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(71) Applicant: DANIEL INDUSTRIES, INC. [US/US]; 9753 Pine Lake Drive, Houston, TX 77055 (US).

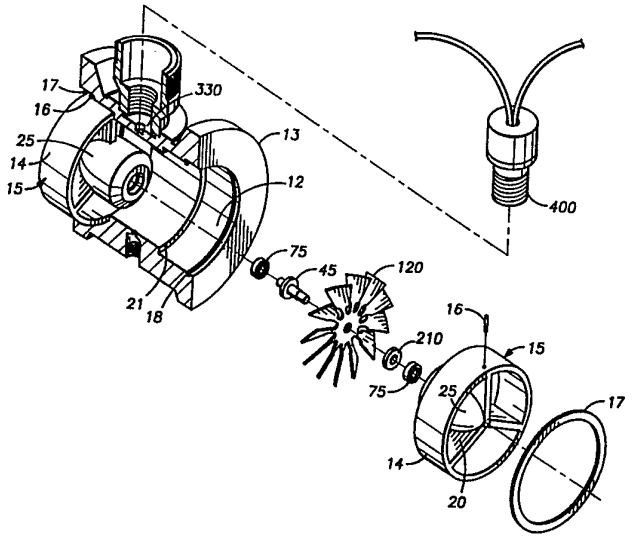
(72) Inventors: ZENGER, Helmut ; 5747 Birdwood, Houston, TX 77096 (US). KUBIN, Bob, E. ; 23307 Good Dale Lane, Spring, TX 77343 (US). GOODSON, Franklin, Dale ; 22010 Red River Drive, Katy, TX 77096 (US). HUSAIN, Zaki, Din ; 15919 Hickory Cove Drive, Houston, TX 77096 (US). ALLEN, Charles, R. ; 12854 Westleigh Drive, Houston, TX 77077 (US).

(74) Agent: OSTFELD, David, M.; Chamberlain, Hrdlicka, White, Williams & Martin, 1400 Citicorp Center, 1200 Smith Street, Houston, TX 77002 (US).

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(54) Title: GAS TURBINE METER



(57) Abstract

A gas turbine meter (1) that is miniaturized based on its design is disclosed. While the size of the gas turbine meter (1) is small, it has a large rangeability over a very large range of pressure. The turbine meter includes a body (10) which is bilateral or symmetrical. Diffusers (15) are included with the turbine meter (1) that maintain the rotor (45) of the turbine meter (1) in position and prevent dust from entering into bearings (75). The rotor (15) of the turbine meter (1) optimally has twelve flat blades (150), each having an angle of 45° from the plane of the blank (12). Close clearance is maintained between the blades (150) and the interior (11) of the meter. Notches (140) are formed at the lower end of the blades (150), thereby forming the shafts (170) of the blades (150) which are optimally sized to increase stiffness. The magnetic strength of the magnetic pick-up (400) has a small genus strength to avoid magnetic drag.

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GAS TURBINE METER

Field of the Invention

The invention relates to flow measurement devices and in particular, to flow measurement devices using turbine meters as a basis of the flow measurement.

Background of the Invention

Pipes are used to transport fluids of all sorts. Because the measurement of these fluids is important, various types of fluid measuring devices such as orifice plates, flow meters, turbine meters, etc. are installed in-line with pipe sections. The use of such a measurement for flow has been known since ancient times.

The present invention relates in general to turbine flow meters. Turbine flow meters usually include a measuring chamber having a flow guide in the front of such chamber, a measuring wheel supported for rotation in the chamber and includes a magnetic device which counts the blade turnings for blades mounted on the hub of the measuring wheel.

The basic theory with regard to electronic turbine meters is that fluid flow through the meter impinges upon the turbine blades which are free to rotate about an axis along the center line of the turbine housing. The angular (rotational) velocity of the turbine rotor is directly proportional to the fluid velocity through the turbine. The output of the turbine meter is measured by an electrical pickup mounted in the meter body. The output frequency of this electrical pickup is proportional to the flow rate. Also, each electrical pulse is proportional to a small incremental volume of flow. This incremental output

is digital in form, and as such, can be totalized with a maximum error of one pulse regardless of the volume measured.

Problems with existing turbine meters include a shift in the meter factor curve over pressure change, rangeability over a large range of pressures, large size, and the intrusion of dirt.

It is an object of the present invention to avoid the meter factor curve change over the operating pressure of the meter, to permit high flow rangeability over a large range of pressure, such as substantially ambient to 1500 p.s.i. It is a further object of the present invention to substantially reduce the size of the meter. An additional object of the present invention is to inhibit intrusion of dirt within the mechanism of the measuring wheels supported for rotation in the chamber.

Summary of the Invention

The present invention discloses a turbine meter that is suitable for either liquid or gas flow which can be installed for use over a large pressure range, such as, for example, ambient to 1500 p.s.i. while maintaining a rangeability of, for example, 10:1 for ambient and 13:1 at 300 p.s.i. The present invention includes a body or housing in which is contained a bilateral or symmetrical configuration of a flow meter. The flow meter includes flow diffusers at each end located in the flow passage of the body and a detector at an interior wall of the body. A rotor is mounted on a rotor shaft between the two flow diffusers. The rotor optimally has twelve flat blades with optimal blade angles of 45°. A close clearance is maintained between the blades and the interior of the meter body which is optimally between .008" and .012". This is achieved through use of

specific stiffness of the blade which stems from the use of a set of notches to form the blades having optimal size for oval notches of width to height ratio of 1.5 to 2.0, such as .169" x .094" for a two inch meter. The notches for most meters would be oval in shape but at the extreme small and large sizes may be other shapes, such as tear drop. A magnetic pick-up is located in the magnet housing immediately juxtaposed with the blades and separated from the blade by the interior wall of the body and the small clearance discussed above. The magnetic strength of such magnet located in the interior wall of the body is between 50 and 200 gauss. The rotor is mounted on the rotor shaft of the shaft by bearings which are precision ball bearings for optimal results. Blade thickness may vary between .01 and .025 of the rotor diameter, such as .020" and .050" for a two inch meter while maintaining the small size of the turbine meter.

Brief Description of the Drawing

For a further understanding of the nature and objects of the present invention, reference is made to the following drawing in which like parts are given like reference numbers and wherein:

Figure 1 is a perspective view of the preferred embodiment of the present invention of the turbine meter;

Figure 2 is a side, partial cross-sectional view of the preferred and alternate embodiment of the present invention of the turbine meter;

Figure 3 is a partial side cross-sectional view of a portion of the preferred and alternate embodiment of Fig. 2;

Figure 4 is a plan view of the rotor shaft of the preferred embodiment of the present invention of the turbine meter;

Figure 5 is a cross-sectional view of the housing of the preferred embodiment of the present invention of the turbine meter;

Figure 6 is a plan view of the rotor of the preferred embodiment of the present invention of the turbine meter prior to the formation of the blade configuration;

Figure 7 is an enlarged view of the portion of Figure 6 labelled "A";

Figure 8 is a side view of the rotor shaft lock washer of the preferred embodiment of the present invention of the turbine meter;

Figure 9 is an exploded view of the alternate embodiment of the turbine meter of the present invention; and

Figure 10 is an exploded view of the preferred embodiment of the turbine meter of the present invention.

Description of the Embodiments

A turbine meter 1 is shown in Figure 1 having sealing faces 10 for appropriate mounting in line. Turbine meter 1 further includes interior opening 11 surrounded by interior wall 12 of body 13. Substantially identical diffusers 15 (Fig. 9) are mounted in opening 11 by spacers 20 which extend from diffusers 15 to an interior hub 14 sized to fit in interior wall 12 of body 13. In this manner, as shown in Fig. 9, turbine meter 1 is symmetrical and can be installed with either end facing the upstream. Locator pins 16 hold hubs 14 onto the interior wall 12. Retainer rings 17 engages grooves 18 in wall 12 to lock hubs 14 in place. Hubs 14 abut interior shoulders 21 formed in wall 12.

Referring to Figs. 2, 9 and 10, the diffusers 15 are shown in two different configurations for contrast only. The alternate configuration of diffuser 15 is designated by indicator 30 (see Fig. 9), and the diffuser of the current design which is preferred is indicated by indicator 25 (see Fig. 10). The difference between the diffuser types is in the back edge 35, 40 of the diffusers 25, 30, respectively. The back edge 35 of diffuser 25 extends inwardly much farther than the back edge 40 of diffuser 30.

As shown in Fig. 2, rotor shaft 45 is located such that its longitudinal axis is substantially identical with the longitudinal axis of the diffusers 15. The ends 50, 59 of rotor shaft 45 extend into interior openings 55 of diffusers 15. Openings 55 have a first bore 60 and a second bore 65 being substantially coaxial, with bore 60 having a larger diameter than bore 65. Bores 60, 65 form a shoulder 70 therebetween.

Rotor shaft 45 is positioned to be substantially coaxial with opening 55 by bearings 75 mounted in bore 60 and abutting shoulder 70 at one end.

Rotor shaft 45 is shaped to include shoulders 80, 89. Shoulder 80 is formed between extended shaft portion 50 and raised portion 85. Shoulder 89 is formed between extended portion 59 and raised portion 88. Rotor hub or shaft 45 also includes a central extended diameter raised portion 100, one side 105 of which faces extended portion 85, and the other side 110 of which faces extended section 88. A bearing 75 also abuts shoulder 80 on the side of face 105, and a second bearing 75 abuts shoulder 89 on the side of face 110, thereby

centering extended shafts 50, 59 of rotor shaft 45 in opening 55. Because of bearings 75, rotor shaft 45 is rotatably mounted within opening 55. Bearings 75 are preferably precision ball bearings, instead of other bearings such as jewel bearings. Precision ball bearings increase life at high speeds and because of the remainder of the features of the preferred embodiment of the present invention, may be used at low flow rates instead of jewel bearings. Jewel bearings and shaft assembly operating at high revolutions per minute do not last very long.

Rotor 120 is slidably mounted on enlarged shaft portion 88 by sliding an opening 130 formed in the center of rotor 120 to fit over extended portions 59, 88.

Before the blades are formed in rotor 120, openings or notches 140 are formed in a rotor 120 blank comprising a circular piece of metal. The notches 140 for most meters would be oval in shape but at the extreme small and large sizes may be other shapes, such as tear drop. For oval notches, the width to height ratio would be preferably 1.5 to 2.0. Typically for a two inch meter the dimensions would be .169" x .094". The notches 140 are located symmetrically about the center of rotor 120 and radially displaced from the center of rotor 120 by at least twenty-five percent of the radius of the rotor 140. The interior end 160 and the opposing exterior end 155 of notches 140 have a radius of curvature of, for example, .047 inches for a two inch meter, and the outer end 155 of each of the notches 140 includes a narrow channel 145, having a width less than or equal to the material thickness of the blades, for example, .025 inches for a two inch meter, extending to the outer circumference 150 of rotor 120.

Typically, these notches 140 extend above the interior end curved portion 160, approximately starting at .315 inches from the center (for a two inch turbine meter) of opening 130 and end at the beginning of the exterior end curved portion 155 which typically starts .484 inches from the center (for a two inch turbine meter) of opening 130. The material between openings 140 forms a shaft 170 leading to flat blade portions 180 that extend from the exterior curved surface of the exterior end 155 to the outer circumference 150 of rotor 120. With regard to the thickness of the flat blade portions 180, blade thickness is preferably in the range of .01 and .025 of the rotor diameter, such as .020 inches to .050 inches for a two inch meter. Shaft 170 permits the flexibility to twist the blade portion 180 relative to the interior of rotor 120.

The blanks for the rotor 120 are not preferably formed by a stamping die. The edges 350 of the flat blade portions 180 are important to the performance of the turbine meter rotor 120 and must be sharp. Sharp edges 350 are needed for liquid as well as gas meters. Accordingly, with a single stage stamping die, care cannot be taken as to what type of edge 350 can be provided, and whether the edges 350 may have to be machined or have additional stamping die stages to be sharp. For rotor 120 blank fabrication, milling or laser cutting will be preferably used for sharpness of leading and trailing edges 350 which effect linearity.

The openings or notches 140 effect the stiffness of the flat blade portion 180. Stiffness is important in a turbine meter to minimize clearances and thus lower weight and size and cost of

substantially all components while maintaining accuracy. The preferred notch 140 size ratio for an oval notch is, as set out above, preferably 1.5 to 2.0, for example, .169 inches by .094 inches for a two inch turbine meter. In addition, because of the extra stiffness, the number of blades may be increased. The flat blade portions 180 may retain the stiffness because of notches 140 while increasing the number of flat blade portions 180, such as above six flat blade portions, such as a range between six to and including twelve flat blade portions 180 with the optimal being twelve flat blade portions 180. The larger number of blades in combination with blade angle gives a greater resolution or frequency to the signal produced by the turbine meter.

The blade angles of flat blade portions 180 are turned in a range between 30° and 60° with respect to the longitudinal axis of the flow path, with an optimal angle of 45°. The angle determines to some extent the speed of the turning of the rotor, which as the angle increases, the speed increases. Slower turning decreases resolution. However, speed decreases bearing life, and speed must be chosen to optimize bearing life and resolution. The use of a 45° angle yields the frequency which typically for a meter of the preferred embodiment is 3000 hertz which is believed to be significantly higher than meters of the prior art. The 45° angle requires the extra stiffness in order to be functional at maximum speeds. In addition, lower angles are much less responsive at low flows, and thus cut the rangeability of the meter at low flow rates and low pressures.

Because of the stiffness, the length of the flat blade portions 180 may be increased, thereby reducing the clearance between the outer surface 150 of blade 180 and the interior surface 360 of portion 320 of interior wall 12. Such clearance in the preferred embodiment is in a range between .008 and .012 inches. The smaller this distance is; the closer the flat blade portions 180 come to the pick-up coil 400 to obtain accurate readings because at high pressures the thickness of portion 320 must be sufficient to withstand the high pressure in the interior opening 11 of the body or housing 13. Further, the weight of the flat blade portions 180 is important so that at low end flow rates, magnetic drag is not experienced as greatly. In addition, at the high end of the pressure range, flexing of the blades 180 can cause collision with the interior surface 360 or alternately may open the gap to surface 360 thereby decreasing signal strength. However, because at the low end, magnetic drag is a factor, increasing weight is not the solution to the stiffening, but the optimizing of the notch 140 is required as discussed above.

Because of the size of the notch 140, the thickness of the flat blade portions 180, the support of extension 100, a large free diameter of the flat blade portions 180 may be used, such as preferable a diameter of five times the diameter of extension 100 to surface 240. This causes significant weight saving.

Rotor 120 is attached to enlarged diameter portion 100 by small welds 200 or with special bonding agents such that one side of rotor 120 securely abuts surface 110. The other side of

rotor 120 abuts a lock washer 210 which is fastened to rotor 120 by a small weld 230 or with special bonding agents. Thus, lock washer 210 and rotor 120 are rotatably mounted about the center axis of opening 55. Preferably resistance welding would be used in manufacture instead of spot welding. The welding 200, 230 of the rotor 120 shaft assembly also improves the attachment of the rotor 120. The welding 200, 230 eliminates potential problems with other type of bonding agents, such as Loctite™, although Loctite™ may be used as a bonding agent. The problems of other type of bonding agents would include improper assembly procedures and part cleaning which are necessary for a bonding of this type to perform the appropriate tasks. The welds 200, 230 or other welding techniques, unlike other techniques, can be visually inspected to determine acceptability, whereas incorrect procedures of assembly and bonding cannot be detected until the equipment falls apart. Because the meter 1 may be used in bi-directional flow, the welding 200, 230 also becomes important because thrust forces on the rotor 120 are transmitted to the lock washer 210 in the reverse flow mode. Further, a welded rotor 120 may increase the maximum temperature limit of the meter 1. Care should be taken to insure that a flat surface of rotor 120 abuts the flat surface 110 of extension 100.

As shown in Figs. 2 and 3, the preferred diffuser 25 includes interior surface 35 which extend substantially over the entire outer circumference 240 of extension 100. Optionally, as shown in Fig. 2, a machine cut 250 into surface 35 may also be formed, but surface 35 would still cover outer circumference 240. The clearance between outer circumference 240 and the interior

surface 250 of extension 35 is very close. Thus, dust would tend not to leak into the bearing 75 area of the mounting of the rotor 120 and rotor shaft 45 with the preferred diffusers 25. In addition, these surfaces will tend to capture the rotor 120 should the bearings fail, preventing damage to the interior 11 of body or housing 13. While not shown in Fig. 2, if a diffuser 25 is used on both sides in place of diffuser 30 (shown on one side of Fig. 2), it would substantially cover the outer circumference of lock washer 210.

Accordingly, the diffuser modification will hold the rotor 120 in place longer after failure of and bearings 75, giving some indication of flow for a longer period of time and preventing the rotor 120 from damaging the bore or interior wall 12 of body 13 and, especially the thin wall 320 under the coil 400.

The housing 13 includes a pressure tap 300 centrally located for which a pressure transducer and transmitter may be attached to measure the pressure in the interior 11 close to the flat blade portions 180.

The housing or body 13 further includes an indented exterior portion 310 that houses the pick-up coil 400 graphically depicted in Fig. 1 and shown in Figs. 9 and 10 which, except as described below, is standard in the art. The pick-up coil 400 includes coils typical of the art which are wound and placed within opening 330. In the preferred embodiment of the present invention, because the blades are so close to the interior wall 360 of the housing 13, and there are so many flat blade portions 180, magnetic strength of the pick-up coil 400 should

be optimized to improve meter performance at low flow rates and avoid magnetic drag. The magnetic strength of the pick-up coil 400 is preferably between 50 and 200 gauss as a function of the number of windings and the wire size of the pick-up coil 400. The thickness 320 below the opening 330 for the pick-up coil 400 must be sufficient to contain the pressure within the interior 11 of the housing or body 13.

In use, after assembly, flow may be introduced on either diffuser 25 of meter 1 which will deflect the flow against the surface of flat blade portions 180 facing the flow. The impingement of the flat blade portions 180 cause flat blade portions 180 to rotate around the axis of rotor shaft 45. As the flat blade portions 180 rotate under the pick-up coil 400 located over surface 320, the presence of the flat blade portions 180 of the rotor 120 will be detected as pulses having a width dependant on the time that surface 150 is juxtaposed in whole or in part with pick-up coil 400. The pulses are subject to signal smoothing and shaping and amplification and other conditioning by preamplification and ultimately used for flow rate and/or flow volume measurement.

The shift on the meter curve as a function of line pressure is dependent on the ratio of the total drag on the rotor to the turning moment on the rotor. Major contributors to the drag are mechanical, frictional, viscous, and magnetic. At the same flow rate with the increasing density of the fluid, the turning moment also increases. For a meter with a mechanical drive, the main source of drag is from the drive. Therefore, a shift of the meter curve occurs at a higher line pressure. With magnetic

pick-up, the drag is significantly reduced. Hence, the shift on the meter curve occurs at a much lower line pressure than that of a turbine meter with mechanical drive. For the miniature turbine meter 1 a significant contribution of drag is from the magnetic field of the pick-up coil. The combination of magnetic pick-up coil strength, choice of bearing, blade thickness, blade angle, and blade clearance has a synergistic effect to minimize the shift of the meter curve to line pressures as low as ambient condition. The curve shift is insignificant and included within the accuracy of the meter.

The embodiments set forth herein are merely illustrative and do not limit the scope of the invention or the details therein. For example, sizing will cause adjustments in various dimensions. It will be appreciated that many other modifications and improvements to the disclosure herein may be made without departing from the scope of the invention or the inventive concepts herein disclosed. Because many varying and different embodiments may be made within the scope of the inventive concept herein taught, including equivalent structures or materials hereafter thought of, and because many modifications may be more in the embodiments herein detailed in accordance with the descriptive requirements of the law, it is to be understood that the details herein are to be interpreted as illustrative and not in a limiting sense.

What is claimed as invention is:

1. The turbine meter of claim 1, wherein the width to height ratio of said notches is 1.5 to 2.0.

2. The turbine meter of claim 1, wherein there is included bearings interposed between said rotor shaft and said diffuser upon which said rotor shaft is mounted.

3. The turbine meter of claim 5, wherein said bearings are precision ball bearings.

4. The turbine meter of claim 1, wherein said notches have width and length and shape for maximizing the number of said blades.

5. The turbine meter of claim 7, wherein the number of said blades is in a range above six.

6. The turbine meter of claim 7, wherein the number of said blades is in a range from seven to twelve.

7. The turbine meter of claim 7, wherein the number of said blades is twelve.

8. The turbine meter of claim 1, wherein the angle of turning of said blades from the plane of the surface of said blank is in a range above thirty degrees.

9. The turbine meter of claim 1, wherein the angle of turning of said blades from the plane of the surface of said blank is in a range from thirty degrees to sixty degrees.

10. The turbine meter of claim 1, wherein the angle of turning of said blades from the plane of the surface of said blank is forty-five degrees.

11. The turbine meter of claim 1, wherein the width of said channels is less than or equal to the thickness of said blades.

12. The turbine meter of claim 1, wherein the thickness of said blades is in a range of .01 to .045 of the diameter of said rotor.

13. The turbine meter of claim 1, wherein said blades are flat.

14. The turbine meter of claim 1, wherein the said blades have sharp lateral edges.

15. The turbine meter of claim 1, wherein said notches are located symmetrically about said center opening and radially displaced from said center opening by at least twenty-five percent of the radius of said blank.

19. The turbine meter of claim 1, wherein said rotor shaft further includes:

an extension;

said rotor abuts said extension; and

the diameter of said rotor is at least five times the diameter of said extension.

20. The turbine meter of claim 1, wherein the number of said blades in the range of seven to twelve blades; and

there is further included a pick-up coil mounted in said housing for detecting the revolutions of said blades of said rotor, said pick-up coil having a gauss strength of fifty to two hundred gauss.

21. The turbine meter of claim 20, wherein the number of blades is twelve.

22. The turbine meter of claim 1, wherein the number of said blades being above six blades; and

there is further included a pick-up coil mounted in said housing for detecting the revolutions of said blades of said rotor, said pick-up coil having a gauss strength of fifty to two hundred gauss.

23. The turbine meter of claim 22, wherein the number of blades is twelve.

24. The turbine meter of claim 1, wherein the clearance between said blades and said interior surface of said housing is in a range of .008 and .012 inches.

25. The turbine meter of claim 1, wherein there is included a pick-up coil responsive to the rotation of said blades, said pick-up coil having a gauss strength of fifty to two hundred gauss.

26. The turbine meter of claim 1, wherein there is further included:

a set of bearings;

said rotor shaft rotatably mounted by said bearings on said diffuser in said interior passage;

a pick-up coil mounted in said housing for detecting the revolutions of said blades of said rotor;

said pick-up coil having a strength and said blades having a thickness, angle and clearance and said bearings having sufficiently low resistance such that the turbine meter has no shift in meter curve above ambient pressure.

27. The turbine meter of claim 1, wherein:

said housing includes a second, opposing entrance and there is included a second diffuser mounted in said interior passage facing said second entrance, said rotor shaft rotatably mounted on said second diffuser in said interior passage;

said rotor shaft has an enlarged portion;

said rotor has two sides, said rotor abutting said large portion on one of said sides of said rotor; and there is further included -

a lock washer mounted on said shaft and abutting the other of said sides of said rotor; and

said rotor welded to said enlarged portion and said lock washer;

whereby the turbine meter is bidirectional.

28. The turbine meter of claim 1, wherein:

said rotor shaft having a raised portion; and

said diffuser having a back edge extending over said raised portion with a narrow gap therebetween.

29. The turbine meter of claim 28, wherein said housing includes:

a second, opposing entrance and there is included a second diffuser mounted in said interior passage facing said second entrance, said rotor shaft having a second raised portion and said rotor shaft rotatably mounted on said second diffuser in said interior passage; and

said second diffuser having a back edge extending over said second raised portion with a second narrow gap.

30. The turbine meter of claim 1, wherein there is further included a second diffuser mounted in said interior passage, each of said diffusers facing outwardly from said passage;

said rotor shaft rotatably mounted on said diffusers, said rotor shaft having an enlarged portion;

said rotor having two sides, said rotor mounted on said shaft and abutting said englarged portion on one of said sides of said rotor;

a lock washer mounted on said shaft and abutting the other of said sides of said rotor; and

said rotor welded to said enlarged portion and said lock washer;

whereby the turbine meter is bidirectional.

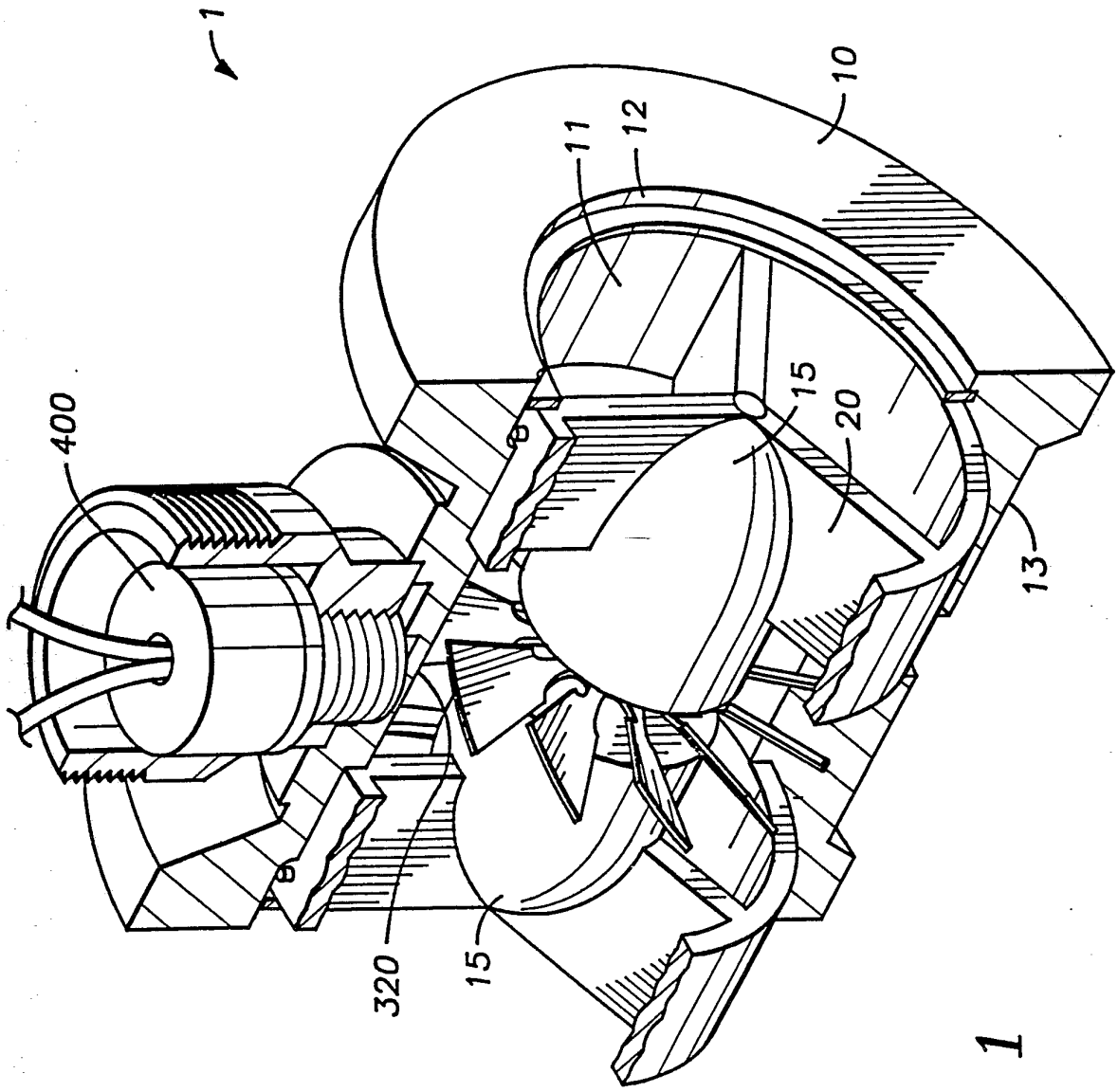


FIG. 1

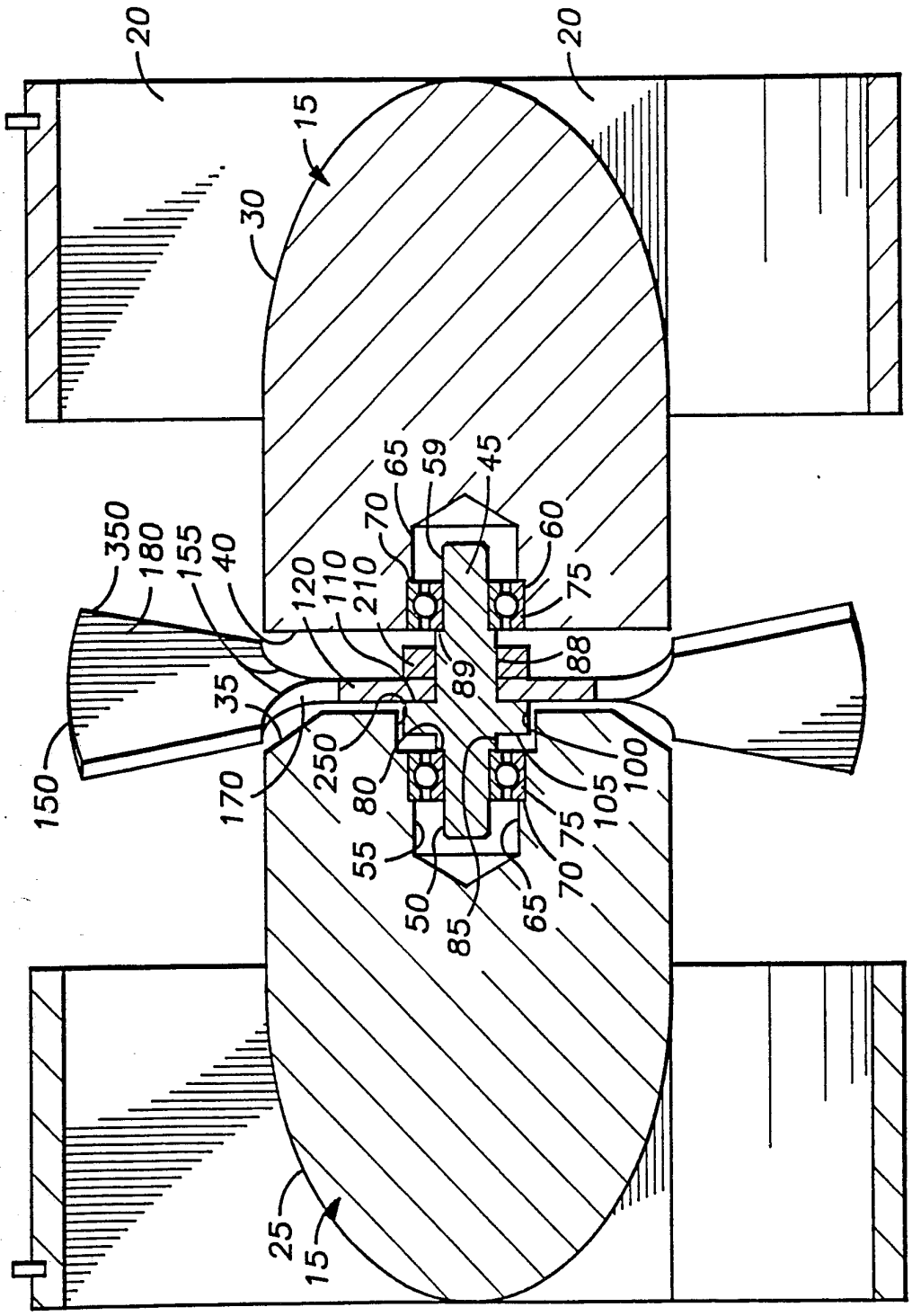

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FIG. 2

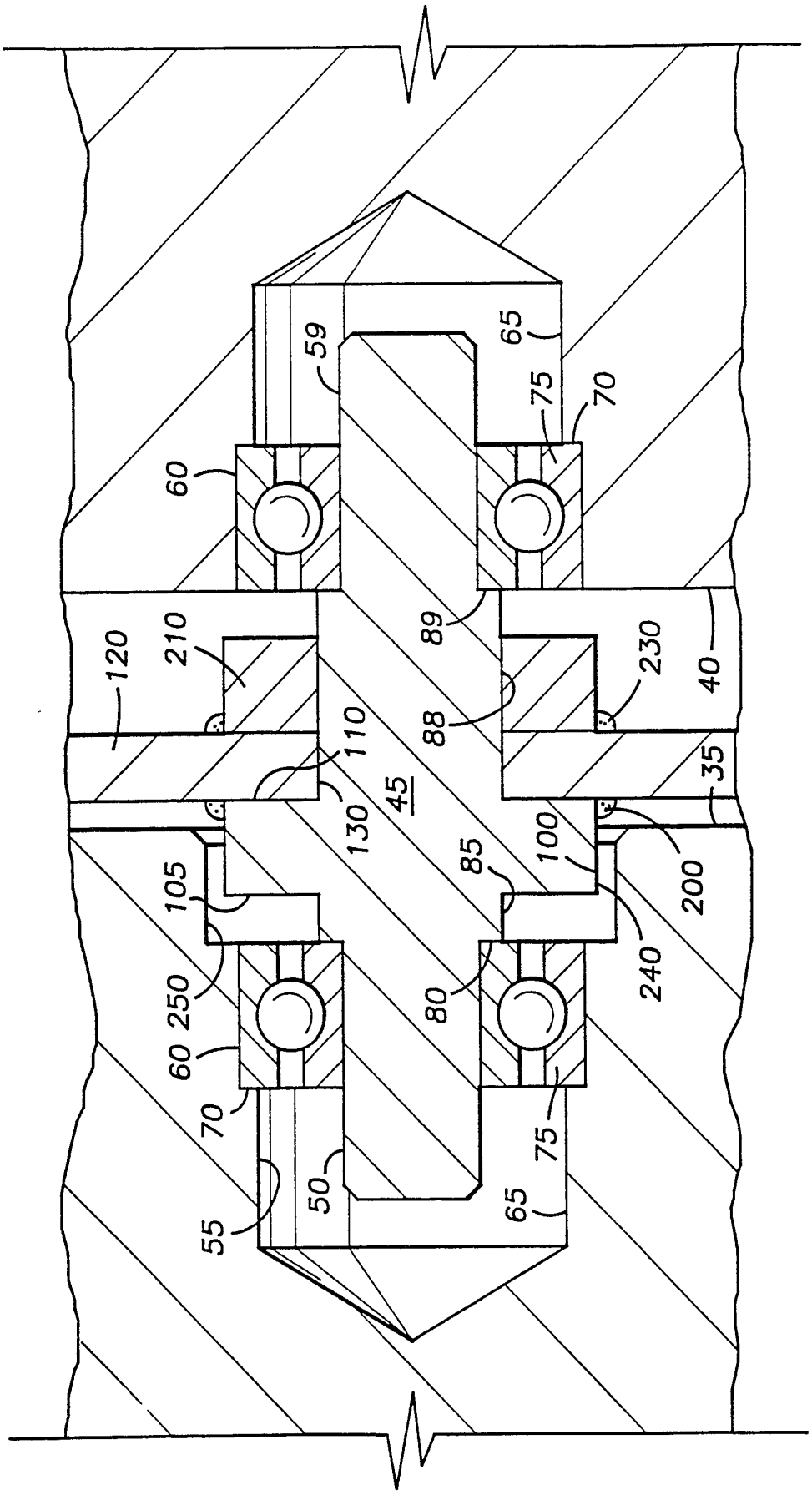

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FIG. 3

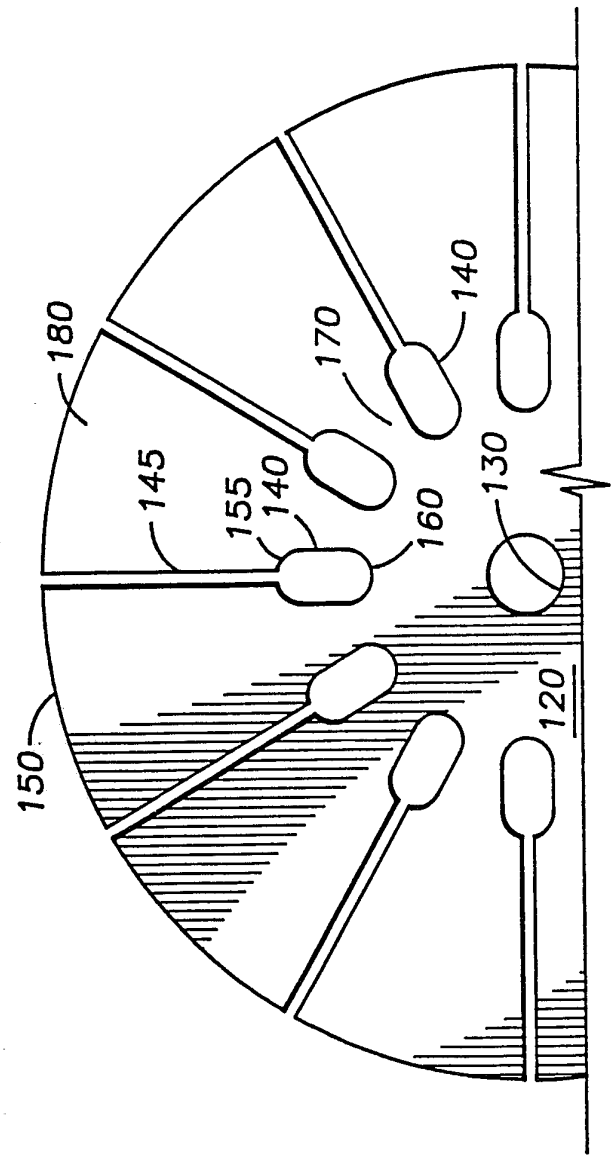


FIG. 7

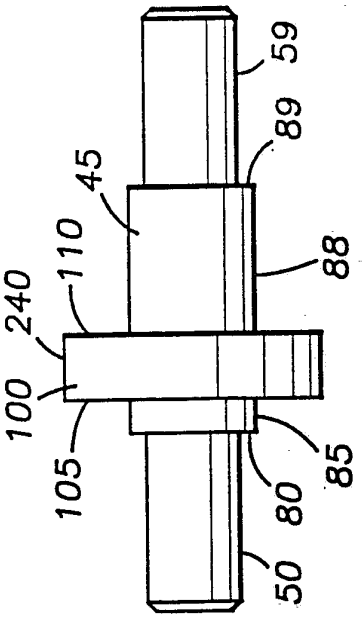


FIG. 4

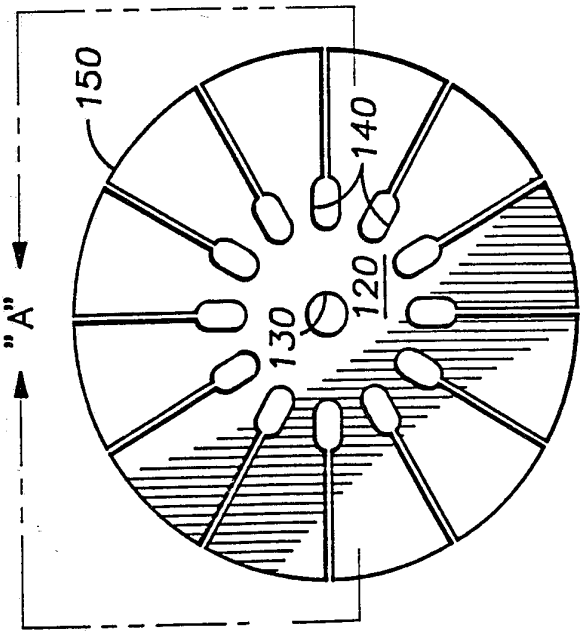


FIG. 6

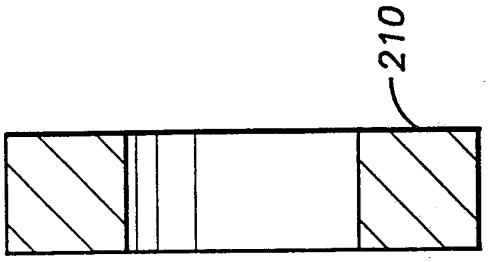


FIG. 8

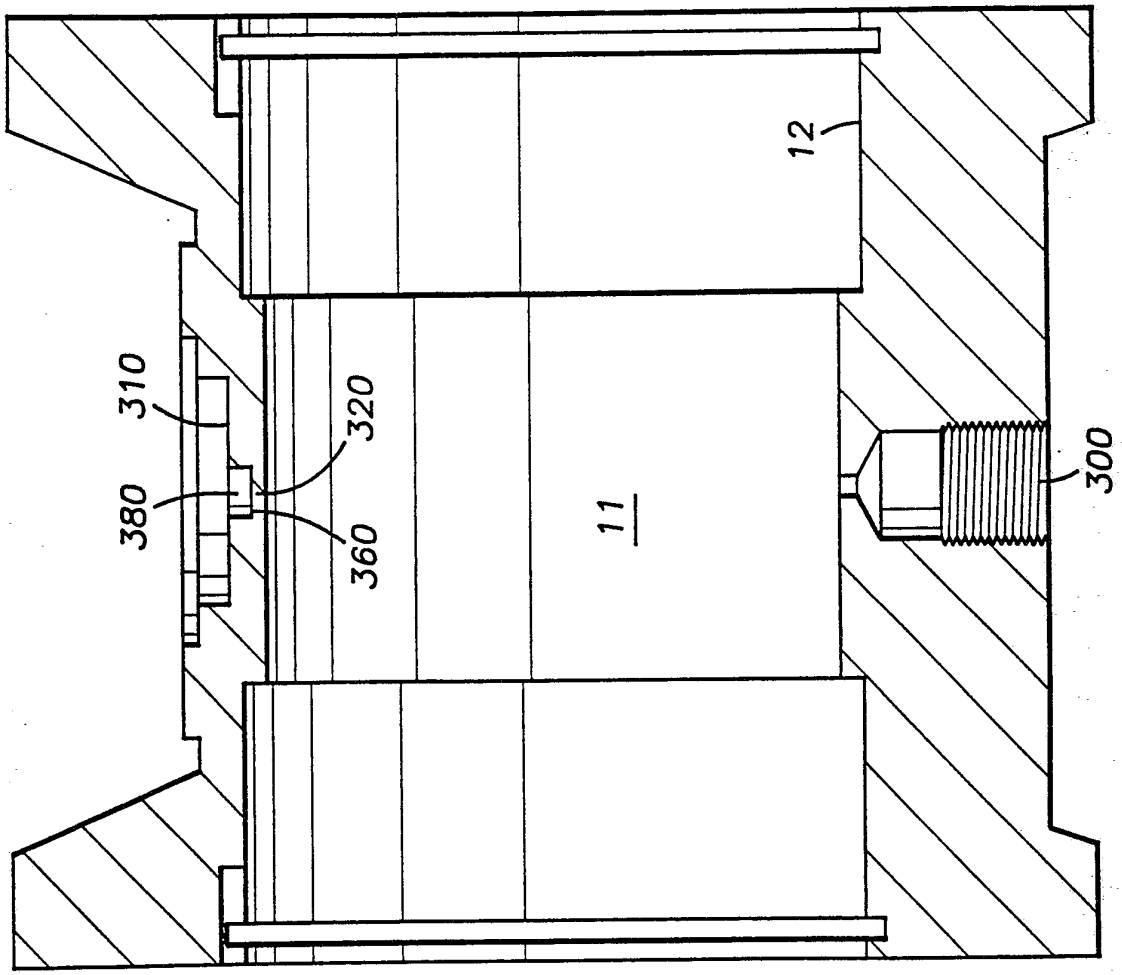


FIG. 5

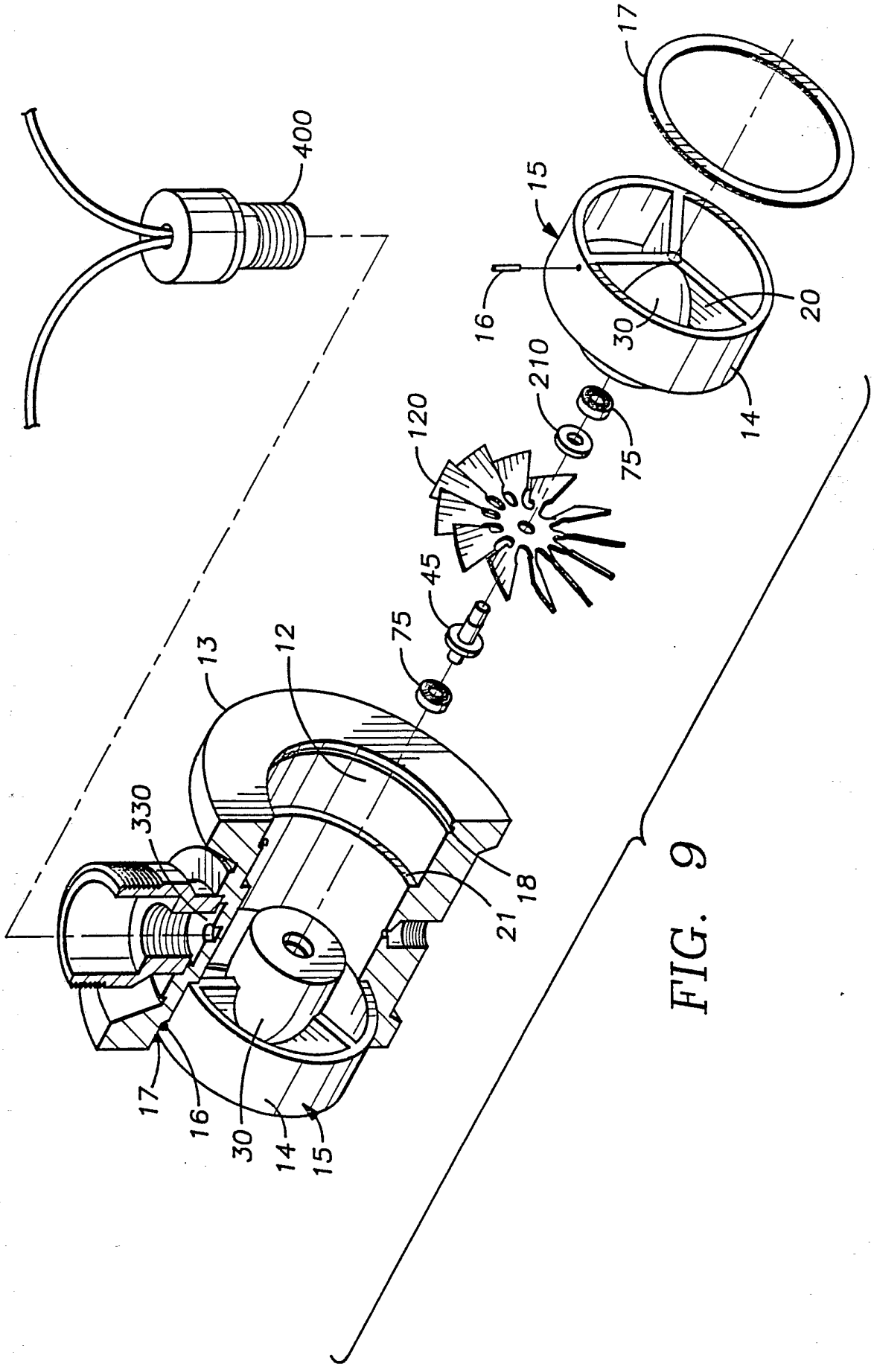


FIG. 9

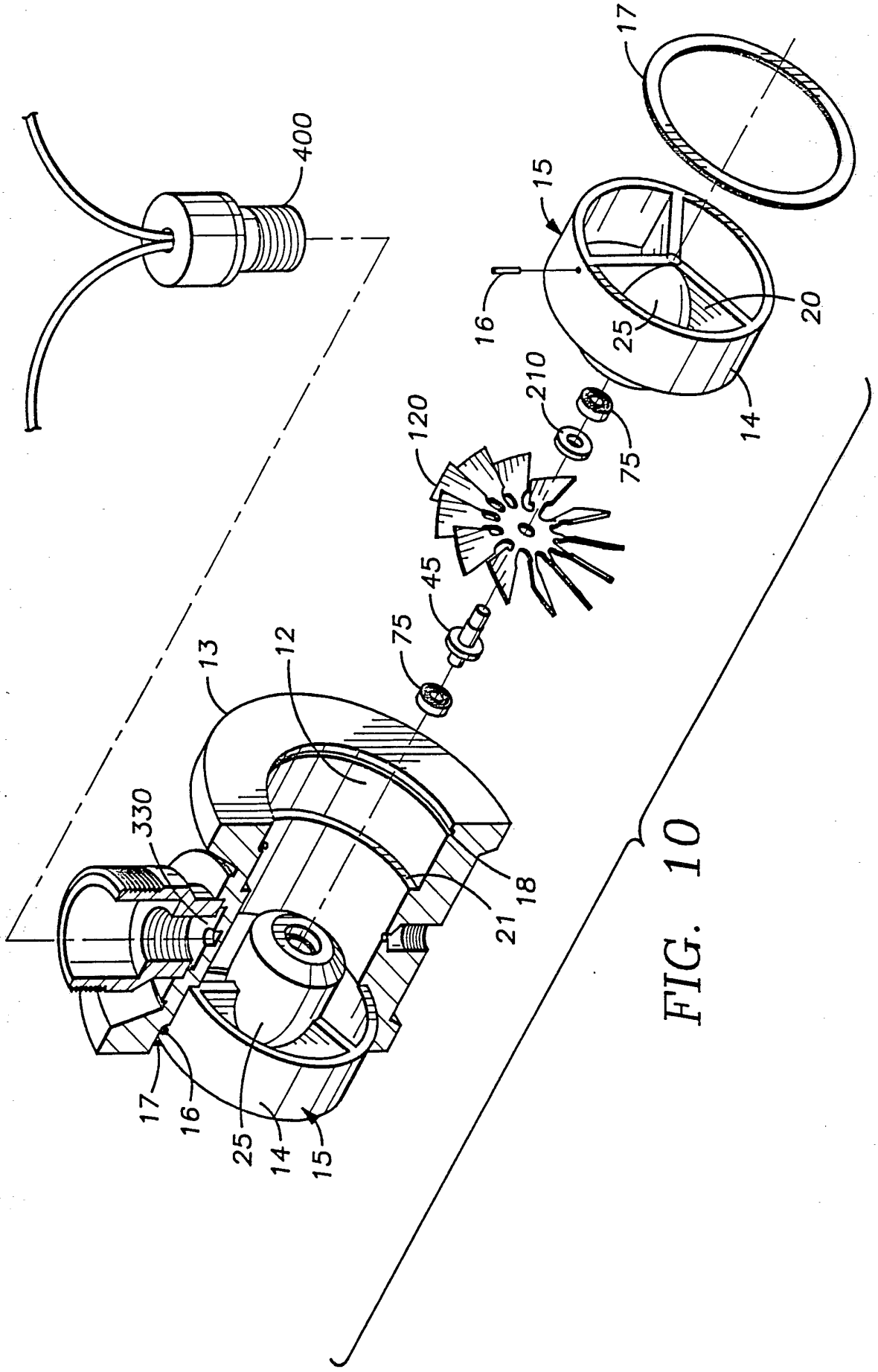


FIG. 10

INTERNATIONAL SEARCH REPORT

PCT/US93/01690

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :G01F 1/12
US CL :73/861.92

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 73/861.78, 861.83, 861.89, 861.91, 861.93, 861.94; 416/204R, 223R, DIG. 3; 73/861.92

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 2,649,243 (Stalker) 18 August 1953	
A	US, A, 3,301,053 (Walch, Jr. et al.) 31 January 1967	
A	US, A, 3,979,957 (Rutgerson et a.) 14 September 1976	
A	US, A, 3,999,432 (Corinx et al) 28 December 1976	
A	US, A, 4,649,756 (Feller) 17 March 1987	
A	EP, A, 0,094,352 (Banbutio) 16 November 1983	
A	JP, A, 5,412,766 (Muramatsu) 30 January 1979	

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be part of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
07 APRIL 1993	30 JUN 1993
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. NOT APPLICABLE	Authorized officer TIMOTHY J. MAY Telephone No. (703) 305-4938

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/01690

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CA, A, 0,757,815 (Gouy) 02 May 1967	1-15, 19-30

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/01690

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 1-15, 19-30
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

PCT Article 17(z)(a)(ii) - there is no independent claim to properly define the scope of the dependent claims. Art cited is based on description.

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.