R. H. RICE & S. A. MOSS.
CENTRIFUGAL COMPRESSOR AND PUMP.
APPLICATION FILED FEB. 8, 1907.

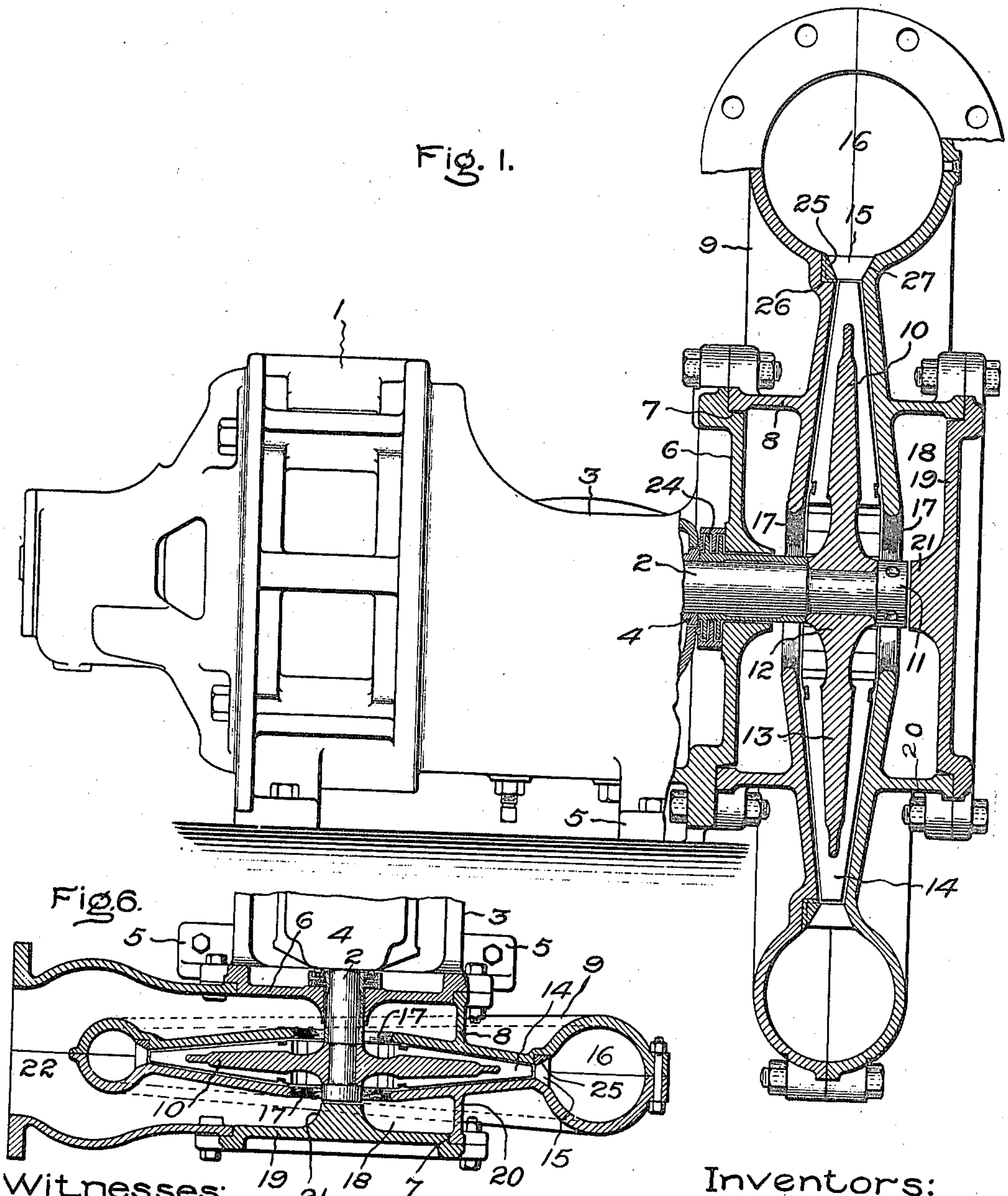
1,041,511.

Patented Oct. 15, 1912.

3 SHEETS—SHEET 1.

Fig. 1.

Fig. 6.



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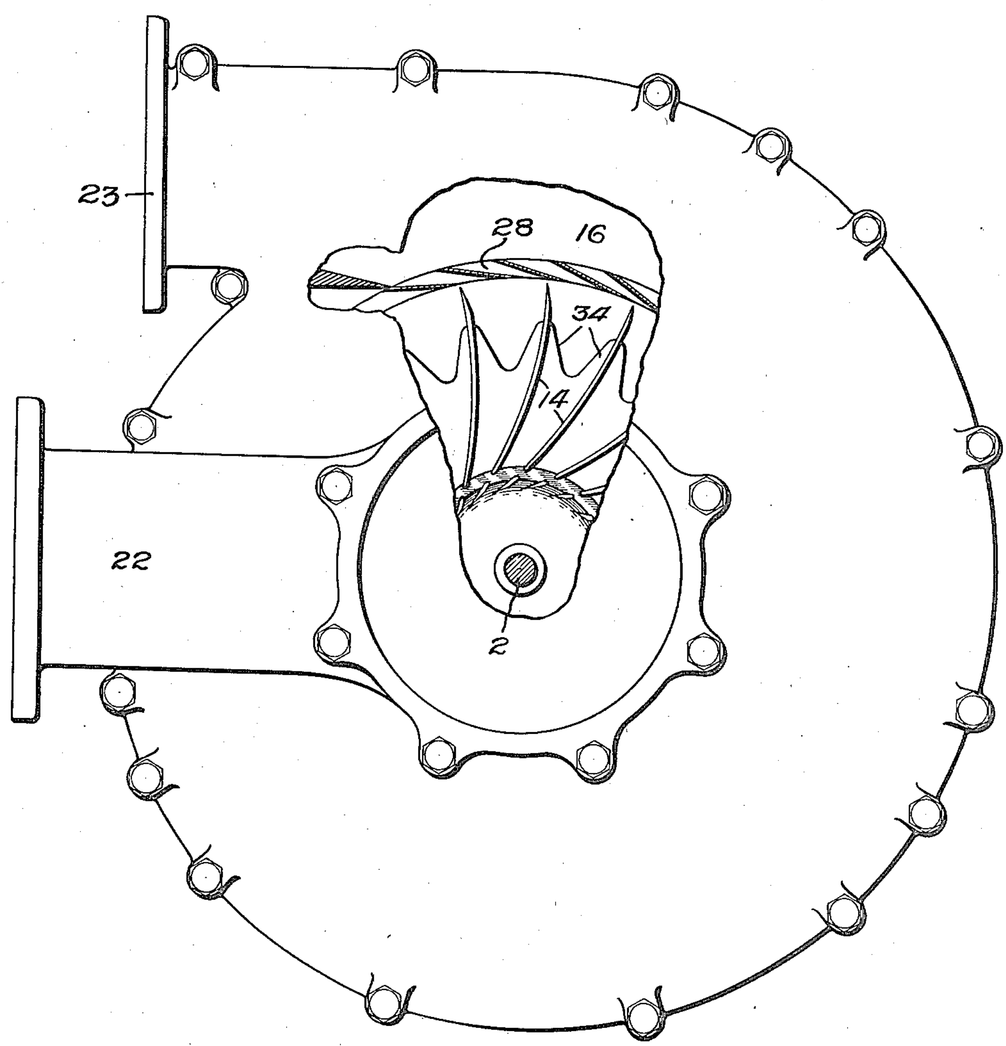
3 SHEETS—SHEET 2.

Fig. 2.



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3 SHEETS—SHEET 3.

Fig. 3

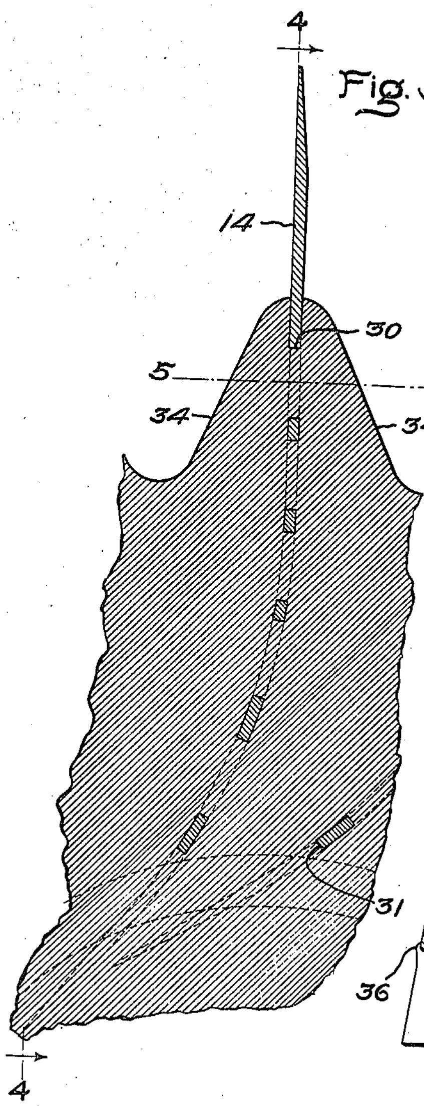
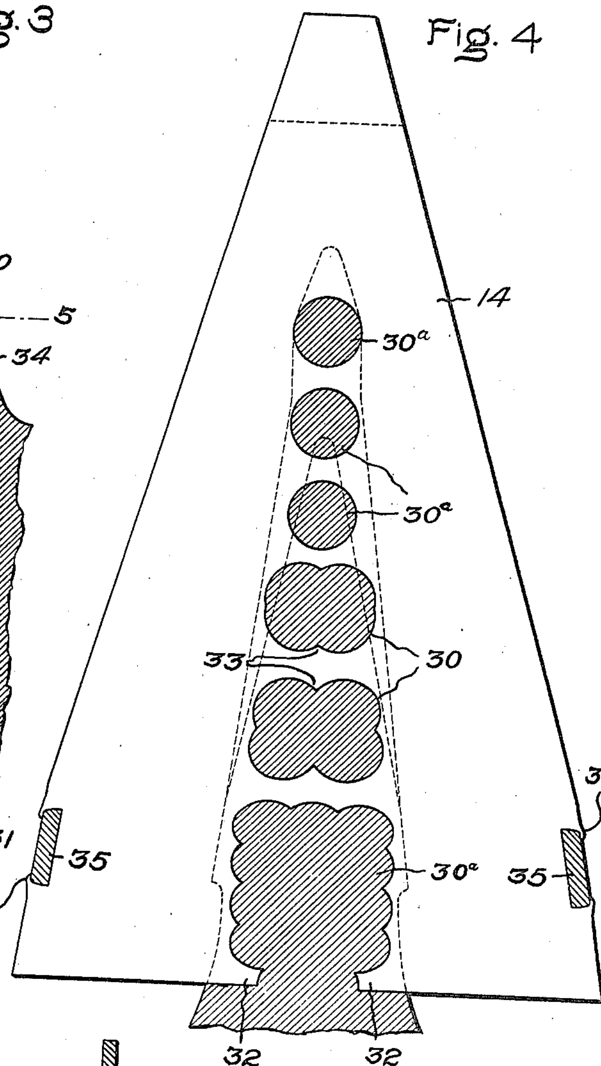


Fig. 4



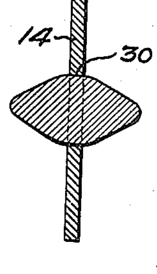


Fig. 5

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UNITED STATES PATENT OFFICE.

RICHARD H. RICE AND SANFORD A. MOSS, OF LYNN, MASSACHUSETTS, ASSIGNORS TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

CENTRIFUGAL COMPRESSOR AND PUMP.

1,041,511. Specification of Letters Patent. Patented Oct. 15, 1912.

Application filed February 8, 1907. Serial No. 356,327.

To all whom it may concern:

Be it known that we, RICHARD H. RICE and SANFORD A. MOSS, citizens of the United States, both residing at Lynn, county of Essex, State of Massachusetts, have invented certain new and useful Improvements in Centrifugal Compressors and Pumps, of which the following is a specification.

The present invention has for its object to improve the construction of centrifugal compressors and pumps, particular reference being made to the means for receiving and directing the passage of fluid into the receiving ends of the impeller blades and to the construction of the impeller blades and the support therefor.

Other features of the invention will be pointed out in the description and claims appended thereto.

In the accompanying drawings which illustrate one of the embodiments of the invention, Figure 1 is a view in elevation of an electric motor direct coupled to a centrifugal compressor, the latter being in section; Fig. 2 is an end view of the compressor with certain of the parts broken away; Fig. 3 is a partial section of the impeller showing how the blades are secured in place by casting the metal of the body around them; Fig. 4 is a section taken on line 4 4 of Fig. 3; Fig. 5 is a section taken on line 5 5 of Fig. 3; and Fig. 6 is a horizontal section of the compressor.

1 represents an electric motor, the revolving member of which is mounted on the shaft 2. The motor shown is of the alternating current type, but any other form of motor can be used. On one end of the motor casing is formed or attached a neck or projection 3 containing a bearing 4 of substantial dimensions and having feet 5 adapted to be secured to a foundation. The main proportion of the motor casing is also provided with supporting feet. The right-hand end of the neck terminates in a vertical wall 6 which forms a part of the casing of the compressor and is provided with a shaft-receiving opening. This wall is provided with a shoulder 7 near the periphery to receive the annular wall 8 formed on the left-hand half 9 of the casing of the compressor. The two are secured by axially-extending bolts which are readily accessible. The arrangement described has the advantage of reducing the number of the parts, the amount of machine work involved, and it eliminates the troubles incident to the lack of alinement. It also has the further advantage that the inlet and discharge conduits can be set at any desired angle to connect with the piping system. This is accomplished by equally spacing the holes in the shoulder 7 and those in the lugs on the annular wall 8 which receive the axially-extending bolts so that the parts can be angularly adjusted.

The impeller 10 is mounted on the shaft 2 and is overhung with respect to the main bearing 4, the opposite end of the shaft being located in a bearing carried by the left-hand head of the motor. The impeller is held in place on the shaft by suitable means, including the nut 11, and can be taken off by removing said nut. The main body of the impeller comprises a steel casting having a hub 12 of suitable proportions and a web 13 which gradually tapers in thickness toward the periphery. The sides of the hub, it will be observed, are cut away and follow such curves that the incoming fluid particles are caused to follow a path which directs them radially to the inner ends of the impeller blades, thereby preventing objectionable eddies and losses due to friction. Extending through the web 13 from side to side are blades 14. These blades are provided with openings or perforations to receive molten metal, when the body is cast, and the metal located in said openings and extending circumferentially serves to hold the parts of the body together against bursting strains and also to hold the blades against centrifugal strains. The blades are widest at the center and gradually decrease in width toward the periphery. On the other hand, since they are arranged in a circle, the receiving ends are nearer together than the discharging ends. Both the receiving and the discharge ends of the blades terminate in planes parallel to the axis. The specific construction of the impeller will be more fully described later. The vertical walls of the compressor casing are located in close proximity to the edges of the blades and are inclined in the same direction. These walls form the sides of the fluid-conveying passages between the blades. At a point just beyond the periphery of the impeller provision is made to receive the annular nozzle 15 which converts the velocity of the fluid as it leaves the blades into pressure and discharges it without objectionable eddies into the scroll or collecting passage 16, the latter being made by suddenly enlarging the opposite walls of the parts of the casing. The vertical side walls of the casing contain fluid-receiving orifices 17 at their centers having well rounded surfaces so that the air irrespective of the direction it has on entering will be turned in a definite and gradual manner into the radial direction. It is desirable to make the diameter of these orifices as large as possible so that the velocity of the entering fluid will be low and hence the losses due to cross-currents and eddies reduced to a minimum. On the other hand, the diameter of the orifice should be less than that of the circle forming the path of the inner ends of the blades so that the particles of the incoming fluid will be properly directed and all have the same, or substantially the same, direction and velocity. Our experience has demonstrated that if a compressor is to have a high degree of efficiency, the fluid must be freely moving when first acted upon by the blades, and without cross-currents or eddies. It is desirable to extend the inner ends of the blades as near to the shaft as possible, for structural reasons, hence a compromise is effected between the diameter at the inner ends of the blades and the diameter of the fluid-receiving orifices 17.

As it is important to supply the fluid undergoing compression as freely as possible to all parts of the orifices, each half of the casing is provided with an axially-extending wall which is located at some considerable distance from the orifices at all points so as not to offer any opposition to the flow. As an example, annular walls 8 and 20 have been shown since they are the easiest to machine. The right-hand annular supply chamber 18 is closed in by a detachable end wall 19 that is bolted to the annular wall 20. The center of the wall 19 is provided with a boss 21 having a well rounded base to prevent the fluid from striking the nut on the end of the shaft. The left-hand annular supply chamber is closed in by the wall 6 as before described. In Fig. 6 the compressor is shown in section, at right angles to that of Fig. 1. Fluid enters the inlet 22 and then divides, one half going to the annular chamber on one side and the other half to the annular chamber on the opposite side. The fluid is discharged from the scroll or collecting passage 16 through the opening 23 Fig. 2. From this figure and also the ones previously described it will be seen that the cross-sectional area of this passage gradually increases from one end to the other.

Where for any reason it is necessary to pack the shaft 2 where it passes through the wall 6 to prevent the impeller from sucking oil from the bearing 4, a packing 24 is provided. Any suitable form of packing can be used for this purpose, a labyrinth packing has been shown in the present illustration.

The annular nozzle 15 is made by casting a plurality of partitions into a ring 25 that is seated on a shoulder 26 formed in the casing. The opposite sides of the partitions may be connected or unconnected as desired. As shown they are unconnected and rest on the inclined portion 27 of the casing. Since the nozzle is annular the arrangement shown will, when the parts of the casing are bolted together, hold it without other means. The nozzle shown is so constructed that the passages 28, Fig. 2, between the partitions expand from the inlet toward the outlet, and by such an amount as will convert the velocity of the fluid discharge from the impeller into pressure, thereby appreciably increasing the efficiency of the apparatus.

The air leaves the impeller at a pressure considerably above atmosphere owing to centrifugal action along the impeller blades. It also has a high velocity due to the rotation of the impeller. This velocity represents practically one-half of the energy put into the air by the impeller, the remainder being represented by the centrifugal pressure. In the usual fan blower this velocity and energy are wholly lost in eddies in the collecting passage or scroll. By the introduction of a nozzle having discharge vanes as described, a considerable portion of the energy represented by the velocity is converted into pressure, thereby giving an appreciable gain in pressure and efficiency.

Referring now more especially to Figs. 2 to 5, inclusive, the specific construction of the impeller will be described. The blades 14 are made out of relatively thin sheet steel and gradually taper in width from the inlet or lower end, Fig. 4, to the upper or discharge end. They are also curved somewhat from end to end so that the air is turned in a definite and gradual manner. In the blades are punched a number of holes 30 gradually increasing in size toward the shaft. Generally speaking, the size of the holes increases with the increase in thickness of the web. In the inner end of each blade a recess 31 is formed, also by the punching process. The object in making a recess instead of a hole is so as not to unduly weaken the metal in the web at this point because the strains are high. It is important to prevent the lower ends of the blades from bending outwardly or distorting due to centrifugal stresses. To prevent this, projections 32 are provided on the inner ends of the blades. It will be observed that the larger of the holes 30 have small points or projections 33; these are left when the stock is cut out by round punches and are desirable since they assist in holding the parts. There is or may be a greater or less fusion between the cast metal in the body of the impeller and that of the blades. Considering the sheets when assembled about the shaft, the holes or perforations 30 therein and the recess 31 are arranged in concentric circles, the diameters of which increase from the shaft outwardly. The portions 30^a which are integral parts of the main body and are formed when the casting is made serve two purposes: First they serve to prevent the wheel from bursting due to centrifugal strains, and second they anchor the blades against all strains and also preserve their alinement. It will be noted in the present illustration that six concentric portions 30^a are provided for securing the parts, but the number can be increased or decreased. It is also to be noted that the cross-sectional area of said portions decreases as the distance from the shaft increases. Two or more of the outer portions may however have the same cross-section. In order to make the impeller as light as possible, yet at the same time strong, the metal at the periphery of the body is cut away leaving projections 34, Fig. 2, one in front and one in the rear of each blade. In other words, the periphery of the body is scalloped and the sheets forming the buckets extend through the points thereof so that each blade at its outer end is braced front and back. These projections or points on opposite sides of the blades are united by the outer portions 30^a of the main body. We further lighten the impeller by omitting side plates therefrom and depend upon the walls of the impeller casing to form the sides of the fluid-carrying passages. Besides materially decreasing the weight and the strains incident to such reduction, the open construction enables the sides of the impeller body to be readily finished. It will be observed that the blades extend entirely through the body of the impeller from one side to the other. By reason of this the use of independent sets of blades on each side of the impeller is avoided, thereby reducing the number of parts, the loss due to waste in material, and the cost of manufacture. Again the blades being of substantial size are more readily shaped and cast into place. An impeller constructed as described will also be exceedingly strong and have a large factor of safety, which is an important consideration in a machine of this kind adapted for high speeds. The impeller will also be balanced as to thrust because it draws its supplies of fluid in equal amounts from opposite sides. It will be seen that the fluid enters in multiple streams and is discharged into a nozzle and scroll common thereto. By experience we have learned that the centrifugal forces of such an impeller are great enough when of the proportions shown to bend over the inner ends of the blades. To avoid this, notches are cut in the edges of the blades and mounted therein are rings 35, one on each side of the body. They are held in place by staking, as at 36. Rings are used because they are of simple and reliable construction, but other devices may be used. These rings are preferably thin in the direction of flow of the fluid undergoing compression, so as not to offer undue opposition. The entrance and exit to the impeller are so arranged as to keep the air in a homogeneous stream.

The machine described will deliver air at a substantially constant pressure at a given speed, which pressure can be varied by changing the speed of the driving shaft. There will be a slight falling off in pressure when the amount of air delivered is comparatively small and also when the amount of air delivered is comparatively large, but for all practical purposes the pressure may be said to be independent of the amount actually delivered.

By substituting an impeller for the one shown having blades with different entrance and exit angles, the machine can be made to deliver fluid at a higher or a lower pressure as desired, the shaft speed remaining the same.

One of the principal advantages of the compressor shown resides in the fact that a large portion of the energy can be added centrifugally to the fluid passing through it in a highly efficient manner. By preference only a comparatively small amount of energy is added to the fluid in the form of kinetic energy, since the efficiency with which this can be converted into pressure energy is comparatively low.

The compressor shown is intended to compress air or other gaseous fluids, or it may be used as a centrifugal pump for pumping liquids.

In accordance with the provisions of the patent statutes, we have described the principle of operation of our invention, together with the apparatus which we now consider to represent the best embodiment thereof; but we desire to have it understood that the apparatus shown is only illustrative and that the invention can be carried out by other means.

What we claim as new and desire to secure by Letters Patent of the United States, is,—

1. In an apparatus of the character described, the combination of an impeller having blades on opposite sides of the body thereof, a casing, the walls of which inclose

the blades on the impeller and are provided with orifices, one in each side, through which the fluid enters, the surfaces of said orifices being well rounded and arranged to direct the entering fluid radially to the blades, chambers formed on opposite sides of the impeller which are bounded on one side by said walls and which are larger in diameter than said orifices and supply fluid thereto, a conduit for supplying said chambers, a scroll receiving fluid from the impeller, and a nozzle having a plurality of partitions with diverging passages between them which receive fluid from the impeller, convert its velocity into pressure, increase its density and discharge it into the scroll.

2. In an apparatus of the character described, the combination of a motor, an impeller driven thereby, a casing for the impeller having a discharge conduit, a projection on the motor with which the casing is united and is angularly adjustable thereon, a supply chamber located between one end of the projection and the casing, and a second supply chamber located on the opposite side of the impeller.

3. In an apparatus of the character described, the combination of a motor, an impeller driven thereby, a casing for the impeller having a discharge conduit, a projection on the motor for uniting it with the casing, a wall located on one side of the casing and coöperating with the projection to form a chamber, walls on the opposite side of the casing arranged to form a chamber, and a conduit for supplying fluid to the chambers.

4. In an apparatus of the character described, the combination of a motor, an impeller driven thereby, a casing for the impeller, a projection on the motor for uniting it with the casing and forming a wall of a supply chamber, a wall coöperating with that supported by the projection and with the casing to form a supply chamber, and conduits for supplying fluid to the chamber and receiving it after passing through the impeller.

5. In an apparatus of the character described, the combination of a motor, an impeller driven thereby, a casing for the impeller, a projection on the motor for uniting it with the casing and forming a wall of a supply chamber, a wall coöperating with that supported by the projection and with the casing to form a supply chamber, walls on the opposite side of the impeller coöperating with the casing to form a second supply chamber, means for supplying fluid to the chambers, and a scroll which receives the fluid after it passes through the impeller.

6. An impeller comprising a cast metal body portion and sheets of metal cast therein, the latter extending through the body to form blades on opposite sides thereof having uncovered edges, and means which anchor the sheets and also prevent the parts of the body between the sheets from separating due to centrifugal strains.

7. An impeller comprising a cast metal body portion with a plurality of perforated sheets of metal which extend through said body to form blades on opposite sides thereof and are anchored in place by concentric portions of the body that pass through the perforations, the said portion holding the parts of the body together at different distances from the axis and resisting centrifugal strain.

8. An impeller comprising a cast metal body portion and perforated sheets of metal extending through the said body and forming buckets on opposite sides thereof, each sheet having a plurality of perforations gradually decreasing in size as the distance from the axis increases, and integral portions of the body which extend through the perforations and form concentric anchoring means that also resist the tendency of the body to disrupt due to centrifugal strains.

9. An impeller comprising a plurality of sheets of metal having irregularly-shaped perforations to receive molten metal when the body portion is cast, and a cast body portion which is of less width than the sheets so that the latter will form blades on opposite sides and which is provided with a hub portion having cut-away sides that are thinner in an axial direction than in the part receiving the sheets to assist in directing the entering fluid.

10. An impeller comprising a cast metal body and a plurality of metal sheets that extend through the body and form blades on opposite sides thereof having uncovered edges, and means for tying the edges of the blades together near their inner ends to resist the effects of centrifugal force.

11. An impeller comprising a cast metal body and a plurality of metal sheets that extend through the body and form blades on opposite sides thereof having uncovered edges, and rings located on opposite sides of the body and seated in notches in the blades and secured in place by staking.

12. An impeller comprising a plurality of perforated sheets of metal extending from the axis outwardly to form blades and a body of metal of less width than the sheets and into which they are cast with portions of the body extending through the perforations, the said body being scalloped at the periphery, the projections of said scallops reinforcing the blades front and back.

13. In an apparatus of the character described, the combination of an impeller body, blades carried by the body which extend on opposite sides thereof, a casing for the impeller whose side walls coöperate with

the impeller to confine the fluid between the blades, and whose integral outer portions form a scroll, said casing and scroll being divided in the plane of the impeller, a shoulder formed on the inside of one part of the casing and located adjacent to the scroll, a wall formed on the inside of the opposite portion of the other part of the casing which is beveled outwardly from the impeller, said wall forming one side of a nozzle, an annular nozzle surrounding the impeller in the plane thereof which rests on the shoulder and is held in place between it and said wall when the parts of the casing are united, said nozzle comprising an outwardly beveled side member which coöperates with the beveled side wall to form an outwardly diverging passage for the fluid discharged by the impeller, and tangentially arranged straight sided partitions for the nozzle that are supported at their edges by the member and said beveled wall, said partitions rapidly increasing in width, measured axially, as the distance from the impeller increases, integral annular walls on the outside of the halves of the casing, covers secured to the annular walls to form with them supply chambers on each side of the impeller, an inlet for supplying fluid to the chambers, and a discharge conduit communicating with the scroll.

14. An impeller comprising a cast-metal body, perforated sheets of metal that are carried by the body and extend outwardly from the axis and on both sides to form blades, each of said sheets having a recess at its lower end with a restricted opening, and means formed integral with the body which fill the recess and the perforations and serve to prevent the body from disrupting and also to anchor the sheets.

15. An impeller, comprising a cast metal body with relatively thin blades supported thereby and having free outer edges, each of said blades having a curved inlet portion and a radially disposed discharge portion which forms a continuation of said inlet portion and is tangentially arranged with respect thereto, and a ring which is attached to the inlet portion of each of said blades near its inner end to prevent said portions from bending under centrifugal stresses.

16. An impeller, comprising a body with blades supported thereby on opposite sides and having free outer edges, each of said blades comprising a curved inlet portion and a radially disposed discharge portion which forms a continuation of the inlet portion and is tangentially arranged with respect thereto, said blades being wider, measured axially, at their inlet ends than at their discharge ends, and rings located on opposite sides of the body and attached to the curved inlet portions only of the blades to prevent them from bending over due to centrifugal stresses.

In witness whereof, we have hereunto set our hands this fifth day of February, 1907.

RICHARD H. RICE.
SANFORD A. MOSS.

Witnesses:
JOHN A. McMANUS, Jr.,
HENRY O. WESTENDARP.