non-interlocking separable abutting contact surfaces to thereby provide a simplified method of manufacture.

To further reduce manufacturing costs, the present invention contemplates the provision of a hydrodynamic wheel assembly in which the outer shell is cast integral with a splined or geared drive hub member or like drive attachment member, thus eliminating expensive bolting or welding.

With the foregoing considerations in mind, one of the primary objects of the present invention is to provide a novel bladed wheel assembly having an outer shell formed integral with mounting posts over which hollow blades are placed in proper position and held in place by an inner shroud or core ring secured to the posts.

Another object of the present invention is to provide a novel hydrodynamic bladed wheel having an outer shell cast integral with a driving hub or the like which may be conveniently machined prior to assembly with the other components of the wheel.

A further object of the present invention resides in the provision of a fabricated or cast hydrodynamic bladed wheel assembly in which the separate members are assembled in a manner to enable the selective use of different combinations of a variety of materials in the manufacture of the assembly. With the present invention, for example, the outer shell may be made from ductile iron, malleable iron, aluminum or magnesium and assembled with an inner core ring made from the same material or any of the other materials mentioned above. The blades may be made from steel, aluminum, magnesium or plastic and assembled with a core ring and shell made from any combination of the materials mentioned above. Thus, it is evident that the shell, core ring and blades may be made from different materials to provide an expanded versatility in design from light to heavy range depending on the application requirements.

Another object of the present invention is to provide for a novel hydrodynamic bladed wheel construction in which the blades are fixedly clamped in non-interlocking separable surface abutting relationship between separately formed blade supporting shell and core sections.

A further object of the present invention is to provide for a novel method of manufacturing a hydrodynamic bladed wheel structure having separately fabricated component parts which are easily made and readily assembled.

Another object of the present invention is to provide for a novel hydrodynamic bladed wheel construction having separable blades, an outer shell and an inner core ring with the core ring being pulled up snugly in non-interlocking abutment with the blades and fastened in place only by means on the shell so as to clamp the blades in a fixed oriented position between the shell and core ring.

A further object of the present invention is to provide a novel hydrodynamic bladed wheel construction in which the blades are detachably interchangeable to provide for different torque multiplication ratios or to facilitate ready replacement of damaged or broken parts.

Another object of the present invention is to provide for a novel hydrodynamic bladed wheel construction which has simplicity of construction and which has a low manufacturing cost.

Still a further object of the present invention resides in the provision of hollow blade members for a hydrodynamic wheel assembly made as an extrusion casting, forging or formed sheet metal from materials such as plastics or aluminum and having smooth and durable surfaces to be extremely sensitive to oil flow. The hollow blade members may be made heavy or light although retaining their outside dimensions and curve configuration.

Further objects of the invention will appear as the description proceeds in connection with the appended claims and the annexed drawings wherein:

FIGURE 1 is a simplified longitudinal sectional view of a hydraulic torque converter embodying bladed impeller and turbine wheels made in accordance with the present invention;

FIGURE 2 is an enlarged sectional fragmentary perspective view of the bladed impeller wheel illustrated in FIGURE 1;

FIGURE 3 is an enlarged fragmentary partially sectioned perspective view of a bladed impeller wheel according to a further embodiment of the present invention;

FIGURE 4 illustrates one form of a hollowed blade utilizable in the hydrodynamic bladed wheels according to the present invention;

FIGURE 5 is a fragmentary front elevational view of a bladed impeller wheel according to still another embodiment of the present invention with a portion of the inner core ring being broken away to show details of the blading and blade mounting structure;

FIGURE 6 is a section taken along lines **6—6** of FIGURE 5;

FIGURE 7 is an enlarged sectional view taken substantially along lines **7—7** of FIGURE 5;

FIGURE 8 is a section similar to that of FIGURE 7 but showing a modified form of the blade structure;

FIGURE 9 is a section similar to that of FIGURE 7 but showing a further modified form of blade structure;

FIGURE 10 is a section similar to that of FIGURE 7 but showing a modified form of the blade and the blade mounting post structure;

FIGURE 11 is a fragmentary front elevational view of a bladed wheel according to still another embodiment of the present invention and illustrating a portion of the inner core ring broken away to show details of the blades and the blade mounting structure;

FIGURE 12 is a cross-section taken substantially along lines **12—12** of FIGURE 11;

FIGURE 13 is a fragmentary perspective sectional view illustrating a bladed wheel according to a further embodiment of the present invention;

FIGURE 14 is a fragmentary perspective view of a bladed wheel similar to that of FIGURE 13 and illustrating still another embodiment of the present invention;

FIGURE 15 is a section taken substantially along lines **15—15** of FIGURE 11;

FIGURE 16 is a section similar to that of FIGURE 15 and illustrating a modified form of blade construction; and

FIGURE 17 is a section similar to FIGURE 15 and illustrating a modified form of the blade and mounting post structure.

Although the present invention is illustrated and described to be embodied in a single stage, two phase torque converter for use with automotive power transmissions, it will be appreciated that the bladed wheel structures to be presently described in detail may also be incorporated into any hydrodynamic coupling device.

Thus, with reference to the drawings and more particularly to FIGURES 1 and 2, the reference numeral **20** generally designates a hydrodynamic bladed wheel assembly embodying the principles of the present invention and constructed as a bladed impeller for incorporation into a torque converter indicated at **22** in FIGURE 1. Torque converter **22** includes a bladed turbine **24** driven by the energy produced by impeller **20**, and a conventional bladed reaction member **26** mounted between impeller **20** and turbine **24** on a conventional one-way clutch unit **28** in the manner shown.

Driving torque is transmitted to impeller **20** by means of an impeller driving flange or turbine cover **30** which is coupled to a drive shaft **32**. Shaft **32** is drivingly connected to an engine output shaft (not shown) for rotating impeller **20**. By rotation of impeller **20**, energy is transmitted to fluid circulated in a toroidal passageway **34** in which the blades of impeller **20**, turbine **24** and reaction member **26** are disposed, to rotate turbine **24**. Turbine **24** is coupled to a drive hub **36** which is secured to a transmission input shaft **38** extending through the casing of converter **22** for connection to a mechanical transmission (not shown). Shaft **38** rotatably extends through a sleeve **40** upon which clutch unit **28** is mounted.

In describing the construction of impeller **20** and the various modified forms of hydrodynamic bladed wheel assemblies according to the present invention, it is understood that the construction and method for carrying out manufacture and assembly of the component parts of the bladed wheel assembly may be equally applied to turbine **24** or to other forms of bladed wheel assemblies utilized in hydrodynamic drive devices.

As is well known, the blades of the fluid wheels in torque converter **22** or other hydrodynamic devices are required to be formed with a complex hydro-foil shape in order to efficiently circulate the converter fluid. This complex curvature of the blades constitutes one of the main reasons for the difficulties previously encountered in making the blades and also in assembling the blades with the supporting inner and outer shroud members of the bladed wheel assembly. Due to the complex curved contour of the blades, integral casting of hydrodynamic bladed wheel assemblies is economically impractical with prior art methods of manufacture. With known methods of manufacture, the blades could not always be properly located and adequately supported with respect to the toroidal path of fluid flowing through passageway 34 of torque converter 22. It has been found that reaction forces due to the fluid flow direction change are greatest in the region of maximum flow deviation. This region can be approximately located along a line bisecting the entrance and exit angle of the blade and constitutes one of the weakest points in former bladed wheel constructions. The present invention overcomes the foregoing shortcomings of prior art constructions and methods of manufacture as will become apparent as the description proceeds.

With reference now to FIGURE 2, impeller 20 is shown to comprise a hollow outer annular shell 44 of semi-toroidal shape, a hollowed annular inner core ring 46 of semi-toroidal shape and a set of circumferentially spaced apart blades 48 fixedly secured between core ring 46 and shell 44. Shell 44 and core ring 46 are separately formed as one-piece structures and may be die cast or forged. Shell 44 and core ring 46 may be made from any material suitable for a preferred application, including aluminum and thermal plastic materials. By casting shell 44 and core ring 46 separately according to the present invention, it will be appreciated that the intricate coring required in casting the shell and core ring as one piece is obviated.

With continued reference to FIGURES 1 and 2, shell 44 is formed with an inwardly directed concave surface 49 facing core ring 46 and delimiting passageway 34. Core ring 46 is arranged radially and axially inwardly with respect to shell 44 and is formed with a convex surface 50 facing surface 49 in spaced relation thereto and delimiting passageway 34. As shown, core ring 46 is hollowed to form an endless channel 51 opening axially outwardly in a direction facing away from shell 44.

As shown in FIGURES 2 and 4, each of the blades 48 is of hollowed three-dimensional curved construction to provide a passage 52 extending completely through the blade. Blades 48 may be fabricated from sheet metal or they may be cast with the hollowed form from suitable light weight materials such as aluminum, magnesium or thermo-plastics.

Blades 48 may be hollow throughout, thus providing only a relatively thin outer wall to save material and weight. Where a more rigid positioning of blades 48 is required for heavier torque load applications, however, a substantially solid blade is provided with a relatively narrow bored or cored passage to facilitate assembly of the blades, in a manner as will be presently described.

To properly secure and locate blades 48 within the assembly of component parts forming impeller 20, shell 44 is integrally formed with a plurality of blade mounting posts 56 equiangularly spaced apart along a common radius. Posts 56 rigidly project axially inwardly from a continuous circumferential ledge portion 58 formed integral with shell 44 and protruding inwardly from the inner concave shell wall surface 49 as shown. The number of posts 56 provided for correspond to the number of blades 48.

Posts 56 are generally conical in shape, being tapered to converge inwardly toward their outer tips. The tip of each post 56 is provided with a recess 64 extending axially inwardly along the longitudinal axis of the post to provide a thin walled annular tip portion 66 for a purpose as will presently appear. Core ring 46 is provided with a plurality of equiangularly spaced apart apertures 68 arranged along a common radius and registering with posts 56 to receive the recessed tips thereof in the manner shown.

In the assembly of the shell, core ring and blade components of impeller 20, the hollowed blades 48 are slidably mounted on posts 56 within outer shell 44 in such a manner as to properly orient blades 48 to achieve a desired direction of fluid flow through passageway 34. The inner and outer edge surfaces of blades 48 are respectively formed to abuttingly match the curvature of the convex surface 50 of core ring 46 and of concave surface 49 or shell 44 such that blades 48 snugly abuttingly inertfit with shell 44 and core ring 46 along smooth separable surfaces. Blades 48 are recessed at 70 to interfittingly receive ledge portion 58 in the manner shown.

As shown in FIGURE 2, the wall surface of passage 52 formed in each of the blades 48 snugly engage the smooth tapered sides of the respective posts 56 extending therethrough. Thus, in the oriented positions of blades 48 on posts 56, blades 48 are in interfitting non-interlocking separable surface abutment with shell 44 and core ring 46.

With continued reference to FIGURE 2, location tabs 74 may be formed integral with blades 48 preferably protruding from a blade edge 76 in spaced relation to passage 52 to more readily locate the blades during the assembly of the component parts of impeller 20. Tabs 74 are interfittingly but non-interlockinly received in equiangularly spaced apart recesses 78 formed inwardly of the interior concave periphery of shell 44. In some instances, location tabs may be provided on the blades on either the leading edge or trailing edge or both, or on either side of the blades to locate them during assembly of the component parts of impeller 20.

After blades 48 are slidably mounted on posts 56, core ring 46 is then mounted in the assembly by freely fitting apertures 68 over the tips of posts 56 and by positioning core ring 46 in snug separable surface abutment with the inner blade edge surfaces indicated at 80 so that the tips of posts 56 project through apertures 68 and into channel 51 in the manner shown.

Core ring 46 is secured to shell 44 with blades 48 fixedly clamped between core ring 46 and shell 44 by deformably flaring the thin walled tipped portion 66 outwardly to thereby secure core ring 46 to posts 56 and thus provide a rigid and unitary tightly interlocked assembly of shell 44, blades 48 and core ring 46.

As shown in FIGURE 2, washers 82 of suitable thickness may be fitted over the tips of posts 56 between the flared wall portions 66 and the concave interior wall surface of core ring 46 to compensate for variations in manufacturing tolerances, thus assuring that core ring 46 is held tightly and snugly against the inner edge surfaces of blades 48.

It is known that the efficiency of hydrodynamic fluid coupling devices predominantly depends on the curvature of the blades and their respective positions in the fluid medium passageway. Another important requirement contributing to effectively high efficiency is that the blades be securely held in place and positively fixed between the outer shell and inner core ring to obtain satisfactory torque multiplication ratios and to absorb the impact of the circulating fluid impinging against the blades to transmit power. Most stresses and strain are exerted at the entrance and exit end of the blades and it is therefore imperative that the blades be securely held against rotation or distortion by the circulating fluid which is forced in a toroidal path through the passages defined by the spaces between the blades. Furthermore, it is desired to prevent rattle and vibration in the assembly as well as keeping the assembly as light as possible to reduce the weight of the rotating masses which create centrifugal forces.

As already mentioned, it is very difficult in prior hydrodynamic devices to meet all of the above requirements without sacrifices in cost or efficiency. The present invention enables blades 48 to be made of a light weight material such as, for instance, magnesium, aluminum, plastic or formed from sheet metal with a three-dimensional shape. With the present invention, the three-dimensional blade member whether solid, entirely hollow or partly hollow withstands greater forces and bending stresses than a single walled sheet metal blade. This is true during the operation of the hydrodynamic device as well as during assembly of the separate members.

With the present novel construction and assembling method, distortion of the blades is effectively prevented. In contrast to other prior devices, the blades themselves are not secured to either the outer shell or core ring, but instead the core ring is secured only to the outer shell by means of the integral posts which extend through the blades with the blades merely being clamped between the outer shell and inner core ring. To prevent the blades from rotation or displacement due to the fluid impact, blade location tabs as shown in FIGURES 12–14 may be provided for and the passages through the blades are shaped to closely fit around the posts. Alternatively, the posts may be set at an angle as shown in FIGURES 10 and 17.

By fabricating blades **48** separately from shell **44** and core ring **46**, light weight material such as sheet metal may be readily utilized in forming the blades to reduce the moment of inertia of the rotating components of the impeller. It further will be appreciated that blades **48**, being in engagement with core ring **46** and shell **44** only along non-interlocking separable abutting contact surfaces, are readily interchangeable with blades of different materials or curvatures simply by removing core ring **46** and sliding blades **48** off posts **56**. As blades **48** are not permanently fixed to either core **46** or to shell **44** as by weld spots, locking tabs or casting, there is no damage to the blades in removing them from the hydrodynamic bladed wheel assembly so that the blades which are removed from one assembly may be readily re-used in other assemblies.

With continued reference to FIGURES 1 and 2, shell **44** is cast or forged integral with an elongated hub **84** formed with a through bore **85** and having a machined internal set of splines **86** and a machined external set of gear teeth **88**. Gear teeth **88** are adopted to transmit torque from impeller **20** for driving auxiliary equipment (not shown). By means of the set of splines **86**, impeller **20** is splined to a secondary drive shaft sleeve **90** extending through bore **85** and being rotatably mounted on shaft **38** in the manner shown. Depending upon the specific application of torque converter **22**, either splines **86** or gear teeth **88** may be omitted. Hub **84** extends axially rearwardly from the body portion of shell **44** containing surface **49**.

The foregoing outer shell structure having an integrally cast drive hub eliminates the necessity of attaching a separately formed hub member by costly bonding or bolting arrangements.

FIGURE 3 illustrates another embodiment of a bladed impellar wheel in which the blade mounting post structure is modified. As shown in FIGURE 3, posts **56** and ledge portion **58** of FIGURE 2 are replaced by a plurality of equiangularly spaced apart blade mounting posts **100** formed integral with outer shell **44** and extending generally axially inwardly toward core ring **46** from the inwardly facing concave surface of shell **44**. Posts **100** are spaced along a common radius and are each formed with substantially flat sides and opposed radially extending tapered edges indicated at **102** which converge toward the tip of the post. The tip of each of the posts **100** is provided with a V-shaped notch located approximately midway between the opposed edges **102** and extending inwardly from the tip of the post to form side-by-side spaced apart tangs **104** and **106** for a purpose as will presently appear. The number of posts **100** correspond to the number of blades embodied in the assembly.

With continued reference to FIGURE 3, core ring **46** is formed with a series of equiangularly spaced apart slots **110** which register with posts **100**. A set of hollowed blades **111** are slidably mounted one on each of the posts **100**. Blades **111** are essentially identical in construction to blades **48** except that the recess **70** is omitted and the passage extending through each blade is shaped to interfit with posts **100**.

To fixedly secure core ring **46** to posts **100**, with blades **111** clamped snugly between core ring **46** and shell **44**, the tips of posts **100** extend through slots **110** and the tangs **104** and **106** are bent over in opposite directions to abuttingly engage the concave interior surface of core ring **46**, as indicated at **112** to snugly engage and lock core ring **46** in position on posts **100**.

To assemble the component parts of the impeller wheel illustrated in FIGURE 3, blades **111** are slidably mounted on posts **100** in outer shell **44** and may be properly positioned by fitting blade tabs **74*a*** into recesses **78*a*** in the same manner as described in the embodiment of FIGURE 2. Core ring **46** is then mounted on posts **100** in abutment with blades **111** and with the tips of posts **100** extending through slots **110** such that tangs **104** and **106** are disposed on the side of core ring **46** facing away from shell **44**. To lock core ring **46** to outer shell **44** and thereby clampingly secure blades **111** in place, tangs **104** and **106** are bent over in opposite directions to abut the concave surface of core ring **46** facing away from shell **44**, thus providing a tightly fitted bladed wheel assembly.

In the embodiment of FIGURES 5–7, modified forms of blade, mounting post and hub constructions are illustrated. With continued reference to FIGURES 5–7, a set of blades **119** are positioned on conically shaped, equiangularly spaced apart posts **120** formed integral with outer shell **44** and extending axially inwardly toward core ring **46** in the same manner as described in the embodiments illustrated in FIGURES 2 and 3. Alternatively, blades **48** may be mounted on posts **120** in place of blades **119**.

Posts **120** are spaced along a common radius and extend through elliptical slots **126** formed in core ring **46**. The tips of posts **120** extending beyond the concave surface of core ring **46** facing away from shell **44** are flared, upset or otherwise distorted to tightly lock core ring **46** to outer shell **44** in snug abutment with blades **119** to securely but non-interlockingly clamp blades **119** in place, thus providing a shock and rattle proof fluid wheel assembly.

As shown in FIGURE 7, each of the blades **119** is provided with a straight through passage **127** and is generally rectangularly shaped in cross-section except for oppositely facing side portions **128** and **129** which are inclined at an acute angle with respect to the longitudinal axis of passage **127**. Side portions **128** and **129** respectively face toward and away from the direction of wheel rotation as indicated by the arrow. Side portion **128** forms with an oppositely facing side portion **130** an enlarged blade region indicated at **131**. Similarly, side portion **129** forms with an oppositely facing side portion **132** an enlarged blade region indicated at **133**. Side portions **130** and **132** are parallel in cross-section and merge respectively with side portions **128** and **129**. Thus, blade **119** is widest at its oppositely facing ends respectively abutting core ring **46** and shell **44** and gradually reduces to minimize thickness at a region approximately midway between its ends. This blade construction improves the stability of the blade and post assembly.

With continued reference to FIGURES 5–7, posts **120** extend along axes which are parallel to the axis of wheel rotation. Posts **120** matingly extend through passages **127** in coaxial relationship therewith. Each of the posts **120** is formed with a widened base portion **134** disposed adjacent to the concave surface of shell **44** and merging with a relatively slim pillar portion **135**. Base portion **134** is formed with an inclined side **135*a*** facing in the direction of wheel rotation and extending at an acute angle with respect to the longitudinal axis of the post. With this structure, the thickness of post **120** is widest immediately adjacent to shell **44** where the post enters its blade **119** and gradually becomes narrower in a direction extending toward pillar portion **135**. This construction of post **120** reinforces the structural strength of the post and blade assembly at a region where the concentration of stress is greatest.

With continuing reference to FIGURES 5 and 6, outer shell **44** is formed integral with a hub **136** having a smooth cylindrical bore **137** and a radially extending annular recess **138** opening into bore **137** approximately midway between opposed end faces of hub **136**. In assembly of the bladed hydrodynamic wheel illustrated in FIGURES 5 and 6 in a hydrodynamic device, the outer shell is arranged to be drivingly connected to a drive shaft member (not shown) by a split ring **138***a* received in recess **138**.

In the assembly of the component parts of the bladed wheel illustrated in FIGURES 5–7, blades **119** are slidably mounted over posts **120** and arranged in their properly oriented positions. Core ring **46** is then mounted on posts **120** with the tips of posts **120** extending through slots **126** in the manner shown with core ring **46** snugly abutting and pulled tightly up against blades **119**. The tips of posts **120** extending through slots **126** are then flared, upset or otherwise distorted to tightly lock core ring **46** to outer shell **44** with blades **119** securely clamped between shell **44** and core ring **46** in the manner similar to that described in the embodiments of FIGURES 2 and 3.

FIGURE 8 illustrates a modified form of blade structure which is essentially the same as that shown in the embodiment of FIGURES 5–7 except that four fillets indicated at **139** are added to the integral structure of blades **119** already described. Fillets **139** are concave in shape and are disposed at the corners of blade **119** abutting core ring **46** and shell **44** with their concave surfaces facing into toroidal passageway **34**. This fillet structure assures a smooth uninterrupted oil flow in passageway **34**.

FIGURE 9 illustrates another modified form of the blade structure for incorporation into the core and shell assembly shown in FIGURES 5–7. In this embodiment of FIGURE 9, a hollowed blade **141** is mounted on each of the posts **120** with each post extending completely and coaxially through a straight passage **142** formed in the blade. As shown, the cross section of blade **141** contained in a plane passing through the axis of passage **142** is generally in the shape of a parallelogram having oppositely facing sides **144** and **146**. Sides **144** and **146** are inclined in the direction of wheel rotation (as indicated by the arrow) and at an acute angle with the longitudinal axis of post **120**. Side **144** terminates at the entrance to passage **142** with the entrance of the blade passage being contained in a plane extending at an acute angle to the longitudinal axis of post **120** to expose a portion of post **120** indicated at **147** and facing generally oppositely from the direction of wheel rotation. Side **146** terminates at the exit of passage **142** with the exit being contained in a plane extending at an acute angle to the longitudinal axis of post **120** to expose a portion of post **120** indicated at **148** and facing in the direction of wheel rotation.

With this blade construction of FIGURE 9, post **120** enters blade **141** near the end of side **144** adjacent a shell **44** and leaves blade **141** near the end of side **146** adjacent to core ring **46**.

FIGURE 10 illustrates another mounting post and blade construction in which shell **44** is provided with a series of equiangularly spaced apart blade mounting posts **149** extending generally axially inwardly from the inwardly directed concave surface of shell **44** along a common circumference. Each post **149** is horizontally inclined at an acute angle with respect to the axis of wheel rotation such that each post slopes away from the direction of wheel rotation.

Mounted on each post **149** is a blade **152** of hollowed construction forming a straight passage **154** through which post **149** matingly extends. The cross section of blade **152** contained in a plane passing through the axis of passage **154** is substantially in the shape of a parallelogram having oppositely facing sides **156** and **158**. Sides **156** and **158** are inclined at an angle coinciding with the angle at which post **149** and passage **154** are inclined. Passage **154** is centered with respect to sides **156** and **158** to provide equal blade thicknesses on both sides of post **149** in the manner shown. Blades **152** are provided with a fillet **160** disposed at each of the corners of the blade and facing into passageway **34** in the same manner as described in the embodiment of FIGURE 8.

In the embodiment of FIGURE 10, the posts **149** are not widened at their bases since the inclination of posts **149** provides sufficient strength.

With continued reference to FIGURE 10, each post **149** of the bladed wheel assembly extends through apertures **164** formed in core ring **46** with core ring **46** being fixedly secured to posts **149** as by flaring or otherwise distorting the tip of each post extending axially beyond the inwardly directed surface of core ring **46** in the same manner as described in the embodiment of FIGURE 7. The assembly of the bladed wheel shown in FIGURE 10 is accomplished in the same manner as described in the previous embodiments.

FIGURES 11 and 12 illustrate another bladed wheel construction in which the shell and core ring components are stamped or otherwise formed from sheet metal instead of casting these component parts in the manner described in the previous embodiments.

With continued reference to FIGURES 11 and 12, the reference numeral **170** designates an inner shell stamped or otherwise formed from sheet metal. Shell **170** is provided with a semi-toroidal body portion **172** which is generally dished shaped to form an endless channel opening axially inwardly.

With continued reference to FIGURES 11 and 12, a sheet metal annular outer shell member **174** is stamped or otherwise formed with a dished shaped body portion **176** which interfittingly abuts the outwardly directed convex surface of shell **170**. Shell **170** is disposed axially inwardly of member **174** and is rigidly fixed to member **174** as by spot welding indicated at **180**.

With continuing reference to FIGURES 11 and 12, a series of relatively flat sided tapered tangs **182** are stamped out of body portion **176** and are bent axially inwardly at right angles to a plane passing perpendicularly through the rotational axis of the bladed wheel in the manner best shown in FIGURE 15. Tangs **182** are equiangularly spaced apart around a common radius and extend axially inwardly through apertures **184** formed in shell **170** (FIGURE 15). By forming tangs **182** and bending them over, apertures **186** are formed in body portion **176** of member **174** as best shown in FIGURE 15.

Tangs **182** take the place of the blade mounting posts described in the previous embodiment and are equal in number to the number of blades to be mounted in the bladed wheel assembly.

Slidably mounted on each of the tangs **182** is a hollowed three-dimensional blade **188** which is substantially of the same construction as blades **119** illustrated in FIGURES 5–7. The cross section of blades **188** in a plane passing about midway between the oppositely facing edges of tangs **182**, however, in more of a parallelogram in shape with each tang entering at one corner of the blade and leaving at the diagonally opposite corner of the blade. Blades **188** may be cast from lightweight metal or plastics.

To properly locate blades **188** in the assembly, the blades are provided with integral narrow projections **192** (FIGURE 12) adjacent to the thin portion of the blades. Projections **192** interfittingly extend into dimpled recesses **193** formed in shell **170** and opening generally radially inwardly in spaced relation to tangs **182**.

As best shown in FIGURES 12 and 15, the outwardly facing edges of blades **188** interfittingly abut the concave surface of inner shell body portion **172** with each blade being of such width to completely cover apertures **184** through which tangs **182** extend, thus preventing any leakage from occurring between blades **188** and the outer shell 174. Apertures 186 formed by bending tangs 182 inwardly are sealed by snug interfitting abutment of body portion 172 with body portion 176. By this structure, blades 188 seal off apertures 184 and body portion 172 coacting with body portion 176 seals off apertures 186 to prevent the escape of fluid from the toroidal chamber delimited by shell 170.

With continuing reference to FIGURES 11, 12, and 15, tangs 182 extend axially beyond the inwardly facing edges of blades 188 and project through apertures 196 formed in an annular dished shaped inner core ring 198. Core ring 198 is stamped or otherwise formed from sheet metal and is shaped with an axially inwardly extending endless channel to provide a convex surface facing the concave surface of body portion 172 and delimiting a segmental portion of a toroidal passageway 202 formed between core ring 198 and inner shell 170.

Core ring 198 is slidably mounted on tangs 182 with its convex surface interfitting abutting the inner edges of blades 188 in assembled relation. The tips of tangs 182 project axially inwardly beyond core ring 198 and into the channel formed thereby. To fixedly secure core ring 198 in place and thus lockingly clamp blades 188 in position between inner shell 170 and core ring 198, the tips of tangs 182 extending beyond core ring 198 are mechanically deformed as by riveting, upsetting or bending. As a result, it will be appreciated that blades 188 are securely locked in position between inner shell 170 and core ring 198 without attaching the blades themselves to either the shell or the core ring with the core ring being secured solely to tangs 182.

In the embodiment illustrated in FIGURE 13, a thin ring 210 is employed to properly locate blades 188 in assembled relationship on tangs 182 in place of recesses 193. In this embodiment, body portion 172 of shell 170 is provided with a radially outwardly offset end portion 212 extending rearwardly from its generally axially extending edge indicated at 214 and forming a shoulder 216. Ring 210 is received in the recess formed by offset portion 212 with its radially outwardly directed surface in snug interfitting abutment with a radially inwardly directed surface 218 formed on offset portion 212.

Ring 210 is formed with a series of equiangularly spaced apart slots 220 formed axially inwardly from the edge facing shoulder 216. Slots 220 correspond in number to the number of blades in the assembly and projections 192 of blades 188 interfittingly extend into slots 220 to thereby locate and secure blades 188 against displacement.

In the embodiment illustrated in FIGURE 14, a resilient flat-sided locking ring 230 is employed to secure core ring 198 in place on tangs 182 without deforming the tips of tangs 182. In this embodiment, the tips of tangs 182 projecting beyond core ring 198 are provided with radially outwardly facing slots 232 immediately adjacent to the concave inner surface of core ring 198. Locking ring 230 snugly extends into slots 232 with its axially outwardly directed surface in snug interfitting abutment with the inwardly directed concave surface of core ring 198 in the manner shown to thus lock core ring 198 to tangs 182. With this construction, it will be appreciated that locking ring 230 is sufficiently deformable so that it may be stretched over the tips of tangs 182 and fitted into slots 232. Since locking ring 230 is readily removable, it is clear that core ring 198 may be detached from tangs 182 to enable the replacement of blades 188.

FIGURE 16 illustrates another blade construction in which the reference numeral 236 generally designates a hollow sheet metal or plastic blade mounted on each one of the tangs 182. Blade 236 is made up of two separate reversely shaped one-piece sections 238 and 240 bonded or otherwise fixedly secured together. Each of the sections 238 and 240 are stamped with or otherwise formed in cross section with a side portion 242 which extends parallel with the rotational axis of the wheel and which merges with an inclined portion 244. Inclined portion 244 terminates in an end portion 246 which is bent over substantially at right angles to portion 242.

With continued reference to FIGURE 16, portion 242 of section 240 matingly and snugly abuts the flat side face of tang 182 facing away from the direction of wheel rotation and has its outwardly directed edge interfittingly abutting the inwardly directed concave surface of body portion 172. The inclined portion 244 of section 240 slopes away from tang 182 at an acute angle and the end portion 246 of section 240 snugly and interfittingly abuts the outwardly directed concave surface of core ring 198. Similarly, portion 242 of section 238 snugly and interfittingly abuts the surface tang 182 facing in the direction of wheel rotation with the inwardly directed free edge of portion 242 in snug interfitting abutment with the outwardly directed convex surface of core ring 198. The inclined portion 244 of section 238 slopes away from tang 182 at an acute angle and in the direction of rotation of the bladed wheel assembly. The end portion 246 of section 238 snugly and interfittingly abuts the inwardly directed concave surface of body portion 172.

As shown in FIGURE 16, sections 238 and 240 are secured together one on each side of its respective tang 182. Sections 238 and 240 form, in cross section, a box-like blade of generally parallelogram shape with tang 182 entering blade 236 at one corner and leaving blade 236 at the diagonally opposite corner. Sections 238 and 240 of blade 236 cooperate to completely cover the aperture 184 through which tang 182 extends to thereby seal off aperture 184 and prevent leakage of fluid from occurring between the blade and the shell assembly.

Referring now to FIGURE 17 in which a modified blade construction is illustrated, the reference 250 generally designates a hollow thin sectioned blade mounted on each of the tangs 182. In this embodiment tangs are not bent completely over at right angles to the direction of wheel rotation but are rather bent only to an acute angle with respect to the direction of wheel rotation in the manner shown. The configuration of blade 250 is similar to that described in the embodiment of FIGURE 10.

In all the embodiments of the present invention, only one integral post or tang for each blade is used to mount the blades between the outer shell assembly and the inner core ring thus enabling the ready substitution of blades of different curvatures within the same outer shell and core ring. With the previously known structures using multiple blade locking arrangements, the replacement of the blades is not possible. By interchanging blades of different curvatures, it is possible to obtain different torque readings by retaining the same overall size of the fluid wheel. The separate formation of the wheel members eliminates the need for expensive intricate coring in methods formerly used.

Furthermore, it is feasible to use different materials for each of the three components for any bladed wheel assembly. For instance, a bladed wheel assembly may have a cast metal outer shell, aluminum or plastic blades and a sheet metal inner core ring.

By choosing any of today's available materials such as steel, ductile iron, malleable iron, aluminum, magnesium or thermoplastics, fabricated or cast, almost any arrangement is possible due to the interchangeability of the separate component parts making up the bladed wheel. This allows the manufacturer to design heavy or light, depending on the specific requirements.

Thus, it will be appreciated that the present invention provides a fabricated hydrodynamic bladed wheel assembly which can be made at substantial reduction in manufacturing costs and which is easily assembled without distorting the critical curvatures of the cast or formed blades. Because of the unique locking of the inner core ring to the outer shell, distortion of the critical blade curvature during assembly is avoided.

The integral construction of the outer shells with their associated hubs eliminates the interlocking and expensive bolting arrangements required with prior art assemblies having separate hub members.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are, therefore, intended to be embraced therein.

What is claimed and desired to be secured by Letters Patent is:

1. A bladed wheel unit for a hydrodynamic fluid torque transmitting device comprising:
 (a) separate coaxially disposed integral inner and outer annular members spaced to provide a generally annular space of substantially constant cross-section therebetween for passage of fluid;
 (b) said outer member having an inwardly facing smoothly curved transversely concave annular inner passage defining surface and said inner member having an outwardly facing smoothly curved transversely convex annular outer passage defining surface opposed thereto;
 (c) said inner member having a series of circumferentially spaced apertures;
 (d) a plurality of posts of one-piece construction with said outer member and projecting through said space and through said apertures;
 (e) a plurality of separate hollow blades mounted on said posts within said space with the inner and outer ends of said blades shaped to tightly and smoothly but separably abut said inner and outer member surfaces respectively;
 (f) cooperating complementary projection and recess means on each said blade and the adjacent interior of said outer member disposed radially outwardly of said posts in the unit and adapted for direct interfitting engagement during assembly as said posts are pushed slidably through said hollow blades, so that said blades are non-rotatably mounted and located in desired relative spacing and orientation within said fluid passage space;
 (g) said blades having end to end through bores fitting snugly and smoothly over said posts so that the blade and posts assemblies are substantially solid throughout; and
 (h) said posts being thicker at their bases where they intersect said concave surface of the outer member; and
 (i) means on the inner ends of said posts and disposed within and coacting with said inner member for securing said inner member in bridging relation across said inner ends of all of said posts for axially holding all of said blades rigidly between said inner and outer members and fastening said members and blades together as a rigid unit.

2. The bladed hydrodynamic torque transmitting unit as defined in claim 1, wherein
 each post has an axially recessed tip formed with a thin wall portion extending axially beyond the surface of said inner annular member facing away from said outer annular member and being deformed with respect to its respective post for securing said inner annular member to said posts in snug abutment with said blades.

3. The bladed hydrodynamic torque transmitting assembly defined in claim 2 comprising:
 (a) annular means mounted on said posts and disposed between said deformed thin wall portion and said inner annular member,
 (b) said annular means being of predetermined thickness to compensate for variations in tolerances in said blades and said inner and outer annular members.

4. The bladed hydrodynamic torque transmitting unit as defined in claim 1, wherein the tips of said posts projecting through said apertures in said inner member are bent over in engagement with the inner surface of said inner annular member.

5. The blade hydrodynamic torque transmitting unit as defined in claim 1 wherein said posts are tapered to converge toward their outer ends, said blade bores forming interior surfaces mating and slidably engaging with the tapered surfaces of said posts.

6. The bladed wheel defined in claim 1 wherein the corners of said blades at the intersections with said concave surface are provided with concave fillets facing into the spaces between said blades.

7. The bladed wheel defined in claim 1 wherein said posts are slanted with respect to the direction of wheel rotation.

8. The bladed wheel defined in claim 7 wherein
 (a) each of said blades is formed with a bore through which its post coaxially extends,
 (b) said bore having opposed ends respectively facing said inner annular member and said outer annular member and respectively containing the exit and entrance to said bore,
 (c) said exit and entrance being formed in planes extending at an acute angle to the axis of said bore to leave portions of each post exposed in the spaces between said blades.

9. The bladed wheel defined in claim 1, wherein each of said blades is generally formed in the shape of a parallelogram in a cross section contained in a plane passing substantially through the longitudinal axis of each of said posts.

10. The bladed wheel as defined in claim 1, wherein
 (a) each of said blades in substantially formed in cross section with a shape of a parallelogram having oppositely facing parallel sides,
 (b) each of said posts having its longitudinal axis extending in parallel relation to said parallel sides.

11. In the bladed wheel unit defined in claim 1, each post at its thicker base being formed iwth an inclined side wall facing the direction of normal rotation of said wheel unit.

12. In the bladed wheel unit defined in claim 11, said posts being thinner where they extend through said apertures and said blades having greater wall thickness where they surround said thinner post portions.

13. The bladed wheel defined in claim 11 wherein said blades are enlarged at opposed end regions where said posts enter and leave said blades.

14. A unitary bladed wheel for a hydrodynamic fluid torque transmitting device, said bladed wheel comprising:
 (a) separately formed coaxially mounted inner and outer annular blade support members forming a generally annular space therebetween;
 (b) a plurality of blades fixedly positioned in said annular space and connected to said members only by separable abutting surfaces which are free of interlock;
 (c) a plurality of integral posts projecting inwardly from said outer member and frictionally through the blades and through apertures in said inner member;
 (d) means on the inner ends of said posts for securing said members and blades together as a rigid unit with said blades extending rigidly between said members and having separable opposite end abutment with said members, and
 (e) each of said blades being formed substantially as a parallelogram in a cross section with each of said posts entering its respective blade at one corners of

said parallelogram and leaving said blade at the corner diagonally opposite from said one corner.

15. The bladed wheel defined in claim **14** wherein each of said blades is made up from two separately formed sections disposed one on each side of each post and secured together to form a hollow box-like blade.

References Cited by the Examiner

UNITED STATES PATENTS

649,014	5/1900	Terry	253—77
748,216	12/1903	Rateau et al.	253—77
1,507,143	9/1924	Toussaint et al.	230—134
1,966,104	7/1934	Noack	253—77
2,304,721	12/1942	Werther	103—115
2,347,034	4/1944	Doran	253—77
2,365,354	12/1944	Pennington	29—156.8
2,371,588	3/1945	Salerni	103—115
2,387,722	10/1945	Dodge	29—156.8
2,479,057	8/1949	Bodger	253—77
2,494,539	1/1950	Bolender	103—115
2,497,041	2/1950	Bodger	253—77
2,500,745	3/1950	Bloomberg	253—77
2,653,547	9/1953	Langdon	103—115
2,690,132	9/1954	Misch	103—115
2,710,580	6/1955	Holzworth	103—115
2,786,646	3/1957	Grantham	253—77

FOREIGN PATENTS

1,185,249	2/1959	France.
720,956	12/1954	Great Britain.

DONLEY J. STOCKING, *Primary Examiner.*

JOSEPH H. BRANSON, JR., *Examiner.*