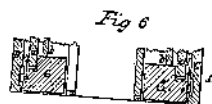
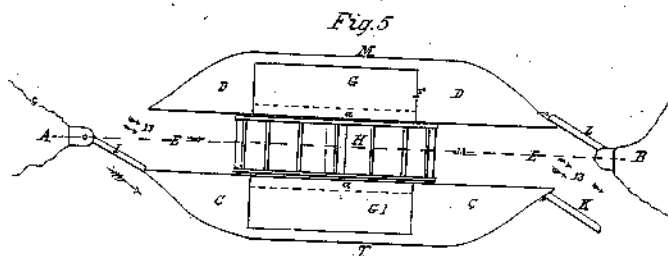
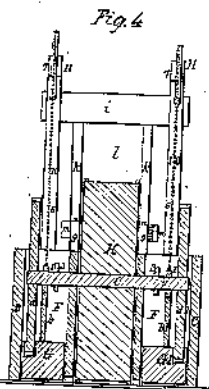
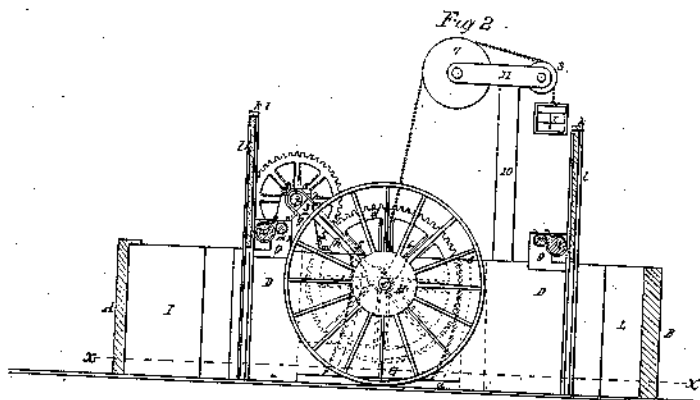
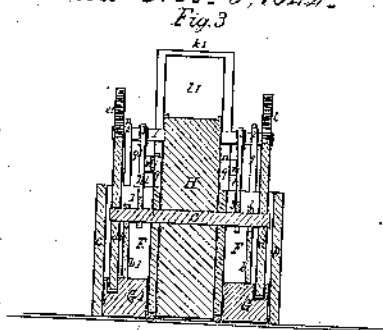
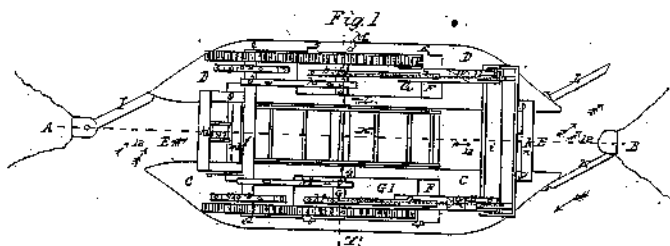


*J. G. Ross,  
Water Wheel,*

*N<sup>o</sup> 3,816.*

*Patented Nov. 9, 1841.*



*Edward Lindell  
W. Bennett*

*John Grant Ross*

# UNITED STATES PATENT OFFICE.

JOHN G. ROSS, OF NEW YORK, N. Y.

## TIDE-WHEEL.

Specification of Letters Patent No. 3,816, dated November 9, 1844.

*To all whom it may concern:*

Be it known that I, JOHN GERARD ROSS, of the city, county, and State of New York, model-maker and machinist, have invented and made certain new and useful improvements in the mechanical arrangement, application, and combination of the parts employed in what is technically known as the "tide-mill," the intent and effect of such improvements being that such mills shall be able to work with less loss of time and be more equally and continuously effective than by any arrangement now in use to my knowledge by arranging the wheel-race and tide-gate, so that the current into and out of the mill-pond shall always run one way in the race, whether the tide be rising or falling, and the wheel or wheels are made to rise and fall with the water so that no interruption of the power occurs except for a short time at the high and low water of each tide; these improvements I designate collectively as "Ross's plematan" or "constant tide-mill," and for the same I seek Letters Patent of the United States; and further know ye that the said improvements and the mode of constructing, arranging, applying, and combining the same are fully and substantially set forth and shown in the following description and in the drawings annexed to and making a part of this specification, wherein—

Figure 1, is a plan of all the parts in place for use; Fig. 2; is a sectional elevation, lengthwise in the line A, B, Fig. 1; Fig. 3, is a cross sectional elevation of the parts, at the end A, of Figs. 1, and 2, seen, as if cut through the wheel; Fig. 4, is a cross sectional elevation of the parts at the end B, of Figs. 1, and 2, seen likewise, as if cut through the wheel; Fig. 5, is a plan of the wheel race, water or tide gate, and parts near the foundation of the dam walls, and wheel race, and below the line  $x, x$ , Fig. 2, and the same letters numbers and other marks of reference, apply to the like parts, in all the several figures.

C, is the outer dam wall, next the tide, on open space of tide water T; D, is the inner dam wall, next the mill pond or inclosed space M; these walls C, and D, together form the wheel race E, and as will be seen hereafter, may be made of any length, to inclose a space as a mill pond, and may work any number of wheels, that the length will conveniently receive: In each of these walls,

on each side the wheel race, abreast of or at the side of each wheel, the walls are to be built so as to form a pit, or opening F, from the surface, down to the foundation, but constructed with openings in the base, next the race at  $a$ , see the Figs. 2, 3, and 4, to admit the rise and fall of the tide, in the pits F, for the purpose of floating the caissons G, G', at the level of the tide water, these may be made of wood, or metal, or both, of a proper size to float, and thereby maintain a uniform height, above the water in the centers of the standards or frames  $b, b'$ , these are secured in any convenient way on the caissons G, G', and are fitted with journal boxes 1, 1, at a proper or proportional height, to receive the shaft  $c$ , of the main tide wheel H, and a curved opening at 4, shown by dotted lines in Fig. 2, as cut into the inner pit walls, allows the shaft  $c$ , to rise and fall with the tide, in the proper line of motion: On each outer end of the shaft  $c$ , is a spur wheel  $d$ , or  $d'$ , these respectively gear into driving wheels  $e, e'$ , on the ends of a shaft  $f$ , see Figs. 1, 2, and 3, which is mounted on journal boxes 2, 2, on standards  $g, g'$ , securely fitted on the solid walls of the dam; Two radius bars  $h, h'$ , are connected by boxes, straps, gibs, and keys 3, 3, to the shafts  $c$ , and  $f$ , and maintain the proper relative positions between the centers of the shafts  $c$ , and  $f$ , and wheels H,  $d$ , and  $e$ , these bars  $h, h'$ , may be best made, with right and left handed screws in the ends, taking into similar nuts, in the stocks to which the boxes and straps are fitted, but any other convenient means may be used, that will maintain the proper adjustments of the gearing and working parts. To secure the proper position of the caissons G, G', at each period of the tide, two circular grooves 5, 5, shown in Fig. 1, in place, and by dotted lines in Fig. 2, as made in the outer side of the pit wall are fitted to receive studs  $o$ , or blocks, carrying rollers on the corresponding parts of the caissons, see the detached Fig. 6, where these are shown, sectionally, in place in the pit and wall, the grooves 5, must be segments of circles, whose common center may be found by the intersection of two rectangular lines, from the bisection of straight lines, to, and from, the upper and lower halves of the line of motion, in the caisson. Two standard posts 10, Figs. 1, 2, and 4, carry a head block 11, in which two large pulleys 7, and

two small pulleys 8, receive chains 6, 6, secured one end by an eye to the standards *b*, *b'*, and passing over the pulleys 7, and 8 terminate, each, in an eye on a box *i*, containing a mass of heavy matter, sufficient to counterpoise the caissons and wheel, and their equipments, in such a way, that the rise and fall of the tide shall have a regular and equal effect on the main wheel H; the frames *k*, *k'*, at either end of the race, form slides for flood gates *l*, *l'*, to shut out the water, for adjustment, or repairs, and these gates are connected by chains *v*, see Figs. 1 and 2, going over roller sheaves *n*, *n'*, to winches *m*, *m'*, fitted with proper ratchets and pawls, and mounted in standards *g*, on the race walls C, and D.

The method of giving a current in the same direction on both the flood and ebb tide is now to be described. The single tide gate I, Fig. 1, is shown, in this figure, as hung to a competent support in the bank or wall at A, Fig. 1, and closed against the inner dam wall D, admitting the current of the rising, or flood tide, from the tide side T, of the dam wall C, to run through the race E, and carry the wheel H, in the direction shown by the arrows 12; the outer current gate K, is shown, shut, from the outer dam wall C, to a shutting jamb fitted to receive it in the bank or wall at B, Fig. 1, where it is kept, by the pressure, caused by the external, or tide water, at T, being higher than that in the mill pond at M, the inner current gate L, being open, to pass the water from the race to the pond M, so that the current, running through the race E, carries the wheel H, as shown by the arrows 12, Fig. 1, and fills the pond M, supplying a water power to run out, when the external tide falls; in Fig. 5, the single tide gate I, is shown shut, against the outer dam wall and forcing the water from the pond side M, of the dam wall D, to pass out, as the tide falls, in the direction of the arrows 13, the inner current gate L is shown as closed, to prevent the water in the pond, passing by that end of the inner dam, and will remain shut, by the internal water, so long as that in the pond M, is higher, than the external, or falling tide water, at T, and the outer current gate K, is shown as open, to pass the water from the race, to the river, or ocean, on the side T, of the dam wall C.

In fitting the caissons, I do not mean to confine, or limit myself to the mode shown, of balancing them and the wheel and equipments by chains and weights, but I intend to use any other convenient mechanical means, for such purposes, that may be substantially the same, in practice and effect, and if when new and dry, the caissons have more power of flotation than is required, a small cock may be fitted, to admit so much water, as is needful to load the caissons to the required

depth; and when, by any cause, the caissons have too much water in them, or become leaky, a small pump may be fitted into either of them, and be attached, in any convenient way, to the main shaft, and worked so as to keep any such leakage pumped out; and as before premised I do not intend to confine, or limit myself, to the construction of dams, whose length shall be only competent to receive one wheel, with its equipments, but I intend to make the double dam walls, and mill race as long, as the localities of situation will allow, and work any number of wheels, that the dam walls will receive, placing the tide gate at one end, and the current gates at the other end of the dams, whatever their length may be. It will be seen, that with any number of wheels, thus fitted, no interruption will take place in the work, except at the dead low water, or high water of each tide, for the instant the water, on either side the dam, is higher than on the opposite side the tide gate I, will go over to, and close on, the lowest side, and the like effect will take place with the current gate, on that side, the other current gate opening, to pass the water, so that the operations of the tide, alone, will change the gates, and set the wheel, or wheels, in work; and it will be seen, that in cases, where the wheel race shall be over about twelve feet wide, it may be proper to make the tide and current gates in two parts, which may be done, in any convenient and effective manner, and the proportions, between the width and height of the gates, must be regulated by the proportion existing, between the width of race chosen, and the rise and fall of the tide, in the given locality. It may be proper, to protect the tide and current gates from wrecks, or drift wood, on the tide side of the dam, but many well known modes can be chosen for doing this, that it is not needful to describe herein.

I am aware, that tide mills have been proposed, or made, with four gates, to run the water alike, on flood and ebb, and requiring manual attendance, to open and shut them, at the turn of the tide; but no tide mills have, to my knowledge, been proposed, or made, with three self acting gates, and longitudinal dam walls, forming the race, in combination with means to float the wheel, or wheels, and maintain an equality of power, during the flood and ebb; and although the means described, or parts of these described, for regulating the wheel, may have been used before, they have not been used, collectively, in tide races, in the manner proposed herein, therefore I limit my claim as follows:

I claim as new, and of my own invention, and desire to secure by Letters Patent—

1. The mode described of fitting the tide gate I, at one end of a race way, formed by

an inner and outer dam wall, in combination with an outer current gate K, and an inner current gate L, at the opposite end of the race way, the whole constructed, and  
5 operating, substantially as herein described.

2. I claim the mode of forming the dam walls with pits, open at the bottom, to receive, and float, the caissons that carry the water wheel, and the combination therewith,  
10 of the described means for regulating, adjusting, and directing the ascent and descent of the wheel, or wheels, substantially as the same are described and shown herein.

3. I claim the combination of the described mode of fitting the gates, and wheel, or  
15 wheels, and making them act together, in the manner described herein.

In witness whereof, I have hereunto set my hand, in the city of New York, this  
20 twentieth day of June, in the year one thousand eight hundred and forty-four.

JOHN GERARD ROSS. [L.S.]

Witnesses:

W. SERRELL,

EDWARD W. SERRELL.

W. H. Hubbard,

Water Wheel.

No. 102939.

Patented May 10, 1870.

fig. 1

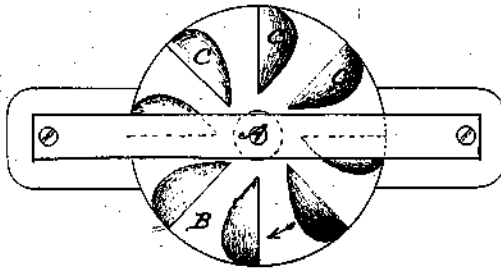


fig. 2

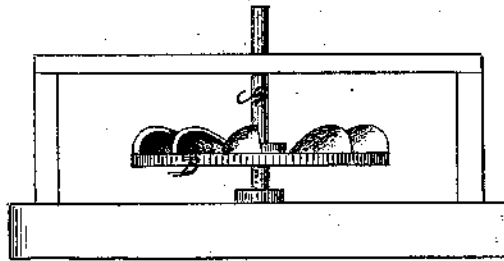


fig. 3.

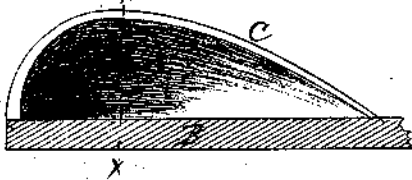
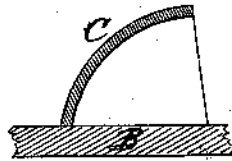


fig. 4



Witnesses  
J. H. Shannon  
A. J. Tubbits

William H. Hubbard  
Inventor  
By his Attorney  
Wm. E. Earle

# United States Patent Office.

WILLIAM H. HUBBARD, OF NEW HAVEN, CONNECTICUT.

Letters Patent No. 102,939, dated May 10, 1870.

## IMPROVEMENT IN WATER-WHEELS.

The Schedule referred to in these Letters Patent and making part of the same.

To all whom it may concern:

Be it known that I, WILLIAM H. HUBBARD, of New Haven, in the county of New Haven and State of Connecticut, have invented a new Improvement in Water-Wheels; and I do hereby declare the following, when taken in connection with the accompanying drawings and the letters of reference marked thereon, to be a full, clear, and exact description of the same, and which said drawings constitute part of this specification, and represent in—

Figure 1, a top view;

Figure 2, a side view; and in

Figures 3 and 4, detached views enlarged.

This invention relates to an improvement in that class of water-wheels commonly used as tub-wheels, or such as have a vertical axis, the object of the invention being to construct a cheap and durable wheel; and

The invention consists in the arrangement of a circular plate or disk upon a vertical axis, and having arranged upon the surface of the said disk parabolic-shaped buckets.

A is the shaft, upon which I arrange a plate or disk,

B, which I form from boiler plate, or other suitable sheet metal.

Then onto the surface of this disk I fix buckets C, equidistant from each other, and radiating from the center, the shape of the bucket being parabolic, a front view of which is shown in fig. 3, and a section of the same on line *z z* in fig. 4.

The water is directed into the bucket about as denoted by the arrow in fig. 1.

The buckets I prefer to form from sheet metal, struck up and riveted to the disk, yet the whole may be cast in one piece.

The wheel is set in the pit in like manner as the ordinary tub-wheel, and this wheel, being very cheap, makes a desirable wheel for grist-mills and other like purposes where small power is required.

I claim as my invention—

The disk B, fixed upon the shaft A, and provided with radial buckets C, of the form and arrangement substantially as described.

Witnesses:

WM H. HUBBARD.

A. J. TIBBITS,

J. H. SHUMWAY.

C. HUXFORD.

APPARATUS FOR PUMPING SHIPS, &c.

No. 173,544.

Patented Feb. 15, 1876.

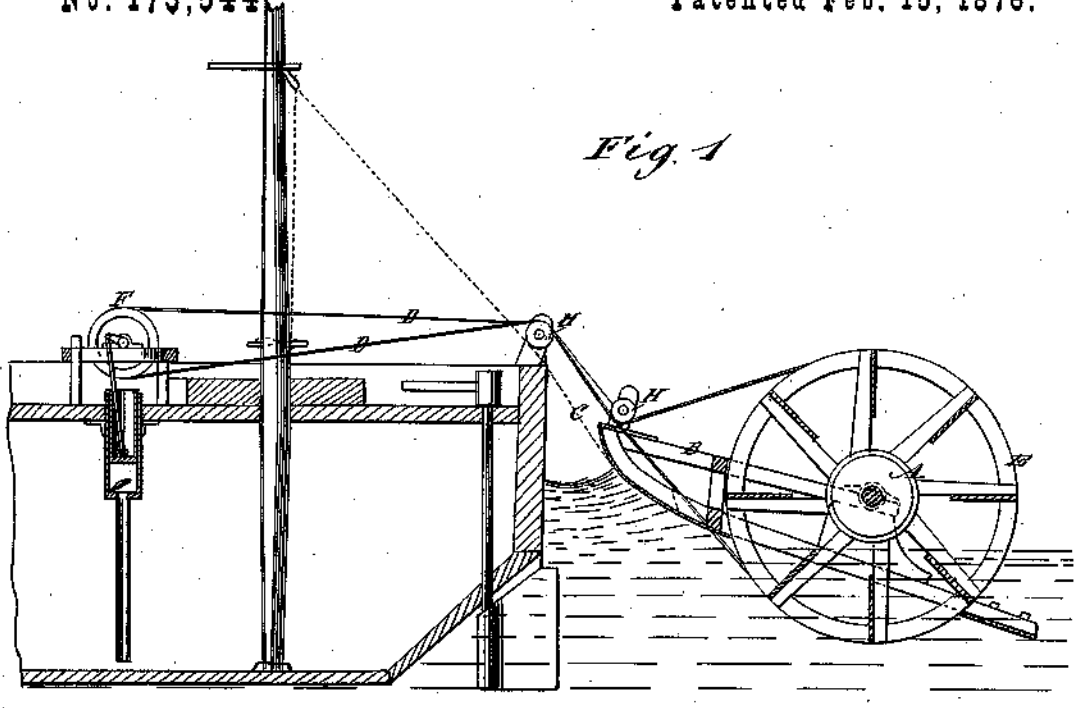


Fig. 1

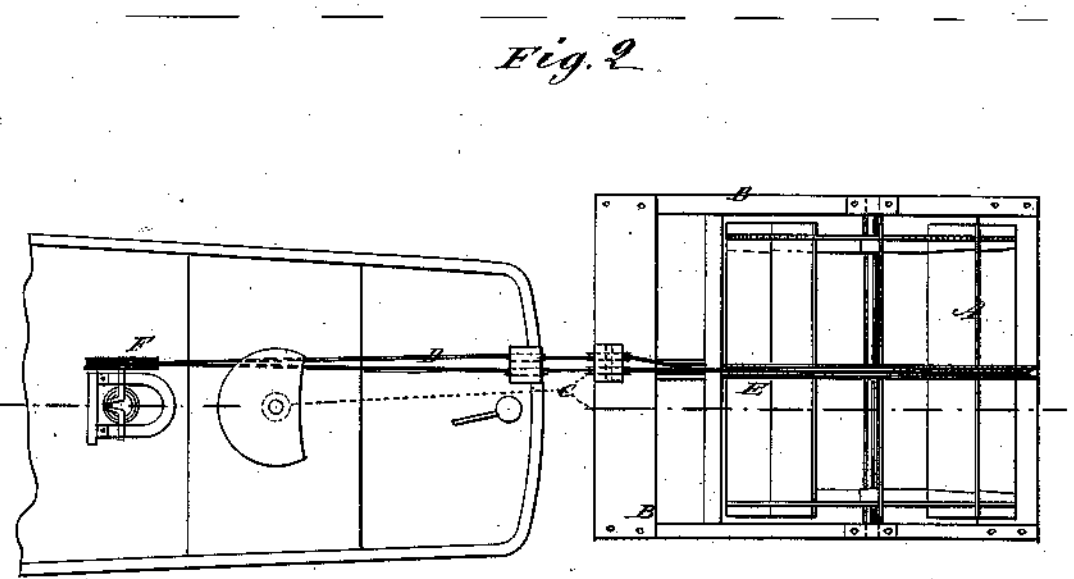


Fig. 2

WITNESSES:

*C. Veroux*  
*Alex. H. Roberts*

INVENTOR:

*C. Huxford*  
BY *Wm. H. [Signature]*  
ATTORNEYS.

# UNITED STATES PATENT OFFICE.

CHARLES HUXFORD, OF EDGARTOWN, MASSACHUSETTS.

## IMPROVEMENT IN APPARATUS FOR PUMPING SHIPS, &c.

Specification forming part of Letters Patent No. 173,544, dated February 15, 1876; application filed December 4, 1875.

*To all whom it may concern:*

Be it known that I, CHARLES HUXFORD, of Edgartown, Martha's Vineyard, in the county of Dukes and State of Massachusetts, have invented a new and Improved Power for Ships' Pumps, of which the following is a specification:

My invention consists of a kind of paddle-wheel mounted on a float and dragging astern of the ship, so as to be revolved by the water, and having an endless rope fitted around it, and around a pulley on the ship, in such manner that the rope is made to work the pump, and thus save the working of it by hand in ships not having steam-power.

Figure 1 is a longitudinal sectional elevation of a portion of a ship and the said power apparatus, and Fig. 2 is a plan view.

Similar letters of reference indicate corresponding parts.

A represents the paddle-wheel, and B a float, on which it is to be carried on the surface of the water suitably for being revolved as the float is towed along by the ship, say by a cable, C. D represents the endless rope

working over the wheel at the middle, where it has a groove, E, therefor; and F, the pulley on the ship, to be turned by the rope for working the pump. H represents guide-pulleys for conducting the rope from the wheel to the pulley.

The apparatus can be lifted on deck and dropped overboard readily, as wanted, by the ship's tackle. It may also be employed for working other machinery on the ship, if preferred.

I am aware that it is not broadly new to operate a ship's pump by a wheel located on a float; but

What I claim is—

The combination, with wheel A, supported on a float, B, and towed by the ship's cable C, of an endless rope, D, working in a groove, E, of wheel, over a float-pulley, H, and over a ship's pulley, F, all arranged as and for the purpose specified.

CHAS. HUXFORD.

Witnesses:

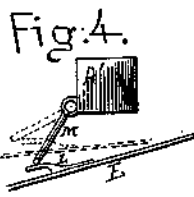
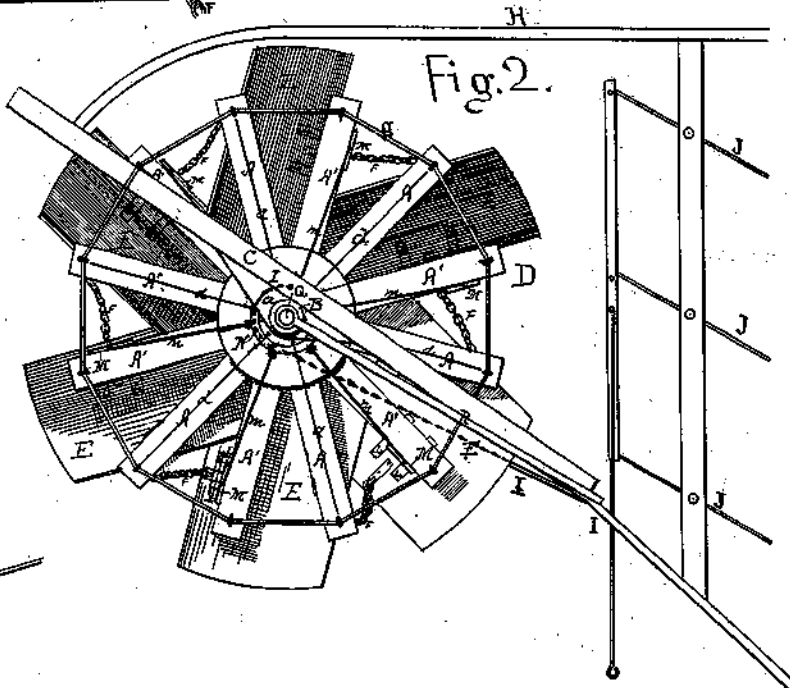
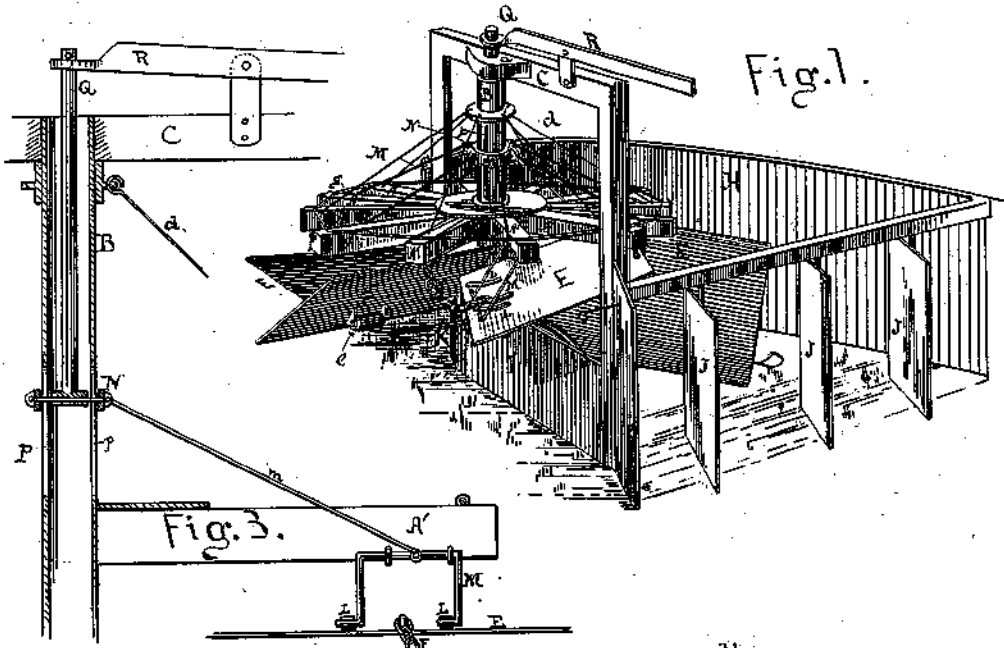
T. B. MOSHER,  
ALEX. F. ROBERTS.



W. W. CLEVELAND.  
Current Water-Wheel.

No. 210,184.

Patented Nov. 26, 1878.



Attest.  
*Aug<sup>d</sup> Jordan*  
*W.P. Lowl*

Inventor.  
*Wallace W. Cleveland*  
*Boyer's Atty*  
*Boyer*

# UNITED STATES PATENT OFFICE.

WALLACE W. CLEVELAND, OF MARSHALL, MICHIGAN.

## IMPROVEMENT IN CURRENT WATER-WHEELS.

Specification forming part of Letters Patent No. **210,184**, dated November 26, 1878; application filed May 2, 1878.

*To all whom it may concern:*

Be it known that I, WALLACE W. CLEVELAND, of Marshall, in Calhoun county, in the State of Michigan, have invented new and useful Improvements on Current Water-Wheels, of which the following is a full and complete description, having reference to the accompanying drawings, wherein—

Figure 1 is a perspective view of my wheel. Fig. 2 is a plan of the same. Fig. 3 is a vertical section. Fig. 4 is an end elevation, showing the action of the latches.

This invention relates to improvements on the wheel for which Letters Patent were issued to me August 3, 1875; and consists, first, in devices for automatically catching up and holding the buckets or floats out of the water when it is desired to stop the wheel; second, in the devices for operating said catches through the wheel-shaft; third, in the extended bulk-head, whereby water is confined and directed upon the skirt of the wheel.

That others may fully understand the invention, I will particularly describe it.

The wheel is constructed with radial arms A A' and a hollow central shaft, B, which stands vertically, and is provided with a suitable step at the bottom and a bearing, *a*, in a supporting-frame, C, which spans the frame D, through which the water is directed.

The floats or buckets E are flat plates, of oblong form and parallel sides, and suitably hinged at one edge to the arms A. Their free edges are attached to said arms, other than those bearing the hinges, so that said floats drop down and hang from the hinged edge in a position nearly vertical, or are raised up to a position substantially horizontal.

The chains F are not employed for the purpose of so raising the floats in the structure of the wheel shown, though they may easily be arranged to do so.

The water is directed upon one side of the wheel by the bulk-head H on one side and a similar bulk-head, I, on the other side, constituting the flume D, and may be cut off entirely by swinging gates J.

The shaft B stands close to the bulk-head I, so that at any one moment only one-half the whole number of floats E are within the flume

and being acted upon by the current. As the wheel revolves, the buckets E which are outside the flume are raised up to pass over the bulk-head I by the track-rod K, and to relieve friction upon said track a friction-roller, *e*, is placed under the free edge of each of said floats.

The radial arms A are supported by truss-rods *d*, and their ends are tied together by the tie-rod *g*.

When it is desired to stop the wheel the buckets or floats may be raised up to a horizontal position. This is the only method when, during freshets, the wheel may be wholly submerged and the gates J unable to shut out the water. At such times the wheel will operate as well as at other times, but cannot be controlled by the gates as at ordinary stage of water. To put the wheel under control by raising the floats and holding them in a horizontal position, I put upon each float one or more straps, L, which are rigidly secured at one end and are free at the other, and curved, as shown, so as to be permanently raised up from the surface of the float at the free end. Upon the arms A', which are intermediate between the arms to which the floats are hinged, I place a number of hooked latch-bolts, M, corresponding to the number of straps L. These hooked bolts are capable of being moved laterally so as to bring their hooked end under and in engagement with the straps L, so that the floats will be thereby supported. The hook-bolts M are also capable of swinging sidewise, so that, having been moved into engaging position over the said straps L, they will be pushed and caused to swing sidewise as the float rises in passing over the bulk-head I, and will drop over the ends of and fall beneath said straps, so as to hold the float up as it moves over the flume.

To effect this movement of the hooked latch-bolts M, I connect each with a sliding collar, N, upon the shaft B by means of rods *m*. The collar N has a cross-bolt, which passes through slots *p* in opposite sides of the shaft B, and is connected at the center with a rod, Q, which passes upward through the upper end of said shaft, and is connected with a lever, R, or other efficient means of controlling it. By raising

or lowering the collar N the several latches M are moved in one direction or the other, as desired, to engage or liberate the floats.

The bulk-head I extends past the shaft B, and then curves around, so as to partly inclose the same and closely approach the inner ends of the floats as they move. The outer end of the bulk-head I thus forms a passage-way between itself and the corresponding end of the bulk-head H, to divert all the water passing upon the floats, and, at low stages, to correspondingly reduce waste of water.

Having described my invention, what I claim as new is—

1. The sliding catch-bolts M, operated by a sliding collar, N, on the wheel-shaft B, and suitable connecting-rods *m*, whereby each bucket may be caught by catch or loop on the front of bucket E, and held up automatically, and the wheel caused to stop without shutting off the water.

2. A hollow wheel-shaft, B, combined with a sliding collar, N, connecting with each catch-bolt M, and operated by rod Q, connected with said collar N at lower end, and extending thence upward through the interior of said shaft to a suitable lever, whereby said collar and the catch-bolts M, to which it is connected, may be operated through the center of the wheel-shaft B.

3. Combined with the bulk-head H and a current water-wheel, substantially as described, a bulk-head, I, extended past the main shaft B, substantially as set forth, to confine and direct the water upon the skirt of the wheel and prevent waste of water.

WALLACE W. CLEVELAND.

Witnesses:

DAVID N. GREEN,  
JAMES R. DICKEY.

(No Model.)

2 Sheets—Sheet 1.

H. BROWN.  
WATER MOTOR.

No. 408,075.

Patented July 30, 1889.

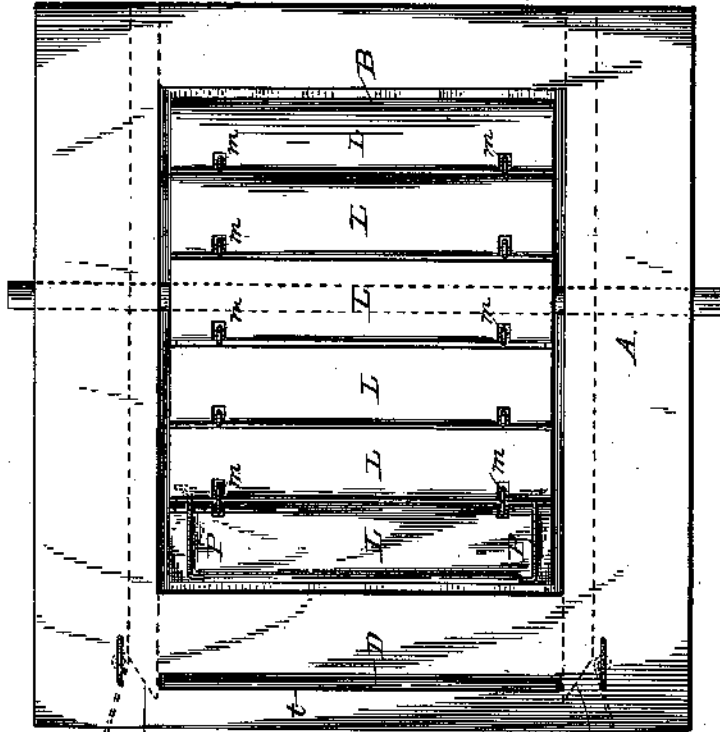


Fig. 1.

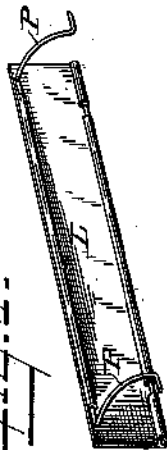


Fig. 2.

WITNESSES

*Josh Blackwood*  
*Albert O. Blackwood*

INVENTOR

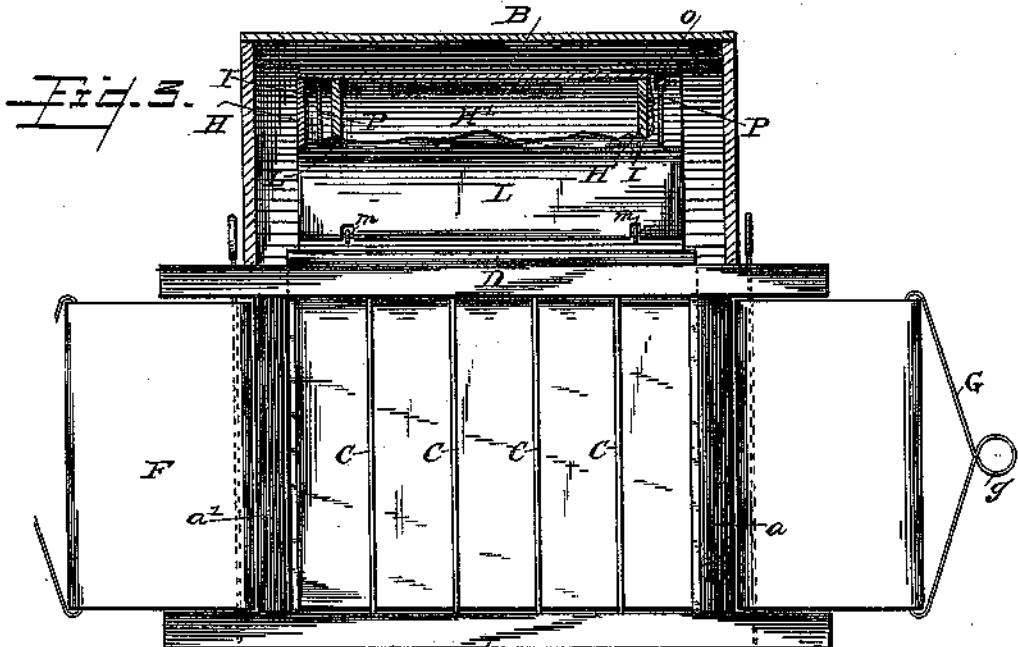
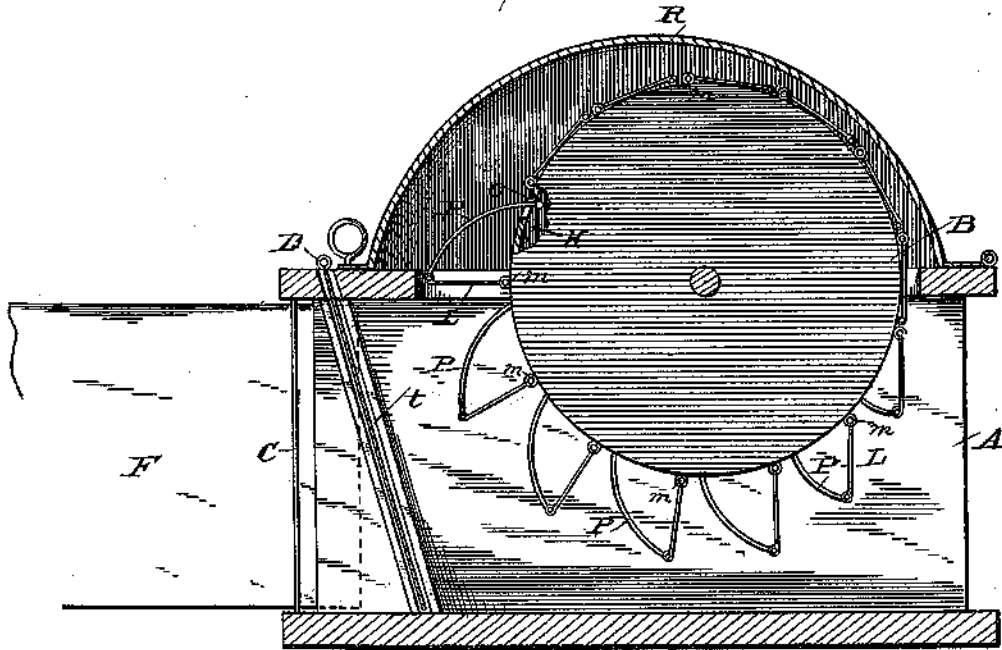
*Hezekiah Brown*  
by *Wm. H. Doolittle*  
Attorney

H. BROWN.  
WATER MOTOR.

408,075.

Patented July 30, 1889.

Fig. 2.



WITNESSES  
 Jost Blackwood  
 Abel B. Blackwood

INVENTOR  
 Ezekiah Brown  
 by Wm. H.

# UNITED STATES PATENT OFFICE.

HEZEKIAH BROWN, OF BROWNSVILLE, KANSAS.

## WATER-MOTOR.

SPECIFICATION forming part of Letters Patent No. 408,075, dated July 30, 1889.

Application filed April 6, 1889. Serial No. 306,193. (No model.)

### To all whom it may concern:

Be it known that I, HEZEKIAH BROWN, a citizen of the United States, residing at Brownsville, in the county of Chautauqua and State of Kansas, have invented certain new and useful Improvements in Water-Motors; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to an apparatus for utilizing the force of currents and streams for operating an undershot wheel fixed upon a floating frame or boat; and it consists of certain improvements in such a wheel, in combination with said float and adjustable wings, as hereinafter described, whereby the power so obtained can be used to actuate any suitable mechanism that may be connected therewith.

My invention is illustrated in the accompanying drawings, in which—

Figure 1 is a plan view; Fig. 2, a longitudinal section; Fig. 3, a front view, partly in section; and Fig. 4, a detail.

Referring to the drawings, A is a frame or float in which the wheel B is mounted.

The open head of the float, designed to face the current, is provided with wires or rods C, arranged at suitable distances apart to prevent the entrance of logs or other obstructions to the wheel, and with a sliding gate D to shut off the current when it is desired to stop the wheel. The slot *t*, through which the gate is passed, is cut on a bevel, so as to hold the gate in an inclined direction against the current, and whereby the gate is made adjustable at any height to regulate the speed of the wheel. The force of the current pressing against the gate will also aid in holding the gate at the desired position.

F F are current boards or sweeps hinged to the sides of the head of the float. The sides of the float at that point are beveled inwardly, as shown at *a' a'*, to permit the sweeps to swing inwardly across the front of the float. The sweeps are each provided with an attachment G, which are adapted to receive cords or ropes, by which the same can be held in any desired position by securing the ropes to the shore. As shown, these attachments G are made of wire bent into a loop *g* at their ends to receive the cord, rope, or chain; but

it is apparent, of course, that other forms of attachment may be adopted.

The sweeps can be brought together in front, or one sweep be placed across the current to stop the access of the same to the wheel. The sweeps are also so hinged that they can be swung back against the sides of the float to let logs or other debris be carried by.

The wheel B consists of a double casing H H'.

H' is an inner water-tight cylinder formed by having its solid heads joined to the outer casing H at a distance inside the outer casing. Between the heads of the outer casing H and the heads of the inner casing spaces or chambers I I are formed at each end of the wheel.

L L are the floats of the wheel hinged to the outer casing H at *m*. They are flat, and when closed lie flat against the wheel. They are connected to rods P. The rods P, secured at one end to the float, are passed through slots *o* in the outer casing H, and then into a chamber I, and at that end simply turned so as to engage with the wall of the chamber and to prevent them from falling out. It will be seen that these rods are free to move through the slots *o* when the floats fall, which the latter do by gravity as the wheel revolves.

R is a cover by which the top of the wheel is protected and water prevented from flowing onto the wheel when the same is submerged or partly submerged.

Having thus described my invention, what I claim is—

The wheel B, consisting of a double casing H H', the latter forming an inner air-tight cylinder, with chambers I at the ends of the wheel formed between the heads of the inner and outer casing and the floats, said outer casing provided with slots *o*, the freely-moving rods P, extending into said chambers and to which the floats are secured, in combination with a frame to support the same, substantially as described.

In testimony whereof I affix my signature in presence of two witnesses.

HEZEKIAH BROWN.

Witnesses:

DANIEL S. MEADOWS,  
EMMETT A. BROWN.

(No Model.)

L. R. WITHERELL.  
WATER MOTOR.

No. 410,132.

Patented Aug. 27 1889.

Fig. 1 -

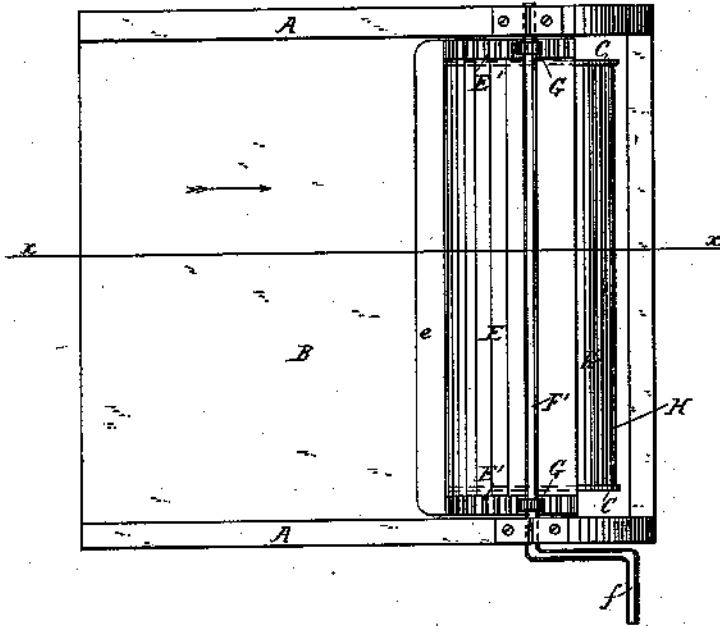
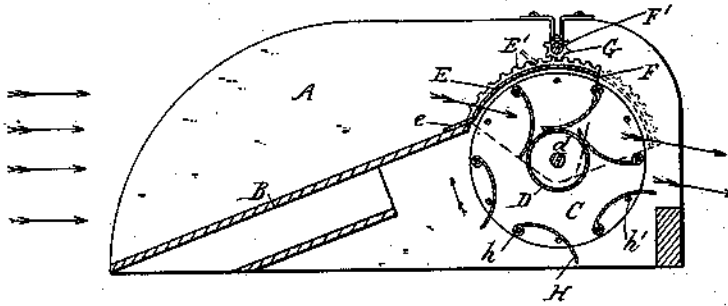


Fig. 2 -



Witnesses

Herbert W. Jenner  
H. Murdoch

Inventor

L. R. Witherell.

By his Attorney

*[Signature]*

# UNITED STATES PATENT OFFICE.

LOREN R. WITHERELL, OF DAVENPORT, IOWA, ASSIGNOR OF THREE-FOURTHS TO EDWIN W. BRADY, OSCAR W. BRADY, AND ALBERT B. BRADY, OF SAME PLACE.

## WATER-MOTOR.

SPECIFICATION forming part of Letters Patent No. 410,132, dated August 27, 1889.

Application filed May 2, 1889. Serial No. 309,384. (No model.)

*To all whom it may concern:*

Be it known that I, LOREN R. WITHERELL, a citizen of the United States, residing at Davenport, in the county of Scott and State of Iowa, have invented certain new and useful Improvements in Water - Wheels; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to water-wheels; and it consists in the novel construction and combination of the parts hereinafter fully described and claimed, whereby the water-wheel is adapted to work when submerged in the current of a running stream, and may be moved about as found convenient.

In the drawings, Figure 1 is a plan view of the machine from above; and Fig. 2 is a cross-section through the same, taken on the line  $x$  in Fig. 1.

The frame of the machine consists of two side plates A A, securely connected together and provided with the inclined water-guide plate B.

The water-wheel is provided with two end disks C, connected together by the cylindrical barrel D. The water-wheel is secured upon a shaft  $d$ , journaled in the side plates A A.

E is a curved plate provided with the longitudinal flange  $e$ , adapted to rest upon the guide-plate B, and F are end flanges which are journaled on the central shaft  $d$  of the water-wheel.

E' are curved toothed racks secured to the ends of the curved plate E, and F' is a shaft provided with a cranked handle  $f$  or other equivalent means for revolving it in its bearings in the side plates A A.

G are toothed pinions secured upon the said shaft F', which gear into the curved toothed racks E'.

H are curved arms pivoted to the disks C near their periphery by means of pins or rods  $h$ . These arms may be straight; but curved arms are preferred, as they hold the water better. The free ends of the said arms are free to oscillate between the cylindrical barrel D and the stops  $h'$  near the periphery of the said disks.

The machine is submerged in any water-course and anchored to the river-bed or secured to piles or to any other suitable support. The arrows in the drawings show the direction of the current. When the curved plate is closed, as shown, the wheel is not revolved by the water. The wheel is started by turning the shaft F' and opening the curved cover. The dotted lines in the drawings show the position of the cover when open to its widest extent. The water rushes up the inclined guide-plate and through the opening between the top of the said guide-plate and the flange  $e$  of the curved plate E. The flange  $e$  causes the water to be deflected, so that a greater volume of it is obliged to pass through the machine. The water strikes against the arms H at the top of the wheel and revolves it in the direction of the arrow. When the arms approach the under side of the wheel, they are turned upon their pivots by the weak water-current passing under the wheel and they fall against the stops  $h'$ , thereby offering very slight resistance to the revolution of the wheel. The speed of the wheel may be adjusted by turning the shaft F' to vary the position of the curved plate and cause more or less water to act upon the wheel, as desired. The wheel is revolved by the upper current of water, which is swifter and more powerful than the water running next the river-bed and in frictional contact therewith.

The power may be conveyed to the shore by means of a shaft, preferably coupled to the water-wheel shaft by a universal joint of approved construction, and a number of similar water-wheels may be used, if desired, and have all their shafts coupled by universal joints, so that it will not be necessary to place them exactly in line on the river-bed.

What I claim is—

1. The combination, with the two side plates and the inclined water-guide plate secured between them, of the water-wheel journaled in the side plates substantially in line with the top of the guide-plate, and the adjustable curved plate provided with flanges at each end having their extremities journaled on the water-wheel shaft, and a longitudinal flange



resting on the upper end of the said guide-plate, substantially as and for the purpose set forth.

2. The combination, with the two side plates  
5 and the inclined water-guide plate secured between them, of the water-wheel provided with a shaft and journaled in the side plates substantially in line with the top of the guide-plate, the curved plate provided with end  
10 flanges pivoted on the water-wheel shaft, and the longitudinal flange resting on the top of

said guide-plate, and a toothed rack, and a revoluble toothed pinion gearing into the said rack for adjusting the position of the said curved plate, substantially as and for the purpose set forth. 15

In testimony whereof I affix my signature in presence of two witnesses.

LOREN R. WITHERELL.

Witnesses:

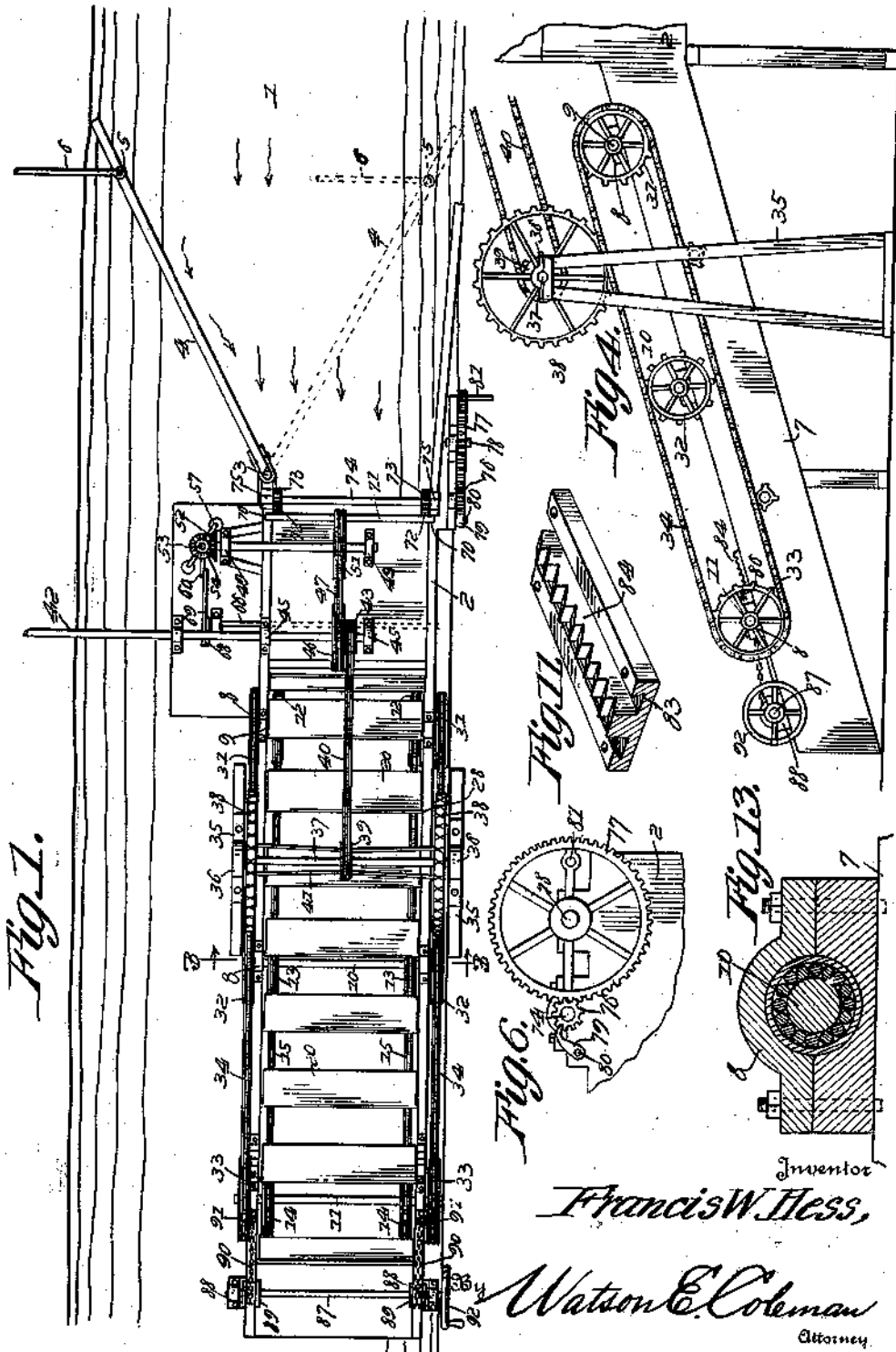
WILFED P. HALL,  
WM. E. PULS.

Dec. 19, 1922.

1,439,416.

F. W. HESS.  
WATER MOTOR.  
FILED JUNE 6, 1921.

3 SHEETS—SHEET 1.

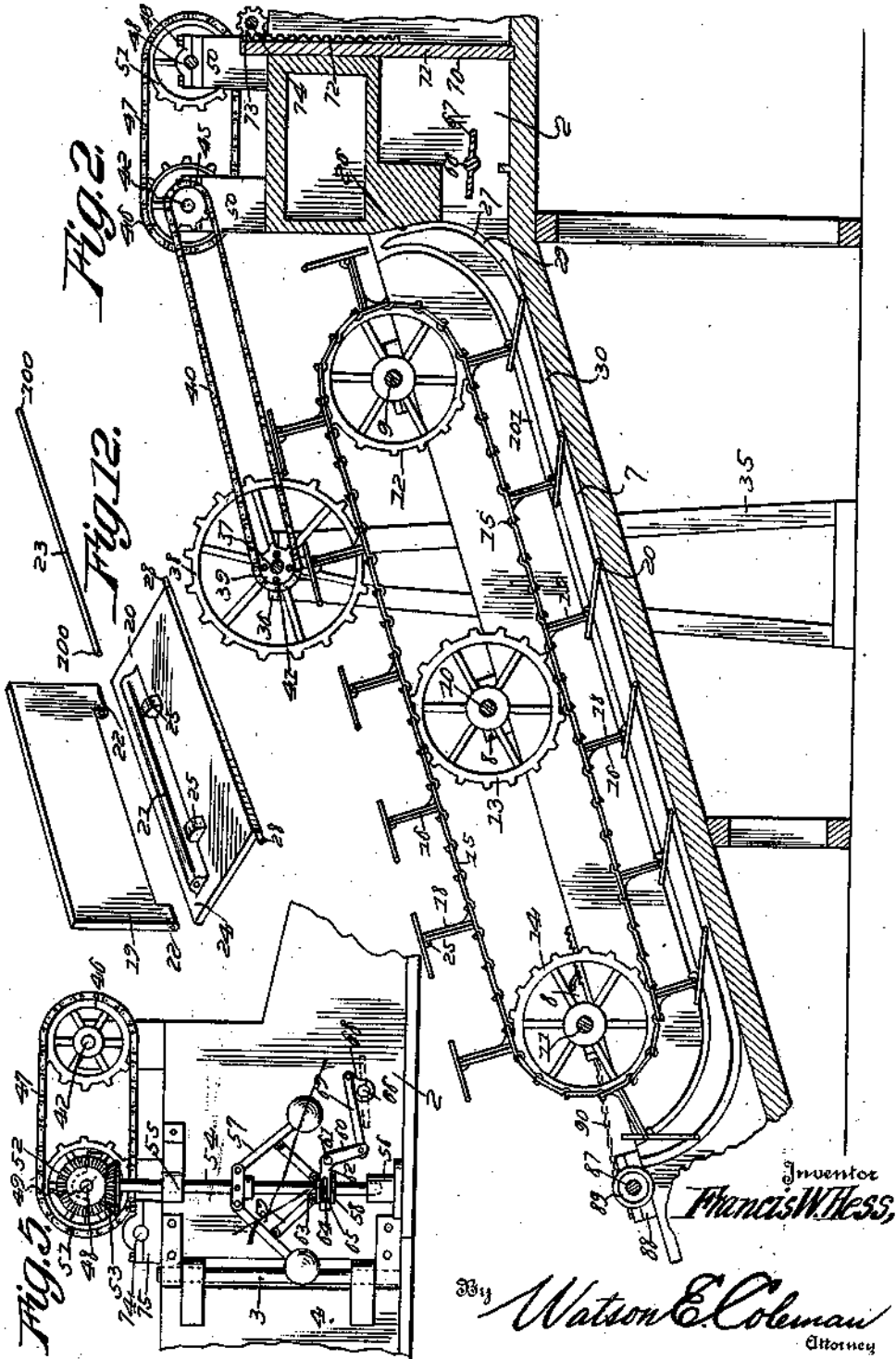


Dec. 19, 1922.

1,439,416.

F. W. HESS.  
WATER MOTOR.  
FILED JUNE 8, 1921.

3 SHEETS—SHEET 2.

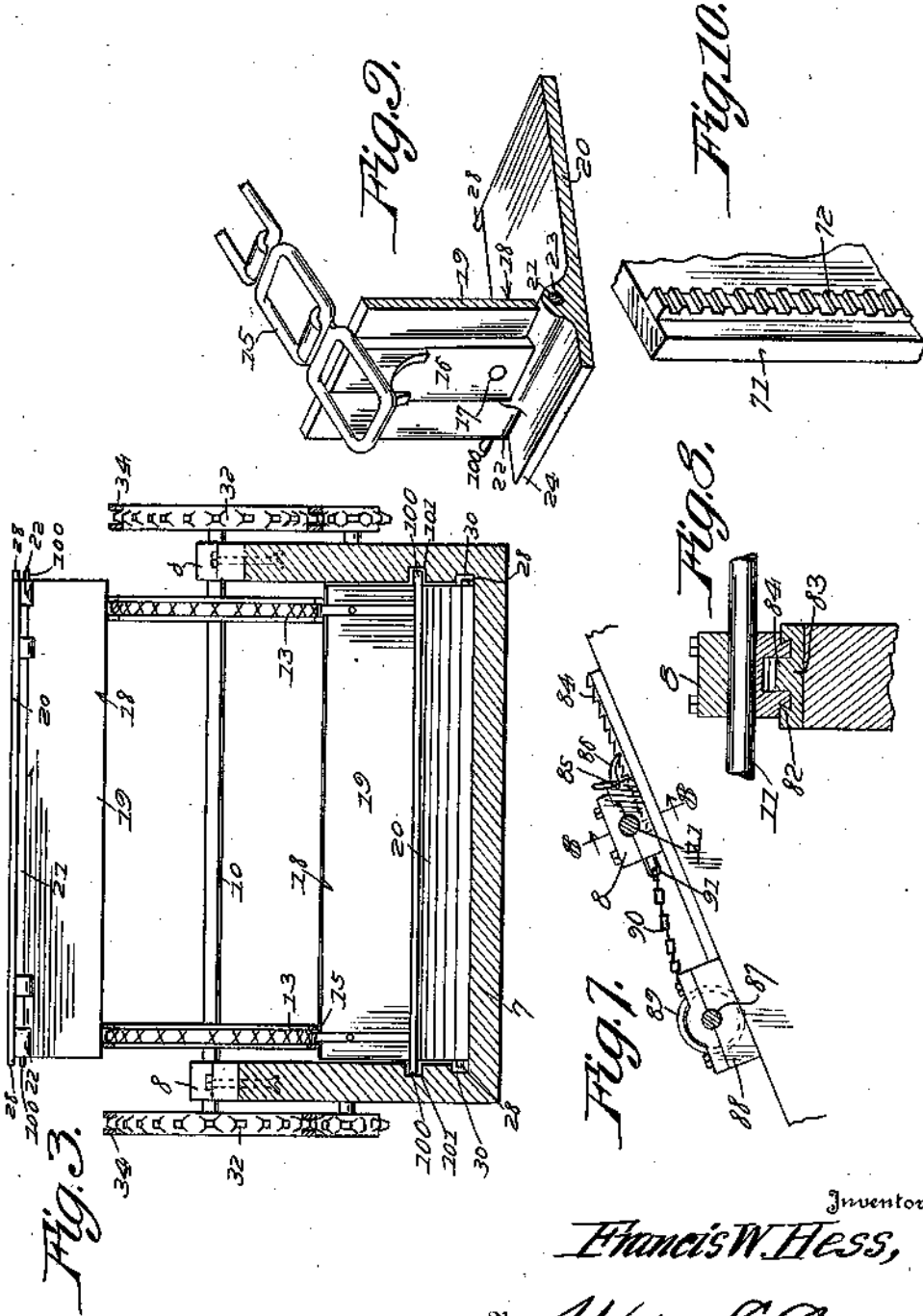


Dec. 19, 1922.

F. W. HESS.  
WATER MOTOR.  
FILED JUNE 6, 1921.

1,439,416.

3 SHEETS—SHEET 3.



Inventor  
*Francis W. Hess,*

*Watson E. Coleman*  
Attorney

# UNITED STATES PATENT OFFICE.

FRANCIS W. HESS, OF KERNSTOWN, VIRGINIA.

WATER MOTOR.

Application filed June 6, 1921. Serial No. 475,317.

To all whom it may concern:

Be it known that I, FRANCIS W. HESS, a citizen of the United States, residing at Kernstown, in the county of Frederick and State of Virginia, have invented certain new and useful Improvements in Water Motors, of which the following is a specification, reference being had to the accompanying drawings.

10 It is the purpose of the present invention to provide an improved motor of this general character, for the purpose of accumulating power to be derived from various streams, and in accomplishing this purpose 15 it is the aim to utilize a flume and sluiceway constructed in the stream, with power generating means in the sluiceway to be actuated by the water as it passes through the flume and the sluiceway, so that the power 20 may be utilized for operating various machinery, such as mills, generators and the like.

Another purpose embodies the provision of means for diverting a part or substantially the entire volume of water through the flume, in combination with means for controlling the discharge of the water into the sluiceway. In fact the discharge of the water may be mainly controlled by a manually operated water gate, there also being means operatively connected with the motor or power generating means, for automatically controlling the discharge of the water into the sluiceway according to the speed 35 of the motor or generating means.

A still further purpose is to provide an apparatus of this general character, wherein the operative connections between the motor or power generating means and the governor mechanism are centrally located relatively to the motor or power generating means, so as to equalize the strain upon the moving parts of the motor.

A further purpose consists in the provision of an endless traveler with depending buckets including gravity members or parts, which move into operative positions, partially by gravity, and partially by the contact of the water with extensions of said 50 parts or elements, so that said parts or elements may drag or engage the bottom of the sluiceway, so that the full force of the water on the buckets may be available.

A still further purpose embodies guides 55 in the lower portions of the opposite walls of the sluiceway for receiving parts of the

buckets, to guide the parts or elements of the buckets, to prevent them from movement upward, thereby avoiding them closing, and losing the effect of the force of 60 the water.

Additionally the invention aims to provide means at the ends of the guides, or rather extensions of the guides, and which are eccentric to the center of the end of the endless traveler, to receive parts of the gravity members of the buckets, to guide said gravity elements into the guides, said extensions acting to limit, in fact to prevent upward movement of the gravity parts 70 or elements of the buckets, particularly at points where the water may have a tendency to close the gravity elements or parts of the buckets.

Also a further purpose embodies the provision of means for regulating the tension of the endless traveler, so as to derive the best results, and to insure holding the endless traveler in position during the operation of the motor. 80

While the design and construction at present illustrated and set forth is deemed preferable, it is obvious that as a result of a reduction of the invention to a more practical form for commercial purposes, the invention may be susceptible of changes, and the right to these changes is claimed, provided they are comprehended within the scope of what is claimed. 85

The invention comprises further features and combination of parts, as will be hereinafter set forth, shown in the drawings and claimed.

In the drawings:—

Figure 1 is a plan view of the improved water motor constructed in accordance with the invention, and shown as applied to a flume and sluiceway constructed in a stream. 95

Figure 2 is a vertical longitudinal sectional view through the motor, thereby disclosing the essential features of construction. 100

Figure 3 is a transverse sectional view on line 3—3 of Figure 1. 105

Figure 4 is a view in side elevation of the sluiceway, showing one of the outside connecting chains of the motor, and illustrating sprockets for holding the lower part of the chain in position and preventing sagging. 110

Figure 5 is a view in side elevation of

[54] POWER MEANS  
 [76] Inventor: Paul E. Saxmann, 6120 E. 21st St., Indianapolis, Ind. 46218  
 [22] Filed: Aug. 13, 1973  
 [21] Appl. No.: 387,686

705,922 7/1902 Gran ..... 415/7  
 1,631,647 6/1927 Robinson ..... 415/7  
 1,892,831 1/1933 Gega ..... 415/202  
 3,644,052 2/1972 Lininger ..... 415/7

FOREIGN PATENTS OR APPLICATIONS

247,969 4/1927 United Kingdom ..... 415/202

[52] U.S. Cl. .... 415/7; 415/202; 417/336  
 [51] Int. Cl. .... F03d 11/04  
 [58] Field of Search ..... 415/2, 3, 4, 6, 7, 152, 415/164, 165, 202; 416/111, 119; 417/336

Primary Examiner—Henry F. Raduazo  
 Attorney, Agent, or Firm—Robert A. Spray

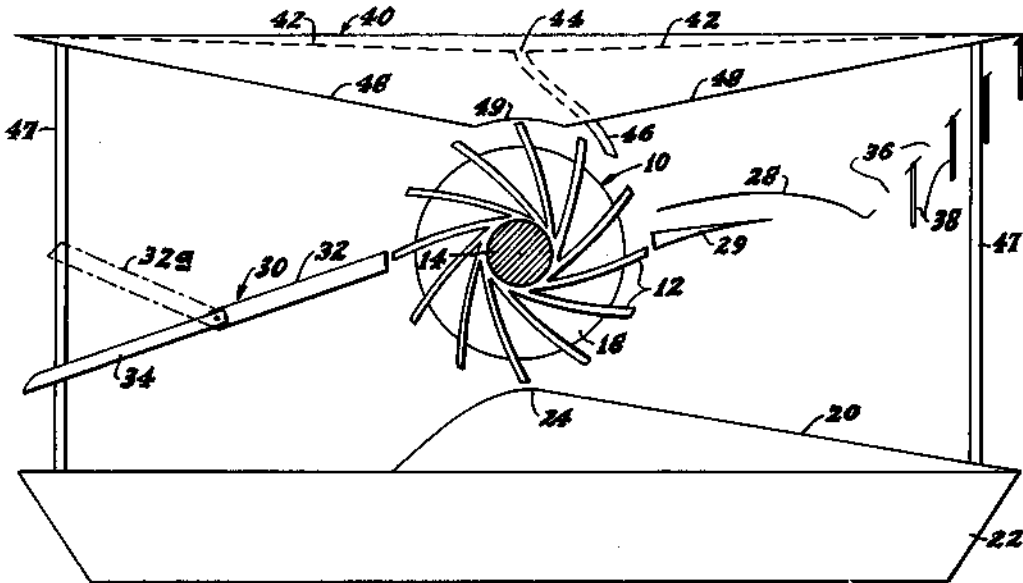
[56] References Cited  
 UNITED STATES PATENTS

9,551 3/1836 Mercer ..... 415/152  
 244,221 7/1881 Fountain et al. .... 415/7  
 648,442 5/1900 Scott ..... 415/4  
 657,528 9/1900 Everson ..... 415/7

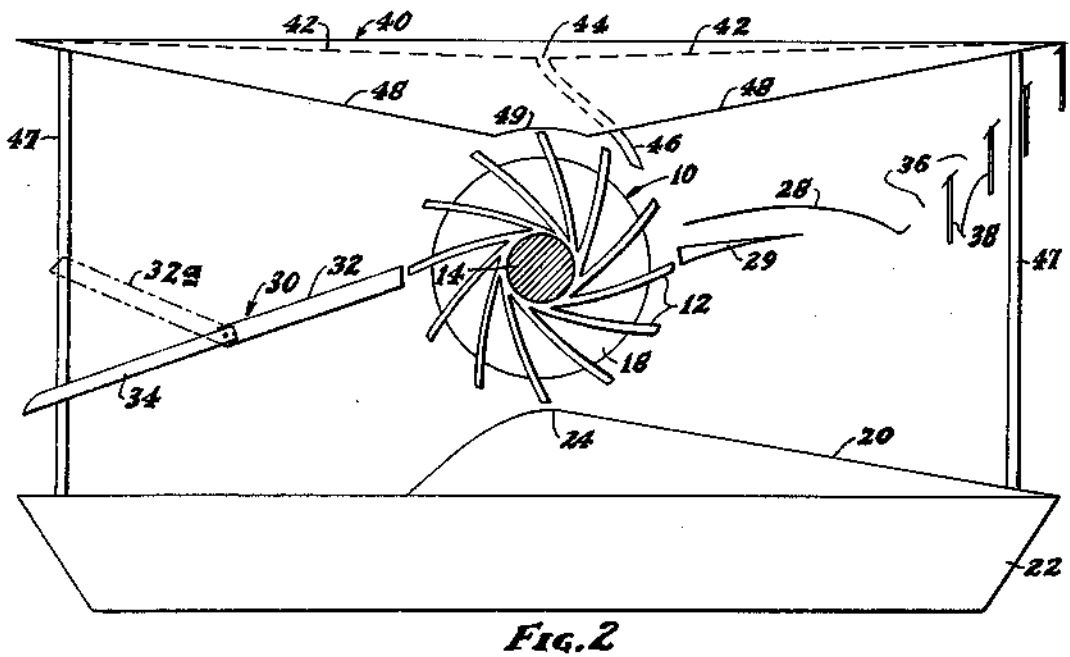
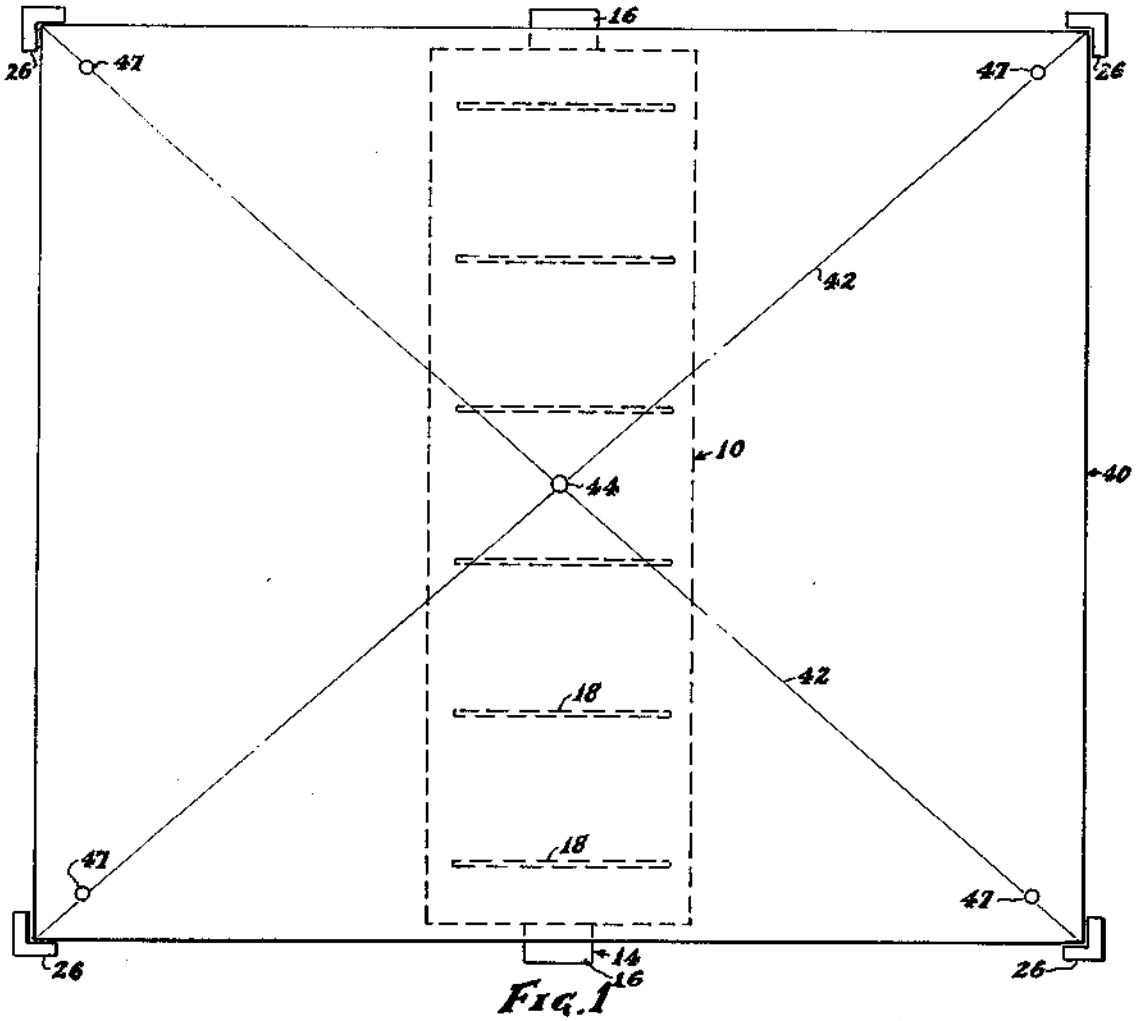
[57] ABSTRACT

A power means for obtaining useful power from moving fluid such as water waves or air motion, having an impeller body and an arrangement of baffle means for guiding the moving fluid to cause it to impart torque to the impeller.

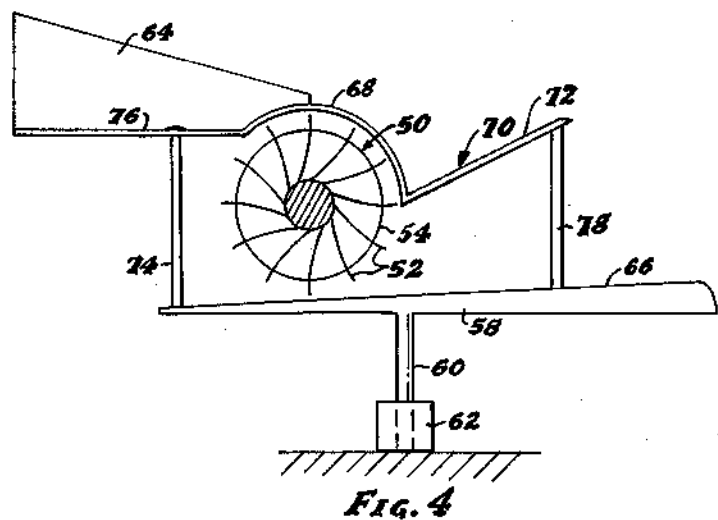
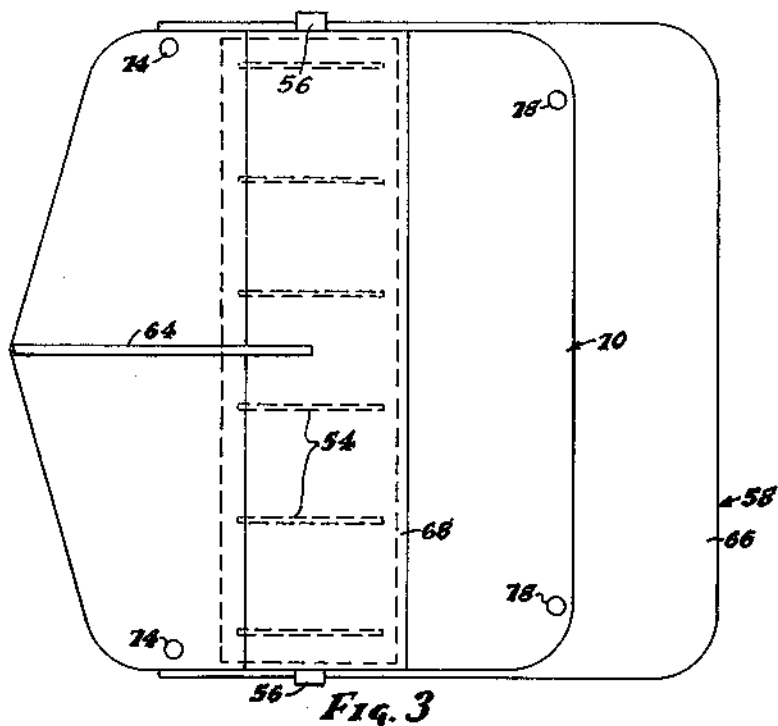
4 Claims, 4 Drawing Figures



SHEET 1 OF 2



SHEET 2 OF 2





## POWER MEANS

This invention provides novel and advantageous device for obtaining power, in a practical manner, from the practically unlimited natural phenomena of moving fluids such as water waves and moving air or wind.

It has of course been well publicized that mankind is currently facing both an "energy crisis" in which energy demands have in many places exceeded the energy production means, and also an "ecological crisis" in which environmental elements such as air have been polluted by many things including the raw materials by which useful energy is produced.

The present invention provides an effective answer to both of those highly-significant problems of mankind. For the source of power by water waves (particularly along shorelines) is practically unlimited, as is the presence of wind as a power source; and the obtaining of power by these devices can be used to provide electrical power by a pollution-free method which, in turn, can be utilized by the consumer to fulfill his special power needs by that electric power in a pollution-free manner.

These advantages are deemed to be so well known, considering all their publicity, and the long need for economical power, that the points will not be belabored by further explanation; for mankind has for ages recognized the unlimited source of water motion and air motion for power, and has tried many methods of harnessing that power. And all but the smallest child has been for years becoming increasingly aware of ecological needs which include the creation of a deliverable power and the subsequent conversion or obtaining of mechanical power from the deliverable power.

The above description is of an introductory and generalized nature. More particular details, features, components and concepts of the invention are set forth in the accompanying more detailed description of illustrative embodiments taken in conjunction with the accompanying somewhat schematic and diagrammatic drawings in which;

FIG. 1 is a plan view of an embodiment of the invention which utilizes the moving power of water waves together with wind and rain to achieve a power source;

FIG. 2 is a side elevational view of the embodiment shown in FIG. 1;

FIG. 3 is a plan view of an embodiment of the invention which utilizes wind power as a power source;

FIG. 4 is a side elevational view of the embodiment shown in FIG. 3.

As shown in the drawings the present inventive concepts provide a power source, utilizing the power of moving fluids such as water waves or air motion; and thus there is obtained a source of power from natural phenomena which are effectively infinite in availability and amount as a source for useful power.

In the embodiment of the invention shown in FIGS. 1 and 2, there is provided a power source which achieves power from moving water waves, but which also achieves supplemental power from the wind and even from the rain.

As shown in FIGS. 1 and 2, the power source includes an impeller body member 10 which comprises a peripheral series of blades or vanes 12 shown as slanted away from the hub 14 in a generally arcuate counter-clockwise form for achieving power as the impeller 10 is caused to revolve in a clockwise direction. It will be understood that the hub 14 is suitably sup-

ported at its ends 16, to permit the desired rotational movement of the impeller 10.

A series of discs or webs 18 are shown located at spaced intervals along the axis of the hub 14 of the impeller 10, in planes perpendicular to the hub 14. These provide a baffle or pocket effect for water or wind (as described below) which may be impinging upon the impeller 10 in the obtaining of power as described below, in situations in which the moving fluid is coming thereagainst from a direction other than perpendicular to the impeller 10.

The water waves will be striking the device, in FIG. 2, from the right. As the water waves move leftwardly (FIG. 2), the under-portion (or undulation) impinges upon an inclined plane or rampage 20, which is a plane which increases in height in the downstream (leftward) direction, and this causes the under-portion of the water waves to be projected in a general upward movement which causes a cresting of the waves. The rampage 20 thus brings about the beginning of the wave cresting, the energy of which is utilized by this device for the production of power, for the water of those wave crests impinges upon the blades 12 causing the impeller 10 to revolve clockwise. In its leftward movement, the water is guided upward toward the impeller 10 by the inclined plane or rampage 20 which is mounted upon the device base 22.

The base 22 of the device is hollow for a sufficient amount of its overall shape that a flotation of the device is achieved such that the top 24 of the inclined plane or rampage 20 is riding substantially at the tide level of the water body. This provides that the leftwardly moving water waves will impinge upon the vanes 12 of the impeller 10 in the desired manner.

As shown in FIG. 1, pilings 26 are shown to maintain the general location of the device with respect to the water body and the shore, yet permit the device to rise and fall (as by tides, etc.) to maintain the above-mentioned desired height of the device with respect to the tide level.

A baffle 28 is shown extending on the rightward side of the impeller 10, at approximately the elevation of the axis of the hub 14; and this baffle 28 provides that water waves will be deflected sufficiently downward that they will impinge upon the impeller 10 only in the portion thereof which is at or below the axis of the hub 14, thus assuring that the water energy will cause only a clockwise rotation of the impeller 10, instead of any unusually high waves causing a retarding effect by pushing against the impeller at a higher level which would produce a counterclockwise component of force against the impeller 10.

Below that panel 28 there is a substantially parallel panel 29 which provides that water dropping downwardly from the panel 28 will continue to move leftwardly, achieving the desired rotational torque effect on the impeller 10, instead of merely dropping vertically in which some of the kinetic energy of the leftwardly movement of the water waves would be wasted.

This device also achieves a source of power from wind coming from the shoreward side, that is wind from the left travelling to the right in FIG. 2, as now is described.

There is shown a wind baffle 30 having a lightweight, moveable rightward portion 32, and a fixed leftward portion 34. When the wind is coming from the shore (that is, the wind is moving rightwardly in FIG. 2) the

moveable panel 32 is in its position shown in FIG. 2, that is, its rightward position, which causes the rightwardly-moving wind to impinge against the vanes 12 of the impeller 10 in the portion above the axis of the impeller hub 14. This, of course, produces a clockwise torque upon the impeller 10 which supplements the above-described water power. This rightwardly-moving wind passes along the upper wall of baffle 28 and thereupon is vented at the right side of the device through openings 36 in the right end-portion of the baffle wall 28.

However, when the wind is coming from the water body, that is, when it is moving leftwardly from the right, the moveable lightweight panel 32 is blown by the leftwardly-moving wind to be in its chain-line position shown at 32a, to permit the venting of the wind through the upper left portion of the device. That is, it provides for the venting of wind which would enter the device and impinge upon the blades 12 in the same manner as the water power described above. Also, it will be noted that the rightward openings 36 are closed, when the wind is blowing leftwardly, by moveable closure plates 38 which close those openings 36 by leftward movement of the wind, yet permit those openings 36 to remain open in the situation of rightward movement of wind.

The device is covered by a hood or roof 40 shown as of generally rectangular shape but with ridges 42 to provide that the roof 40 has enough concavity to collect rain water. This rain water, in turn, passes through an opening 44 in the roof 40 which leads through a conduit 46 to a position adjacent the impeller 10 and on the right hand side (FIG. 2), providing that rain water striking the vanes 12 will also provide a supplementary clockwise torque to the impeller 10.

The canopy hood 40 is shown as supported from the base member 22 by four supporting posts 47, each located adjacent a corner of the overall device.

The roof 40 is shown as provided with a bottom wall 48 which provides a slanting surface above and at both sides of the impeller 10, these slanting panels 48 having at their juncture a downwardly concave cylindrical section 49 which provides a closure or housing-portion for the moving impeller blades 12.

In the embodiment shown in FIGS. 3 and 4, the device achieves power from wind, as a moving fluid. As shown, this device comprises an impeller body 50 with vanes 52 and axially spaced disc members 54 which may be substantially identical to impeller body 10 of the embodiment described above. This impeller body 50 has its ends 56 supported in suitable bearings, which provide that the impeller is located in a fixed position with respect to the device, but is rotationally moveable.

The device includes a base or frame section 58 having a downwardly-extending supporting post 60, which is freely rotatable within a supporting base 62; and the device is provided with a vertical panel 64 which provides a rudder by which the wind itself causes the device frame 58 to rotate (supporting post 60 with respect to base 62) so that the rotor or impeller 50 will present its axis perpendicular to the direction of wind travel, for maximum power effect and efficiency. The support post 60, it will be noted, is located in a location offset from the location of the fixed rudder vane 64, providing that the effect of wind against the rudder 64 will provide the rotational torque to orient the device as just mentioned.

The frame 58 is shown as a large panel, generally horizontal, whose upper surface 66 extends past the impeller 50 in a location closely spaced to the path of the outer tips of the impeller blades 52. The upper location of the path of the tips of the impeller blades 52 is shown as confined by a cylindrical portion 68 of an upper closure panel 70; and that upper closure panel 70, at the windward (right in FIG. 4) side of the impeller 50 is shown as provided by a slanting portion 72, which provides that incoming wind will be directed against only the lower portion of the impeller 50, thus achieving a clockwise rotational torque of that impeller 50.

The wind, which impinges against the impeller blades 52 (from the right of FIG. 4) exits from the device at the left end of the device, which is open. The lower frame panel 58 extends leftwardly only an amount sufficient to provide a base for a supporting post 74, which extends upwardly and supports a leftward portion 76 of the upper panel 70, which in turn supports the rudder vane 64. Adjacent the right end of frame 58 there are similar posts 78 which support the right hand portion 72 of the upper wall member 70.

It is thus seen that a power means according to the present inventive concepts provides a new and advantageous power means having advantages of ecology, practicality, a harnessing of practically unlimited natural forces with a minimum or zero pollution incidentals, etc., providing an economical and practically pollution-free energy source.

Accordingly, it will thus be seen from the foregoing description of the invention according to these illustrative embodiments, considered with the accompanying drawings, that the present invention provides a new and useful energy device, having desired advantages and characteristics, and accomplishing its intended objects, including those hereinbefore pointed out and others which are inherent in the invention.

Modifications and variations may be effected without departing from the scope of the novel concepts of the invention; accordingly, the invention is not limited to the specific embodiments or form or arrangement of parts herein described or shown.

What is claimed is:

1. Power means for obtaining useful power from moving fluid such as water waves or air motion, comprising:

an impeller body member;

means supporting said impeller body member for rotational motion about a horizontal axis; and baffle means for guiding the moving fluid to operatively impinge against the impeller body member to impart torque thereto in a certain rotational direction;

in a combination with two vertically-spaced baffles on the side of the impeller body member from which the moving water comes, the upper one having means serving to confine the water so as to operatively impinge against the impeller body member only along the lower portion thereof which produces rotational torque in the said certain rotational direction, and the lower one having means serving to confine the water thus deflected by the upper one to cause it to continue to move to operatively impinge against the impeller body member in a torque-producing manner in contrast to merely dropping vertically and in effect losing some of its kinetic energy.

5

2. Power means for obtaining useful power from moving fluid such as water waves or air motion, comprising:

an impeller body member;  
means supporting said impeller body member for rotational motion about a horizontal axis; and  
baffle means which defines the upper extent of the water impinging on the impeller body for guiding the moving fluid to operatively impinge against the impeller body member to impart torque thereto in a certain rotational direction;

in a combination in which, above the said baffle means which define the upper extent of the water impinging against the impeller body member, means provided with openings which are provided with wind-actuated closure members, which are moveable so as to be caused to close by wind coming from the direction of the water so as to block that wind from exerting a retarding torque against the impeller body in what would be the rotational direction opposite the certain direction of torque achieved by the water, but which are otherwise open, thereby to permit the exit of wind which has travelled in the opposite direction to impinge upon the upper portion impeller body member to cause supplementary power torque in that same certain direction as aforesaid.

3. Power means for obtaining useful power from moving fluid such as water waves or air motion, comprising:

an impeller body member;  
means supporting said impeller body member for rotational motion about a horizontal axis; and  
vertically spaced baffle means for guiding the moving fluid to operatively impinge against the impeller body member to impart torque thereto in a certain rotational direction;

6

in a combination with means comprising a movable baffle member for utilizing the power of moving wind coming from the direction opposite that of the said moving water, the said baffle member being supported so as to have a lower position baffling wind to the upper portion of the impeller body member when the wind is coming from the direction opposite the moving water, thus blocking it from impingeing against the impeller body member in a manner to retard the torque in the said rotational direction, means on the baffle member to raise a portion thereof to an upraised position permitting exit of wind coming from the same direction as the water.

4. Power means for obtaining useful power from moving fluid such as water waves or air motion, comprising:

an impeller body member;  
means supporting said impeller body member for rotational motion about a horizontal axis; and  
vertically spaced baffle means for guiding the moving fluid to operatively impinge against the impeller body member to impart torque thereto in a certain rotational direction;  
in a combination with a baffle providing a lower panel for guidance of the water to the impeller body member is an inclined panel means which leads to substantially the path of the tips of the blade members of the impeller body member; and  
in which the said lower panel inclination causes the under-portion of the water waves to be projected in a general upward movement which causes a cresting of the waves, the breaking of the wave creating being a major contributor of energy utilized in imparting torque to the impeller.

\* \* \* \* \*

40

45

50

55

60

65

[54] **PRESSURIZED WATER WHEEL**

[76] **Inventor:** William S. Kerby, 5102 N. Seneca, Wichita, Kans. 67204

[22] **Filed:** Aug. 11, 1975

[21] **Appl. No.:** 603,358

[52] **U.S. Cl.** ..... 415/2; 415/8; 415/148; 415/202; 415/203

[51] **Int. Cl.<sup>2</sup>** ..... F01D 1/08; F01D 25/24

[58] **Field of Search** ..... 415/2-4, 415/8, 66, 148, 202, 203

[56] **References Cited**

**UNITED STATES PATENTS**

|           |         |                   |         |
|-----------|---------|-------------------|---------|
| 1,436,933 | 11/1922 | Banki .....       | 415/202 |
| 1,474,571 | 11/1923 | Wielgolaski ..... | 415/202 |
| 1,792,761 | 2/1931  | Ring .....        | 415/202 |

**FOREIGN PATENTS OR APPLICATIONS**

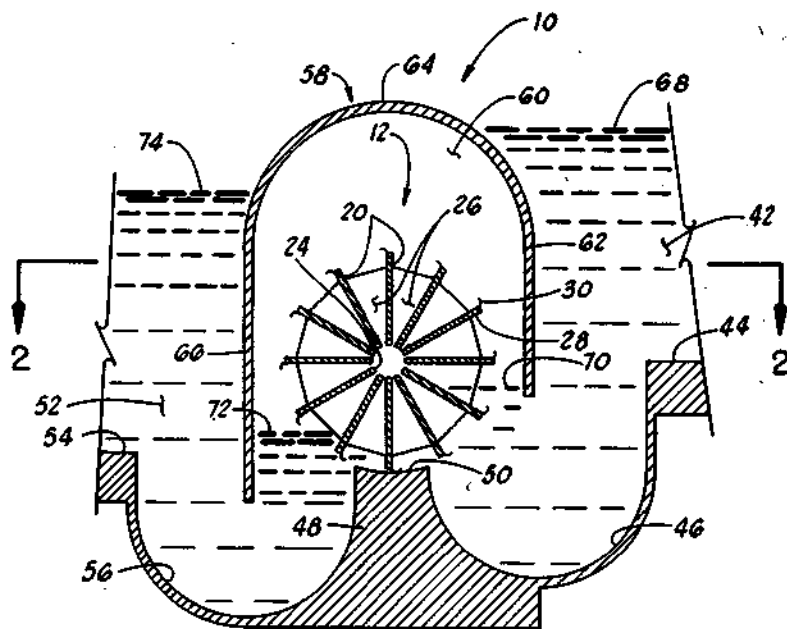
|           |         |                      |         |
|-----------|---------|----------------------|---------|
| 559,239   | 9/1923  | France .....         | 415/2   |
| 1,041,534 | 10/1953 | France .....         | 415/202 |
| 9,651     | 12/1923 | Netherlands .....    | 415/8   |
| 4,670     | 1907    | United Kingdom ..... | 415/3   |

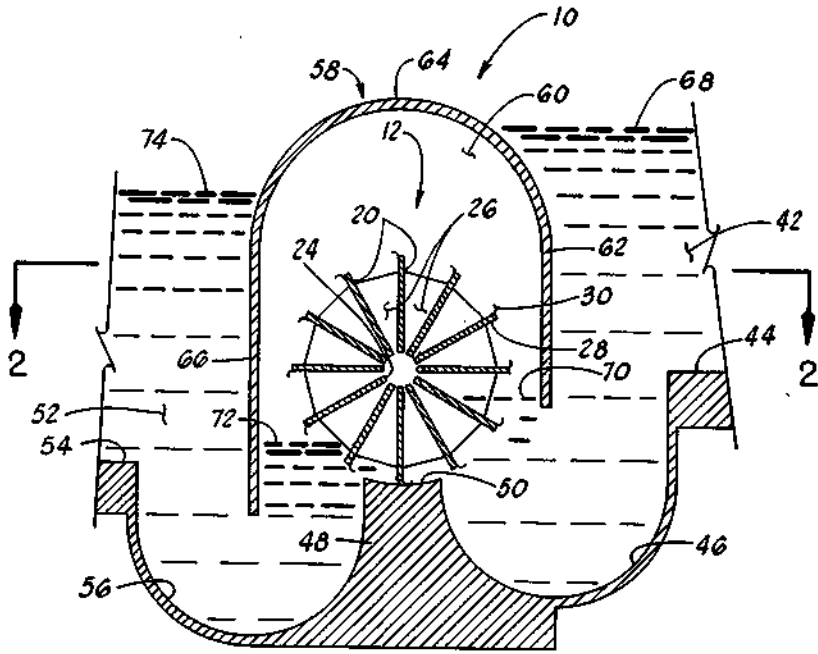
*Primary Examiner*—Carlton R. Croyle  
*Assistant Examiner*—Robert E. Garrett  
*Attorney, Agent, or Firm*—John H. Widdowson; Edwin H. Crabtree

[57] **ABSTRACT**

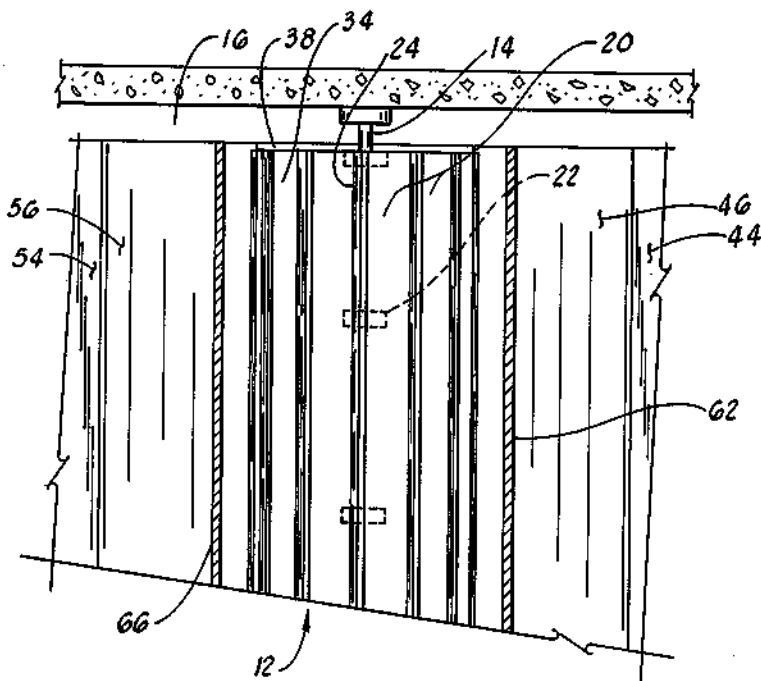
A waterwheel assembly has entry and outlet flow directing channel portions and a flow directing member below the waterwheel. The waterwheel has a plurality of radially disposed paddles mounted on a rotatable shaft and arranged with spaces between the paddles in open fluid communication in the center portion of the waterwheel. The upper portion of the waterwheel is enclosed in a pressurized air cavity so water is kept in the lower portion of the waterwheel. A method of controlling the water flow in a watershed includes directing water flow through small channels which connect with larger channels with flow controlling waterwheels in the channels at selected location so that releasing water through the waterwheels controls water flow and thus regulates runoff in the watershed area.

**5 Claims, 6 Drawing Figures**





**FIG. 1**



**FIG. 2**

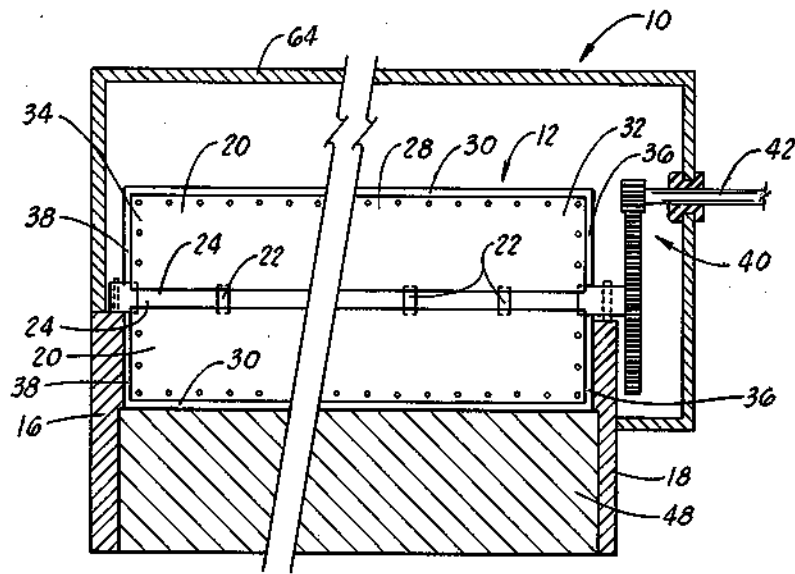


FIG. 2

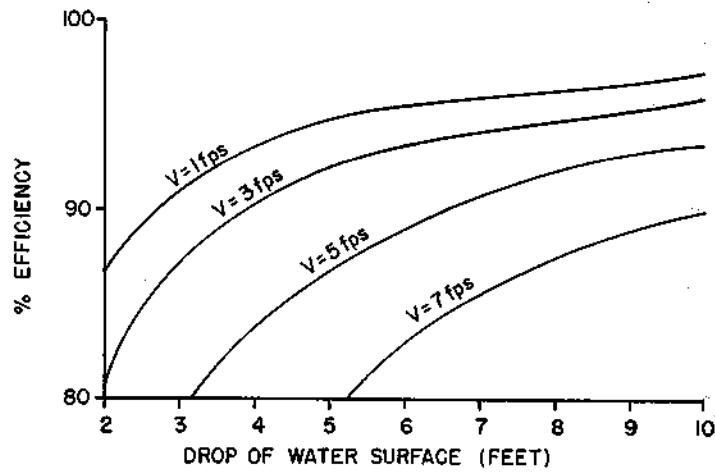


FIG. 3

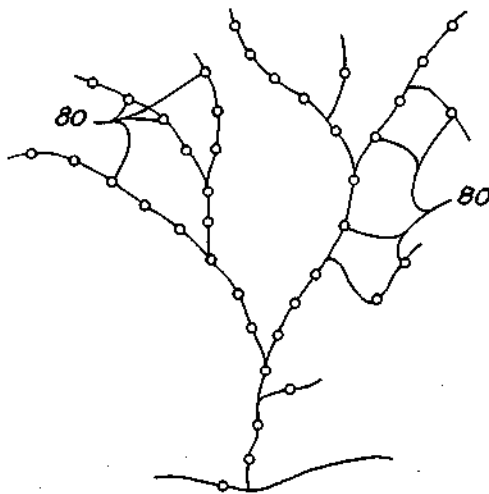


FIG. 5

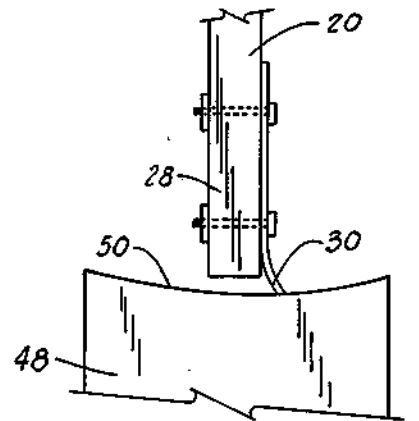


FIG. 4

## PRESSURIZED WATER WHEEL

### CROSS REFERENCE TO RELATED DOCUMENT

The waterwheel invention disclosed in this application is a subject of a document disclosure number 026943 filed in the Patent Trademark Office, Dec. 26, 1973, by the inventor.

### BACKGROUND OF THE INVENTION

This invention is related to waterwheels wherein water passing through the lower portion of a vertical positioned waterwheel rotates same. It is also related to the control of runoff and water flow in a watershed area.

In general prior art waterwheels and water driven turbines are low efficiency prime movers because they are structured such that a substantial portion of the perimeter of the wheel is enclosed in the water and only a small portion of it is subjected to forces from the moving water stream therefore considerable drag is incurred by the major portion of the wheel. In these prior art waterwheels and turbines generally a large head of water is needed to obtain any substantial power output from the device and in such constructions a large head loss is usually occurred through the associated structure necessary to get the water to the blades or paddles of the turbine or waterwheel. Almost without exception waterwheels are operated with water passing onto an upper portion of the wheel and being carried by it to a lower elevation on which requires special channeling and water diversion necessary to get the water to such an elevation and in proper position to fall on the wheel. Obviously these constructions require sizing of the wheel and proportions to the available head and topical location which dictate the size of the waterwheel.

In the current practice water control in a watershed area is accomplished by arranging the water movement such that it passes through a plurality of channels, streams, rivers and the like so the water is moved off of the land at a reasonably rapid rate. This method of water control in watershed area simply provides for rapid removal of the water from the watershed area to move it down stream and eventually to the ocean. This method control has inherent disadvantages in that it causes great amount of soil erosion as well as providing for dangerous conditions flood-wise and times of high rain fall or during spring thaws. An additional disadvantage of this present method of water control is that it does not provide for retention of water onto the land which in turn decreases the amount of water available for replenishing the under ground water supply and maintaining water content in the land.

### SUMMARY OF THE INVENTION

In an embodiment of the waterwheel structure of this invention it includes a waterwheel having a plurality of paddles which are arranged so the spaces between the paddles are in open fluid communication in the center portion of the wheel. The waterwheel is mounted in a water flow directing structure having an entry channel and outlet channel to direct water flow through the lower portion of the waterwheel. The waterwheel is enclosed in a housing like structure such that the upper portion thereof is operated in an air cavity. In a specific embodiment of the method of controlling water flow in a watershed area the method includes steps of directing

the water flow through a plurality of channels, forming a reservoir in the channels, installing a flow regulating waterwheel at the outlet of each reservoir and releasing water to flow through the waterwheels.

One object of this invention is to provide a waterwheel structure overcoming the disadvantages of the prior arts and devices and thereby providing a high efficiency waterwheel for use with relatively small water heads.

Still, one other object of this invention is to provide a waterwheel structure which has a waterwheel that is rotated about a horizontally disposed axis and has a supporting structure which directs water flow through the lower portion of the waterwheel while maintaining the upper portion of the waterwheel in a pressurized air cavity.

Still, another object of this invention is to provide a waterwheel structure which can be used for the generation of electrical power by utilizing relatively small water heads through channeled flows.

Yet, another object of this invention is to provide a waterwheel which will operate much in the manner of a watergate to regulate the flow of water in a channel that can be used in a watershed area to control motion of water in the watershed area.

Yet, another object of this invention is to provide a method of controlling water flow in a watershed area which retains water on the land in a plurality of interconnecting channels throughout the area and further wherein the water flow from the reservoir is regulated by flow control watergates or flow controlling waterwheels.

Various other objects, advantages, and features of the invention will become apparent to those skilled in the art from the following discussion, taken in conjunction with the accompanying drawings, in which:

### DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross sectional elevation view of the waterwheel of this invention shown with water flowing there-through;

FIG. 2 is a cross sectional view of the waterwheel and associated structure shown in FIG. 1, with this view being taken on a line 2—2 of FIG. 1;

FIG. 3 is a cut away view of the waterwheel and associated structure taken along the axis of rotation of the waterwheel and showing mounting of the waterwheel and paddles in full view with mechanical apparatus for extracting rotary mechanical power;

FIG. 4 is an enlarged cross sectional view of the bottom channel flow directing member and the tip of a waterwheel paddle showing the seal member on the paddle;

FIG. 5 is a graph of estimated theoretical efficiency for the waterwheel versus drop of water surface for several flow velocities; and

FIG. 6 is a graphical illustration of a watershed area with a plurality of interconnecting water channels joining together, circles on the channels indicate waterwheels.

The following is a discussion and description of the specific embodiments of the waterwheel structure and the method of water control in a watershed area of this invention, such being made with reference to the drawings, whereupon the same reference numerals are used to indicate the same or similar parts and/or structures. It is to be understood that such discussion and description is not to unduly limit the scope of the invention.

## DETAILED DESCRIPTION

Referring to the drawings in detail and in particular to FIG. 1 wherein the waterwheel and channel flow apparatus of this invention, indicated generally at 10 is shown with water flowing through same from the right to the left. The waterwheel alone, indicated generally at 12 is supported by short shaft 14 extending from its opposite ends which are rotatably mounted in bearings supported on sides 16 and 18 of the flow channel structure. Shaft 14 rigidly supports a plurality of paddles 20.

Shaft 14 is rigidly mounted on paddles 20 by supports 22 at their outer end portions. The inner edge 24 of paddles 20 is displaced from shaft 14 and these inner edges are spaced from one another as shown in FIG. 1. The inner edge 24 of the paddles 20 is attached to the ends of the supports 22 shown in FIG. 3 for maintaining the paddles 20 in a spaced relationship from the shaft 14. Spacing of inner paddle edges 24 is an important feature of the waterwheel structure because it allows open fluid communication between the spaces 26 between paddles 20. Each paddle on its elongated outside edge 28 is provided with a resilient wiper 30. Paddle end edges 32 and 34 are also provided with wipers 36 and 38, respectively. Wipers 30, 36 and 38 rub on interior portions of the flow channel structure will be described hereinafter. Shafts 14 can be fitted with a mechanical gearing, as indicated generally at 40 in FIG. 3, for connecting it with another shaft 42 to utilize rotary power developed by the waterwheel.

The particular flow channel apparatus 10 includes an entry channel leading to waterwheel 12, an outlet channel from the waterwheel and a bottom channel flow directing assembly beneath the waterwheel. Entry channel 42 has a smooth bottom which can be flat if desired to a point immediately ahead of waterwheel 12 at which point the flow channel drops and has a generally semi-cylindrical shaped bottom 46, as shown in FIG. 1. Entry channel 42 joins an upright flow directing member 48 immediately below waterwheel 12. Upright flow directing member 48 has a curved upper surface 50 which is shaped to allow wipers 30 on the paddle edges 28 to rub as they pass. FIG. 4 shows the upper end portion of upright flow directing member 48 with the end of a paddle 20 and wiper 30. Outlet channel 52 can be constructed having a flat bottom 54 downstream from a point located immediately downstream of waterwheel 12 where at such point the channel bottom is preferably partially cylindrically shaped and cross-sectionally round as indicated at 56. Curved channel bottom outlet 56 joins the downstream side of upright flow directing member 48 and extends to a point substantially downstream of waterwheel 12.

It is to be understood that the rounded and partially cylindrical configuration of the channel bottom immediately ahead of and downstream of waterwheel 12 can be changed from that shown if such is the desire of the user. In any circumstance the shape of the channel bottom should be smoothly contoured in a uniform and evenly changing curvilinear shape when seen in cross section in order to provide smooth water flow into and away from waterwheel 12 for the purpose of minimizing turbulence.

Waterwheel 12 has the upper portion thereof enclosed in a housing indicated generally at 58 to form an air cavity 60 above the upper portion of waterwheel 12. Housing 58 has an upright entry wall portion 62 extending upward from a point slightly below the eleva-

tion of shaft 14. A housing top portion 64 joins the upper portion of entry wall portion 62 and extends downstream over the top of waterwheel 12. It is desirable for the top portion 64 of the waterwheel housing 58 to be disposed above the upper end of paddle 20, as shown in FIGS. 1 and 3, so entry wall 62 and top portion 64 will provide somewhat of a water barrier in entry channel 42. An outlet upright wall portion 66 joins the downstream side of housing top portion 64 and extends to a point substantially below the elevation of the upper end of upright flow directing member 48. Preferably, entry wall portion 62 and outlet wall portion 66 are positioned approximately in the center portion of the rounded channel bottoms 46 and 56 so that water can flow in a smooth flow into and out of waterwheel 12.

FIG. 1 shows in normal operating water levels inside housing 58. In normal operation water at the inlet side of waterwheel 12 is maintained at a water level 70 slightly below the elevation of the upper end of the lowermost paddle in the vertical position. This water level 70 is adjusted by changing air pressure in cavity 60 as necessary to balance it against the head existing between inlet water surface 68. Obviously air pressure in cavity 60 must be precisely regulated and correlated with atmospheric pressure to maintain water surface 70 at the desired point. In the outlet side of waterwheel 12 water passes through spaces 26 between paddles 20 and exits the waterwheel at a water surface level 72 below the elevation of water level 70. The water level 74 in outlet channel 52 is below water surface elevation 68 in entry channel 42, therefore, air pressure in cavity 60 necessary to maintain water surface level 70 as desired will cause water level 72 in the outlet side of waterwheel 12 to be displaced below water level 70. The air pressure in cavity 60 necessary to maintain the surface levels 70 and 72 can be supplied by an air pressure tank, air compressor, or the like, connected to the cavity 60. The air pressure required to maintain the necessary surface levels 70 can be controlled by a float means or any other sensing device co-acting with the source of air pressure. It is to be noted that outlet wall housing portion 66 extends substantially below entry housing wall portion 62. This is necessary to insure that air from cavity 60 does not pass underneath the bottom of outlet wall portion 66. During operation of waterwheel 12, it is to be noted that air passes between paddle spaces 26 as water moves into these spaces at their outer portions along on the periphery of the waterwheel. This feature of the waterwheel structure of this invention keeps the water down below the upper end of the lower vertically disposed paddle so it moves through the lower portion of waterwheel 12. Water is not carried into upper portions of waterwheel 12 except for splashing, which is relatively minor.

FIG. 5 shows an estimated performance chart for the waterwheel and flow channel structure 10 of this invention. In FIG. 5 percentage of efficiency is plotted versus water drop in feet for several water velocities in feet per second. Specific velocities are indicated on the curves. In calculating the curves shown in FIG. 5 head loss is estimated from the following formula:

$$\text{Head Loss} = (V^2/2g) + 0.25 \text{ feet}$$

In this formula 0.25 is added for head losses within the housing structure. It is to be noted that percent efficiency for even a small drop of water surface for a



nominal flow rate is a rather high percentage which is to be compared with conventional turbines as described above which have a percent efficiency of generally less than 10%. Considering losses from headwater elevation to turbine inlet, losses from turbine outlet to tailwater and leaks. From FIG. 5 it is obvious that the waterwheel and flow channel structure of this invention are desired to operate at a very high efficiency with relatively low head conditions. Relatively low head conditions includes a total head from inlet to outlet of below ten feet. In the operation of the waterwheel of this invention it is preferably sized so that average velocity of water through the waterwheel is within the range of 1 to 10 feet per second. On the average it is expected that the average velocity through the waterwheel will be within the range of 2 to 3 feet per second for normal conditions with peak flow rates having an average velocity of between 5 to 10 feet per second. Obviously the rotational speed entirely developed by the waterwheel and flow channel apparatus of this invention would be dependent on the radius of the waterwheel, the head pressure, leaks, head pressure losses and other factors. However, it is to be understood that mechanical rotating power produced by waterwheel 12 can be coupled to generators for the production of electrical power or it can be connected to other mechanical devices for making use of the rotary power.

In regard to the method of controlling water flow in a watershed area of this invention it is to be understood that this method differs substantially from presently practiced methods of watershed control. The novel method of this invention was conceived and designed with the full intention of utilizing the novel waterwheel structure of this invention. Basically the novel method of this invention involves close regulation of runoff and retention of water on the land for later release through the waterwheels to extract useful work from the water as it moves downstream at a later time under regulated conditions.

In applying the waterwheel and flow channel structure of this invention to a watershed area it is initially necessary to arrange the streams, water flow channels, rivers, etc. in the watershed area in a general arrangement as illustrated in FIG. 6. In FIG. 6 the water carrying channels indicated by the lines are connected in a branching fashion so that water picked up by one stream will move into other connected channels. Each of the water carrying channels or the like are positioned in the watershed area to pick up runoff from a designated area in the adjacent terrain. Along these channels or the like a plurality of flow regulating waterwheels are installed as indicated by the circles 80 in FIG. 6. These waterwheels are installed at selected locations spaced along the channels to temporarily store water in the connecting channels. The channels which connect the waterwheels are each arranged such that it's surface water is virtually level. At the outlet of each of the reservoirs a flow regulating waterwheel is installed. The flow regulating waterwheels are namely the waterwheel and flow channel structure as described above. It is to be noted that by selective placement of the waterwheels the water surface drop in the channels can be adjusted for each to be within the desired operating range of the waterwheel and flow channel apparatus 10.

In operation of a watershed area the water flow control is regulated by releasing water through the flow

regulating waterwheels at a rate such that it maintains an essentially smooth, level, and practically non-turbulent flow in the water channel. A flow rate of  $\frac{1}{2}$  feet per second or less will substantially eliminate significant soil erosion problems. By releasing water so that it flows through the channels in this manner the problem of soil erosion is minimized. Also a great quantity of water is held onto the land so that it can be absorbed by the land and available for use as needed. An additional feature in retaining water on the land is that it lessens the impact of peak rains which endanger flood-prone areas downstream. It is to be noted that by regulating water flow so that it moves normally in a non-turbulent flow through the channels it substantially eliminates soil erosion and eliminates the necessity for paved channels, riprap, and other expensive flow control facilities necessary with present state of the art high velocity water channels. Also the low velocity non-turbulent flow will allow particles in the water to drop out thus clarify water in the channel.

In the selection of the sites for the flow regulating waterwheels they are preferably chosen where elevation drops between the upper channel water surface and lower channel water surface and can be arranged to be between 2 and 10 feet. More preferably the sites are selected at points where elevation drops are within the range of 3 to 8 feet. It is to be noted that by selecting the flow regulating waterwheel sites in designated areas which are not too remote from civilization these devices can be used for the generation of electrical power for utilization by residents of the immediate area or connected with a power transmission network for use at a distant point.

In the manufacture of the waterwheel structure and associated apparatus of this invention it is obvious that it can be constructed to achieve the end product with far less effort than required from some state of the art hydroelectric plants and water regulating and retaining facilities. Because the waterwheel structure and the flow channel structure is relatively simple in form it can be cast or formed of concrete or other suitable materials with the waterwheel being constructed much as conventional turbines, waterwheels, pumps and the like are constructed. In utilizing a watershed water control method of this invention it is obvious that the waterwheel, flow channel directing structure and flow regulating apparatus of this invention make it possible to carry out the method as disclosed. The method of water control in a watershed area is unique to the present art because it retains water on the land and carefully regulates the rate of runoff by the use of the flow regulating device.

In the use and operation of the waterwheel structure of this invention, it is seen that same provides a waterwheel structure which can be used for the generation of rotary mechanical power and which also can be used to regulate water flow through a channel or the like. In carrying out the method of this invention it is seen that the method of water control for a watershed area regulates the amount of water retained on the land by using interconnected reservoirs and channels. The method of watershed control retains water on the land and regulates runoff so that the flow rate through the channels is relatively low and thereby overcomes disadvantages of the present methods by reducing or substantially eliminating soil erosion while at the same time lessening the danger of flooding downstream. It is to be noted that water channels created by using this invention

would provide water for irrigation purposes as well as recreation.

As will become apparent from the foregoing description of the applicant's waterwheel structure a relatively waterwheel apparatus has been provided for use in a channel to generate rotary mechanical power. The waterwheel structure is relatively simple to construct yet it functions with a quite high efficiency and can be used essentially continuously in a water channel with an adequate supply of water. The method of water control of the applicant provides a simple method of controlling water flow in a watershed area by retaining water in reservoirs and regulating its flow rate downstream. The method is economical to utilize as a whole because it utilizes water power to produce rotary mechanical energy which can be used to generate electrical power. Additionally the method of water control is advantageous from a safety point of view because it lessens problems due to flooding and it moves water at a relatively low velocity.

While the invention has been described in conjunction with preferred specific embodiments thereof, it will be understood that this description is intended to illustrate and not limit the scope of the invention, which is defined by the following claims:

I claim:

- 1. A waterwheel and flow directing means therefor, comprising:
  - a. a waterwheel having a plurality of radially disposed paddles mounted on a shaft in a spaced relation with spaces between said paddles being in open fluid communication at the center portion of the waterwheel,
  - b. a flow directing means having an entry channel portion in fluid communication with the upstream side of said waterwheel, and outlet channel portion in fluid communication with the downstream side of said waterwheel, and
  - c. a housing rigidly mounted over said water wheel,
  - d. a means to pressurize an upper portion of said waterwheel mounted over said water wheel in a stationary position, said means to pressurize being constructed and adapted to in use retain air in an upper portion of said waterwheel, and
  - e. a bottom channel flow directing member mounted below said waterwheel and having the upper surface thereof contactable with the lowermost portion of said waterwheel paddles as said waterwheel rotates to direct water through a lower portion of said waterwheel,
  - f. means to maintain a pressure head on the entry channel portion which is greater than that on the outlet channel portion, said water wheel and flow

directing means being constructed and adapted to in use receive water in said entry channel portion, pass same beneath said entry wall, through the lower portion of said waterwheel underneath said outlet wall and out through said outlet channel portion.

2. The waterwheel flow directing means of claim 1, wherein said housing having one wall extending upward from a point essentially immediately below the upper end portion of an essentially vertically positioned paddle located at the bottom portion of said waterwheel in said entry channel portion and having another wall extending upward from a point substantially below said blades in said outlet channel.

3. The waterwheel flow directing means of claim 2, wherein:

- a. said bottom channel flow directing member has an upright portion extending upward from a bottom portion of said channel below said waterwheel,
- b. said inlet channel portion has a recessed portion upstream of said waterwheel extending from a point substantially ahead of said waterwheel to said bottom channel flow directing member, and
- c. said outlet channel portion has a recessed portion downstream of said waterwheel extending from a point substantially downstream of said waterwheel to said bottom channel flow directing member.

4. The waterwheel flow directing means of claim 3, wherein:

- a. said entry channel portion and said outlet channel portion have upright sides in the portion thereof adjacent said waterwheel with said channel sides contacting the sealing relation the opposed ends of said waterwheel,
- b. said housing extends beneath said channel sides, and
- c. said housing extends substantially above said waterwheel and has the upper end thereof above the water level in said inlet channel portion.

5. The waterwheel and flow directing means of claim 4, wherein:

- a. said inlet channel recessed portion and said outlet channel recessed portion have an essentially semi-circular curvature,
- b. said shaft is rotatably mounted with said channel sides and is mechanically connected through one of said sides to an external point, and
- c. said paddles have seal means on ends thereof and outer edges thereof to seal with said channel sides and said bottom channel flow directing member, respectively.

\* \* \* \* \*

55

60

65

[54] WATER WHEEL ASSEMBLY

[76] Inventor: **Lui Gotti**, P.O. Box 333, El Centro, Calif. 92243

[21] Appl. No.: **568,611**

[22] Filed: **Apr. 16, 1975**

[51] Int. Cl.<sup>2</sup> ..... **F03B 7/00**

[52] U.S. Cl. .... **415/202; 416/197 B; 416/185**

[58] Field of Search ..... **416/197, 185, 197 B, 416/184, DIG. 6, DIG. 4; 415/202, 203**

[56] **References Cited**

**U.S. PATENT DOCUMENTS**

|           |         |                       |           |
|-----------|---------|-----------------------|-----------|
| 109,925   | 12/1870 | Millard .....         | 416/197 X |
| 282,122   | 7/1883  | Schramm .....         | 416/23 X  |
| 338,778   | 3/1886  | Rasmussen .....       | 415/202   |
| 515,674   | 2/1894  | Guldhaug .....        | 415/202 X |
| 606,926   | 7/1898  | Horst .....           | 416/197   |
| 642,067   | 1/1900  | Bash et al. ....      | 415/202 X |
| 673,340   | 4/1901  | Hubartt .....         | 415/202   |
| 973,241   | 10/1910 | Vestal et al. ....    | 416/184   |
| 1,294,050 | 2/1919  | Chute .....           | 415/202   |
| 1,430,406 | 9/1922  | Schulthes et al. .... | 416/119   |
| 1,522,437 | 1/1925  | Gommer .....          | 416/197   |
| 1,790,175 | 1/1931  | Spencer .....         | 416/13 X  |

|           |         |                 |           |
|-----------|---------|-----------------|-----------|
| 2,097,667 | 11/1937 | Johnson .....   | 416/119   |
| 3,644,052 | 2/1972  | Liningner ..... | 415/202 X |

**FOREIGN PATENT DOCUMENTS**

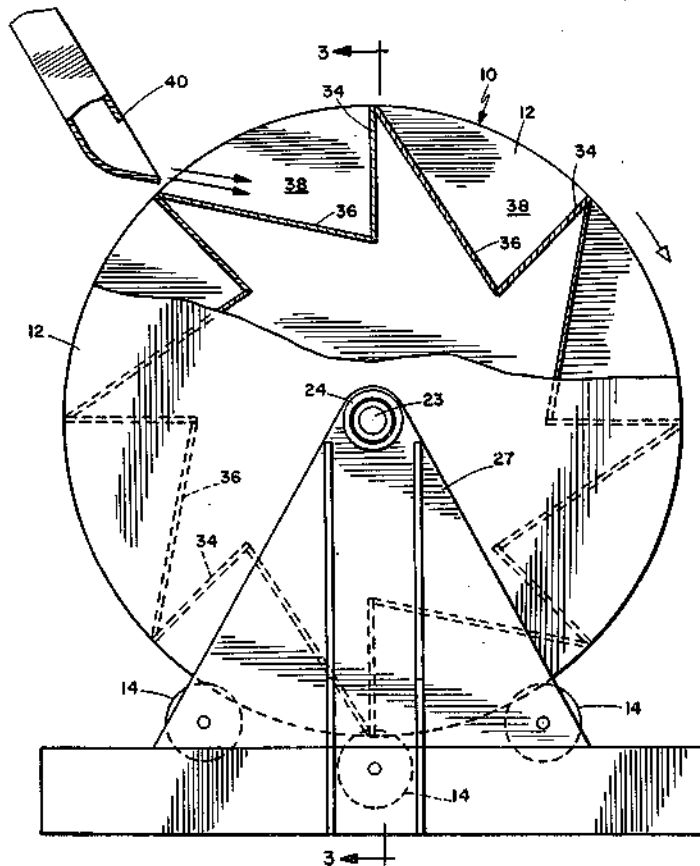
|         |        |                      |         |
|---------|--------|----------------------|---------|
| 512,438 | 5/1955 | Canada .....         | 415/202 |
| 744,540 | 1/1944 | Germany .....        | 416/13  |
| 17,758  | 7/1912 | United Kingdom ..... | 415/202 |
| 2,530   | 2/1909 | United Kingdom ..... | 415/202 |

*Primary Examiner*—Everette A. Powell, Jr.  
*Attorney, Agent, or Firm*—Ralph S. Branscomb

[57] **ABSTRACT**

The invention comprises a water wheel having spaced parallel circular side walls supported on bearings which are rotationally mounted in a stationary base, these bearings preferably being the wheels of railroad cars, there being a plurality of generally radially extended paddle elements disposed between the side walls and extending from the periphery thereof, and including an upwardly extended chute connected to an elevated water supply, this chute having a lower end shaped to deflect water generally horizontally and tangentially into the upper portion of the water wheel and against the paddle elements.

**1 Claim, 4 Drawing Figures**



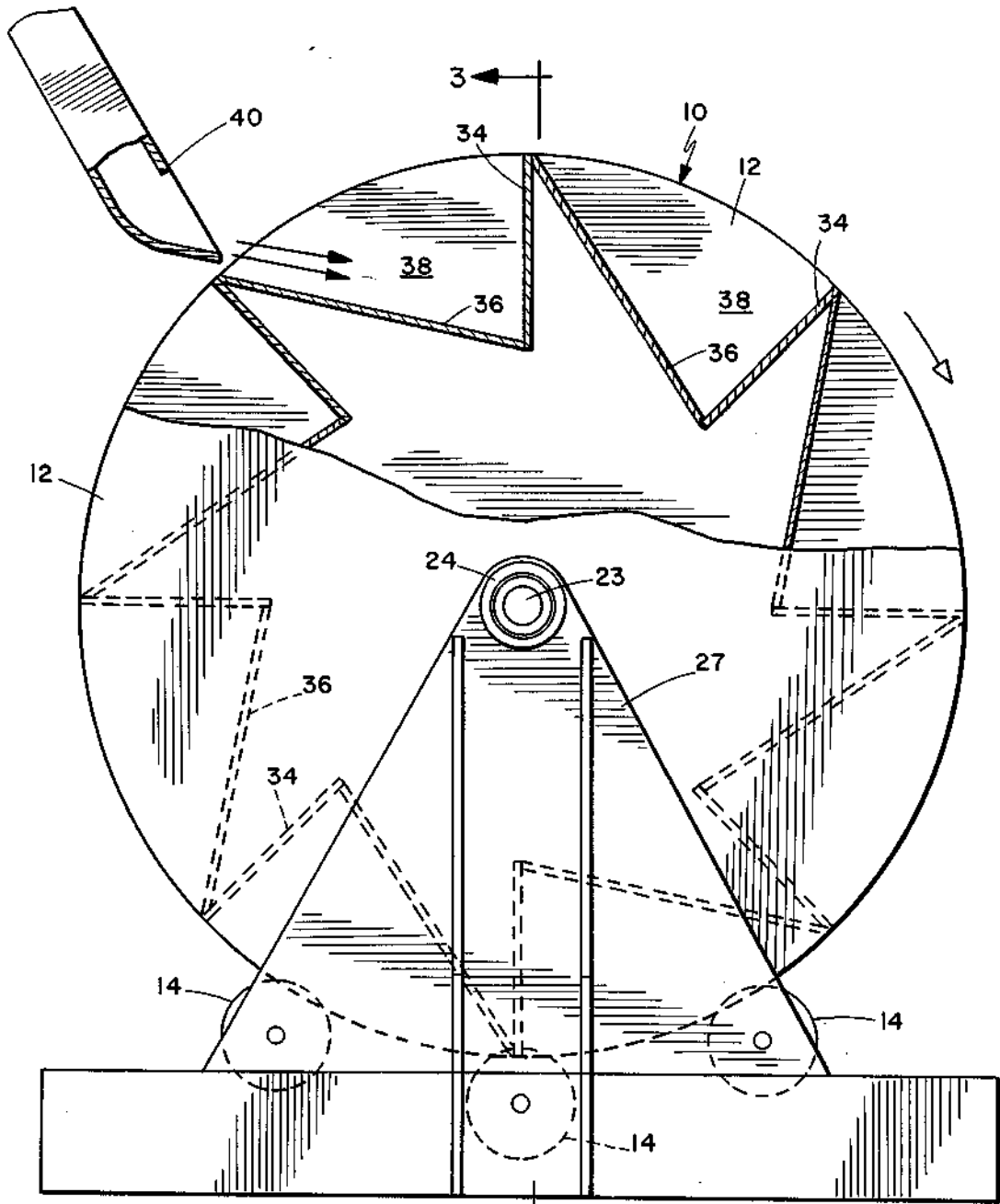


Fig. 1

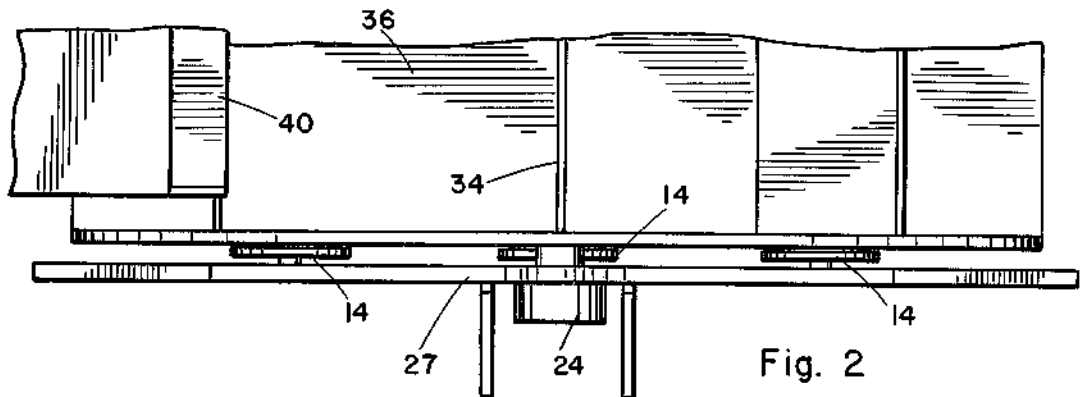


Fig. 2

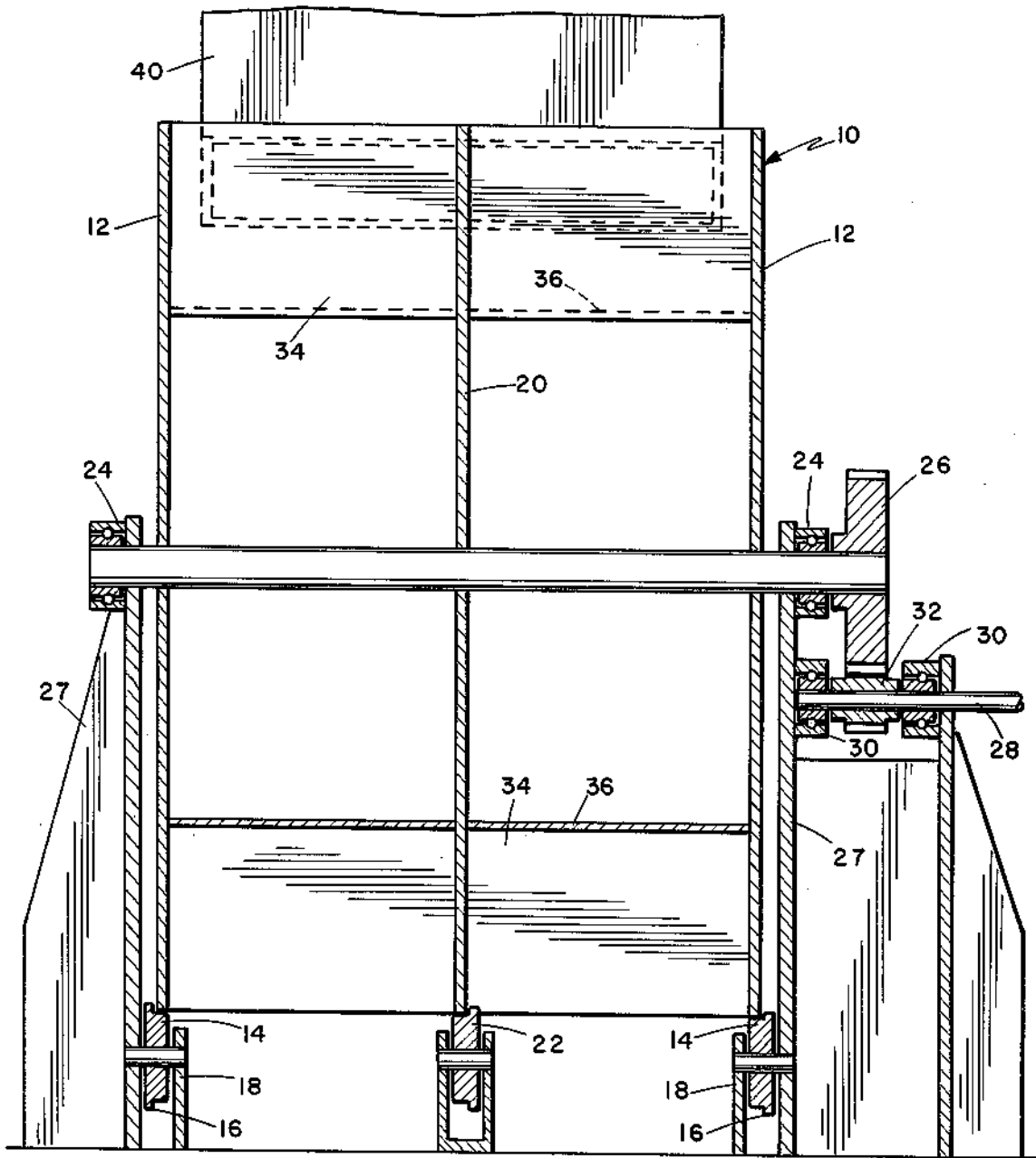


Fig. 3

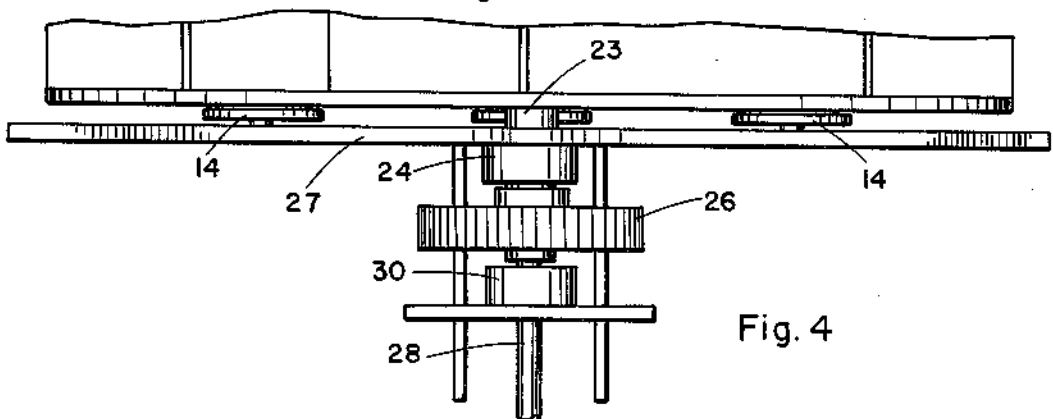


Fig. 4

## WATER WHEEL ASSEMBLY

### BACKGROUND OF THE INVENTION

The art of extracting power from moving water is old and includes numerous and different types of paddle wheels designed to extract power from moving streams and rivers, those having cup-like paddles which are operated by the gravitational force of water supplied from above, and modern hydroelectric turbines wherein high pressure water is utilized to drive the turbine structure. The water wheels of this prior art are conventionally supported by a central axle which is directly coupled to a power take off shaft, requiring the use of extremely heavy duty bearings in the power take off mechanism. There is a need for a water wheel assembly which utilizes both the pressure generated from an elevated water supply and the force of gravity on one quarter of the water wheel, and is supported other than by the central axle so that the power take-off linkage is separated from the support bearings.

### SUMMARY OF THE INVENTION

The present invention comprises a water wheel assembly which fulfills the above mentioned need and includes three spaced parallel circular wall elements having a central axle passing therethrough which connects with the power take-off mechanism, the water wheel being supported by a plurality of preferably railroad-type wheels journalled in a base structure beneath these walls. A plurality of radially extended paddle elements mounted to and between the outer walls are driven by substantially horizontally-directed water impinging on the paddles from a chute which delivers water from an elevated supply, whereby the potential energy of the elevated water supply is utilized with a simple water wheel and in the absence of a complicated turbine structure. Each of the paddle elements is also provided with a panel connected between the radially inner end of the paddle and the periphery of the wall to contain the water from the chute during approximately one quarter of the rotational cycle of the wheel so that the gravitational pull on this confined water is used to drive the wheel in addition to the force of the fast-moving water from the chute.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation view of the water wheel assembly with a sidewall partially cut away;

FIG. 2 is a top view of a portion of the assembly;

FIG. 3 is a sectional view taken along lines 3—3 of FIG. 1;

FIG. 4 is a top view of the gear mechanism and a portion of the water wheel assembly.

### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The invention includes a water wheel, generally indicated at 10, comprising a pair of spaced, circular side walls 12, each of which is supported on a plurality of bearing elements 14, which are preferably rail road wheels having flanges 16 disposed on the outer edge of the walls for lateral stability. The railroad wheels are journalled in supports 18 which are mounted in any suitable base. Parallel to and between sidewalls 12 there may be an additional circular wall 20, this wall being supported by similar bearings 22. The number of the wheels 18 and 22 may be any number greater than 1 for

each of the circular walls and need not be limited to 3, and it may be seen that the water wheel structure can rotate on these wheels or bearings independent of any additional support.

An axle 23 passes centrally through all three walls and is journalled in any suitable bearing structure 24, these bearing means being supported by upright stanchions 27 which are firmly secured at their lower extremities in concrete or otherwise stabilized. One end of the axle is provided with a driving gear 26 which delivers power to a take off shaft 28 journalled in the bearings 30, the power take off shaft having a gear 32 matching with the gear 26. Of course, any suitable transmission structure and power take off means could be used. As previously noted, the support for the wheel structure is provided by the bearing elements 18 and 22 so that the bearings 24 need not be exceptionally heavy duty.

A plurality of radially extended paddle elements 34 are mounted between the side walls 12 at angularly spaced intervals, these paddles, of course, being spaced and extending inwardly partway from the circumference of the side walls. Each of these paddle elements has a panel 36 joined to the inner edge thereof and extending at an angle on the order of 90° to the circumferences of the side walls to form a pocket-like cavity 38 between the side walls.

A water chute 40 extends upwardly from the water wheel to a water supply, not shown, to the lower end of the chute which opens and has a shelf-like deflection panel to direct water from the elevated source generally toward the paddle elements 34 as they are sequentially exposed during the rotation of the wheel. It would also, of course, be possible to substitute one or more pipes for the chute 40, the essential feature of the conduit being used, being that it directs the water directly against the paddle element.

In operation of the device, it can be seen that water supplied from the chute 40 will be delivered at high speeds against the paddles 34, the force derived therefrom causing the wheel to turn at a rapid rate. As the wheel rotates, water will be trapped in the pockets 38 and under the force of gravity will further force the wheel to rotate in the clockwise direction as shown in FIG. 1. Thus the full potential energy of the elevated water supply is extracted by the water wheel without the use of high pressure turbines and without the need for an exceptionally large wheel or conveyor assembly that extends substantially to the height of the water supply.

I claim:

1. A water wheel assembly comprising:

- a. a water wheel having
  - i. a pair of spaced parallel circular side walls;
  - ii. a plurality of radially extended paddles mounted to and between peripheral portions of said side walls, each of said paddles having a radially inner edge and a panel mounted to and between said side walls and extending from the radially inner edge of the respective paddle substantially normally thereto and extending substantially to the circumference of said side walls;
- b. means of supporting said water wheel for rotation on a horizontal axis comprising a plurality of flanged railroad car wheels rotationally mounted beneath and in supporting contact with said side walls and having flanges thereof mutually oppositely disposed to laterally secure said water wheel,

3

said wheels each being non-translatory and having an axis parallel to the axis of said water wheel and the axes of said side walls;

c. a generally straight conduit extending upwardly to an elevated water supply and being open at the lower end, the lower end of said conduit being directed generally across the upper portion of said water wheel normal to the axis thereof such that

4

water gushing from said conduit is directed generally toward consecutive ones of said paddles as said water wheel rotates;

d. said water wheel having an axle, and including mechanical linkage means coupling said axle to a power take-off shaft.

\* \* \* \* \*

10

15

20

25

30

35

40

45

50

55

60

65

[54] WATER-POWER MOTOR

[76] Inventors: Einar Granath, Apelvagen 15; Alf Granath, both of Apelvagen 15, 141 46 Huddinge, Sweden

[21] Appl. No.: 626,962

[22] Filed: Oct. 29, 1975

[30] Foreign Application Priority Data

Oct. 30, 1974 Sweden ..... 7413654

[51] Int. Cl.<sup>2</sup> ..... F03B 13/12

[52] U.S. Cl. .... 415/2; 415/8; 417/329; 417/330

[58] Field of Search ..... 415/2-4, 415/8; 417/329, 330, 334; 416/142

[56] References Cited

U.S. PATENT DOCUMENTS

|           |         |               |         |
|-----------|---------|---------------|---------|
| 8,36X     | 3/1808  | Johnson       | 416/142 |
| 641,233   | 1/1900  | Roell         | 417/330 |
| 833,361   | 10/1906 | Wilmore       | 415/4   |
| 913,770   | 3/1909  | Rockwell, Jr. | 415/4   |
| 1,003,635 | 9/1911  | Melander      | 415/4   |
| 3,807,890 | 4/1974  | Wright        | 415/2   |

FOREIGN PATENT DOCUMENTS

|         |        |        |       |
|---------|--------|--------|-------|
| 11,062  | 5/1854 | France | 415/8 |
| 997,942 | 1/1952 | France | 415/3 |

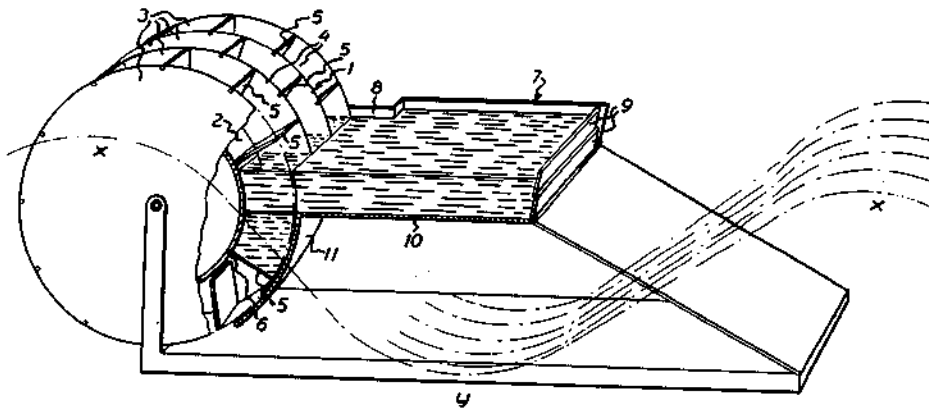
Primary Examiner—C. J. Husar

Attorney, Agent, or Firm—Beveridge, DeGrandi, Kline & Lunsford

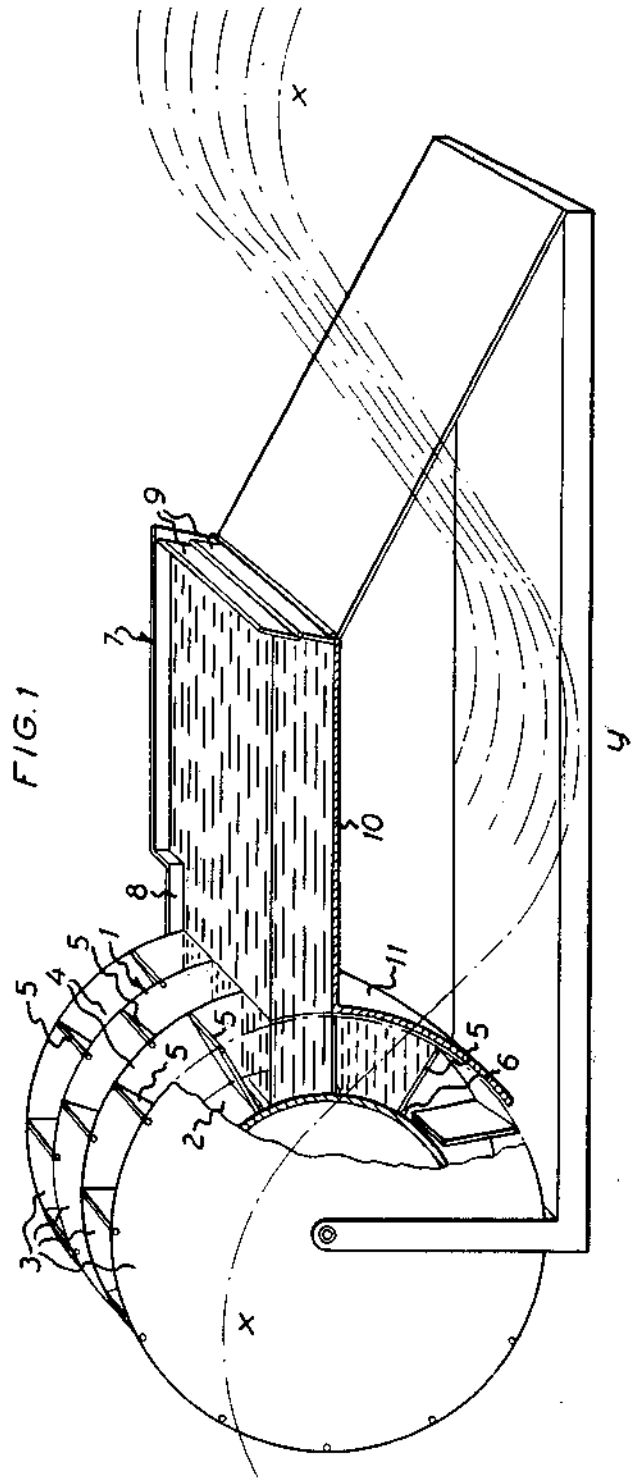
[57] ABSTRACT

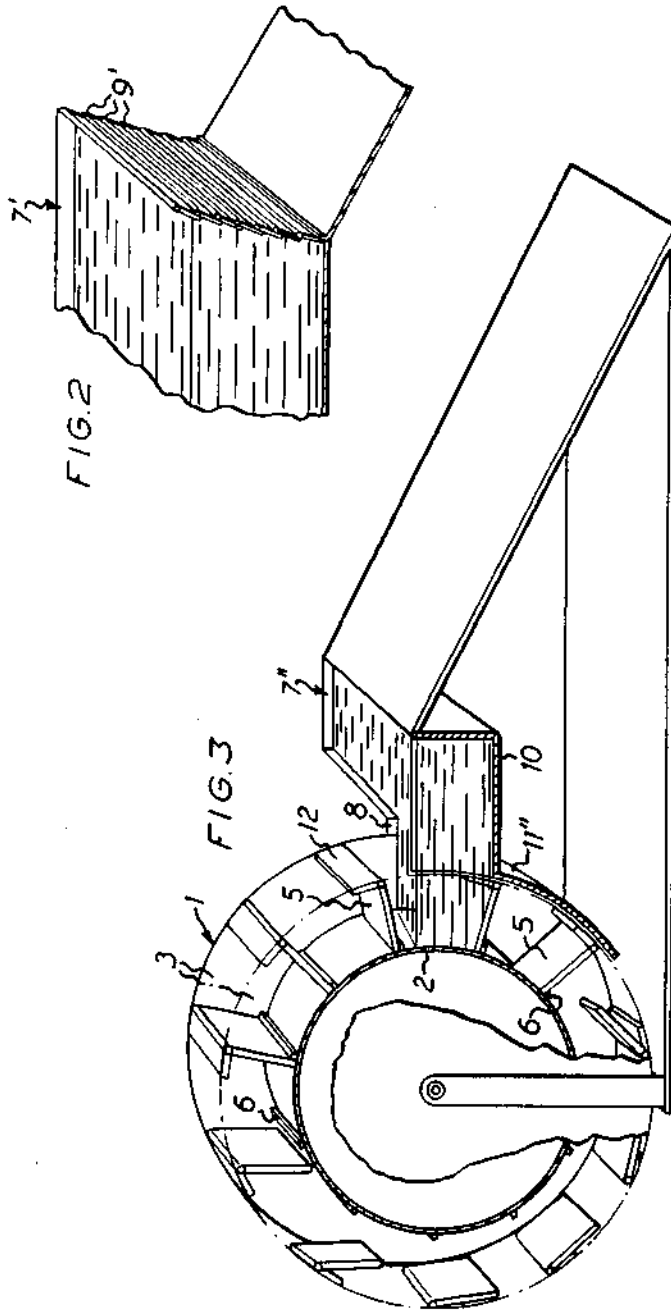
The invention relates to a water-power motor adapted to be driven by a rising and falling water surface, for instance the wave motion thereof. The novel features of the invention reside in that the water-power motor comprises one or more driving wheels each of which has a plurality of compartments defined in one direction by bottom shutters pivotally mounted in the wheel and allowing the wheel to rotate under water without any appreciable resistance, and in that the wheel or wheels are adapted to cooperate with an equalizer device in the form of a container which is supplied with water when the water surface is on a relatively high level and which in its turn supplies water to the wheel or wheels when the water surface is on a relatively low level.

8 Claims, 3 Drawing Figures









## WATER-POWER MOTOR

The present invention relates to a water-power motor preferably for rotating at a relatively low speed by the action of a rising and falling water surface, for instance the wave motion thereof. The motor comprises at least one wheel rotatable on a horizontal axis and a plurality of compartments disposed peripherally in a suitable fashion in the wheel, each compartment being defined by axially and radially disposed walls and by a pivotally mounted shutter disposed transversely of the peripheral surface of the wheel and forming when in one position the bottom of the compartment while allowing when in another position free tangential passage of water through the compartment, said shutter being mounted in such a manner that during one revolution of the wheel it will swing by gravity between a closed position and an open position, and a container is arranged adjacent said wheel to cooperate therewith, from which container water successively flows into the compartments thereby causing the wheel to rotate.

Swedish Pat. Specification No. 363,876 discloses a water-power motor comprising a number of buckets or compartments which are arranged in a rotatable wheel and provided with pivotally mounted bottoms.

The object of the present invention is to provide an apparatus of substantially the same type as the known water-power motor according to said patent specification, which apparatus — despite its simplified construction with regard to the wheel proper — when in use for exploiting wave motion energy offers a smoother run and higher efficiency than the water-power motor according to said patent. The novel features of the apparatus according to the invention reside in that the compartments which are arranged at the wheel periphery and have three fixed walls, are adapted to cooperate with a surface stationary relative to the wheel, which surface during part of the revolution closes the compartment at least partially in the outward direction.

The apparatus according to the invention will be described in greater detail hereinbelow with reference to the accompanying drawings, in which:

FIG. 1 schematically illustrates an embodiment of the apparatus as viewed obliquely from the side and partially in cross-section;

FIG. 2 illustrates, broken away, a portion of an equalizer container having modified inlet flaps; and

FIG. 3, like FIG. 1, schematically illustrates an apparatus in which the wheel and the equalizer container have been modified.

In the embodiment of FIG. 1, the wheel 1 comprises a central tubular portion 2, the outwardly facing surface of which forms the inner boundary wall of the compartments, and lateral discs 3 of which the portions located outside the central portion form the side walls of the compartments. Shutters 5 are pivotally mounted adjacent the peripheral portion 4 of the lateral discs 3 and, when in a radial position of abutment against support members 6 provided at the central portion, said shutters form the bottoms of the compartments.

When the compartments descend into the water at the lower portion of the wheel, the shutters are swung backwards against the direction of rotation and thus offer no resistance to the rotary motion of the wheel. During the continuing rotation of the wheel the shutters will resume by gravity such a position as to form again the bottoms of the compartments.

In order to perform its intended function the wheel 1 preferably cooperates with an equalizer container 7 comprising an open-top channel-shaped portion 8 having a bottom and side walls. At one end of the portion 8 are provided flaps 9 which open inwardly and, as shown, pivot about horizontal shafts, but which may of course be of any suitable design. At the opposite end of the channel-shaped portion 8 the side walls of the container extend up to and join the peripheral curvature of the outer lateral discs 3 of the wheel 1. The bottom 10 of the channel-shaped portion is provided with a curved portion 11 extending a distance along the periphery of the wheel 1, preferably a distance corresponding to the peripheral distance between two consecutive shutters.

As will appear from FIG. 1, the wheel is composed of a number of sections, each section being provided with a series of pivotally mounted shutters. The shutters in the different sections are offset with respect to each other, whereby an effect of overlapping is gained. Due to the fact that water contained in one compartment exerts a motive force on the wheel, while at the same time the filling of another compartment has just begun, the rotational movement of the wheel will become smoother and more uniform.

The motor is intended to be positioned in the water such that the wave crests X should be able to enter into and fill the equalizer container 7. The water collected therein will then fill the compartments of the wheel successively thereby causing the wheel to rotate also during the passage of a subsequent wave trough y.

In the embodiment of FIG. 2, the equalizer container 7' has a substantially greater capacity as compared with the container 7 in FIG. 1. The increased depth of the container 7' has necessitated the provision of additional inlet flaps 9'. The flaps are movably mounted in such a manner that flaps inside which there is still water from a previous wave or waves will remain closed, whereas the other flaps are free to open inwardly so as to permit more water to enter. By using the apparatus according to FIG. 2, it is possible to obtain a more uniform water supply and ensure continued rotation of the wheel, even though the supply of water should cease as a result of temporarily lower waves during some periods.

The embodiment of FIG. 3 differs from that of FIG. 1, in that the wheel comprises only one section and in that the compartments have a low outer wall 12 having a height substantially equal to half of a pivotal shutter. As in the embodiment of FIG. 1, the equalizer container 7'', here having no inlet flaps, is provided with an extension 11'', augmenting, together with the low outer walls 12 of the compartments, the capacity of the compartments when these move along the portion of their circular path during which they are filled with water.

The invention must not be considered restricted to that described above or shown in the drawings but may be modified in various ways within the spirit and scope of the accompanying claims.

What we claim and desire to secure by Letters Patent is:

1. A water-power motor, preferably for rotating at a relatively low speed by the action of a rising and falling water surface, for instance the wave motion thereof, wherein said motor comprises at least one wheel rotatable on a horizontal axis and a plurality of compartments disposed peripherally in a suitable fashion in said at least one wheel, each compartment being defined by axially and radially disposed walls and by a pivotally mounted shutter disposed transversely of the peripheral

3

4

surface of said wheel and forming when in one position the bottom of the compartment while allowing when in another position free tangential passage of water through the compartment, said shutter being mounted in such a manner that during one revolution of the wheel it will swing by gravity between a closed position and an open position, and wherein a container is arranged adjacent said wheel to cooperate therewith, from which container water successively flows into the compartments thereby causing the wheel to rotate, said container being formed so as to allow unimpeded inflow of water therinto but permitting outflow of water therefrom only via the compartments of the wheel.

2. A water-power motor as claimed in claim 1, wherein the compartments arranged at the periphery of the wheel and provided with three fixed walls are adapted to cooperate with a surface which is stationary with respect to the wheel, and adapted to close at least part of the compartment in the downward direction during part of the revolution thereof.

3. A water-power motor as claimed in claim 2, wherein said stationary surface is arranged at the container serving as an equalizer and adapted to be filled with water from the wave crests, and wherein said

container whose open, one end extends up to and joins wheel portions defining the compartments, is in direct communication with the space of a registering compartment.

4. A water-power motor as claimed in claim 2, wherein said stationary surface alone is adapted to define the wheel compartments in one direction.

5. A water-power motor as claimed in claim 2, wherein said stationary surface is adapted to cooperate with a wall arranged at the compartment, and to define together with said wall a wheel compartment in said one direction (FIG. 3).

6. A water-power motor as claimed in claim 1, wherein said equalizer container is provided with inlet flaps serving as one-way valves.

7. A water-power motor as claimed in claim 6, wherein a number of superposed inlet valves are separately mounted such that only flaps unaffected by the water held in the container open to allow water to enter.

8. A water-power motor as claimed in claim 1, wherein the pivotal bottom shutters are mounted adjacent the outer portion of the compartments.

\* \* \* \* \*

25

30

35

40

45

50

55

60

65

[54] **DEVICE FOR EXTRACTING ENERGY FROM WATER WAVES**

[75] Inventor: Robert C. H. Russell, Wallingford, England

[73] Assignee: The Secretary of State for Energy, in Her Britannic Majesty's Government of the United Kingdom of Great Britain and Northern Ireland, England

[21] Appl. No.: 802,908

[22] Filed: Jun. 2, 1977

[30] Foreign Application Priority Data

Jun. 9, 1976 [GB] United Kingdom ..... 23951/76

[51] Int. Cl.<sup>2</sup> ..... F03D 7/00

[52] U.S. Cl. .... 415/2; 415/7; 60/497; 290/53; 417/330

[58] Field of Search ..... 415/2-4, 415/7; 417/330, 331; 290/53; 60/495, 497, 501, 502

[56] References Cited

U.S. PATENT DOCUMENTS

1,143,118 6/1915 Hoffman ..... 415/7  
 1,338,326 4/1920 Peck ..... 415/7

1,782,277 11/1930 Smith ..... 415/7  
 1,811,565 6/1931 Schwabacher ..... 290/53  
 1,962,047 6/1934 Young ..... 60/497  
 2,820,148 1/1958 Southwick ..... 290/53  
 4,076,447 2/1978 Granath et al. .... 415/2  
 4,076,448 2/1978 Sanders ..... 415/2

FOREIGN PATENT DOCUMENTS

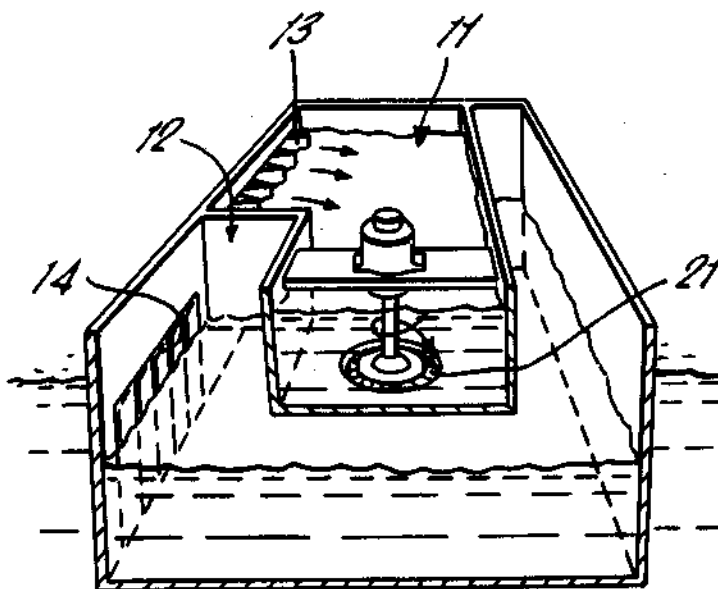
404027 6/1970 Australia ..... 60/495

Primary Examiner—C. J. Husar  
 Attorney, Agent, or Firm—Larson, Taylor & Hinds

[57] ABSTRACT

A device for extracting energy from water waves comprises high-level and low-level reservoirs with non-return valves for permitting water from wave crests to enter the high-level reservoir (but not return) and for permitting water from the low-level reservoir to escape as a water wave trough passes but preventing entry of water from the crests into the low-level reservoir. The non-return valves operate over a vertical extent and are such as to accommodate the variation in time with depth at which water pressure changes from high on one side and low the other to low on the one side and high on the other.

9 Claims, 5 Drawing Figures



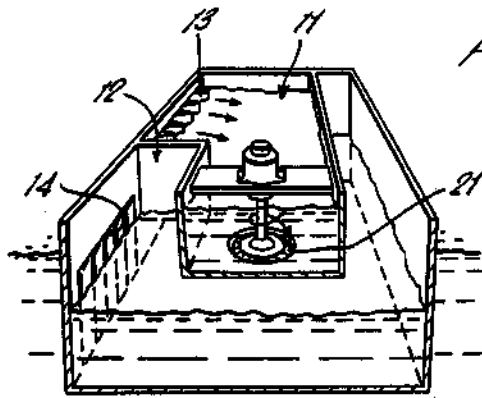


FIG. 1.

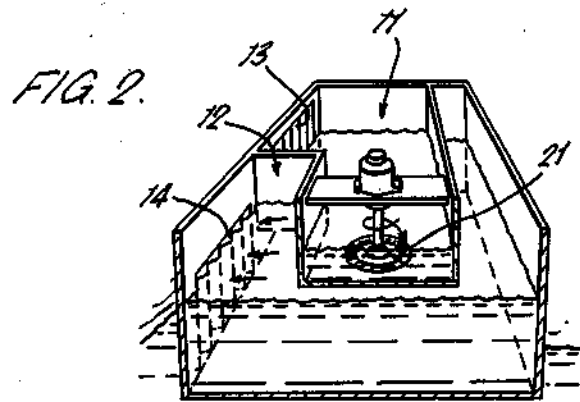


FIG. 2.

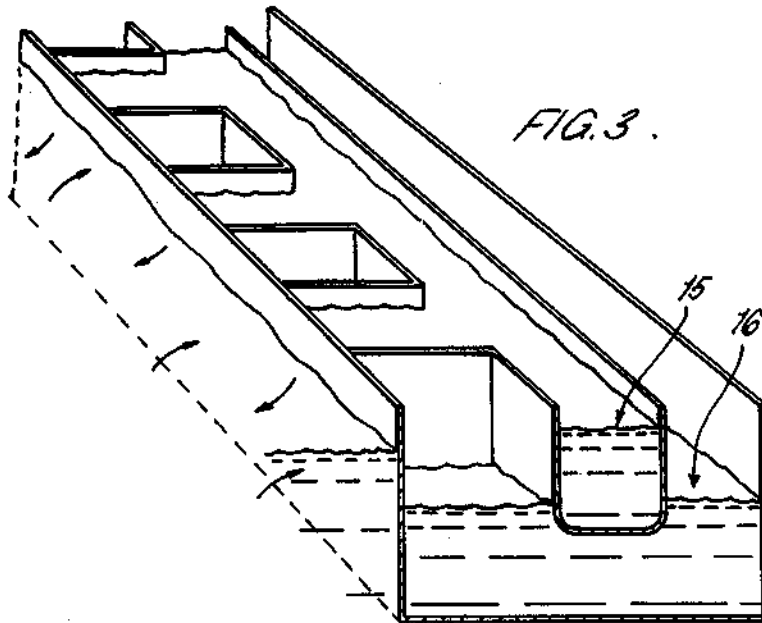


FIG. 3.

FIG. 4.

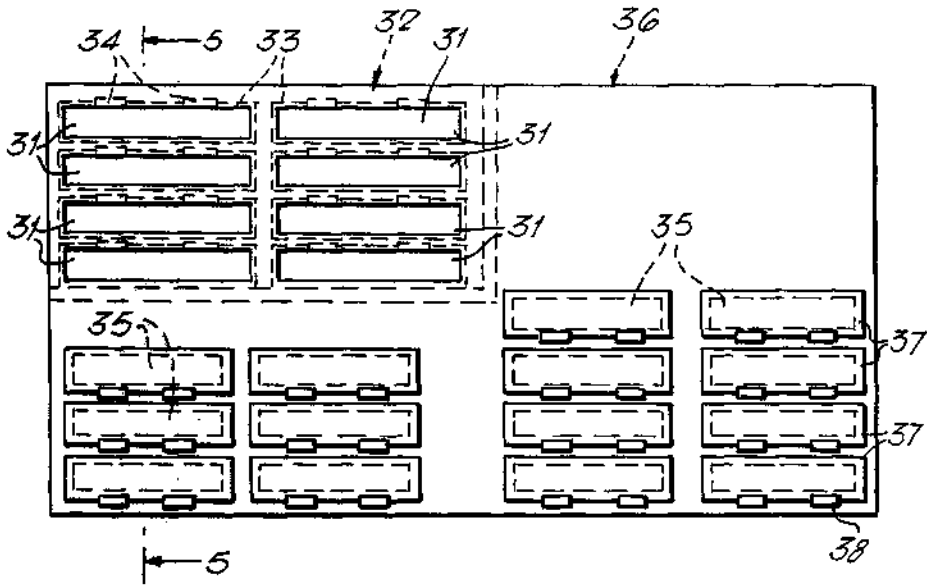
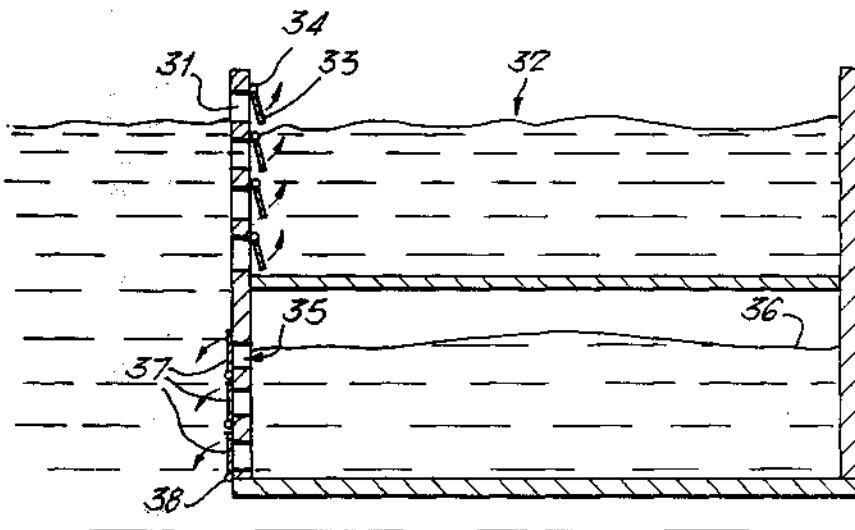


FIG. 5.



## DEVICE FOR EXTRACTING ENERGY FROM WATER WAVES

The invention relates to a device for extracting energy from water surface waves and is intended, in particular, for use in extracting energy from waves on the surface of the sea.

There have been previous proposals to provide a water reservoir in which wave energy is converted into a pressure head of water held above the mean level of the sea surface by allowing the wave crests to drive into the reservoir through non-return valves.

There has recently been described a device in which the efficiency of wave energy extraction on this principle is improved by arranging a series of high and low level reservoirs with non-return flap valves which permit the wave crests to drive water into the high level reservoirs and water in the low level reservoirs to be extracted into the wave troughs.

The present invention is concerned with an improvement of the latter device and is based upon the appreciation that the non-return valves, which extend vertically over the full range of wave height which it is desired to convert, should be capable of responding to pressure changes which do not occur simultaneously at all points up and down the vertical extent of the non-return valves.

Accordingly the invention provides a device for extraction of energy from water waves comprising a structure defining at least one high-level reservoir and at least one low-level reservoir, first non-return valve means operative over a vertical extent of the high level reservoir, which first non-return valve means open to permit passage of water into the high-level reservoir but close to prevent passage of water out of the high-level reservoir, second non-return valve means operative over a vertical extent of the low-level reservoir, which second non-return valve means open to permit passage of water out of the low level reservoir but close to prevent passage of water into the low-level reservoir, the first and the second non-return valve means being adapted to respond to changes in water pressure across the valve means which occur at different times at different vertical positions up and down the vertical extent of the valve means, thereby to permit passage of water at one vertical position where the pressure difference across the valve means is in the forward direction whilst remaining closed or substantially closed at another vertical position where the pressure difference across the valve means is in the return direction.

The non-return valve means preferably comprise apertures and hinged flaps which move with the water in one direction to open the apertures and in the other direction to close the apertures.

In one arrangement according to the invention the apertures are vertically extending slits with corresponding vertically extending flaps hinged on a vertical axis. In this case the flaps are so constructed as to be capable of twisting so that they can be open at the top whilst closed at the bottom.

Alternatively the non-return valve means comprise a plurality of apertures and associated flaps hinged horizontally, of short vertical extent and arranged one above another to provide the required overall vertical extent of the non-return valve means. In this way the hinged flaps at the various vertical levels can open and

close independently of one another and in response to local pressure variations.

Preferably the flaps are constructed to have a density close to that of the water in which the device is to be used. Vertically hinged flaps and horizontally hinged flaps for a high level reservoir are desirably of density slightly greater than that of the water. Horizontally hinged flaps for a low level reservoir are desirably hinged at their lower edges and constructed to have a density slightly greater than that of the water.

In one arrangement according to the invention a plurality of high-level reservoirs are intercommunicating to form a group and a plurality of low-level reservoirs are intercommunicating to form a group and a turbine is driven by water allowed to pass through it from the group of high-level reservoirs to the group of low-level reservoirs.

In another arrangement according to the invention, a series of high- and low-level reservoir pairs are arranged so as to be acted upon in sequence by crests and troughs reaching the device and, in each pair, water flows from the high-level reservoir to the low-level reservoir via a vertical axis turbine.

Specific constructions of apparatus embodying the invention will now be described by way of example and with reference to the drawings filed herewith, in which:

FIGS. 1 and 2 are diagrammatic perspective views, partly in section, to illustrate the principle of operation of the device,

FIG. 3 is a diagrammatic perspective view, partly in section, of a device having a plurality of intercommunicating high-level reservoirs and a plurality of intercommunicating low-level reservoirs,

FIG. 4 is a diagrammatic side view of part of another device, and

FIG. 5 is a diagrammatic sectional view on the line 5—5 of FIG. 4.

Referring to the drawings, the device comprises a series of compartments alternately comprising (or forming part of) respectively high-level and low-level reservoirs 11, 12. As shown in FIGS. 1 and 2 a series of vertically hinged flaps 13 in the wall of the high-level reservoir 11 permit passage of water into the reservoir but prevent return of water back past the flaps 13. A corresponding series of vertically hinged flaps 14 in the wall of the low-level reservoir 12 permit passage of water out of the reservoir but prevent return of water into the reservoir. FIGS. 1 and 2 show diagrammatically a vertical axis turbine 21 arranged to be driven by flow of water from the high-level reservoir 11 into the low-level reservoir 12.

FIG. 3 shows how a plurality of compartments are arranged to provide alternate wall sections coupled via non-return valves with the high-level and low-level reservoirs respectively. The compartments forming the high-level reservoir are intercommunicating via a channel 15 (FIG. 3) whilst the compartments forming the low-level reservoir are intercommunicating via a channel 16 (FIG. 3).

Operation of the device will be apparent from FIGS. 1 and 2. As a wave crest reaches a compartment of the high-level reservoir 11, and the water level outside rises above that in the reservoir 11, the flaps 13 hinge open (FIG. 1) so that water is taken into the reservoir 11. When the outside water level falls below that in the high-level reservoir 11, the flaps 13 close (FIG. 2). As a wave trough reaches a compartment of the low-level reservoir 12, and the water level outside falls below that



in the reservoir 12, the flaps 14 hinge open (FIG. 2) releasing water from the low level reservoir. When the outside water level again rises above that in the low-level reservoir 12, the flaps 14 close (FIG. 1).

FIGS. 1 and 2 show, in highly diagrammatic form a vertical axis turbine driven by water from the high-level reservoir 12.

In one arrangement, each compartment is separate and a turbine is provided in each pair of compartments between that which forms the high-level reservoir and that which forms the low-level reservoir. In the arrangement shown in FIG. 3, where the compartments are intercommunicating in groups, only one turbine would be required for each pair of groups forming respectively high- and low-level reservoirs.

In accordance with the invention, the vertically hinged flaps 13, 14 are constructed to be capable of twisting so that, for example, they can open at the top whilst remaining substantially closed at the bottom or vice-versa. For this purpose the flaps are conveniently constructed of rubber or similar material. In this way the flaps accommodate the variation in time with depth at which water pressure on one side of the flaps rises above and falls below that on the other side.

An alternative configuration, illustrated in FIGS. 4 and 5, is to hinge the flaps horizontally, each flap being of short vertical extent and arranged in series one above another, thus having an appearance similar to the slats of a venetian blind.

Referring to FIGS. 4 and 5, apertures 31 provide access to high level reservoir 32. Flow through these apertures 31 is controlled by flaps 33 hinged (e.g. at 34) horizontally. The flaps 33 are of short vertical extent so that they can open and close independently of one another to accommodate the variation in time with depth at which water pressure on one side of the flaps rises above and falls below that on the other side. The flaps 33 are also of limited horizontal extent to avoid the problem, where wave approach is not at right angles to the flaps, of a flap 33 held open by a wave crest at one end whilst the trough is already approaching the other end of the flap.

Apertures 35 provide outlets from the low level reservoir 36 and flow through these apertures 35 is controlled by flaps 37 hinged horizontally (e.g. at 38). It will be noted that these flaps 37 for the low level reservoir are hinged at their lower edge rather than at the top. The reason for this is that these flaps 37 are required to close as the water wave on the outside is rising up the side of the reservoir wall. If the flaps 37 are hinged at the top, the rising water tends to carry the flaps upwards and hold them open when they should be shut. Provided the flaps 37 are slightly buoyant, this problem is avoided or reduced by hinging at the lower edge of the flaps 37.

It is important that the valve should open from closed to wide open with the minimum flow of water and the minimum impedance to water flow. To this end the flaps, where vertically hinged, are constructed of material of density close to, but slightly above, that of the water in which the device is used. In the arrangement employing horizontally hinged flaps, there is the advantage that the weight of the flaps for the high level reservoir, or, if necessary, added weight, serves to provide a small bias towards the closed position. As mentioned above, flaps for the low level reservoir are desirably slightly buoyant (lower density than water) and are

hinged at their edges. Here the buoyancy provides a small bias towards the closed position.

Choice of the dimensions of the flaps and the compartments are important. Thus, the dimension of the flaps perpendicular to the hinge should be short to reduce the water movement necessary to fully open or fully close the flap. Volume flow has therefore to be increased by increasing the number of flap valves rather than by increasing their size.

For horizontally hinged flaps, the dimension from hinge to edge must be small relative to the orbit length, that is the distance which the water particles move in executing the wave motion.

The distance between the divide walls that separate areas of inward opening valves from areas of outward-opening valves, and also separation of high-level from low-level reservoirs, should for maximum efficiency, be small compared with the average wavelength of the waves from which the device is to extract energy.

The overall size, or reach, of the reservoirs will have an optimum determined by a compromise between quantities of structural material involved and the desirability of capturing the maximum water movement from each wave.

The device may comprise a structure built on, or anchored to, the sea bed or may, alternatively be constructed in the form of a large floating structure of total size significantly greater than the average wave length.

The device has advantages over most mechanical systems designed for extraction of energy from water waves in that it is not sensitive to wave period and does not require to be tuned to suit the period of the oncoming waves. The device does benefit, however, from being tuned to an appropriate wave-height since it is desirable for maximum efficiency to pass flow through the turbines at such a rate as to maintain a certain head difference between high-level and low-level reservoirs, and this is a fraction, around half, of the waveheight at sea.

The invention is not restricted to the details of the foregoing examples. For instance, flap valves need not necessarily be employed but other forms of non-return valve may be employed provided these meet the operational requirements described above. A possibility, for example, is a honeycomb arrangement of ball valves, but it is doubtful if these could compete with flap valves in respect of the requirements for maximum volume flow and minimum water movement from fully closed to fully open positions.

I claim:

1. A device for extraction of energy from water waves comprising a structure defining at least one high-level reservoir and at least one low-level reservoir, first non-return valve means operative over a vertical extent of the high level reservoir, which first non-return valve means open to permit passage of water into the high-level reservoir but close to prevent passage of water out of the high-level reservoir, second non-return valve means operative over a vertical extent of the low-level reservoir, which second non-return valve means open to permit passage of water out of the low-level reservoir but close to prevent passage of water into the low-level reservoir, the first and the second non-return valve means operating at one vertical position at least partly independently of operation at another vertical position thereby to respond to changes in water pressure across the valve means which occur at different times at different vertical positions up and down the vertical extent of

the valve means, and to permit passage of water at one vertical position where the pressure difference across the valve means is in the forward direction while remaining closed or substantially closed at another vertical position where the pressure difference across the valve means is in the return direction and power generating means driven by the flow of water from the high-level reservoir to the low-level reservoir under the pressure head established by the difference in water levels in the respective reservoirs.

2. A device as claimed in claim 1, wherein the non-return valve means comprise apertures and hinged flaps which move with the water in one direction to open the apertures and in the other direction to close the apertures.

3. A device as claimed in claim 2, wherein the apertures are vertically extending slits and the flaps are correspondingly vertically extending and are hinged on a vertical axis, the flaps being so constructed as to be capable of twisting so that they can be open at the top whilst closed at the bottom.

4. A device as claimed in claim 2, wherein the non-return valve means comprise a plurality of apertures and associated flaps hinged horizontally, of short vertical extent and arranged one above another to provide the required overall vertical extent of the non-return valve means.

5. A device as claimed in claim 2, wherein the flaps are constructed to have a density close to that of the water in which the device is to be used.

6. A device as claimed in claim 3, wherein the flaps are constructed to have a density close to but slightly greater than that of the water in which the device is to be used.

7. A device as claimed in claim 4, wherein the flaps for the high level reservoir are hinged along their upper edges and are constructed to have a density close to but slightly greater than that of the water in which the device is to be used and the flaps for the low level reservoir are hinged along their lower edges and are constructed to have a density close to but slightly less than that of the water in which the device is to be used.

8. A device as claimed in claim 1, wherein a plurality of high-level reservoirs are intercommunicating to form a group and a plurality of low-level reservoirs are intercommunicating to form a group and a turbine is driven by water allowed to pass through it from the group of high-level reservoirs to the group of low-level reservoirs.

9. A device as claimed in claim 1, wherein a series of high- and low-level reservoir pairs are arranged so as to be acted upon in sequence by waterwave crests and troughs reaching the device and, in each pair, water flows from the high-level reservoir to the low-level reservoir via a vertical axis turbine.

\* \* \* \* \*

30

35

40

45

50

55

60

65

- [54] WATER WHEEL ELECTRIC GENERATION DEVICE
- [76] Inventor: Edward R. Rogers, 69 Prescott Ave., Chelsea, Mass. 02150
- [21] Appl. No.: 94,960
- [22] Filed: Nov. 16, 1979
- [51] Int. Cl.<sup>3</sup> ..... F03B 13/12
- [52] U.S. Cl. .... 290/53; 417/334
- [58] Field of Search ..... 416/9, 142 B, 86; 417/336, 334; 290/53

[56] **References Cited**  
**U.S. PATENT DOCUMENTS**

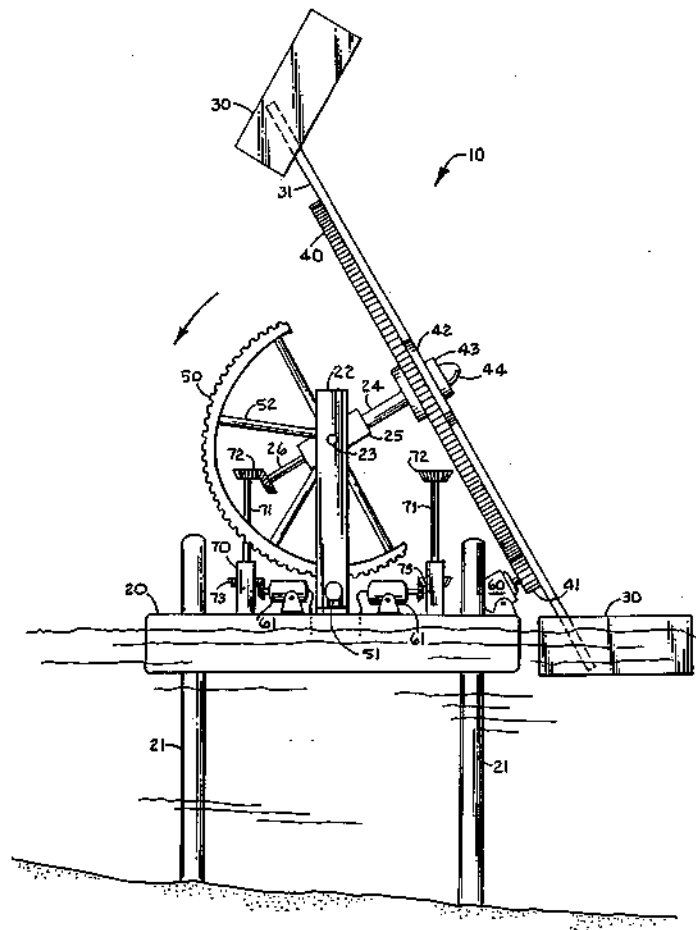
|           |        |         |         |
|-----------|--------|---------|---------|
| 1,067,064 | 7/1912 | Ripson  | 416/142 |
| 1,112,352 | 5/1913 | Booth   | 417/334 |
| 1,241,297 | 7/1914 | Stauber | 417/334 |
| 1,488,387 | 3/1924 | Gordon  | 416/88  |

Primary Examiner—J. V. Truhe  
 Assistant Examiner—Donald Rebsch

[57] **ABSTRACT**

An improved water powered electric generating device which comprises a buoyant platform and a plurality of pylons fixedly mounted in the ocean or riverbed and which slidably engages the buoyant platform, and a tower means fixedly mounted to the buoyant platform and upwardly extending therefrom. Axle means are rotatable about an axis and pivotally adapted to the tower means and include means to rotate the axle means in an arc of substantially 120°, connected on one end to the tower means and on the other end to the axle means. The axle means and a plurality of radially and outwardly directed paddle arms are fixedly mounted to the first gear means and formed at the outward end thereof into a paddle to engage the moving water and rotate the first gear means. Pinion gear means toothedly engage the first gear means and are rotated thereby, and generator means are adapted to the pinion gear means and activated thereby to produce electricity.

3 Claims, 2 Drawing Figures



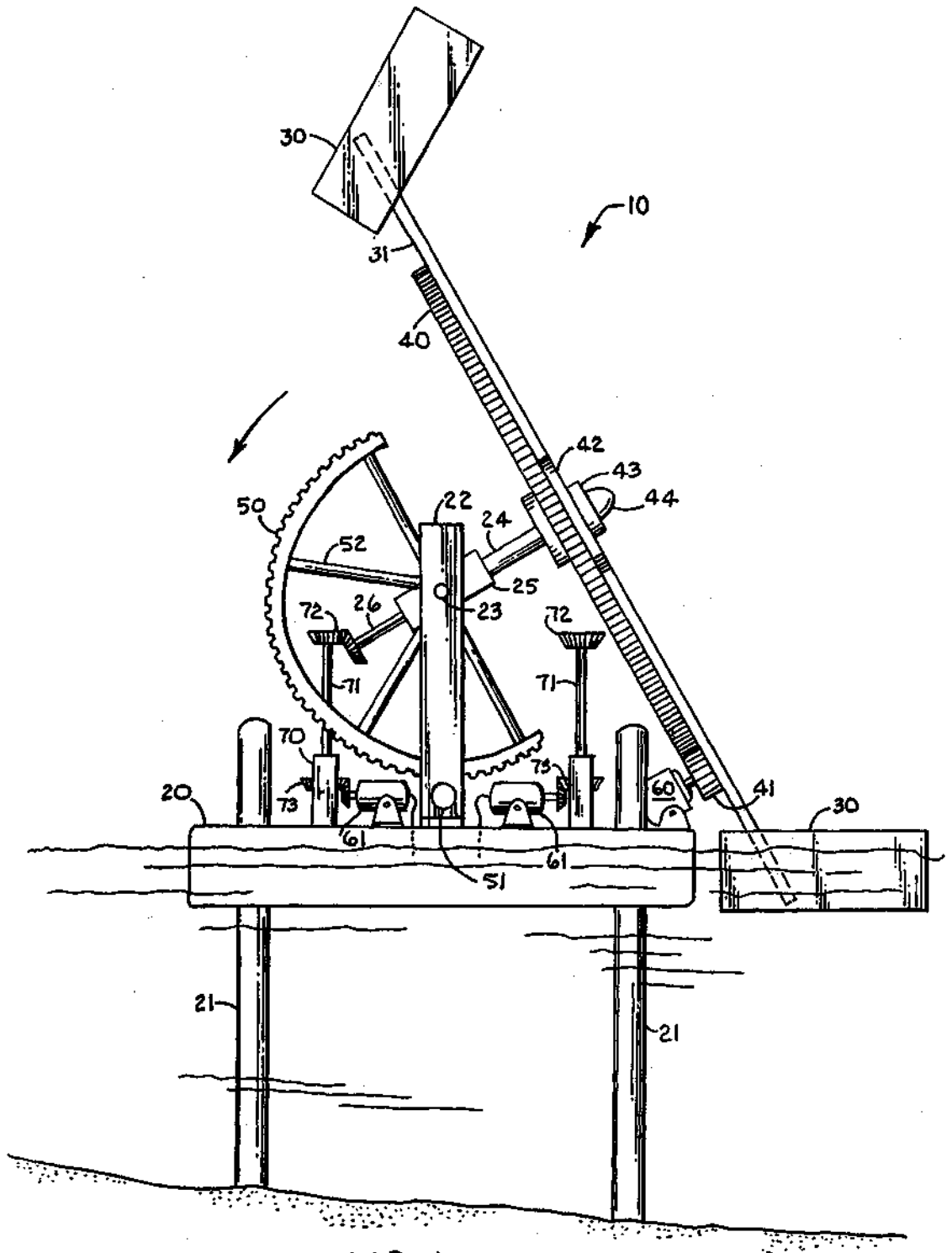


FIG. 1

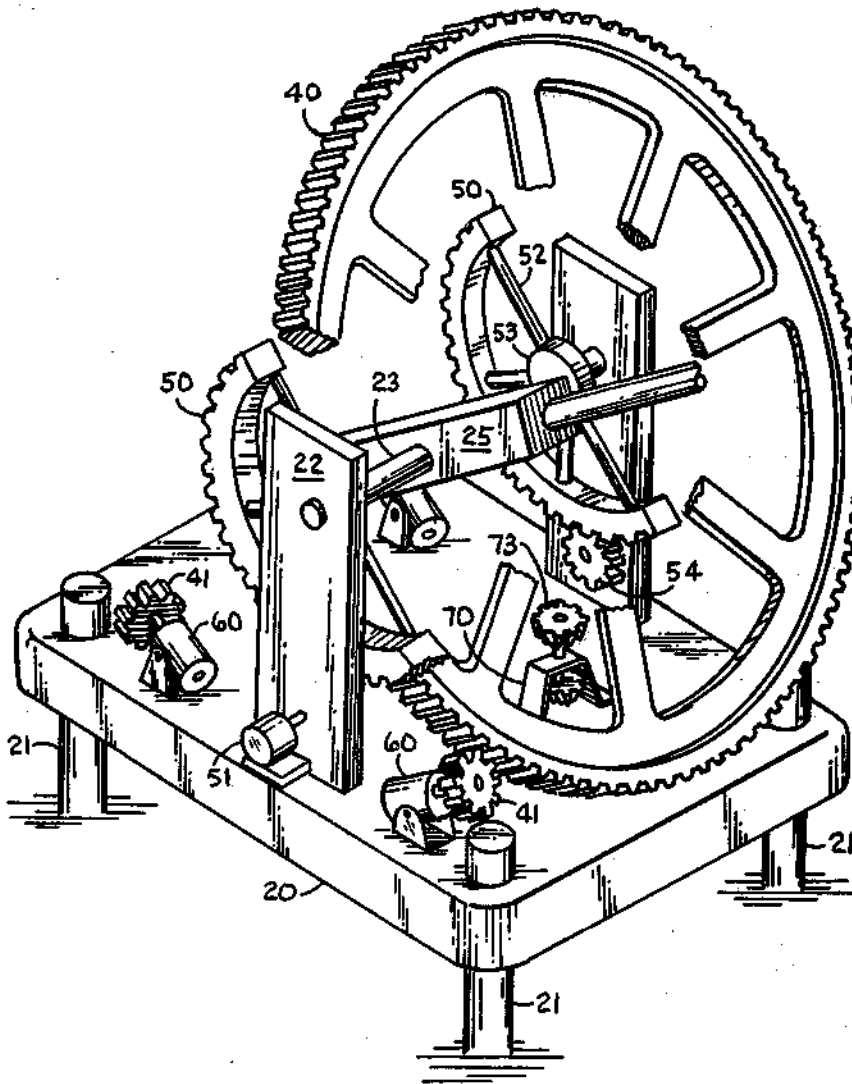


FIG. 2

## WATER WHEEL ELECTRIC GENERATION DEVICE

### BACKGROUND OF THE INVENTION

The so-called "energy crisis" has directed inventors to consider use of means to generate electricity by harnessing the sun, wind and tidal ebb and flow. Of particular interest in the present invention is the use of the aforementioned tidal ebb and flow for the production of useful electric power. Various devices are known but are not wholly satisfactory for a variety of reasons.

For example, U.S. Pat. No. 3,959,663 teaches a complicated device for generating electric power by utilizing a platform which rises and falls, with high tide rising and developing a certain potential energy which is converted to kinetic energy as the platform falls to the low tide level, by the incorporation of a pendulum mechanism. This device generates energy only twice a day as there are only two tidal changes in a 24-hour period.

U.S. Pat. No. 3,604,942 teaches a rotor turbine device suitable to be positioned in a river current and rotated, thereby generating electricity.

There exists then a need for a water powered electric generating device which is simple to operate, stable while in use, and inexpensive while simple in construction. In addition this device should have relatively few parts and overcome the disadvantages of prior devices.

### SUMMARY OF THE INVENTION

My invention relates to an improved water power electric generating device. I have discovered an improved water power electric generating device which comprises a buoyant platform and a plurality of pylons fixedly mounted in the ocean or river-bed and which slidably engages the buoyant platform, and a tower means fixedly mounted to the buoyant platform and upwardly extending therefrom. Axle means are rotatable about an axis and pivotally adapted to the tower means and include means to rotate the axle means in an arc of substantially 120°, connected to one end to the tower means and on the other end to the axle means. The axle means and a plurality of radially and outwardly directed paddle arms are fixedly mounted to the first gear means and formed at the outward end thereof into a paddle to engage the moving water and rotate the first gear means. Pinion gear means toothedly engage the first gear means and are rotated thereby, and generator means are adapted to the pinion gear means and activated thereby to produce electricity.

Preferably and optionally my water power electric generating device pivots in an upwardly directed arc from one position substantially 120° to a second position.

My invention provides numerous advantages over those devices found in the prior art. It is an advantage of my invention to utilize not only the flow but also the ebb tide to generate electricity.

Further advantages of my invention are that it is secure and stable while in use and is strong and durable, simple to manufacture, efficient, and economical in the generation of electric power.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective, illustrative side view of the device.

FIG. 2 is a detailed perspective view of the power wheel means.

### DETAILED DESCRIPTION OF THE DRAWINGS

Referring now in particular to the accompanying drawings, my water powered electric generating device is generally indicated in FIG. 1 at 10, and includes buoyant platform 20, slidably engaging a multiplicity of pylons 21. The rise and fall of the buoyant platform on said pylons is dictated by the change of tide from high to low and vice versa. A tower member 22, having pivot 23, supported therethrough is fixedly mounted on said buoyant platform. Rotor shaft 24 extends substantially upwardly from rotor shaft housing 25, and rotor shaft extension 26, extends substantially downwardly from said rotor shaft housing.

Bull gear 40 is mounted onto the rotor shaft and affixed thereto by collar 43 and nut 44. A plurality of arms 31, extend outwardly from the center of said bull gear, each of which has at one end thereof a paddle means 30, and at the other end attaches to the arm support 42.

Pinion 41 toothedly engages said bull gear at one end thereof and at the other end thereof engages generator 60. A second pinion and generator are located at the other end of the substantially 120° arc (see FIG. 2) so that the bull gear may engage said pinions to generate electricity both at ebb and flow tides.

Gear segment 50, supported by gear support 52, and attached to gear drive 51, revolves the bull gear in the substantially 120° arc to engage the other pinion/generator means to generate electricity upon the changing tide or to let navigation pass the water power electric generating device system.

Further electric power is obtained from the cooperation of upper bull gear 72, supported by extension 71, and support 70, and lower bull gear 73, which adapt to center generators 61 to produce more electricity. This beveled gear system is duplicated at the other end of the substantially 120° arc of the bull gear.

Typically when the water powered electric generator device is in use the paddle means contact the water surface and are driven by the flow of the tide or the current in the river in one direction which rotates the bull gear which in turn rotates the pinions at a rapid rate, generating electricity. At the change of tides the power wheel means is rotated 120° and catches the tidal flow in the opposite direction, turning the bull gear and once again generating electricity. On a river, the bull gear can be rotated 120° to allow passage of boats. As illustrated and described, my water power electric generating device has numerous advantages over the present devices used for generating electricity from the tidal and river flows.

What I claim is:

1. A water power electric generating device comprising:

- (a) a buoyant platform
- (b) a plurality of pylons, fixedly mounted in the ocean or river-bed, slidably engaging said buoyant platform;
- (c) tower means fixedly mounted to said buoyant platform and upwardly extending therefrom;
- (d) axle means rotatable about an axis and pivotally adapted to said tower means;
- (e) means to rotate said axle means in an arc of substantially 120° connecting on one end to said tower means and on the other end to said axle means;

3

4

(f) first gear means fixedly mounted to said axle means;

(g) a plurality of radially and outwardly directed paddle arms fixedly mounted to said first gear means and formed at the outward end thereof into a paddle to engage the moving water and rotate said first gear means;

(h) pinion gear means toothedly engaging said first gear means and rotated thereby;

(i) generator means adapted to said pinion gear means and activated thereby to produce electricity.

2. The water power electric generating device of claim 1, wherein said axle means further comprise:

(a) axle housing means disposed about said axle means;

(b) shaft means disposed through said axle housing means substantially perpendicularly to said axle means transfixing said tower means and adapted thereto to allow pivoting of said first gear means in an arc substantially 120°.

3. The water power electric generating device of claim 2, wherein said means to rotate said axle means further comprise:

(a) a gear segment means fixedly mounted to said shaft means and moveable between a first position substantially 120° to a second position;

(b) gear segment drive means engaging said gear segment means and when activated moves said gear segment means between said first and said second positions.

\* \* \* \* \*

20

25

30

35

40

45

50

55

60

65

[54] APPARATUS FOR CONVERTING FLOW OF WATER INTO ELECTRICAL POWER

[76] Inventor: Marvin Olson, 4457 Open Meadow Ct., San Jose, Calif. 95129

[21] Appl. No.: 499,317

[22] Filed: May 31, 1983

[51] Int. Cl.<sup>3</sup> ..... F03B 7/00

[52] U.S. Cl. .... 290/54; 290/42; 290/43; 290/55

[58] Field of Search ..... 290/1 R, 42, 43, 44, 290/53, 54, 55; 60/495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507; 416/132 B, 178, 84, 85; 417/330, 333, 334; 198/702, 701, 703, 704, 608; 415/2-7

[56] References Cited

U.S. PATENT DOCUMENTS

|           |        |                   |           |
|-----------|--------|-------------------|-----------|
| 363,244   | 5/1887 | Kates .....       | 416/84 X  |
| 559,798   | 5/1896 | Harding .         |           |
| 1,291,768 | 1/1919 | Cole .....        | 198/702   |
| 1,413,930 | 4/1922 | Orr et al. ....   | 198/702   |
| 1,764,539 | 6/1930 | Stinson .....     | 198/702   |
| 2,322,415 | 6/1943 | Buckbee .....     | 198/701 X |
| 2,848,189 | 8/1958 | Caloia .....      | 253/11    |
| 3,262,411 | 7/1966 | Kaltenecker ..... | 114/5     |
| 3,446,171 | 5/1969 | Panoff .....      | 114/5     |

|           |         |                 |          |
|-----------|---------|-----------------|----------|
| 3,752,738 | 8/1973  | Naymark .....   | 176/87   |
| 3,912,937 | 10/1975 | Lesser .....    | 290/54 X |
| 3,995,170 | 11/1976 | Graybill .....  | 290/44 X |
| 4,001,596 | 1/1977  | Kurtzbein ..... | 290/53   |
| 4,023,041 | 5/1977  | Chappell .....  | 290/42 X |
| 4,204,406 | 5/1980  | Hopfe .....     | 60/398   |
| 4,270,056 | 5/1981  | Wright .....    | 290/54   |
| 4,301,377 | 11/1981 | Rydz .....      | 290/54 X |
| 4,359,868 | 11/1982 | Slonim .....    | 60/501   |

OTHER PUBLICATIONS

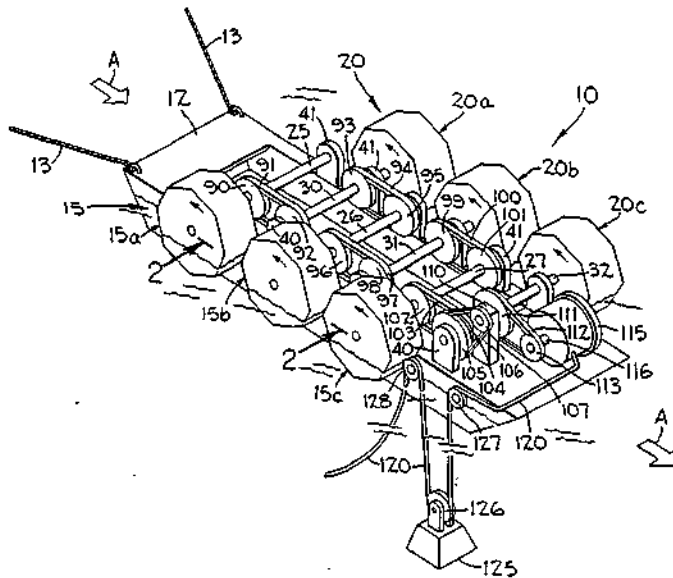
Pictorial Handbook of Technical Devices by Grafstein and Schwarz, 1971, Chemical Publishing Co., Inc., pp. 452 and 453.

Primary Examiner—William M. Shoop  
 Assistant Examiner—Paul Shik Luen Ip  
 Attorney, Agent, or Firm—Jack M. Wiseman

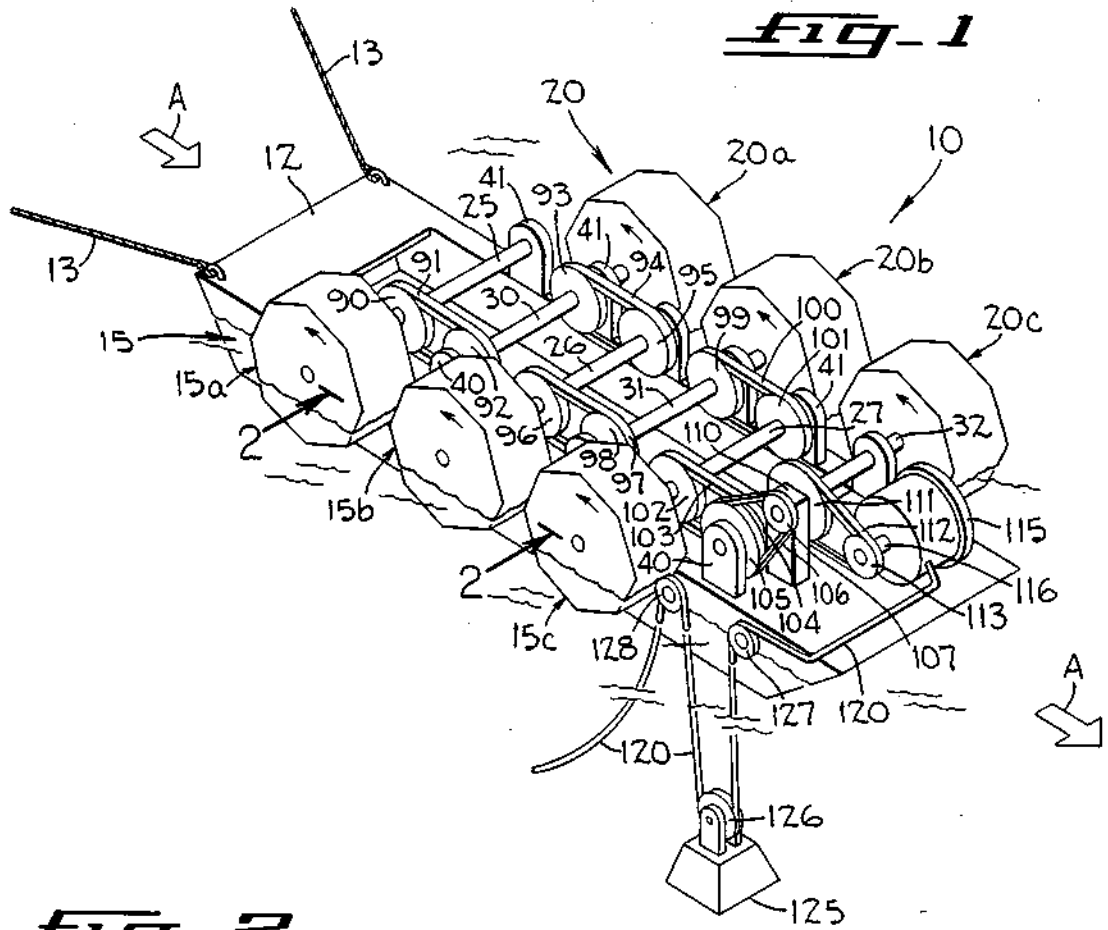
[57] ABSTRACT

Apparatus for generating electrical power includes a floatable platform, which supports a plurality of water wheels. The shafts of the water wheels are interconnected in tandem for driving an electric generator. The speed of rotation of each of the water wheels is regulated by adjustably positioning the respective vanes thereof.

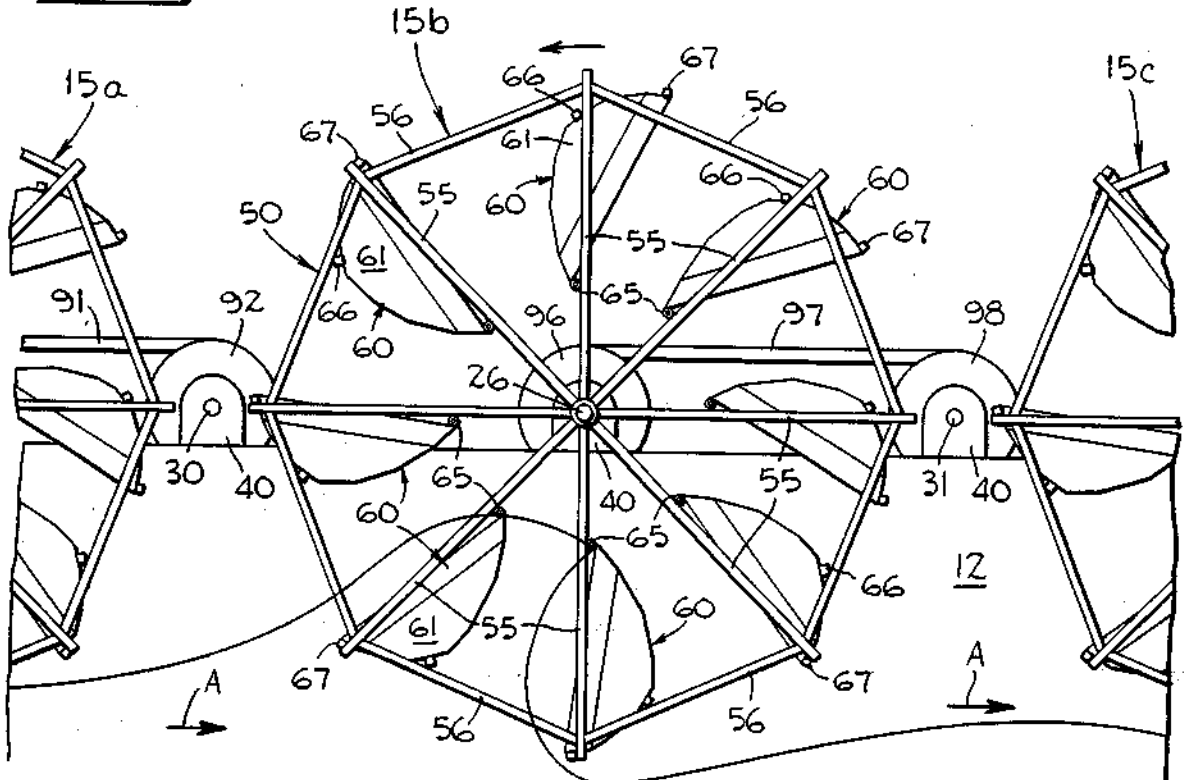
7 Claims, 4 Drawing Figures



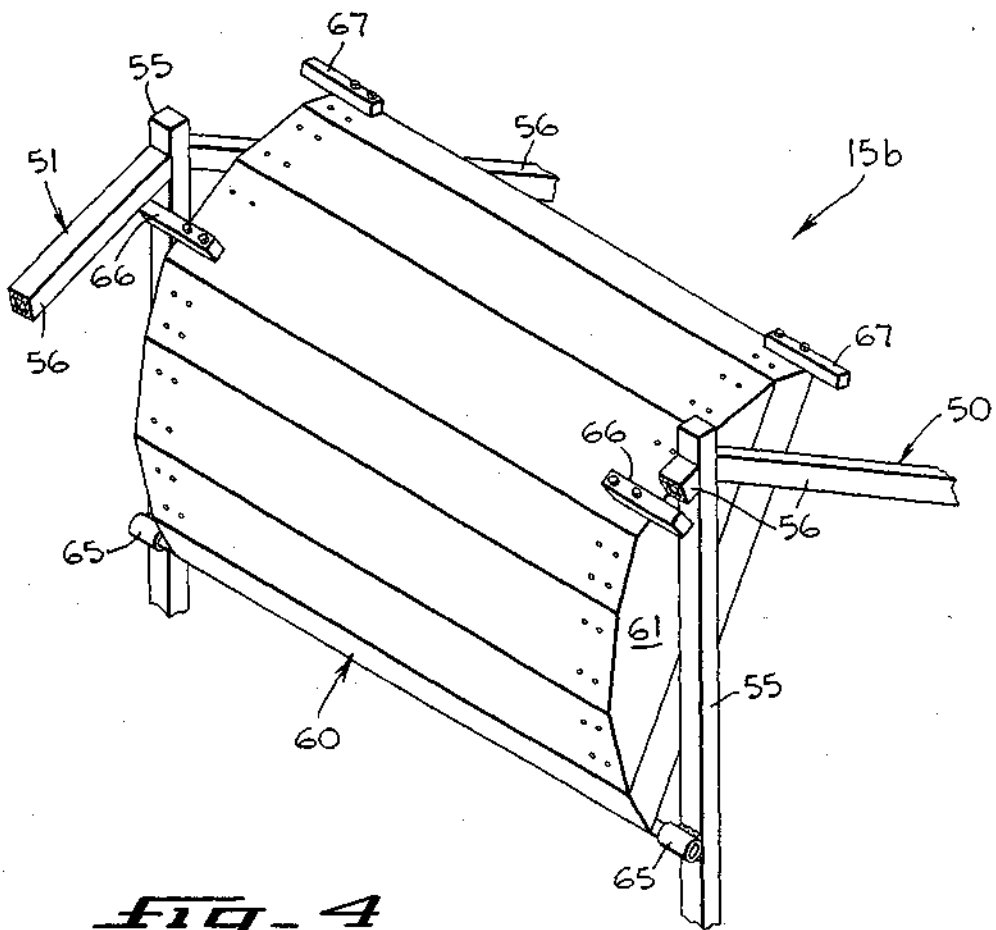
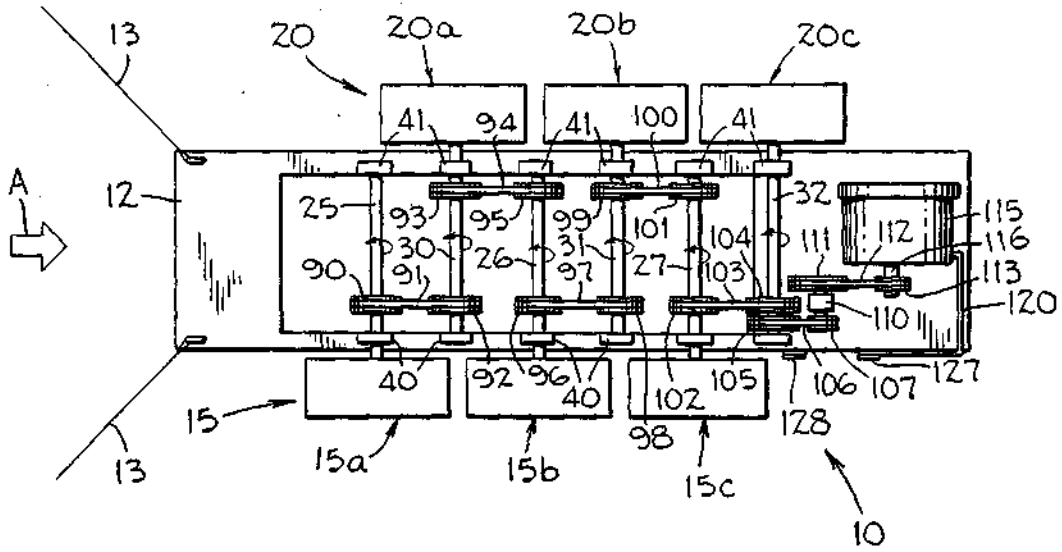




**FIG-2**



**FIG. 3**



**FIG. 4**

## APPARATUS FOR CONVERTING FLOW OF WATER INTO ELECTRICAL POWER

### BACKGROUND OF THE INVENTION

The present invention relates in general to apparatus for converting the flow of water into electrical power, and more particularly to apparatus for converting the flow of water into electrical power wherein such apparatus is carried by a floatable platform.

The water wheel has been used extensively for the generation of electric power. It has taken many forms including the current wheel in which water advances the lowermost vanes to rotate the wheel for the generation of power. Similarly, the undershot water wheel has the lower vanes advanced by the fall of water to rotate the wheel for the generation of power.

The use of barges and hulls for supporting power plants has been known. In the patent to Sherman Nymark, No. 3,752,738, there is disclosed a nuclear reactor plant floatable as a hull for transport from a place of construction to mooring at a site of ultimate use. In the patent to Panoff et al., No. 3,446,171, there is disclosed a marine nuclear plant having a containment vessel connected to the bottom of a ship. The patent to Kallenecker, No. 3,262,411, discloses a process plant installed on a barge. The process plant can be erected on the barge in one location and then towed to another location where the barge becomes the foundation for the process plant.

In the patent to Harding, No. 559,798, there is disclosed a float. On the float is a mechanism that rises and falls with the movement of waves for generating power. The patent of Caloia, No. 2,848,189, discloses an apparatus for producing electric power from the action of water waves. The apparatus may be installed on a pier. The patent to Hopfe, No. 4,204,406, discloses apparatus for extracting hydrodynamic energy from ocean waves. The apparatus includes a floating platform.

### SUMMARY OF THE PRESENT INVENTION

An object of the present invention is to provide apparatus for generating electrical power wherein the apparatus includes a floatable platform and hydrodynamic power generated is extracted from the waves or flow of water.

Another object of the present invention is to provide apparatus for generating electrical power wherein the apparatus includes a floatable platform and electrical power is generated by the accumulative hydrodynamic power derived from the movement of water wheels.

The apparatus of the present invention for generating electrical power includes a floatable platform which supports devices operable through the waves or movement of water. The apparatus includes an electric generator and a plurality of water wheels which rotate in response to the waves or movement of water. The hydrodynamic power output is derived from the water wheels, the speed of rotation of which is regulated by adjustably positioning the vanes thereof.

A feature of the present invention is the tandem arrangement for accumulating power from movement of water wheels to drive an electric generator.

### DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic perspective view of apparatus embodying the present invention for converting the waves or movement of water into electrical power.

FIG. 2 is an enlarged diagrammatic fragmentary side elevational view of the apparatus shown in FIG. 1 taken along the line 2--2 of FIG. 1.

FIG. 3 is a diagrammatic plan view of the apparatus shown in FIG. 1.

FIG. 4 is a fragmentary diagrammatic perspective view of a water wheel shown in FIG. 2 to particularly illustrate the construction of a vane thereof.

### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Illustrated in FIGS. 1 and 3 is the apparatus 10 embodying the present invention for converting the waves or flow of water into electrical power. The apparatus 10 comprises a suitable floatable platform 12 for supporting the apparatus 10 in water. The floatable platform 12 may be in the form of a hull, barge or the like. The direction of water flow or wave motion for operating the apparatus 10 is shown by the arrows A in FIGS. 1 and 2.

The apparatus 10 can be towed in water to various locations suitable for converting the flow of water into electrical power. After reaching a desired location in water, the apparatus 10 is anchored for mooring in a well-known manner through suitable cables 13. The cables 13 can be secured to suitable anchors, piers or the like, not shown.

Carried by the floatable platform 12 along the respective sides thereof are two sets of water wheels 15 and 20. The set of water wheels 15 includes a suitable number of water wheels, by way of example, water wheels 15a-15c, which are disposed in longitudinally spaced relation. The set of water wheels 20 includes a suitable number of water wheels, by way of example, water wheels 20a-20c, which are disposed in longitudinally spaced relation. In the preferred embodiment, there are seven water wheels in the set 15 and seven water wheels in the set 20.

The water wheels 15a-15c are fixedly secured to axially disposed shafts 25-27, respectively, to impart rotation thereto. In a similar manner, the water wheels 20a-20c are fixedly secured to axially disposed shafts 30-32 to impart rotation thereto. The shafts 25-27 and 30-32 are journaled for rotation by suitable confronting upstanding supports or ears 40 and 41. The supports 40 are fixed to one side of the floatable platform 12 and the supports 41 are fixed to the other side of the floatable platform 12. The supports 40 are aligned transversely with respective supports 41. Each shaft 25-27 and 30-32 is journaled for rotation by a transversely aligned support 40 and support 41.

The water wheels 15a-15c and 20a-20c are similar in construction and in operation. For purposes of brevity, only the water wheel 15b will be described in detail.

The water wheel 15b (FIG. 2) comprises a pair of upright octagonal frames 50 and 51 spaced apart in the transverse direction. The frames 50 and 51 receive at the axes thereof the shaft 26 and are fixed to the shaft 26 to impart rotation thereto. The octagonal frames 50 and 51 are similar in construction. Each octagonal frame comprises radially disposed members or braces 55 fixed to the shaft 26. The distal ends of successive braces 55 are joined by peripheral members or braces 56. Successive

sive braces 55 joined by a brace 56 define a triangular sector of the associated frame.

Disposed between the frames 50 and 51 are water wheel vanes 60. The vanes 60 are similar in construction and in operation. Each vane 60 comprises a suitably shaped body 61 for being subject to the force applied by the wave or flow of water. The opening of the hollow or scooped shaped body faces in the direction of the flow of water. In the exemplary embodiment, there are eight sectors to the frames 50 and 51. At the vertex of each set of axially spaced, parallel sectors of the frames 50 and 51 is disposed a vane 60. The vanes 60 extend radially inwardly from the associated vertices along the associated radial braces 55 and extend outwardly in the direction of rotation along the associated peripheral braces 56. The vanes 60 are attached to the frames 50 and 51 to impart rotation thereto. Thus, the lower vanes 60 (FIG. 2) are partially immersed in water and are exposed to the flow of water of the force applied by the waves in the direction of the arrows A to be impelled for rotation in the counterclockwise direction as viewed in FIGS. 1 and 2 causing the frames 50 and 51 to rotate in the same direction. The rotation of the frames 50 and 51 impart rotation to the shaft 26.

Each vane 60 is attached to its associated braces 55 by suitable journals or bearings 65. Mounted on each vane 60 are stops 66 and 67. The stops 66 are adjustably secured to the vane 60 by nuts and bolts, and engage their associated radial braces 55 to limit the movement of the vane 60 under impact from the wave or flow of water. In a similar manner, the stops 67 are adjustably secured to the vane 60 by nuts and bolts, and engage their associated peripheral braces 56 to limit the movement of the vane 60 under impact from the wave or flow of water. The nuts and bolts securing the stops 66 and 67 to the vanes 60 are selectively inserted in openings spaced along the arcuate direction of the vane. The vanes 60 are adjustably positioned by the stops 66 and 67, when subjected to waves or movement of water, to regulate the hydrodynamic force applied to the vanes 60. In so doing, the cup exposure of each vane 60 to the wave or movement of water is adjusted. By regulating the applied hydrodynamic force applied to a vane or adjusting the cup exposure of the vane, the speed of rotation of the associated water wheel is regulated. The regulation of the speed of rotation of the water wheels regulates the revolutions per minute of an electric generator, thereby regulating the cyclic output of the generated current and voltage. More specifically, the vanes are adjusted to the size of the applied waves. The larger the wave, the smaller the effective size of the cup. Conversely, the smaller the wave, the larger the effective size of the cup.

Fixed to the shaft 25 is a pulley or sheave 90. Rotation of the water wheel 15a rotates the shaft 25, which, in turn, rotates the pulley 90. Trained around the pulley 90 is an endless belt 91, which is also trained around a pulley 92. The pulley 92 is fixed to the shaft 30. Also fixed to the shaft 30 is a pulley 93. The rotation of the water wheel 20a imparts rotation to the shaft 30 and the rotation of the endless belt 91 imparts rotation to the shaft 30. Thus, there is dual application of hydrodynamic power applied to the shaft 30, which is transferred or transmitted through the pulley 93.

Trained around the pulley 93 is an endless belt 94, which is also trained around a pulley or sheave 95. The pulley 95 is fixed to the shaft 26 to impart rotation thereto. Also fixed to the shaft 26 is a pulley or sheave

96. Rotation of the water wheel 15b imparts rotation to the shaft 26. Therefore, hydrodynamic power is applied to the shaft 26 through the pulley 95 and the water wheel 15b. Trained around the pulley 96 is an endless belt 97. Thus, accumulated hydrodynamic power from the water wheels 15a, 20a and 15b is transferred or transmitted through the pulley 96.

Fixedly secured to the shaft 31 for imparting rotation thereto is a pulley or sheave 98. Trained around the sheave 98 is the endless belt 97. The endless belt 97 imparts rotation to the sheave 98 to transfer hydrodynamic power to the shaft 31. The water wheel 20b is also fixed to the shaft 31 to transfer hydrodynamic power to the shaft 31. Fixed to the shaft 31 to transfer or transmit hydrodynamic power therefrom is a pulley or sheave 99. Thus, hydrodynamic power from the water wheels 15a, 20a, 15b and 20b is transmitted or transferred from the pulley 99.

Trained around the pulley 99 is an endless belt 100. The endless belt 100 is trained around a pulley or sheave 101 to transfer hydrodynamic power thereto. In turn, the pulley 101 is fixed to the shaft 27 to transfer hydrodynamic power thereto. The water wheel 15c is fixed to the shaft 27 to transfer hydrodynamic power thereto. Fixed to the shaft 27 for transferring hydrodynamic power from the shaft 27 is a pulley or sheave 102. Trained around the pulley 102 to be driven thereby is an endless belt 103. Hence, hydrodynamic power from the water wheels 15a, 20a, 15b, 20b, 15c is transferred through the endless belt 103.

The endless belt 103 is also trained around a pulley or sheave 104, which is fixed to the shaft 32. The water wheel 20c is fixed to the shaft 32 to transfer hydrodynamic power thereto. In addition thereto, a sheave or pulley 105 is fixed to the shaft 32 to be rotated thereby. Hence, hydrodynamic power from the water wheels 15a-15c and 20a-20c is transferred or transmitted through the sheave 105.

Trained around the sheave 105 is an endless belt 106. The endless belt 106 is trained around a pulley or sheave 107 at the input side of a power drive apparatus 110. At the output side of the power drive apparatus 110 is a sheave or a pulley 111. Trained around the pulley 111 is an endless belt 112, which is also trained around a sheave or pulley 113 of an electric generator 115. Rotation of the pulley 113 imparts rotation to a shaft 116 of the electric generator 115.

Connected to the output side of the electric generator 115 is a cable 120 for the transmission of electric power to a remote location. The apparatus 10 is anchored to a fixed location, in the manner heretofore described, while operating as a source of electric power generation. Intermediate the ends of the output power cable 120 in the vicinity of the floatable platform 12 is a suitable weight 125 (FIG. 1). At the top of the weight 125 is a pulley 126. On the floatable platform 12 in longitudinally spaced relation are pulleys 127 and 128. The pulleys 126-128 are journaled for rotation. The output power cable 120 is trained around the pulley 127, then around the pulley 126 and then around the pulley 128 with the free end thereof extending from the pulley 128 to a remote location for the transfer of electric power. The weight 125 maintains tension in the electric power cable 120 in spite of movement of the floatable platform 12 with respect to its mooring through the mooring cable 13.

In the preferred embodiment, the endless belts are in the form of stainless steel chains and the pulleys or

sheaves are in the form of suitable gears. The transmission of hydrodynamic power or the retransmission of hydrodynamic power is a serial or tandem arrangement. Thus, there is an accumulative effect of power input for rotating the input shaft of the electric generator 115. The speed of rotation of the input shaft of the electric generator 115 is maintained relatively constant by adjustment of the positions of the vanes 60. The increased power applied to the input shaft of the electric generator 115 enables a greater electric power output by being able to employ an electric generator rated for the higher power output. In making adjustment to the effective cup size of the vanes by adjusting the positions thereof through the stops 66 and 67, the vanes 60 are adjusted to conform with the energy peaks of the applied waves, as shown in FIG. 2.

I claim:

1. Apparatus for converting the flow of water into electric power comprising:

- (a) a floatable platform formed with opposite sides;
- (b) a plurality of water wheels mounted on each side of said platform for rotation and adapted to be impelled by the flow of water for rotation;
- (c) coupling means interconnecting said water wheels for transmitting hydrodynamic power, said coupling means comprising an axial shaft for each of said water wheels respectively, said axial shafts being rotatable in response to its associated water wheel being impelled to rotate by the flow of water, successive water wheels of said water wheels being located on said opposite sides of said platform, said coupling means interconnecting successive axial shafts of said axial shafts for transferring

hydrodynamic power successively from axial shaft to axial shaft for progressively increasing the magnitude of transferred hydrodynamic power; and (d) electric generating means responsive to the transmission of said hydrodynamic power for generating electric power.

2. Apparatus as claimed in claim 1 wherein each of said water wheels comprise a plurality of vanes disposed peripherally along its associated water wheel.

3. Apparatus as claimed in claim 2 wherein means on each of said vanes are adjustable for controlling the speed of rotation of its associated water wheel.

4. Apparatus as claimed in claim 2 wherein means on each of said vanes are adjustable to vary the position of its associated vane relative to the associated water wheel.

5. Apparatus as claimed in claim 1 and comprising means attached to said floatable platform for anchoring said floatable platform.

6. Apparatus as claimed in claim 1 and comprising an output power cable connected to said electric generating means.

7. Apparatus as claimed in claim 6 and comprising a weight with a pulley around which said output power cable is trained, and guide pulleys on said floatable platform around which said output power cable is trained, said pulley for said weight being disposed between said guide pulleys, whereby said output power cable is trained around one guide pulley, then said pulley for said weight and then the other of said output power cable, the free end of said output power cable being adapted for connection to a remote location.

\* \* \* \* \*

35

40

45

50

55

60

65

[54] PIGGY BACK WATER POWER GENERATOR

[76] Inventor: B. Ryland Wiggs, 3630 Villanova Ct., Bethlehem, Pa. 18017

[21] Appl. No.: 652,841

[22] Filed: Sep. 21, 1984

[51] Int. Cl.<sup>4</sup> ..... F03B 7/00

[52] U.S. Cl. .... 290/54; 416/247 A

[58] Field of Search ..... 290/43, 54; 415/2, 7; 416/9, 85, 247 R, 247 A

[56] References Cited

U.S. PATENT DOCUMENTS

|           |         |          |           |
|-----------|---------|----------|-----------|
| 928,782   | 7/1909  | Morrison | 416/247 A |
| 1,780,584 | 11/1930 | Fachnie  | 416/247 A |
| 4,104,536 | 8/1978  | Gutsfeld | 290/54    |
| 4,270,056 | 5/1981  | Wright   | 290/54    |

FOREIGN PATENT DOCUMENTS

|         |        |                      |        |
|---------|--------|----------------------|--------|
| 2730735 | 1/1979 | Fed. Rep. of Germany | 415/7  |
| 1005948 | 4/1952 | France               | 416/85 |

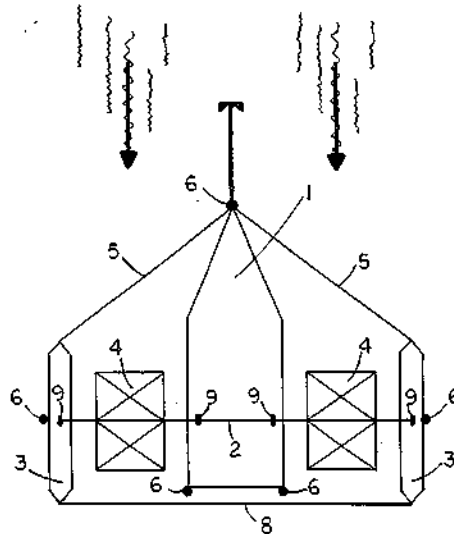
Primary Examiner—William M. Shoop, Jr.

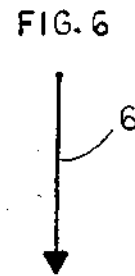
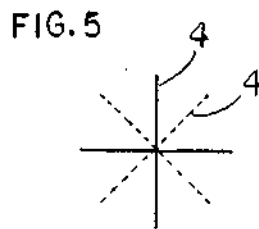
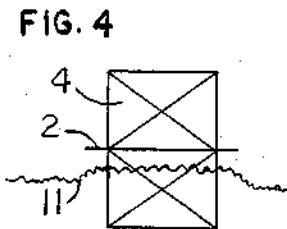
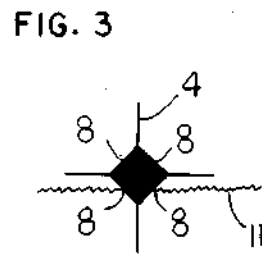
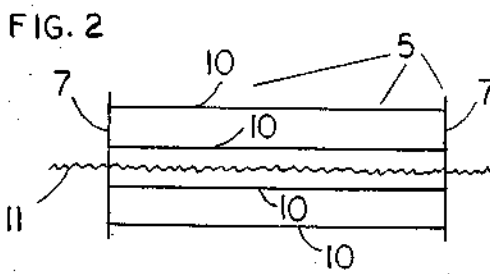
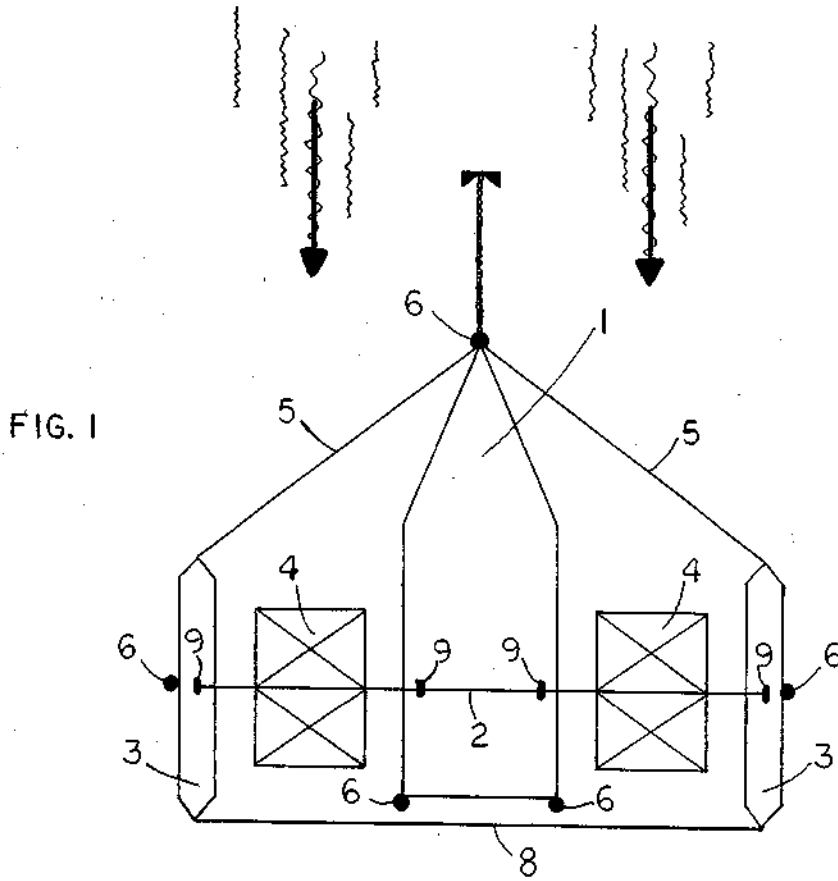
Assistant Examiner—W. E. Duncanson, Jr.

[57] ABSTRACT

A water power apparatus, composed of independent design features, which provides for: (1) utilization of a central boat with two paddle wheels and respective side stabilizers, with one wheel being located on each respective side of the boat, connected by a central axle or a flexible coupling; (2) two respective and connected sets of paddle wheels, with the blades on each of the two respective wheels placed 90° apart, with each set of wheels being situated a lateral distance, apart from the other, of at least one-half the width of a respective paddle wheel blade, and with the blades on one wheel set being staggered 45° from the other; (3) an "angled" front deflection screen with cord or rods running parallel to the water surface; (4) a paddle wheel blade surface area extended above the water surface, with fully enclosed sides, so as to totally capture all water "head" created against the blade by the current flow; and (5) "legs", with cone-shaped bottoms, for the generating vessel to rest on, preventing bottom jamming of the paddle wheels during periods of low water levels.

4 Claims, 6 Drawing Figures





## PIGGY BACK WATER POWER GENERATOR

### SUMMARY OF THE INVENTION

This invention relates to an actual, working, hydraulic generating machine which may be used to generate mechanical power and/or electricity from a boat or vessel moored or anchored in a stream or current of water.

Additionally, independent objects of this power generating system are to provide relatively continuous and smooth revolutions of the paddle wheels in conjunction with optimum actual operating efficiency; to provide self-cleaning ice and/or debris protection; to provide paddles which capture artificial water "head" and which prevent swamping of the supporting vessel; and to provide a means of supporting the entire generating vessel in periods of low water.

The present invention differs from other related inventions in a number of substantial and basic respects. The differing aspects are discussed categorically as follows:

(1) No U.S. Patents of record show utilization of a central boat with a single paddle wheel on each respective side. See, inter alia, U.S. Pat. Nos. 4,352,990; 4,301,377; 4,270,056; 1,439,848; and 1,200,693 where the working paddle wheels are centrally located and the gearing and/or generators are designed to be situated on the side or at the rear. Additionally, see U.S. Pat. No. 1,368,454 and see Int. Cl<sup>3</sup>. F03B17/06, B63B35/02, where working paddle wheels are located in front and in back of each other, respectively.

The proposed subject design, with a central boat utilizing a single identical paddle wheel on each respective side is more efficient for the following reasons: (a) the heavy gearing and/or machinery and/or generator is centrally located, permitting equal weight distribution and enhancing stability and anchoring of the total generating vessel in the water; and (b) the area beneath the central boat, between the two respective paddle wheels, provides a central free-flow buffer area for water deflected to the side off of each respective paddle, thereby preventing respective angled water flow interference (and resulting loss of power) and allowing only the direct current flow to hit the actual paddle surface area.

It is important that the paddle wheels not be placed directly in each other's path (one directly in front of the other) as contemplated by the aforesaid U.S. Pat. No. 1,368,454 and by the aforesaid Int. Cl<sup>3</sup>. F03B17/06, B63B35/02, because the forward paddle wheel slows the water speed as energy is exerted, and the rear paddle wheel will, consequently, operate at substantially less than its potential in the unhindered normal current flow.

It is also important that the paddle wheels not be placed directly side by side, in staggered positions, as contemplated by the aforesaid U.S. Pat. No. 4,270,056, because water will always be deflected at an angle from the forward paddle into its adjacent paddle to its rear. Such deflected water flow disturbs the direct and right angled optimum flow into the rear paddle, thus resulting in a loss of potential power and efficiency. Factually, testing has shown the respective staggered wheels should generally be spaced at least one-half paddle wheel width apart for efficient operation.

Lastly, unlike all the other aforesaid U.S. Patent paddle wheel designs, it is important that more than one

centrally located paddle wheel be used. By using only one central paddle, the user will either suffer a substantial loss of potential energy via utilizing a large number of paddles around his central axel (the more paddles used, the less energy produced), or the user will run the risk of stalling his wheel when using a lesser number of paddles when maximum energy production is required (the fewer the number of paddles, the greater the span between paddles situate at exactly a right angle to the water flow, where maximum energy production occurs, and the greater the risk of the actual stopping of the wheel due to lack of flow against right angled, or close to right angled, paddle surface area under a full power load).

(2) No U.S. Patents of record show and/or claim utilization of two respective paddle wheels, with a buffer zone in between, with each respective wheel utilizing four paddles, equally spaced at 90° angles, and respectively staggered around a central axel. Please refer to all of the above-reference patents.

The eight paddles, spaced at 45° apart, as shown on the aforesaid U.S. Pat. Nos. 1,439,848 and 1,200,963, are too numerous and, while reducing the risk of stalling, they substantially reduce potential power efficiency.

The three paddles, spaced at 120° apart, as shown on the aforesaid U.S. Pat. No. 4,270,056, are too few and, while increasing potential power efficiency, they substantially increase the risk of stalling. This is possibly why two staggered sets of side by side 120° spaced paddles were contemplated. However, while positioning the paddles in one adjacent group, so they bisect the angles formed by the blades in the directly adjacent group, will help prevent stalling, as aforesaid, the resulting deflected water flow, via having the two sets side by side, will reduce potential efficiency of the total paddle area exposed to the right-angled water flow. Additionally, under a full power load, the distance between any two such 60° staggered blades is too great so as to insure prevention of stalling, and the revolutions, if made, will be in a jerky, rather than smooth, fashion inhibiting effective utilization of power.

In fact, lengthy and detailed testing has shown the optimum number of paddle wheel blades to be those contemplated and shown herein. Namely, four paddles, spaced 90° apart, with two such sets of paddle wheels staggered at 45° and coupled together, but with sufficient distance (at least one-half paddle wheel blade width) in between the two sets for water deflected from one set not to affect the other. Additionally, this number and combination of paddle wheels is sufficient to safely prevent stalling under full power output, and to simultaneously and uniformly (without excessive jerking) extract a maximum amount of energy from the current flow absent hinderance from an excessive number of paddle blades.

(3) No U.S. Patents of record shown and/or claim utilization of an "angled" deflection screen.

While the aforesaid U.S. Pat. No. 1,368,454 utilizes the concept of a debris screen, nowhere is the screen shown and/or claimed to be angled. In fact, a flat debris screen, at a right angle to the current will eventually clog up with floating debris and/or ice, thereby reducing and/or totally stopping power output from the waterwheels.

Consequently, in order to prevent such a situation, the screen must be angled so as to allow the current to push debris along the screen and off to the side of the



generating vessel. Thus, an angled debris screen will be continuously self-cleaning.

Additionally, the screen must extend below and above the water surface so as to deflect debris and so as to provide a safety barrier for boaters. The screen should consist of a small diameter, but strong, bar, cord, or wire. The bar or cord must be small enough so as not to significantly interrupt the current flow approaching the paddle wheels, but strong enough to withstand the impact of ice flows.

Lastly, the screen should have no vertical cords or bars. The screen should consist of a number of cords or bars stretched in a horizontal fashion from the central front forward point to the extreme side of a respective paddle wheel. The inclusion of vertical cords or bars, as contemplated in the above-referenced patents of record, will tend only to catch branches and other irregularly shaped objects, resulting in restriction and/or blockage of water flow.

(4) No U.S. Patents of record show and/or claim the extension of the paddle wheel surface, and the side enclosure of same, to a sufficient height above the normal water level so as to insure capture of the "head" of water which will always be artificially created by the current rushing against a respective paddle.

While U.S. Pat. No. 1,439,848 contemplates cupping the lower portion of paddle wheel blades when using falling water, the paddles are contemplated as being "opened" and submerged when solely utilizing current.

Detailed testing has shown it to be advantageous to extend the paddle surface area to a sufficient height above the actual water surface elevation so as to capture the entire "head" of water which results from the current flow encountering the paddle and from the current simultaneously pushing itself in an upward (as well as sideways) manner. Additionally, the heightened paddle surface area's respective sides must be fully enclosed. The heightened and enclosed paddle surface area is important for three reasons.

The first reason is that the captured "head" adds weight to the falling paddle blade and helps push it down. The second reason is that if any portion of the head were allowed to escape over, or around, its respective paddle blade, it would add weight to the opposite paddle blade on its way out of the water, and potential efficiency and power would be substantially reduced. The third reason is that the head, if not contained, would swamp the adjacent boat in a strong current.

(5) No U.S. Patents of record show and/or claim "legs" for the generating vessel and/or machine.

Legs are important, and are a necessity for practical operation in rivers or tidal areas. Without legs, in periods of low water, the paddle wheel blades would simply jam into the bottom of the river, or tidal area, and stop.

Legs affixed to the perimeters, with cone-shaped bottoms, extending slightly beyond paddle wheel depth, will support the generating vessel in periods of low water, allowing the paddle wheels to continue to turn. The legs will simply rise and float with the vessel during periods of normal high water flows. Cone-shaped bottoms on each respective leg will assist in preventing the legs from sticking in mud or sand.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a complete top view.

FIG. 2 is a side view of the angled debris screen.

FIG. 3 is a side view of a paddle wheel.

FIG. 4 is a front view of a paddle wheel.

FIG. 5 is a side view of both paddle wheels.

FIG. 6 is a side view of a generating vessel support leg.

#### DETAILED DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a boat, or vessel, 1 anchored in a current of water (depicted by elongated arrows). The vessel 1 has been equipped with complete "Piggy-Back" power generating apparatus.

The equipment consists of one central axle 2 straddling the back of the vessel 1, mounted on pillow block bearings 9, with side stabilizers 3 consisting of plastic or metal clad styrofoam or other flotation.

The axle 2 is turned via water flow pushing against the respective paddle wheels 4 which are separated by a distance of at least one-half their respective width to minimize or prevent angled side water flow deflection from one to the other. The mechanical energy generated is conveyed to power generating equipment via gearing positioned on the central axle or on the interior side of each respective paddle wheel. The power can then be transmitted to appropriate on-board power generating equipment.

For safety purposes, as well as for debris and ice protection, an "angled" front debris screen 5 is fastened from the forward center of the vessel to the extreme respective end of each paddle wheel. Angling the screen, which will consist of rods or cord or wire solely running parallel to the water surface, will create a self-cleaning effect and prevent debris build up and/or water flow blockage. A rear above-water safety screen 8 is also shown.

To prevent the paddle wheels from jamming into the bottom of the river or other sub-surface ground during periods of low water levels, legs 6 are attached to support the entire generating vessel.

FIG. 2 depicts a side view of the front angled debris screen 5, which, as aforesaid, will consist of rods or cord or wire 10 solely running parallel to the water surface 11. The rods or cord 10 will be placed both above and below the water line 11 for dual purposes of safety and equipment protection. The rods or cord 10 will be affixed to vertical rods 7 situated solely at the respective extreme ends. This will prevent branches or other debris from snagging and restricting water flow.

FIG. 3 shows a side view of one respective paddle wheel 4 with fully enclosed top sides 8 designed to capture and efficiently use the artificial water "head" created by the current pushing upwards against the paddle wheel blades. The top side enclosures 8 are also designed to prevent detrimental overflow of the head onto opposite paddle wheel blades as well as to prevent potential swamping of the central boat. The top side enclosures 8 must extend below the normal surface water elevation 11.

FIG. 4 shows a front view of one respective paddle wheel 4, the surface area of which has been extended above the water line 11 to the axle 2 so as to capture and prevent water "head" overflow, as well as to utilize the additional weight of same.

FIG. 5 shows a side view of the two sets of paddle wheels 4 as same would individually appear without the aforesaid top side enclosures as shown hereinabove in FIG. 3. There are four blades on each respective paddle wheel placed at 90° angles to one another. The blades on one paddle wheel (shown in solid lines) are staggered so the second set of paddle wheel blades on the far end

5

6

of the axle (shown in broken lines) are situated at 45° angles to the first set.

FIG. 6 shows a side view of the cone-bottom legs 6 designed to support the entire generating vessel during periods of low water levels, thus preventing the paddle wheels from jamming into the bottom and stopping.

I claim:

1. A power generating system including a central, watertight, floating boat containing gearing and an electric generator; two watertight, floating outrigger pontoons smaller in size than the central boat; two paddle wheels with one respective paddle wheel on each side of the central boat, with each respective paddle wheel having four flat blades spaced 90° apart, each blade having a solid surface area from the central connecting axle to the extremities of each blade, with each respective paddle wheel's four blades being offset 45° from the other paddle wheel's four blades, with the spacing between the paddle wheels being a minimum of one-half the width of the blades; with each respective wheel's central axle being situation high enough above the water surface to capture all of the incoming water's head build up, in conjunction with the sides of each respective paddle wheel being enclosed from the central axle to a point at or near the outside extreme end of

each respective paddle wheel; and with a shaft connecting both paddle wheels to the generator via gearing.

2. The power generating system as in claim 1, wherein the outrigger pontoons and central boat are equipped with legs with cone shaped bottoms for the purposes of protecting the paddle wheel blades in low water, protecting against sinking in mud or sand, and for ease of withdrawal from the bottom as the water rises.

3. The power generating system as in claim 1, with a forward angled-back deflection screen with protective cables or bars running parallel, not vertical, to the water's surface, located below the water surface for protection from ice and debris, and located above the water surface for protection of rafters or boaters, extending from the center bow of the central boat to the outermost forward point of each respective outrigger pontoon.

4. The power generating system as in claim 1, with a stern, or rear, non-angled deflection screen with protective cables or bars running parallel, not vertical, to the water's surface, located solely above the water surface, for protection of boaters, extending from the stern, or rear, of one respective outrigger pontoon to the stern, or rear, of the other respective outrigger pontoon, extending either behind, through, or across the stern, or rear, of the central boat.

\* \* \* \* \*

30

35

40

45

50

55

60

65

- [54] MECHANISM FOR ACTUATING DEFLECTOR OF PELTON WHEEL
- [75] Inventor: Kentaro Ichikawa, Chigasaki, Japan
- [73] Assignee: Kabushiki Kaisha Toshiba, Kawasaki, Japan
- [21] Appl. No.: 908,308
- [22] Filed: Sep. 17, 1986
- [30] Foreign Application Priority Data  
 Sep. 18, 1985 [JP] Japan ..... 60-206056
- [51] Int. Cl.<sup>4</sup> ..... F04D 15/02
- [52] U.S. Cl. .... 415/35
- [58] Field of Search ..... 415/35, 202, 148, 150, 415/157

- [56] References Cited
- U.S. PATENT DOCUMENTS
- 1,706,812 3/1929 Pfau ..... 415/35
- 2,491,059 12/1949 Ring ..... 415/35
- 2,701,706 2/1955 Bon ..... 415/35
- 3,275,008 9/1966 Kerensky ..... 415/35

- FOREIGN PATENT DOCUMENTS
- 59966 8/1922 Austria ..... 415/35
- 73135 3/1922 Switzerland ..... 415/35

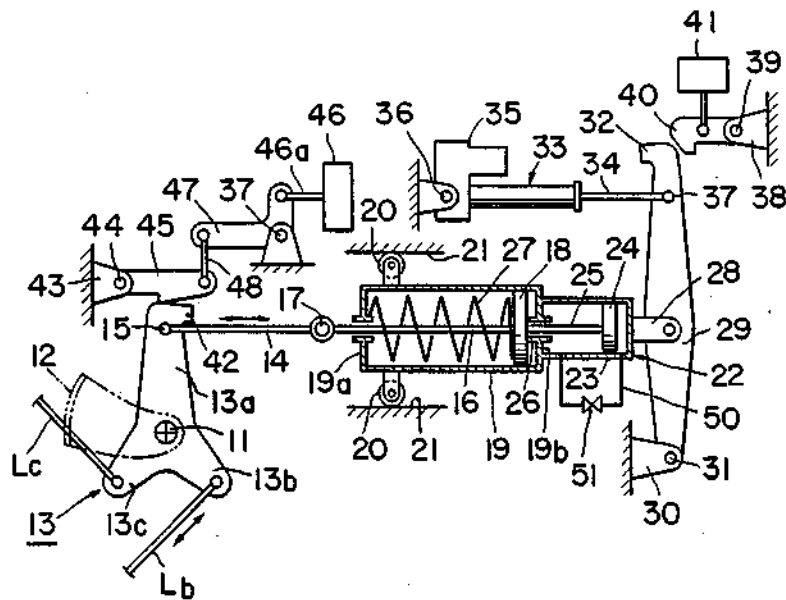
OTHER PUBLICATIONS

Fuji Jiho, vol. 55, No. 5, 1982, p. 30.  
 Primary Examiner—Robert E. Garrett  
 Assistant Examiner—John T. Kwon  
 Attorney, Agent, or Firm—Schwartz, Jeffery, Schwaab, Mack, Blumenthal & Evans

[57] ABSTRACT

One end of an operating rod is connected to a deflector arm which causes a jet deflector of a Pelton wheel to open or close while the other end of the operating rod carries a spring bearing plate which is disposed in the bore of a cylinder which is movable in the axial direction of the operating rod. A spring is accommodated in the bore of the cylinder on the side of the operating rod. One end of the cylinder is pin connected to the midpoint between the ends of a swinging lever whose one end is pivotally supported and whose other end is connected to an electric servomotor so that upon energization of the servomotor, the swinging lever is caused to undergo a reciprocal angular motion. The deflector is forced to move to its full closure position by the release of the energy stored in the spring.

8 Claims, 8 Drawing Figures



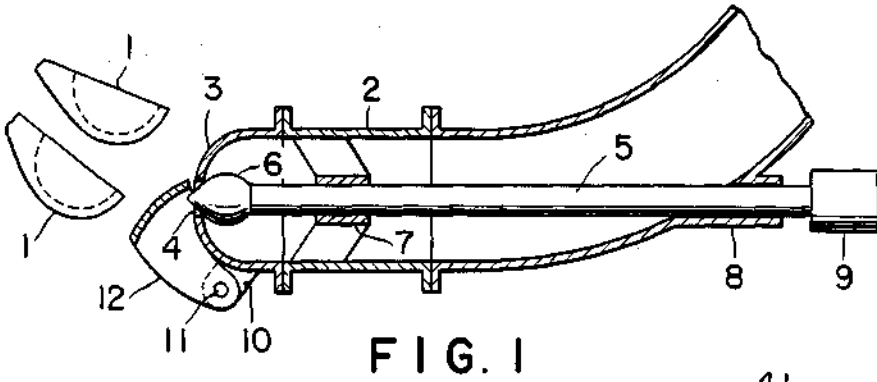


FIG. 1

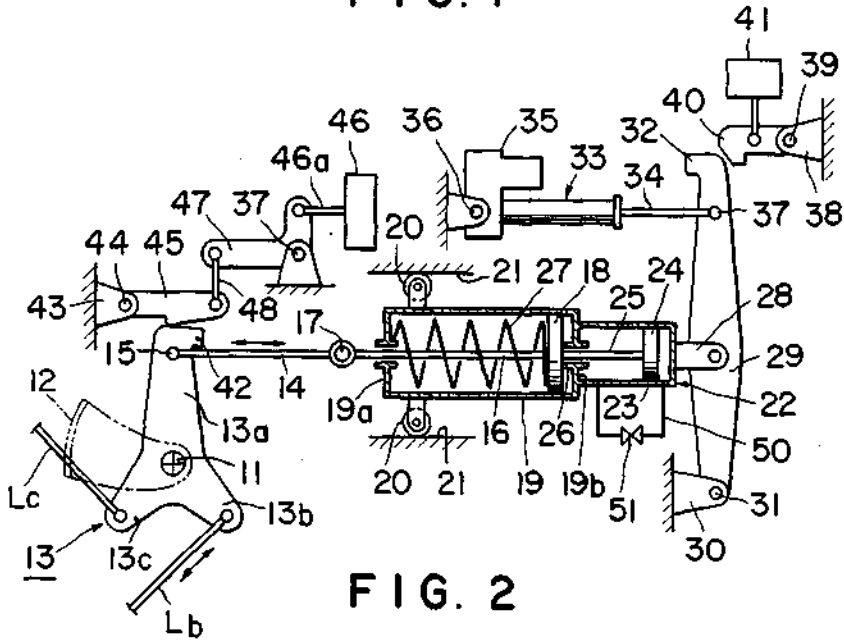


FIG. 2

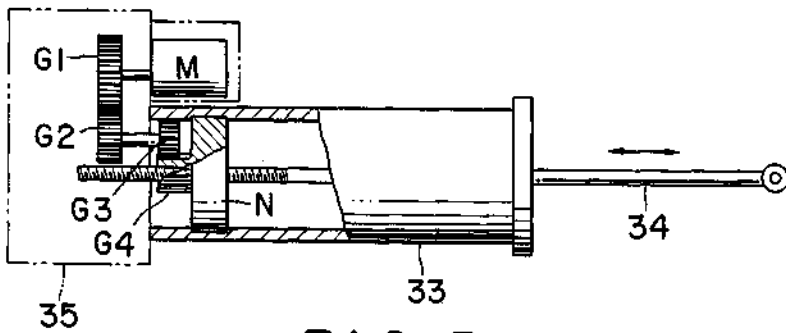


FIG. 3

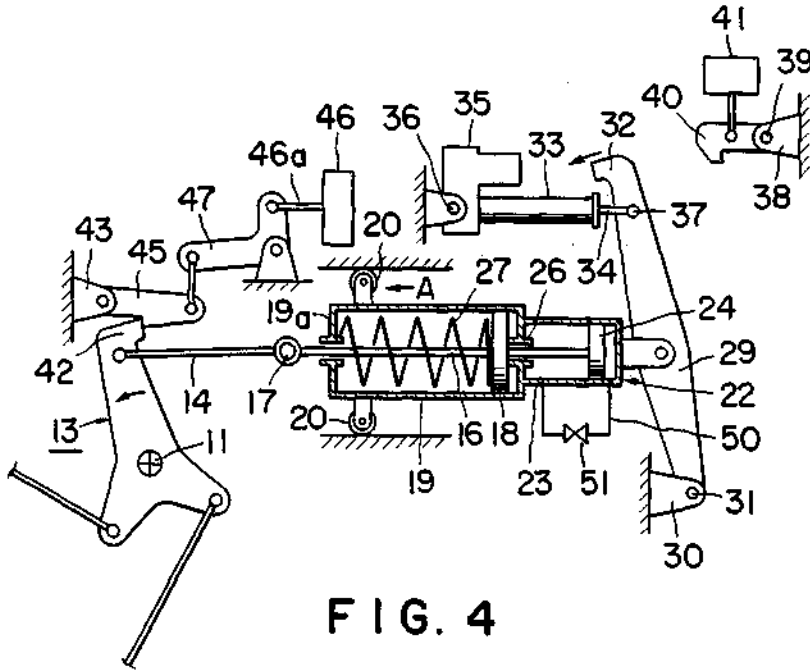


FIG. 4

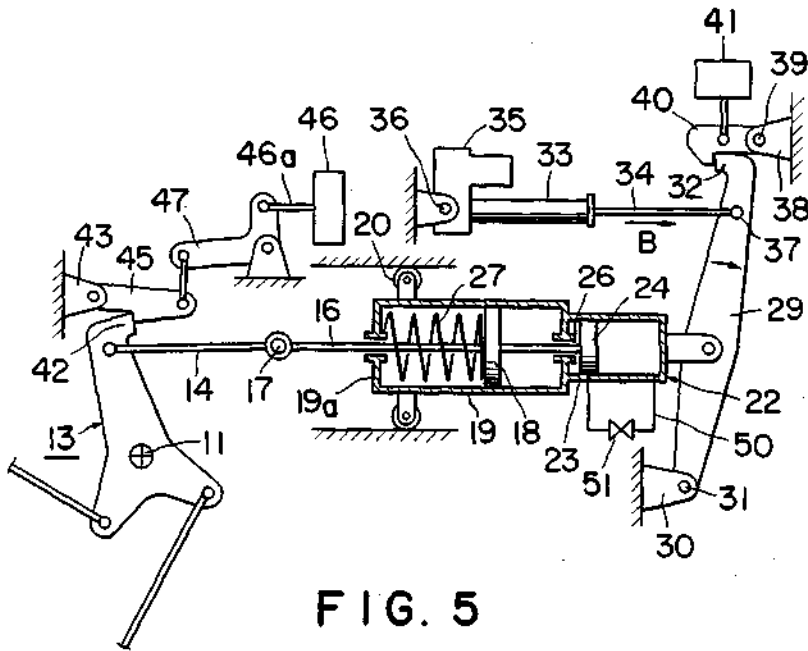


FIG. 5

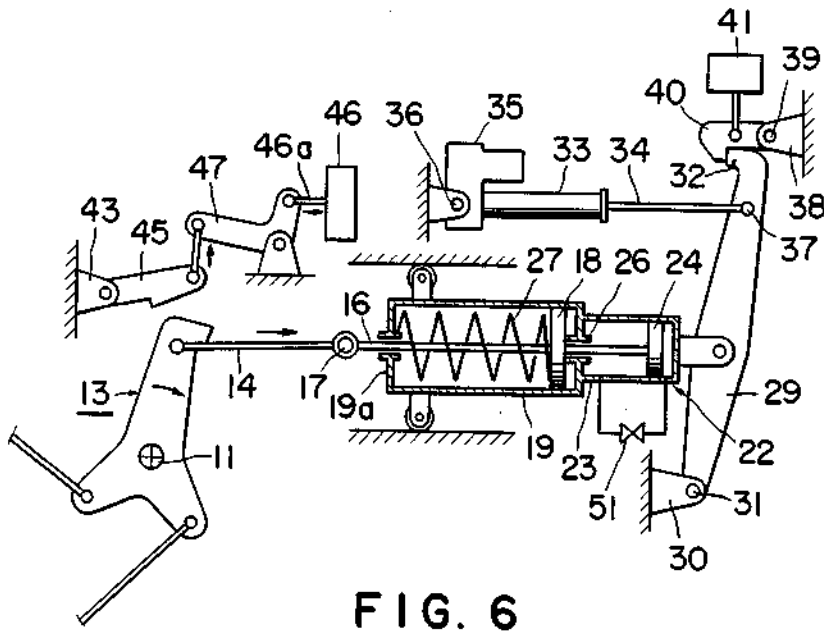


FIG. 6

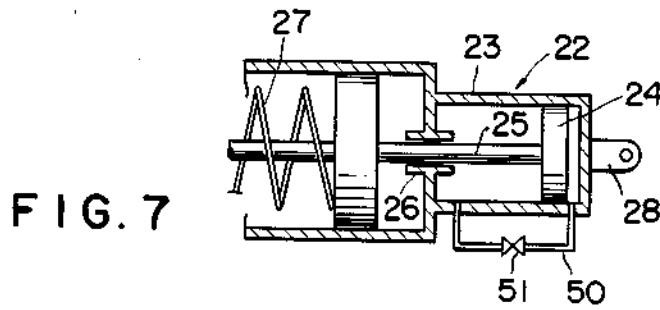


FIG. 7

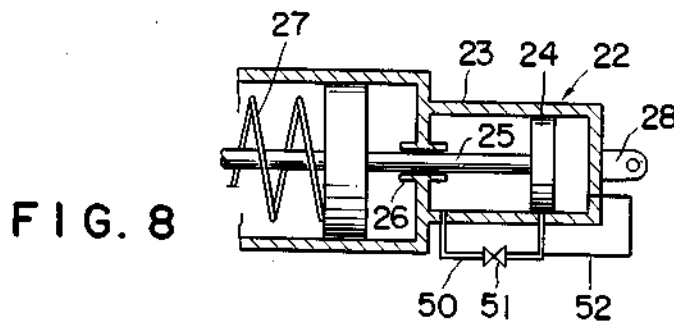


FIG. 8

## MECHANISM FOR ACTUATING DEFLECTOR OF PELTON WHEEL

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

The present invention relates to a mechanism for actuating a deflector of a Pelton wheel (turbine or unit) and more particularly to such a mechanism of the type in which an electric servomotor is used to maintain the deflector in its opened position, and the stored energy of a spring is used to close the deflector.

#### 2. Description of the Prior Art

A Pelton wheel is of a type of impulse turbine and is usually operated from a high-head source ranging from 200 to 1,800 meters when the volume of water available is relatively small. The water under pressure which is introduced into the casing of the Pelton wheel is accelerated when it is forced to flow through a nozzle and then the resulting high-velocity jet impinges on the buckets of the turbine wheel or runner, whereby the runner is rotated. A deflector is disposed at the discharge end of the nozzle pipe so that in the case of an emergency, the high-velocity jet emerging from the nozzle is deflected and thereby prevented from impinging on the buckets of the runner. A mechanism which uses a fluid operated servomotor for opening and closing the deflector has been well known in the art, but the fluid operated servomotor needs not only a source for supplying oil under pressure but also a device for controlling the pressure of the working oil so that there arises the problem of such associated or auxiliary equipment becoming complicated in construction and large in size for the output of the Pelton wheel. In addition, in the case of a system in which a fluid operated servomotor is activated to push an operating rod to close the deflector, there arises a problem in that a large force due to high hydraulic pressure acts on the rod in its axial direction, causing buckling of the operating rod.

In order to solve the above described problems, there has been proposed a system in which a fluid operated servomotor is combined with a coiled spring so that the deflector is moved to and maintained at the opened position by the fluid operated servomotor and, in the case of an emergency, the operating rod is actuated by the force of the coiled spring, thereby closing the deflector (Fuji Jiho, Vol. 55, No. 5, Page 30, published in 1982). However, according to the above-described prior art system, the force of the coiled spring is exerted on the operating rod in the direction in which the operating rod is compressed, so that there arises the problem of unavoidable buckling of the operating rod.

### SUMMARY OF THE INVENTION

In view of the above, the primary object of the present invention is to provide a mechanism for actuating a deflector of a Pelton wheel which can substantially overcome the above and other problems encountered in the prior art deflector actuating mechanism, and which, in the case of an emergency, exerts tensile strength on a deflector operating rod from a spring, thereby closing the deflector.

To the above and other ends, a mechanism for actuating a deflector of a Pelton wheel in accordance with the present invention comprises a deflector arm for rotating the deflector, an operating rod whose one end is pin connected to said deflector arm and whose other end carries a spring bearing plate, a cylinder which accom-

modates said spring bearing plate therein and which is guided for movement in the axial direction of said operating rod, spring means which is accommodated in the bore of the cylinder on the side of the operating rod and whose stored energy pulls the operating rod, a swinging lever whose one end is pivotally supported and whose midpoint is pin connected to one end of the cylinder, an electric servomotor connected to the free end of said swinging lever so as to cause reciprocable angular movement of the swinging lever, first engaging means engageable with the free end of the swinging lever, thereby maintaining the swinging lever stationary, and second engaging means for maintaining the deflector arm in the fully opened position.

According to the present invention, when the deflector is moved to the full closure position, the force of the spring means is exerted on the operating rod as a pulling force. That is, no spring force is exerted to push the operating rod so that the operating rod is prevented from buckling. The operating end of the output rod of an electric servomotor acts on the outer end of the swinging lever, whereby less force is required to balance the force of the spring means because of lever action.

The above and other objects, effects, features and advantages of the present invention will become more apparent from the following description of a preferred embodiment thereof when taken in conjunction with the accompanying drawings.

### BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. 1 is a fragmentary side view in longitudinal section showing buckets of a Pelton wheel, a nozzle mechanism and a deflector to which a deflector actuating mechanism in accordance with the present invention is applied;

FIG. 2 is a schematic view showing a preferred embodiment of the mechanism for actuating a deflector of a Pelton wheel in accordance with the present invention;

FIG. 3 is a side view, in longitudinal section, showing schematically the essential construction of an electric servomotor used in the deflector actuating mechanism;

FIGS. 4, 5 and 6 are schematic views similar to FIG. 2 indicating various states of the deflector actuating mechanism in the operation thereof, in which FIG. 4 indicates the state of the mechanism for maintaining the deflector in the opened position, FIG. 5 the state wherein a coil spring is energized by compressing, and FIG. 6 the state wherein the deflector is maintained in the fully closed or deflecting position; and

FIGS. 7 and 8 are fragmentary side views, in longitudinal section, respectively indicating operational states of a dash pot.

### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 shows two of the several buckets of a Pelton wheel, a nozzle mechanism, and a deflector to which a deflector actuating mechanism in accordance with the present invention is applied. Reference numeral 1 designates one of the buckets of the Pelton wheel runner. The nozzle mechanism for ejecting a water jet against the buckets 1 has a nozzle pipe 2 with a nozzle tip 3 securely joined to the discharge or forward end thereof. A nozzle orifice 4 is formed at the forward end of the

nozzle tip 3. A needle stem 5 is extended through the nozzle pipe 2 in such a way that the needle stem 5 can be reciprocated along the axis of the nozzle pipe 2. The forward end of the needle stem 5, that is, a needle valve 6 can be moved into and out of the nozzle orifice 4, thereby controlling the water jet. The needle stem 5 is slideably supported by bearings 7 and 8 so as to be reciprocated in the axial direction by a fluid operated servomotor 9. A deflector 12 is fixedly carried by a deflector shaft 11, which in turn is pivotally supported by a bracket 10 attached to a portion of the nozzle tip 3.

The deflector 12 is moved between a fully closed or deflecting position in which the deflector 12 covers the nozzle orifice 4 and an opened position in which the deflector 12 is withdrawn out of the flow of the water jet emerging from the nozzle orifice 4 by a deflector actuating mechanism to be described in detail hereinafter.

FIG. 2 shows schematically a preferred embodiment of the mechanism for actuating a deflector in accordance with the present invention. An inverted Y-shaped deflector arm 13 is fixedly carried by one end of the deflector shaft 11 and comprises a first arm 13a on which is exerted an operating force, a second arm 13b and a third arm 13c for transmitting a force which causes other deflectors to open or close through link rods Lb and Lc.

One end of a first operating rod 14 is pivotally connected by a pin 15 to the distal or outer end of the first arm 13a, while the other end thereof is pivotally connected by a pin 17 to one end of a second operating rod 16. A spring bearing or retaining plate 18 is fixedly and coaxially joined to the other end of the second operating rod 16 and is slideably disposed within a cylinder 19. A guide roller 20 is rollably attached to the outer cylindrical surface of the cylinder 19 and is adapted to roll on a stationary guide surface 21. End plates 19a and 19b are joined to end and close opposite ends of the cylinder 19, and a dash pot 22 is coaxially joined to the outer surface of the end plate 19b.

The dash pot 22 comprises a dash pot cylinder 23 and a piston 24 slideably disposed in the cylinder 23. The piston 24 and the spring bearing plate 18 in the cylinder 19 are interconnected to each other through a connecting rod 25. A stopper 26 is fixed to the end plate 19b at a portion thereof through which the connecting rod 25 is extended.

A coil spring 27 for closing the deflector 12 is loaded between the forward end plate 19a and the spring bearing plate 18 within the cylinder 19.

A connecting member 28 which is extended from the end wall remote from the deflector arm 13 of the dash pot 22 is pivotally connected by a pin to the midpoint between the ends of a swinging lever 29, whose one end is pivoted by a pin 31 to a supporting bracket 30, and whose other end is formed into an engaging portion 32. The swinging lever 29 is caused to swing about the pin 31 by an electric servomotor 33 of a conventional type available on the market.

As shown in FIG. 3, this servomotor 33 comprises a screw rod 34 and a driving mechanism 35 for imparting reciprocating motion to the screw rod 34. The driving mechanism 35 comprises an electric motor M, power transmitting gears G1, G2 and G3, and a combination of a gear G4 and a nut N integrally and coaxially joined thereto and screw engaged with the screw rod 34. When the nut N is rotated, translational movement in the axial direction is imparted to the screw rod 34. The

rear end of the casing of the driving mechanism 35 is pivotally supported by a pin 36, and the outer end of the screw rod 34 is pin connected by a pin 37 to the swing lever 29 at a part thereof near its engaging portion 32.

The engaging portion 32 at one end of the swinging lever 29 is adapted to engage with a first hook 40 which is pivotally supported through a pin 39 on a bracket 38. When an electromagnetic solenoid 41 is energized, the first hook 40 is released and is engaged with the engaging portion 32 by the force of a return spring. The first hook 40 and the electromagnetic solenoid 41 constitute a first engaging means.

An engaging portion 42 is extended from the distal or outer end of the first arm 13a of the deflector arm 13 and is adapted to engage with a second hook 45, which is pivotally supported through a pin 44 on a bracket 43. The second hook 45 is actuated by an electromagnetic solenoid 46. The outer end of the plunger 46a of the solenoid 46 is pin connected to one end of a bell crank lever 47, whose other end is pin connected to the second hook 45 through a connecting rod 48. The second hook 45, the electric solenoid 46, and the bell crank arm 47 constitute a second engaging means.

Referring next to FIGS. 4, 5 and 6, the mode of operation of the deflector actuating mechanism of the above-described construction will now be described in detail.

In order to hold the deflector 12 at the released or open position, the electromagnetic solenoid 41 is energized so that the first hook 40 is caused to move upwardly as shown in FIG. 4. Then the first hook 40 is disengaged from the engaging portion 32 at the upper end of the swinging lever 29, and the screw rod 34 of the electric servomotor 33 is retracted so that the swinging lever 29 is caused to rotate in the counterclockwise direction in FIG. 4. Therefore the cylinder 19 is guided by the guide rollers 20 to move in the direction indicated by an arrow A so that the first and second operating rods 14 and 16 are also caused to move in the direction indicated by the arrow A, thereby causing the deflector arm 13 to rotate in the counterclockwise direction. The rotation of the deflector arm 13 is transmitted through the deflector shaft 11 to the deflector 12 so that the latter is displaced to the open position. When the deflector 12 reaches the open position, a return spring (not shown) in the electromagnetic solenoid 46 causes the bell crank arm 47 to rotate in the counterclockwise direction so that the second hook 45 is placed into engagement with the engaging portion 42 of the first arm 13a of the deflector arm 13.

Next the electric servomotor 33 is energized so that the screw rod 34 is extended in the direction indicated by an arrow B in FIG. 5. As a result, the swinging lever 29 is caused to rotate in the clockwise direction so that the engaging portion 32 of the swinging lever 29 is placed into engagement with the first hook 40, whereby the swinging lever 29 is locked. In this case, since the deflector arm 13 is in engagement with the second hook 45, the first and second operating rods 14 and 16 and the spring bearing plate 18 remain stationary, but because of the rotation in the clockwise direction of the swinging lever 29, only the cylinder 19 and the dash pot cylinder 23 are caused to move to the right. As a result, the coil spring 27 interposed between the end plate 19a on the side of the deflector arm 13 and the spring bearing plate 18 is compressed within the cylinder 19, whereby energy is stored in the coil spring 27.



5

Normally the Pelton wheel rotates while the deflector 12 is maintained in the open position and the coil spring 27 is compressed to store energy as described above.

When the deflector 12 must be rapidly moved to the closed position because of interruption of the load on the main machine driven by the Pelton wheel while the Pelton wheel is rotating, the electromagnetic solenoid 46 is energized so as to cause the bell crank arm 47 to rotate in the clockwise direction as shown in FIG. 6. Consequently the second hook 45 is swung upward to its releasing position so that it is disengaged from the deflector arm 13 which has been maintained in the open position. Therefore the energy stored in the compressed coil spring 27 between the end plate 19a and the spring bearing plate 18 is released to apply force to the first and second operating rods 14 and 16. As a result, the first and second operating rods 14 and 16 are shifted to the right in FIG. 6, whereby the deflector arm 13 is pulled by the first and second operating rods 14 and 16 to rotate in the clockwise direction. Consequently, the deflector shaft 11 is also caused to rotate in the clockwise direction to move the deflector 12 to the closure position.

In this case, the swinging lever 29 is arrested by the first hook 40 so that the cylinder 23 of the dash pot connected to the swinging lever 29 and the cylinder 19 remain stationary, but the piston 24 is forced to move to the right in FIG. 6 within the cylinder 23 of the dash pot 22. The displacement velocity of the piston 24 can be easily controlled, for instance as shown in FIG. 7, by intercommunicating the cylinder chambers defined in front of and behind of the piston 24 through a bypass passage 50 and controlling the degree of opening of a flow control valve 51 installed in the bypass passage. Therefore, the closing velocity of the deflector 12 which rotates in unison with the deflector arm 13 can be controlled. It is preferable that the dash pot 22 be provided with a slow closure device which, when the deflector 12 is brought to a point in vicinity of the complete closure position as indicated in FIG. 8, closes a bypass passage 50 so as to cause the working oil to flow into an extremely small oil discharge pipe 52, whereby when the deflector 12 is brought to and maintained at the total closure position, exertion of excessive impact load on the stopper 26 disposed at the end plate of the cylinder is prevented.

While the deflector actuating mechanism of this invention has been described in the foregoing disclosure principally with respect to its relation to a single jet deflector, it will be obvious that the mechanism of this invention is capable of actuating a plurality of jet deflectors of a single Pelton wheel as briefly indicated hereinbefore by reference to one example wherein two additional deflectors are actuated through link rods Lb and Lc connected to the second and third arms 13b and 13c of the deflector arm 13.

What is claimed is:

1. A mechanism for actuating a deflector of a Pelton wheel comprising a deflector arm for rotating the de-

6

flector, an operating rod whose one end is pin connected to said deflector arm and whose other end carries a spring bearing plate, a cylinder in which said spring bearing plate is enclosed, and which is guided for movement in the axial direction of said operating rod, spring means which is disposed in the bore of said cylinder on the side of said operating rod and whose stored energy pulls said operating rod, a swinging lever whose one end is pivotally supported and whose midpoint is connected to one end of said cylinder, an electric servomotor connected to the free end of said swinging lever so as to cause reciprocable angular movement of said swinging lever, a first engaging means engageable with said free end of said swinging lever, thereby maintaining said swinging lever stationary, and a second engaging means for maintaining said deflector arm in the fully opened position.

2. A mechanism for actuating a deflector of a Pelton wheel as set forth in claim 1 characterized in that said deflector arm is fixed to one end of a deflector shaft for opening and closing said deflector.

3. A mechanism for actuating a deflector of a Pelton wheel as set forth in claim 1 characterized in that said operating rod comprises a first operating rod and a second operating rod which are interconnected to each other by a pin.

4. A mechanism for actuating a deflector of a Pelton wheel as set forth in claim 1 characterized in that a plurality of guide rollers are rollably mounted on the outer cylindrical surface of said cylinder and roll over stationary guide surfaces.

5. A mechanism for actuating a deflector of a Pelton wheel as set forth in claim 1 characterized in that said first engaging means comprises a hook whose one end is pivoted and whose other end terminates in an engaging portion and an electromagnetic solenoid for causing said hook to move between a locking position and an unlocking or releasing position.

6. A mechanism for actuating a deflector of a Pelton wheel as set forth in claim 1 characterized in that said second engaging means comprises a hook whose one end is pivoted and whose other end terminates in an engaging portion and an electromagnetic solenoid for causing said hook to move between a locking position and an unlocking or releasing position through a bell crank arm.

7. A mechanism for actuating a deflector of a Pelton wheel as set forth in claim 1 characterized in that said spring bearing plate is connected through a connecting rod to a dash pot piston which is disposed in a dash pot cylinder directly joined to said cylinder and pin connected to the midpoint between the ends of said swinging lever.

8. A mechanism for actuating a deflector of a Pelton wheel as set forth in claim 7 characterized in that said dash pot cylinder is communicatively connected to a bypass pipe bypassing said dash pot piston, and a flow control valve is installed in said bypass pipe.

\* \* \* \* \*

[54] PELTON TURBINE

[75] Inventor: Josef Erlach, Ravensburg-Oberzell, Fed. Rep. of Germany

[73] Assignee: Sulzer Brothers Limited, Winterthur, Switzerland

[21] Appl. No.: 405,736

[22] Filed: Sep. 11, 1989

[30] Foreign Application Priority Data

Oct. 6, 1988 [CH] Switzerland ..... 3714/88

[51] Int. Cl.<sup>5</sup> ..... F03B 7/00

[52] U.S. Cl. .... 415/202; 416/197 B

[58] Field of Search ..... 415/202, 201, 203, 88, 415/92, 91; 416/197 B, 197 R

[56] References Cited

U.S. PATENT DOCUMENTS

|           |         |          |       |           |
|-----------|---------|----------|-------|-----------|
| 584,579   | 6/1897  | Davidson | ..... | 416/197 R |
| 906,049   | 12/1908 | Memmel   | ..... | 415/202   |
| 927,657   | 7/1909  | Kemble   | ..... | 415/202   |
| 1,448,893 | 3/1923  | Wiki     | ..... | 415/202   |
| 4,345,160 | 8/1982  | Smith    | ..... | 416/197 B |

FOREIGN PATENT DOCUMENTS

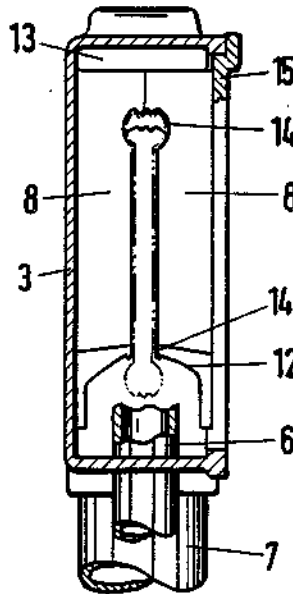
|         |        |                        |
|---------|--------|------------------------|
| 0012314 | 1/1881 | Fed. Rep. of Germany . |
| 0319779 | 3/1921 | Fed. Rep. of Germany . |
| 0615445 | 7/1935 | Fed. Rep. of Germany . |

Primary Examiner—Robert E. Garrett  
Assistant Examiner—Hoang Nguyen  
Attorney, Agent, or Firm—Kenyon & Kenyon

[57] ABSTRACT

The Pelton turbine includes a wheel disc with buckets mounted within a casing on a rotatable drive shaft. At least one nozzle is provided for expelling a fluid jet tangentially of the disc onto the buckets. A partition divides the interior of the housing into a spray fluid and outlet region and an upper ventilation region. The driving fluid falls from the buckets into a sump in the outlet region while residual fluid is wiped off the turbine wheel by the partition. The ventilation region allows ventilation of the casing and also produces a flow of gas for increasing the pressure in the sump to improve the outflow of fluid.

20 Claims, 2 Drawing Sheets



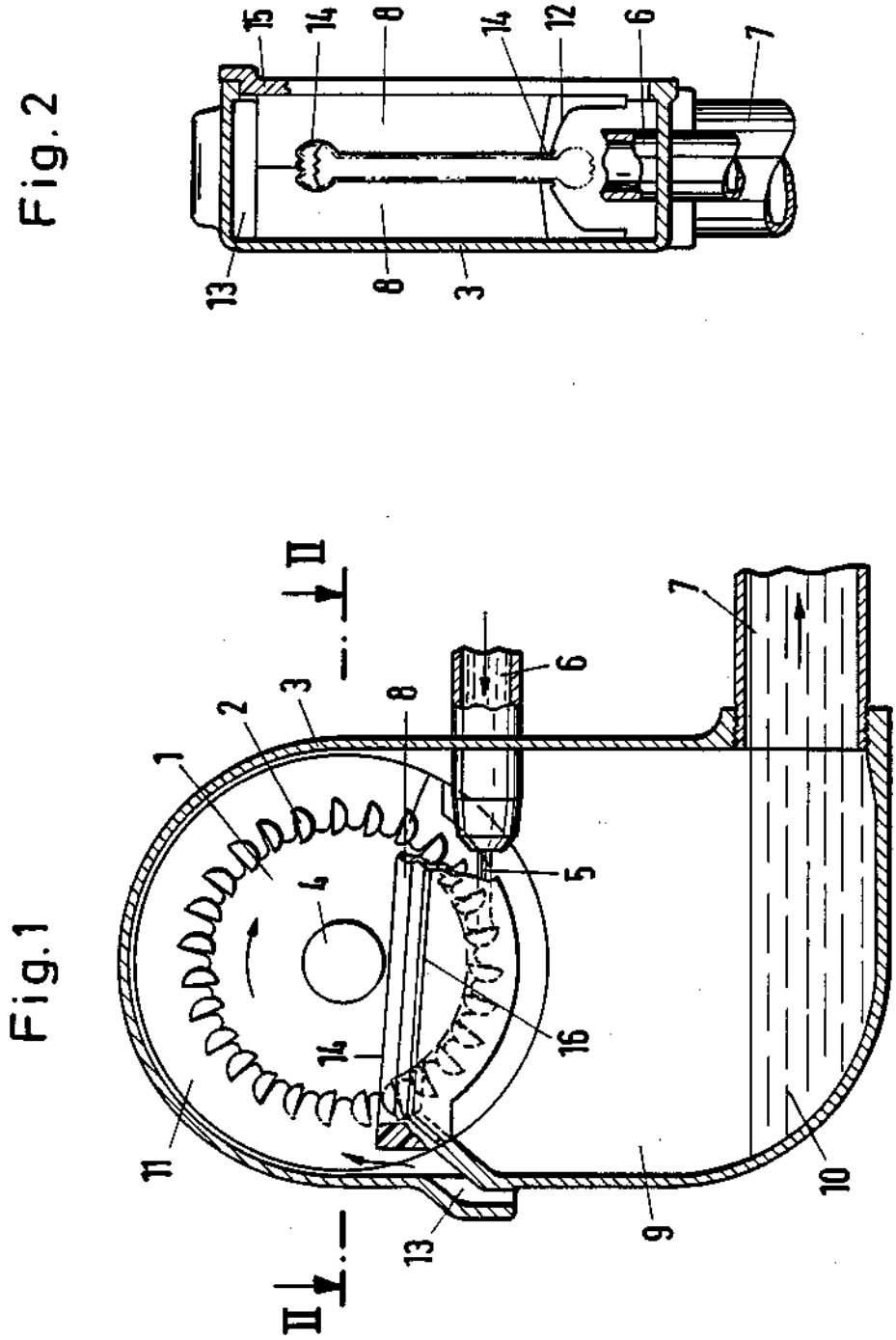
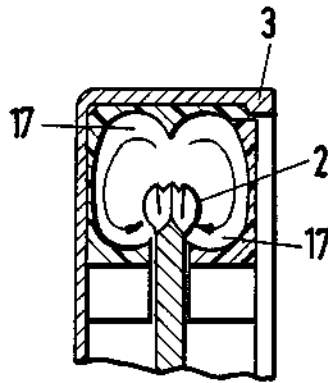


Fig. 2

Fig. 1

Fig. 3



## PELTON TURBINE

This invention relates to a Pelton turbine.

As is known, Pelton turbines are used for driving electricity generators or as a direct drive for working machines. Generally, such Pelton turbines include a casing in which a turbine wheel with a wheel disc and buckets is mounted along with a drive shaft which passes through the casing. In addition, at least one jet is provided for expelling fluid from a high pressure nozzle tangentially of the wheel disc onto the buckets so as to cause rotation of the disc and drive shaft. The casing has also been provided with a fluid outlet for removal of the spent fluid. Turbines of this type are described in German Pat. Nos. 12,314; 319,779 and 615,445.

Because of the reversal of momentum of the jet of drive fluid on the buckets, mechanical power is delivered to the turbine wheel. In the case of an electricity generator, the power is delivered at a constant speed. In addition, the driving fluid which is diverted in the buckets falls into a sump below the wheel disc and, in the process, some of the fluid sprays onto the casing walls. As is known, the efficiency of a Pelton turbine is closely dependent on the success of keeping vagrant spray water away from the turbine wheel and the buckets. In some cases, the drive shaft has been disposed on a horizontal axis while the lower region of the turbine wheel is acted upon by the fluid jets. In these cases, the upper region of the casing has been provided with vertical metal sheets parallel to the plane of the turbine wheel while horizontal sheets are disposed opposite the high pressure nozzle in order to prevent spray water from reaching the upper region of the casing.

In Pelton turbines used at variable speed for driving working machines, these conventional baffles do not give satisfactory results. On the one hand, the outlet conditions from the buckets vary as a result of the large but necessary fluctuations in speed and load. This, in turn, results in considerable differences in spray fluid conditions. On the other hand, there are great variations in the amounts of fluids and these have to be taken into account in the construction by providing high overflow levels so that large quantities of fluid can be discharged without the turbine wheel becoming immersed in the sump. Favorable conditions, favorable efficiency, can be obtained only within narrow limits and when conditions are approximately constant.

Accordingly, it is an object of the invention to improve the efficiency of a Pelton turbine.

It is another object of the invention to reduce the amount of spray water on a rotating wheel disc of a Pelton turbine.

It is another objects of the invention to be able to use a Pelton turbine at variable speeds and outputs.

It is another object of the invention to obtain low dissipation losses and high efficiency in the operation of a Pelton turbine.

Briefly, the invention provides a Pelton turbine which is comprised of a casing having a fluid outlet, a drive shaft extending through the casing, a wheel disc mounted on the shaft within the casing with a plurality of buckets peripherally mounted thereon and at least one nozzle for expelling a fluid jet tangentially of a lower portion of the disc onto the buckets for rotating the disc and shaft. In accordance with the invention, a partition is disposed in the casing to separate an upper ventilation region from a lower spray fluid and outlet

region thereof. This partition has an opening for passage of the disc into the separated regions.

By means of the partition, which closely abuts the turbine wheel, the spray fluid is efficiently separated from the wheel disc and buckets without rebounding and is returned to a fluid sump in the lower end of the casing even if there are variations in speed and load.

The partition is located so that more than half the turbine wheel rotates in the relatively dry ventilation region. The overall result is low dissipation losses and high efficiency. In this respect, the efficiency characteristics depending on speed and load are high and flatter than in previously known constructions.

The casing is also provided with a ventilation outlet which communicates with the ventilation region.

In addition, the partition is provided with a large opening at one end for passage of the buckets there-through from the ventilation region into the spray fluid and outlet region. Thus, the quantities of gas (e.g. air) rotating with the turbine wheel are used to build up a pressure cushion above the liquid sump thus efficiently assisting the outflow of fluid particularly at high speeds. This advantage can be taken into account in the dimensional construction of the fluid outlet, that is, by reducing the required overflow level and, thus, reducing the overall height.

The effect of ventilating the turbine wheel is so great that liquid can be discharged over obstacles which are higher than the liquid level in the turbine sump. This effect is further intensified if a double guide duct is provided in the ventilation region of the casing and, over a limited length around the periphery of the wheel disc, to return the radially outgoing gas to the bases of the buckets for further acceleration. The resulting kinetic energy can be converted to pressure.

These and other objects and advantages of the invention will become more apparent from the following detailed description taken in conjunction with the accompanying drawings wherein:

FIG. 1 illustrates a cross sectional view of a Pelton turbine constructed in accordance with the invention;

FIG. 2 illustrates a view taken on line II—II of FIG. 1; and

FIG. 3 illustrates a diagrammatic radial section through a casing and turbine wheel employing a guide duct for increasing ventilation in accordance with the invention.

Referring to FIG. 1, the Pelton turbine comprises a turbine wheel having a wheel disc 1 and a plurality of buckets 2 peripherally mounted on the wheel disc 1. In addition, the turbine has a casing 3 for housing the disc 1 and buckets while a rotatable drive shaft 4 passes through the casing 3 and receives the wheel disc 1 in mounted relation.

As indicated, the Pelton turbine has a high-pressure nozzle 6 passing through the casing 3 for expelling a fluid jet 5 tangentially of the disc 1 and sequentially onto the buckets 2 for rotating the disc 1 and the shaft 4 in known fashion. The casing 3 also has a fluid outlet 7 at a lower end which communicates with a sump 10 for receiving spent fluid which has been ejected onto the buckets 2.

The direction of the fluid jet 5 and the direction of rotation of the disc 1 are indicated by arrows.

Referring to FIGS. 1 and 2, the transversely disposed partition 8 is disposed in the casing 3 to separate a lower spray and outlet region 9 from an upper ventilation region 11. This partition 8 is contoured so as to sealingly

engage with the casing 3 while being in sealing relation with the wheel 1. In addition, as indicated in FIG. 2, the partition 8 has suitable openings for passage of the buckets 2. As shown in FIG. 1, the partition 8 is disposed above the nozzle 6 so as to maintain the fluid and, particularly, sprays of fluid, below the partition 8 within the spray fluid and outlet region 9. In this way, all of the fluid can be dumped into the sump 10 for removal through the outlet 7. In addition, the sealing relation between the partition 8 and the disc 1 permits fluid which has been sprayed onto the disc 1 to be wiped off the disc 1 and buckets into the sump 10. In this way, the wheel disc 1 may rotate in air within the ventilation region 11.

The casing 3 is also provided with a ventilation opening 13 which communicates with the ventilation region 11. As indicated, the ventilation opening 13 is connected to atmosphere and opens into the ventilation region 11 precisely at a place where the buckets 2 leave the spray fluid and outlet region 9. As indicated in FIG. 2, the partition 8 has a relatively large opening at the opposite end for passage of the buckets 2 from the ventilation region 11 into the spray fluid and outlet region 9. This opening is of parabolic shape and has an apex on the wheel disc 1. As also indicated, the remaining contour of the partition 8 is spaced from the disc 1 with a clearance 14 of the order of 5% of the width of a respective bucket. In this respect, a contactless sealing means faces the disc in order to seal the ventilation region 11 from the spray fluid and outlet region 9.

Apart from the aperture 12 and the recess for the turbine wheel, the partition 8 is connected in seal-tight manner to the casing 3 via a soft seal 16 (see FIG. 1). As also illustrated, the partition 8 has a curved part extending radially outwardly of the buckets 2 which is directed into the spray fluid and outlet region 9 for discharging spray fluid. The partition 8 also has a sloped upper part which extends downwardly toward one end, that is, toward the opening 12. This permits quantities of gas which rotate with the wheel disc 1 to be used to build up a pressure cushion within the region 9 above the sump 10. This serves to assist the outflow of fluid through the outlet 7, particularly at high speeds.

The partition 8 may be made of any suitable material such as plastic. Also, the partition 8 may be made as an integral part of the casing 3. As indicated in FIG. 2, a removable side wall 15 is located on the side of the casing 3 in order to provide for access into the interior of the casing 3.

The partition 8 has a thickness at the end where the buckets 2 move from the spray fluid and outward region 9 into the ventilation region 11 which is equal to the distance of at least one bucket 2 to the following one. Thus, at any particular time, one bucket enters the contour region of the partition 8 before the bucket in front leaves the contour of the partition 8.

Referring to FIG. 3, in order to increase the ventilation effect, a double guide duct 17 is incorporated into the ventilation region 11 and is peripherally spaced about the disc 1 in order to deflect a radially outwardly flowing gas stream for return towards the bases of the buckets 2 as indicated by the arrows.

The operation of the Pelton turbine may be varied from time-to-time, for example, by varying the speed and/or load moment. This may be accomplished by varying the amount of fluid ejected by the nozzle 6.

The invention thus provides a Pelton turbine of improved construction which is capable of operating in a

relatively efficient manner. Further, the invention provides a relatively simple means of keeping vagrant spray water away from the turbine wheel and buckets of a Pelton turbine.

I claim:

1. A Pelton turbine comprising a casing having a fluid outlet; a transversely disposed partition in said casing separating a spray fluid and outlet region from a ventilation region therein; a rotatable drive shaft extending through said casing; a wheel disc mounted on said shaft within said casing and passing through said partition; a plurality of peripherally mounted buckets on said disc; and at least one high-pressure nozzle in said spray fluid and outlet region below said partition for expelling a fluid jet tangentially of said disc sequentially onto said buckets for rotating said disc and said shaft.
2. A Pelton turbine as set forth in claim 1 wherein said partition is disposed across said disc to place about a third of the periphery of said disc in said spray fluid and outlet region.
3. A Pelton turbine as set forth in claim 1 wherein said casing includes a ventilation opening communicating with said ventilation region.
4. A Pelton turbine as set forth in claim 1 wherein said partition has a large opening at one end for passage of said buckets therethrough from said ventilation region into said spray fluid and outlet region, and wherein said partition is spaced from said disc with a clearance of the order of 5% of the width of a respective bucket.
5. A Pelton turbine as set forth in claim 4 wherein said partition has a thickness at a second end for passage of said buckets therethrough from said spray fluid and outlet region into said ventilation equal to the distance of at least one bucket to the following one.
6. A Pelton turbine as set forth in claim 1 wherein said partition has a contactless sealing means facing said disc to seal said regions from each other across said disc.
7. A Pelton turbine as set forth in claim 1 wherein said partition is connected in seal-tight manner to said casing at opposite sides thereof.
8. A Pelton turbine as set forth in claim 1 wherein said partition has a curved part extending radially outwardly of said buckets and directed into said spray fluid and outlet region for discharging spray fluid and a sloped upper part extending downwardly toward one end with a large opening thereat relative to said disc.
9. A Pelton turbine as set forth in claim 1 wherein said partition is made of plastic.
10. A Pelton turbine as set forth in claim 1 wherein said partition is an integral part of said casing.
11. A Pelton turbine as set forth in claim 1 which further comprises a double guide duct in said ventilation region peripherally spaced about said disc to deflect a radially outwardly flowing gas stream for return towards the bases of said buckets.
12. A Pelton turbine as set forth in claim 1 wherein said nozzle is adapted to expel a variable fluid jet to vary the speed of said shaft.
13. A Pelton turbine comprising a casing having a fluid outlet; a drive shaft extending through said casing; a wheel disc mounted on said shaft within said casing; a plurality of buckets peripherally mounted on said wheel disc;

5

at least one nozzle for expelling a fluid jet tangentially of a lower portion of said disc and onto said buckets for rotating said disc and said shaft; and a partition disposed in said casing to separate an upper ventilation region from a lower spray fluid and outlet region thereof, said partition having an opening for passage of said disc therethrough into said regions.

14. A Pelton turbine as set forth in claim 13 wherein said partition is disposed across said disc to place about a third of the periphery of said disc in said spray fluid and outlet region.

15. A Pelton turbine as set forth in claim 13 wherein said partition has a curved part extending radially outwardly of said buckets and directed into said spray fluid and outlet region for discharging spray fluid.

6

16. A Pelton turbine as set forth in claim 15 wherein said partition has a large opening at one end for passage of said buckets therethrough from said ventilation region into said spray fluid and outlet region.

17. A Pelton turbine as set forth in claim 13 wherein said casing includes a ventilation opening communicating with said ventilation region.

18. A Pelton turbine as set forth in claim 13 wherein said partition has a pair of walls parallel to said disc to define a channel for passage of said brackets therethrough.

19. A Pelton turbine as set forth in claim 18 wherein each said wall has a curved part directed into said spray fluid and outlet region and said nozzle is aligned with said channel.

20. A Pelton turbine as set forth in claim 13 wherein said partition is sealingly connected to said casing.

\* \* \* \* \*

20

25

30

35

40

45

50

55

60

65

# United States Patent [19]

Yada et al.

[11] Patent Number: **5,035,579**

[45] Date of Patent: **Jul. 30, 1991**

[54] **WATER-TURBINE RUNNER AND PROCESS FOR MANUFACTURING THE SAME**

[75] Inventors: **Masami Yada; Takao Funamoto; Michio Kitamura; Junzo Komatsu; Masakazu Midorikawa; Tsugio Yoshikawa, all of Hitachi, Japan**

[73] Assignee: **Hitachi, Ltd., Tokyo, Japan**

[21] Appl. No.: **436,701**

[22] Filed: **Nov. 15, 1989**

[30] **Foreign Application Priority Data**

Nov. 22, 1988 [JP] Japan ..... 63-295147

[51] Int. Cl.<sup>5</sup> ..... **B63H 1/00**

[52] U.S. Cl. .... **416/241 R; 415/200; 29/889.7**

[58] Field of Search ..... **415/228, 200; 416/241 R; 29/889, 889.7**

[56] **References Cited**

### U.S. PATENT DOCUMENTS

3,765,793 10/1973 Savonuzzi ..... 416/213 R  
3,902,823 9/1975 Minato et al. .... 416/241 R  
4,322,200 3/1982 Stiegelmeier ..... 416/188

4,609,577 9/1986 Long ..... 420/56  
4,850,187 7/1989 Siga et al. .... 416/241 R

### FOREIGN PATENT DOCUMENTS

60-53737 of 1985 Japan .  
1114819 9/1984 U.S.S.R. .... 416/186 R  
1515296 6/1978 United Kingdom ..... 416/188

*Primary Examiner*—Edward K. Look  
*Assistant Examiner*—Hoang Nguyen  
*Attorney, Agent, or Firm*—Antonelli, Terry, Stout & Kraus

[57] **ABSTRACT**

A water turbine runner has a plurality of vanes, each made of a rolled steel plates which contains, by weight, 0.01 to 0.10% of C, 0.10 to 1.0% of Si, 0.10 to 2% of Mn, 2 to 7% of Ni, 10 to 15% of Cr and 0.10 to 4% of Mo, 71.9 to 87.7% of Fe, and which has a metallic structure mixture containing, by volume, martensite and 10 to 35% of residual austenite. Each of the vanes is made of a plurality of plate pieces, cut out from the rolled steel plate, press-formed in a shape of a part of the vane and joined by welding into the complete vane.

**14 Claims, 3 Drawing Sheets**

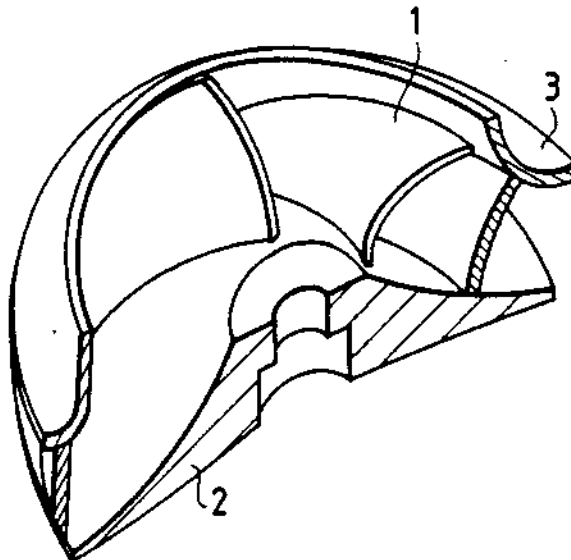




FIG. 1

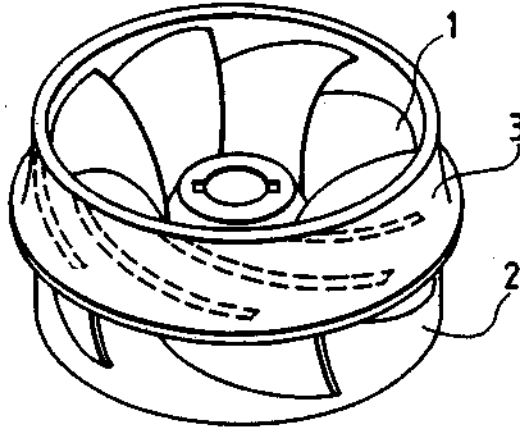


FIG. 2

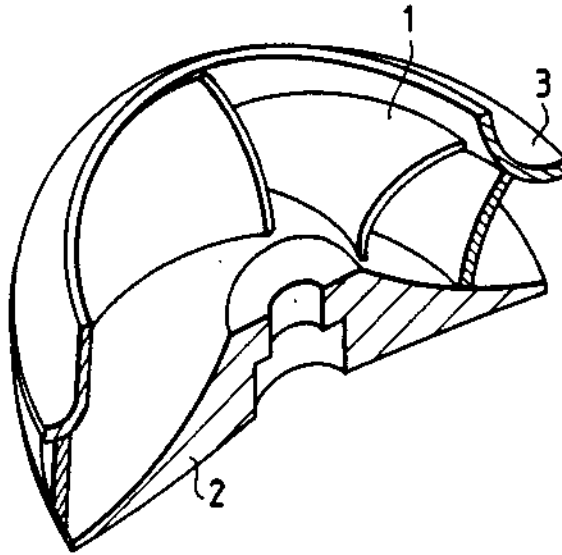


FIG. 3

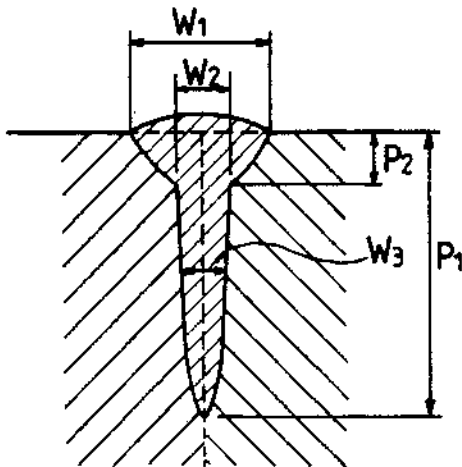


FIG. 4

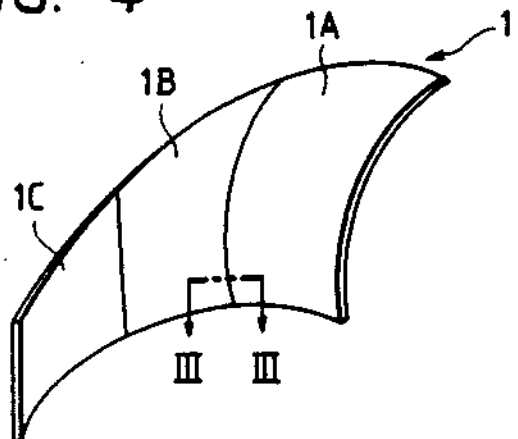


FIG. 5a

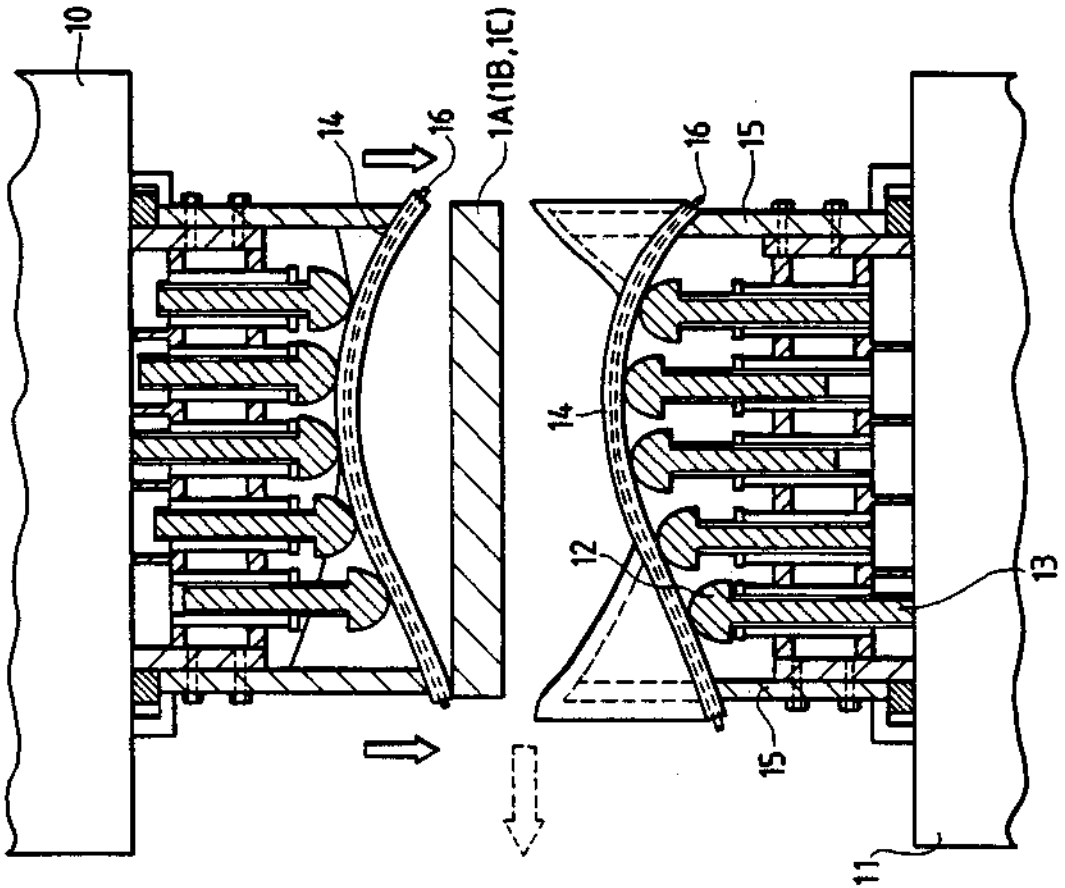


FIG. 5b

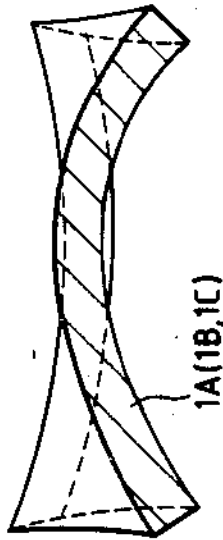
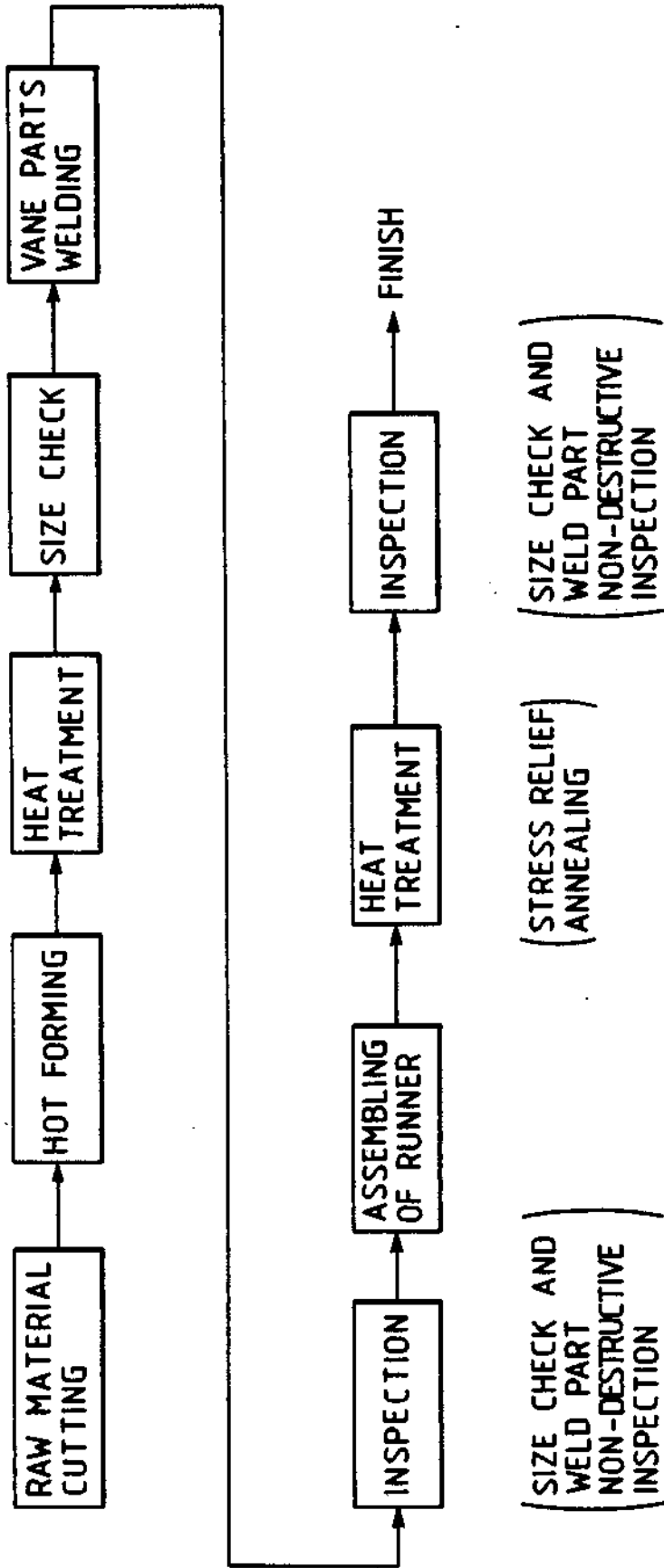


FIG. 6



## WATER-TURBINE RUNNER AND PROCESS FOR MANUFACTURING THE SAME

### BACKGROUND OF THE INVENTION

The present invention relates to a water-turbine runner having a welded structure using a high strength and tough steel plate, and to a process for manufacturing the water-turbine runner.

In order to improve power generating efficiency in recent years, hydro-electric power generation has tended to have a higher and higher lift or head. This tendency requires a water-turbine runner of accordingly higher strength and toughness.

In the prior art, the water-turbine runner has been made of 13Cr steel, i.e., martensite stainless steel which is excellent in cavitation resisting characteristics. This 13Cr steel does not contain Ni. In accordance with the requirement for the output rise and the efficiency improvement of a single water-turbine runner, however, there has been developed 13Cr steel which contains Ni and has an excellent toughness. There has been proposed a water-turbine runner which is one piece cast or plural pieces separately cast of the 13Cr steel as is disclosed in Japanese Patent Publication No. 60-53737.

However, the prior art described above has the following problems:

- a) A sufficient toughness cannot be achieved because of defects intrinsic to the casting such as a shrinkage cavity and segregation.
- b) For detecting the defects, a non-destructive inspection is used such as the ultrasonic flaw detection or the radiation inspection, but this requires a number or steps for inspecting the whole structure of the three-dimensional water-turbine runner with high precision.
- c) The casting defects detected by the non-destructive inspection are remedied by arc welding with covered electrodes, in which the 13Cr steel is liable to incur a weld crack. In order to avoid this weld crack, pre-and post-heating steps are required which undesirably increases the number of steps in the remedial operations.
- d) The finishing of the cast surface of the water turbine runner requires a great number of steps.

### SUMMARY OF THE INVENTION

An object of the present invention is to provide a highly strong and through water-turbine runner and a process for manufacturing the same a reduced number of steps.

Briefly state, the present invention utilizes a plurality of vanes of a water-turbine runner, each made of a rolled steel plate which contains, by weight, 0.01 to 0.10% of C, 0.10 to 1.0% of Si, 0.10 to 2% of Mn, 2 to 7% of Ni, 10 to 15% of Cr and 0.10 to 3% of Mo, 71.9 to 87.7% of Fe, and which has a metallic structure of a mixture containing, by volume, martensite and 10 to 35% of residual austenite, and the vanes are assembled by welding.

Further, the above-mentioned plurality of vanes, each made of a plurality of plate pieces, are cut out from the abovementioned rolled steel plate in accordance with the present invention, press-formed in a shape of a part of the vane and then joined by welding into the complete vane.

Further rolled steel plate or plate pieces are controlled in accordance with the present invention so that

oxygen and nitrogen will be less than 60 ppm and 150 ppm, respectively.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view showing a Francis water-turbine runner to which is applied the present invention;

FIG. 2 is a sectional view of the runner shown in FIG. 1 taken along a plane passing along a central axis of the Francis water-turbine runner in;

FIG. 3 is a diagram showing a bead shape taken along III—III of FIG. 4;

FIG. 4 is a perspective view showing an assembled runner vane;

FIG. 5a is a sectional view of a die fed with a vane member;

FIG. 5b is a sectional view of the vane member; and

FIG. 6 is a flow chart showing the process of manufacturing the runner in accordance with the present invention.

### DETAILED DESCRIPTION OF A PRESENT PREFERRED EMBODIMENT

As shown in FIGS. 1 and 2, the Francis water-turbine runner comprises a crown ring 2 having a center portion to be connected to a drive shaft, a band 3, and a plurality of vanes 1 each interposed between the crown 2 and the band 3 and welded thereto. The vanes 1 each are made of one piece or several pieces or rolled steel plate which will be later described.

The water-turbine runner according to the present invention comprises a plurality of vanes each made of a rolled steel plate which comprises, by weight, 0.01 to 0.10% of C, 0.10 to 1.0% of Si, 0.10 to 2% of Mn, 2 to 7% of Ni, 10 to 15% of Cr and 0.10 to 3% of Mo, and 71.9 to 87.7% of Fe, and oxygen and nitrogen contents being preferably 60 ppm at most and 150 ppm at most, respectively. The runner has a metallic structure of a mixture containing, by volume, martensite and 10 to 35% of residual austenite and is assembled by welding.

The major components Cr and Ni are necessary for imparting strength and cavitation resistance to the water-turbine runner and are contained essentially as in cast steel. In the electron beam welding of a high alloy steel such as the 13Cr steel, however, in order to prevent welding defects and retain the toughness, the contents of oxygen and nitrogen in the steel have to be controlled, and it is essential for the base metal quality to have no cavity.

The reasons for restriction the chemical components in the steel plates are as follows.

The component C when, over 0.10%, will deteriorate the weldability and the notch toughness on the contrary to the increase in the strength. When the component C is below 0.01%, on the other hand, problems in strength and meltability arise.

The component Si has to be more than 0.1% as a deoxidizer in the steel production, but the steel becomes hard and fragile if the Si content exceeds 1%. Thus, Si content is restricted within the range 0.1 to 1.0%.

The component Mn has deoxidizing and desulfurizing actions and contributes as an austenitizing element to the toughness. However, the problem of welding hardness occurs if the Mn content exceeds 2%.

The component Ni is also an austenitizing element and has to be contained within the 2 to 7% range, preferably 4 to 6% so as to retain the amount of the residual

austenite. Over 7% of the component Ni, however, increases the residual austenite so as to reduce strength.

was measured to determine the amount of corrosion of the test surface.

TABLE 1

| Sample | C    | Si   | Mn   | Ni   | Cr    | Mo   | O      | N      | Remarks |
|--------|------|------|------|------|-------|------|--------|--------|---------|
| No. 1  | 0.03 | 0.45 | 0.58 | 5.0  | 12.41 | 0.27 | 0.0057 | 0.0126 | Rolled  |
| No. 2  | 0.04 | 0.33 | 0.60 | 5.25 | 12.60 | 0.26 | 0.0039 | 0.0089 | ditto   |
| No. 3  | 0.04 | 0.31 | 0.62 | 5.12 | 12.50 | 0.26 | 0.0054 | 0.0082 | ditto   |
| No. 4  | 0.05 | 0.47 | 0.59 | 5.20 | 12.45 | 0.24 | 0.0046 | 0.0362 | Forged  |
| No. 5  | 0.04 | 0.44 | 0.72 | 4.93 | 12.42 | 0.25 | 0.0128 | 0.0476 | Cast    |
| No. 6  | 0.07 | 0.45 | 0.51 | 5.05 | 12.73 | 0.21 | 0.0103 | 0.0424 | ditto   |

Sample Nos. 1 to 3 are illustrative of the invention  
Sample Nos. 4 to 6 are illustrative of conventional steels

TABLE 2

|  | Sample No. |      |      |     |     |     |
|--|------------|------|------|-----|-----|-----|
|  | 1          | 2    | 3    | 4   | 5   | 6   |
| Tensile Strength (kgf/mm <sup>2</sup> )                              | 85.0       | 84.6 | 87.0 | 86  | 84  | 85  |
| 0.2% Yield Point (kgf/mm <sup>2</sup> )                              | 70.5       | 71.0 | 64.0 | 69  | 64  | 64  |
| Elongation (%)   | 26         | 26   | 24   | 25  | 19  | 20  |
| Reduction (%)  | 71         | 70   | 69   | 70  | 61  | 63  |
| Residual Austenite (%)   | 32         | 30   | 31   | 29  | 30  | 31  |
| CE Test  | 50         | 47   | 53   | 59  | 60  | 68  |
| Corrosiveness (mg) 2 mm V-Notch Charpy Impact Value (kgf-m) at 0° C. | 14         | 16   | 19   | 13  | 6   | 8   |
| Fracture Toughness (kgf · mm <sup>-3/2</sup> ) at 0° C.              | 620        | 600  | 605  | 580 | 390 | 350 |

Sample Nos. 1 to 3 are illustrative of the invention  
Sample Nos. 4 to 6 are illustrative of conventional steels

The component Cr is fundamental for corrosion resistance and has to be no less than 10% so as to retain the corrosion resistance in plain water. If, however, the Cr content increases, the delta ferrite increases to make the steel fragile so that the upper limit of Cr content is 15%.

The component Mo is a carbide producing element which is remarkably effective in improving the fatigue strength in water and presents annealing brittleness. Over 3%, of Mo content, however, weakens those effects so as to increase hardenability and lower the toughness.

Oxygen reduces the toughness of a metal to be welded and increases the incidence of internal defects such as blow holes, especially in electron beam welding. Consequently, the oxygen content has to have an upper limit of 60 ppm.

The nitrogen component is bonded, if in trace amounts, to the aluminum in the steel to act as fine cores of crystal particles. However, when present in excess, the nitrogen not only segregates in the austenite particles but also causes blow holes like the oxygen component so that its content has to have an upper limit of 150 ppm.

The steel structure of the present invention is mainly in the mixed state of martensite and residual austenite. The amount of this residual austenite may be more than 10% from the standpoint of toughness and less than 35% from the standpoint of strength.

Moreover, the forementioned steel is rolled and cut into predetermined sizes after non-destructive inspection and visual inspection so that it may be used for components of the water-turbine runner. These inspections of the steel plate not only are highly efficient but also can improve the accuracy. As a matter of fact, these inspections cover about eighty to ninety percent of the total inspections of the water runner.

Then, the steel plate is subjected to plastic working with a mold having a three-dimensional curve and is assembled by being welded with an electron beam.

The material of the vanes 1 will be described hereunder.

Table 1 enumerates the chemical components of the sample steels of the aforementioned water-turbine runner, and Table 2 enumerates the mechanical properties of the sample steels. In Table 2, there are also enumerated the results of both the cavitation erosion (Ce) tests and the destructive toughness tests.

In the cavitation erosion tests, a magnetic strain oscillation type tester was used. The test conditions were as follows: the frequency was 6.5 kHz; the amplitude was 120 m; the test liquid was service-water; the test liquid temperature was 25° C.; and the test time was 2 hours. The difference between the weights of the test surface having a diameter of 22 mm before and after the tests

In the fracture toughness tests, the fracture toughness at 0° C. was determined by the elastic/plastic fracture toughness testing method using a compact tension test piece having a thickness of 12.7 mm in conformity to the ASTM E813-81.

Next, the test results will be described. The Samples Nos. 1 to 3 belong to the rolled steels of the present invention. The Samples Nos. 4 to 6 belong to the steels for comparison, and of these, Samples Nos. 5 and 6 are cast steels similar to those of the water-turbine runner of the prior art, and Sample No. 41 is forged steel. These steels are composed mainly of 5Ni-13Cr but have different contents of oxygen and nitrogen gases.

For tensile strength and the 0.2% yield point, no substantial difference is found between the cast steel and the rolled steel. However, the rolled steel is found to have larger values of elongation and reduction than those of the cast steel and, accordingly, to be slightly more ductile.

As to the characteristics required for preventing the structures from being broken, such as the impact value or the fracture toughness, moreover, the rolled steel is seen in Table 2 to be far superior to the cast steel. This superiority is influenced by the difference in the amounts of non-metallic inclusions contained in the steels and is caused by the fact that the rolled steel has a lower cleanness (Total) of 0.033 to 0.053 than that of the cast steel of 0.11 to 0.14.

Next, the results of the examination of the electron beam weldability of the 5Ni-13Cr steel will be described.

The electron beam welding method is being applied more frequently to large-sized thick structures of carbon steel in accordance with the development of a high-power apparatus, because this method produces less

welding deformation and thus can weld a thick plate in one path.

What has to be considered, we have found, especially for practising the electron beam welding in a high strength water-turbine runner, is the presence of welding defects such as porosity or hot cracking and the various characteristics such as the mechanical properties of the welded portions and the rupture toughness.

The examined results of the weldability of the 5Ni-13Cr steel are enumerated below in Table 3, wherein the bead shape reference characters, W<sub>1</sub>, W<sub>2</sub>, W<sub>3</sub>, P<sub>1</sub> and P<sub>2</sub> are shown in FIG. 3. The samples were worked to have a plate thickness of 80 mm and were welded at their I-shaped abutting portions with an acceleration voltage of 90 kV, a beam current of 300 to 350 mA, a beam oscillation of a diameter of 0.5 mm × 500 Hz, and the focal point 80 mm below the surface of the materials to be welded.

TABLE 3

|                                     | Sample No. |      |                |      |      |      |
|-------------------------------------|------------|------|----------------|------|------|------|
|                                     | 1          | 2    | 3              | 4    | 5    | 6    |
| Thickness (mm)                      | 80         | 80   | 80             | 80   | 80   | 80   |
| <u>Gas Content (ppm)</u>            |            |      |                |      |      |      |
| O                                   | 57         | 39   | 54             | 46   | 128  | 103  |
| N                                   | 126        | 82   | 82             | 362  | 476  | 424  |
| <u>EB Welding Condition</u>         |            |      |                |      |      |      |
| Acceleration Voltage (kv)           | 90         | 90   | 90             | 90   | 90   | 90   |
| Beam Current (mA)                   | 310        | 310  | 310            | 300  | 330  | 350  |
| Focus Position (mm)                 | -80        | -80  | -80            | -80  | -80  | -80  |
| Welding Speed (mm/min)              | 150        | 150  | 150            | 150  | 150  | 150  |
| Beam Oscillations                   |            |      | 0.5 φ × 500 Hz |      |      |      |
| <u>Bead Shape (mm)</u>              |            |      |                |      |      |      |
| W <sub>1</sub>                      | 16.9       | 17.1 | 17.1           | 16.5 | 19.0 | 20.5 |
| W <sub>2</sub>                      | 6.7        | 6.8  | 6.8            | 6.5  | 7.0  | 7.5  |
| W <sub>3</sub>                      | 5.1        | 5.1  | 5.1            | 5.0  | 5.2  | 5.5  |
| P <sub>1</sub>                      | 71         | 71   | 71             | 70   | 72   | 75   |
| P <sub>2</sub>                      | 6.6        | 6.6  | 6.6            | 6.5  | 7.2  | 7.4  |
| <u>Inspection of Welded Portion</u> |            |      |                |      |      |      |
| UT (Defect)                         | NO         | NO   | NO             | YES  | YES  | YES  |
| Section (Defect)                    | NO         | NO   | NO             | YES  | YES  | YES  |

Sample Nos. 1 to 3 are illustrative of the Invention  
Sample Nos. 4 to 6 are illustrative of conventional steels

Although none of the samples were hot-cracked, Samples Nos. 4 to 6 were found to have porosity in the vicinity of the center of the welded metal. Our various investigations have revealed that the porosity was caused by the influences of the oxygen and nitrogen gases contained in the steel. As seen from the Table 1, Samples Nos. 4 to 6 had an oxygen content of about 50 to 130 ppm and a nitrogen content of about 360 to 480 ppm.

In view of these findings, the relations between the occurrence of the porosity and the oxygen and nitrogen in the 5Ni-13Cr steel were examined, and we found that neither hot cracks nor porosity was caused with the oxygen content set at 60 ppm and the nitrogen content set at 150 ppm.

Such steels are also confirmed to exhibit excellent characteristics in the fracture toughness of not only the base metal when the oxygen and nitrogen contents are set at 60 ppm and 150 ppm, respectively but also welded metal.

The compared results of the fracture toughness and the cavitation corrosion of the electron beam welded metal are enumerated between the steels of the present invention (Sample No. 1) and the conventional steels (Sample No. 5) used, for comparison in Table 4 below.

TABLE 4

| Sample        | Welding       | Fracture Toughness (kg · mm <sup>-3/2</sup> ) | Cavitation Corrosion (mg) |
|---------------|---------------|---|---------------------------|
| No. 1 (Inv.)  | Electron Beam | 625   | 55                        |
| No. 5 (Comp.) | Electron Beam | 410   | 60                        |

The two steels are not substantially different in cavitation characteristics, but the present steel of the invention is higher by 30% in fracture toughness than the comparison steel. It is evident that this difference is influenced by the cleanness and oxygen content of the base metal.

The results of the steel of the present invention (Sample No. 1) upon the tensile tests of the electron beam welded joints are enumerated in comparison to the conventional steels (Sample No. 5) in Table 5.

TABLE 5

| Sample        | Welding       | Tensile Strength (kgf/mm <sup>2</sup> ) | Yield Point (kgf/mm <sup>2</sup> ) | Elongation (%) | Fracture Position |
|---------------|---------------|---|------------------------------------|----------------|-------------------|
| No. 1 (Inv.)  | Electron Beam | 84.8                                    | 75.0                               | 24.6           | Base Metal        |
| No. 5 (Comp.) | SMAW          | 64.3                                    | 47.9                               | 60             | Welded Metal      |

From Table 5, it is apparent that the electron beam welded metal is not softened but has a strength identical to that of the base metal. Incidentally, the strength in case the sealed metal arc weld (SMAW) was used is enumerated in Table 5 but takes a far lower strength than the electron beam welding in the case of the austenite welding rod.

The most practical rolled steel has a content consisting essentially of by weight, 0.02 to 0.05% C, 0.2 to 0.5% Si, 0.5 to 1.0% Mn, 4.5 to 5.8% Ni, 12 to 14% Cr, 0.2 to 20% Mo and the balance of Fe, wherein P, S, O and N as unavoidable contents are less than 0.03%, less than 0.015%, less than 60 ppm, less than 150 ppm, respectively.

Thus, it has been found that the rolled steel used in the present invention has superior electron beam weld-

ability and notch toughness of the joint to the cast metal. On the basis of these results, a half-size water-turbine runner was trial manufactured.

Next, manufacture of the water-turbine runner will be described.

The vanes 1 each are sized to have a length of 8,000 mm, a maximum width of 1,700 mm, and a thickness of 80 mm.

Each of the vanes 1, as shown in FIG. 4, comprises three vane pieces 1A, 1B, 1C, each of which is cut off piece from a rolled plate in such a manner that the rolling direction of the rolled plate coincides with a longitudinal direction of the vane 1, and is press-formed by hot-and cold working by using a multispindle plastic working press.

The press has a structure, as shown in FIG. 5a, in which movable rods 13 carrying semispherical movable heads 12 are attached to upper and lower tables 10 and 11 arranged vertically to face each other. To the leading ends of the movable heads 12, there are fixed a pair of pressing plates 14 which have three-dimensional curves and are supported at their two side ends by supporting side plates 15. In each of the pressing plates 14, moreover, there are disposed water conduits 16 for cooling the pressing plates 14. The movable rods 13 are held by hydraulic means at positions where the heads 12 are in contact with the pressing plates 14, and the movable rods 13 associated with the upper table 10 are moved downwardly by the upper table 10 as shown by the arrow.

When the cut-off plate pieces 1A, 1B and 1C are disposed on the lower pressing plate 14 and pressed by the pressing plate moving downwards with the table 10 to follow the three-dimensional curves, they are heated in advance to about 950° C. and then pressed between the upper and lower pressing plates 14. The pressure upon the cut off plate pieces 1A, 1B and 1C is continued until the martensite transformation is ended to prevent the vane pieces 1A, 1B and 1C from buckling and from being deformed by the thermal expansion of the martensite transformation, which might otherwise be caused if the pressure were released before the end of the martensite transformation.

The vane pieces 1A, 1B, and 1C thus formed by the press as shown in FIG. 5b, are welded and integrated into a one piece vane 1 by a three-dimensional electron beam welder, and the integrated structure is then subjected to the sizing inspection and the non-destructive inspection.

The thus manufactured vanes 1 are arranged on the crown ring 2 and the band 3 shown in FIGS. 1 and 2 and welded thereto, whereby the water-turbine runner is fully produced.

The procedures for manufacturing the water-turbine runner described above are shown in the flow chart of FIG. 6.

According to FIG. 6 raw material in the form of a rolled steel plate is cut to produce a plurality of plates pieces 1A, 1B, 1C. The plate pieces are formed by hot-working, the formed plate pieces of vane pieces 1A, 1B, 1C, are heated to a temperature of 590°±20° C. and then cooled, thereby annealing the pieces so that 100% martensite is converted to be a mixture of martensite and 10 to 35% by volume of residual austenite. The annealed vane pieces are then subjected to size check, and welded to a integrate the pieces into one complete vane form by electron beam welding. The formed vane is subjected to size check and non-destructive inspec-

tion of the weld portion. The vane 1 is assembled into the runner by welding, the assembled runner is subjected to heat treatment to relieve strain and control the residual austenite amount to a predetermined amount. The heat treated runner is checked in size and inspected of the welded portion in a non-destructive manner, whereby the runner is completed.

The present invention can be applied to the manufacture of not only the vane 1 but also the band 2, that is, the band 2 also can be made of the above-mentioned rolled steel plate press formed in the band shape. The crown ring preferably is cast of a steel having the same content as mentioned rolled steel plate except for nitrogen and oxygen.

As has been described hereinbefore, according to the present invention, it is possible to provide a highly strong, tough and corrosion-resisting water-turbine runner so that fracture safety reliability can be improved.

The present invention has high economical merit because the number of manufacturing steps can be reduced.

What is Claimed is:

1. A water-turbine runner comprising a rotary member with a central portion for connecting a drive shaft, and a plurality of vanes each provided on said rotary member, each of said vanes is made of a rolled steel plate comprising, by weight, 0.01 to 0.10% of C, 0.10 to 1.0% of Si, 0.10 to 2% of Mn, 4 to 6% of Ni, 10 to 15% of Cr and 0.10 to 3% of Mo, and 71.9 to 87.7% of Fe, and has a metallic mixture containing, by volume, martensite and 10 to 35% of residual austenite, and wherein weld means are provided for mounting said vanes on said rotary member.

2. The water turbine runner according to claim 1, wherein each of said vanes comprises a plurality of vane pieces made of the rolled steel plate, and wherein weld means are provided for integrating said vane pieces into the respective vanes.

3. The water-turbine runner according to claim 1, wherein oxygen and nitrogen contained in said rolled steel plate are 60 ppm maximum and 150 ppm maximum, respectively.

4. The water-turbine runner according to claim 3, wherein said weld means for mounting said vanes on said rotary member are effected by electron beam welding, and wherein welded portions of said rotary member contain 10 to 35% by volume of residual austenite.

5. The water-turbine runner according to claim 4, wherein the welded portions are heat treated.

6. A water-turbine runner comprising a crown ring and a plurality of vanes each mounted on said crown ring, each of said vanes comprising a plurality of plate pieces cut off from a rolled steel plate consisting essentially of, by weight, 0.01 to 0.10% C, 0.10 to 1.0% of Si, 0.10 to 2% of Mn, 4 to 6% of Ni, 10 to 15% of Cr and 0.10 to 3% of Mo, and the balance of Fe, and which has a metallic mixture containing, by volume, martensite and 10 to 35% of residual austenite, wherein each of said plate pieces has a shape of a portion of the respective vanes, and weld means are provided for integrating said plate pieces into the respective vanes.

7. The water-turbine runner according to claim 6, wherein a maximum oxygen content and maximum nitrogen content in said rolled steel plate are 60 ppm and 150 ppm, respectively.

8. The water-turbine runner according to claim 7, wherein welded portions contain 10 to 35% by volume of residual austenite.

9. The water-turbine runner according to claim 6, wherein said plate is melted to have a controlled maximum oxygen content of 60 ppm and a controlled maximum nitrogen content of 150 ppm.

10. The water-turbine runner according to claim 6, wherein welded portions join the plate pieces to form said vanes.

11. The water-turbine runner according to claim 8, wherein the welded portions comprise heat treated electron beam welds.

12. A water-turbine runner comprising: a crown ring with a shaft receiving portion at a central portion thereof, a band and a plurality of vanes interposed between said crown ring and said band, wherein each of said plurality of vanes comprise plate pieces consisting essentially of, by weight, 0.02 to 0.05% of C, 0.2 to 0.5% of Si, 0.5 to 1% of Mn, 4.5 to 5.8% of Ni, 12 to 14% of Cr and 0.2 to 2% of Mo, and the balance of Fe, a maximum oxygen and a maximum nitrogen contained in said rolled steel plate being 60 ppm and 150 ppm, respectively, and which has a metallic mixture containing, by vol-

ume, martensite and 10 to 35% of residual austenite.

13. A process for manufacturing a water-turbine runner, comprising the steps of:

forming into a three-dimensional shape a rolled steel plate which contains, by weight, 0.01 to 0.10% of C, 0.10 to 1.0% of Si, 0.10 to 2% of Mn, 4 to 6% of Ni, 10 to 15% of Cr and 0.10 to 3% of Mo, 71.9 to 87.7% of Fe, the oxygen content being no greater than 60 ppm, and the nitrogen being no greater than 150 ppm, and which has a metallic structure mixture containing martensite and residual austenite and which is regulated such that the residual austenite is 10 to 35% by volume;

electron beam welding the formed steel plate; and subjecting the steel plate to a heat treatment so that welded portions contain 10 to 35% of residual austenite by volume.

14. A water-turbine runner manufacturing process as set forth in claim 13, wherein the step of forming said rolled steel plate into the three-dimensional shape includes the steps of: heating said rolled steel plate; and subsequently holding the heated steel plate under pressure from a forming starting temperature to an Ms critical temperature.

\* \* \* \* \*

30

35

40

45

50

55

60

65





US005154566A

# United States Patent [19]

[11] Patent Number: **5,154,566**

Enterria et al.

[45] Date of Patent: **Oct. 13, 1992**

[54] **PERFECTED HYDRAULIC MACHINE  
PREFERABLY FOR MINIMUM HEIGHT  
WATERFALLS**

[76] Inventors: **Gonzalez J. J. Enterria; Durio E. Siloniz**, both of Avenida de Moratalaz, 149, Madrid, Spain

[21] Appl. No.: **652,925**

[22] Filed: **Feb. 8, 1991**

[51] Int. Cl.<sup>5</sup> ..... **F03B 13/12; F03B 15/06; F03D 7/00**

[52] U.S. Cl. .... **415/3.1; 415/7; 415/8; 415/906; 416/197 A**

[58] Field of Search ..... **416/197 A; 415/7, 3.1, 415/906, 8**

[56] **References Cited**

**U.S. PATENT DOCUMENTS**

|           |         |                |           |
|-----------|---------|----------------|-----------|
| 1,082,883 | 12/1913 | Lefler         | 415/7     |
| 4,076,447 | 2/1978  | Granata et al. | 415/8     |
| 4,204,795 | 5/1980  | Forrest        | 416/197 A |

**FOREIGN PATENT DOCUMENTS**

|         |        |        |           |
|---------|--------|--------|-----------|
| 0557416 | 8/1923 | France | 416/197 A |
| 0028878 | 2/1982 | Japan  | 416/197 A |

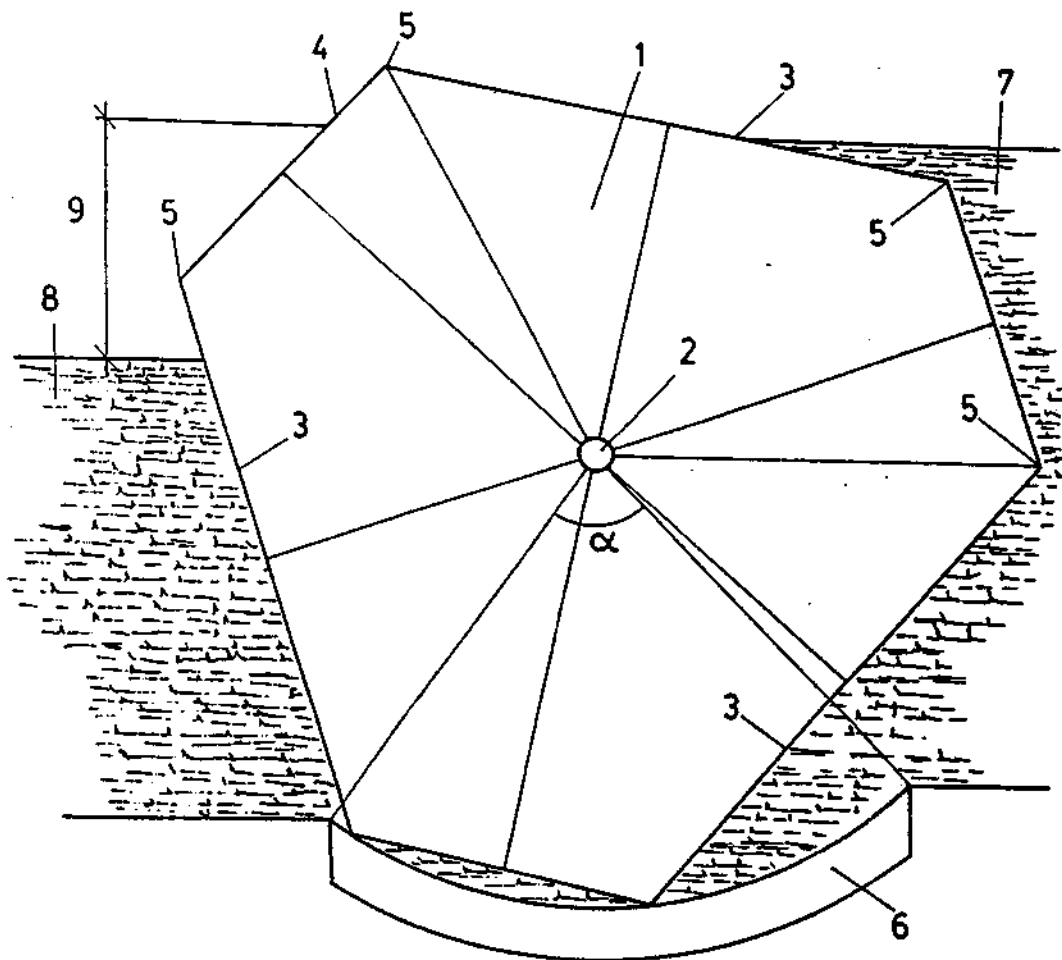
*Primary Examiner*—Thomas E. Denion  
*Attorney, Agent, or Firm*—Peter L. Michaelson

[57] **ABSTRACT**

This machine consists of an impeller formed by a right prism with a minimum weight/volume ratio and which has an irregular hexagonal section, three sides of which are bigger than the other three, and with said hexagon's vertexes belonging to a single circumference. The second body of said machine is formed by an open cylindrical chamber, concentric to the impeller, with an angle of approximately 83 degrees.

Its basic characteristic is its high performance in obtaining energy produced by minimum height waterfalls.

**16 Claims, 1 Drawing Sheet**



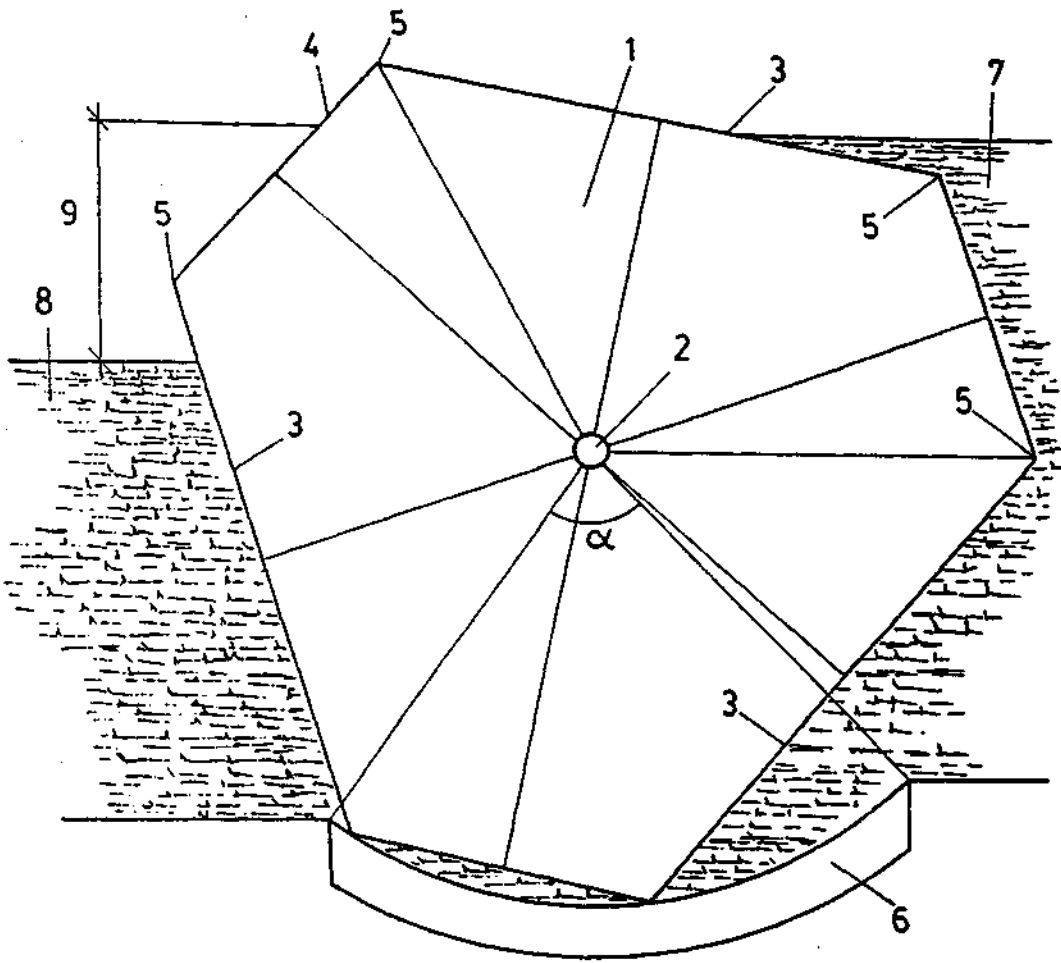


FIG. 1

## PERFECTED HYDRAULIC MACHINE PREFERABLY FOR MINIMUM HEIGHT WATERFALLS

### TECHNICAL FIELD OF THE INVENTION

The present invention consists of a perfected hydraulic machine preferably used for minimum height waterfalls, which offers a series of very important advantages over the present hydraulic machines destined for similar jobs.

### BACKGROUND ART

We wish to point out that in order for present hydraulic systems to transform and use hydraulic energy with an acceptable yield, they must use waterfall heights of over 2 meters, as under 2 meters the performance drops to levels that make the use of these bodies of water uneconomical.

The present hydraulic machines are generally classified as action and reaction turbines. Of the former, we find the so-called "PELTON" turbines with an ideal field of application between 20 and 300 meters high waterfalls.

In the second group, and in first place we find the so-called "FRANCIS" turbines with an application range of between 4 and 200 meters, while—in second place—we find those called "KAPLAN", with a vertical or horizontal axle with an application range of between 2 and 20 meters for the waterfall height.

Finally, we mention the so-called double impulse or cross-flow turbines whose application range varies between 2 and 200 meters of waterfall height.

From the present hydraulic machines mentioned, it is clear that no hydraulic machine exists for waterfall heights of less than 2 meters that offers a normally acceptable performance and which would make use of any of these machines economical.

The Applicant's own Invention Patent number 8703324 should be mentioned, which refers to a hydraulic machine consisting of an impeller housed in an open cylindrical chamber, formed by a right prism that has a minimum weight/volume ratio and whose right section is an equilateral triangle with curved sides.

However, with this present invention, the object obtained is a perfected hydraulic machine which amply surpasses Patent 8703324, thus obtaining a much higher yield, in addition to having achieved a more simple impeller design, as this invention is based on straight planes while in Patent 8703324 this had to be carried out by means of curved profiles which were difficult to produce and any variation in the profile's shape greatly influenced the machine's final yield.

### SUMMARY OF THE INVENTION

The invention is a hydraulic machine comprising a first body, or impeller formed by a right prism whose weight/volume ratio is minimum and it forms an irregular hexagonal section with three sides being larger than the other three and this hexagon's vertexes form a sole circumference. The hydraulic machine's second body consists of an open cylindrical chamber, concentric to the impeller and covering an angle of approximately 83 degrees, which is clearly less than to the 120 degrees required in Invention Patent 8703324.

The impeller's vertexes are in charge of closing the chamber, and the impeller's edges—when passing the closure section during its cycloidivides the machine's

upward water section and downward water section; thus achieving that the pressures originating in the areas—and which are of different intensities—depending on the level of water reached in each one, act efficiently on the impeller's submerged surfaces.

Based on its form of operation, this machine could be classified as a positive displacement volumetric machine because with each revolution the impeller displaces a constant volume of water from the upper water area to the lower water area. Thanks to these characteristics and knowing the machine's revolutions per minute and the available waterfall capacity, the impeller's length can be adjusted to adapt itself to this condition.

### BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 depicts a sectional drawing of a hydraulic machine constructed in accordance with the teachings of the present invention.

### DETAILED DESCRIPTION OF THE INVENTION

In order to give a detailed description of the invention, we refer to the attached drawing, which has been represented in the preferred manner of realization, as an example but without any limitations whatsoever.

FIG. 1, which is the only drawing, represents a sectional drawing of the inventive hydraulic machine, showing the impeller's right section -1- consisting of a minimum-density right prism, transversally semi-submerged in the water flow's stream with its axle -2- being parallel to the waterfall plane. This prism's right section is an irregular hexagon that has two unequal sides, a larger side -3- and the other side -4- alternating, with each and every one of the vertexes -5- of said hexagon belonging to a single circumference whose center is axle -2-.

This impeller -1- is placed inside a cylindrical chamber -6- concentric to the impeller, thus obtaining contact between the impeller -1- and the chamber or by means of the impeller's vertexes -5- or in other words by the edges of the impeller's prismatic body.

This cylindrical chamber -6- covers an inside angle of approximately 83 degrees, coinciding with the angle covered by any one of the three larger sides, whose exact angle is  $82^{\circ} 31' 57.65$  degrees thus obtaining a regular operation while the angle covered inside the smaller sides is  $37^{\circ} 28' 2.65$  degrees.

The magnitude of the hexagon's larger sides is 1.31912 times the circumference's radius, where it is inscribed, while the smaller side has a value of 0.642338 times the circumference's radius where the hexagon is inscribed.

The inventive hydraulic machine is completed with a body or housing where the impeller is housed, which is not represented in this figure, as it is not necessary to explain the invention.

The density of the impeller -1- should be as low as possible, as one of the forces that will act on same—and which will have a definite influence on the impeller's movement—will be the upward force imposed on same. Due to the volume displaced by Archimedes' principle, this force will be equal to the volume of displaced liquid. Therefore, the lower the impeller's density, the greater this force's influence will be on its final yield.

On each side of the impeller we have the two water masses -7- and -8- with -9- being the difference in level

between both masses and which constitutes the waterfall being used in the installation.

The main advantage of this turbine, as it is described, is its total adaptability to any waterfall condition, such as flow, height, etc. and it requires a minimum infrastructure for its installation.

By using this turbine, a suitable performance is obtained for water flows which have not been used up to now due to this technique's being uneconomical and because no devices existed for using this energy with a minimum acceptable performance. This machines can be used for continental water sources as well as for taking advantage of sea water and only certain technical changes are required merely to adapt the machine to the desired application.

Due to its construction, the yields are maintained when the water flow direction is inverted, therefore its operation is directly reversible.

We claim:

1. A hydraulic machine for operating in cooperation with a minimum height waterfall comprising:

a hexagonal shape impeller having six sides, three of said sides being equal in length and longer than the remaining three of said sides, said remaining three sides being equal in length so as to define three short sides and three long sides, wherein said long sides alternate with said short sides to define the hexagonal shape of said impeller, and having six vertexes, each vertex being formed where a corresponding one of said long sides intersects a corresponding one of said short sides equidistant from an axis of rotation of said impeller; and

axle means attached to said impeller at said axis of rotation for enabling said impeller to rotate about said axis in response to said minimum height waterfall.

2. The hydraulic machine of claim 1 further comprises:

a housing having an inner cylindrical surface concentric to said axis of rotation and having a radius substantially equal to the distance of each said vertex of said impeller from said axis of rotation; and wherein said inner surface is approximately 83 degrees in arc length and is proximate to each said vertex of said impeller to form a seal between each said vertex and said inner surface.

3. The hydraulic machine of claim 1 wherein each one of said long sides and said distance to each said vertex define a central angle of 82 degrees, 31 minutes and 57.65 seconds and each one of said short sides and said distance to each said vertex define a central angle of 37 degrees, 28 minutes and 2.35 seconds.

4. The hydraulic machine of claim 2 wherein each one of said long sides and said distance to each said vertex define a central angle of 82 degrees, 31 minutes and 57.65 seconds and each one of said short sides and

said distance to each said vertex define a central angle of 37 degrees, 28 minutes and 2.35 seconds.

5. The hydraulic machine of claim 1 wherein each one of said long sides has a length equal to 1.31912 times said distance from said axis of rotation to each said vertex and each one of said short sides has a length equal to 0.642338 times said distance from said axis of rotation to each said vertex.

6. The hydraulic machine of claim 2 wherein each one of said long sides has a length equal to 1.31912 times said distance from said axis of rotation to each said vertex and each one of said short sides has a length equal to 0.642338 times said distance from said axis of rotation to each said vertex.

7. The hydraulic machine of claim 3 wherein each one of said long sides has a length equal to 1.31912 times said distance from said axis of rotation to each said vertex and each one of said short sides has a length equal to 0.642338 times said distance from said axis of rotation to each said vertex.

8. The hydraulic machine of claim 4 wherein each one of said long sides has a length equal to 1.31912 times said distance from said axis of rotation to each said vertex and each one of said short sides has a length equal to 0.642338 times said distance from said axis of rotation to each said vertex.

9. The hydraulic machine of claim 1 wherein said hexagonal shape impeller is rotatable about said axis of rotation in two directions and generates an identical yield from rotation in either direction.

10. The hydraulic machine of claim 2 wherein said hexagonal shape impeller is rotatable about said axis of rotation in two directions and generates an identical yield from rotation in either direction.

11. The hydraulic machine of claim 3 wherein said hexagonal shape impeller is rotatable about said axis of rotation in two directions and generates an identical yield from rotation in either direction.

12. The hydraulic machine of claim 4 wherein said hexagonal shape impeller is rotatable about said axis of rotation in two directions and generates an identical yield from rotation in either direction.

13. The hydraulic machine of claim 5 wherein said hexagonal shape impeller is rotatable about said axis of rotation in two directions and generates an identical yield from rotation in either direction.

14. The hydraulic machine of claim 6 wherein said hexagonal shape impeller is rotatable about said axis of rotation in two directions and generates an identical yield from rotation in either direction.

15. The hydraulic machine of claim 7 wherein said hexagonal shape impeller is rotatable about said axis of rotation in two directions and generates an identical yield from rotation in either direction.

16. The hydraulic machine of claim 8 wherein said hexagonal shape impeller is rotatable about said axis of rotation in two directions and generates an identical yield from rotation in either direction.

\* \* \* \* \*

60

65



US005938403A

**United States Patent** [19]  
**Okada et al.**

[11] **Patent Number:** **5,938,403**  
[45] **Date of Patent:** **Aug. 17, 1999**

[54] **RUNNER, WATER WHEEL AND METHOD OF MANUFACTURING THE SAME**

4,241,110 12/1980 Ueda et al. .... 416/214 B X  
5,458,460 10/1995 Okada et al. .... 415/229

[75] Inventors: **Ryoji Okada**, Ibaraki-ken; **Kazuo Niikura**, Hitachi; **Keiji Taguchi**, Ibaraki-ken; **Kiyohito Tani**, Hitachi, all of Japan

**FOREIGN PATENT DOCUMENTS**

569704 6/1945 United Kingdom ..... 416/213 A  
728972 4/1955 United Kingdom ..... 415/200

[73] Assignee: **Hitachi, Ltd.**, Tokyo, Japan

*Primary Examiner*—John E. Ryznic  
*Attorney, Agent, or Firm*—Antonelli, Terry, Stout & Kraus, LLP

[21] Appl. No.: **08/815,853**

[57] **ABSTRACT**

[22] Filed: **Mar. 12, 1997**

[30] **Foreign Application Priority Data**

Mar. 13, 1996 [JP] Japan ..... 8-056311

A water machinery runner, which is highly reliable and is so excellent in wear and corrosion resistances that it can be used even under conditions where sediment is contained in a fluid includes crown **21**, band **22** and blade **23** of a water machinery runner **2** to be rotated by a working fluid or a fluid flowing in a passage. The elements of the machinery runner are coated on at least portions of their individual surfaces with a first surface film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a chromium carbide, and a second surface film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a tungsten carbide.

[51] **Int. Cl.<sup>6</sup>** ..... **F03B 3/12**

[52] **U.S. Cl.** ..... **415/200; 416/241 R**

[58] **Field of Search** ..... 415/200, 229; 416/213 R, 213 A, 241 R, 241 B; 427/450, 451; 29/889.21, 527.4; 228/159

[56] **References Cited**

**U.S. PATENT DOCUMENTS**

3,758,233 9/1973 Cross et al. .... 416/241 R X

**39 Claims, 6 Drawing Sheets**

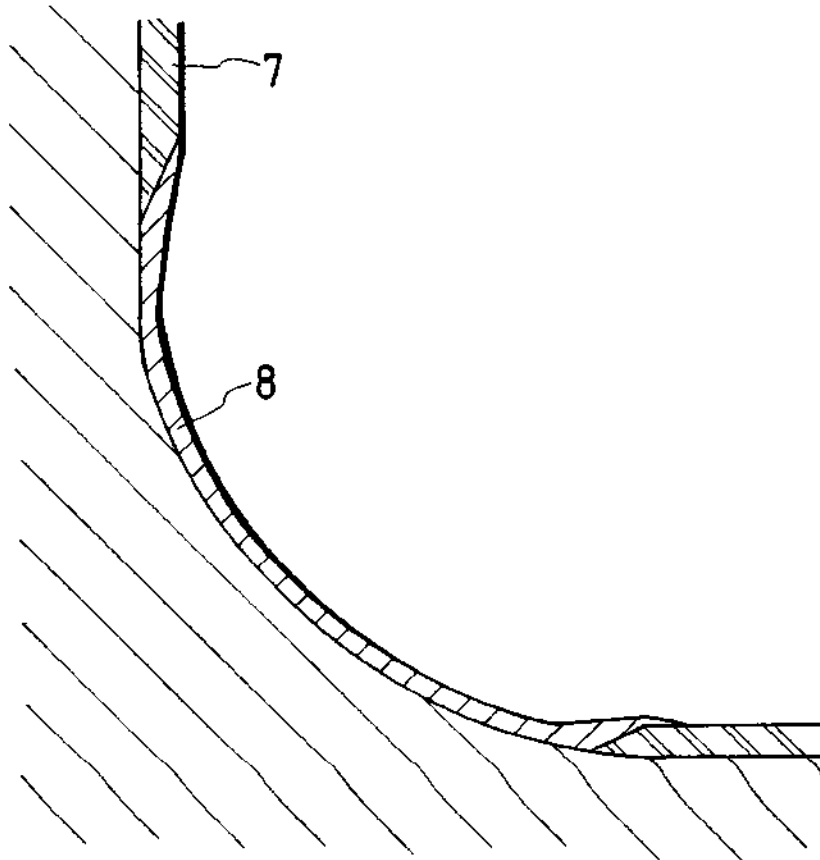


FIG. 1

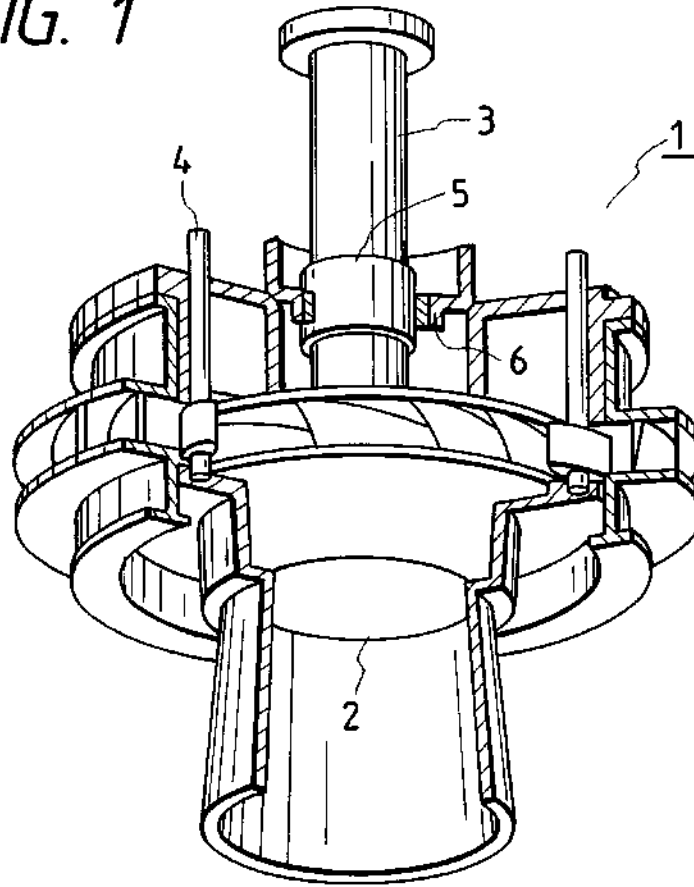


FIG. 2

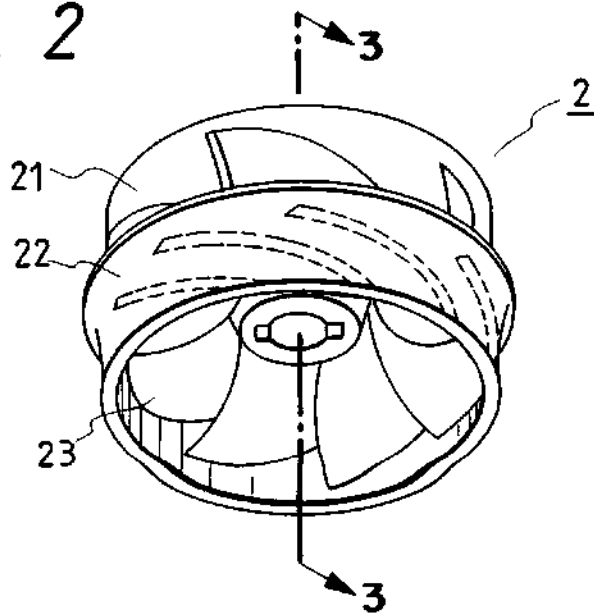


FIG. 3

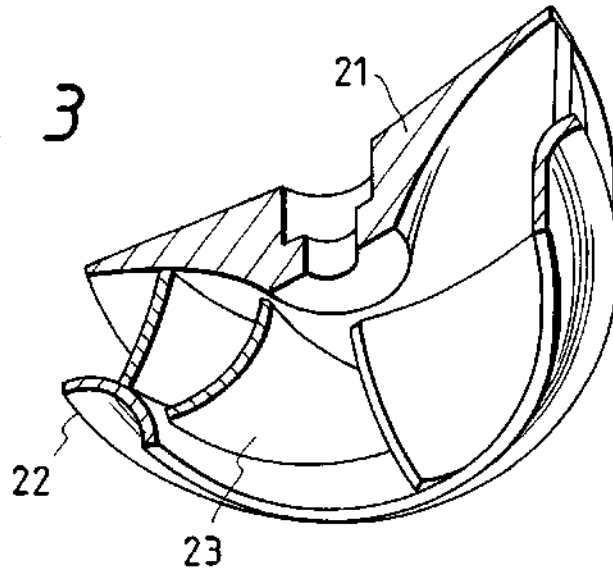


FIG. 4

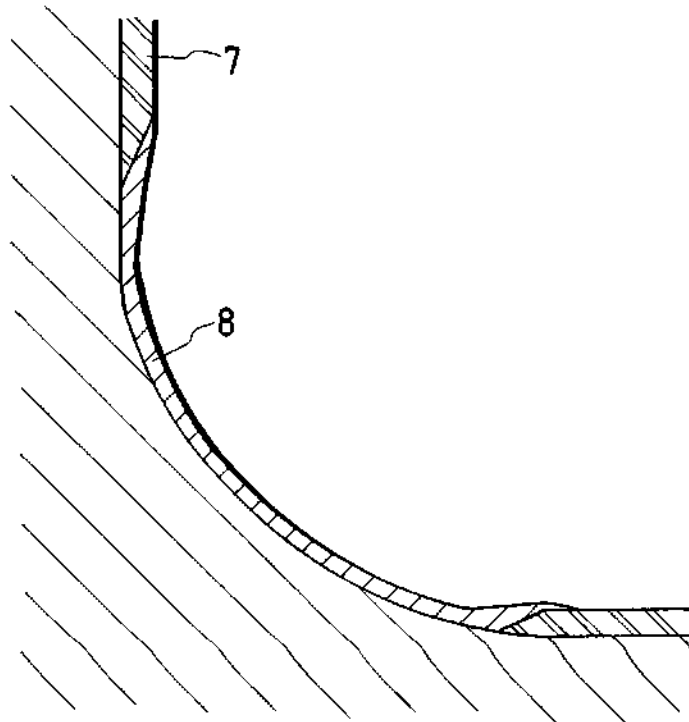


FIG. 5

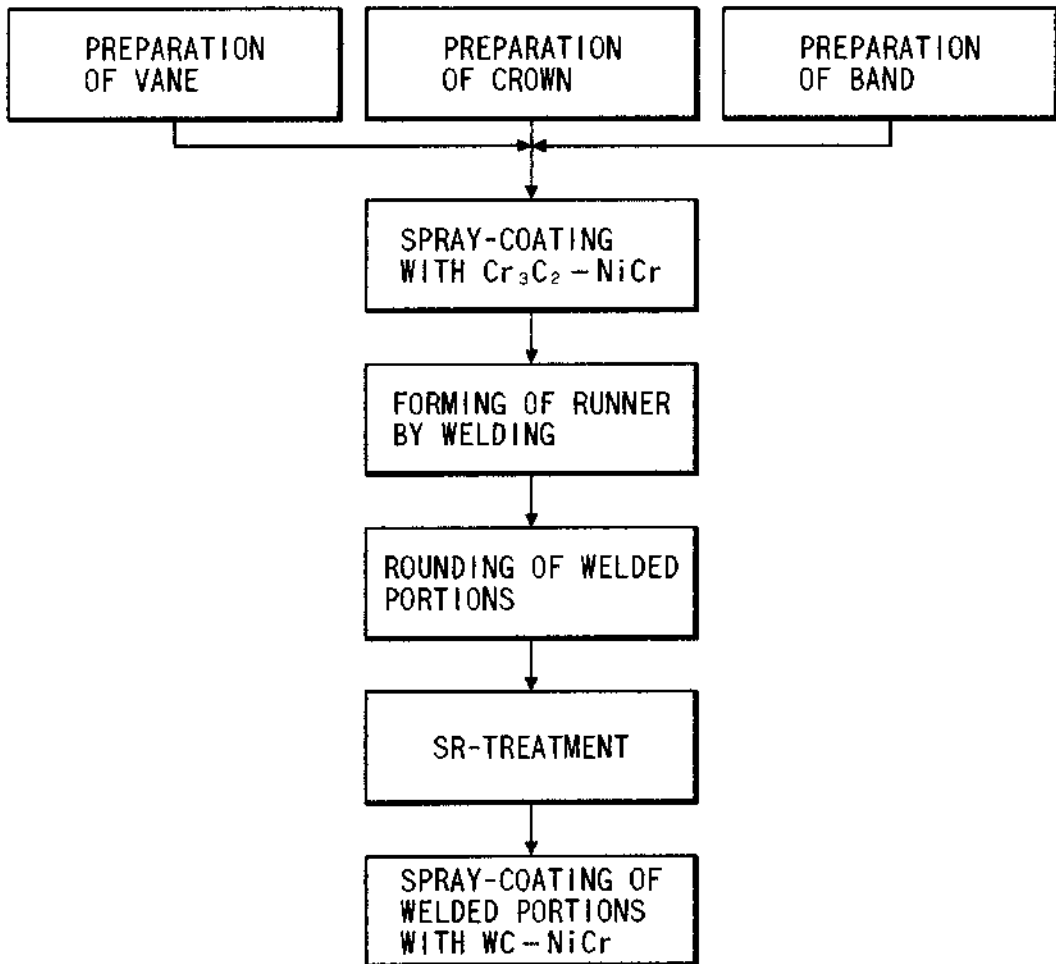




FIG. 6

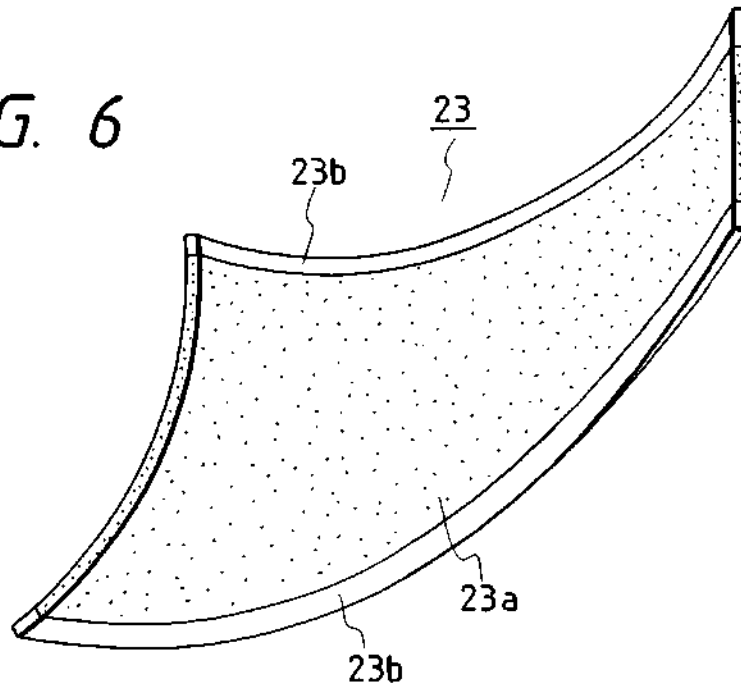


FIG. 7

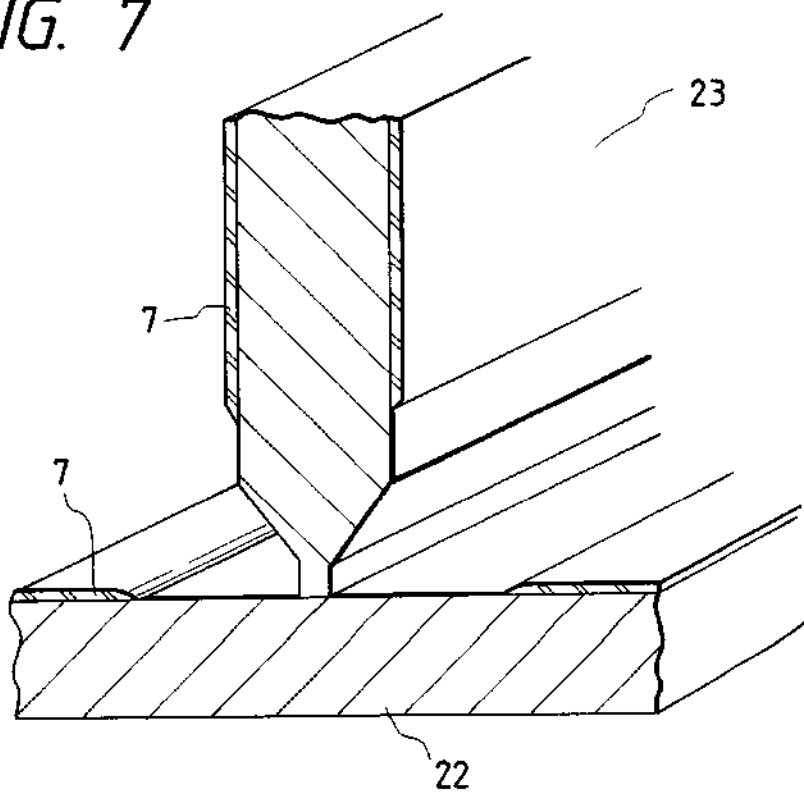


FIG. 8

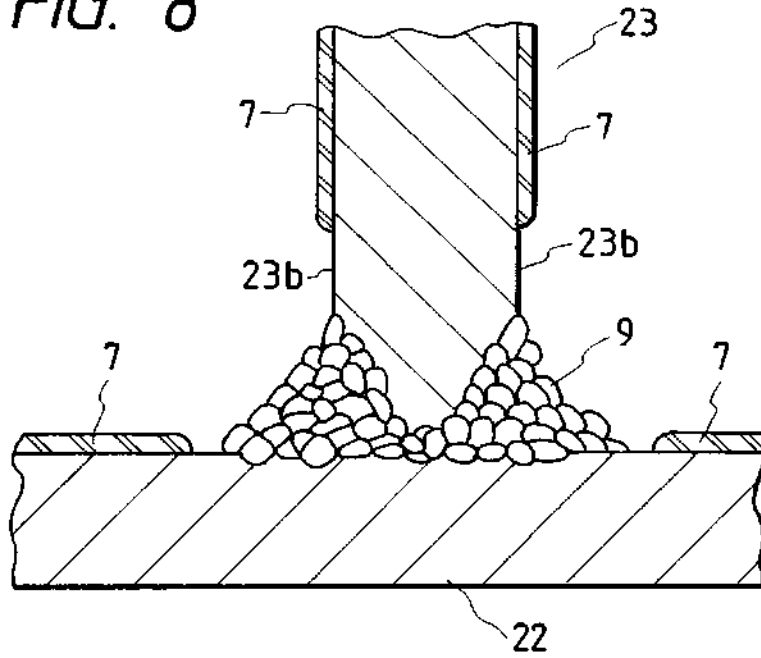


FIG. 9

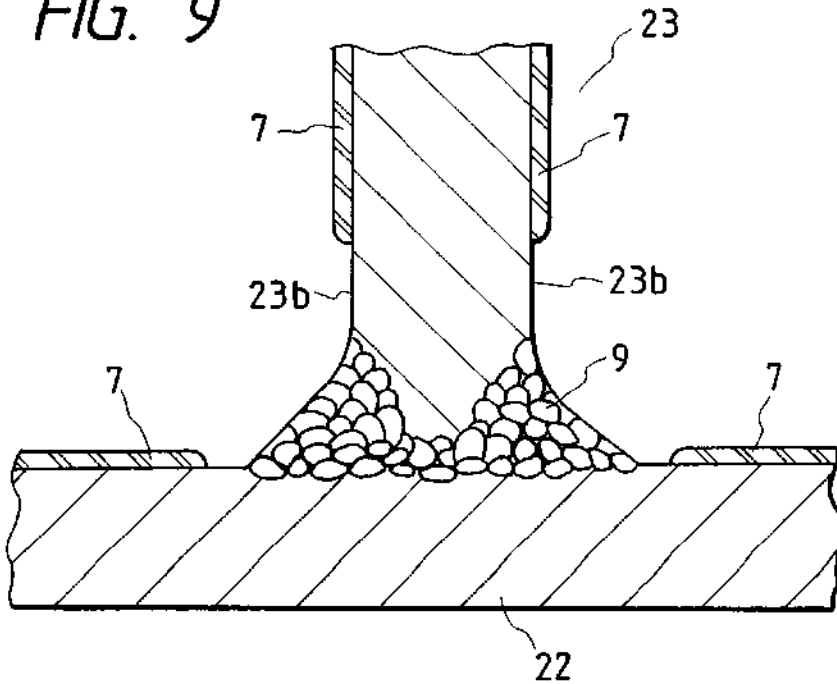
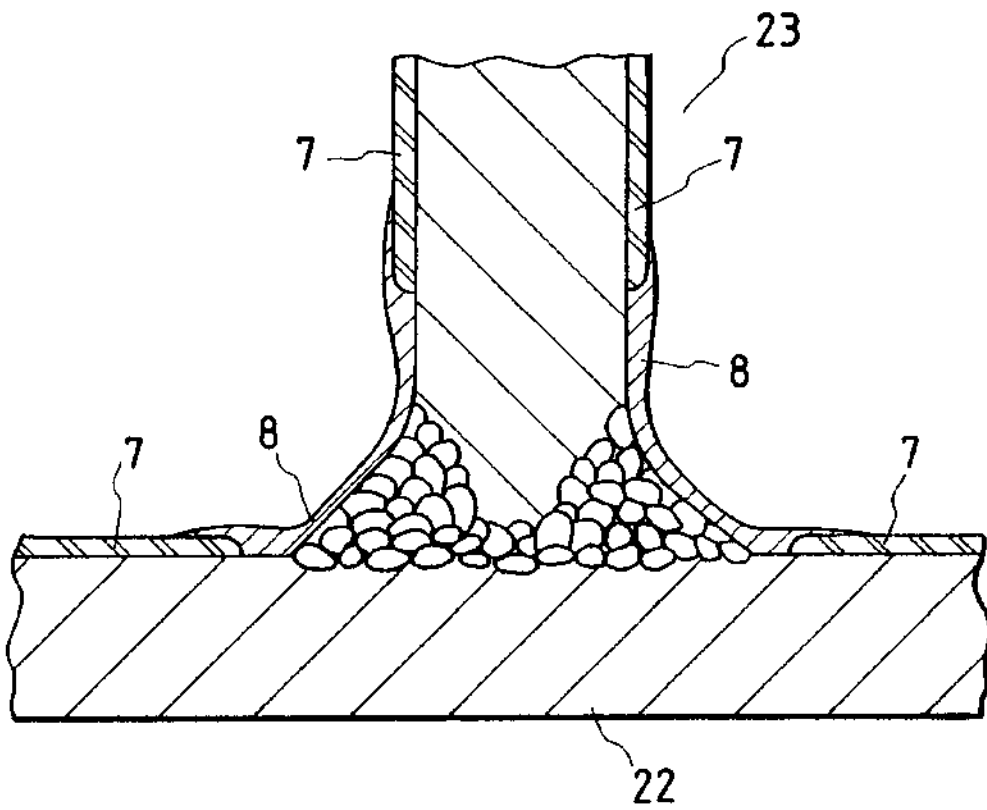


FIG. 10



## RUNNER, WATER WHEEL AND METHOD OF MANUFACTURING THE SAME

### BACKGROUND OF THE INVENTION

The present invention relates to a runner and a water wheel, which exhibit excellent wear and corrosion resistance characteristics, and a method of manufacturing the same.

In recent years, a water wheel is more and more used under conditions where solid substances, such as sediment, is contained in a fluid. A runner, as driven under those conditions, is damaged by the combination of the wear due to impact with the sediment (referred to as "sedimental wear") and cavitation damage. Therefore, the portion to be damaged has been either lined with a resin, such as rubber, or spray-coated with a very hard material, such as a ceramics material. This technique is disclosed in Japanese Patent Laid-Open No. 47477/1991.

Generally speaking, a runner having a three-dimensional shape is frequently manufactured using a casting method. In a large-sized runner, on the other hand, there sometimes a method of assembling the runner by welding is used. In this case, stainless materials are welded into an assembly so as to enhance the mechanical strength of the runner. Specifically, a blade, a crown and a band or a shroud are separately formed of stainless materials, and the blade is welded between the crown and the band or the shroud to form the runner. At this time, the runner thus prepared is subjected, if necessary, to heat treatment so as to remove the residual stress established during the welding operation. This technique is disclosed in Japanese Patent Laid-Open No. 140465/1990.

In the case of sediment wear, on the other hand, the use of a variety of hard coatings has been investigated. For example, the bucket and needle chip of the Pelton wheel have been coated on their inner faces with a tungsten carbide surface film having a gradient composition by a vacuum plasma spray-coating method, as disclosed in Japanese Patent Laid-Open No. 88201/1994. On the other hand, the portion of the water wheel limited to the runner, which will be worn by sediment, is build-up welded with a Co alloy containing C, Si, Mn, Cr, Mo, Ni or Fe, as disclosed in Japanese Patent Laid-Open No. 75767/1990.

When the water machinery is to be used under conditions where sediment is contained in the fluid, as described above, the runner has to be coated with a very hard material, so that it may be prevented from being damaged by sediment wear and cavitation damage. Because of the three-dimensional shape, however, the runner is not easy to coat with the hard material.

The plating method can be used easily to coat an article having a complicated shape, but this method has the following problems when applied to the present invention. The Cr plating method is one of the most widely used electrolytic plating methods and can provide the highest surface film hardness in Vickers hardness (as will be expressed as "Hv") of about 1,000, of all the plated films. Because of the electrolytic plating, however, the electrolytic concentration is caused to vary due to the shape so as to make it difficult to have an even film thickness.

Because of the strain in the surface film, moreover, it is difficult with the plating method to form a thick film, i.e., a film having a sufficient thickness to protect against sediment wear and cavitation damage. On the other hand, Ni—P plating is a nonelectrolytic plating method so that it can form a surface film having an even thickness independently of the shape. As in the Cr plating method, however, with the Ni—P

plating method it is difficult, due to the strain in the surface film, to form a thick film or a sufficient surface film to protect against sediment wear and cavitation damage. Moreover, both the Cr plating method and the Ni—P plating method are not practical for application to large-sized parts, such as a water wheel runner, from the point of view of the required facilities, because they require a step of dipping an article in a bath.

The hard coating film to be formed by the spray-coating method has a sufficient wear resistance to sediment wear and cavitation damage and can produce a sufficiently thick surface film easily. However, the use of the spray-coating method has the following problems. A proper distance is required between a spray-coating gun and the runner so as to form a satisfactory spray-coated surface film, and a relatively wide space is required due to the restriction provided by the size of the spray-coating gun. Therefore, it is difficult to spray coat a three-dimensional runner in a narrow space with a satisfactory surface film having sufficient hardness and adhesive strength.

The technique, as disclosed in the aforementioned Japanese Patent Laid-Open No. 88201/1994, is directed to a vacuum plasma spray-coating method which is applied to small-shaped parts having shapes facilitating a spray-coating treatment, that is members to be coated which can be accommodated in an evacuated container for the treatment. Therefore, the application of such a vacuum plasma spray-coating method to large-sized parts is difficult, and the application of the vacuum plasma spray-coating method to three-dimensional parts having complicated shapes is even more difficult. These problems have not been solved by the technique as disclosed in the aforementioned Japanese Patent Laid-Open No. 88201/1994.

On the other hand, the technique, as disclosed in the aforementioned Japanese Patent Laid-Open No. 75767/1990, is directed to a build-up welding treatment which is applied to a portion easy to be treated. Since the build-up welding is accompanied by a melting, it can form a reformed layer having a high adhesive strength, but a high calorie source is required to cause deformation by heat if treatment is applied to a large area. Therefore, the application of this technique to a water wheel runner is practically limited to a limited portion, and so it is difficult to treat the entire face of the runner, as required. Moreover, the application of plasma spray-coating to three-dimensional parts having complicated shapes is also more difficult, as in the technique disclosed in the aforementioned Japanese Patent Laid-Open No. 88201/1994. In addition, the Co alloy has a surface film hardness which is insufficient in the case of high sediment density so that a sufficient wear resistance cannot be achieved. These problems have not been solved by the technique disclosed in the aforementioned Japanese Patent Laid-Open No. 75767/1990.

As described above, it is difficult to coat a runner having a three-dimensional shape in a narrow space with a satisfactory surface film having a sufficient hardness and adhesive strength by using the spray-coating method. Specifically, when the spray-coating method is used, it is necessary to use the aforementioned manufacturing method using a welding operation for the assembly. However, when a surface film coating is applied by the spray-coating method to a runner manufactured using a welding operation, the following problems have been brought to light by detailed investigations.

First of all, the parts, spray-coated all over the surfaces thereof, can neither be welded nor provide a satisfactory

welding strength. Moreover, the temperature of the parts will be raised in the vicinity of the welded portions by the welding heat so that a thermal strain is caused in the hard surface films generally having a smaller coefficient of thermal expansion than those of metals, thereby to cause a separation of the surface films or a lower adhesive strength. This makes it impossible to effectively coat the welded portions and their vicinities with the surface films.

However, the welded portions of the runner, i.e., the joints between the crown and the blade and between the shroud or band and the blade, have a relatively high flow speed and a high sedimental collision frequency so that they are liable to experience sediment wear and cavitation damage. These portions are damaged, if coated with no surface film, by sediment wear and cavitation damage thereby to cause the performance to drop or the lifetime to shorten.

On the other hand, if the crown and the blade, and the shroud or band and the blade, spray-coated with no film in the vicinity of the welded portions, are welded, and these individual welded portions are then spray-coated, after being welded, with the surface films, the following problems result, as has been brought to light by the detailed investigations.

In order to achieve a sufficient adhesive strength, the surfaces to be coated have to be properly roughened, before being coated with the spray-coated films, by a sandblasting treatment. In the case of the present example, however, the spray-coated films are already present in the vicinity of the welded portions and may be damaged by the sandblasting treatment thereby to reduce the adhesive strength. In order to remove the residual strain from the welded portions, moreover, the welded structures have to be subjected to a heat treatment, referred to as a Stress Releasing treatment ("SR-treatment"). Generally speaking, since the hard surface film to be formed by the spray-coating method has a small coefficient of thermal expansion, the coating surface film, as formed before the welding operation, may be separated or broken by thermal strain if a proper temperature is set at the SR-treatment. When the welded portions are coated with spray-coated surface films before the SR-treatment, on the other hand, other strains are caused in the surface films by the release, as effected by the SR-treatment, of the residual strain in the welded portions, so that a separation and breakage of the surface films become more likely to occur.

### SUMMARY OF THE INVENTION

The present invention contemplates to solve the above-specified problems and has an object to provide a runner and a water wheel, which have such excellent wear and corrosion resistance characteristics that they can be used even under conditions where sediment is contained in a fluid being handled, and a method of manufacturing the same.

In order to achieve the above-specified object, according to a feature of the present invention, there is provided a runner to be rotated by a working fluid or a fluid flowing in a passage. The runner is coated on at least a portion of its surface with a first surface film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a chromium carbide, and a second surface film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a tungsten carbide.

According to another feature of the present invention, there is provided a runner to be rotated by a working fluid or a fluid flowing in a passage and comprising components including a crown, a band and a blade. The components are

coated, on at least portions of their surfaces, with a first surface film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a chromium carbide, and, on at least portions of the joint between said crown and said blade and the joint between said band and said blade, are coated with a second surface film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a tungsten carbide.

According to another feature of the present invention, there is provided a water wheel comprising a runner driven to rotate by a working fluid or a fluid flowing in a passage; a spindle to be rotated together with said runner; a bearing supporting said spindle; and a generator connected to said spindle to rotate together.

According to another feature of the present invention, there is provided a method of manufacturing a runner to be rotated by a working fluid or a fluid flowing in a passage, comprising the steps of coating at least a portion of the surface of said runner with a first surface film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a chromium carbide; and then coating the same with a second surface film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a tungsten carbide.

According to another feature of the present invention, there is provided a method of manufacturing a water wheel including a runner having a crown, a band and a blade, a spindle, a bearing and a generator, comprising the steps of coating at least portions of the surfaces of its crown, band and blade forming no runner or before being jointed, with a first surface film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a chromium carbide; jointing said blade between said crown and said band to form said runner; heating the assembly at a temperature of 350° C. or higher and 650° C. or lower, desirably at 400° C. or higher and 650° C. or lower for 1 to 30 hours; and coating at least portions of the joint between said crown and said blade and the joint between said band and said blade, with a second surface film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a tungsten carbide.

According to the present invention, there is provided a runner coated on at least a portion of its surface with a first surface film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a chromium carbide; and a second surface film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a tungsten carbide.

The runner is coated on at least a portion of its surface with a first surface film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a chromium carbide and having a Vickers hardness of 700 or more; and a second surface film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a tungsten carbide and having a higher Vickers hardness of 1,000 or more than that of said first surface film.

The first surface film and the second surface film, that is, the first surface film composed of  $Cr_3C_2$  as chromium carbide and the second surface film composed of WC as tungsten carbide have a hardness of Hv 700 or more and a hardness of Hv 1,000 or more, and they exhibit excellent corrosion resistance. The sediment is composed mainly of feldspar and quartz, of which the feldspar has a hardness of Hv 600 to 700, whereas the quartz has a hardness of Hv 900 to 1,000. In the case of sediment wear, the wear resistance abruptly rises if the hardness of sediment particles is exceeded. By coating with a surface film having a hardness

of Hv 700 or Hv 1,000 or more, therefore, a sufficient wear resistance can be exhibited for preventing sediment wear and cavitation damage.

If a spray-coating method is used as the surface film coating method, the first surface film can be made as thick as several tenths mm to 1 mm, and the second surface film can be made as thick as several tenths mm to 0.5 mm. As a result, the surface films can be coated, if spray-coated, to have thickness capable of warranting a sufficient lifetime against sediment wear and cavitation damage.

Spray-coating is divided into a variety of methods, which are selected in accordance with their merits and demerits. A spray-coating method capable of forming the most dense surface film is the vacuum spray-coating method in which plasma spray-coating is executed under a reduced pressure. This vacuum spray-coating method cannot be practically applied to large-sized parts as in the present example, because the part to be treated will have to be coated in an evacuated container. Other methods capable of forming a coated dense surface film are a detonation spray-coating method and a high velocity oxygen fuel spray-coating method. The deterioration spray-coating method covers a wide coating area so that it is suitable for the coating of a large-sized planer member. However, the detonation spray-coating method requires a spray-coating gun and large-sized facilities, so that it is difficult to homogeneously a member which has a three-dimensional shape, such as a runner, or to coat a narrow space, such as a joint.

On the other hand, the high velocity oxygen fuel spray-coating method can form a dense surface film and requires only a relatively small gun and reasonable facilities, so that it can form a homogeneous and dense surface film for a member which has a three-dimensional shape or in a narrow space at a joint.

When a runner is to be manufactured, its components, i.e., a crown, a band and a blade, are individually coated with a first surface film containing a metal selected from the group consisting of Ni, Cr and Co and 50 wt. % to 90 wt. %, desirably 70 wt. % to 90 wt. % of  $\text{Cr}_3\text{C}_2$ , and the film is made as thick as 0.3 mm to 1.0 mm while leaving the region within 20 mm, desirably 50 mm, from the leading ends of the welded portion, as an uncoated portion.

The first surface film composed of  $\text{Cr}_3\text{C}_2$  and Ni, Cr or Co is changed in its hardness by the content of  $\text{Cr}_3\text{C}_2$ . As the amount of  $\text{Cr}_3\text{C}_2$  increases, the hardness rises, but the toughness is lost so that the film becomes fragile, and so the surface film is liable to be broken or separated, thereby to lower its reliability. For the amount of  $\text{Cr}_3\text{C}_2$  ranging from 50 wt. % to 90 wt. %, the surface film has a sufficient hardness against sediment wear and can keep its toughness.

Within this range, moreover, the surface film has excellent corrosion and wear resistance to sediment wear. If the sedimental density is high, the amount of  $\text{Cr}_3\text{C}_2$  has to be increased to enhance the hardness. In this case, the amount of  $\text{Cr}_3\text{C}_2$  is desired to be in a range from 70 wt. % to 90 wt. %. For this range, the surface film can have a hardness of Hv 700 or more.

Since a number of fine voids are present in a spray-coated film, the surface film has to be as thick as 0.3 mm or more so that it may exhibit excellent corrosion and wear resistances. If the spray-coated film becomes thicker, its internal strain becomes higher to thereby lower the adhesive strength. From the point of view of the adhesive strength, this surface film has to be less thick than 1.0 mm. If the wear resistance of the surface film is considered, on the other hand, a sufficient lifetime can be expected for a thickness of

1.0 mm, and the thickness is desired to be less than 1.0 mm from the point of view of reducing the work and the energy extended. From the points specified above, a sufficient lifetime can be warranted against sediment wear and cavitation damage of the runner if the film thickness is set to a range from 0.3 mm to 1.0 mm, with the result that the productivity and the energy economy are improved.

The coefficient of thermal expansion of the first surface film containing  $\text{Cr}_3\text{C}_2$  and Ni, Cr or Co is lower than that of a material such as iron or stainless steel. As a result, a thermal strain may be caused, if thermally influenced by the welding operation, to thereby lower the adhesive strength of the surface film. If, however, the region within 20 mm, desirably 50 mm, from the leading end of the welded portion is left uncovered, the thermal influences at the welding time can be avoided, so that an excellent adhesive strength of the first surface film can be isolated from the influences of the welding operation.

At this time, moreover, a metal plate having a thickness larger, desirably two times or more, than that of the first surface film is employed to form the uncovered portion of the first surface film. Since the spray-coating method, especially the high-speed flame spray-coating method, uses a remarkably high speed for the gas to be sprayed, a rupture is caused if the masking material has an insufficient strength. Without a sufficient thickness, moreover, the surface films are liable to merge at their masking portion and coated portion so that they are liable to separate at their end portions. On the other hand, these disadvantages can be avoided if a metal plate having a thickness two times as large as that of the surface film is used as the masking material.

When the runner is to be manufactured, on the other hand, the crown, the blade and band, as coated with the first surface film, are welded to prepare the water machinery runner, and are then heated at a temperature of 350° C. or higher and 650° C. or lower, desirably of 400° C. or higher and 650° C. or lower, for 1 to 30 hours. By this heat treatment of the proper temperature, the residual strain is released from the welded portions so that the deformation due to the strain release at the runner operating time and the drop in the fatigue strength of the welded portions are prevented, thereby to enhance the reliability. In the first surface film, moreover, the adhesive strength between the metal phase of Ni, Cr or Co and the  $\text{Cr}_3\text{C}_2$  particles increases to increase the hardness of the surface film, and accordingly the resistances to sediment wear and cavitation damage are also increased. Moreover, the adhesive strength in the interface between the first surface film and the parent material increases to suppress the surface film separation. As a result, even if the surface film is cracked by some shock, it is prevented from being separated and coming out, thereby to enhance the reliability.

At higher heating temperatures, the release of the residual strain from the welded portions, the increase in the adhesive strength between the metal phase of Ni, Cr or Co and  $\text{Cr}_3\text{C}_2$  in the surface film, and the increase in the adhesive strength in the interface between the surface film and the parent material progress faster, but thermal strain is caused due to the difference in the coefficient of thermal expansion between the surface film and the parent material, as has been described above. The temperature is desired to be at 650° C. or less if the influences upon the surface film by the thermal strain are considered. If the releasing rate of the residual strain from the welded portions and the rate of improvement of the surface film are considered, on the other hand, the temperature is limited by 350° C. If the temperature is lower than this level, the heat treatment takes too long to be used for industrial applications.

If practical applications are considered, the temperature is desired to be in a range from 400° C. to 650° C. If the temperature range from 350° C. to 650° C. is examined, the treatment takes 20 hours at the minimum at 350° C., but the treatment is effective even for 1 hour at 650° C. Within the temperature range from 400° C. to 650° C., the treatment converges for 30 hours. If the effect and the energy economy are considered, therefore, the heating time period is desired to range from 1 hour to 30 hours.

When the runner is to be manufactured, the joints between the crown and the blade and between the band and the blade are coated, after being heated, with a second surface film containing at least one metal selected from the group consisting Ni, Cr and Co and 50 wt. % and more and 90 wt. % or less, desirably 70 wt. % or more and 90 wt. % or less of WC and having a thickness from 0.1 mm to 0.5 mm, and this second surface film is overlapped at least partially on the first surface film.

The second surface film containing WC and Ni, Cr or Co has a hardness of Hv 1,000 or more and excellent corrosion and wear resistances to sediment wear. If the amount of WC is increased, on the other hand, the surface film hardness increases, but the surface film loses its toughness and becomes fragile so that it is liable to be broken and separated, thereby to lower its reliability. If the WC amount is within the range from 50 wt. % to 90 wt. %, the surface film can have a sufficient hardness against sediment wear and can keep its toughness. When the sediment density is high, however, the WC amount has to be increased to enhance the surface film hardness. In this case, the WC amount is desirably in a range from 70 wt. % to 90 wt. %.

The joints between the crown and the blade and between the band and the blade are portions where the flow speed and the sediment impact frequency are so high that sediment wear and cavitation damage are liable to occur. This damage can be prevented by coating the joints with the second surface film.

In the high-speed flame spray-coating method, the carbide particles are neither molten nor decomposed, but collide against and deposit on the members while being in the form of particles. For a higher density and larger particle weight, therefore, the carbide particles highly bite into the parent material to establish a high and satisfactory adhesive strength. The WC particles having a large gravity highly bite into the parent material so that a sufficient adhesive strength can be achieved from the surface roughness by the grinding work without sandblasting treatment for the pretreatment. Since the WC is harder than Cr<sub>3</sub>C<sub>2</sub>, moreover, it sufficiently bites into the first surface film already coated, to establish a satisfactory adhesive strength.

In order that the spray-coated film composed of WC and Ni, Cr or Co, that is, the second surface film, may exhibit excellent corrosion and wear resistances, its thickness has to exceed 0.1 mm. As the thickness increases, on the other hand, the strain in the second surface film increases to lower the adhesive strength. From this adhesive strength, this spray-coated film has to be less than 0.5 mm. If the wear resistance of this second surface film is considered, a sufficient lifetime is expected for a film thickness of 0.5 mm, and a thickness less than this value of 0.5 mm is desired for reducing the processing and economizing energy.

The rupture and separation of a surface film are liable to occur from the end portion of the film. By causing the second surface film to partially overlap on the first surface film, therefore, the parent material is coated without any seam so that the resistance to sediment wear and cavitation damage and the reliability can be enhanced.

The coefficient of thermal coefficient of the second surface film is smaller than that of the first surface film if the deposition percentages of the contained metals are equal, so that a higher thermal strain is caused due to the difference in the coefficient of thermal expansion-from the parent material. On the other hand, the welded portions are deformed by releasing the residual strain. As a result, the thermal strain and the strain caused by the release of the residual strain are applied to the second surface film coating the welded portions. Since the spray-coated films may be broken or separated by the added strains, the welded portions have to be coated with the second surface film after being heated to a temperature of 350° C. or more and 650° C. or less.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view partly in section of a water wheel including a hydraulic machinery runner according to one embodiment of the present invention;

FIG. 2 is a perspective view of the water machinery to one embodiment of the present runner according invention;

FIG. 3 is a perspective view, partially in section, showing the water machinery runner according to the embodiment of the present invention;

FIG. 4 is an enlarged section of the water machinery according to the embodiment of the present invention;

FIG. 5 is a flow chart showing a procedure for manufacturing the water machinery runner according to the embodiment of the present invention;

FIG. 6 is a perspective view showing a blade of the water machinery runner according to the embodiment of the present invention;

FIG. 7 is a perspective view showing the blade and the band-welded portion of the water machinery runner according to the embodiment of the present invention;

FIG. 8 is a section showing the blade and the band-welded portion, before being rounded, of the water machinery runner according to the embodiment of the present invention;

FIG. 9 is a section showing the blade and the band-welded portion, after being rounded, of the water machinery runner according to the embodiment of the present invention: and

FIG. 10 is a section showing the blade and the band-welded portion, after being coated with a surface film, of the water machinery runner according to the embodiment of the present invention.

#### DESCRIPTION OF THE PREFERRED EMBODIMENT

A water machinery runner and its method of manufacture according to one embodiment of the present invention will be described in the following with reference to the accompanying drawings.

FIG. 1 shows the construction of a water wheel having a water machinery runner according to the embodiment of the present invention. In order to more clearly illustrate the internal structure, the water wheel is illustrated with its casing being partially split. As to the hatching of the split section, incidentally, different kinds of hatching are not used in FIG. 1 for individual members so as to avoid complexity in the view.

As shown in FIG. 1, a water wheel 1 is constructed to include a water machinery runner 2 (referred to simply as a "runner"), a shaft 3, a guide vane 4, a sleeve 5 and a bearing 6. The runner 2 is rotated by flowing water coming in

through the guide vane 4. Simultaneously with this, the shaft 3, which is connected to the runner 2, is rotated. The (not-shown) generator, which is connected to the shaft 3, generates electric power when it is rotated.

If much sediment is contained in the flowing water coming into the runner 2, this runner 2 and the guide vane 4 will become worn by the impact of the sediment particles therewith. In order to prevent such sediment wear, the runner 2 and the guide vane 4 are coated at their portions where the water flow speed and the sediment impact frequency are anticipated to be so high as to cause sediment wear, the coating including a first surface film of  $\text{Cr}_3\text{C}_2$ —16 wt. % of Ni—4 wt. % of Cr (expressed by “ $\text{Cr}_3\text{C}_2$ —20% NiCr”) and a second surface film of WC—20 wt. % of Ni—5 wt. % of Cr (expressed by “WC—25% NiCr”).

Especially, the runner 2 is coated, at its crown, band and blade where the water flow speed and sediment impact frequency are anticipated to be so high as to cause sediment wear, with a surface film of  $\text{Cr}_3\text{C}_2$ —20% NiCr having a thickness from 0.3 mm to 1.0 mm, and, at its joints between the crown and the blade and between the band and the blade, with a surface film of WC—25% NiCr having a thickness from 0.1 mm to 0.5 mm. Moreover, the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film and the WC—25% NiCr are partially overlapped, and this overlap is given a structure having a lower layer of the  $\text{Cr}_3\text{C}_2$ —20% NiCr and an upper layer of the WC—25% NiCr.

FIG. 2 is a perspective view showing the entirety of the runner of FIG. 1, and FIG. 3 is a perspective section taken along the line A—A of FIG. 2. As shown in FIGS. 2 and 3, the runner 2 is constructed to include a crown 21, a band 22 and a blade 23. The crown 21 and the blade 23, and the band 22 and the blade 23, are individually welded to form the runner 2.

FIG. 4 is an enlarged section showing the welded portions between the crown 21 and the blade 23 and between the band 22 and the blade 23. Incidentally, the hatched sections of the crown 21, the band 22 and the blade 23 are not discriminated in FIG. 4. In FIG. 4, reference numeral 7 designates the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film (or the first surface film), and numeral 8 designates the WC—25% NiCr surface film (or the second surface film). These two surface films are partially overlapped within a range of about 10 mm to 50 mm.

In the present embodiment, the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film 7 and the WC—25% NiCr surface film 8 were formed by a high velocity oxygen fuel spray-coating method. In particular, the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film and the WC 25% NiCr surface film were examined as to the contents of  $\text{Cr}_3\text{C}_2$  and WC, and these examinations have revealed that the range from 50 wt. % to 90 wt. % is good for preventing sediment wear and cavitation damage. However, if the sediment density exceeds  $2 \text{ Kg/m}^3$  as in the Yangtze River, the Yellow River or a river after a heavy rainfall, for example, the percentages of  $\text{Cr}_3\text{C}_2$  and WC have to be increased to enhance the surface film hardness. In this case, the amounts of  $\text{Cr}_3\text{C}_2$  and WC are desirably in a range from 70 wt. % to 90 wt. %. On the other hand, the proper metallic components of the surface films are Ni, Cr and Co from the point of view of corrosion resistance, hardness and toughness. These metals can provide, if selected and combined, satisfactory corrosion resistance, hardness and toughness.

The  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film 7 has a hardness of Hv 700 or more, whereas the WC—25% NiCr surface film 8 has a hardness of Hv 1,000 or more, and they exhibit excellent corrosion resistance. The sediment is composed

mainly of feldspar and quartz, of which the feldspar has a hardness of Hv 600 to 700, whereas the quartz has a hardness of Hv 900 to 1,000. With regard to sediment wear, the wear resistance abruptly rises if the hardness of sediment particles is exceeded. By the coating with a surface film having a hardness of Hv 700 or Hv 1,000 or more, therefore, a sufficient wear resistance can be exhibited for protection against sediment wear and cavitation damage.

The hardness of the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film 7 and the WC—25% NiCr surface film 8 will change depending upon the amounts of  $\text{Cr}_3\text{C}_2$  and WC. If the amounts of  $\text{Cr}_3\text{C}_2$  and WC increase, the hardness of the surface films will be raised, but their toughness will be lost so that they become fragile, with the result that they are liable to be broken and separated, which undesirably lowers their reliability. For amounts of  $\text{Cr}_3\text{C}_2$  and WC from 50 wt. % to 90 wt. %, the surface films can have sufficient hardness against sediment wear to keep their toughness.

Within this range, on the other hand, the corrosion resistance and the wear resistance to sediment wear are excellent. If the sediment density exceeds  $2 \text{ Kg/m}^3$  as in the Yangtze River, the Yellow River or a river after a heavy rainfall, for example, the amounts of  $\text{Cr}_3\text{C}_2$  and WC have to be raised to enhance the surface film hardness. In this case, it is desirable if the amounts of  $\text{Cr}_3\text{C}_2$  and WC fall within a range from 70 wt. % to 90 wt. %, for which a hardness of more than Hv 700 and Hv 1,000 can be achieved for the surface films.

Since a number of fine voids are present in a spray-coated film, the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film 7 has to be as thick as 0.3 mm or more so that it may exhibit excellent corrosion and wear resistances. If the spray-coated film becomes thicker, its internal strain becomes higher, resulting in a lowering of the adhesive strength. From the point of view of the adhesive strength, the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film 7 has to be less than 1.0 mm thick.

If the wear resistance of the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film 7 is considered, on the other hand, a sufficient lifetime can be expected for a thickness of 1.0 mm, however it may be desirable for the thickness is desired to be less than 1.0 mm from the point of view of reducing the work and the energy expended.

There is also a proper thickness range for the WC—25% NiCr surface film 8. Generally speaking, the surface film containing WC is harder and has a higher internal strain, when formed, than the surface film containing  $\text{Cr}_3\text{C}_2$ . Because of the spray-coated film, however, a number of fine voids are present as in the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film.

For excellent corrosion and wear resistances, therefore, the surface film has to be no less than 0.1 mm. As described above, on the other hand, it is required from the point of view of the strain that the surface film be thinner than 0.5 mm. Considering the wear resistance, moreover, the surface film is expected to have a sufficient lifetime if it has a thickness of 0.5 mm. A thickness of no more than 0.5 mm is also desired for reducing the work and for improving the energy economy.

The rupture and separation of the spray-coated film are liable to start from the end portions of the surface film. By coating the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film 7 in a partially overlapped manner with the WC—25% NiCr surface film 8, therefore, the parent material can be coated without any seam to enhance the reliability and the wear resistance to sediment wear and cavitation damage.

Since a number of voids are present in the spray-coated film, an overlap of at least 10 mm between the aforementioned  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film 7 and the WC—25%



NiCr surface film **8** is required from the point of view of the reliability. Since this effect converges if the overlap exceeds 50 mm, an extension ranging from 10 mm to 50 mm is proper for the required efficiency.

In the high velocity oxygen fuel spray-coating method, the carbide particles will neither be melted nor decomposed, but will impact against and deposit on the components as they are in the particle state. As a result, the denser and heavier particles can bite more deeply to establish a satisfactory adhesive strength. The WC particles having a large specific gravity bite deeply so that a sufficient adhesive strength can be achieved with the surface roughness of the grinding treatment without the pretreatment of sandblasting. Since WC has a higher hardness than  $\text{Cr}_3\text{C}_2$ , moreover, the overlying WC—25% NiCr surface film **8** can sufficiently bite into the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film **7** to establish a sufficient adhesive strength.

Incidentally in the case of use under a low sediment density, it is not always necessary to provide the WC—25% NiCr surface film as the upper layer coating. The  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film can be used by itself, and the percentage of  $\text{Cr}_3\text{C}_2$  is desirably increased in this case. In this case, moreover, the portions, which are left uncoated with the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film, are desirably sandblasted while protecting the applied  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film.

Next, the method of manufacturing a water machinery runner according to one embodiment of the present invention will be described with reference to FIGS. **5** to **10**.

FIG. **5** shows the steps of the water wheel runner according to one embodiment of the present invention. First of all, the crown **21**, the band **22** and the blade **23** are individually prepared. Next, the crown **21**, the band **22** and the blade **23** thus individually prepared are coated with the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film **7** by the high velocity oxygen fuel spray-coating method. of the various spray-coating methods, this high velocity oxygen fuel spray-coating method can form a dense surface film and is required to have relatively small spray-coating guns and facilities so that it can form a homogeneous and dense surface film on a member having a three-dimensional shape and a narrow space, as at the joints. Thus, the high velocity oxygen fuel spray-coating method is the most proper one for coating a member having a three-dimensional shape, such as the runner **2**.

When the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film **7** is to be applied, a metal plate, which is thicker than, desirably two times thick as, the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film **7**, is applied to the portions to be welded, thereby to protect the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film **7**. The metal plate has sufficient strength and heat resistance, if it is two times as thick as or thicker than the surface film, against the high-speed gas in the high velocity oxygen fuel spray-coating method so that rupture and scattering can be prevented. With two-times the thickness of the surface film, moreover, satisfactory surface film end portions can be formed without any merging between the masking portions and the surface film to be coated.

Next, the crown **21** and the blade **23**, and the band **22** and the blade **23** are welded to form the runner **2**. After this welding operation, the welded portions **9** are worked into a proper rounded (R-machined) shape to prevent any stress concentration at the time of running. Next, the runner **2** is placed in a furnace and is subjected to the SR-treatment at a temperature ranging from 350° C. to 650° C., desirably from 400° C. to 650° C. for a time period ranging from 1 hour to 30 hours.

In the present embodiment, the runner **2** is held at 550° C. for 15 hours and is then cooled down in the furnace. Incidentally, the time period of 15 hours is a holding time at 550° C. During this heat treatment at 550° C., the surface film hardness is raised for the holding time of about 5 hours or longer, and the adhesive strength is drastically improved for the holding time of about 10 hours or longer. The runner **2** is such a large-sized part that it cannot be abruptly heated and cooled with ease, and this abrupt temperature change is not proper for the thermal strain of the surface film. The runner **2** is held in the furnace at 550° C. for 15 hours and is then gently cooled in the furnace. After sufficient cooling, the oxide films on the welded and rounded portions are ground again, and the welded portions are then coated with the WC—25% NiCr surface film **8**.

Here will be detailed the aforementioned steps with reference to FIGS. **6** to **10**.

FIG. **6** shows a perspective of the exterior of the blade **23** which is coated with the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film **7** by the high velocity oxygen fuel spray-coating method. The blade **23** is coated all over its surface, except for the portions to be welded to the crown **21** and the band **22**, with the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film **7**.

Reference numeral **23a** appearing in FIG. **6** does not present a section, but shows the portion coated with the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film **7**. The unhatched portions are the uncoated portions **23b** extending by 40 mm at the least and by 70 mm at the most from the end faces to be welded. In these uncoated portions **23b**, after being welded, the distance between the end portions of the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film **7** and the welded portions ranges from 20 mm to 50 mm (as will be detailed hereinafter). Although not especially shown, the crown **21** and the band **22** are likewise coated with the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film **7**.

The  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film **7** has a smaller coefficient of thermal expansion than that of materials such as iron or stainless steel. As a result, the thermal influences from the welding operation may cause the thermal strain to lower the adhesive strength of the surface film. If, however, the region within the range of 20 mm, desirably 50 mm from the portions to be welded, are left uncoated, the thermal influences of the welding operation can be avoided, thereby to leave the satisfactory adhesive strength of the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film **7** uninfluenced by the welding operation.

The details of the subsequent welding and rounding (or R-machining) operations will be described by taking up the welding operations of the band **22** and the blade **23**.

FIG. **7** is a section showing the portions of the band **22** and the blade **23** that are to be welded. The crown **21** and the blade **23**, and the band **22** and the blade **23**, are completely penetration-welded to have shapes as shown in FIG. **7**.

FIG. **8** presents a section as seen after the welding operation. Incidentally, a welded portion **9** appearing in FIG. **8** indicates a weld line, which is laminated in multiple layers, but is not hatched. The uncoated portion **23b** having no coating of the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film **7**, ranging from 40 mm to 70 mm from the end faces to be welded extends, after being welded, such that the end portions of the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film **7** and the welded portion **9** are spaced from each other by 20 to 50 mm.

FIG. **9** is a section showing that the welded portion **9** is ground into a proper rounded (R-machined) shape. After this shaping treatment, the runner is subjected to a SR-treatment in which it is placed in the furnace and held at a temperature ranging from 350° C. to 650° C., desirably from 400° C. to 650° C., for a time period from 1 hour to 30 hours.

Due to the heat treatment at this temperature, the residual strain is released from the welded portion so that the deformation resulting from the strain release and the drop in the fatigue strength of the welded portion can be prevented at the time of use to enhance the reliability. In the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film 7, moreover, the adhesive strength between the Ni or Cr and the  $\text{Cr}_3\text{C}_2$  particles is enhanced so that the surface film hardness is increased, so as to raise the wear resistance to sediment wear and cavitation damage.

In the interface between the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film 7 and the parent material, moreover, the adhesive strength is increased so as to suppress the surface film separation. As a result, even if the surface film is cracked by some shock, the separation and coming-out of the surface film are suppressed, thereby to enhance the reliability.

At a higher heating temperature, the release of the residual strain from the welded portion, the increase in the adhesive strength between the metal phase of Ni or Cr and the  $\text{Cr}_3\text{C}_2$  particles in the surface film, and the increase in the adhesive strength in the interface between the surface film and the parent material progress the faster, but a thermal strain is caused by the difference in the coefficient of thermal expansion between the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film 7 and the parent material. The temperature is desirably kept lower than 650° C. if the influences of the thermal strain upon the surface film are taken into consideration.

If, moreover, the rate of releasing the residual strain from the welded portion and the rate of improving the surface film are considered, the temperature is limited by 350° C., and the lower temperature will take a longer time period, thereby to make the processing of industrial applications difficult. For practical applications, the desired temperature ranges from 400° C. to 650° C. If the examinations are made for a temperature ranging from 350° C. to 650° C., the heating effect takes 20 hours at the minimum at 350° C., but 1 hour at the minimum at 650° C. This effect converges for 30 hours if examinations are made for the temperature ranging from 400° C. to 650° C. In consideration of the effect and the energy economy, therefore, the heating time period is desirably set in a range from 1 hour to 30 hours.

FIG. 10 shows the sectional shape after the R-shaped welded portion is coated with the WC—25% NiCr surface film 8. This WC—25% NiCr surface film 8 is partially overlapped on the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film 7. Due to this partially overlapped coating, the parent material is coated without any seam so that the wear resistance to sediment wear and cavitation damage is increased, thereby to enhance the reliability.

The reason why the coating of the WC—25% NiCr surface film 8 is executed after the SR-treatment is as follows. The WC—25% NiCr surface film 8 has a smaller coefficient of thermal expansion than the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film 7 so that, in the SR-treatment more thermal strain is produced than in the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film 7. Since the residual strain is released from the welded portion, moreover, more strain may be established to crack the WC—25% NiCr surface film 8 even if the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film 7 is within a temperature range s which will invite neither separation nor cracking.

Therefore, the welded portion has to be coated with the WC—25% NiCr surface film 8 after the SR-treatment. Moreover, the WC—25% NiCr surface film has a high density in the WC particles and accordingly a high adhesive strength so that it is suitable for the coating of the welded portion of the present embodiment, in which the whole surface cannot be sandblasted because of the influences upon the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film 7.

Incidentally, in the aforementioned embodiment, the spray-coating surface film is exemplified by use of the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film 7 and the WC—25% NiCr surface film 8, but the present invention should not be limited to this composition, as has been described hereinbefore. The surface films suited for use in accordance with the present invention are exemplified by a  $\text{Cr}_3\text{C}_2$ —15% NiCr surface film, a  $\text{Cr}_3\text{C}_2$ —25% NiCr surface film, a  $\text{Cr}_3\text{C}_2$ —15% CoCr surface film, a  $\text{Cr}_3\text{C}_2$ —20% CoCr surface film, a  $\text{Cr}_3\text{C}_2$ —25% CoCr surface film, a WC—15% NiCr surface film, a WC—20% NiCr surface film, a WC—15% Co surface film, a WC—20% Co surface film, a WC—25% Co surface film, a WC—15% CoCr surface film, a WC—20% CoCr surface film and a WC—25% CoCr surface film, which have excellent surface film strengths and adhesive strengths.

In the aforementioned embodiment, a high velocity oxygen fuel spray-coating method is used when the crown 21, the band 22 and the blade 23, as individually prepared, are coated with the  $\text{Cr}_3\text{C}_2$ —20% NiCr surface film 7. When these individual parts are to be spray-coated, however, the method should not be limited to use of the high velocity oxygen fuel spray-coating method, because the space is not narrow, but can be widened to an explosion spray-coating method or to a vacuum plasma spray-coating method in dependence upon the sizes of the parts.

According to the present invention, it is possible to realize a runner which is so excellent in wear and corrosion resistances that it can be used under conditions in which the fluid contains sediment, and it is possible to manufacture the runner efficiently at a low cost.

It is also possible to realize water machinery so excellent in its wear and corrosion resistances that it can be used under conditions in which the fluid contains sediment, and it is possible to manufacture the water machinery efficiently at a low cost.

What is claimed is:

1. A runner comprising a surface coated on at least a portion thereof with a first surface film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a chromium carbide; and a second surface film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a tungsten carbide, wherein said first surface film and said second surface film are overlapped at least partially.

2. A runner comprising a crown, band and blade is coated, on at least a portion of the surfaces of its crown, band and blade, with a first surface film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a chromium carbide, and, on at least a portion of a joint between said crown and said blade and a joint between said band and said blade, with a second surface film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a tungsten carbide.

3. A runner comprising a surface coated on at least a portion thereof with a first film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a chromium carbide and having a Vickers hardness of 700 or more; and a second surface film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a tungsten carbide and having a higher Vickers hardness of 1,000 or more than that of said surface film, wherein said first surface film and said second surface film were overlapped at least partially.

4. A runner comprising a crown, band and blade is coated, on at least a portion of the surfaces of its crown, band and blade, with a first surface film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a chromium

carbide, and having a Vickers hardness of 700 or more and, on at least a portion of a joint between said crown and said blade and a joint between said band and said blade, with a second surface film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a tungsten carbide and having a higher Vickers hardness of 1,000 or more than that of said first surface film.

5. A runner according to any of claim 2 to 4, wherein said first surface film and said second surface film are overlapped at least partially.
6. A runner according to any of claims 1 to 4, wherein said first surface film forms a lower layer whereas said second surface film forms an upper film in their overlapped portions.
7. A runner according to any of claims 1 to 4, wherein said first surface film contains 50 to 90 wt. % of chromium carbide whereas said second surface film contains 50 to 90 wt. % of tungsten carbide.
8. A runner according to any of claims 1 to 4, wherein the chromium carbide in said first surface film is  $\text{Cr}_3\text{C}_2$  whereas the tungsten carbide in said second surface film is WC.
9. A runner according to any of claims 1 to 4, wherein said first surface film contains 70 to 90 wt. % of chromium carbide whereas said second surface film contains 70 to 90 wt. % of tungsten carbide.
10. A runner according to claim 5, wherein said first surface film forms a lower layer whereas said second surface film forms an upper film in their overlapped portions.
11. A runner according to claim 5, wherein said first surface film contains 50 to 90 wt. % of chromium carbide whereas said second surface film contains 50 to 90 wt. % of tungsten carbide.
12. A runner according to claim 5, wherein the chromium carbide in said first surface film is  $\text{Cr}_3\text{C}_2$  whereas the tungsten carbide in said second surface film is WC.
13. A runner according to claim 6, wherein said first surface film contains 50 to 90 wt. % of chromium carbide whereas said second surface film contains 50 to 90 wt. % of tungsten carbide.
14. A runner according to claim 6, wherein the chromium carbide in said first surface film is  $\text{Cr}_3\text{C}_2$  whereas the tungsten carbide in said second surface film is WC.
15. A runner according to claim 6, wherein said first surface film contains 70 to 90 wt. % of chromium carbide whereas said second surface film contains 70 to 90 wt. % of tungsten carbide.
16. A runner according to claim 5, wherein said first surface film contains 70 to 90 wt. % of chromium carbide whereas said second surface film contains 70 to 90 wt. % of tungsten carbide.
17. A water wheel for driving a generator comprising: a runner according to any of claims 1-4 driven to rotate by a working fluid or a fluid flowing in a passage; a guide vane arranged around said runner; a spindle fitted in said runner; and a bearing supporting said spindle.
18. A runner according to claim 17, wherein said first surface film forms a lower layer whereas said second surface film forms an upper film in their overlapped portions.
19. A runner according to claim 17, wherein said first surface film contains 50 to 90 wt. % of chromium carbide whereas said second surface film contains 50 to 90 wt. % of tungsten carbide.
20. A runner according to claim 17, wherein the chromium carbide in said first surface film is  $\text{Cr}_3\text{C}_2$  whereas the tungsten carbide in said second surface film is WC.

21. A runner according to claim 17, wherein said first surface film contains 70 to 90 wt. % of chromium carbide whereas said second surface film contains 70 to 90 wt. % of tungsten carbide.

22. A water wheel for driving a generator comprising: a runner driven to rotate by a working fluid or a fluid flowing in a passage; a guide vane arranged around said runner; a spindle fitted in said runner; and a bearing supporting said spindle;

wherein said runner and said guide vane are coated on at least portions of their surfaces with a first surface film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a chromium carbide; and a second surface film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a tungsten carbide.

23. A water wheel for driving a generator comprising: a runner according to any of claims 1-4 driven to rotate by a working fluid or a fluid containing  $2 \text{ Kg/m}^3$  or more solid particles; a guide vane arranged around said runner; a spindle fitted in said runner; and a bearing supporting said spindle.

24. A runner according to claim 23, wherein said first surface film forms a lower layer whereas said second surface film forms an upper film in their overlapped portions.

25. A runner according to claim 23, wherein said first surface film contains 50 to 90 wt. % of chromium carbide whereas said second surface film contains 50 to 90 wt. % of tungsten carbide.

26. A runner according to claim 23, wherein the chromium carbide in said first surface film is  $\text{Cr}_3\text{C}_2$  whereas the tungsten carbide in said second surface film is WC.

27. A runner according to claim 23, wherein said first surface film contains 70 to 90 wt. % of chromium carbide whereas said second surface film contains 70 to 90 wt. % of tungsten carbide.

28. A method of manufacturing a water wheel having a runner, comprising the steps of: coating at least a portion of the surface of its runner with a first surface film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a chromium carbide; and then coating the same with a second surface film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a tungsten carbide.

29. A method of manufacturing a water wheel having a crown, band and blade, comprising the steps of: coating at least portions of the surfaces of its crown, band and blade forming no runner or before jointed, with a first surface film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a chromium carbide; jointing said blade between said crown and said band to form said runner; heating the assembly at a temperature in a range of  $350^\circ \text{C}$ . or higher and  $650^\circ \text{C}$ . or lower, for 1 to 30 hours; and coating at least portions of the joint between said crown and said blade and the joint between said band and said blade, with a second surface film containing a metal, as selected from the group consisting of Ni, Cr and Co, and a tungsten carbide.

30. A method of manufacturing a water wheel according to claim 29,

wherein said runner is formed by jointing said blade between said crown and said band by welding.

31. A method of manufacturing a water wheel according to any of claims 28 to 30,

wherein when at least the portions of the surfaces of said crown, said band and said blade are to be coated with said first surface film, the regions within 20 mm, from

17

the leading ends of the welded portions between said crown and said blade and between said band and said blade are left uncoated.

32. A method of manufacturing a water wheel according to any of claims 28 to 30,

wherein the coating method of said first surface film and said second surface film is a spray-coating method.

33. A method of manufacturing a water wheel according to any of claims 28 to 30,

wherein when said joints between said crown and said blade and between said band and said blade are coated with said second surface film after said runner has been heated, said second surface film is overlapped at least partially on said first surface film.

34. A method of manufacturing a water wheel according to any of claims 28 to 30,

wherein said first surface film contains 50 to 90 % of chromium carbide whereas said second surface film contains 50 to 90 wt. %, of tungsten carbide.

18

35. A method for manufacturing a water wheel according to any of claims 28 to 30,

wherein the chromium carbide in said first surface film is  $\text{Cr}_3\text{C}_2$  whereas the tungsten carbide in said second surface film is WC.

36. A method according to claim 29, wherein the heating is carried out at a temperature in a range of 400° C. or higher and 650° C. or lower.

37. A method according to claim 31, wherein regions within 50 mm of said leading ends are left uncovered.

38. A method according to claim 32, wherein said spray-coating method is a high-speed flame spray-coating method.

39. A method according to claim 34, wherein said first surface film contains 70 to 90 wt. % of chromium carbide, whereas said second surface contains 70 to 90 wt. % of tungsten carbide.

\* \* \* \* \*



US005947678A

# United States Patent [19] Bergstein

[11] **Patent Number:** **5,947,678**  
[45] **Date of Patent:** **Sep. 7, 1999**

- [54] **WATER WHEEL WITH CYLINDRICAL BLADES**
- [76] **Inventor:** **Frank D. Bergstein**, 1201 Edgecliff Pl., Cincinnati, Ohio 45206
- [21] **Appl. No.:** **09/109,222**
- [22] **Filed:** **Jun. 30, 1998**
- [51] **Int. Cl.<sup>6</sup>** ..... **F03B 7/00**
- [52] **U.S. Cl.** ..... **415/3.1; 415/202; 415/203; 416/197 A**
- [58] **Field of Search** ..... **415/2.1, 3.1, 4.1, 415/202, 203, 204, 205, 224, 906; 416/197 A**

### FOREIGN PATENT DOCUMENTS

|          |        |                |       |           |
|----------|--------|----------------|-------|-----------|
| 503530   | 6/1920 | France         | ..... | 415/2.1   |
| 56-41402 | 4/1981 | Japan          | ..... | 416/197 A |
| 57-32075 | 2/1982 | Japan          | ..... | 415/2.1   |
| 63-75365 | 4/1988 | Japan          | ..... | 415/3.1   |
| 121      | 1/1902 | United Kingdom | ..... | 415/203   |

### OTHER PUBLICATIONS

IBM Technical Disclosure Bulletin, vol. 9, No. 2, Jul. 1966.

*Primary Examiner*—Christopher Verdier  
*Attorney, Agent, or Firm*—Davidson & Gribbell LLP

### [57] ABSTRACT

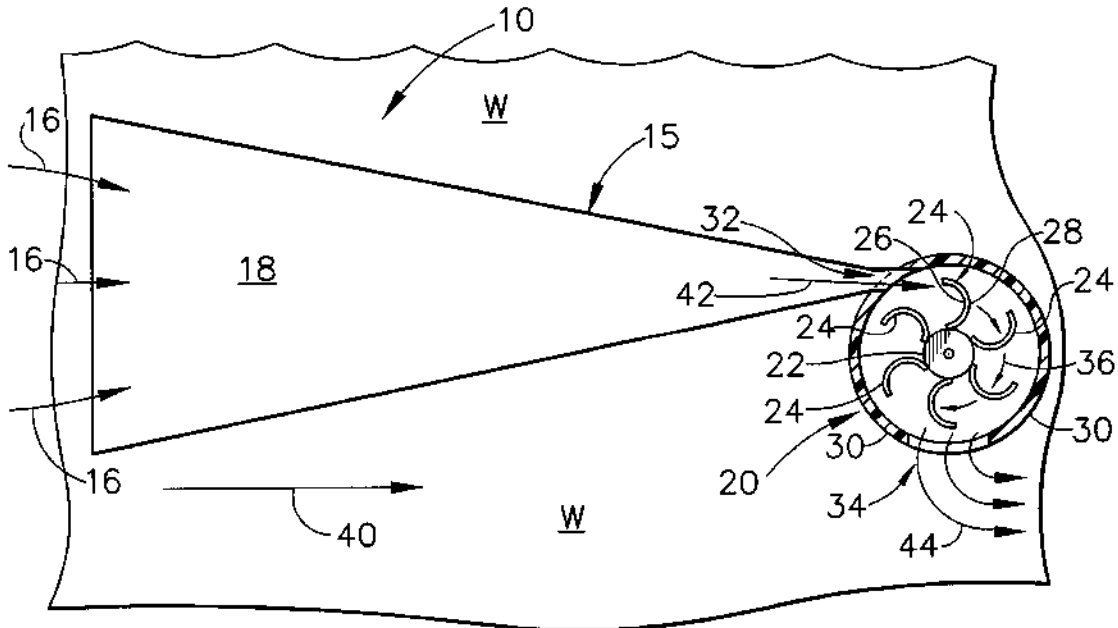
An improved liquid rotor device is provided having a cylindrically-shaped hub, which is supported by a horizontal shaft, and having several curved blades which are attached to the outer portions of the rotating hub. The horizontal shaft preferably rotates with the hub so that it can mechanically drive a device such as an electrical generator. The multiple blades mounted to the exterior surface of the hub are curved such that the longitudinal axis of each blade is parallel to the axis of rotation (i.e., the horizontal shaft). Each blade is arcuate in shape and preferably comprises a portion of the cylindrical wall of a hollow cylinder. In one embodiment of the, the rotating hub and blades sub-assembly is surrounded by a hollow cylindrical housing that is entirely submerged in a liquid, such as water. The surrounding hollow cylindrical housing has an inlet to receive the liquid into the area of the rotating blades and an outlet through which the liquid is discharged. The inlet preferably is in communication with the discharge of a constricting chamber that has a large opening area and a small discharge area, such as a portion of a venturi. By use of this chamber, the velocity of the liquid is increased as it approaches the inlet.

**7 Claims, 6 Drawing Sheets**

### [56] References Cited

#### U.S. PATENT DOCUMENTS

|           |         |              |       |         |
|-----------|---------|--------------|-------|---------|
| 431,739   | 7/1890  | Buhlman      | ..... | 415/202 |
| 646,713   | 4/1900  | Symons       | .     |         |
| 1,293,110 | 2/1919  | Karafas      | .     |         |
| 2,097,286 | 10/1937 | McGee        | .     |         |
| 4,039,849 | 8/1977  | Mater        | .     |         |
| 4,258,271 | 3/1981  | Chappell     | .     |         |
| 4,365,934 | 12/1982 | Mason        | .     |         |
| 4,436,480 | 3/1984  | Vary         | .     |         |
| 4,463,555 | 8/1984  | Wilcoxson    | .     |         |
| 4,467,217 | 8/1984  | Roussey      | .     |         |
| 4,512,714 | 4/1985  | Kaesser      | .     |         |
| 4,519,742 | 5/1985  | Van Buytene  | .     |         |
| 4,776,762 | 10/1988 | Blowers, Sr. | .     |         |
| 4,872,805 | 10/1989 | Horiuchi     | .     |         |
| 4,890,976 | 1/1990  | Jansson      | .     |         |
| 4,923,368 | 5/1990  | Martin       | .     |         |
| 5,088,884 | 2/1992  | Bergstein    | ..... | 415/3.1 |
| 5,249,923 | 10/1993 | Negus        | .     |         |
| 5,440,175 | 8/1995  | Mayo, Jr.    | .     |         |



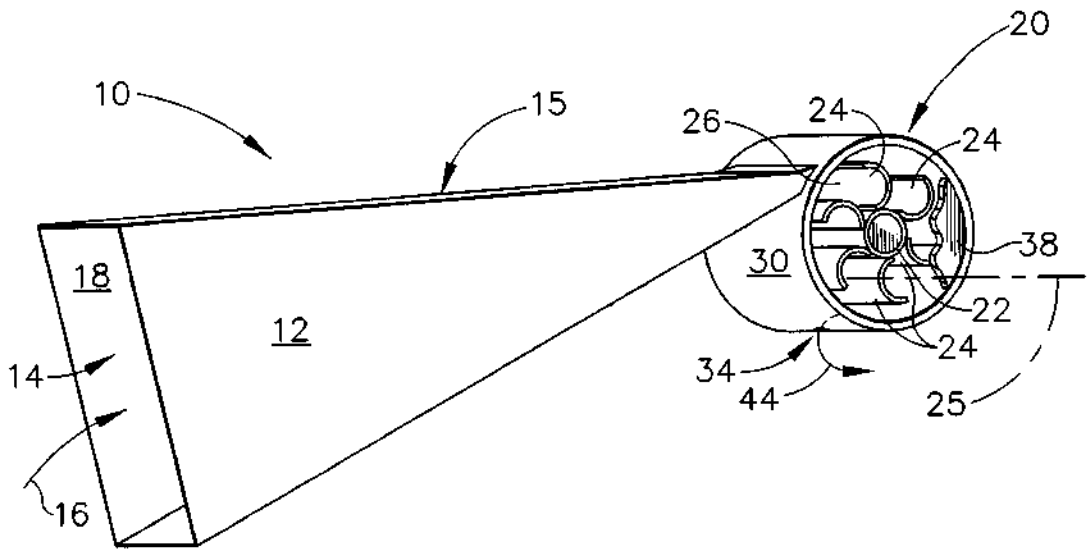


FIG. 1

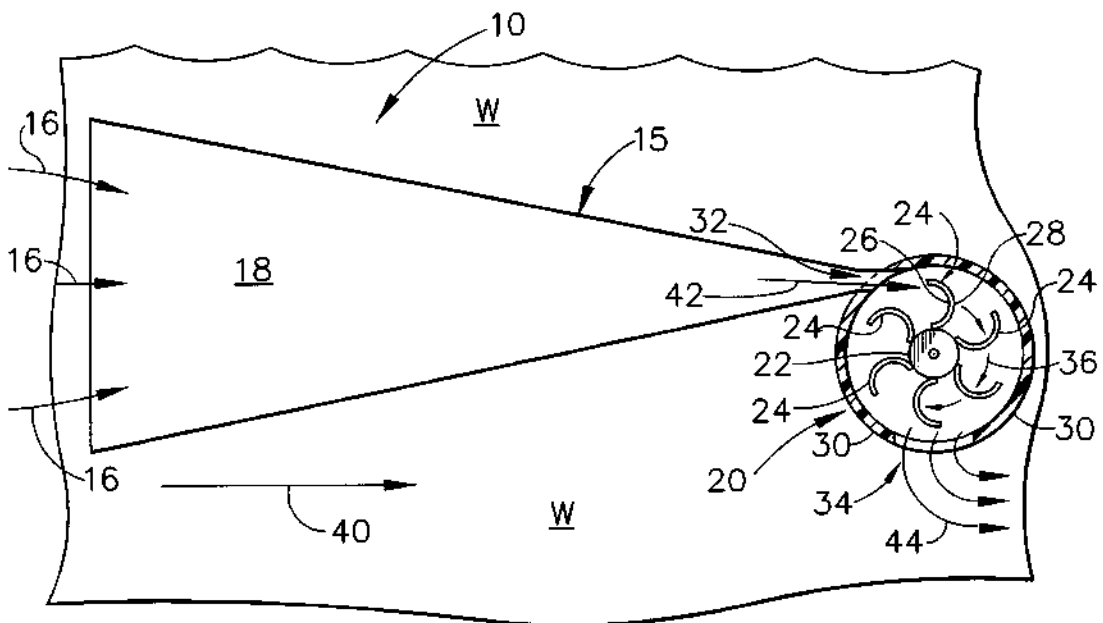


FIG. 2

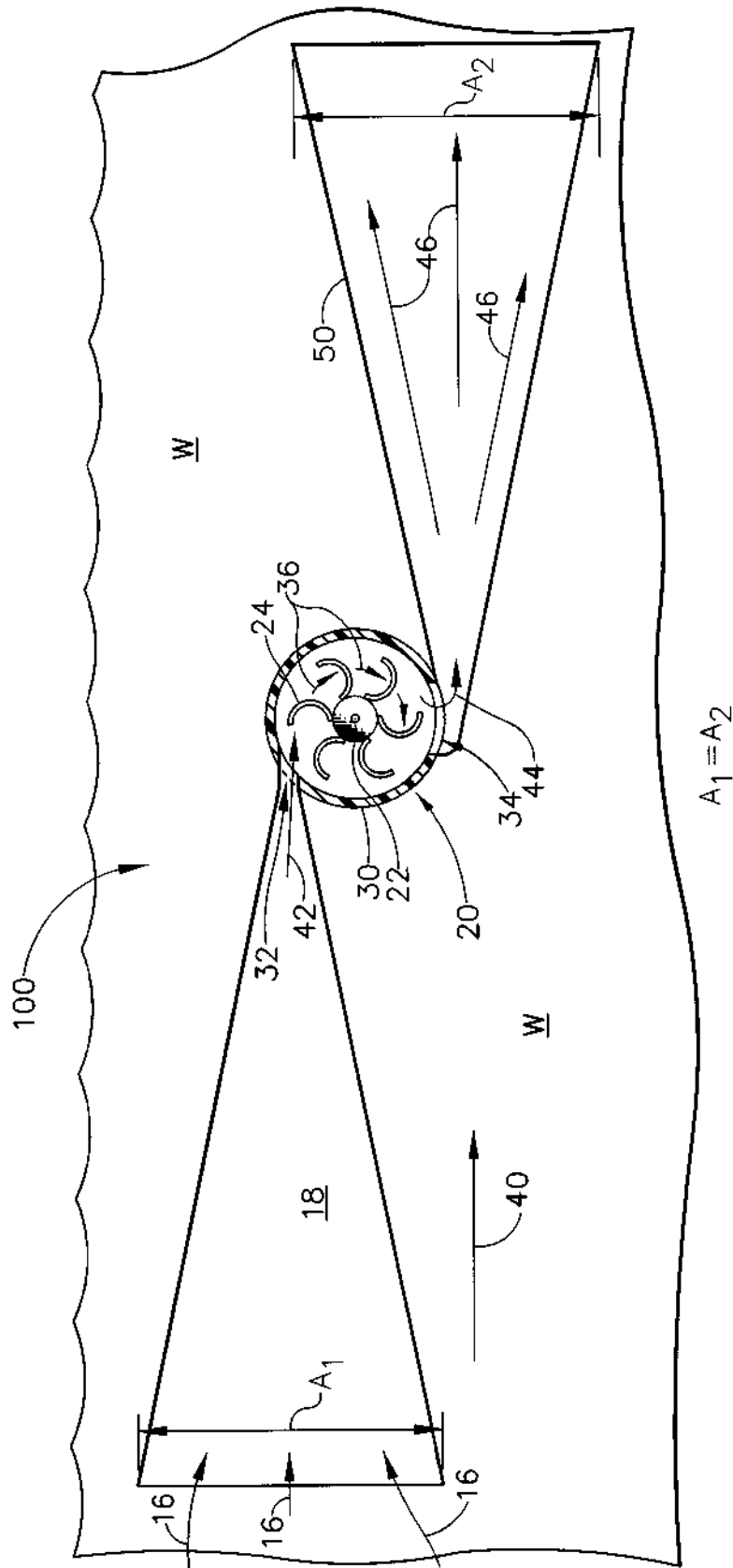


FIG. 3

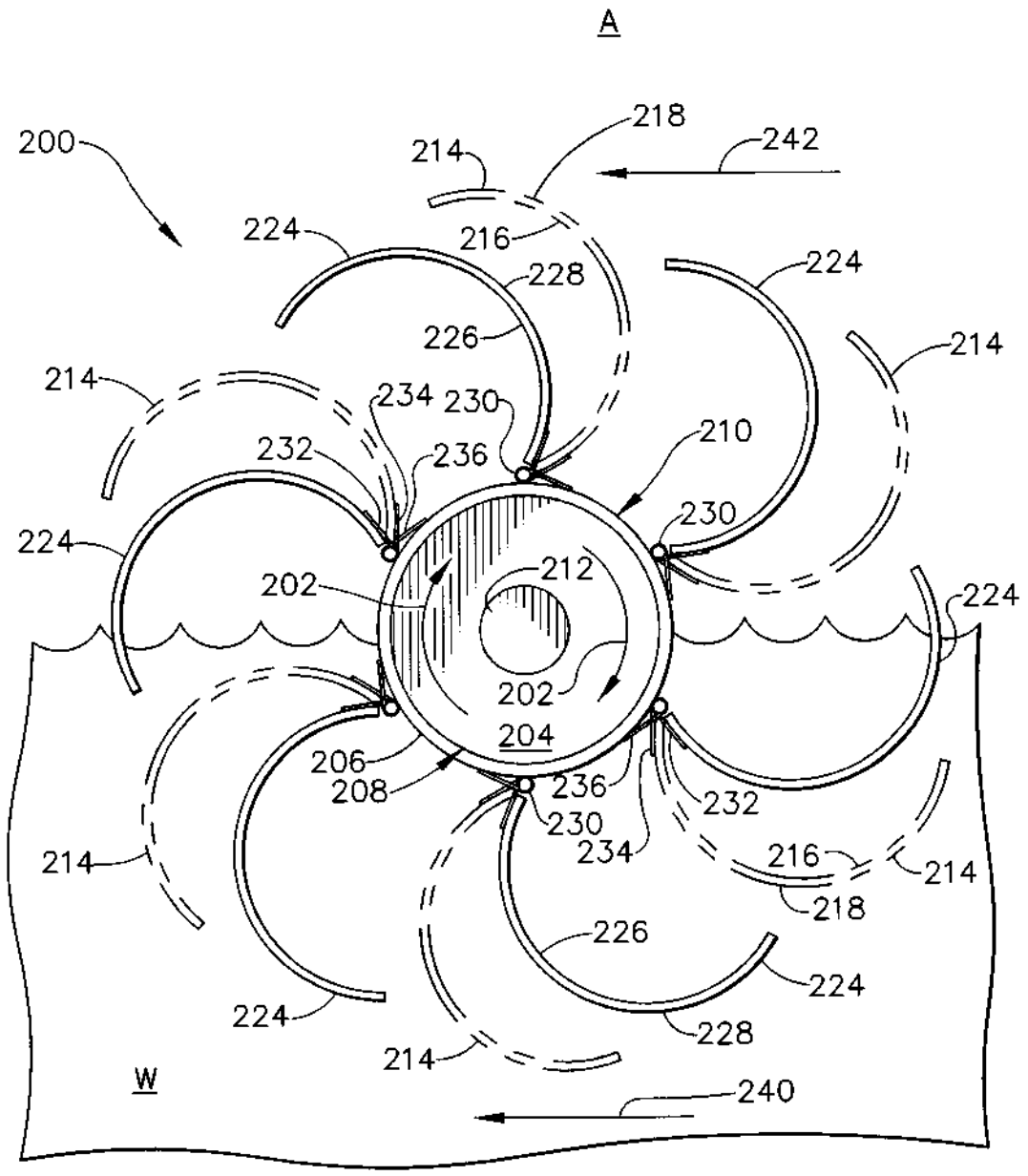


FIG. 4



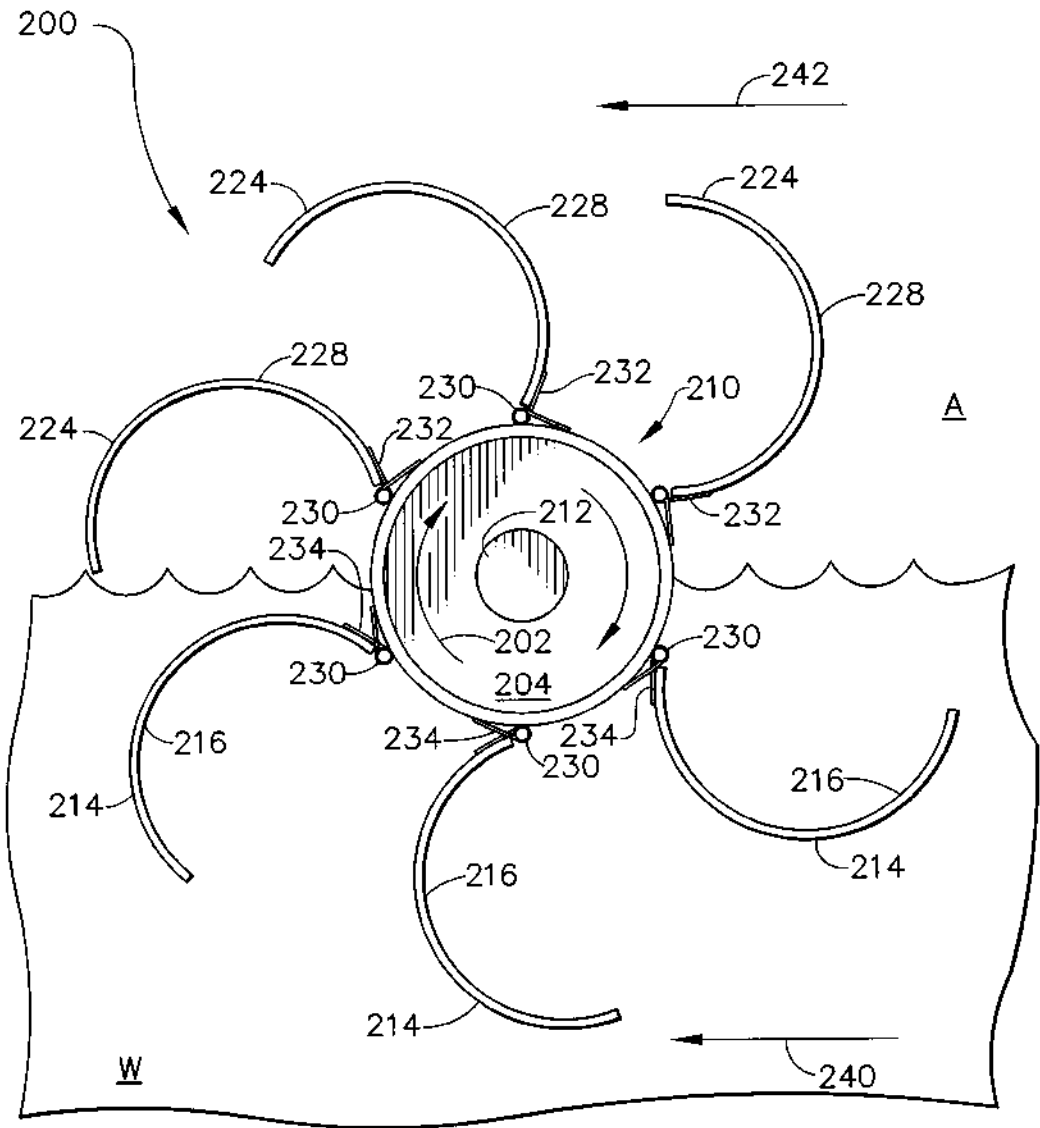


FIG. 5

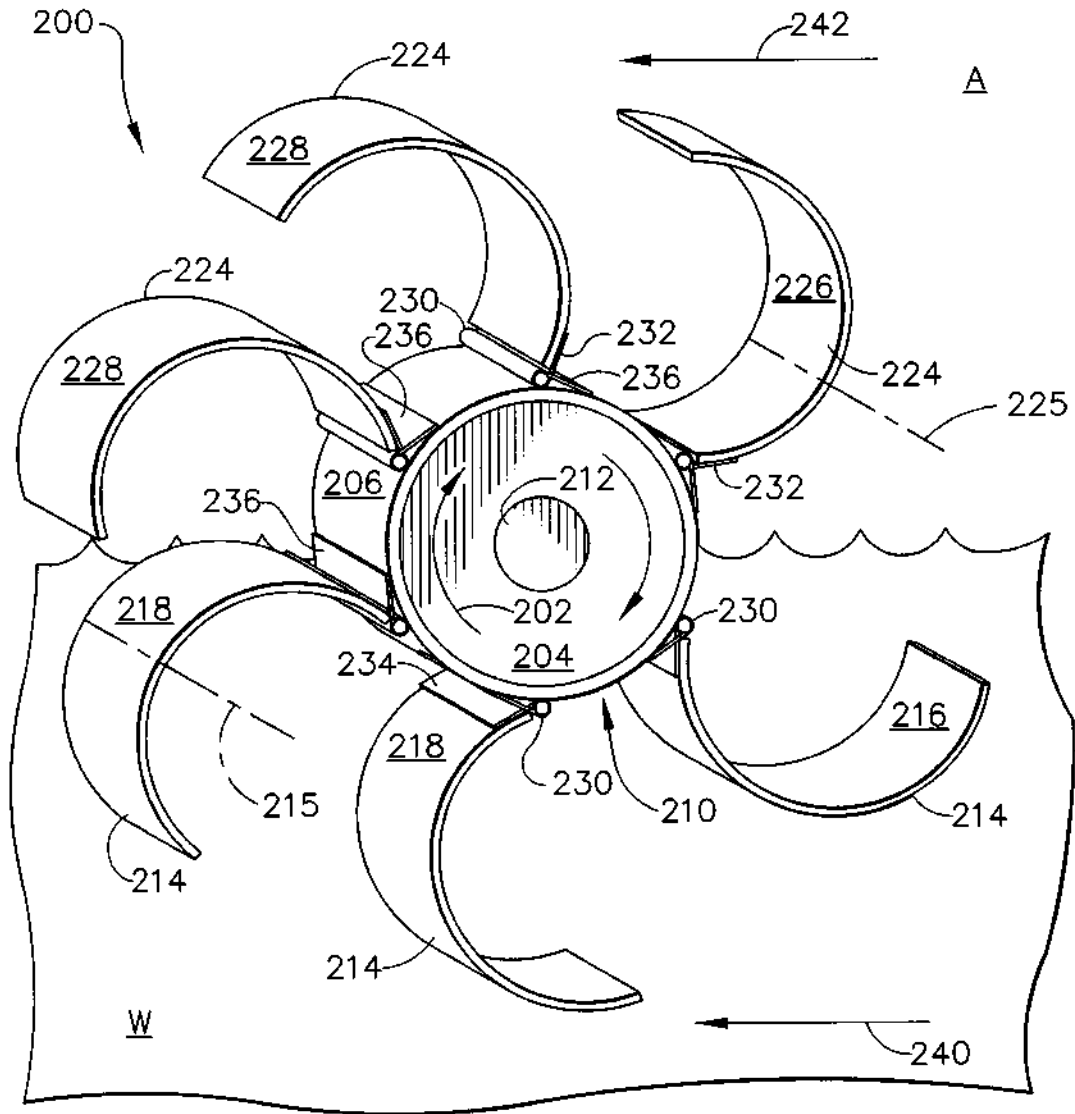


FIG. 6

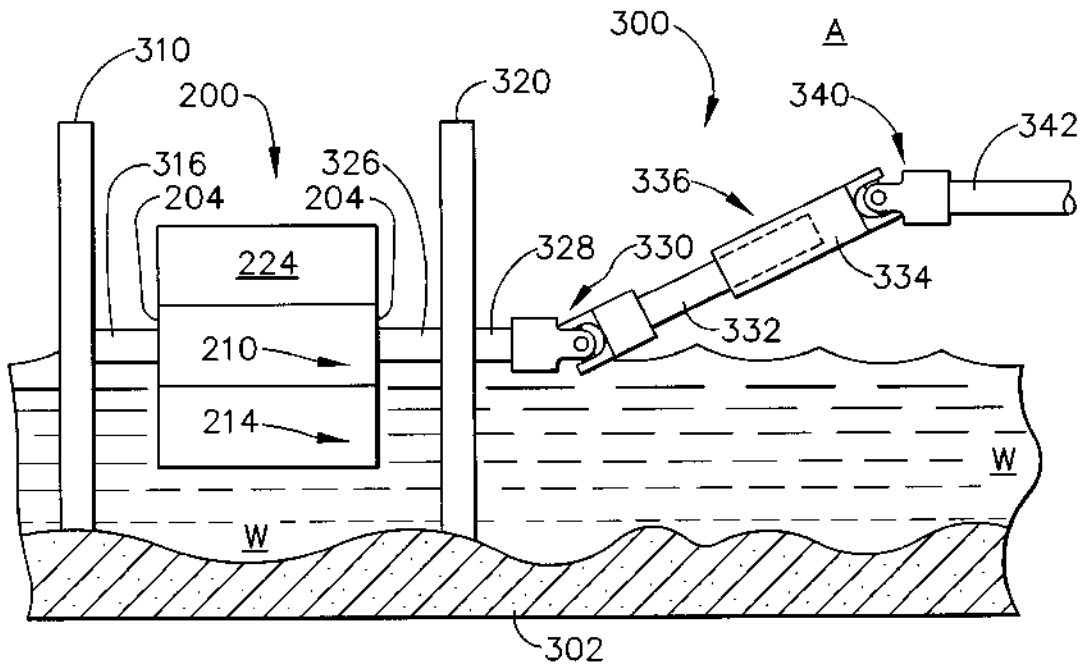


FIG. 7

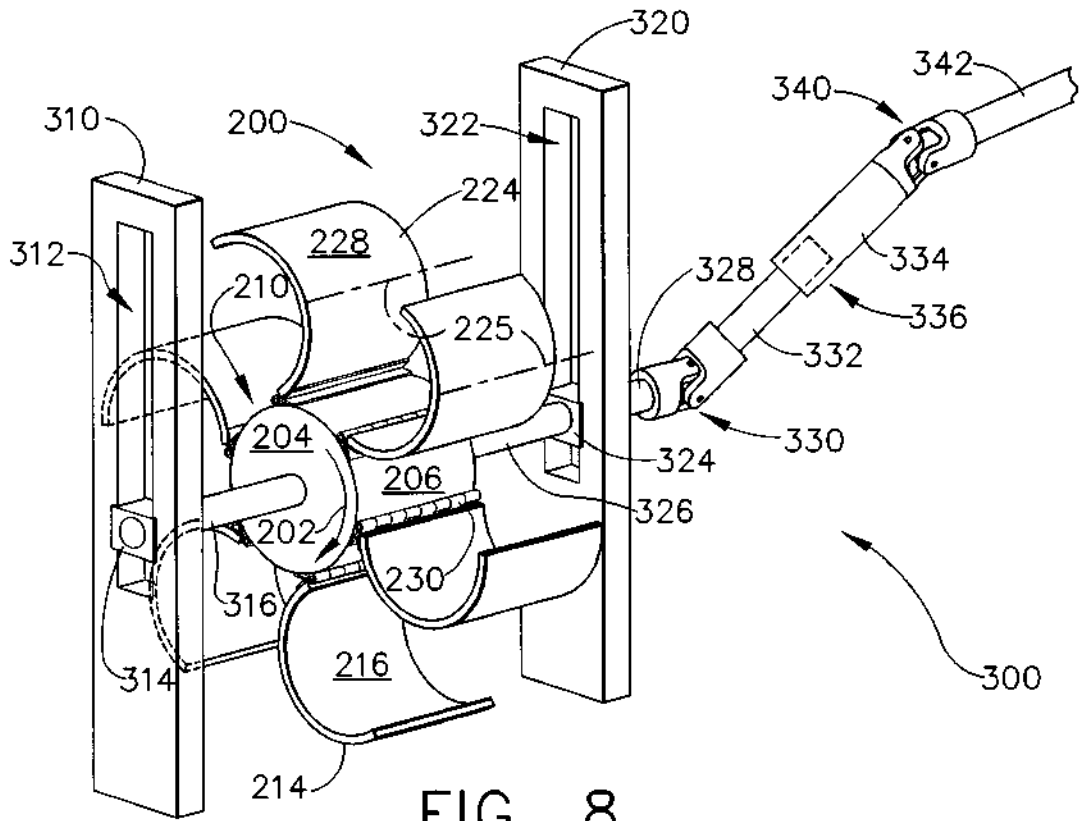


FIG. 8

# WATER WHEEL WITH CYLINDRICAL BLADES

## TECHNICAL FIELD

The present invention relates generally to water or liquid rotor equipment and is particularly directed to water rotors of the type which can be used to drive electrical generators, or other mechanical equipment. The invention will be specifically disclosed in connection with a water rotor having multiple curved blades in one plane which, in one embodiment captures the liquid for a large portion of their rotation, and in a second embodiment utilizes hinged blades to present less air friction to the wind direction.

## BACKGROUND OF THE INVENTION

Water rotor machines (or water wheels) are quite old in the art, and have been in use for centuries. Many water rotors are known as "turbines" and typically have a large vertical drop through which the water travels before striking the blades of the turbine, thereby gaining velocity to apply a greater force. Other water rotors or water wheels are submerged and use an inlet and an outlet through which the passage of the water is directed.

An example of a conventional water wheel having an inlet and outlet is U.S. Pat. No. 5,440,175 (by Mayo), which discloses a water wheel-driven generating unit that is to be used at a low head dam site. The inlet to the water wheel is an adjustable chute that extends from the dam crest to the water wheel. The Mayo water wheel has rotating longitudinal buckets (i.e., blades) that are designed to develop maximum energy over a wide range of flow conditions, and also to discharge debris. The buckets are vented as necessary to improve filling and discharge, and also to minimize vibration. Retention of water in the buckets until each one reaches the lowest point of travel is provided by an adjustable shroud. The shape of the bucket periphery is curved from an angle parallel to the chute at its lowest slope to an angle passing through the center of rotation of the water wheel, with the outer curved radius equal to one-half the bucket depth. The shroud can be moved away from the main housing to allow debris to be dislodged. Vents are provided near each bucket to allow an escape path for any air trapped between the filling water as the buckets rotate. Later, as the buckets become empty of water, air must take its place and the vents are designed to allow air back into the bucket to create smooth water dumping.

U.S. Pat. No. 1,293,110 (by Karafas) discloses a water wheel used on a ship, having an inlet and an outlet at the bottom. The blades of the impeller have a generally curved appearance and are very closely spaced together, essentially comprising pairs of half-blades that are mounted into one overall junction near the hub of the wheel.

U.S. Pat. No. 4,436,480 (by Vary) discloses a hydro-turbine apparatus to generate electricity. The turbine spins in the vertical plane and is designed to be submerged in a channel of water that will spin its vanes upon impact. On the inlet side of the turbine, a scoop member captures water flowing toward the turbine wheel and directs it behind each of the rotating vanes. This arrangement dumps water behind the rotating vanes at the earliest advantageous moment, since normally water would not effectively act on a vane until it is about to its horizontal position. The inlet and outlet of the turbine wheel are approximately 180 degrees from one another along the rotational movement of the vanes.

Some of the prior water wheels are provided with a buoyant rotatable drum in which the blades travel both

through liquid and through a gas (i.e., air). For example, U.S. Pat. No. 2,097,286 (by McGee) discloses a power generating apparatus that uses a water wheel that is placed in a river. The McGee water wheel has curved blades that run parallel to one another, and have a somewhat concave shape to catch the current flow of the water. The water wheel is buoyant, and can rise or fall with the water level of the river. A vertical post is embedded in the river bottom, and an arm is pivotally attached by a pivot pin to the post. A DC generator is mounted within the interior of the cylindrical drum that holds the water wheel and its parallel blades.

Another patent that discloses a water wheel in which blades can protrude into air is U.S. Pat. No. 4,519,742 (by Van Buytene) which discloses a water wheel-type device that has a rotatable shaft with blades that are moved by flowing water. Each of the blades has at least one gate and a slide that can move the gate from an open to a closed position. When the gate is in its open position, it will allow fluid to pass through a corresponding opening in the blade. This would occur when the blade is protruding into air, so as to minimize friction caused by the air against the blade. When the blade enters the water, the gate slides to its closed position so that the water will impact against the gate to help force the blade to rotate in the proper direction.

U.S. Pat. No. 646,713 (by Symons) discloses a water wheel comprising a drum having hinged blades that present their surfaces in desirable positions while in the water, and do not waste the power of the wheel by forcing the water downward as they enter the water, or by lifting water as they rise or by encountering an unnecessary resistance of air as they rotate out of the water. The blades at positions "i<sup>15</sup>" and "i<sup>16</sup>" catch the water flow as the blades are about to leave the liquid domain and enter the gaseous domain. Once the blades are out of the water, the blades, by their own weight, pivot to the positions shown as "i<sup>1</sup>" and "i<sup>2</sup>", and come to rest against an arm "n". The blades stay in that relative position until the blades are about to re-enter the water, at which time the blades further pivot to a position that is radial with respect to the center of the water wheel. This is illustrated by the dashed lines in the lower left quadrant and the very middle bottom spoke of the water wheel on FIG. 2. According to Symons, the blades are in their "feathered" position, ostensibly to minimize their friction or drag upon re-entering the water. After the blades have passed again into the water, they stay in the feathered position until they have rotated another 90 degrees, and they finally begin to pivot again so that they will catch the water and can then further help to propel the water wheel when back at their original positions at i<sup>15</sup> and i<sup>16</sup>. There is some inefficiency in this design, particularly since the blades must re-pivot while they are already in the water, and thereby provide no thrust during the re-pivoting that would help propel the rotation of the water wheel.

It would be advantageous to provide a water rotor having a greater efficiency by capturing the water for a very large portion of the rotational travel of the blade of the water rotor. For water rotors that are buoyant and have blades that travel through the air for a portion of their rotation, it would be advantageous to minimize the air friction or wind resistance of the rotating blades during the portion of rotation that they travel through the air, especially at times when the air is moving in a direction that generally opposes such rotation.

## OBJECTS OF THE INVENTION

Accordingly, it is a primary object of the present invention to provide a liquid rotor device which efficiently operates

when fully submerged by "trapping" the moving liquid for a large percentage of the rotational travel of the blades from the time the liquid enters at an inlet until it is discharged at an outlet.

It is another object of the present invention to provide a submerged liquid rotor device that has a constricting venturi effect to increase the velocity of the moving liquid as that liquid enters the inlet of the liquid rotor.

It is a further object of the present invention to increase the efficiency of a liquid rotor device by providing an expanding venturi effect at its outlet to further increase the efficiency by lowering the pressure differential between the inlet and the outlet of the liquid rotor device.

It is a yet further object of the present invention to provide a buoyant liquid rotor device in which the blades travel both through a liquid and through gaseous air during portions of their rotation, and in which the blades present a reduced air resistance in situations where the wind direction would oppose rotation of the blades.

It is yet another object of the present invention to provide a buoyant liquid rotor device that has hinged blades to both increase the efficiency of the blades as they travel through the liquid, and to reduce the air resistance of the blades as they travel through the gaseous air in situations where the wind direction would otherwise oppose the travel of such blades.

It is yet a further object of the present invention to provide a buoyant liquid rotor device that is capable of floating up or down in a vertical plane while driving a pivotable shaft that will, in turn, drive an electrical generator.

Additional objects, advantages and other novel features of the invention will be set forth in part in the description that follows and in part will become apparent to those skilled in the art upon examination of the following or may be learned with the practice of the invention.

### SUMMARY OF THE INVENTION

To achieve the foregoing and other objects, and in accordance with one aspect of the present invention, an improved liquid rotor device is provided having a cylindrically-shaped hub, which is supported by a horizontal shaft, and having several curved blades which are attached to the outer portions of the rotating hub. The horizontal shaft preferably rotates with the hub so that it can mechanically drive a device such as an electrical generator. The multiple blades mounted to the exterior surface of the hub are curved such that the longitudinal axis of each blade is parallel to the axis of rotation (i.e., the horizontal shaft). Each blade is arcuate in shape and preferably comprises a portion of the cylindrical wall of a hollow cylinder.

In one embodiment of the present invention, the rotating hub and blades sub-assembly is surrounded by a hollow cylindrical housing that is entirely submerged in a liquid, such as water. The surrounding hollow cylindrical housing has an inlet to receive the liquid into the area of the rotating blades and an outlet through which the liquid is discharged. The inlet preferably is in communication with the discharge of a constricting chamber that has a large opening area and a small discharge area, such as a portion of a venturi. By use of this chamber, the velocity of the liquid is increased as it approaches the inlet. In an alternative embodiment, the discharge is in communication with a second expanding chamber that has a small intake area and a large exhaust area through which the discharge liquid will pass. In this alternative embodiment, it is preferred that the area of the intake of the first constricting chamber is substantially equal to the

area of the exhaust of the expanding second chamber, thereby minimizing the hydraulic losses through the system.

In a second embodiment, the rotating hub and blades sub-assembly is made to be buoyant so that the centerline of the rotating hub will be approximately at the surface of the liquid, so that the liquid rotor will essentially float along the surface of, for example, a stream, river or canal. In this second embodiment, there is no surrounding hollow cylindrical housing, but instead the curved blades are directly exposed to the moving liquid, as well as to the wind of the gaseous air above the surface of the liquid. If the direction of the liquid current is substantially the same as the wind direction, then the wind will tend to inhibit the rotation of the blades and hub sub-assembly. In order to provide a reduced cross-sectional area against which the wind can act, the curved blades are hinged at the surface of the cylindrical hub, so that the wind will have less surface area to act against.

In another alternative embodiment, the buoyant wind rotor is supported by a pair of vertical supports which constrain the liquid rotor to floating up and down in a single vertical plane. The horizontal shaft running through the rotating hub is supported by a bearing surface that will ride up and down along these vertical supports. The mechanical output of the liquid rotor is then connected to a set of shafts, including one shaft that can move through an angle by use of universal joints. This same shaft will preferably be adjustable in length, so as to allow the liquid rotor sub-assembly to remain fixed in one location in the horizontal plane while moving up or down in the vertical plane. At the same time, the driven equipment (e.g., an electrical generator) will be able to remain at a single stationary point in the horizontal plane.

Still other objects of the present invention will become apparent to those skilled in this art from the following description and drawings wherein there is described and shown a preferred embodiment of this invention in one of the best modes contemplated for carrying out the invention. As will be realized, the invention is capable of other different embodiments, and its several details are capable of modification in various, obvious aspects all without departing from the invention. Accordingly, the drawings and descriptions will be regarded as illustrative in nature and not as restrictive.

### BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings incorporated in and forming a part of the specification illustrate several aspects of the present invention, and together with the description and claims serve to explain the principles of the invention. In the drawings:

FIG. 1 is a perspective view of a liquid rotor apparatus having a rotatable cylindrical hub with curved blades attached, surrounded by a hollow cylinder and having a constricting intake chamber attached to the inlet of the hollow cylinder, constructed in accordance with the principles of the present invention.

FIG. 2 is a side elevational view of the liquid rotor apparatus of FIG. 1.

FIG. 3 is a side elevational view of a liquid rotor apparatus similar to that of FIG. 1, however, an expanding exhaust chamber is attached to the outlet of the hollow cylinder.

FIG. 4 is a side elevational view of a buoyant liquid rotor apparatus having a cylindrical hub and curved blades that are hinged at their point of connection to the cylindrical hub, as constructed according to the principles of the present invention.

FIG. 5 is a side elevational view of the buoyant liquid rotor apparatus of FIG. 4 in which the curved blades are shown in their typical operating positions.

FIG. 6 is a perspective view of the buoyant liquid rotor apparatus of FIG. 5.

FIG. 7 is a front elevational view of the buoyant liquid rotor apparatus of FIG. 4 as mounted to a set of vertical supports and having an output shaft to drive an electrical generator.

FIG. 8 is a perspective view of the buoyant liquid rotor apparatus and vertical support assembly of FIG. 7.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Reference will now be made in detail to the present preferred embodiment of the invention, an example of which is illustrated in the accompanying drawings, wherein like numerals indicate the same elements throughout the views.

Referring now to the drawings, FIGS. 1 and 2 show a liquid rotor assembly generally designated by the reference numeral 10, having a sub-assembly 20 that contains a rotating hub 22 and set of blades 24, along with an intake chamber 15 having an opening 14. As seen on FIG. 2, the liquid rotor assembly 10 is totally submerged within a liquid (e.g., water) which is generally depicted by the letter "W", and the direction of travel of the liquid as it enters the chamber through opening 14 is indicated at the arrows 16. This liquid direction corresponds to the direction of the current, which is indicated at the arrow 40.

As seen on FIG. 1, the intake chamber 15 has a side wall 12, an intake opening 14 and a second side wall 18. On FIG. 2, the intake chamber 15 is seen to discharge its liquid contents along the path of the arrow 42, which flows through an inlet opening 32 in a hollow cylinder 30 with side walls (such as at 38) that acts as the housing for the liquid rotor sub-assembly 20. A similar opening at the reference numeral 34 in the hollow cylinder 30 acts as the outlet of the liquid rotor sub-assembly 20.

The liquid rotor apparatus 10 will preferably be submerged in water that has a constant motion, such as in the case of a canal, stream, or river. The liquid flow would enter intake chamber 15 at the arrows 16, then be somewhat increased in velocity due to the shape of the side walls 12 and 18 of intake chamber 15 before the liquid enters the inlet 32 along the arrow 42. Once the liquid flows through inlet 32, the liquid will strike the surface of the rotatable blades 24, which each have a curved profile with a concave surface 26 and a convex surface 28. The liquid will strike the concave surface 26 thereby propelling the blades in a clockwise direction as seen on FIG. 2. The liquid will continue to follow the arrows 36 while pushing against the blades 24, thereby moving them in a clockwise direction until the liquid reaches outlet 34, which is another opening in the cylindrical housing 30 through which the liquid will discharge along the arrows 44.

The liquid rotor sub-assembly 20 comprises a rotating hub 22, a set of curved blades 24, and a hollow cylindrical housing 30 having inlet and outlet openings 32 and 34, respectively. Blades 24 preferably are semi-circular in profile (as seen from their sides, as in FIG. 2) which gives them a "C"-type shape in appearance, and each blade 24 has a longitudinal axis depicted by the reference numeral 25. This longitudinal axis 25 is substantially in parallel with the axis of rotation (i.e., the centerline) of rotating hub 22.

The rotating hub 22 will preferably be connected to some type of output shaft (not shown), which will be similar to the

output shaft 328 depicted on FIGS. 7 and 8. As stated above, the liquid velocity will somewhat increase as it travels through the constricting shape of the intake chamber 15, between the times that the liquid travels along the arrows 16 until it arrives at the arrow 42. This will help to increase the efficiency of the liquid rotor apparatus 10, and to increase its power output.

Another feature that will tend to increase efficiency of the liquid rotor apparatus 10 is the locations of the inlet 32 and outlet 34 as compared to the rotational travel of the blades 24. As the liquid enters at the inlet 32, it will contact the rotatable blades 24 for over 180 degrees of their rotational travel before reaching the outlet 34. This insures that most of the power behind the flowing liquid will be imparted to the rotatable blades 24 for a long duration of their rotational travel. The discharge opening 34 is placed near the very bottom of the cylindrical housing 30 so as to not greatly interfere with other liquid flowing within the body of water W, and also is placed so as to essentially prevent the outside liquid from entering at the discharge opening 34.

The materials used for all portions of the liquid rotor apparatus 10 preferably are to be impervious to rust or other form of corrosion, while at the same time being materials that are easy to construct and assemble. The rotatable hub 22 and blades 24 preferably are made of a light-weight material, such as plastic, so as to provide the least amount of inertia to rotational movement. Of course, metal materials could be used for the same components. In the preferred embodiment, the blades 24 are constructed of PVC material, and comprise a semi-circular section of a PVC pipe, and are attached to the rotatable hub 22 along a substantially linear edge of cylindrical PVC pipe section by an adhesive material. Naturally, other forms of attachment and other construction materials could be used to build the liquid rotor apparatus 10, without departing from the principles of the present invention.

On FIG. 3, an alternative embodiment liquid rotor apparatus 100 is provided in which its outlet 34 does not dump liquid directly back into the infinite volume of the stream, river, or canal, but instead directs the liquid into an exhaust chamber 50 which expands in area as the liquid follows downstream along the arrows 46. It is preferred that the area of the opening of intake chamber 15, designated by "A<sub>1</sub>" be substantially equal to the area at the discharge opening of the exhaust chamber 50, at the area designated as "A<sub>2</sub>". In this manner, the total liquid rotor apparatus 100 will have a venturi-type shape, and will incur a minimal back-pressure due to the constriction and then expansion of the areas through which the liquid flows as it passes through rotor apparatus 100.

As in the liquid rotor apparatus 10 depicted on FIGS. 1 and 2, the apparatus 100 of FIG. 3 has a greater efficiency by causing the liquid to travel through a large portion of the rotational travel of the blades 24 between the inlet 32 and the outlet 34 of the liquid rotor sub-assembly 20. In fact, while using an exhaust chamber 50, the outlet opening 34 could be located even further clockwise along the travel of the liquid movement along arrows 36, thereby providing a greater efficiency. This would be possible since the exhaust chamber 50 would protect the outlet opening 34 from interference with the outside liquid current 40. There would be a certain trade-off when attempting to move the outlet opening 34 further along the rotational travel of the blades 24, since the liquid would have to change direction by over 90 degrees as it travels along the arrow 44 and enters the smaller cross-section area of the exhaust chamber 50. The configuration shown on FIG. 3 is probably the optimum arrangement with respect to efficiency.

It will be understood that the venturi shape provided by the inlet and discharge chambers could be modified without departing from the principles of the present invention. Moreover, it will be understood that the precise locations of the inlet and outlet of the housing for the liquid rotor assembly could be modified without departing from the principles of the present invention.

A second embodiment generally designated by the reference number **200** of a liquid rotor apparatus is depicted on FIG. 4 in which the entire apparatus is made buoyant so that it will float on the surface of the liquid body. On FIG. 4, a cylindrical hub **210** comprises an outer housing **206**, a centerline shaft **212**, and an interior chamber **208**. This entire hub sub-assembly **210** rotates in the clockwise direction on FIG. 4, as indicated by the arrows **202**.

The chamber **208** will preferably be filled with a gaseous compound such as air so that the entire liquid rotor apparatus **200** will float at approximately the centerline of the shaft **212**. This is accomplished by providing an air-tight end plate **204** (see FIGS. 6, 7, and 8) that will seal the chamber **208** on both sides of the water rotor apparatus **200**. By filling the chamber with the proper quantity and compound of a gas, the proper buoyancy will be achieved so that the liquid rotor apparatus **200** will float in the body of water designated by the letter "W" on FIG. 4.

The liquid body on which the liquid rotor apparatus **200** is to be placed will preferably have continuous current, as indicated by the arrow **240**, so that the blades of the liquid rotor apparatus will be forced to rotate because of this current. The apparatus **200** will, therefore, be most useful in a canal, stream, or river which always flows in a single direction. Since the liquid rotor apparatus **200** is made buoyant, its blades will extend above the water line through about 50% of the blades' rotational travel, and the direction of the air may oppose the rotation of these blades, as for example, when the wind is in the direction depicted by the arrow **242** for the body of air designated by the letter "A".

In order to present a smaller surface area as a target against which the wind will impact, the blades of the liquid rotor apparatus **200** are hinged at their connecting point to the outer cylindrical surface of the hub **210**. On FIG. 4, each of the six blades is shown in its two extreme positions, in solid lines for situations where the blades **224** are in a position to present a lower surface area profile to the direction of the wind, and a second position in dashed lines for the blades **214** when in their position where the direction of the liquid current will propel the blades to rotate the liquid rotor assembly **200**. The reference number designations **214** and **224** represent the two different positions for the same physical blade in each of the six blade positions depicted on FIG. 4. Each blade has a concave and convex surface, and for the blades **214** depicted in dashed lines, the concave surface is at **216** and the convex surface is at **218**. For the blades **224** depicted in their low surface area profile position, the concave surface is depicted at **226** and the convex surface at **228**.

Blades **224** (and **214**) preferably are semi-circular in profile (as seen from their sides, as in FIG. 4) which gives them a "C"-type shape in appearance, and each blade **224** and **214** has a longitudinal axis depicted by the reference numerals **225** and **215**, respectively (see FIG. 6). The longitudinal axes **225** and **215** are substantially in parallel with the axis of rotation (i.e., the centerline) of rotating hub **210**.

Each of the curved blades is attached to a hinge **230** along a substantially linear edge of cylindrical PVC pipe section

making up the blade, of which hinges **230**, in the preferred embodiment, have a pair of flanges that will act as the hinges' attachment points. One of the flanges, at reference numeral **236**, attaches the hinge to the outer surface of the cylindrical housing **206**. The other flange is depicted as reference numeral **232** when the blade is in its lower surface area profile position at **224**, and this same hinge is given the reference numeral **234** when its corresponding blade is in its "dashed" position **214**.

Many different materials could be used to construct the liquid rotor apparatus **200**, although all materials should be impervious to rust or other type of corrosion when immersed in water (or other operating liquid) for long durations. This is particularly important for the hinges **230**, because they must remain relative free to operate so that the blades can be moved from their one extreme position at **224** to their opposite extreme position at **214** without any undue friction. In the preferred embodiment, the curved blades are constructed of a portion of a PVC pipe, which is cut into two halves along its centerline axis, each half becoming one of the blades depicted on FIG. 4.

FIG. 5 illustrates the liquid rotor apparatus **200** with the blades in their typical operating positions when the water (or other liquid) current direction **240** is in the same direction as the wind direction **242**. In this situation, the submerged blades **214** will be forced into their "liquid driven position" by force of the liquid water moving in the direction **240**. When this occurs, the rotational movement of the blades will cause the entire liquid rotor assembly **200** to rotate in the clockwise direction as viewed on FIG. 5. However, once the blades become free of the liquid water (e.g., along the left side of FIG. 5), then the force of gravity and the wind direction **242** will cause the blades to move into their lower wind resistance profile position **224**. If the wind is strong enough, the blades will remain in their lower surface area profile position **224** until they are again submerged along the right hand side of FIG. 5. Once they re-enter the liquid water, the blades will be forced into their liquid-driven positions **214**.

FIG. 6 is a perspective view depicting the liquid rotor apparatus **200** of FIG. 5. The blades are in their same positions as illustrated in FIG. 5, and some of the construction features of the apparatus **200** are more clearly discernible on FIG. 6.

FIGS. 7 and 8 illustrate the liquid rotor apparatus **200** as it is mounted in a set of vertical supports that retain the apparatus **200** within a single vertical plane as it moves up and down with the level of the liquid water W. On FIG. 7, it can be seen that two vertical supports **310** and **320** are constructed so as to be in parallel with one another, and which protrude from the body of air "A", through the body of liquid water "W", and into the earth at reference numeral **302**. Two rotatable half-shafts at reference numerals **316** and **326** are used to mount the liquid rotor apparatus **200** between the vertical supports **310** and **320**. The mechanical output of the rotor apparatus **200** is provided through the half-shaft **326**, through its bearing **324** (see FIG. 8), and into an output shaft **328**. The mechanical drive continues through a universal joint **330**, then through a pivotable shaft assembly **336**, through another universal joint **340**, and into a final output shaft **342** which is used to drive an electrical generator (not shown) that preferably is mounted on the shore.

As the liquid rotor apparatus **200** rises and falls, due to the changing level of the liquid water "W", the angle of the pivotable shaft assembly **336** will change with respect to the horizontal plane. In view of this fact, the shaft assembly **336**

preferably comprises two separate shafts **332** and **334** which will contain internal and external spline so that the total length of the shaft assembly **336** can vary as the angle of the shaft changes with respect to the horizontal plane. In this manner, the liquid rotor apparatus **200** can remain positioned in a fixed location with respect to the horizontal distance to the electrical generator, which would also be mounted at a fixed horizontal position with respect to the earth.

On FIG. **8**, the bearings **314** and **324** can be viewed, and which receive the half-shafts **316** and **326**. In addition, vertical slots **312** and **322** in their respective vertical supports **310** and **320** can be viewed, and these slots allow the bearings **314** and **324** to slide up and down within the vertical plane, thereby allowing the liquid rotor apparatus **200** to remain in a fixed horizontal position while vertically floating up and down as the liquid level rises and falls.

The materials used for the vertical supports, shafts, and universal joints should all be selected having physical properties so as to be relatively impervious to rust or other corrosion when immersed in water for long durations. This is particular important for the sliding bearing and slot combinations **312**, **314**, and **322**, **344**. This is also important for the universal joints **330** and **340**.

A large variety of materials could be used to construct the features depicted in the liquid rotor apparatus **200**, and its associated vertical supports and output shaft assemblies, without departing from the principles of the present invention. It will be understood that other blade shape configurations could be used along with the hinged connection points to the cylindrical hub **210** without departing from the principles of the present invention.

The foregoing description of a preferred embodiment of the invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Obvious modifications or variations are possible in light of the above teachings. The embodiment was chosen and described in order to best illustrate the principles of the invention and its practical application to thereby enable one of ordinary skill in the art to best utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the claims appended hereto.

I claim:

**1.** A submerged liquid rotor apparatus, comprising: a rotatable central hub having a cylindrical surface; a plurality of curved blades attached to an outer surface of said central hub such that said blades exhibit a rotational travel in accordance with rotational movement of said hub; a substantially cylindrical housing with circular end walls that surrounds said rotatable central hub and curved blades, said housing having an inlet and an outlet, said inlet and outlet being spaced apart along the rotational travel of said blades

by over 180 degrees; and an intake chamber in communication with said inlet, said intake chamber having an intake opening of an area that is larger than an area of said inlet, wherein said inlet acts as a discharge opening for said intake chamber; and wherein said intake opening and said outlet are each in direct communication with a liquid medium.

**2.** The submerged liquid rotor apparatus as recited in claim **10**, wherein said blades are driven by a liquid that enters from said liquid medium through said intake chamber and said inlet, then exits through said outlet into said liquid medium.

**3.** The submerged liquid rotor apparatus as recited in claim **2**, wherein said liquid comprises water.

**4.** The submerged liquid rotor apparatus as recited in claim **1**, wherein each of said plurality of curved blades comprises a portion of a cylindrical wall of a hollow cylinder such that the longitudinal axis of each of said blades is substantially parallel with an axis of rotation of said central hub, wherein the physical attachment of each of said blades to said hub comprises a substantially linear edge of said portion of said cylindrical wall of said hollow cylinder.

**5.** A liquid rotor apparatus, comprising: a rotatable central hub having a cylindrical surface; a plurality of curved blades attached to an outer surface of said central hub, wherein each of said plurality of curved blades comprises a portion of a cylindrical wall of a hollow cylinder such that the longitudinal axis of each of said blades is substantially parallel with an axis of rotation of said central hub, wherein the physical attachment of each of said blades to said hub comprises a substantially linear edge of said portion of said cylindrical wall of said hollow cylinder; and a substantially cylindrical housing with circular end walls that surrounds said rotatable central hub and curved blades, said housing having an inlet and an outlet, said inlet and outlet being spaced apart along the rotational travel of said blades by over 180 degrees; an intake chamber in communication with said inlet, said intake chamber having an intake opening of an area that is larger than an area of said inlet, wherein said inlet acts as a discharge opening for said intake chamber;

wherein said liquid rotor apparatus is entirely submerged in a liquid medium, said intake opening and said outlet each being in direct communication with said liquid medium, and wherein all of said blades exhibit a rotational travel in accordance with rotational movement of said hub.

**6.** The submerged liquid rotor apparatus as recited in claim **5**, wherein said blades are driven by a liquid that enters from said liquid medium through said intake chamber and said inlet, then exits through said outlet into said liquid medium.

**7.** The submerged liquid rotor apparatus as recited in claim **6**, wherein said liquid comprises water.

\* \* \* \* \*





US006210113B1

(12) **United States Patent**  
**Ihrenberger**

(10) **Patent No.:** **US 6,210,113 B1**  
(45) **Date of Patent:** **Apr. 3, 2001**

(54) **WATER WHEEL TURBINE FOR WATER POWER STATIONS**

(76) **Inventor:** **Adolf Ihnenberger**, Kaiser Lothar Str. 19, A-6600 Reutte (AT)

(\* ) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) **Appl. No.:** **09/445,280**

(22) **PCT Filed:** **Apr. 6, 1999**

(86) **PCT No.:** **PCT/EP99/02317**

§ 371 Date: **Jan. 24, 2000**

§ 102(e) Date: **Jan. 24, 2000**

(87) **PCT Pub. No.:** **WO99/51876**

**PCT Pub. Date:** **Oct. 14, 1999**

(30) **Foreign Application Priority Data**

Apr. 6, 1998 (EP) ..... 9810623

(51) **Int. Cl.<sup>7</sup>** ..... **F03B 7/00**

(52) **U.S. Cl.** ..... **416/116; 416/197 A; 415/3.1; 415/6; 415/141; 415/906**

(58) **Field of Search** ..... **416/101, 116, 416/88, 197 A, 197 B; 415/3.1, 6, 141, 202, 906**

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

|           |   |         |         |       |           |
|-----------|---|---------|---------|-------|-----------|
| 194,897   | * | 9/1877  | DeHaven | ..... | 415/141   |
| 652,852   | * | 7/1900  | Libbey  | ..... | 415/141   |
| 818,825   | * | 4/1906  | Hicks   | ..... | 416/116   |
| 1,361,467 | * | 12/1920 | Kincaid | ..... | 416/197 B |
| 1,773,010 | * | 8/1930  | Rixe    | ..... |           |
| 4,385,497 | * | 5/1983  | Scott   | ..... |           |

**FOREIGN PATENT DOCUMENTS**

|          |   |         |      |       |  |
|----------|---|---------|------|-------|--|
| 370513   | * | 3/1923  | (DE) | ..... |  |
| 4339236  | * | 5/1995  | (DE) | ..... |  |
| 19517261 | * | 11/1996 | (DE) | ..... |  |
| 1078558  | * | 11/1954 | (FR) | ..... |  |

\* cited by examiner

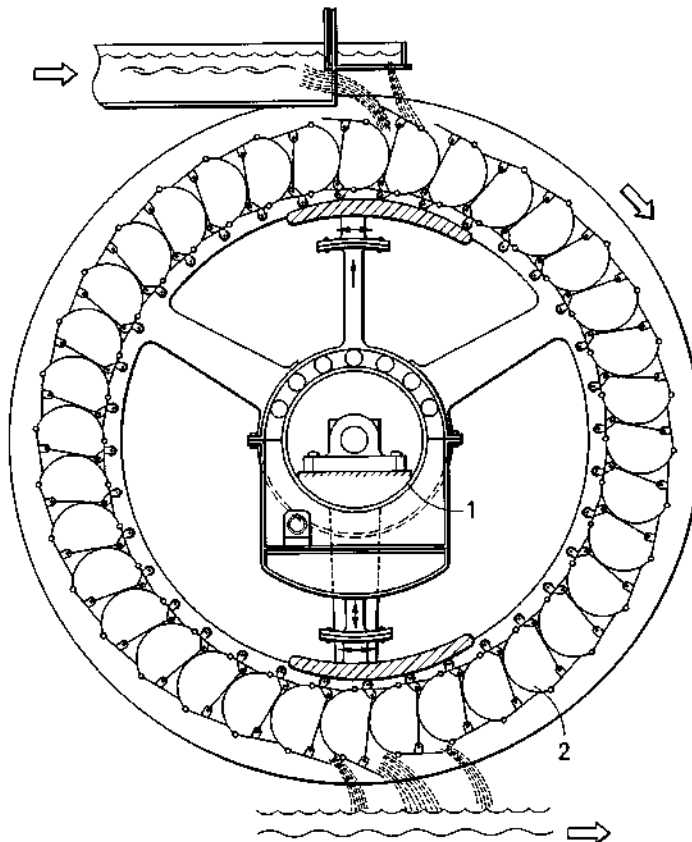
*Primary Examiner*—Christopher Verdier

(74) *Attorney, Agent, or Firm*—Morgan & Finnegan LLP

(57) **ABSTRACT**

A waterwheel turbine for application in hydropower plants is provided. This turbine exploits primarily the head of the watercourse for energy recovery. The cells of the waterwheel turbine are each provided with a pair of mechanically linked flaps for controlling the inflow of water as well as venting of air. Special control devices permit these installations to be operated at high efficiency.

**9 Claims, 4 Drawing Sheets**



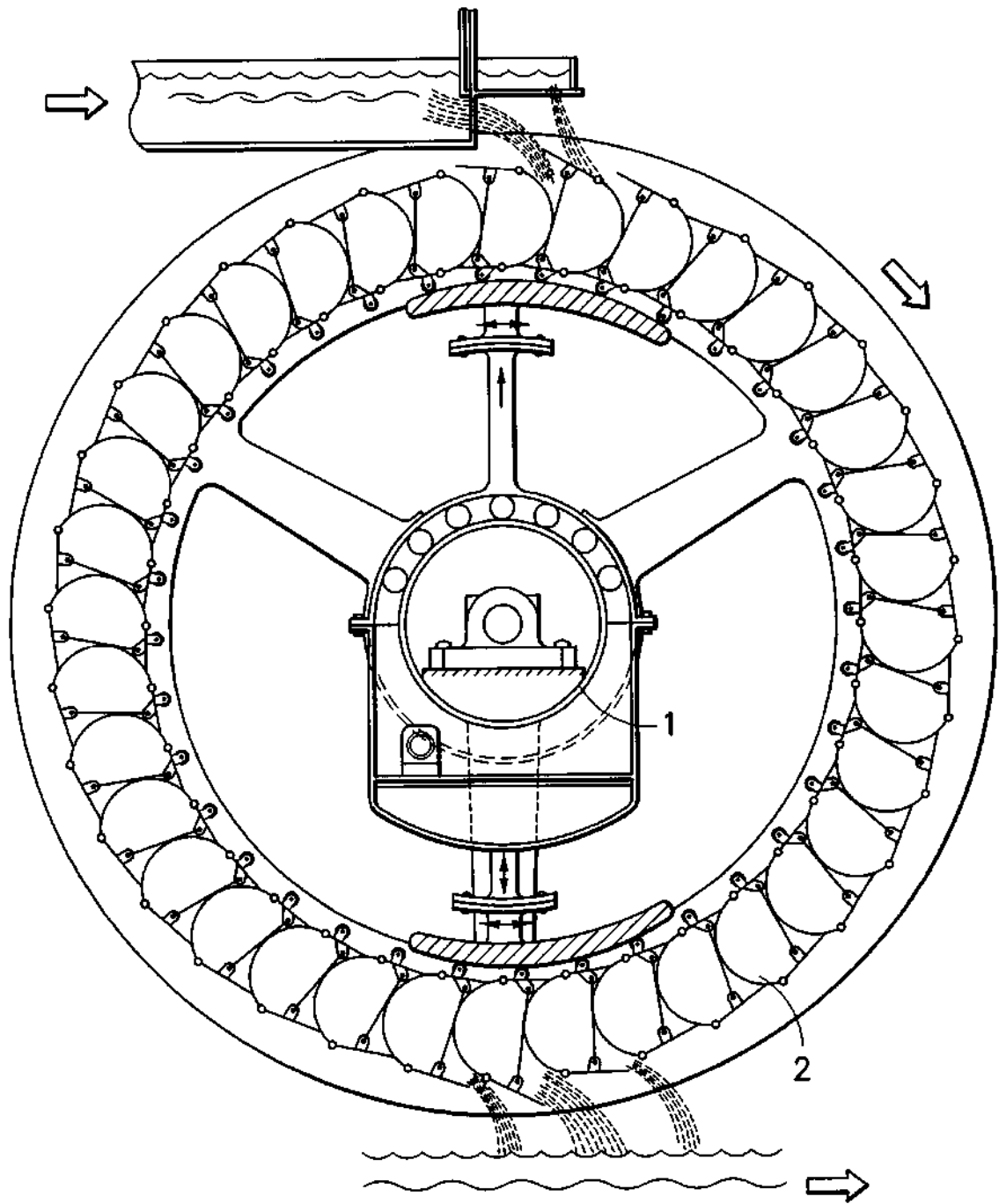


FIG. 1

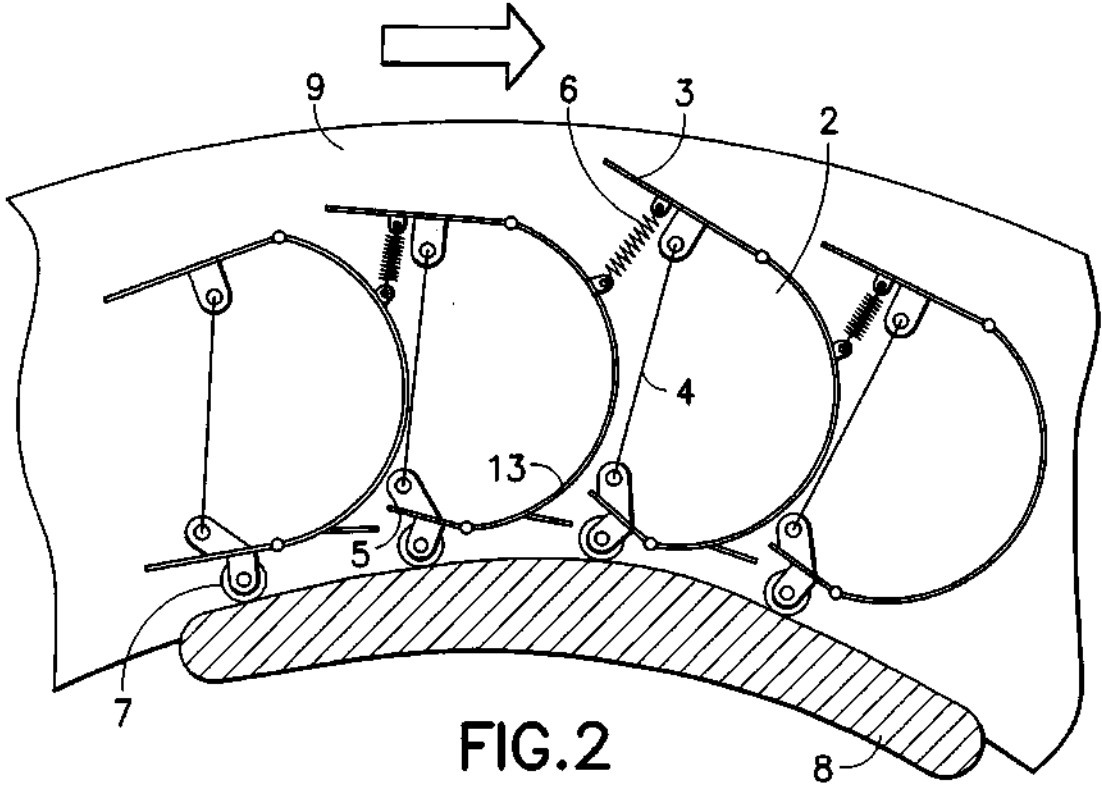


FIG. 2

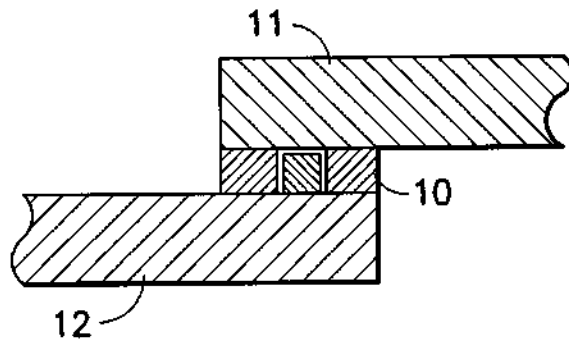


FIG. 4

FIG.3.1

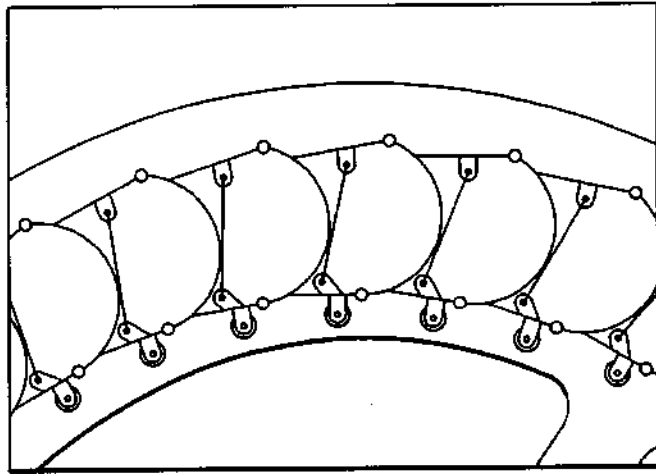


FIG.3.2

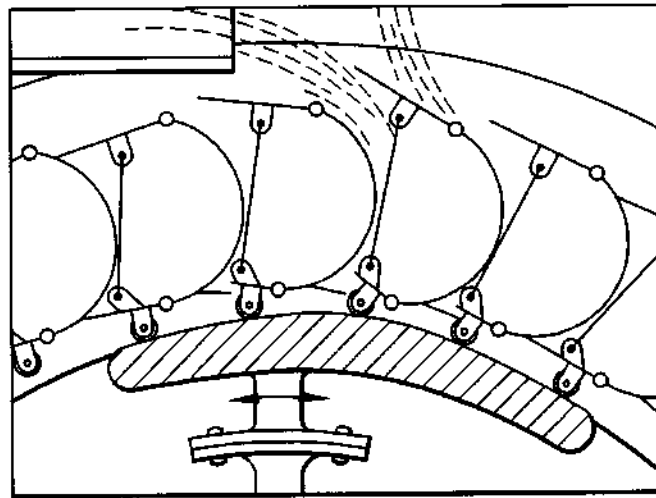
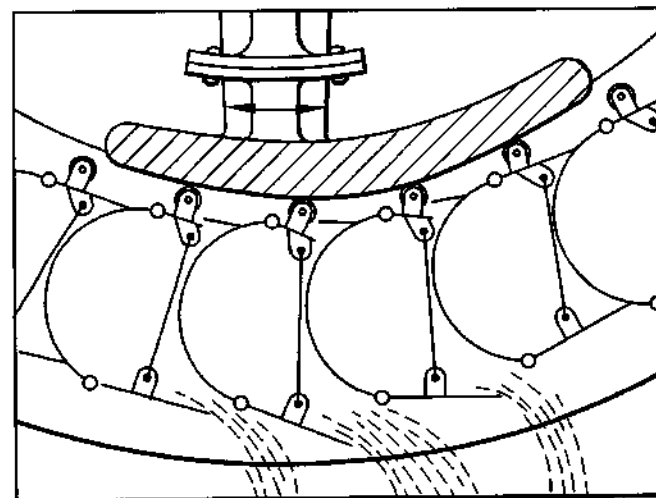


FIG.3.3



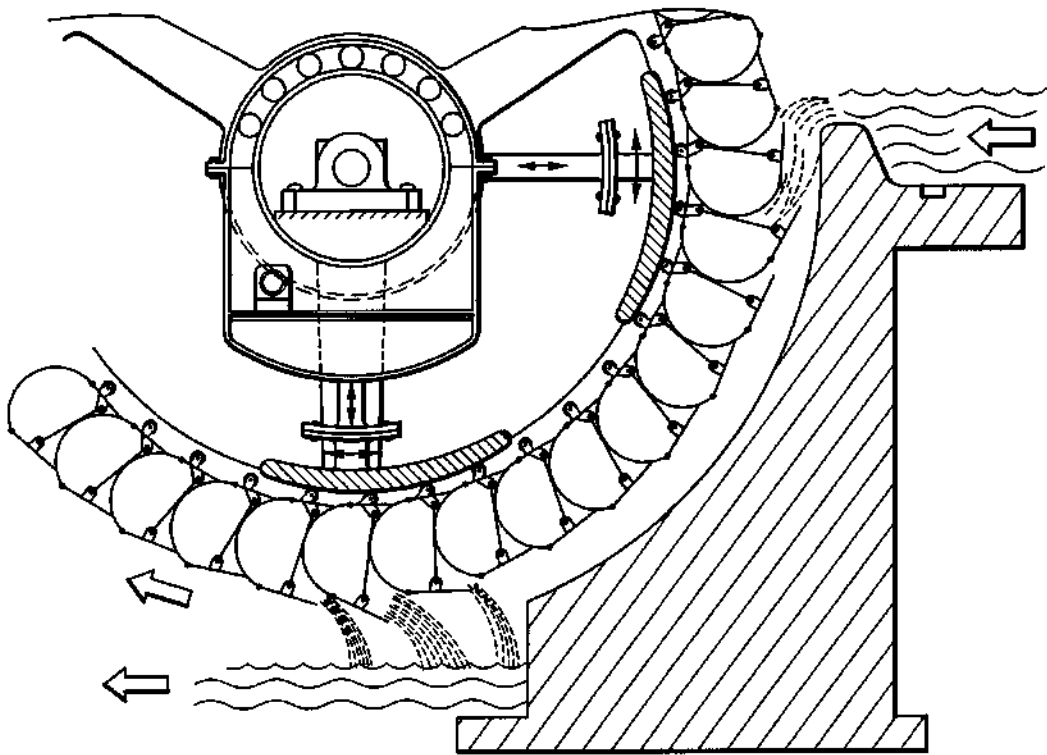


FIG. 5

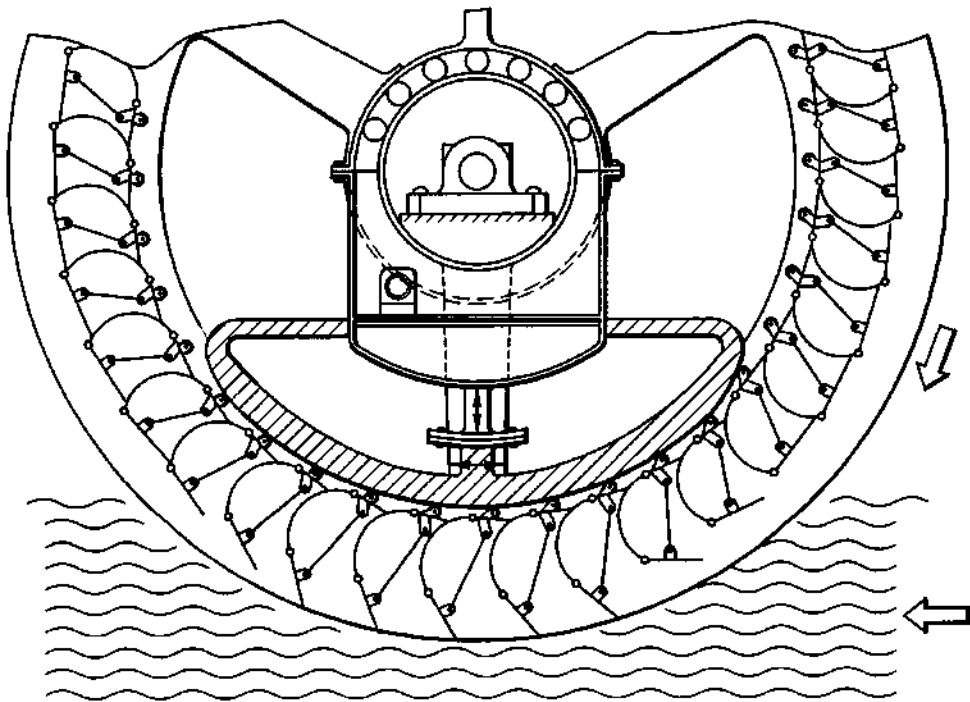


FIG. 6

## WATER WHEEL TURBINE FOR WATER POWER STATIONS

### FIELD OF INVENTION

The invention concerns a waterwheel, or rather a waterwheel turbine, for hydropower plants utilizing the head of a watercourse. This waterwheel turbine is characterized by a horizontal wheel shaft and a number of cells uniformly spaced wall-to-wall around the periphery of the wheel. These cells are closed off at each side, and are provided with openings for filling and discharge of water.

### BACKGROUND OF THE INVENTION

Waterwheels have been known since antiquity and have served principally for generating mechanical power. With the widespread introduction of commercial plants, in particular for generating electricity, water turbines have largely displaced the waterwheel. Consequently, the efforts devoted in the past decades to further technical development and improvement of the performance of waterwheels have been correspondingly small.

Whereas by definition, waterwheels gain mechanical energy from the potential energy of the water, in waterwheel turbines the potential energy as well as, to a usable degree, the kinetic energy of the flowing water is exploited in appropriately formed buckets, or cell walls. Within the class of turbomachinery, the waterwheel turbine is categorized as an impulse turbine.

Providing an overview of the present status of this technology is the book: *Bau von Wasserkraftanlagen* by König/Jehle, published by C. F. Müller Verlag, third completely revised edition, 1997, containing planning documents for practical applications. Starting on Page 197, one chapter deals with waterwheels. It describes their advantages over turbines, such as comparatively straightforward subsurface works and low-cost, cut-and-cover construction techniques. At the same time, the descriptions of examples of constructed plants present, as a generally accepted disadvantage inherent to this class of devices, the premature outflow of more or less significant water volumes from the amount originally entering each cell, before it attains its submerged level.

The usual graphical representation of the efficiency,  $\eta$ , of a waterwheel as a function of the quotient,  $Q_n/Q$ , where  $Q_n$  is the normal rated flow and  $Q$  the actual flow, makes this clear, as in this the maximum efficiency is always less than unity (100%), and remains unchanged over wide variations of the degree of filling of the cells.

In the past, there has been no lack of proposals for improving the cell geometry of waterwheels, or waterwheel turbines, in particular with designs for minimizing water loss from a cell before it has fully traversed the water head. These were concentrated on a projection of the discharge lip of the cell opening, as well as on cell designs for which the virtual center of gravity of the water filling the cell attains a level which is as low as possible beneath that of the inflow and discharge opening. But in this connection, it is known to the specialist that as the length of a cell increases in the radial direction, the directly usable head between the headrace and the tailrace is reduced by an amount approximately double this cell dimension. Hence, increasing this dimension at the cost of only partially filled cells always represents a disadvantageous compromise referred to the theoretically exploitable water energy.

DE 3621312 A1 describes, for example, a waterwheel whose cup-shaped cells are so formed that the tongue

projecting far from a cell wall according to invention, prevents the cups emptying too early.

For the task of better exploiting minor water reserves with low volumetric flow and low head, DE 3938748 C2 proposes a solution in which premature discharge of water from a cell is prevented by a pneumatic sealing system for the cells. In this, sealing of the open cells against stationary external boundaries and walls is by means of sealing rings to which pneumatic pressure is applied. The disadvantage of this solution is that any type of sliding seal gives rise to substantial frictional losses, and therefore reductions in efficiency and also involves wear. A waterwheel turbine in accordance with the generic term of claim 1 is known from U.S. Pat. No. 4,385,497.

The purpose of this invention is therefore, by specially designing the cells of waterwheels, or rather of waterwheel turbines, to increase their efficiency in comparison with known designs, referred to the actual water inflow rate to the plant per unit of time and the actual available head. Alternatively formulated, the task is to fill the cells with the water directed to them by way of a channel rapidly, without appreciable water losses and with a high degree of filling, and to exploit the potential of the filled water mass over an effective height approaching that of the water head to generate torque and transmit energy via the wheel shaft better than in known systems. Apart from the water's potential energy, its impulse energy from filling and emptying the individual cells, which is always exploitable in the case of flowing waters without the need for special measures, is to be effectively converted to torque.

### SUMMARY OF THE INVENTION

According to the invention, this task is solved by a waterwheel turbine of the type described above in which the shut-off flap is mechanically connected via a link rod (4) with a second air flap (5), serving to vent air from or admit air to the cell, and the waterwheel turbine possesses a stationary control device with mechanical transmission elements to simultaneously open or close the shut-off and air flaps.

In view of the premature water loss from the cells of a waterwheel installation according to the present state of the art, closing off the cells would appear at first sight to be the obvious design choice. However, in combination with the simultaneous and indispensable requirement to fill and empty the cells within very short periods, apparently this solution has up to now been discarded by the specialist. The problems of air displacement, as are generally known from rapid filling and emptying of bottles, apply equally in this case.

By means of the feature according to the invention—that is mechanical linkage of water shut-off flap and air flap—this problem can be solved surprisingly effectively for the waterwheel turbine by a suitable flap control device. The high degree of cell filling within the short time interval inherent to this system was surprising to the specialist.

The solution employing flaps according to the invention—or rather a pair of flaps—for each cell, requires an effective control device to open and close them. An advantageous design of this control device is to provide for their opening by mechanical means against the force of a compression or tension spring, by a roller rigidly mounted at the outside of the flap, predominantly the air flap, which for its part traverses over the curved surface of a stationary cam at a predetermined point during waterwheel rotation, in this way successively opening the flaps of each cell to a set

angle, and then allowing them to close again. The closing action is supported, or made possible, by spring force.

The flaps could just as easily be opened and closed, for example by means of torsionally-loaded springs in the flap hinges.

The stationary control device for operating the flaps could be installed in the hydropower plant outside of the waterwheel turbine.

It is particularly advantageous, however, to mount the control device stationary within the rotating unit.

By mounting the control element on the wheel shaft and fixing it in position by attachment of a comparatively heavy pendulum weight under the shaft, this requirement is very effectively met. Such a solution permits precise flap actuation uninfluenced by relative movements between the wheel and its surroundings. Additionally, this shaft mounting means that the cam can be positioned in any radial direction as seen from the wheel shaft.

But this possibility of positioning the cam at various angles fulfills a first prerequisite for allowing the waterwheel turbine to be applied according to the invention not only in overshot but also in middle-shot and even, if needed in undershot operation.

A second condition for effective application to these various types of operation is the possibility for adjusting actuation of the flaps with regard to timing and maximum flap opening. To suit the type of operation, cams with differing profiles and curvatures may be employed, or the distance between the cam and the transmission elements rigidly attached to the flaps can be varied.

The conventional waterwheel derives its torque primarily from the potential energy of the water. With the waterwheel turbine according to the invention, an appreciable proportion of the power is provided by the kinetic energy of the flowing water. The contribution of this kinetic energy is substantially increased in the solution of a waterwheel turbine according to the invention if, in place of pure overshot incident flow, the water is made to impinge the cell under pressure. This may be implemented, for example, by directing the water to the turbine in a closed channel under appropriate pressure as laminar flow for discharge through a wide jet exit.

Because in its intended operation the completely closed cells will open comparatively rapidly only just before they attain their lowest point in the rotational path, as the water flows out, it imparts a reaction impulse to the waterwheel, making an appreciable contribution to the total torque.

In comparison with the severe water losses some way ahead of the bottom dead center and the failure to exploit the reaction impulse of water discharge as in the current state of the art, this signifies an energy gain from two sources.

Depending on cell wall geometry and the direction of inflow of the water, also when filling the cells an appreciable proportion of the torque could be contributed by the impact of the water on the cell wall.

Designs of the waterwheel turbine according to the invention are limited neither by geometry nor the materials used. Corrosion resistant metal plates could just as easily be used as a design in the form of a cylindrical shell with covers welded onto each end.

A feature of all innovative designs is the wall-to-wall occupancy of a peripheral annulus of the waterwheel turbine with water, which means there are no dead interstitial segments limiting the transportable water volumes, or where cells are not located with immediately adjacent walls, to obtain the same transportable water volume higher cell walls

in the radial direction would be needed. Higher cells in the radial direction mean, as stated in connection with the state of the art, a greater reduction of the useable head—the potential height—in comparison to the total water head.

As is known from conventional waterwheels, it is also possible to subdivide the cells of the innovative waterwheel turbines across their widths, so that, for example, with too little flow and a correspondingly reduced inflow channel width, one compartment of a cell can be filled completely, instead of only partially filling the cells across their entire width, which would result in reduced efficiency.

But means to vary the degree of filling of the cells could also be designed and used for controlling the running speed of the novel turbine. The degree of filling could likewise be varied by moving the flap opening point by shifting the cam, or by changing out the control elements.

Whereas conventional waterwheels with open cells in accordance with the state of the art experience no difficulties in starting the wheel running, as the overflow from the topmost filled cells fill in turn the next lowest cells, until a sufficient torque builds up to overcome the static friction between wheel shaft and bearing, this principle cannot be applied to the waterwheel turbine according to the invention. Instead, each cell wall immediately adjacent to a neighboring cell is provided with a suitably dimensioned hole, which during normal rotational operation has no measurable influence on the efficiency, but at startup of the wheel will fill a sufficient number of cells successively to generate the necessary breakaway torque.

The designs of the invention as described above have been limited to pure mechanical solutions, as far as the motions of the flaps and their control device were concerned. For control of the flaps, with or without transmission by way of a cam, also electromagnetic, pneumatic and hydraulic control elements could be used.

All designs according to the invention taken together exhibit the following advantages:

- short cell filling times
- high degree of filling of cells
- water retained in cells as long as possible up to emptying
- exploitation of the impulse energy of the water when cells fill
- exploitation of reaction impulse energy of the water when cells empty
- optimal utilization of water head
- quiet running and little noise generated during cells emptying of cells
- no cavitation from low flow rates
- no wall friction and turbulence losses
- very high efficiency, also at partial load
- long service life with virtually no maintenance
- can be integrated unobtrusively into the landscape.

A rough calculation indicates that the efficiency of this waterwheel turbine in overshot operation is some 98%, thus substantially exceeding the known values for Kaplan, Pelton, Francis and direct flow turbines. Conventional waterwheels can attain only substantially lower efficiencies. However, even in middle-shot and undershot operation, the advantage of the adjustability of the shut-off and air flaps proves its worth. In the last-named operation case, with conventional cells and bucket geometries, substantial braking losses occur during immersion in the water.

The torque generated by the waterwheel turbine is taken off from the wheel shaft, either via gearbox and transmission

elements to mechanically drive machinery, or via coupled electricity generators.

By applying new technologies, such as controlled frequency converters as current or voltage converters in two- or four-quadrant operation, "gearless" electricity generation equipment may be provided, through which a high economic value must be assigned to plants exploiting hydropower according to the invention (small and micro hydropower plants). Such concepts are appropriate for solving today's problems of electricity generation by low-speed waterwheels, as well as problems of matching rotational speed to synchronous speeds, parallel network operation and island operation at stable frequency.

The waterwheel turbine's quietness of running and absence of the appreciable noise generated by conventional waterwheels as they discharge from a large height on the one hand, and from the mechanical transmission elements on the other, permit gearless electricity generation even in areas which are sensitive under environmental policy aspects.

Increasing environmental awareness, for instance in connection with CO<sub>2</sub> discharges, extends the applicability of waterwheel turbines according to the invention also into the range of micro hydropower plants. The endeavor to apply renewable energies in preference to other forms likewise favors its application.

#### DESCRIPTION OF THE DRAWINGS

In the following, the invention will be described in greater detail on the basis of the figures, which illustrate a design example.

FIG. 1 shows a schematic of the innovative waterwheel turbine in side elevation in its preferred overshot design.

FIG. 2 shows a detail of FIG. 1 in section.

FIGS. 3.1-3.3 shows in a sequence of schematics the three basic operating conditions of a waterwheel turbine according to the invention, specifically its cells, as depicted in FIG. 1, with closed cells during the rotation phase, as well as cells as they open and close during the filling and emptying phases.

FIG. 4 shows in a detail of FIG. 1 the flap closure mechanism of a cell.

FIG. 5 shows a segment of a waterwheel turbine like in FIG. 1, but in middle-shot operation.

FIG. 6 shows a segment of a waterwheel turbine like in FIG. 1, but in undershot operation.

The figures show the preferred design of the waterwheel turbine in overshot operation (FIG. 1), but also in middle-shot (FIG. 5) and in undershot (FIG. 6) operation. From the figures, the various preferred extents of water flap opening can be seen, in each case to suit the type of operation.

#### DETAILED DESCRIPTION OF THE INVENTION

A lightweight hollow wheel shaft (1) supports the hub of the waterwheel turbine and the latter is connected through spokes to the two wheel rims (9), serving to support the cells (2), and at the same time providing the end limits of the closed cells.

A cell is filled with water by way of the shut-off flap (3) held open in the correct position, which in turn is connected mechanically via a rod (4) with an air flap (5). This pair of flaps is actuated by a roller (7). This roller serves as transmission element for the control commands, generated by the roller traversing the face of a profiled cam (8), to impart the opening and closing motions to the pair of flaps.

FIG. 3.2 illustrates the continuously changing flap position as the cells fill, and FIG. 3.3 the situation as the cells empty.

Mounting of the cells with no gaps between them and the successive positions of the cell shut-off flaps permit a high degree of cell filling.

FIG. 4 shows in accordance with a preferred design, how the cells can be adequately sealed by square bar sections (10) attached to the shut-off flap (11) and the fixed cell wall (12).

The pair of flaps open against the force of the tension spring 6, as shown particularly clearly in FIG. 2.

During rotation away from their filling points, the cells remain closed, as shown in FIG. 3.1, until just before the bottom dead center, they are made to empty with the same control mechanism as used for filling.

The air flap (5) of each cell serves both for air release during filling and to admit air during emptying.

This effective cell venting arrangement can be ensured by taking measures known in the art when designing cell wall and flaps, for example by mounting flow baffles in the cell.

The high efficiency of the illustrated waterwheel turbine in exploiting the potential energy of the water is appreciably supplemented by additionally utilizing the impulse energy of the water as it enters and leaves the cells. Of decisive importance for this is that the opening and closing points of the cells be precisely controlled as the wheel rotates. This can only be done with cells that can be closed.

Problems of blocking the impinging water jet by the next cell as are known from wheels with fixed buckets, like the Pelton wheel, do not arise with the waterwheel turbine, as this can be eliminated by adjusting the approach angle of the shut-off flap.

The cam forms a part of the complete control device, which is mounted stationary on the wheel shaft. This device is thus a component of the installation which retains its spatial location. Whereas one of the two required cams is always arranged in the emptying section, the other one needed for controlling admission of the water can be mounted in any position radially around the wheel by adjusting the associated location element relative to the stationary pendulum weight as required, and connecting this element to the weight with a detachable fastener. The double-ended arrows marked in FIG. 1 on the location elements for the cam indicate that these permit fine positioning of the cams, and thus also fine adjustment of flap motions.

To ensure self-starting of the waterwheel turbine, a hole is bored through the wall of each cell (13). This allows, starting from filling of the cell in the filling position, successive slow filling of the preceding cells, until the breakaway torque needed for starting wheel motion is generated.

What is claimed is:

1. A waterwheel turbine for hydropower plants using a head of water, with a horizontal turbine shaft and a plurality of wall-to-wall disposed cells closed at their end faces, said cells accepting and discharging water through cell openings, each cell opening having a closing flap, characterized in that the closing flap is mechanically connected by a linkage to an air flap serving the purpose of ventilation and air admission, and in that the waterwheel turbine has a stationary control device and mechanical transmission elements for the simultaneous opening and closing of the closing flap and air flap.

2. A waterwheel turbine according to claim 1, wherein the control device is mounted in a stationary manner on the turbine shaft.



7

3. A waterwheel turbine according to claim 1, wherein the control device has elements by means of which the flaps of the cell are opened and closed in different, predeterminable radial directions with reference to the turbine shaft.

4. A waterwheel turbine according to claim 1, wherein the control device has transmission elements by means of which individual pairs of flaps are continuously opened and closed within a predetermined radial-angle range with reference to the turbine shaft.

5. A waterwheel turbine according to claim 4, wherein the transmission elements are a roller, rigidly connected to a flap, and a stationary cam plate, the roller rolling over the cam surface of the cam plate.

6. A waterwheel turbine according to claim 1, wherein the control device has elements by means of which the maximum opening width of a pair of flaps is variably adjustable.

8

7. A waterwheel turbine according to claim 1, wherein attached to the flap is a mechanical spring by means of which the closed pair of flaps is opened against the force of the spring.

8. A waterwheel turbine according to claim 1, wherein the control device comprises hydraulically or pneumatically controllable elements for opening and closing individual pairs of flaps.

9. A waterwheel turbine according to claim 1, wherein the components thereof are designed for the admission of water also at higher pressure.

\* \* \* \* \*



US006309179B1

(12) **United States Patent**  
**Holden**

(10) **Patent No.:** **US 6,309,179 B1**  
(45) **Date of Patent:** **Oct. 30, 2001**

(54) **HYDRO TURBINE**

(75) **Inventor:** **Joseph T. Holden**, Conway, AR (US)

(73) **Assignee:** **Futec, Inc.**, Houston, TX (US)

(\*) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) **Appl. No.:** **09/448,021**

(22) **Filed:** **Nov. 23, 1999**

(51) **Int. Cl.<sup>7</sup>** ..... **F03B 1/04**

(52) **U.S. Cl.** ..... **415/202; 415/3.1; 415/98; 415/101; 415/224; 290/54**

(58) **Field of Search** ..... **415/202, 203, 415/224, 2.1, 3.1, 906, 103, 105, 106, 98, 101; 416/200 R, 200 A; 290/43, 54**

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

- 267,675 \* 11/1882 Cory ..... 415/202
- 751,326 \* 2/1904 McAdams ..... 415/202
- 1,039,025 \* 9/1912 Carroll ..... 415/224

**FOREIGN PATENT DOCUMENTS**

- 53-33405 \* 3/1978 (JP) ..... 416/200 R
- 14443 \* 3/1926 (NL) ..... 415/202
- 91/13259 \* 9/1991 (WO) ..... 416/220 R

\* cited by examiner

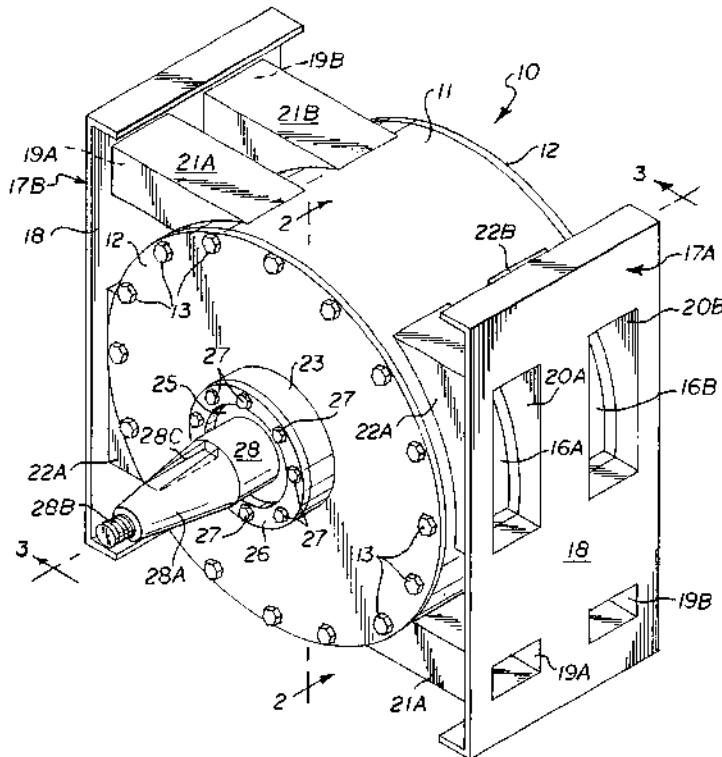
*Primary Examiner*—Christopher Verdier

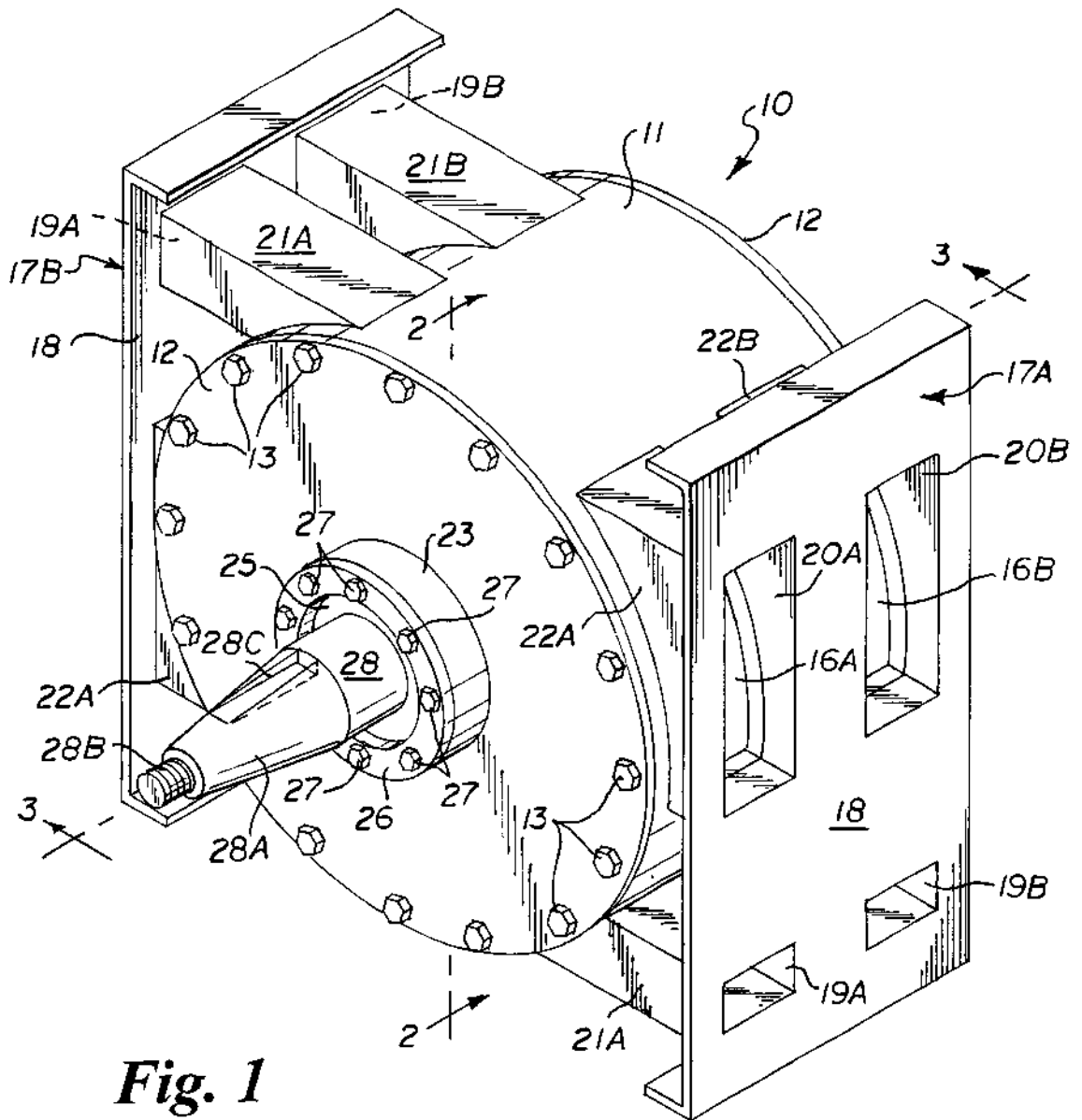
(74) *Attorney, Agent, or Firm*—Kenneth A. Roddy

(57) **ABSTRACT**

A hydro turbine has a housing with a cylindrical chamber and opposed end walls with laterally spaced smaller rectangular inlets and laterally spaced larger rectangular outlets formed in upper and lower portions of the chamber side wall in horizontally opposed relation. Smaller rectangular inlet ducts adjoin the inlets, and larger rectangular outlet ducts adjoin the outlets. A cylindrical runner surrounding a power take-off shaft is rotatably enclosed in the chamber and has a central cylindrical hub divided into laterally spaced hub portions with a first and second plurality of circumferentially spaced peripheral blades extending angularly outward from each hub portion, the first plurality of blades being circumferentially offset from the second. Arcuate laterally spaced upper and lower flow passageways of rectangular cross section defined between the central hub portions and circumferential segments of the chamber side wall extend between the upper inlets and outlets and lower inlets and outlets, respectively. The runner and shaft are rotated by conducting an incompressible liquid through each or selected ones of the inlet ducts and discharging it through the respective outlet ducts. The offset blades divide the rectangular flow passageways into unequal volumes such that the volume and head pressure of the incoming liquid is alternately greater or less on one side of the runner than the other side to facilitate rotation and discharge of the liquid.

**9 Claims, 6 Drawing Sheets**





**Fig. 1**



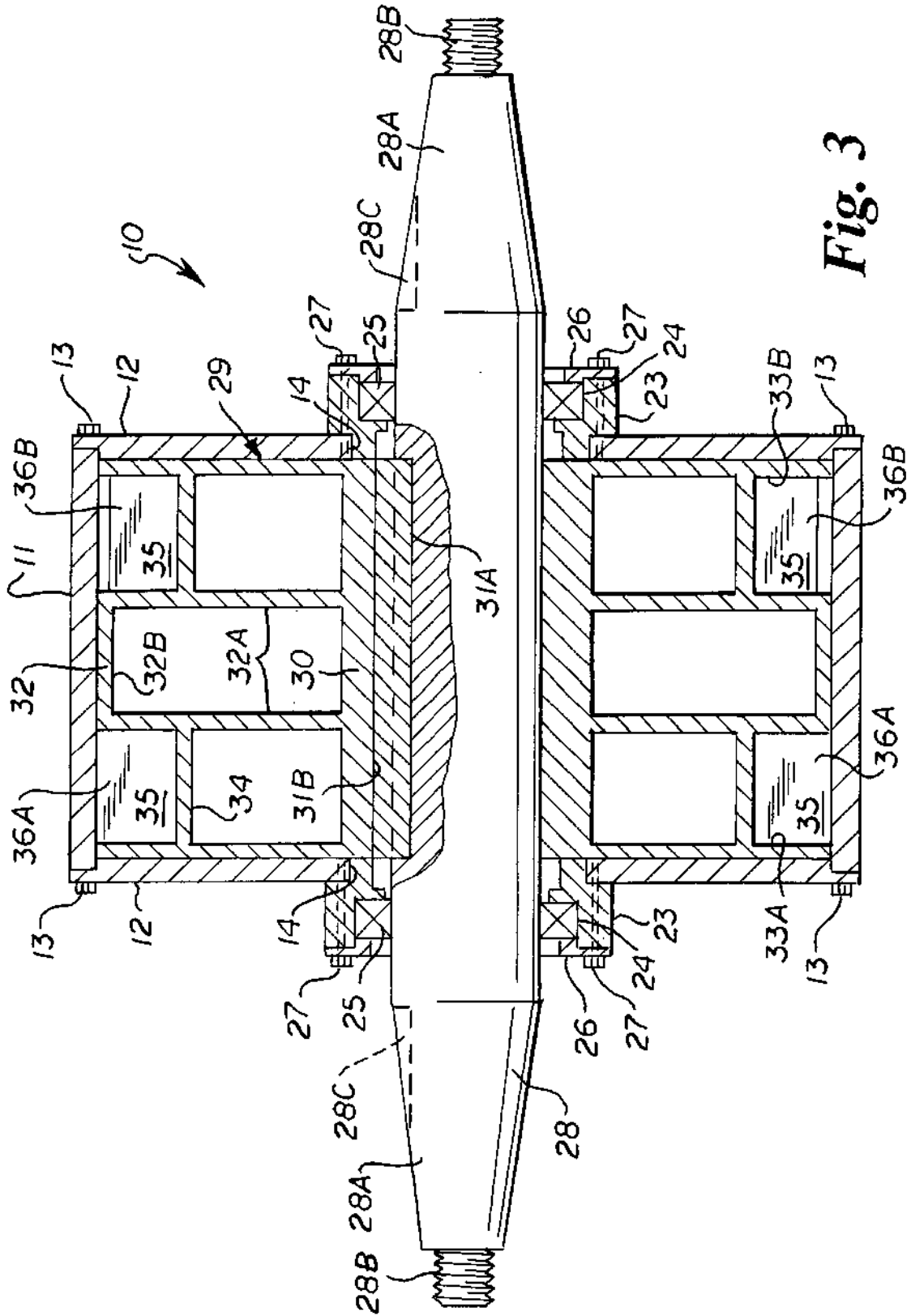


Fig. 3

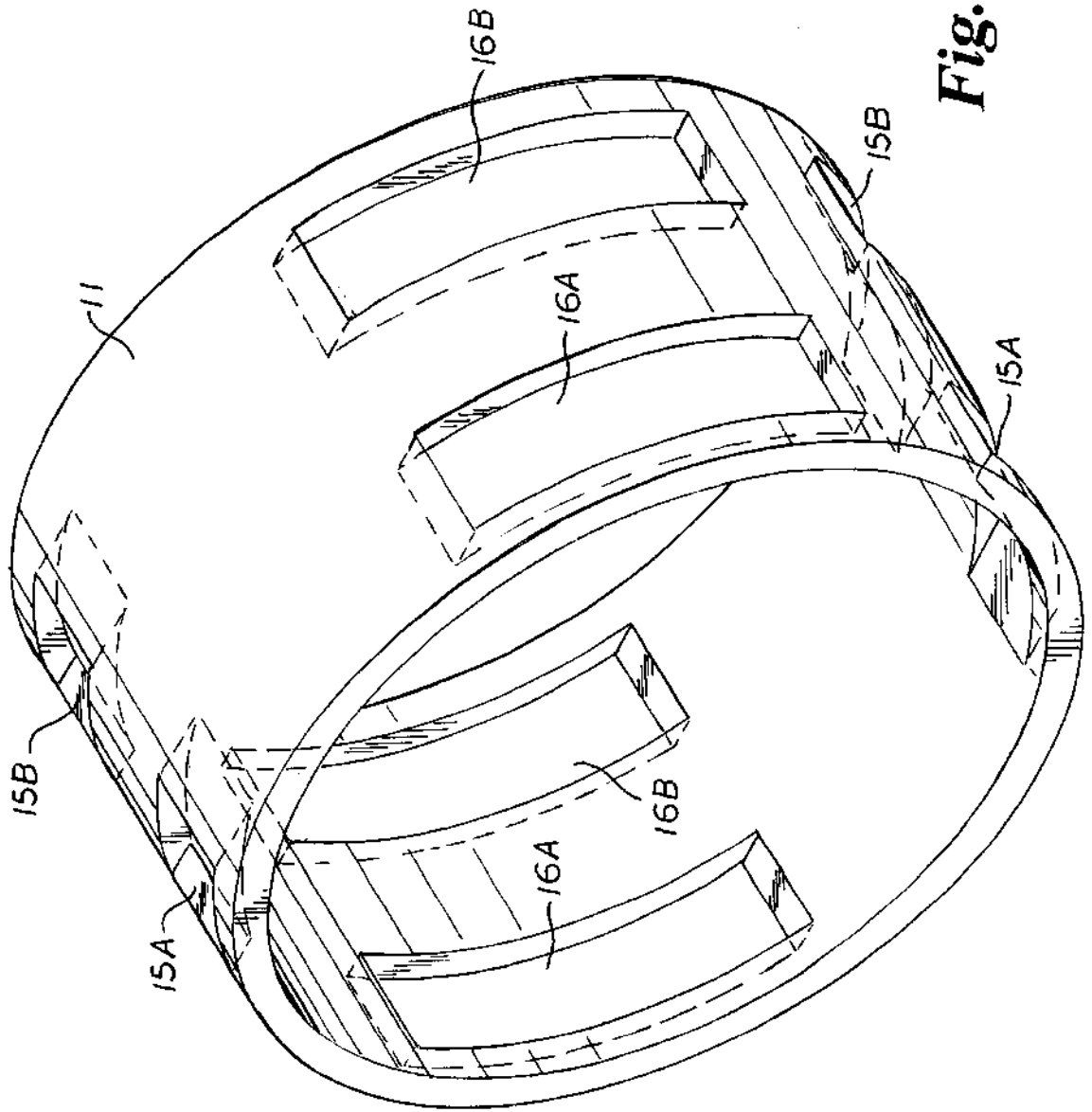
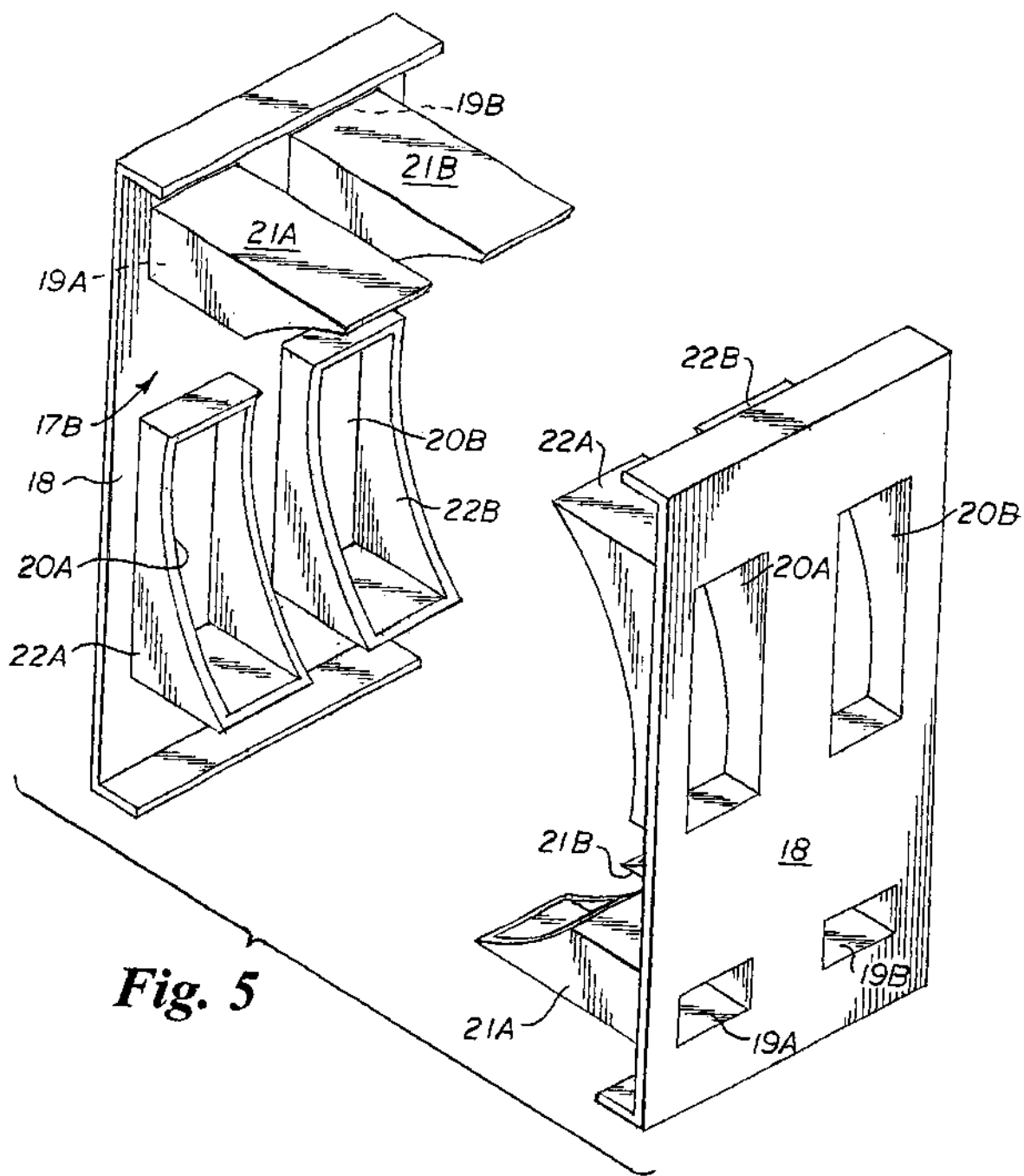


Fig. 4



**Fig. 5**

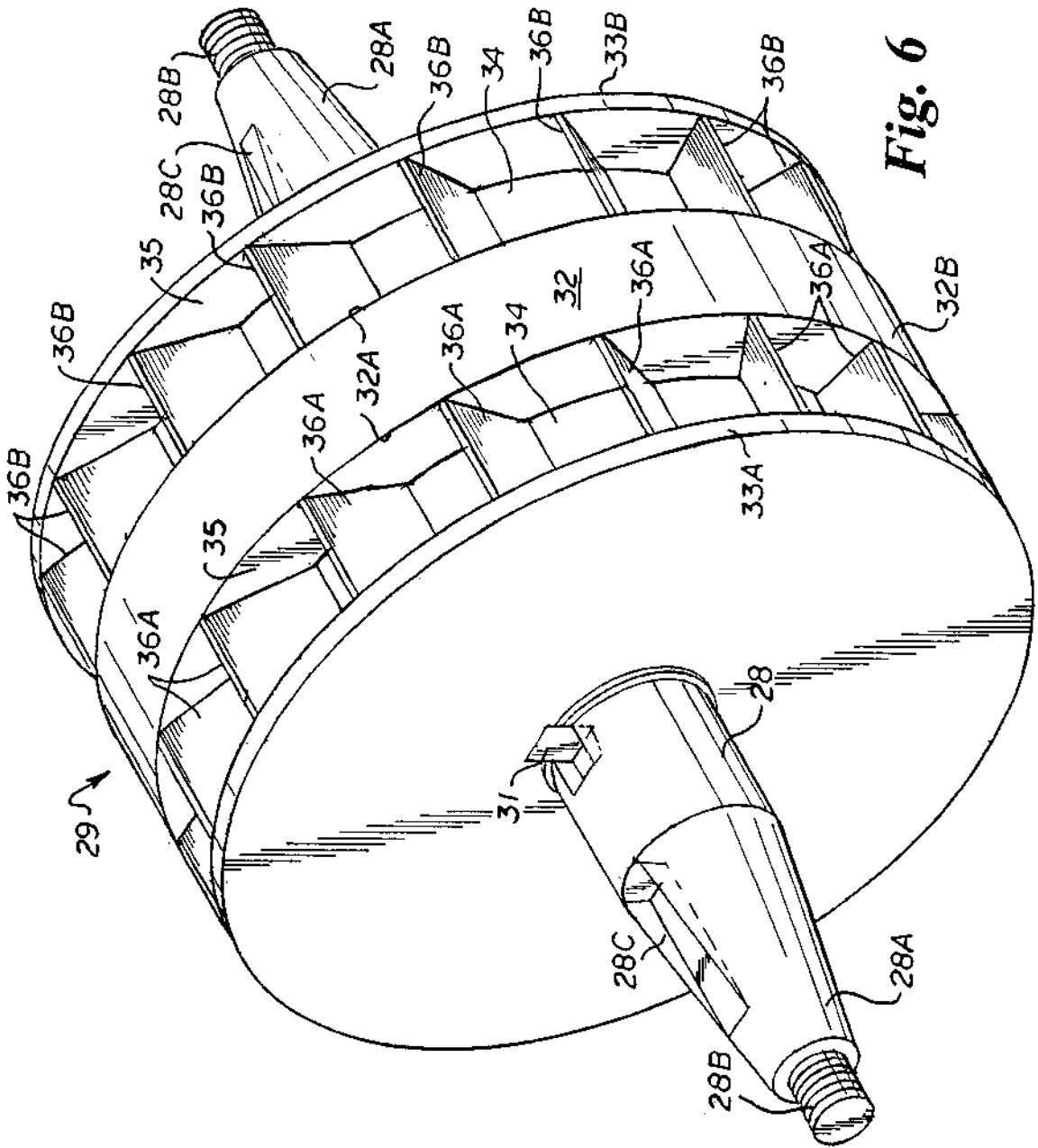


Fig. 6



**HYDRO TURBINE****BACKGROUND OF THE INVENTION****1. Field of the Invention**

This invention relates generally to fluid impulse turbines, and more particularly to a hydro turbine having a runner with laterally spaced circumferentially offset blades and inlets and outlets of rectangular cross section that alter the fluid flow characteristics and increase efficiency.

**2. Brief Description of the Prior Art**

A number of different types of turbines have been designed to cover the broad range of hydropower site conditions found around the world. The primary types of hydroelectric turbines used for generating hydroelectric power are commonly classified as "impulse" or "reaction" types. Customarily, certain types of turbines are used for specific head pressures.

Turbines used for low to medium head pressure applications are usually of the reaction type and include Francis and fixed and variable pitch (Kaplan) propeller turbines. The runner or turbine "wheel" of a reaction turbine is completely submerged in water.

Turbines used for high head pressure applications are generally of the impulse type. Impulse turbines include the Pelton, Turgo and crossflow (Mitchell-Banki) designs. Most conventional impulse turbines are designed for a specific horsepower, RPM, and water pressure.

A conventional impulse turbine is a fixed-blade turbine having a runner with curved blades rotatably disposed in a protective casing. The runner of an impulse turbine spins in the air and is driven by high-speed jets of water. Water is metered to the turbine through "needle valves" which send jets of water into the turbine blades to turn the turbine, and the casing merely controls splashing. If water flow is decreased in a conventional impulse turbine, the turbine will lose efficiency.

The main characteristic of a "crossflow" turbine (also called a Mitchell-Banki turbine) is that it has a drum-shaped runner with a series of curved blades and the runner shaft is disposed horizontally, unlike Pelton and Turgo turbines which can have either horizontal or vertical shaft orientation. In the crossflow turbine a rectangular nozzle directs a broad rectangular water jet onto the full length of the runner. The water jet strikes the blades once flowing from the periphery to the center imparting most of its kinetic energy, and then flows outward from the center imparting a small amount of energy before leaving the turbine.

Harloff, U.S. Pat. No. 4,279,569 discloses a cross-flow turbine machine that extracts energy from a moving fluid. The fluid comprises both liquids and gases. Fluid is guided into the rotor by inlet guide means and then flows through a first rotor, through the interior, through the second rotor, through the exit, and through the diffuser to exit the machine at ambient pressure. Torque is applied to the output shaft due to the change in angular momentum of the fluid across the turbine rotor.

Drees, U.S. Pat. No. 4,368,392 discloses a water turbine for open stream use featuring a vertical-axis cross-flow turbine in which cyclically-pitching blades are supported from one end only to permit the supporting structure and power generation gear to be supported out of the water. In preferred embodiments, there is independent pitch control of the turbine blades to make the blades responsive to the instantaneous flow in their vicinities.

Ossberger et al, U.S. Pat. No. 4,579,506 discloses a horizontal-inflow, vertical-outflow cross-flow turbine hav-

ing a casing, a runner, a horizontal inlet and a vertical outlet. The inlet is divided by a pivoted guide vane to form a pair of inlet passages. A horizontally extending admission passage is connected to the casing at the inlet side thereof, and a vertically extending discharge passage is formed as a draft tube and connected to the casing at the outlet thereof. The inlet and the guide vane are arranged such that the inlet flow to the runner is directed downward at an angle of about 40° with respect to the horizontal, and the outlet flow from the runner is directed substantially vertically. At the outlet there are a pair of side spaces on either side of the runner resulting in an increased cross section conforming to the cross section of the draft tube. Both of these side spaces are vented to the atmosphere by a single venting valve so that the suction pressure in the draft tube does not exceed a predetermined value.

Miller et al, U.S. Pat. 4,464,580 discloses a hydro-electric turbo-machine having a rotor member movable relative to a stationary housing member with a ring-shaped or annular seal between both of these members which serves to seal pressurized water from an external space or region. One of both of these members possesses a sealing surface against which there is pressed a sealing body of the seal which is inserted into the other member.

Stenild, U.S. Pat. No. 5,456,585 discloses a positive displacement fluid motor having a chamber and a rotor having stiff blades which at their outer ends are provided with wings of elastomeric material fastened to the reverse side of the blades in relation to the direction of rotation. The wings are deflected by a wall part in the chamber when passing between the outlet and inlet of the chamber.

The present invention is distinguished over the prior art in general, and these patents in particular, by a hydro turbine having a housing with a cylindrical chamber and opposed end walls with laterally spaced smaller rectangular inlets and laterally spaced larger rectangular outlets formed in upper and lower portions of the chamber side wall in horizontally opposed relation. Smaller rectangular inlet ducts adjoin the inlets, and larger rectangular outlet ducts adjoin the outlets. A cylindrical runner surrounding a power take-off shaft is rotatably enclosed in the chamber and has a central cylindrical hub divided into laterally spaced hub portions with a first and second plurality of circumferentially spaced peripheral blades extending angularly outward from each hub portion, the first plurality of blades being circumferentially offset from the second. Arcuate laterally spaced upper and lower flow passageways of rectangular cross section defined between the central hub portions and circumferential segments of the chamber side wall extend between the upper inlets and outlets and lower inlets and outlets, respectively. The runner and shaft are rotated by conducting an incompressible liquid through each or selected ones of the inlet ducts and discharging it through the respective outlet ducts. The offset blades divide the rectangular flow passageways into unequal volumes such that the volume and head pressure of the incoming liquid is alternately greater or less on one side of the runner than the other side to facilitate rotation and discharge of the liquid.

**SUMMARY OF THE INVENTION**

It is therefore an object of the present invention to provide a hydro turbine that will operate at substantially the same efficiency over a range of pressure heads.

It is another object of this invention to provide a hydro turbine that will operate at different RPM settings and water pressures without losing efficiency.



US006409466B1

(12) **United States Patent**  
**Lamont**

(10) **Patent No.:** **US 6,409,466 B1**  
(45) **Date of Patent:** **Jun. 25, 2002**

(54) **HYDRO TURBINE**

4,274,009 A \* 6/1981 Parker, Sr. .... 290/43

(76) **Inventor:** **John S. Lamont**, 30th Floor-360 Main Street, Winnipeg Manitoba (CA), R3C 3Z3

\* cited by examiner

(\*) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 12 days.

*Primary Examiner*—F. Daniel Lopez  
*Assistant Examiner*—Kimya N McCoy  
(74) *Attorney, Agent, or Firm*—Ryan W. Dupuis; Adrian D. Battison; Michael R. Williams

(21) **Appl. No.:** **09/645,314**

(57) **ABSTRACT**

(22) **Filed:** **Aug. 25, 2000**

An underwater turbine arrangement is herein described. The water driven turbine comprises a housing having a shaft mounted for rotation about an axis therein. The shaft includes a plurality of flights arranged to drive rotation of the shaft. Mounted onto the housing is a funnel having a mouth greater in size than the housing and a discharge of similar size as the housing. Thus, water entering the funnel is constricted before being passed onto the housing, thereby increasing the force with which the shaft is rotated, thereby increasing the amount of energy produced.

(51) **Int. Cl.<sup>7</sup>** ..... **F03B 13/12**

(52) **U.S. Cl.** ..... **415/3.1; 415/72**

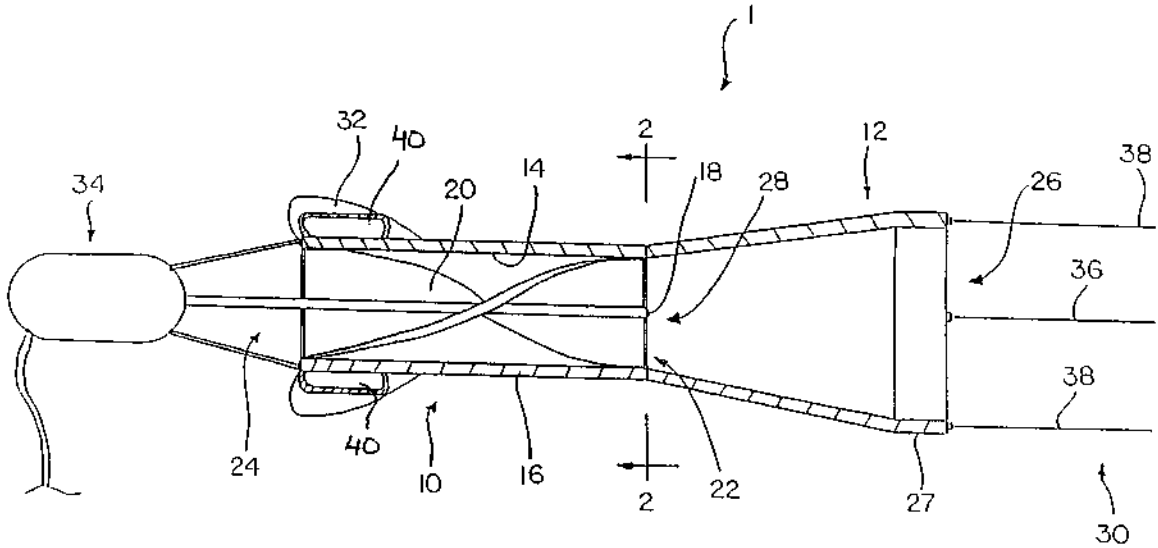
(58) **Field of Search** ..... 60/398; 415/4.1, 415/4.2, 4.4, 3.1, 71, 72, 73, 909, 907; 417/334, 336; 290/54

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

4,258,271 A \* 3/1981 Chappell et al. .... 290/54

**20 Claims, 3 Drawing Sheets**





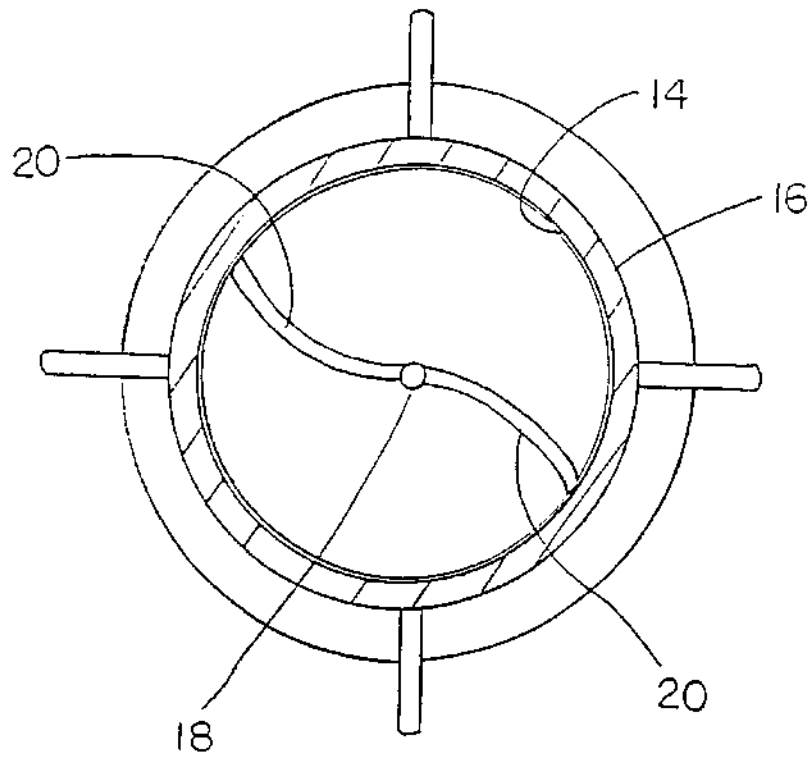


FIG. 2

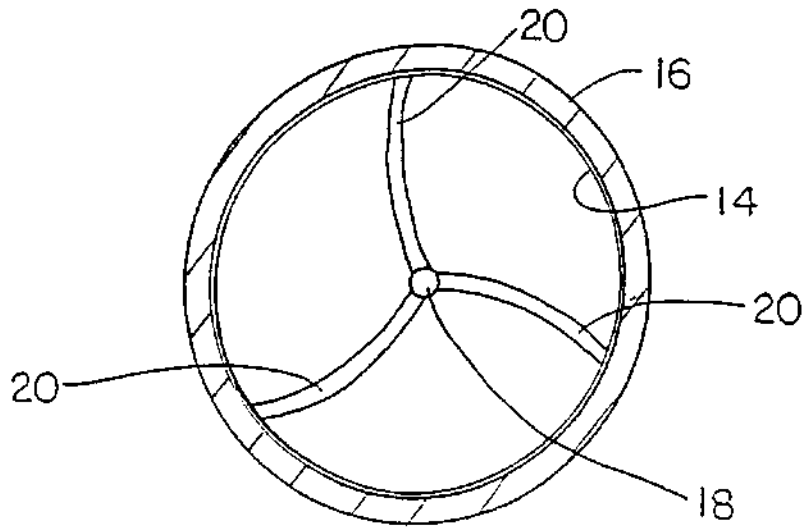


FIG. 3

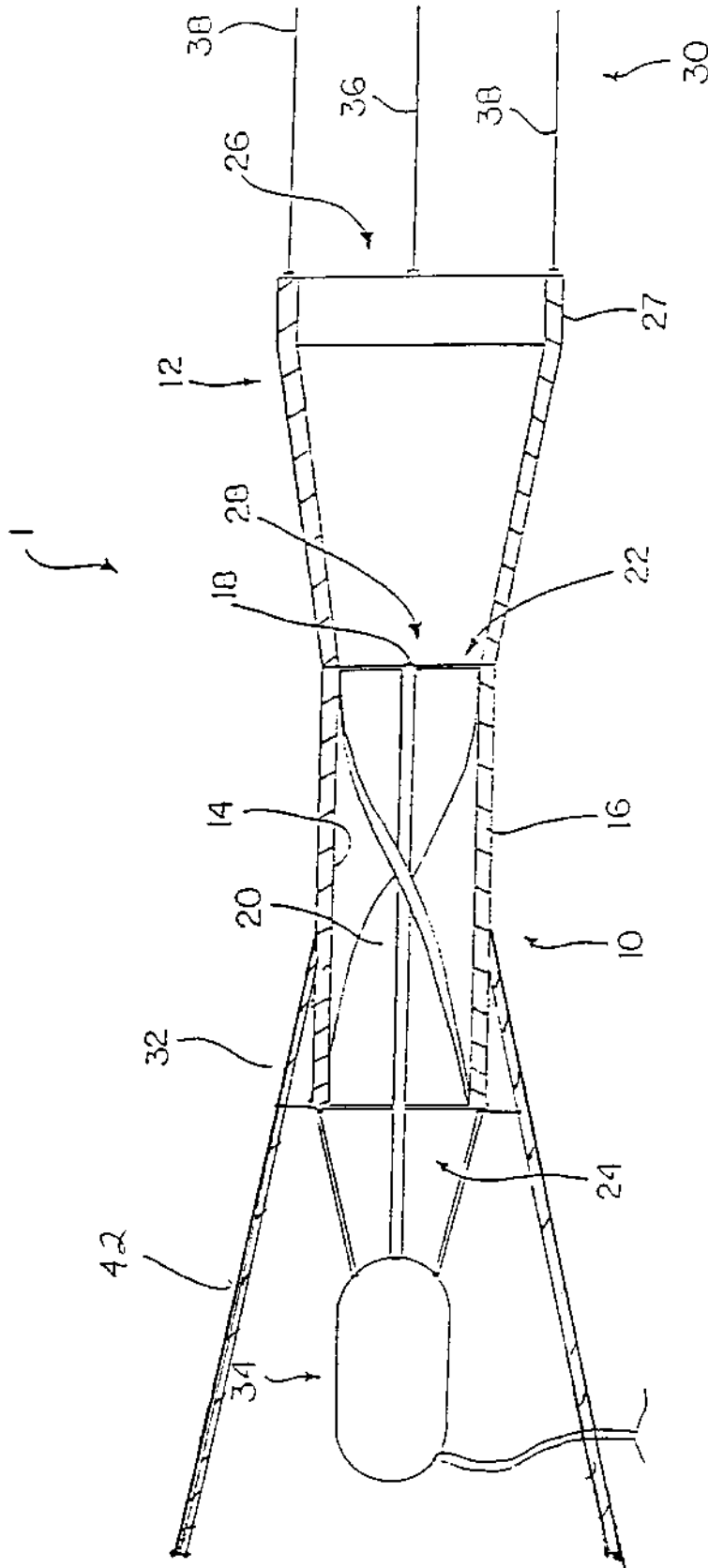


FIG. 4

# 1

## HYDRO TURBINE

U.S. Pat. No. 4,219,303 teaches an underwater power plant which includes electrical generators and machine rooms within the device. Clearly, a device such as this is simply too large for use in streams or rivers and is suitable only for use in ocean currents.

### BACKGROUND OF THE INVENTION

There are a number of devices taught in the prior art for converting energy from the flow of a fluid (such as air or water) to electrical energy.

For example, U.S. Pat. No. 4,412,417 teaches a turbine arranged to be anchored on the surface of a body of water for converting "wave energy" to electrical energy. The device includes a shaft having a helical flight displaced therearound. The flight is not enclosed and the waves passing along the flight causes the shaft to rotate, thereby generating electrical power. U.S. Pat. No. 4,849,647 teaches a similar floating turbine that floats on and is exposed to a body of water.

U.S. Pat. No. 5,664,418 teaches a turbine arrangement including vanes for concentrating the wind.

One difficulty faced by devices such as these is that the flow intensity of the fluid, whether wind or wave, is highly variable and dependent upon weather conditions. That is, in conditions wherein there is little or no wind, the above-described device would not produce much power, whereas a strong wind could lead to conditions which would damage the device. As such, these devices are impractical, as the amount of electrical power generated at a given time is highly variable and unpredictable. This is not the case with underwater currents, which are generally more constant both in terms of intensity and direction, making underwater currents more suitable as potential sources for electrical power.

U.S. Pat. No. 4,219,303 teaches an underwater power plant which includes electrical generators and machine rooms within the device. Clearly, a device such as this is simply too large for use in streams or rivers and is suitable only for use in ocean currents.

U.S. Pat. No. 4,025,220 teaches a turbine for use in water or air which includes a "flexible fluid current collector" for increasing the flow of a fluid, the device being arranged for use in either air or water. It is of note that the collector described is composed of fabric.

Clearly, a device that is arranged for generating electrical power from underwater currents that can also be used in streams and rivers and the like is needed.

### SUMMARY OF THE INVENTION

According to the invention, there is provided a water driven turbine for converting the energy of an underwater current comprising: a hollow tubular open ended housing, said housing having an entry end for accepting the water and an exit end for releasing the water; a shaft mounted within the housing, said shaft arranged to rotate within the housing about an axis of rotation; connection means on the shaft for operably linking the shaft to a generator such that rotation of the shaft generates electrical power; blade means arranged about the shaft, said blade means extending along a length of the shaft; and a funnel mounted onto the entry end of the housing, said funnel having a mouth and a discharge, said mouth having a diameter greater than the diameter of the housing, said discharge having a diameter approximately

# 2

equal to the diameter of the housing, wherein the discharge of the funnel is mounted onto the entry end of the housing such that the water entering the funnel at the mouth passes through the housing and contacts the blade means, thereby rotating the shaft and generating electrical power.

The generator may be positioned behind the exit end of the housing relative to the mouth of the funnel.

The diameter of the mouth may be approximately 50% greater than the diameter of the discharge.

The water driven turbine may include fins mounted on an upper surface and a lower surface of the housing for preventing twisting of the water driven turbine.

The fins may be mounted on the housing proximal to the exit end of the housing.

The water driven turbine may include buoyancy means mounted on the water driven turbine.

The buoyancy means may be mounted within the fins.

There may be three blade means or two blade means.

The water driven turbine may include tether means mounted within the funnel for stabilizing the water driven turbine.

One embodiment of the invention will now be described in conjunction with the accompanying drawings in which:

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view in cross-section of the turbine.

FIG. 2 is a cross-sectional view along line 2—2 in FIG. 1.

FIG. 3 is a front view of an alternative arrangement of the flight.

FIG. 4 is a side view in cross-section of an alternative arrangement of the turbine.

In the drawings like characters of reference indicate corresponding parts in the different figures.

### DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings, a water driven turbine 1 for converting an underwater current into electrical power comprises a housing 10, a funnel 12 and a generator 34.

As shown in FIG. 1, the housing 10 is tubular, open-ended and hollow, comprising an inner surface 14, an outer surface 16, a shaft 18, an entry end 22 and an exit end 24. The shaft 18 is mounted within the housing 10 such that the shaft 18 rotates within the housing 10 about an axis of rotation, as described below. The shaft 18 includes flights 20 which extend about the shaft 18 along the length of the shaft 18. It is of note that there may be several flights 20 arranged about the shaft, depending upon conditions and the intended use. For example, FIGS. 1 and 2 show an embodiment of the invention wherein there are two flights whereas FIG. 3 shows an embodiment having three flights. As will be apparent to one knowledgeable in the arts, the three flight shaft will have a larger surface area than the two flight shaft. In the embodiment shown in FIG. 1, the flights 20 extend around the shaft 18 in a helical or twisted arrangement. Specifically, the flights 20 are struck by a flow of water passing through the housing 10 which in drives rotation of the shaft 18, as described below. However, it is of note that other suitable arrangements of flights 20 known in the art may also be used. It is of note that the shaft 18 may be mounted within the housing 10 in a hub such that the shaft 18 can rotate freely. The hub is mounted to the housing by a plurality of legs, the legs being arranged so as to minimize their interference with water flow through the water driven turbine 1.

The funnel 12 is composed of a rigid material and comprises a mouth 26 and a discharge 28. It is of note that the mouth 26 is arranged to be of a greater diameter than the discharge 28 for increasing the velocity and inertial force in the flow of water as it passes through the funnel 12 compared to the current as described below. Furthermore, as can be seen in FIG. 1, the decrease in diameter between the mouth 26 and the discharge 28 is gradual, so that water is not forced out of the water driven turbine 1, as water diverted away from the water driven turbine 1 cannot be used to drive the shaft 18 and is in effect wasted energy. Furthermore, as can be seen in FIG. 1, the mouth 26 includes a lip 27 that is of a fixed diameter and acts to retain incoming water flow, as described below. Specifically, in the embodiment shown in FIG. 1, the diameter of the mouth 26 is approximately 50% greater than that of the discharge 28. As a result of this arrangement, the surface area at the mouth 26 of the funnel 12 is greater than the surface area at the discharge 28. Furthermore, as shown in FIG. 1, the discharge 28 is of a similar diameter as the entry end 22 of the housing 10. It is of note that other ratios may also be utilized, according to the conditions in which the water driven turbine 1 is to be used.

In the embodiment shown in FIG. 1, tether means 30 are connected to the funnel 12 for anchoring the water driven turbine 1 in the waterway. Specifically, the tether means 30 comprises side cables 36 and top and bottom cables 38 which are mounted to the front face of the lip 27, as shown in FIG. 1. The cables 38 are connected to a support structure (not shown) for securing and stabilizing the water driven turbine 1 in the underwater current, as described below. In addition, in the embodiment shown in FIG. 1, the water driven turbine 1 includes fins 32 for further stabilizing the position of the water driven turbine 1 in the waterway. In the embodiment shown in FIG. 1, the fins 32 are mounted on the outer surface 16 of the housing 10 above and below the shaft 18, proximal to the exit end 22. Thus, as a result of the tethering means 30 and the fin 32, the water driven turbine 1 will not rotate, twist or turn when exposed to the water current, meaning that maximum efficiency is retained. That is, the water driven turbine 1 remains positioned within the water flow such that the maximum flow of water is directed through the water driven turbine 1. As will be appreciated by one knowledgeable in the art, other tether means 30 or fins 32 at other locations along the water driven turbine 1 may also be used for stabilizing the water driven turbine 1.

As can be seen in FIG. 1, the shaft 18 is operably linked to the generator 34. The details of the generator are not shown as these will be well known to one knowledgeable in the art. It is of note that in the embodiment shown in FIG. 1, the shaft 18 is connected directly to the generator 34 and the generator 34 is mounted to the housing 10 behind the exit end 22. Specifically, the generator 34 is mounted to the exit end 22 of the housing 10 by support bars such that the shaft 18 is connected to the generator in a straight line. In other embodiments, the generator 34 may be located at a distance to the water driven turbine 1. It is of note that in some embodiments the generator 34 may be positioned in a non-linear arrangement relative to the shaft 18 using means known in the art.

It is of note that in the embodiment shown in FIG. 1, the fins 32 include buoyancy means 40 within the fins 32 for counter-acting the weight of the generator 34. That is, as discussed above, the fins 32 are mounted proximal to the exit end 22 and therefore proximal to the generator 34, for counter-balancing the weight of the generator 34. As a result of this arrangement, the water driven turbine 1 does not tilt when in use.

For use, the funnel 12 is mounted onto the housing 10 such that the entry end 22 of the housing 10 contacts the discharge 28 of the funnel 12. The water driven turbine 1 is then lowered into the body of water, below the surface of the body of water and the water driven turbine 1 is positioned such that the water current flows through the water driven turbine 1 as described below. Specifically, the water driven turbine 1 is positioned such that the current in the body of water directs the flow of water directly into the mouth 26 of the funnel 12. It is of note that the shaft 18 is operably linked to the generator 34, as described below.

In use, as discussed above, the water driven turbine 1 is positioned such that the current in the body of water directs water to flow into the mouth 26 of the funnel 12 at the lip 27. As discussed above, the diameter of the mouth 26 of the funnel 12 is greater than the diameter of the discharge 28 of the funnel. As a result of this arrangement, the velocity and inertial force of the water flow increases as it passes through the funnel 12 from the mouth 26 to the discharge 28. In this manner, the inertial force and velocity of the water is increased relative to the water flow caused by the natural current in the body of water. As noted above, the lip 27 is of a fixed diameter and acts to prevent backflow of the water once it enters the funnel 12. Furthermore, once water enters the funnel 12, it must exit through the exit end 24 of the housing 10 and the funnel 12. Thus, the flow of water passes through the housing 10 at the entry end 22 and exits the housing 10 through the exit end 24. As the water passes through the housing 10, the water strikes the flights 20, thereby driving rotation of the shaft 18. Rotation of the shaft 18 in turn generates electrical power at the generator 34. It is of note that the flights 20 are fitted within the housing 10 for maximum surface area and minimum clearance within the housing 10 so that the shaft 18 rotates freely within the housing 10. That is, the flights 20 are arranged to have maximum surface area and are arranged about the shaft 18 to maximize contact with the flow of water, so that electrical power generation is more efficient. Specifically, once the flow of water enters the water driven turbine 1, it must pass over the flights 20. Furthermore, the funnel 12 increases the velocity of the flow of water and passes the flow of water directly to the housing 10 without allowing water to flow back out of the funnel and escape, as discussed above.

In an alternative embodiment, the water driven turbine 1 includes a cone 42 mounted to the housing 10 and extending past the exit end 24, as shown in FIG. 4. Specifically, the cone 42 is connected to and extends outwardly and rearwardly from a position on the housing 10 past the exit end 24. Furthermore, the cone 42 may be connected to the housing at positions proximal to the exit end 24, as shown in FIG. 4. It is also of note that the cone 42 increases in diameter while extending rearwardly from the housing 10, such that the cone 42 is most narrow at the point that is mounted to the housing 10 and most wide at the distal end of the cone 42 relative to the housing 10. As a result of this arrangement, water exiting avoids the turbulence and restraining effect which would result from contact with the flow of water passing outside the device at the immediate exit, and the expanded volume available to the exiting water will enhance the velocity of flow throughout the device by eliminating some back pressure. Further, the cone will increase the velocity of flow of the water passing outside of the cone, which in turn will have a pulling effect on the water exit from inside the cone, enhancing its velocity of flow.

Thus, the above-described water driven turbine 1 is arranged for converting underwater currents to electrical power. Furthermore, the design is such that the water driven

5

turbine 1 can be used in bodies of water such as lakes, streams and rivers, where prior art water driven turbines are not suitable or impractical. Specifically, the water driven turbine is arranged to increase velocity in a natural water flow and to direct the water over a plurality of flights. Water passing over the flights drives rotation of a shaft which is in turn linked to a generator, resulting in the production of electrical power.

While the preferred embodiments of the invention have been described above, it will be recognized and understood that various modifications may be made therein, and the appended claims are intended to cover all such modifications which may fall within the spirit and scope of the invention.

What is claimed is:

1. A water driven turbine for converting the energy of an underwater current comprising:
  - a hollow tubular open ended housing, said housing having an entry end for accepting the water and an exit end for releasing the water;
  - a shaft mounted within the housing, said shaft arranged to rotate within the housing about an axis of rotation;
  - connection means on the shaft for operably linking the shaft to a generator such that rotation of the shaft generates electrical power;
  - blade means arranged about the shaft, said blade means extending along a length of the shaft;
  - a funnel mounted onto the entry end of the housing, said funnel having a mouth and a discharge, said mouth having a diameter greater than the diameter of the housing, said discharge having a diameter approximately equal to the diameter of the housing; and
  - tether means mounted on the funnel for stabilizing the water driven turbine;
  - wherein the discharge of the funnel is mounted onto the entry end of the housing such that the water entering the funnel at the mouth passes through the housing and contacts the blade means, thereby rotating the shaft and generating electrical power.
2. The water driven turbine according to claim 1 wherein the generator is positioned behind the exit end of the housing relative to the mouth of the funnel.
3. The water driven turbine according to claim 1 wherein the diameter of the mouth is approximately twice the diameter of the discharge.
4. The water driven turbine according to claim 1 including fins mounted on an upper surface and a lower surface of the housing for preventing twisting of the water driven turbine.
5. The water driven turbine according to claim 4 wherein the fins are mounted on the housing proximal to the exit end of the housing.
6. The water driven turbine according to claim 5 including buoyancy means mounted on the water driven turbine.
7. The water driven turbine according to claim 6 wherein the buoyancy means are mounted within the fins.
8. The water driven turbine according to claim 1 wherein there are three blade means.
9. The water driven turbine according to claim 1 wherein there are two blade means.
10. The water driven turbine according to claim 1 wherein the funnel includes a lip of fixed diameter adjacent to the mouth for preventing backflow.
11. The water driven turbine according to claim 1 including a cone mounted to the housing, said cone extending rearwardly beyond the exit end.
12. The water driven turbine according to claim 12, wherein the diameter of the cone increases as the cone extends rearwardly.

6

13. A water driven turbine for converting the energy of an underwater current comprising:

a hollow tubular open ended housing, said housing having an entry end for accepting the water and an exit end for releasing the water;

a shaft mounted within the housing, said shaft arranged to rotate within the housing about an axis of rotation;

connection means on the shaft for operably linking the shaft to a generator such that rotation of the shaft generates electrical power;

blade means arranged about the shaft, said blade means extending along a length of the shaft; and

a funnel mounted onto the entry end of the housing, said funnel having a mouth, a discharge and a lip of fixed diameter projecting from the mouth for preventing backflow, said mouth having a diameter greater than the diameter of the housing, said discharge having a diameter approximately equal to the diameter of the housing;

wherein the discharge of the funnel is mounted onto the entry end of the housing such that the water entering the funnel at the mouth passes through the housing and contacts the blade means, thereby rotating the shaft and generating electrical power.

14. The water driven turbine according to claim 13 including tether means mounted within the funnel for stabilizing the water driven turbine.

15. The water driven turbine according to claim 13 wherein the generator is positioned behind the exit end of the housing relative to the mouth of the funnel.

16. The water driven turbine according to claim 13 wherein there is provided buoyancy means adjacent the exit end of the housing.

17. The water driven turbine according to claim 13 wherein the generator is positioned at the exit end of the housing and wherein there is provided buoyancy means supporting the exit end of the housing and tether means supporting the entry end of the housing.

18. A water driven turbine for converting the energy of an underwater current comprising:

a hollow tubular open ended housing, said housing having an entry end for accepting the water and an exit end for releasing the water;

a shaft mounted within the housing, said shaft arranged to rotate within the housing about an axis of rotation;

connection means on the shaft for operably linking the shaft to a generator such that rotation of the shaft generates electrical power, the generator being located adjacent the exit end of the housing;

blade means arranged about the shaft, said blade means extending along a length of the shaft;

a funnel mounted onto the entry end of the housing, said funnel having a mouth and a discharge, said mouth having a diameter greater than the diameter of the housing, said discharge having a diameter approximately equal to the diameter of the housing;

tether means supported adjacent the funnel at the entry end of the housing for stabilizing the water driven turbine; and

buoyancy means adjacent the exit end of the housing for supporting the generator;

wherein the discharge of the funnel is mounted onto the entry end of the housing such that the water entering the funnel at the mouth passes through the housing and contacts the blade means, thereby rotating the shaft and generating electrical power.



**7**

**19.** The water driven turbine according to claim **18** wherein there are provided fins supported on the housing adjacent the exit end of the housing, the buoyancy means being supported within the fins.

**8**

**20.** The water driven turbine according to claim **18** wherein the tether means are supported on the funnel.

\* \* \* \* \*



US006443697B1

(12) **United States Patent**  
Rossi et al.

(10) **Patent No.:** US 6,443,697 B1  
(45) **Date of Patent:** Sep. 3, 2002

(54) **TURBINE WHEEL AND PELTON TURBINE  
EQUIPPED WITH SAME**

(56) **References Cited**

(75) **Inventors:** Georges Rossi, Saint Ismier; Louis  
Finet, Vif; Jean-Marie Roman,  
Echirolles, all of (FR)

U.S. PATENT DOCUMENTS

4,950,130 A \* 8/1990 Erlach ..... 415/202

(73) **Assignee:** ALSTOM Power Hydro, Grenoble  
(FR)

FOREIGN PATENT DOCUMENTS

FR 570 124 A \* 4/1924  
GB 688 577 A \* 3/1953

(\*) **Notice:** Subject to any disclaimer, the term of this  
patent is extended or adjusted under 35  
U.S.C. 154(b) by 0 days.

\* cited by examiner

(21) **Appl. No.:** 09/646,285

*Primary Examiner*—F. Daniel Lopez  
*Assistant Examiner*—Kimya N McCoy

(22) **PCT Filed:** Mar. 22, 1999

(74) *Attorney, Agent, or Firm*—Dowell & Dowell, P.C.

(86) **PCT No.:** PCT/FR99/00670

(57) **ABSTRACT**

§ 371 (c)(1),  
(2), (4) **Date:** Sep. 15, 2000

The invention concerns a Pelton turbine wheel comprising a rim (1) and several buckets (2) distributed at the rim periphery, characterised in that it comprises at least a ring-shaped flange (5, 6) integral with the rim and provided with housings (7) for receiving the buckets. The flange is capable of absorbing at least part of the efforts transmitted by the buckets (2) to the rim (1) and forms a peripheral strip (9) at external radial zones of the housings (7). The transmission of the efforts from the buckets (2) to the wheel rim (2) is carried out without generating too considerable a concentration zone of mechanical stresses.

(87) **PCT Pub. No.:** WO99/49213

**PCT Pub. Date:** Sep. 30, 1999

(30) **Foreign Application Priority Data**

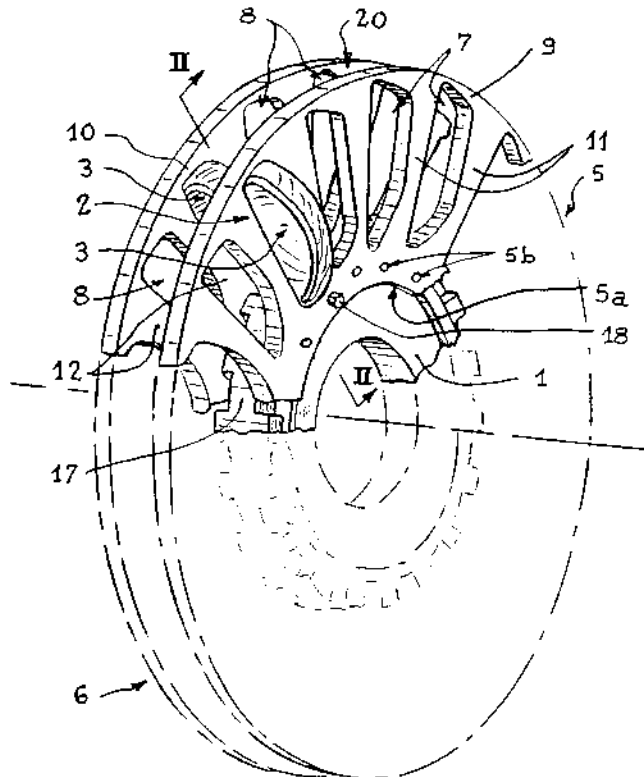
Mar. 23, 1998 (FR) ..... 98 03780

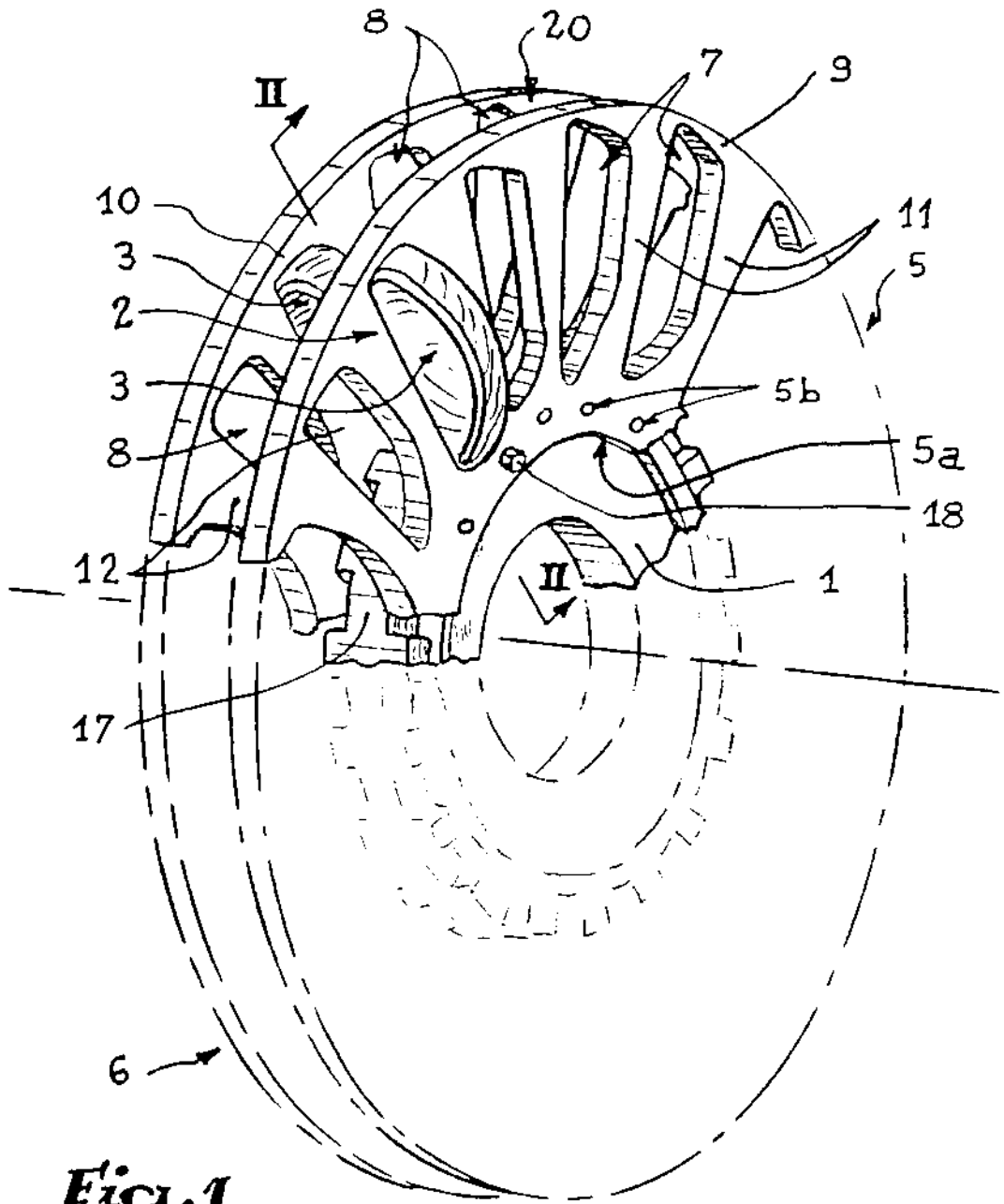
(51) **Int. Cl.<sup>7</sup>** ..... F01D 1/02; F03B 1/04

(52) **U.S. Cl.** ..... 415/202

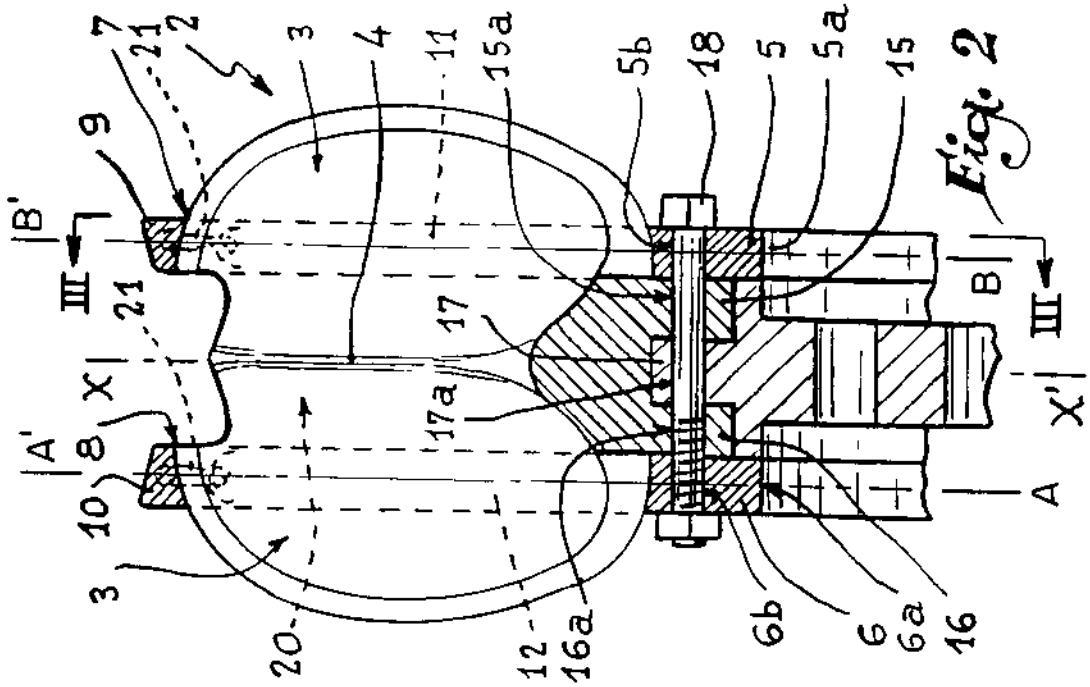
(58) **Field of Search** ..... 415/202; 416/197 B,  
416/197 A, 214 R, 214 A, 190, 192

**10 Claims, 3 Drawing Sheets**

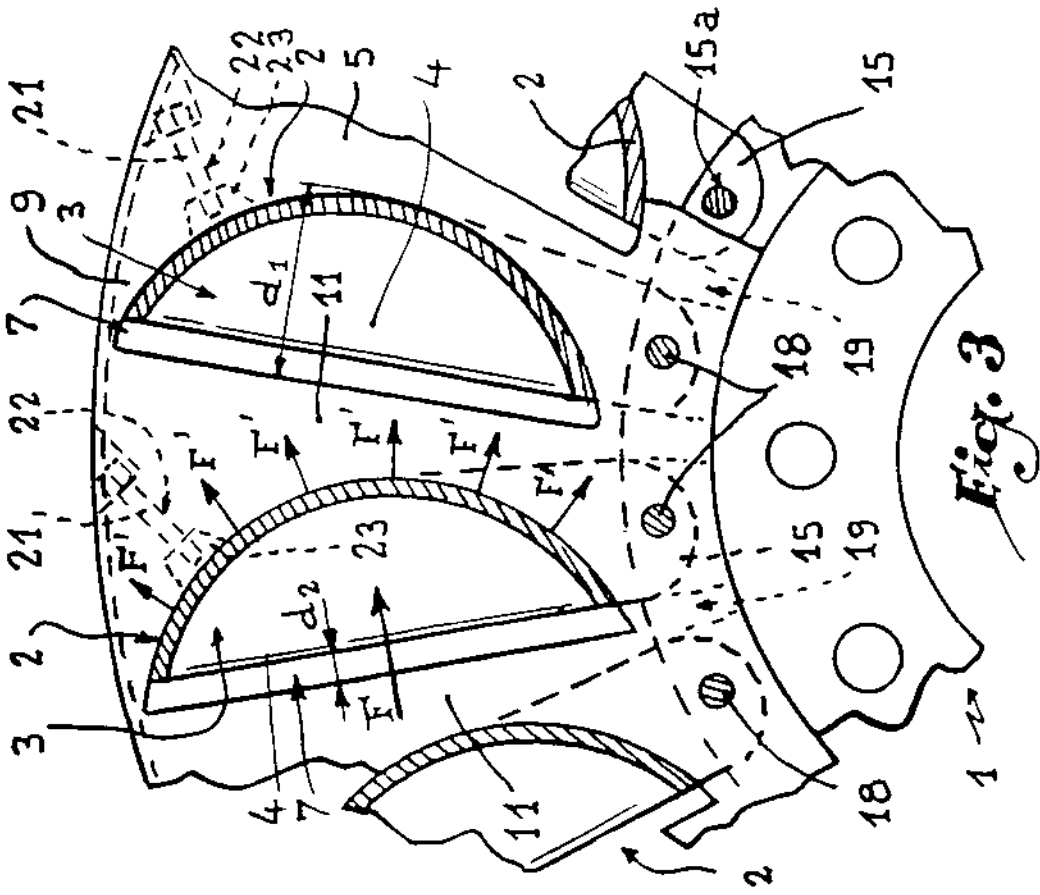




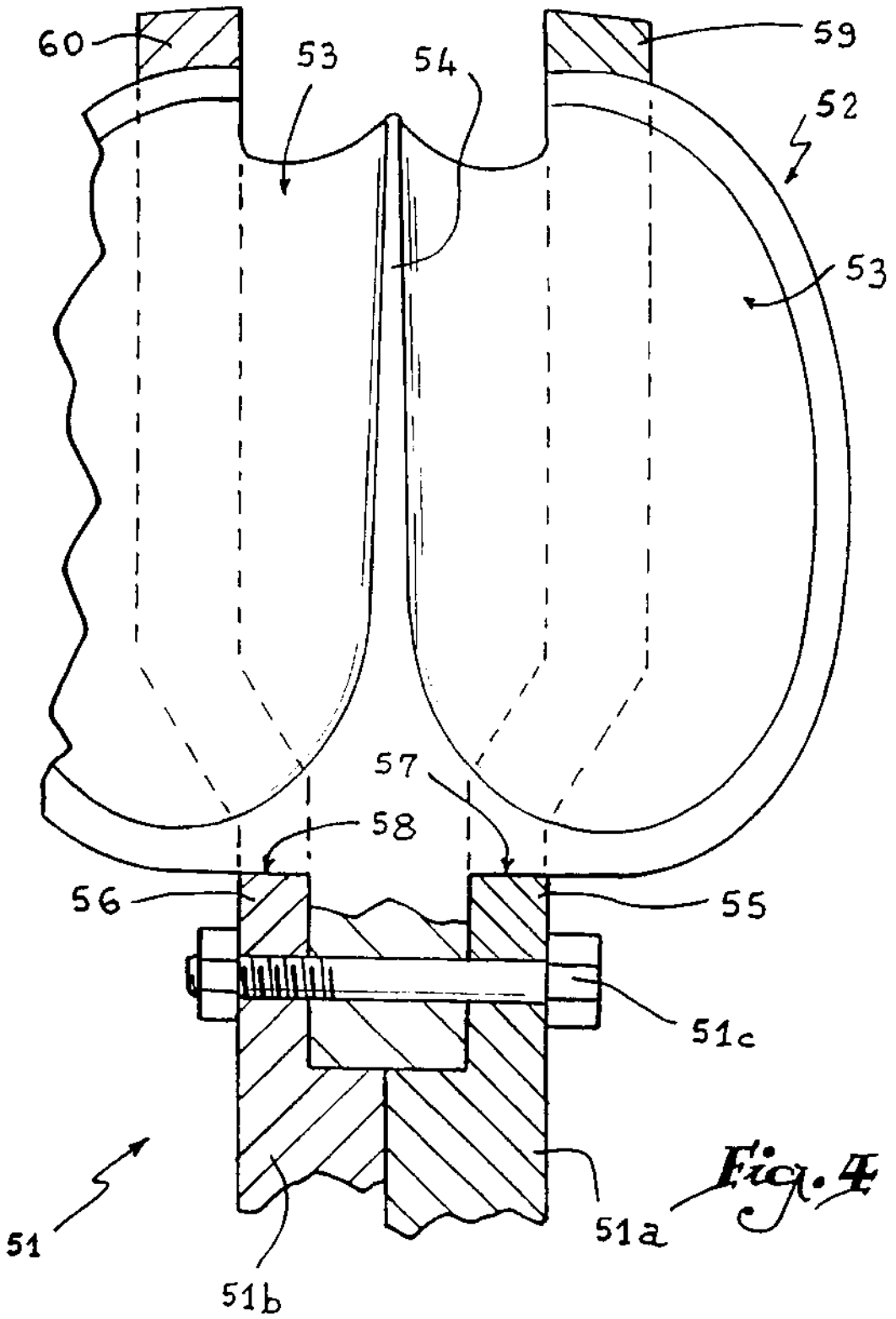
*Fig. 1*



*Fig. 2*



*Fig. 3*



## TURBINE WHEEL AND PELTON TURBINE EQUIPPED WITH SAME

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

The present invention relates to a turbine wheel and to a Pelton-type turbine equipped with such a wheel.

#### 2. Brief Description of the Related Art

Pelton turbines are conventionally used for transforming the kinetic energy of a fluid, such as the water of a waterfall, into mechanical energy. Such transformation is effected by rotating the turbine wheel under the effect of a tangential effort exerted, on buckets disposed on the periphery of a wheel rim, by a jet of water emerging from one or more injector nozzles distributed around the wheel.

The effort created on each bucket is transmitted to the wheel rim through an area of attachment of the bucket on the wheel rim. This area of attachment, defined by the geometrical intersection of the bucket with the rim, is subjected to considerable mechanical stresses. In effect, each bucket may be mechanically modeled as a beam fixed on one side only, with the result that it undergoes a considerable bending strain due to the effort of the jet. In addition, high vibratory stresses are applied to the bucket and there is a danger of resonance of the bucket or the rim.

In known devices, particularly of EP-A-0 346 681 or of EP-A-0 522 336, attempts have been made to overcome these drawbacks by reinforcing the area of attachment of the buckets on the wheel rim. This leads to structures which are complicated and therefore expensive, and of reduced reliability. In addition, each bucket remains attached to the rim by one side, with the result that the nature of the problems encountered is not fundamentally changed.

FR-A-704 875 teaches making the buckets of a turbine about on one another by means of rings mounted on their periphery. The distribution of the efforts is not optimum and arms must be interposed between adjacent buckets, being mounted with the greatest care, which results in a non-homogeneous distribution of the efforts.

### SUMMARY OF THE INVENTION

It is a particular object of the present invention to overcome these problems by proposing a turbine wheel of Pelton type in which the buckets are connected to the wheel rim so that the mechanical stresses are not concentrated in an area of attachment of the bucket to the rim and the dangers of resonance of the wheel are substantially reduced thanks to an optimized distribution of efforts.

In that spirit, the invention relates to a wheel of the above type, which comprises at least one annular disk fast with the wheel rim and provided with housings for receiving the buckets. This disk is adapted to absorb at least part of the efforts transmitted by the buckets to the rim and forms a peripheral band at the level of the outer radial areas of the housings.

Thanks to the invention, the disk which is on one piece and surrounds the buckets, makes it possible to support them, near the rim, in an intermediate area and in an outer radial area, with the result that each bucket is maintained efficiently in its inner, outer and central radial areas and that the effort to which it is subjected, due to the existence of the jet of fluid driving the turbine, has for its effect to apply it on the disk. This effort is in that case not concentrated solely in one area of attachment of the bucket to the wheel rim, but distributed over the whole of the disk. In other words, the

tangential effort created on a bucket is transmitted to the disk. The bucket and that part of the disk supporting the bucket may be mechanically modeled as a beam on two bearings, and even a beam bearing on its length, the first bearing being towards the wheel rim, while the second bearing is constituted by the peripheral band of the disk. Such a distribution of the efforts induces a reduction of the stresses exerted on the mechanical components, which makes it possible to envisage pieces of lesser thickness.

Taking the foregoing into account, a turbine wheel according to the invention may be made of metal, composite material or be a mixed structure. For example, certain pieces, such as the wheel rim or the disk, are made of metal, while other pieces, such as the buckets, are made of composite synthetic material. A wheel rim or a disk made of composite plastics material may also be associated with metal buckets.

In addition, the presence of the outer peripheral band of the disk, which creates a continuity of matter outside the wheel, makes it possible substantially to reduce the vibratory stresses exerted on the buckets. In effect, the peripheral band contributes to distributing these stresses on the different buckets, with the result that the equivalent inherent mode of each bucket is no longer that of a beam fitted at one end only, as in the devices of the prior art, but that of a beam fitted on one side and bearing on or fitted on the other side.

Finally, it has been surprisingly found that the presence of the disk makes it possible very substantially to improve the aerodynamic performances of the wheel of the invention. In effect, the disk makes it possible to limit the so-called "ventilator" effect of the wheel during rotation, i.e. the recirculation of the air between the outside of the wheel and the spaces between two consecutive buckets, due to the movement of rotation. Such reduction of the transverse air movements with respect to the buckets was able to be quantified, by laboratory tests, at about 20% of the braking force due to the ventilation of the wheel in the absence of disk. In this way, the invention also enables the yield of a Pelton turbine wheel to be substantially improved.

According to a first advantageous aspect of the invention, the wheel comprises two disks disposed on either side of one or more injector nozzles of the turbine. This aspect of the invention makes it possible to dispose the disks opposite each bowl or scoop of the buckets when the buckets are double, as is conventionally the case in Pelton turbines. In that case, the disks may be provided to be substantially aligned on the median axes of the scoops of the buckets.

According to another advantageous aspect of the invention, the disk or disks is/are provided with spokes each adapted to substantially fill the space separating two adjacent buckets of the wheel. Thanks to this aspect of the invention, the spokes present a sufficient cross-section to absorb the mechanical stresses transmitted by the buckets. Moreover, the fact that they substantially fill the space separating two buckets makes it possible to optimize the reduction of the "ventilator" effect.

According to a first embodiment of the invention, the disk or disks is/are in the form of a perforated ring, means for removably mounting the or each disk on the wheel rim being provided near an inner edge of the or each disk.

According to a second embodiment of the invention, the disk or disks is/are formed in one piece with at least part of the wheel rim. Thanks to this aspect of the invention, transfer of the efforts of the disk towards the wheel rim is optimized. In addition, assembly of the turbine wheel may be facilitated. In that case, the wheel rim may be provided

to be formed by two half-rims, each half-rim extending radially towards the outside by a disk.

According to another advantageous aspect of the invention, applicable whatever the embodiment, the buckets are removably fixed on the disk or disks and/or the wheel rim. This aspect of the invention guarantees a good dimensional stability of the wheel during use and an efficient transfer of the efforts from the buckets towards the wheel rim. In addition, the operations of maintenance on the buckets or the disks are facilitated.

According to another aspect, the bucket may be permanently fixed on the disk or disks and/or the wheel rim.

The invention also relates to a Pelton-type turbine comprising a wheel as described hereinbefore. Such a turbine may be manufactured more economically than the prior art ones since it is possible to optimize the dimensioning of the pieces by taking into account the fact that the mechanical stresses are better distributed over the wheel. In addition, the yield of this turbine is improved by reduction of the ventilator effect.

The invention will be more readily understood and other advantages thereof will appear more clearly from the following description of two embodiments of a turbine wheel in accordance with its principle, given solely by way of example and made with reference to the accompanying drawings, in which:

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partial perspective view of a Pelton turbine wheel according to the invention.

FIG. 2 is a section along line II—II of FIG. 1.

FIG. 3 is a section along line III—III of FIG. 2, and

FIG. 4 is a view similar to FIG. 2 for a turbine wheel in accordance with a second embodiment of the invention.

#### DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, the turbine wheel shown in FIG. 1 comprises a wheel rim 1 and buckets 2, eighteen in number in the example shown, distributed on the periphery of the rim 1. Each bucket comprises two scoops 3 separated by a central edge 4 intended to be disposed opposite one or more water or steam injector nozzles (not shown). The rim 1 is provided to be mounted on a movement transfer shaft (likewise not shown).

In order to render the drawing clearer, only one bucket has been shown in FIG. 1.

In accordance with the invention, two disks 5 and 6 in annular form are mounted on the rim 1 and contribute to maintaining the buckets 2 with respect to this rim. The disks 5 and 6 are respectively provided with housings 7 and 8 in which the scoops 3 of the buckets 2 are respectively inserted. The housings 7 and 8 may be machined or obtained by moulding in the disks 5 and 6. Each of the disks 5 and 6 passes radially and outwardly of the buckets 2, with the result that two continuous bands 9 and 10 are respectively defined in the outer peripheral areas of the disks 5 and 6. These continuous bands 9 and 10 connect spokes 11 and 12 respectively belonging to disks 5 and 6. Each housing 7 of the disk 5 is defined by two adjacent spokes 11 forming part of the disk 5 and by the band 9, while each housing 8 of disk 6 is defined by two adjacent spokes 12 forming part of the disk 6 and by the band 10.

In this way, each bucket 2 is supported both by the wheel rim 1 and by the two disks 5 and 6 which each form a

one-piece annular ring around the rim 1, with the result that the efforts of thrust F, visible in FIG. 3 and transmitted to a bucket 2 by the jet of water or steam, are distributed in efforts F' in the spokes 11 or 12 of the disks 5 or 6 from which they are transmitted to the rim 1. Part of these efforts may also transit via the area of attachment of the buckets on the rim as in the known devices. Thanks to this distribution, the area of attachment of the buckets 2 on the wheel rim 1 is not a critical mechanical stress area.

Assembly of the buckets and the disks on the wheel rim 1 is more clearly apparent in FIGS. 2 and 3. XX' is the axis of the central edge 4 of a bucket 2. The bucket 2 comprises two tabs 15 and 16 adapted to be disposed on either side of an outer radial part 17 of the rim 1. The elements 15 to 17 are respectively provided with a central bore 15a, 16a or 17a for receiving a locking screw 18. The disks 5 and 6 are provided to be disposed on either side of the rim 1 and of tabs 15 and 16 and comprise, near their respective inner edges 5a and 6a, bores 5b and 6b provided to be aligned with bores 15a, 16a and 17a, with the result that the screw 18 successively traverses the disk 5, the tab 15, the radial part 17, the tab 16 and the disk 6. In this way, disks 5 and 6 and bucket 2 are removably mounted on the wheel rim 1.

The efforts F due to the water or steam jet transmitted to the different buckets 2 do not transit solely via the tabs 15 and 16 of each bucket 2, but are distributed over the periphery of the rim 1, thanks to the disks 5 and 6 and, in particular, to bands 9 and 10.

In order to improve the rigidity of the assembly, and as is more particularly apparent in FIG. 3, area 17 of the rim 1 may be provided to be made by removing material with respect to the nominal width of the rim 1 which is conserved in the space 19 separating two continuous areas 17.

It will be understood that the geometry of the spokes 11 and 12 is adapted to the outer shape of the buckets, with the result that the latter are immobilized inside the housings 7 and 8 by cooperation of shapes, this presenting the additional advantage that the spokes 11 and 12 substantially fill the space separating two adjacent buckets of the wheel, with the result that the aerodynamic separation of the inner volume 20 defined between the two disks 5 and 6 with respect to the outside of these disks is optimized. In other words, the transverse circulation of air through the inner volume 20 is limited.

It will be noted that the disks 5 and 6 are substantially aligned on the median axes AA' and BB' of the scoops 3 of the buckets 2. This induces the spokes 11 and 12 of the disks 5 and 6 to be spaced apart from the bottom of the scoops 3 by a distance  $d_1$  and from the edges of the scoops by a distance  $d_2$ , distances sufficient in order not to disturb the flow of water or steam towards the outside of the volume 20. The fact that distance  $d_2$  is substantially smaller than distance  $d_1$  corresponds to the fact that the spokes 11 and 12 substantially fill the space separating two adjacent buckets.

As is more clearly apparent in FIG. 3, each bucket 2 is also rendered fast with the disk 6 thanks to a locking screw 21 housed in a bore 22 in the disk 6 and adapted to engage in a rear boss 23 of the bucket 2. An identical construction is provided at the level of disk 5. The screw 21 improves the immobilization of the bucket 2 with respect to the disk 5.

In the second embodiment shown in FIG. 4, elements similar to those of the embodiment of FIGS. 1 to 3 bear identical references increased by 50. In this embodiment, the wheel rim 51 is formed by two half-rims 51a and 51b adapted to be assembled together, for example by means of screws 51c.

The half-rim **51a** extends radially towards the outside by a one-piece ring **55** forming an annular disk whose function is identical to that of disk **5** of the previous embodiment. The ring or disk **55** extends radially to the outside of a bucket **52** provided with two scoops **53** separated by a central edge **54**. Similarly, the half-rim **51b** extends by a ring or annular disk **56** adapted to support the buckets **52**. The rings **55** and **56** are provided with housings **57**, **58** for receiving the buckets **52**, while continuous bands **59** and **60**, respectively belonging to disks **55** and **56**, define housings **57** and **58** in their outer radial part.

As elements **51a** and **55** on the one hand, **51b** and **56** on the other hand, are formed in one piece, transmission of the efforts between disks **55** and **56** and the wheel rim **51** is optimal.

A Pelton turbine wheel according to this second embodiment is assembled by bringing the half-rims **51a** and **51b** towards each other, while buckets **52** are distributed radially in a position close to their final position, this making it possible to wedge a shank or tongue **52a** of each bucket **52** between the half-rims **51a** and **51b**, thus improving the anchoring of the buckets **52** with respect to the wheel rim **51**. A screw **51c** advantageously passes through the shank **52a** of each bucket **52**.

According to a variant of the invention (not shown), the wheel rim **51** and the disks **55** and **56** may be provided to be formed in one piece. In other words, the half-rims **51a** and **51b** are in that case joined in one piece, obtained by moulding and/or machining.

The effect of improvement of the ventilation of the turbine described with reference to the embodiment of FIGS. **1** to **3** is also obtained with the device of the second embodiment.

Taking into account the relatively low level of stresses undergone by the buckets and the rim of a turbine wheel according to the invention, it may be envisaged to make these pieces and the disks of materials which, up to now, were not envisaged for this type of device. In particular, the use of composite resin, possibly reinforced with fibers, may be envisaged, certain pieces still being able to be made of metal.

As the buckets can be manufactured independently of the wheel rim and disks, they may be provided to be coated with an anti-abrasion or anti-erosion product before being assembled. In particular, the technical teaching of Applicants' Patent Application EP-A-0 543 753 may be applied.

A turbine wheel according to the invention is assembled from a wheel rim, one or two disks, and from buckets or buckets bearing reinforcements. These different components may be assembled by the means described and shown in the Figures or by any other appropriate means such as, in particular, cooperation of shapes, wedging, hooping, welding, soldering, adhesive bonding.

The invention has been represented with buckets removably mounted on the wheel rim and the disk. It is also possible to provide for these buckets to be mounted permanently on the wheel rim and/or the disk, in particular welded, soldered or bonded in position. Similarly, a one-piece wheel obtained by moulding may be produced, this wheel comprising a rim, one or two disks and buckets.

What is claimed is:

1. In a turbine wheel of the Pelton type, including a wheel rim and a plurality of buckets spaced about a periphery of the rim, the improvement comprising: at least one annular

disk in the form of a continuous ring secured to the rim so as to extend radially outwardly with respect to the rim, said at least one annular disk having a plurality of spaced openings provided within an outer portion thereof spaced inwardly of an outer peripheral edge and radially outwardly of the rim for receiving the plurality of buckets, said at least one annular disk extending radially outwardly relative to said plurality of buckets such that said plurality of buckets are positioned within said spaced openings so that forces directed thereto are transmitted along a full length of each of said plurality of buckets to said at least one annular disk such that said at least one annular disk is adapted to absorb and transmit forces on said plurality of buckets to said rim, and said length being taken along a plane of said at least one annular disk; wherein said outer peripheral edge of said at least one annular disk forms a continuous annular portion of said at least one annular disk.

2. The turbine wheel according to claim **1**, including two annular disks secured in spaced relationship with one another to the rim for supporting said plurality of buckets.

3. The turbine wheel according to claim **2**, wherein each of said plurality of buckets includes two scoops, said two annular disks being substantially aligned on median axes (AA', BB') of said scoops.

4. The turbine wheel according to claim **3**, wherein each of said two annular disks include spokes which are integrally, connected at their outer ends and which spokes extend between two adjacent of said plurality of buckets of the turbine wheel.

5. The turbine wheel according to claim **1**, wherein said at least one annular disk is in a form of a perforated ring, and means for removably mounting said at least one annular disk on the rim being provided in a vicinity of an inner edge of said at least one annular disk.

6. The turbine wheel according to claim **1**, wherein said at least one annular disk is formed in one piece with the rim.

7. The turbine wheel according to claim **6**, wherein the wheel rim is formed by two parts as half-rims adapted to be assembled together.

8. The turbine wheel according to claim **1**, wherein said plurality of buckets are removably mounted on said at least one annular disk.

9. The turbine wheel according to claim **1** wherein said plurality of buckets are permanently mounted on said at least one annular disk.

10. A Pelton-type turbine comprising a turbine wheel including a wheel rim, and a plurality of buckets spaced about the periphery of said rim at least one annular disk in the form of a continuous ring secured to the rim and having a plurality of spaced openings provided within an outer portion thereof spaced inwardly of an outer peripheral edge for receiving the plurality of buckets, said at least one annular disk extending radially outwardly relative to said plurality of buckets such that said plurality of buckets are positioned within said spaced openings so that forces directed thereto are transmitted along a full length of said plurality of buckets to said at least one annular disk and such that said at least one annular disk is adapted to absorb and transmit forces on said plurality of buckets to the rim, and said length being taken along a plane of said at least one annular disk; wherein said outer peripheral edge of said at least one annular disk forms a continuous annular portion of said at least one annular disk.

\* \* \* \*





US006448669B1

(12) **United States Patent**  
**Elder**

(10) **Patent No.:** **US 6,448,669 B1**  
(45) **Date of Patent:** **Sep. 10, 2002**

(54) **WATER POWER GENERATION SYSTEM**

GB 2231805 A 11/1990  
JP 55-69701 5/1980 ..... 416/197 A

(76) Inventor: **Dillyn M. Elder**, 1513 E. Lake St., Fort Collins, CO (US) 80524

**OTHER PUBLICATIONS**

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

U.S. patent application Ser. No. 09/452,734, "Improved Wind Turbine System", filed Dec. 1, 1999, 28 pages and 11 drawings.

U.S. Provisional Application, 60/110,519, "Improved Wind Turbine System", filed Dec. 1, 1998, 11 pages and 11 drawings.

(21) Appl. No.: **09/789,961**

*Primary Examiner*—Nicholas Ponomarenko

(22) Filed: **Feb. 20, 2001**

**Related U.S. Application Data**

(57) **ABSTRACT**

(63) Continuation-in-part of application No. 09/452,734, filed on Dec. 1, 1999, now Pat. No. 6,191,496.

(60) Provisional application No. 60/110,519, filed on Dec. 1, 1998.

(51) **Int. Cl.<sup>7</sup>** ..... **F03D 3/04**

(52) **U.S. Cl.** ..... **290/54; 290/43**

(58) **Field of Search** ..... 290/43, 44, 54, 290/55

The present invention relates to a turbine used to convert wind or fluid energy, and in some embodiments the kinetic energy of water, into mechanical energy, more specifically, a long axis type of vertical-axis turbine allowing large columns of air or water to be harnessed. These devices differ from horizontal-axis (propeller) type windmills or watermills which typically rotate about a vertical axis in order that they may face directly into a wind. The present invention is designed to be employed as a cost effective alternate power source in any wind or water current condition from a breeze to a gale wind, to a slow to moderate to fast water currents. To increase the structural integrity, the torque generating elements, namely, the rotor blades, are not directly attached to the shaft but rather, they attach to the round top and bottom rotor cage plates through which torque forces generated can be transferred to the shaft. The unique design of an open cover on the top of the wind or water turbine allows wind or water from the direction above the turbine to be harnessed. The top shield structure has created a calm wind or water area between the shield and the top of the rotor cage that helps reduce turbidity and greatly facilitates wind or water exhaust from the system.

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

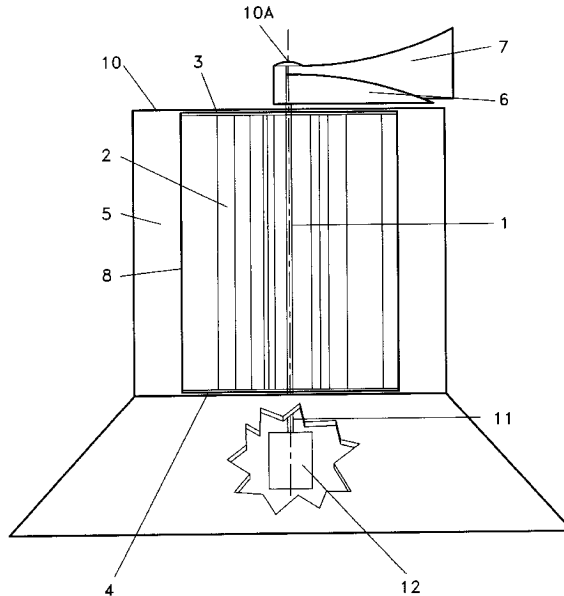
143,100 A 9/1873 Sheplar et al.  
175,530 A 3/1876 Vernor  
201,400 A 3/1878 Everhart

(List continued on next page.)

**FOREIGN PATENT DOCUMENTS**

DE 867380 2/1953  
EP 167694 1/1986 ..... 415/4.2  
EP 0216384 4/1987  
FR 515652 4/1921  
FR 727519 3/1931  
FR 61140 3/1955 ..... 416/236

**70 Claims, 12 Drawing Sheets**



U.S. PATENT DOCUMENTS

|             |         |                     |           |                |         |                        |           |
|-------------|---------|---------------------|-----------|----------------|---------|------------------------|-----------|
| 399,171 A   | 3/1889  | Townsend            |           | 4,075,500 A    | 2/1978  | Oman et al. ....       | 290/55    |
| 455,858 A   | 7/1891  | Pepper .....        | 416/197 A | 4,140,433 A    | 2/1979  | Eckel .....            | 415/2     |
| 485,933 A   | 11/1892 | Herman              |           | 4,168,439 A    | 9/1979  | Palma .....            | 290/44    |
| 535,193 A   | 3/1895  | Chapman             |           | 4,204,799 A    | 5/1980  | de Geus .....          | 415/2     |
| 537,494 A   | 4/1895  | Stevens et al. .... | 415/907   | 4,247,252 A    | 1/1981  | Seki et al. ....       | 416/44    |
| 588,572 A   | 8/1897  | Hardaway            |           | 4,247,253 A    | 1/1981  | Seki et al. ....       | 416/44    |
| 600,893 A   | 3/1898  | Schmucker           |           | 4,291,233 A    | 9/1981  | Kirschbaum .....       | 290/1 C   |
| 640,901 A   | 1/1900  | Hardaway            |           | 4,362,470 A    | 12/1982 | Lacastro et al. ....   | 416/197 A |
| 993,120 A   | 5/1911  | Sterner             |           | 4,415,814 A    | 11/1983 | Martinez .....         | 290/55    |
| 1,523,295 A | 1/1925  | Ryan                |           | 4,474,529 A    | 10/1984 | Kinsey .....           | 415/2 R   |
| 1,583,165 A | 5/1926  | Nicholson .....     | 416/236 R | 4,551,631 A    | 11/1985 | Trigilio .....         | 290/55    |
| 1,615,675 A | 1/1927  | Bender              |           | 4,571,152 A    | 2/1986  | Tater .....            | 415/4     |
| 1,758,560 A | 5/1930  | Currie .....        | 416/236 R | 4,632,637 A    | 12/1986 | Traudt .....           | 416/41    |
| 1,835,018 A | 12/1931 | Darrieus            |           | 4,652,206 A    | 3/1987  | Yeoman .....           | 415/4     |
| 1,935,097 A | 11/1933 | Nelson .....        | 170/15    | 4,695,736 A    | 9/1987  | Doman et al. ....      | 290/44    |
| 2,067,542 A | 1/1937  | Penton .....        | 170/12    | 4,748,339 A    | 5/1988  | Jamieson .....         | 290/55    |
| 2,406,268 A | 8/1946  | Terhune .....       | 170/26    | 4,818,181 A    | 4/1989  | Kodric .....           | 416/196 A |
| 3,339,078 A | 8/1967  | Crompton .....      | 290/44    | 4,834,610 A    | 5/1989  | Bond, III .....        | 415/3     |
| 3,902,072 A | 8/1975  | Quinn .....         | 290/44    | 4,850,792 A    | 7/1989  | Yeoman .....           | 415/4.2   |
| 3,942,909 A | 3/1976  | Yengst .....        | 416/132 B | 5,083,039 A    | 1/1992  | Richardson et al. .... | 290/44    |
| 3,970,409 A | 7/1976  | Luchuk .....        | 416/145   | 5,380,149 A    | 1/1995  | Valsamidis .....       | 415/2.1   |
| 3,994,621 A | 11/1976 | Bogle .....         | 415/186   | 5,391,926 A    | 2/1995  | Staley et al. ....     | 290/55    |
| 4,031,405 A | 6/1977  | Asperger .....      | 290/55    | 5,503,530 A    | 4/1996  | Walters .....          | 416/197 A |
| 4,035,658 A | 7/1977  | Diggs .....         | 290/55    | 5,852,331 A    | 12/1998 | Giorgini .....         | 290/55    |
| 4,045,144 A | 8/1977  | Loth .....          | 415/1     | 6,191,496 B1 * | 2/2001  | Elder .....            | 290/44    |

\* cited by examiner

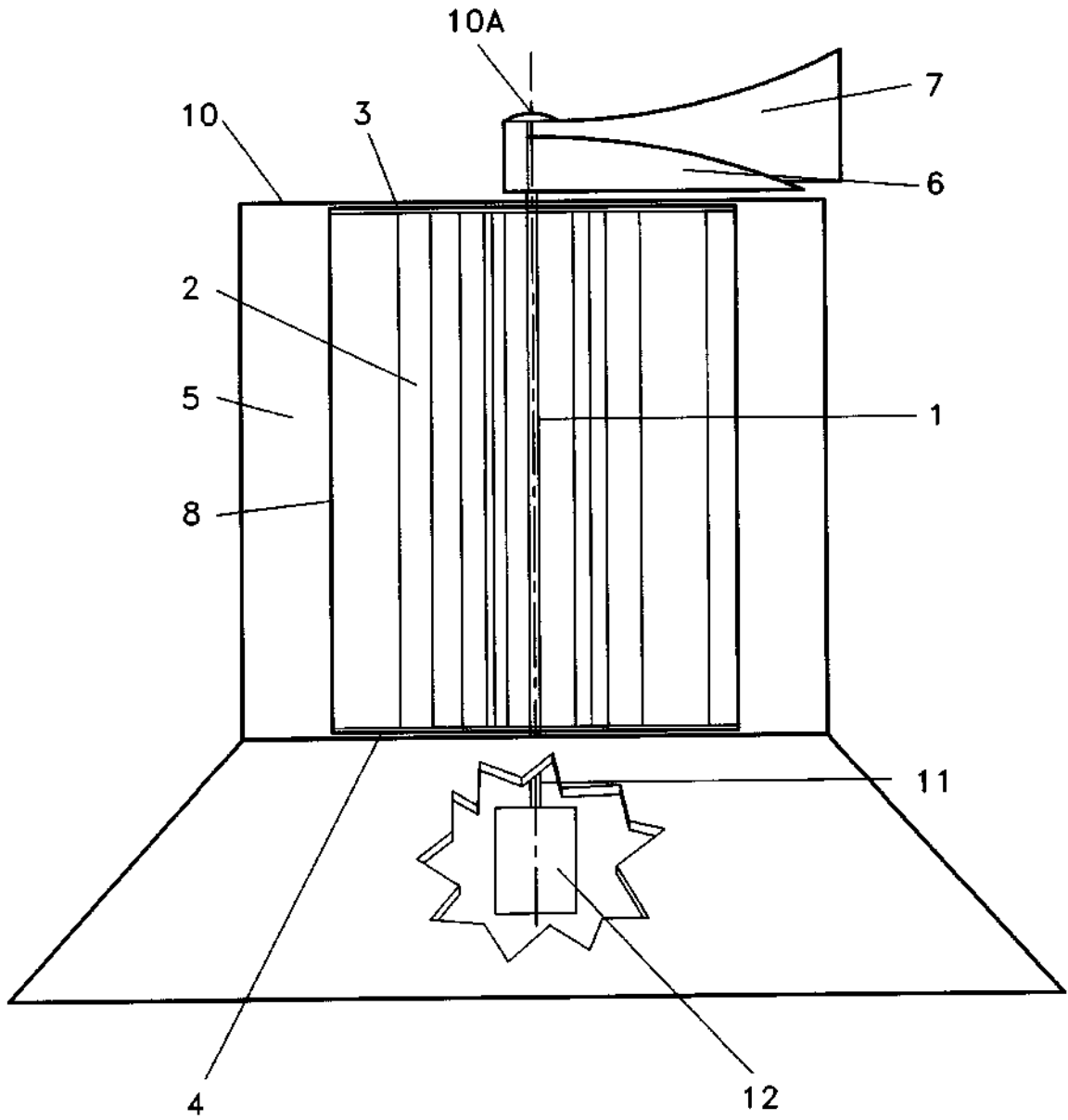


Fig. 1

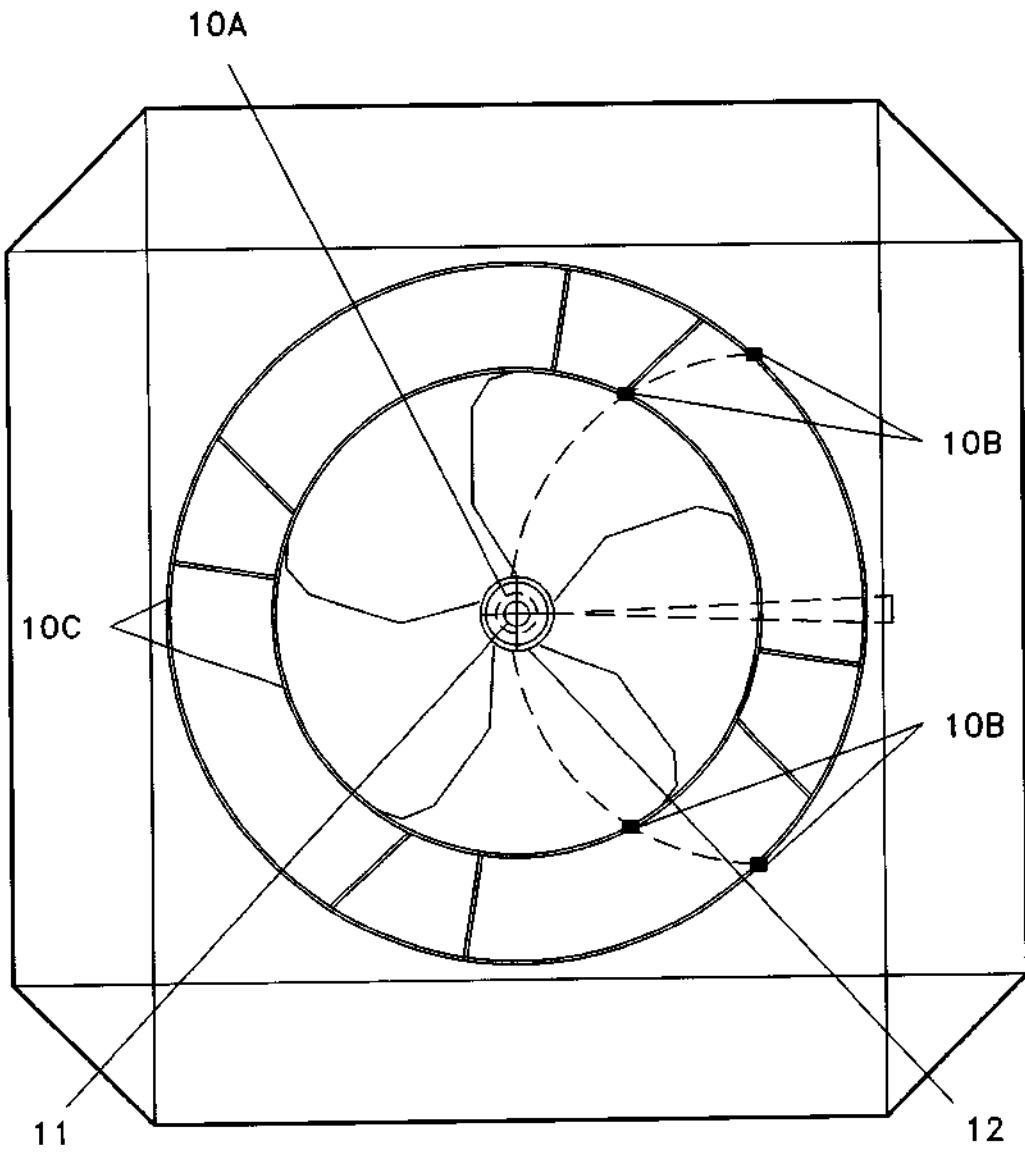


Fig. 1A

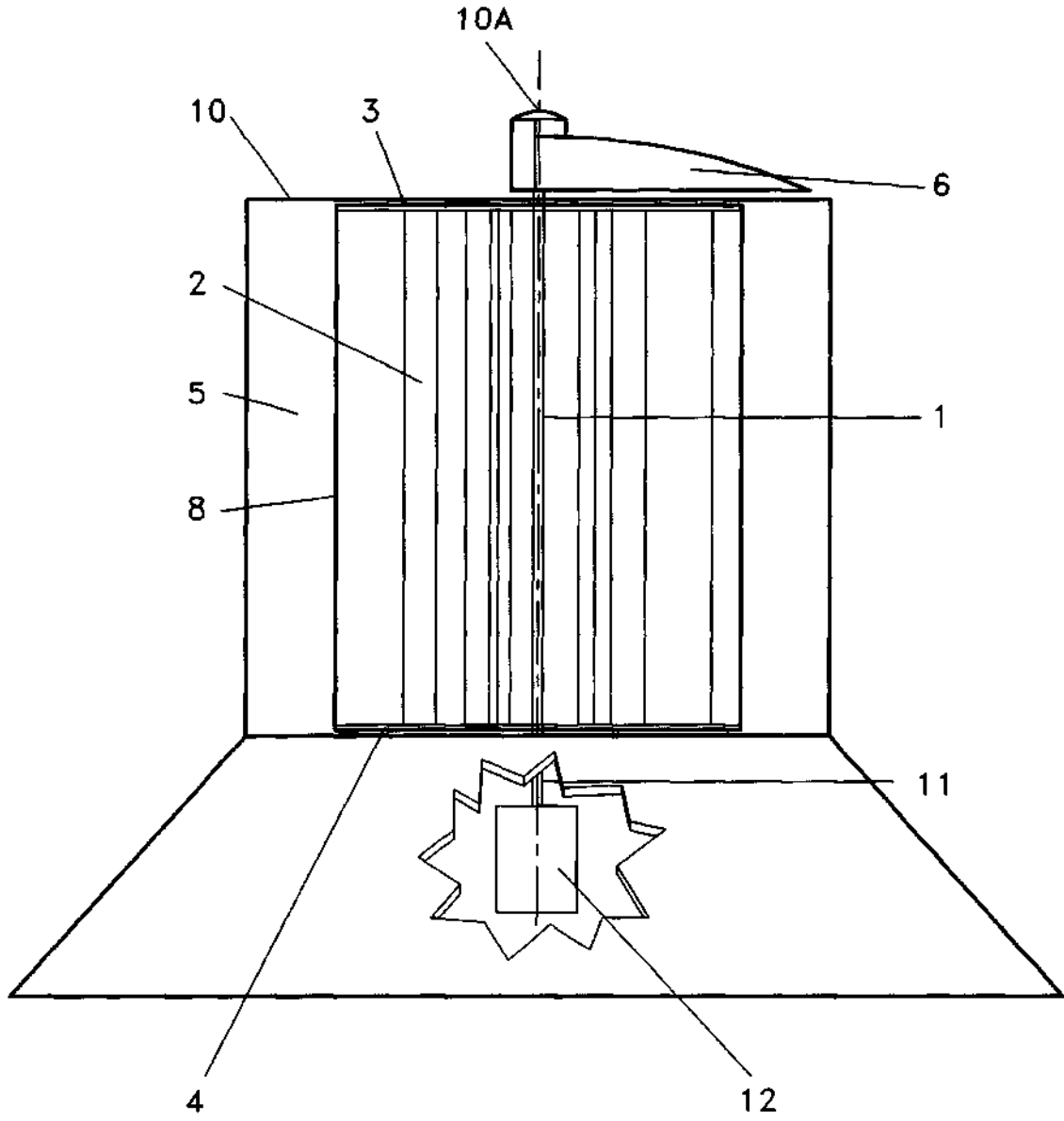


Fig. 1B

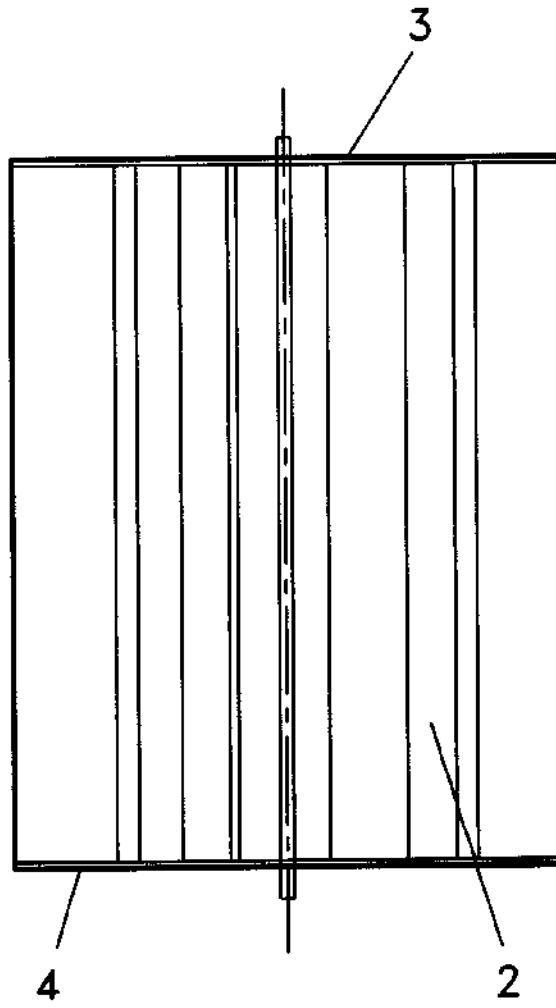


Fig. 2

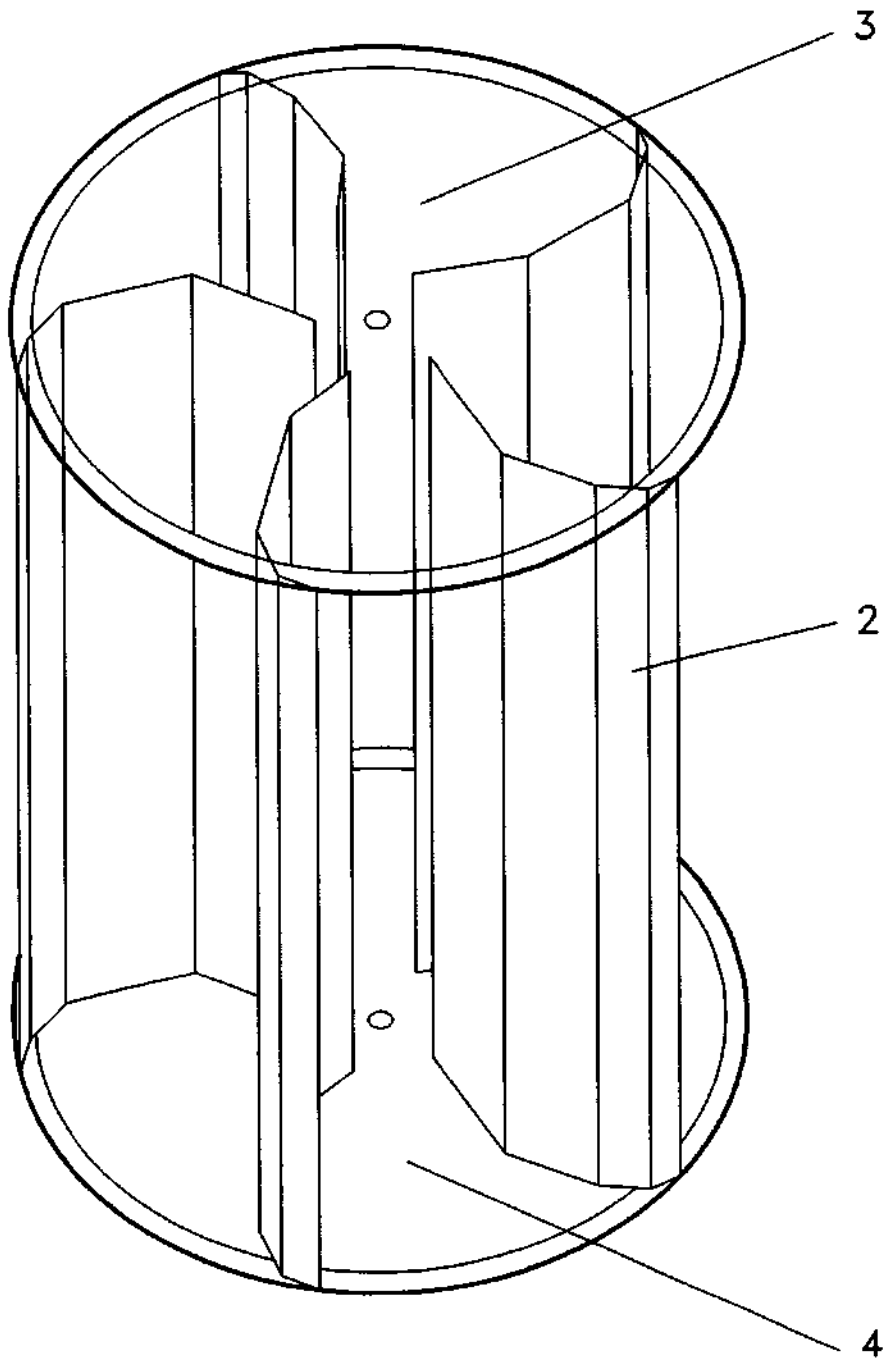


Fig. 2A

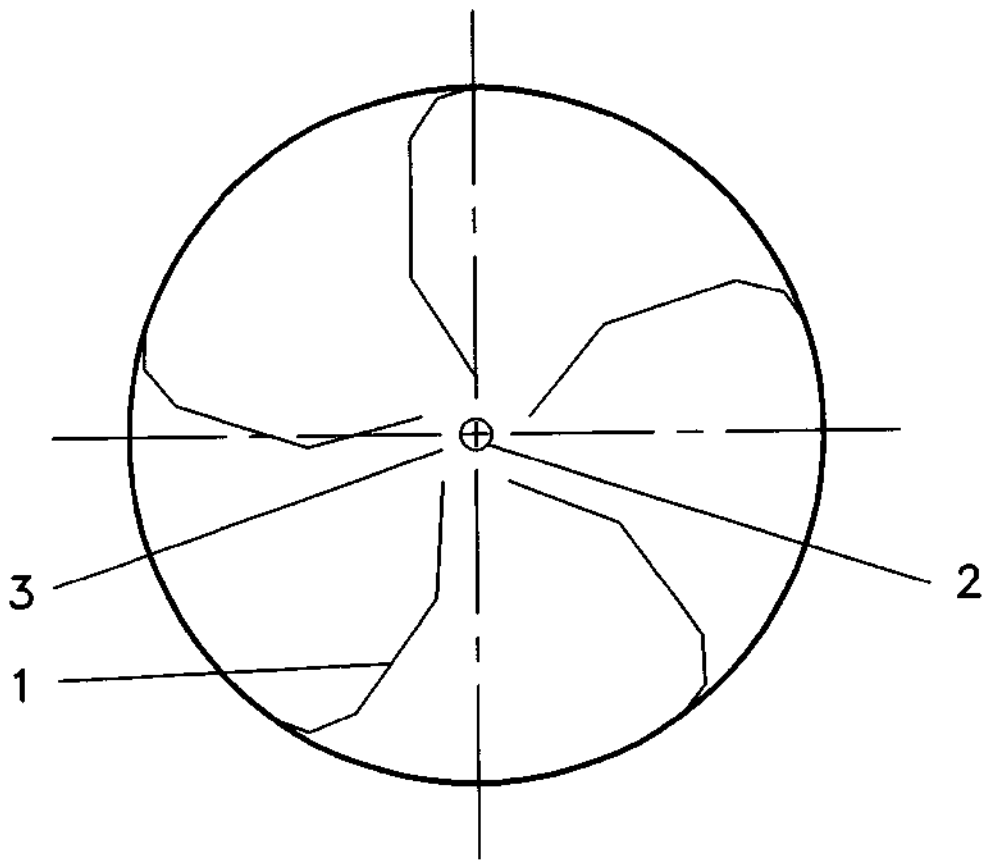


Fig. 3



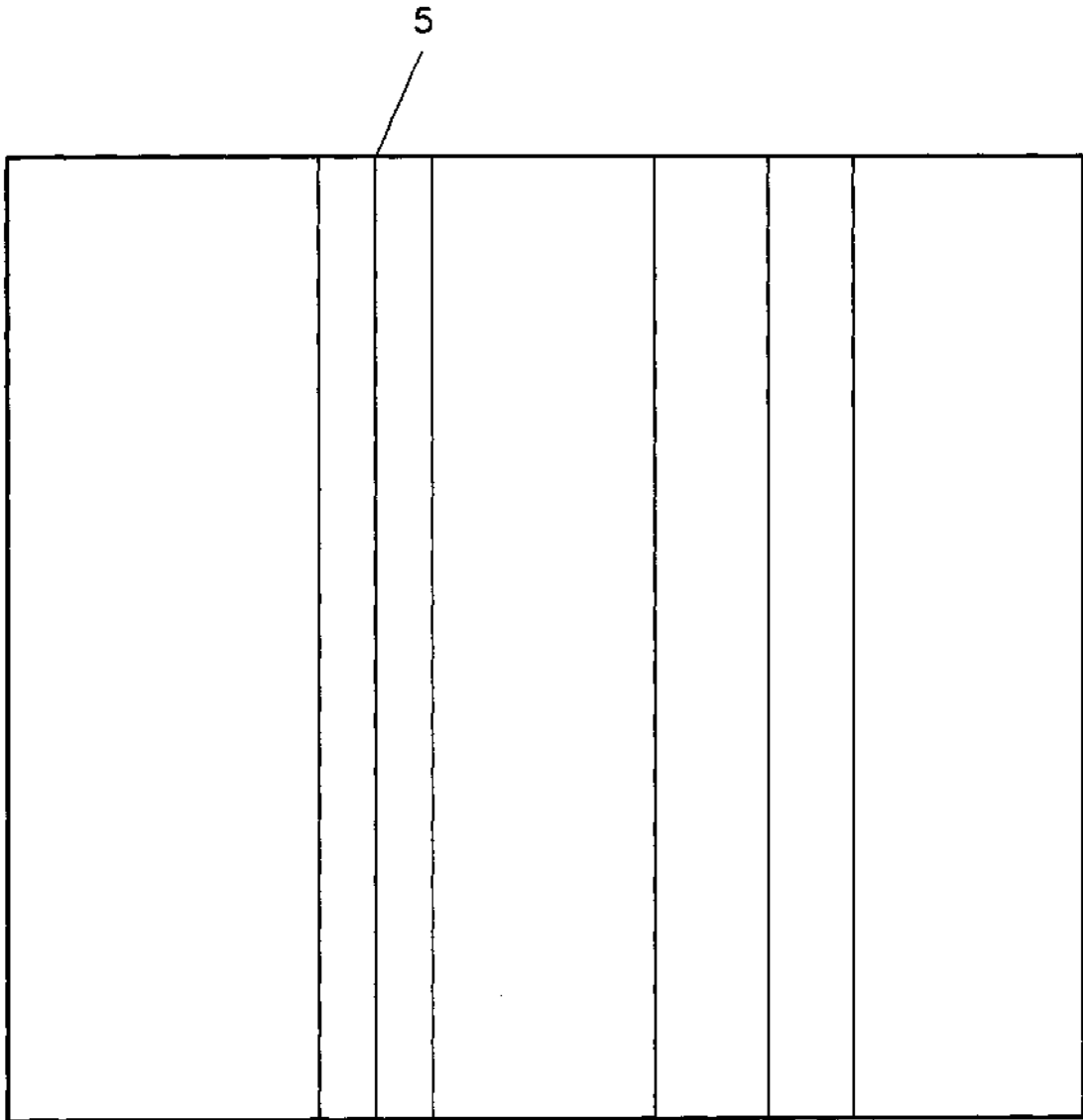


Fig. 4

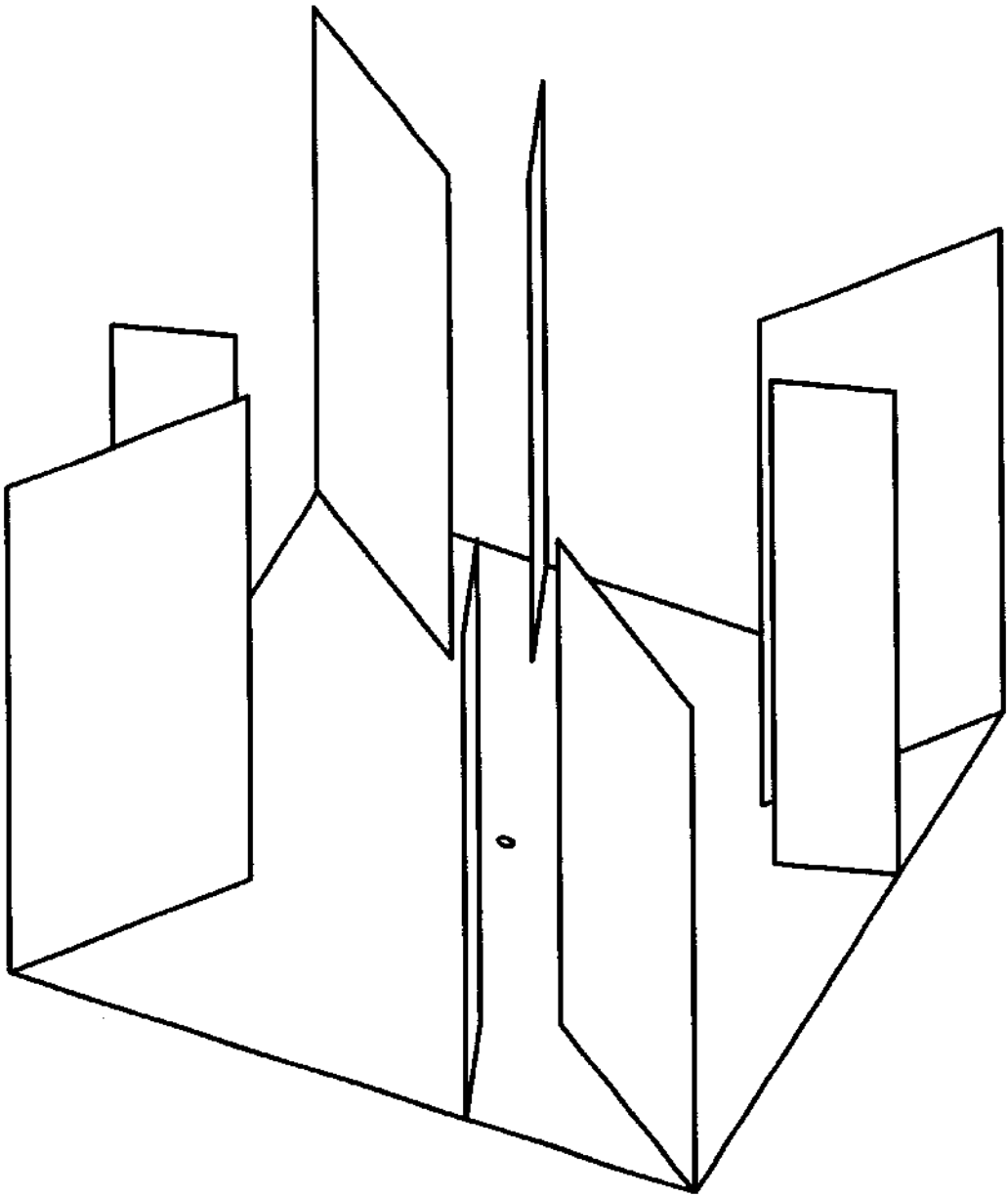


Fig. 4A

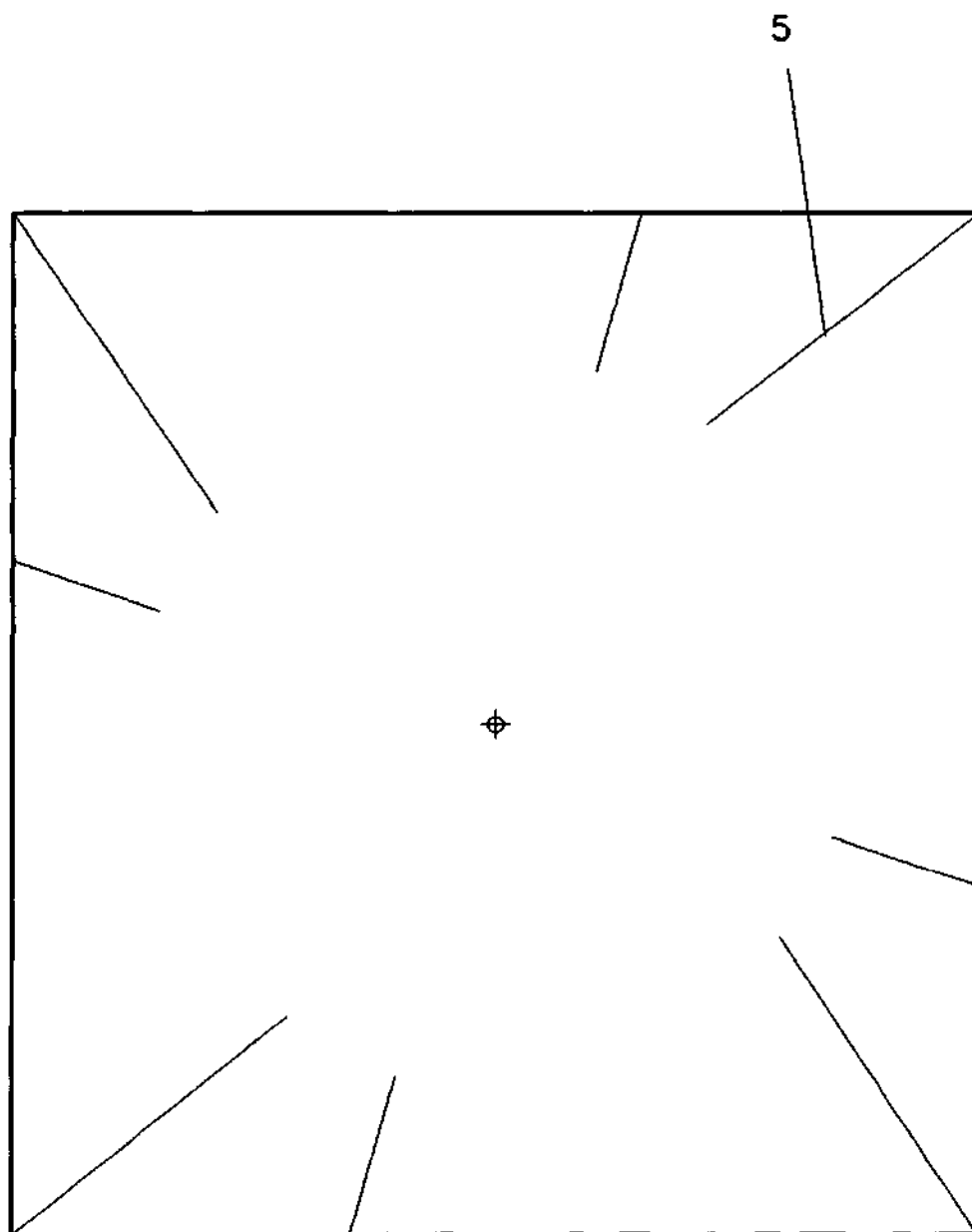


Fig. 4B

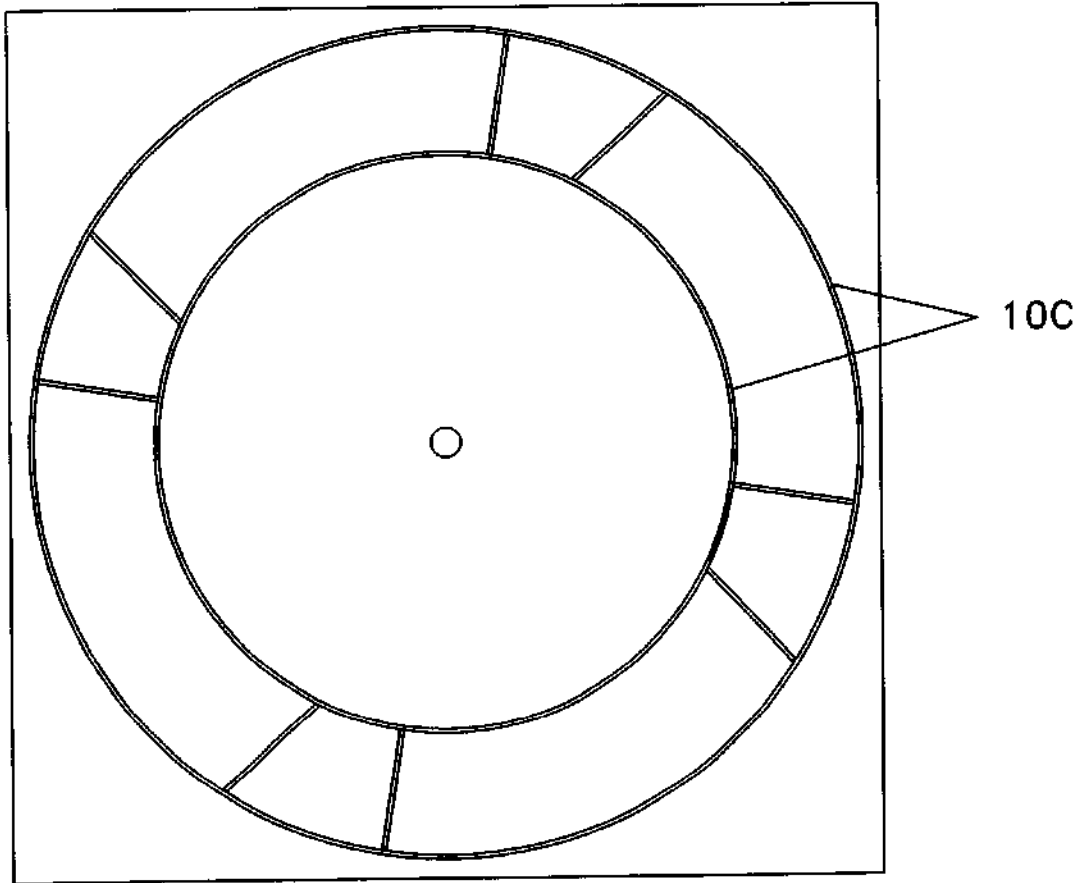


Fig. 5

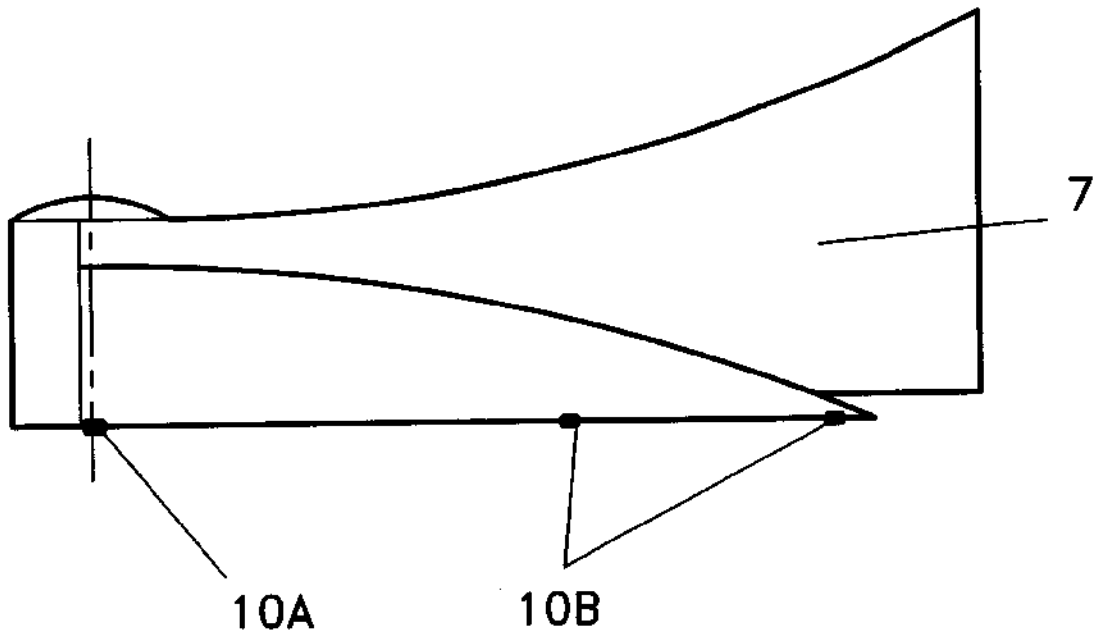


Fig. 6

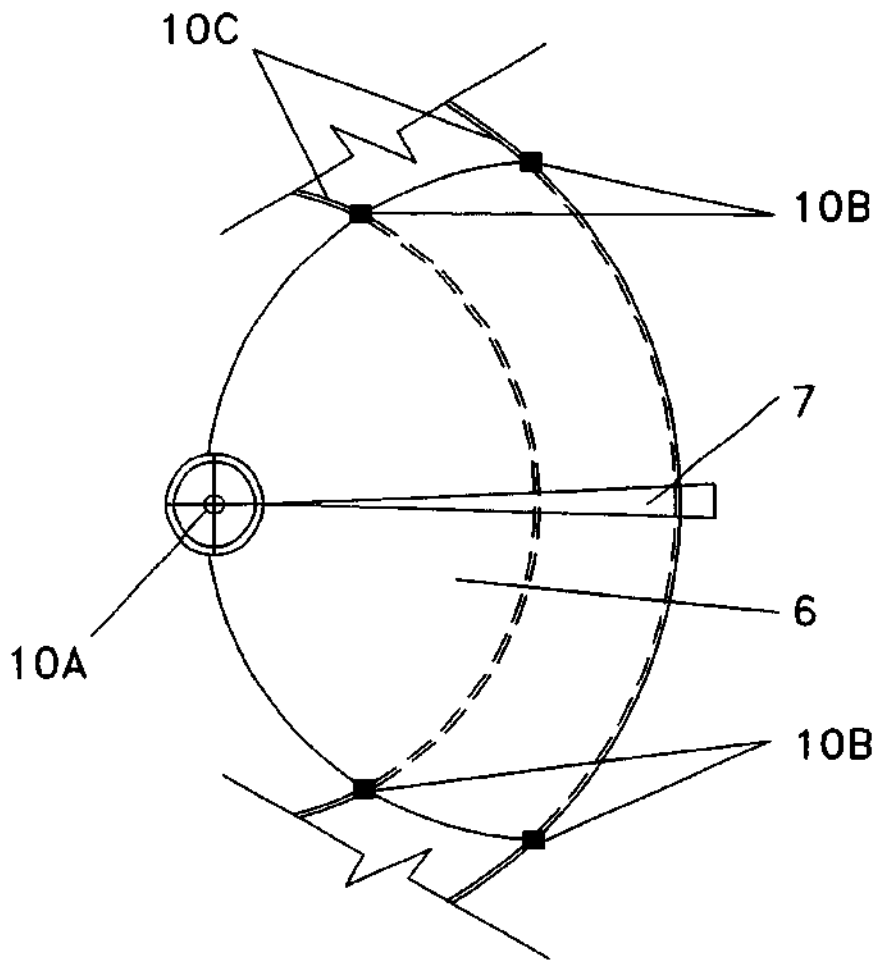


Fig. 7

**WATER POWER GENERATION SYSTEM**

This continuation-in-part application claims priority to the U.S. non-provisional application Ser. No. 09/452,734, filed Dec. 1, 1999, now U.S. Pat. No. 6,191,496 which in turn claims the benefit of provisional application Ser. No. 60/110,519, filed on Dec. 1, 1998, the contents of each that application are hereby incorporated by reference.

**BACKGROUND OF THE INVENTION**

The present invention relates to water turbines generally, used to convert water kinetic energy into mechanical energy, and more specifically, vertical-axis turbines. Although from some perspectives it is a different problem, the invention may, perhaps surprisingly, present understandings which can also apply to the field of wind power generation and vice versa. The present invention may specifically be related to turbine systems used in power generation from such resources as wind or moving or running water. Although the present invention may be described herein, in accordance with certain embodiments, with regard to the conversion of wind energy, it should be understood that the disclosed concepts of turbine systems and power generation may also be applicable to other fluidic resources, such as moving or running water, even though the two fields can be considered very different in the art from some perspectives.

Vertical-axis turbines are typically of a long axis type, allowing large columns of air to be harnessed. These devices differ from horizontal-axis (propeller) type windmills which typically pivot about a vertical axis in order that they may face directly into a wind. The present invention more specifically relates to vertical-axis turbines designed to be employed as a cost effective alternate power source in any wind condition.

Wind as a source of energy is a concept that has been promoted for some time. According to one source, there is evidence which shows that windmills were in use in Babylon and in China as early as 2000 B.C. The U.S. Patent and Trademark Office has granted patents on windmill devices dating back to the early to mid 1800's. Despite the continued research and development in this age old technology, until the present invention, no windmill or wind turbine device has successfully appropriately addressed some of the most important problems which have seemingly made the harnessing of wind not economically feasible. While wind is unquestionably a large potential source of energy, estimated to be about 5 kW per acre in the United States, its variability in velocity has made it an unreliable source. Many devices such as U.S. Pat. Nos. 4850792 to Yeoman, 4,035,658 to Diggs and 2,406,268 to Terhune have relied on the ability of concentrating low to moderate winds for producing power. Others, like those shown in U.S. Pat. Nos. 4,834,610 to Bond and 4,075,500 to Oman, et al. (a horizontal-axis turbine), have accomplished the harnessing variable wind speeds by using modern variable speed governors. No device currently known to the present inventors is capable of adequately harnessing low and high-winds for power production. High winds are characterized, for purposes of discussion as currents having average velocities above 45 m.p.h., or having gusts greater than 60 m.p.h. Many devices are designed to fold and/or feather in winds reaching certain levels. Such devices are illustrated in U.S. Pat. Nos. 4,818, 181 to Kodric, 4,632,637 to Traudt, and 3,942,909 to Yengst. These techniques, while intended to protect the structural integrity of the windmill, decrease a device's ability to produce power. Others, such as Pat. No. 5,391,926 to Staley

and Elder, attempt to harness high winds emanating from any direction for power production but low to moderate winds have been unable to produce adequate torque for continual reliable power generation. Until the present invention variable winds have been an untapped source of energy by those skilled in the relevant art.

In the past, wind driven power generators of all sorts have attempted to harness the energy present in the wind. Some have concentrated their efforts in the low to moderate wind range and suffer periodic damage from the occasional high wind while others work well in the moderate to high wind range with little or no success in harnessing low speed wind. No prior art has effectively drawn useable power from the slight breeze all the way to gale force winds. Perhaps one of the biggest reasons for the lack of all wind turbines has to do with the structural integrity of typical wind devices. By design many are lightweight, inadequately supported, and made from insufficient materials. A number of these devices are comprised of a multitude of moving parts, such as rotors, stators, vanes, shields, and the like. These parts not only compromise the integrity of the machine, but also require continuous maintenance, repair and/or replacement. For such a device, which may produce only a few kilowatts of power, the costs soon begin to outweigh the benefits. Another concept widely used is to build large multi-story wind turbines capable of producing at or near the megawatt level. Two such devices are shown in U.S. Pat. Nos. 3,902, 072 to Quinn, and 3,994,621 to Bogie. It is believed that these devices would cost close to \$100 million to build and several hundred thousand to maintain each year. Another example is the 1.25 MW generator installed near Rutland, Vermont. This is believed to be the largest windmill ever built in the United States, having two main blades each 175 feet in diameter. This facility operated intermittently between 1941 and 1945, during the war years when most resources were being used for war efforts. In 1945 one of the blades broke due to material fatigue and was never repaired, presumably due to a lack of cost efficiency. Similar to the smaller units, these large devices become cost prohibitive on a much larger scale. The present invention solves this second problem by presenting a low cost, low maintenance, cost efficient wind turbine. While certain aspects of the design have been known, until the present invention the proper combination of elements, new and old, has not been achieved to provide a commercially viable product.

Variable wind velocity is not, of course, the only obstacle in harnessing kinetic energy from the wind. Wind direction has been another area of study and development. Wind currents are typically unpredictable, and due to topography, upper air disturbances, changing weather patterns, or seasonal variations, they rarely blow in the same direction for any substantial length of time. For this reason effective wind machines must be capable of immediately accommodating winds from a full 360 degrees. Some devices have attempted to accomplish this goal with pivoting shields, and stators or wind directing vanes. U.S. Pat. Nos. 4,474,529 to Kinsey, 5,37,494 to Stevens et al., the Yengst patent, and many other devices illustrate such an approach. As mentioned previously, additional moving parts usually detract from a machine's cost effectiveness. While not in the field of the present invention horizontal-axis machines typically pivot the entire rotor assembly so that it may face upwind. Still other designs leave the rotor assembly open (that is, no wind directing vanes or stators are utilized) so that winds from any horizontal direction may impart rotation upon the rotor assembly. This leaves the rotor completely open to the harshness and destructive abilities of the wind. Once again

the present invention solves this problem by providing 360 degrees of wind reception, in all types of wind conditions.

The present invention, in its various embodiments, recognizes and addresses these and other problems and overcomes many limitations encountered by those skilled in the art. Many devices and procedures have taught the use of folding or feathering in high wind conditions, and thus have been unable to realize the potential power of high winds. Others, such as the Staley and Elder patent have attempted to address the damaging characteristics of high winds by stressing structural integrity and durability to the point of sacrificing the ability to produce adequate torque in the low to moderate wind speed range. It is not economically feasible to build a wind turbine that can only produce mechanical power during periods of high wind. The entire range of wind conditions must be fully utilized for a wind turbine to be commercially viable. Problems such as high cost and high maintenance of most wind energy facilities exist in the field, but such problems have not been adequately addressed by those skilled in the art. While high velocity wind is a well known natural occurrence with high kinetic energy, its value in the field of vertical-axis wind turbines has not only been ignored to some extent, it has often been looked upon as a detriment. The prior art has taught away from the present invention by stressing rotor attachment and stator curvature. Rather than supplying a system which affords only an incremental increase in performance over the prior art, the present invention utilizes techniques which were not previously considered in order to achieve what may perhaps be leaps in performance compared to the prior art. Further, the present invention has achieved a more full utilization of a previously untapped precious natural resource, the wind.

The present invention also provides, in various embodiments, systems which allow for other fluidic resources to be utilized in techniques that may not have been previously considered. The present invention further discloses systems and techniques for the conversion of energy from fluidic sources such as moving or running water. Prior attempts to harness water, for example, as a source of kinetic energy may have suffered from common issues related to fluidic energy conversion as identified above. The concepts and techniques of the present invention, therefore, provide turbine systems and techniques which may not only be directed to sources of energy such as water, but which may further address inadequacies of past efforts.

### SUMMARY OF INVENTION

The present invention discloses, in some embodiments, a wind turbine to operate in all wind conditions, such as velocities up to 130 mph, and frequently changing wind directions. The device provides a reliable and effective means for directing air currents into and out of the rotor cage assembly. Rather than supplying a system which affords only an incremental increase in performance and design over the prior art, the present invention utilizes combinations and techniques which were not previously considered to achieve an increase in performance unparalleled by the prior art. This invention serves to operate with a minimum number of movable parts and systems, to optimize potential power production by allowing energy from high winds to be harnessed as well as low and moderate winds, and to optimize air current intake and exhaust by providing immediate accommodations to winds from any given direction.

In additional embodiments, the present invention discloses a fluid turbine, and in some embodiments a water turbine, operable in various moving or running fluidic

conditions, and in some embodiments water conditions, such as slow to medium to fast water currents and frequently changing water current direction. Accordingly, the invention serves to operate with a minimum number of parts and systems, to optimize potential power production by allowing energy from fast or swift moving water currents or other fluid to be harnessed, as well as slow to medium or moderate currents, and to optimize water current intake and exhaust by providing immediate accommodations to water current from any given direction.

In general terms, the invention involves various embodiments of a vertical-axis wind turbine. Many of the elements of this device achieve several different objectives which, when combined, act to achieve the mentioned increases in performance. In the preferred embodiment, the invention discloses stationary stators for more effectively directing currents into the rotor cage assembly to impart a higher rotational velocity and greater torque upon the turbine shaft through some torque generating elements such as the rotor blades. In addition, the stationary stators provide a structural integrity necessary for operation during high wind conditions. This aspect also prevents the disruption of rotation by shielding the rotors from winds counter-directional to their rotation which may occur as the wind shifts. The invention, in additional embodiments, may further involve the above described concepts and features for vertical-axis water turbine.

Importantly, the invention breaks from several time honored traditions in harnessing wind and water energy. By recognizing and utilizing the potential energy of all winds and water currents, and by designing an apparatus with resistance to the destructiveness of these winds and water currents during standard operation the present invention achieves its goals.

Accordingly, the present invention provides an omni-wind, vertical-axis turbine. The stated invention acts to convert wind currents into mechanical energy which energy may then be transferred from a turbine or the like to be used to directly act upon a water pump, or to drive an electrical generator (or more generically an energy-utilizing device) for use as an alternate power source. The turbine may be equipped with any number of rotors and stators which interact with the variable wind currents during operation. In addition, a minimum number of moving parts is used to increase reliability, to decrease maintenance, and to decrease production costs. The invention, in additional embodiments, may further involve the above described concepts and features for vertical-axis water turbine.

It is an object of the present invention to provide a design which is capable of operation in a variety of wind conditions. Such conditions include, but are not limited to, winds from any direction which possess a horizontal component, even where such wind direction is capable of frequent changes, winds reaching velocities of 130 m.p.h. or more, and winds with continuously changing velocities. It is an object that the present invention be capable of standard operation during these conditions without any need for employing folding and feathering techniques, or a speed control or braking system. The invention, in additional embodiments, may further involve the above described concepts and features directed to particular water or other fluid characteristics for vertical-axis water turbine.

It is another object of the present invention to provide a design which is capable of immediately accommodating winds from any direction having a horizontal component, as stated earlier. It is an object that this immediate readiness of



the present invention be achievable with no moving parts. The invention, in additional embodiments, may further involve the above described concepts and features for vertical-axis water turbine.

It is, therefore, an object of the present invention to provide a design which utilizes a minimum of moving parts for improved reliability. It is an object that necessary maintenance and replacement of any parts should be minimized, and the durability of the entire apparatus be vastly improved.

Additionally, it is an object of the present invention to provide a design which may be applicable to other fluid systems such as water or other fluids.

Naturally, further objects of the invention are disclosed throughout other areas of the specification and claims.

#### BRIEF DESCRIPTION OF DRAWINGS

Drawing 1 is a perspective view of an embodiment of the invention from the side.

Drawing 1A is a perspective of the new invention from the top.

Drawing 1B depicts a side view of a second embodiment of the invention.

Drawing 2 is a view of the rotor cage from the side.

Drawing 2A is a conceptual drawing of the rotor cage assembly from the side.

Drawing 3 is a perspective view of the rotor cage from the top showing the alignment of the rotor blades.

Drawing 4 is a view of the stator blades from the side.

Drawing 4A is a conceptual drawing of the stator blades from the side.

Drawing 4B is a top view of the stator blades showing their alignment.

Drawing 5 shows the stator cage cover which allows the invention to be "topless."

Drawing 6 is a view of the top shield from the side.

Drawing 7 is a perspective view of the top shield from above.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following descriptions and referenced drawings are for selected preferred embodiments of the present invention. Naturally, changes may be made to the disclosed embodiments while still falling within the scope and spirit of the present invention and the patent granted to its inventor.

As can be seen from the drawings, the basic concepts of the present invention may be embodied in many different ways. FIG. 1 and 1A show the preferred embodiment of the wind turbine (8) having a shaft (1) that is turned by rotor blades (2) that are attached to a top rotor cage plate (3) and bottom rotor cage plate (4) then drive an energy-transfer element (11) and an energy-utilizing device (12) (both shown as contained within or at the base). The height of these rotor blades in one of the preferred embodiments is 4 feet 8 inches but will vary proportionally with the size of the unit built. Furthermore, in accordance with preferred embodiments of the present invention, from 2 to 5 blade elements may be used. Wind, and in some embodiments water or other fluid, is compressed and directed to the rotor blades (2) by numerous stator blades (5). Wind with a downward diagonal thrust can be accommodated by the rotor blades (2) through use of an open stator cage cover (10) that renders the turbine (8) at least partially topless and

increases efficiency by up to an estimated 20% over any prior art. Wind attempting to enter the turbine (8) against the prevailing wind direction and hence against the direction of the rotors is deflected by top shield (6). Top shield (6) has a central pivoting point and an outer terminus and moves about the open top of turbine (8) by use of a center bearing (10A) side bearings (10B) and bearing race (10C). The movement of the top shield (6) to a downwind position is aided by the top shield vane (7). FIG. 1B depicts a second embodiment of the present invention wherein top shield (6) is not provided with a vane. The top shield (6) creates an area on the downwind side of the turbine (8) that is of low turbidity and increases the invention's ability to exhaust wind passing through the machine. The top shield (6) does not at any time hinder the accommodation of productive winds from any direction.

The above described features of an embodiment of the present invention may further be applicable to other fluid resources, such as water, and in particular, water turbines. The present invention, in alternative embodiments, may provide a fluid turbine system directed to particular fluid currents, and in some embodiments, water currents. The above description of the present invention, therefore, equally applies to systems for fluid currents, and in particular, water currents.

FIG. 2 and 2A show the rotor cage (1) which may be of a double wall design constructed of a lightweight composite material as is commonly used in the aircraft and boating industries. Total rigidity and structural integrity may be enhanced by the top rotor cage plate (3) and the bottom rotor cage plate (4).

Please note that the top plate (3) may be arced slightly to better compress and direct air or other fluid into the rotor cage. A reverse angle on the bottom rotor cage plate (4) may accomplish the same task but with an upward thrust.

Only the top and bottom rotor cage plates may be attached to the shaft. This unique aspect can aid in the invention's ability to readily accept, utilize and exhaust wind or other fluid. Structural integrity and rigidity may be enhanced by the rotor blades being attached in two places rather than directly to the shaft as in previous art. The present invention also provides particular embodiments directed to fluid currents, and in some embodiments, water currents. The above description equally applies to systems for fluid currents, and in particular, water currents.

FIG. 3 shows the layout of the rotor blades (1) with respect to each other as well as to the shaft (2). Special note should be taken of the space (3) between the shaft (2) and the inside edge of the rotor blades (1). This space is a substantial component of one embodiment of the invention in a number of ways. First, by allowing some of the air, water, or other fluid to flow through the center of the machine, the air or water impacts the blade on the downwind side of the invention adding to thrust and aiding in the exhaust cycle. The space between the shaft and rotor can also achieve greater torque by pushing the kinetic energy of the wind or water current to be exerted further away from the center point (i.e., the shaft). The flat surfaces of the rotor blades allow wind or water current to impart its force and be immediately deflected. A curved or cupped surface (as described in previous art) may allow air or water to collect in the curvature and cushion the force of subsequent winds. The layout of the rotor cage in the preferred embodiment is shown but it must be mentioned that changes may be made to the layout without departing from the broad aspect of the present invention. Of course, the present invention may

provide particular embodiments directed to fluid currents, and in some embodiments, water currents. The above description of the present invention equally applies to systems for fluid currents, and in particular, water currents.

The deflected air, water or other fluid from the rotor blades is also able to find its way through the space between the shaft and the rotor blades to aid in the invention's ability to exhaust. The space between the rotor blades and the shaft in the preferred embodiment vary proportionately with the size of the unit built.

In FIG. 4, 4A and 4B, the stator blades (5) are arranged around the circumference of the rotor cage in equidistant pairs. In the preferred embodiment 8 blades are shown but more or fewer blades could be used without substantially departing from the broad aspect of the present invention. Unlike previous art, which had curved stator blades it has been found that straight stators that are offset from the center point allows air to enter the turbine with less turbidity and thus more force. When an attempt is made to bend or change the direction of air currents (as previous art has done with curved stator blades), or as in fluidic currents generally, such as water currents, the force of the wind may be greatly diminished. Straight stators, while directing air into the invention, can have a minimal effect on the loss of kinetic energy. The wind turbine has been designed to accept all available winds regardless of their speed and thus has no need for a stator design that would dampen or lessen the force of the wind. The stator blades may be constructed of the same lightweight composite as the rotor cage and are of a double wall design. The width of the double walls enhances structural stability and rigidity while the resultant stator blades are lightweight and are easily shipped and erected. Of course, the present invention may provide particular embodiments directed to fluid currents, and in some embodiments, water currents. The above description of the present invention equally applies to systems for fluid currents, and in particular, water currents.

The overall weight of the components can be an integral part of the invention. While mass (i.e., weight) can be used to dampen or deaden vibration, the new invention operates so smoothly that lightweight materials will not jeopardize structural integrity and will allow the turbine to be placed atop existing buildings or in environmentally sensitive areas or areas where large erection equipment would have no access, or in accordance with some embodiments of the present invention, either partially or completely submerged.

FIG. 5 depicts the alignment of the stator cage cover. This is the part of the invention that allows the turbine to be virtually topless with regard to incoming currents of air or water. Once properly attached to the stator blades, the turbine is structurally sound and is ready to withstand with regard to wind turbine embodiments, winds in excess of 100 m.p.h. Air currents approaching the rotor cage that have a slightly downward thrust pass through the open top (between the bearing races) and impact the rotor blades creating rotation. Previous art was able to accommodate wind currents that moved horizontally only, and thus, were able to accommodate only a portion of the wind that can be handled by the new invention. Of course, the present invention may provide particular embodiments directed to fluid currents, and in some embodiments, water currents. The above description of the present invention regarding current speed and direction equally applies to systems for fluid currents, and in particular, water currents.

The stator cage cover may be constructed of rigid steel with concentric braces to ensure structural stability. On the

top side of the concentric braces are bearing races to accommodate the top shield bearings.

FIGS. 6 and 7 show the top shield and top shield vane (also constructed of lightweight composite). The top shield may be laminated for strength while the vane can be a double wall design to create enough drag to rotate the top shield to a downwind position. FIG. 1B depicts a second, alternative embodiment wherein the vane technique is not incorporated, such embodiment usable for any fluid current.

Once the shield is in proper position, wind or water with a downward thrust is also allowed to enter the wind or water turbine. (Modeling done to date shows that the open top embodiment increases performance by up to about 20%.) The top shield prevents conflicting winds or waters, or the current thereof, and in some embodiments down currents, from entering the invention from the downwind side that would interfere with rotation or exhausting. The space between the top shield and the rotor cage can create a space of calm air or water that may improve the invention's exhausting characteristics and that has a dampening feature. The front side or upwind or up current side of the top shield is slightly convex on the horizontal plane and may prevent the top shield from buffeting during periods of high winds or fast water currents. The center bearing (10A) of the top shield (6) can allow the mechanism to pivot easily while wheels or bearings (10B) resting on the concentric bearing races (10C) may carry the weight of the top shield. The wind or water vane or tail of the top shield (7) can aid in the top shield's ability to move into a position opposing the wind or water current and may enhance the shield's stability during operation.

It is important to note that the previously described invention may be applicable to fluid systems generally, and in some embodiments, is directed to water turbine systems. All of the disclosure presented herein should be considered enabling disclosure not only for wind turbines and systems thereof, but of systems and techniques for any fluid medium, and in some embodiments, to water and water currents.

As can be easily understood from the foregoing, the basic concepts of the present invention may be embodied in a variety of ways. It involves both the harnessing of kinetic energy techniques as well as devices to accomplish the appropriate harnessing of energy. In this application, the harnessing techniques are disclosed as part of the results shown to be achieved by the various devices described, including turbine systems, and as steps which are inherent to utilization. They are simply the natural result of utilizing the devices as intended and described. In addition, while some devices are disclosed, it should be understood that these not only accomplish certain methods but also can be varied in a number of ways. Importantly, as to all of the foregoing, all of these facets should be understood to be encompassed by this disclosure.

It should also be understood that a variety of changes may be made without departing from the essence of the invention. Such changes are also implicitly included in the description. They still fall within the scope of this invention. A broad disclosure encompassing both the explicit embodiment(s) shown, the great variety of implicit alternative embodiments, and the broad methods or processes and the like are encompassed by this disclosure.

Further, each of the various elements of the invention and claims may also be achieved in a variety of manners. This disclosure should be understood to encompass each such variation, be it a variation of an embodiment of any apparatus embodiment, a method or process embodiment, or

even merely a variation of any element of these. Particularly, it should be understood that as the disclosure relates to elements of the invention, the words for each element may be expressed by equivalent apparatus terms or method terms—even if only the function or result is the same. Such equivalent, broader, or even more generic terms should be considered to be encompassed in the description of each element or action. Such terms can be substituted where desired to make explicit the implicitly broad coverage to which this invention is entitled. As but one example, it should be understood that all actions may be expressed as a means for taking that action or as an element which causes that action. Similarly, each physical element disclosed should be understood to encompass a disclosure of the action which that physical element facilitates. Regarding this last aspect, as but one example, the disclosure of a “shield” should be understood to encompass disclosure of the act of “shielding”—whether explicitly discussed or not—and, conversely, were there effectively disclosure of the act of “shielding”, such a disclosure should be understood to encompass disclosure of a “shield” and even a “means for shielding”. Such changes and alternative terms are to be understood to be explicitly included in the description.

Any patents, publications, or other references mentioned in this application for patent are hereby incorporated by reference. In addition, as to each term used it should be understood that unless its utilization in this application is inconsistent with such interpretation, common dictionary definitions should be understood as incorporated for each term and all definitions, alternative terms, and synonyms such as contained in the Random House Webster’s Unabridged Dictionary, second edition are hereby incorporated by reference. Finally, all references listed in the information statement filed with the application are hereby incorporated by reference, however, as to each of the above, to the extent that such information or statements incorporated by reference might be considered inconsistent with the patenting of this/these invention(s) such statements are expressly not to be considered as made by the applicant(s).

Thus, the applicant(s) should be understood to have support to claim at least: i) each of the turbine devices as herein disclosed and described, ii) the related methods disclosed and described, iii) similar, equivalent, and even implicit variations of each of these devices and methods, iv) those alternative designs which accomplish each of the functions shown as are disclosed and described, v) those alternative designs and methods which accomplish each of the functions shown as are implicit to accomplish that which is disclosed and described, vi) each feature, component, and step shown as separate and independent inventions, vii) the applications enhanced by the various systems or components disclosed, viii) the resulting products produced by such systems or components, and ix) methods and apparatuses substantially as described hereinbefore and with reference to any of the accompanying examples, and x) the various combinations and permutations of each of the elements disclosed. Further, if or when used, the use of the transitional phrase “comprising” is used to maintain the “open-end” claims herein, according to traditional claim interpretation. Thus, unless the context requires otherwise, it should be understood that the term “comprise” or variations such as “comprises” or “comprising”, are intended to imply the inclusion of a stated element or step or group of elements or steps but not the exclusion of any other element or step or group of elements or steps. Such terms should be interpreted in their most expansive form so as to afford the applicant the broadest coverage legally permissible.

I claim:

1. A vertically rotating water turbine, comprising:
  - a. a water-collecting base with a bottom surface defining an area and a top surface defining an area wherein said area of said bottom surface is larger than said area of said top surface and wherein said top surface comprises an energy-transfer element and wherein said water-collecting base comprises an upward tapered base having an angle to smoothly direct water currents;
  - b. a vertically rotating shaft with a top end and a bottom end wherein said bottom end is mechanically connected to said energy-transfer element;
  - c. an energy-utilizing device responsive to said shaft through said energy-transfer element of the top surface of said base;
  - d. a round top plate attached in the vicinity of the top end of said vertically rotating shaft;
  - e. a round bottom plate that defines a diameter and is attached to said vertically rotating shaft at a location above the top surface of said base;
  - f. a plurality of vertically oriented torque generating elements having outer edges and inner edges which are located circumferentially around said vertically rotating shaft between said round top plate and said round bottom plate and are attached to said round top plate and said round bottom plate at their ends to form a cage assembly;
  - g. a plurality of vertically oriented flat water directing elements arranged circumferentially around said cage assembly and adjacent to said outer edges of said vertically oriented flat torque generating elements;
  - h. an open cover comprising concentric braces comprising two side bearings; and
  - i. a top shield having a central pivoting point and an outer terminus above said side bearings of said open cover.
2. A vertically rotating water turbine as described in claim 1 wherein said angle to smoothly direct water currents is between 20° to 45°.
3. A vertically rotating water turbine as described in claim 2 wherein said top surface of said base comprises a square surface, wherein said bottom surface of said base comprises 8 corners and wherein said base comprises a special spacial geometry that has planar surfaces connecting said bottom surface to said top surface.
4. A vertically rotating water turbine as described in claim 1 wherein said vertically rotating shaft is responsive to said cage assembly and passively rotates.
5. A vertically rotating water turbine as described in claim 1 wherein each of said plurality of vertically oriented torque generating elements is solely attached to said round top plate and said round bottom plate at its ends to form said cage assembly.
6. A vertically rotating water turbine as described in claim 5 wherein each of said torque generating elements has at least three differently oriented surfaces.
7. A vertically rotating water turbine as described in claim 6 wherein each adjacent pair of said differently oriented surfaces comprises an angle wherein said angle is about 147°.
8. A vertically rotating water turbine as described in claim 7 wherein said plurality of said torque generating elements comprises from 2 to 5 torque generating elements.
9. A vertically rotating water turbine as described in claim 8 wherein said torque generating elements are free from said vertically rotating shaft wherein each of said inner edges of said torque generating elements and said vertically rotating shaft form a free space.

## 11

10. A vertically rotating water turbine as described in claim 9 wherein said free space comprises an exhaust space.

11. A vertically rotating water turbine as described in claim 9 wherein said torque generating elements comprise rotor blades.

12. A vertically rotating water turbine as described in claim 11 wherein each of said rotor blades is about 4'8" in height.

13. A vertically rotating water turbine as described in claim 12 wherein said rotor blades immediately accommodate all water conditions from the full 360 degrees.

14. A vertically rotating water turbine as described in claim 13 wherein said cage assembly comprises a rotor cage assembly wherein said top round plate is a top rotor cage plate and said bottom round plate is a bottom rotor cage plate.

15. A vertically rotating water turbine as described in claim 14 wherein said rotor blades are capable of imparting rotation force upon said vertically rotating shaft indirectly through said rotor cage assembly during periods of sufficient water currents.

16. A vertically rotating water turbine as described in claim 15 wherein said rotor cage assembly is capable of responding to a change in current direction.

17. A vertically rotating water turbine as described in claim 16 wherein said rotor blades have a double wall design.

18. A vertically rotating water turbine as described in claim 1 wherein said flat water directing elements are attached to said base in equidistance pairs.

19. A vertically rotating water turbine as described in claim 18 wherein said flat water directing elements comprise at least two pairs.

20. A vertically rotating water turbine as described in claim 19 wherein said flat water directing elements comprise at least four pairs.

21. A vertically rotating water turbine as described in claim 20 wherein each pair of said flat water direct elements are circumferentially arranged on said base and comprise a water current pathway with an entrance opening larger than an exit opening toward said rotor blades.

22. A vertically rotating water turbine as described in claim 20 wherein said flat water directing elements comprise stationary stator blades.

23. A vertically rotating water turbine as described in claim 22 wherein said stator blades comprise flat vertical surfaces that have a minimal coefficient of friction when water currents pass through them.

24. A vertically rotating water turbine as described in claim 23 wherein said stator blades each face a specific direction to sufficiently accommodate water current from that specific direction.

25. A vertically rotating water turbine as described in claim 24 wherein said stator blades comprise double walls.

26. A vertically rotating water turbine as described in claim 1 wherein said open cover comprises an open stator cage cover.

27. A vertically rotating water turbine as described in claim 26 wherein said open stator cage cover comprises concentric bearing races that have a center bearing and two circular side bearings.

28. A vertically rotating water turbine as described in claim 1 wherein said top shield comprises a laminated top shield.

29. A vertically rotating water turbine as described in claim 24 and further comprising a calm water surface which forms a calm water area above at least a portion of said cage assembly.

## 12

30. A vertically rotating water turbine as described in claim 29 wherein said calm water surface comprises a convex surface on its up current side and a concave surface on its downcurrent side, wherein said downcurrent side forms said calm water area above said cage assembly.

31. A vertically rotating water turbine as described in claim 29 or 30 wherein said calm water area comprises an exhaust area.

32. A vertically rotating water turbine as described in claim 31 wherein said top shield covers less than about one third of said open cover area above said open cover.

33. A vertically rotating water turbine as described in claim 32 wherein said central pivoting point of said top shield is responsive to said central bearing of said open cover, wherein said outer terminus is responsive to said outer side bearing and wherein said top shield rotates in response to water direction.

34. A vertically rotating water turbine as described in claim 33 wherein said top shield enhances water harness and wherein said top shield comprises a vane.

35. A vertically rotating water turbine as described in claim 34 wherein said vane creates enough drag force to rotate said top shield to a downcurrent position in response to water directions and comprises double walls.

36. A vertically rotating water turbine as described in claim 1 wherein said water turbine comprises a long axis vertical turbine that is an omniscurrent turbine.

37. A vertically rotating water turbine as described in claims 1, 6, 12, 19, 25, 28, 36 wherein each of said elements comprises a lightweight material.

38. A method of harnessing kinetic energy from water currents, comprising the steps of:

- a. providing a base on which a water turbine is set and in which an energy utilizing device is located;
- b. providing a torque generating device on said base wherein said torque generating device comprises torque generating elements, a top plate, a bottom plate and a vertical shaft;
- c. providing a kinetic energy cascade pathway wherein kinetic energy from water currents is transferred from said torque generating elements to said shaft via said top and bottom plates;
- d. directing water currents from slow to fast currents regardless of direction onto said torque generating elements;
- e. compressing said water currents by gradually narrowing their pathways toward said torque generating elements to generate compressed water currents;
- f. collecting said compressed water currents;
- g. moving said torque generating elements around said shaft with said water currents;
- h. generating a torque force using said kinetic energy;
- i. converting said torque force into mechanical energy;
- j. driving said energy utilizing device with said mechanical energy; and
- k. smoothly exhausting said water currents.

39. A method of harnessing kinetic energy from water currents as described in claim 38 wherein said step of providing a base comprises the step of improving structural integrity of said water turbine by steadily attaching said water turbine to said base.

40. A method of harnessing kinetic energy from water currents as described in claim 38 and further comprising the step of creating a free water passing area in said water turbine.

41. A method of harnessing kinetic energy from water currents as described in claim 38 wherein said step of providing a kinetic energy cascade pathway comprises the step of utilizing a water directing base.

42. A method of harnessing kinetic energy from water currents as described in claim 41 wherein said step of providing a torque generating device comprises the step of utilizing curved torque generating elements.

43. A method of harnessing kinetic energy from water currents as described in claim 41 wherein said step of providing a torque generating device comprises the step of utilizing angled torque generating elements.

44. A method of harnessing kinetic energy from water currents as described in claim 43 wherein said step of providing a kinetic energy cascade pathway comprises the step of minimizing number of moving parts in said water turbine.

45. A method of harnessing kinetic energy from water currents as described in claim 44 wherein said step of minimizing said number of moving parts in said water turbine comprises the step of minimizing the number of said angled torque generating elements.

46. A method of harnessing kinetic energy from water currents as described in claim 45 wherein said step of providing a torque generating device on said base comprises the step of attaching said torque generating elements to said top plate and said bottom plate at their ends.

47. A method of harnessing kinetic energy from water currents as described in claim 46 wherein said step of providing a torque generating device on said base comprises the step of attaching said torque generating elements solely to said top plate and said bottom plate at their ends.

48. A method of harnessing kinetic energy from water currents as described in claim 47 wherein said step of providing a torque generating device comprises the step of efficiently utilizing water kinetic energy to generate said torque force.

49. A method of harnessing kinetic energy from water currents as described in claim 48 wherein said step of efficiently utilizing water kinetic energy to generate said torque force comprises the step of accommodating water currents from the full 360 degrees.

50. A method of harnessing kinetic energy from water currents as described in claim 49 wherein said step of efficiently utilizing water kinetic energy to generate said torque force comprises the step of accommodating all water conditions from slow to medium to fast water conditions.

51. A method of harnessing kinetic energy from water currents as described in claim 50 wherein said step of accommodating comprises the step of reducing weight of said water turbine by constructing said water turbine with lightweight materials.

52. A method of harnessing kinetic energy from water currents as described in claims 38, 41, 44, and 46 wherein said step of providing a kinetic energy cascade pathway comprises the step of combining said torque generating elements, said top plate, said bottom plate and said vertical shaft in a way that said torque force is transferred from said torque generating elements to said vertical shaft indirectly via said top plate and said bottom plate.

53. A method of harnessing kinetic energy from water currents as described in claim 38 wherein said step of directing water currents from slow to fast currents regardless of direction onto said torque generating elements comprises the step of defining pathways of said water currents.

54. A method of harnessing kinetic energy from water currents as described in claim 53 wherein said step of

compressing said water currents comprises the step of concentrating strength of said kinetic energy.

55. A method of harnessing kinetic energy from water currents as described in claim 54 wherein said step of moving said torque generating elements comprises the step of imparting high rotational velocity upon said vertical shaft.

56. A method of harnessing kinetic energy from water currents as described in claim 54 wherein said step of moving said torque generating elements comprises the step of optimizing a rotating velocity of said vertical shaft.

57. A method of harnessing kinetic energy from water currents as described in claim 56 wherein said step of converting said torque force into mechanical energy comprises the step of transferring said torque force from said vertical shaft to said energy utilizing device.

58. A method of harnessing kinetic energy from water currents as described in claim 38 wherein said step of efficiently collecting said water kinetic energy with said torque generating elements comprises the step of efficiently collecting kinetic energy from water currents from above said water turbine.

59. A method of harnessing kinetic energy from water currents as described in claim 58 wherein said step of efficiently collecting kinetic energy from water currents above said water turbine comprises the step of opening said water turbine from its top.

60. A method of harnessing kinetic energy from water currents as described in claim 54 wherein said step of efficiently collecting kinetic energy from water currents above said water turbine comprises the step of preventing counter-prevailing water currents from imparting upon said torque generating elements.

61. A method of harnessing kinetic energy from water currents as described in claim 60 wherein said step of preventing counter-prevailing water currents from imparting upon said torque generating elements comprises the step of shielding at least a partial opening area of said water turbine.

62. A method of harnessing kinetic energy from water currents as described in claim 61 wherein said step of shielding at least a partial opening area of said water turbine comprises the step of providing a calm water area on a downcurrent side with standard stability.

63. A method of harnessing kinetic energy from water currents as described in claim 62 wherein said step of preventing counter-prevailing water currents from imparting upon said torque generating elements comprises the step of shielding a downcurrent area above said water turbine.

64. A method of harnessing kinetic energy from water currents as described in claim 38 wherein said step of smoothly exhausting said water currents comprises the step of building a free water current escape passway.

65. A method of harnessing kinetic energy from water currents as described in claim 64 wherein said step of smoothly exhausting said water currents comprises the step of constructing a calm area with standard stability.

66. A vertically rotating water turbine, comprising:

- a. a base with a bottom surface defining an area and a top surface defining an area wherein said area of said bottom surface is larger than said area of said top surface and wherein said top surface comprises an energy-transfer element and wherein said base comprises an upward tapered base having an angle to smoothly direct water currents;
- b. a vertically rotating shaft with a top end and a bottom end wherein said bottom end is mechanically connected to said energy-transfer element;
- c. an energy-utilizing device responsive to said shaft through said energy-transfer element of the top surface of said base;

15

- d. a round top plate attached to said vertically rotating shaft;
- e. a round bottom plate that defines a diameter and is attached to said vertically rotating shaft;
- f. a plurality of vertically oriented flat torque generating elements having outer edges and inner edges which are localized circumferentially around said vertically rotating shaft at a space between said round top plate and said bottom plate and are attached therein to said round top plate and said bottom plate at their ends to form a cage assembly;
- g. a plurality of vertically oriented flat water directing elements arranged circumferentially around said cage assembly and adjacent to said out edges of said vertically oriented flat torque generating elements;
- h. an open cover comprising concentric braces; and
- i. a dampening top shield above said open cover having a central pivoting point and a convex front side surface with an outer terminus above said concentric braces above said open cover.

67. A vertically rotating water turbine as described in claim 66 wherein said dampening top shield further comprises a shield of exhausting water against counter-prevailing water currents.

68. A vertically rotating water turbine as described in claim 66 further comprising a top shield vane wherein said dampening top shield is responsive to said top shield vane.

69. A method of harnessing kinetic energy water currents, said method comprising the steps of:

- a. establishing a base on which a water turbine is set and in which an energy utilizing device is located;
- b. creating a torque generating device on said base wherein said torque generating device comprises

16

torque generating elements, a round top plate, a round bottom plate and a vertical shaft;

- c. creating a kinetic energy cascade pathway wherein said kinetic energy is transferred from said torque generating elements to said shaft via said top and bottom plates;
- d. directing water currents from slow to medium to fast currents regardless of direction onto said torque generating elements;
- e. directionally compressing said water currents by gradually narrowing their pathways toward said torque generating elements to generate compressed water currents;
- f. creating a top shield having an up current surface;
- g. dampening said torque generating elements with said top shield to accommodate high water force;
- h. collecting said compressed water currents;
- i. kinetically, vertically and axially imparting said torque generating elements around a shaft with water currents;
- j. generating a torque force using said kinetic energy;
- k. converting said torque force into mechanical energy;
- l. driving said energy utilizing device with said mechanical energy; and
- m. smoothly exhausting water.

70. A method of harnessing kinetic energy from water current conditions as described in claim 69 wherein said step of creating a top shield having an up current surface comprises the step of creating a calm water area with standard stability.

\* \* \* \* \*



US006499939B2

(12) **United States Patent**  
**Downing**

(10) **Patent No.:** **US 6,499,939 B2**  
(45) **Date of Patent:** **Dec. 31, 2002**

(54) **WATER WHEEL**

5,098,264 A \* 3/1992 Lew ..... 416/119  
6,006,518 A \* 12/1999 Geary ..... 60/398

(76) Inventor: **Eric E Downing**, 30921 Orwell Rd.,  
Ontario, WI (US) 54651

**FOREIGN PATENT DOCUMENTS**

(\* ) Notice: Subject to any disclaimer, the term of this  
patent is extended or adjusted under 35  
U.S.C. 154(b) by 0 days.

FR 2286955 A \* 4/1976 ..... 415/402  
JP 56-14870 A \* 2/1981 ..... 416/17  
JP 56-20776 A \* 2/1981 ..... 416/17

\* cited by examiner

(21) Appl. No.: **09/817,988**

*Primary Examiner*—John E. Ryznic

(22) Filed: **Mar. 27, 2001**

(74) *Attorney, Agent, or Firm*—Michael I. Kroll

(65) **Prior Publication Data**

(57) **ABSTRACT**

US 2002/0141858 A1 Oct. 3, 2002

(51) **Int. Cl.**<sup>7</sup> ..... **F03B 7/00**

(52) **U.S. Cl.** ..... **415/3.1; 416/119; 416/140**

(58) **Field of Search** ..... 415/2.1, 3.1, 4.1,  
415/4.2, 4.4, 121.2, 208.1; 416/9, 17, 117,  
119, 140

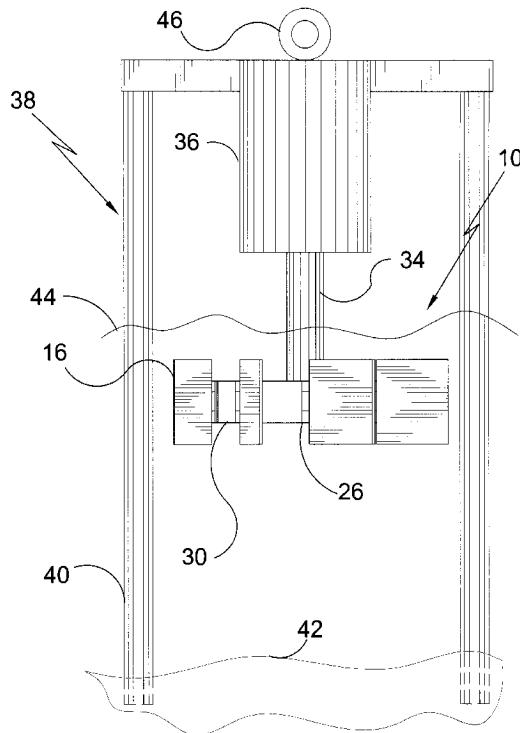
The present invention **10** discloses a wheel-like member **30** consisting of a central circular body member **18** having a plurality of spokes **22** radiating from its outside perimeter that attach to the inside perimeter of an outer circular body member **24**. On the outside perimeter of the outer circular body member a plurality of hinges **26** with paddles **16** are attached thereto that can only open to a pre-determined angle "A" from the wheel **30** that ensures water current **14** is caught by the paddles on only one side of the wheel which causes the wheel to rotate in only one direction. The kinetic energy stored in the wheel **30** while rotating is harnessed through a drive shaft **34** connected to the central circular body member **18** that connects to a generator **36** placed perpendicular to the central circular body member **18**. To keep the generator **36** and drive shaft **34** in place a plurality of support members **40**, with cross-member support couplers **48** are disposed into the bed **42** of the river or ocean that the device **10** is being used in.

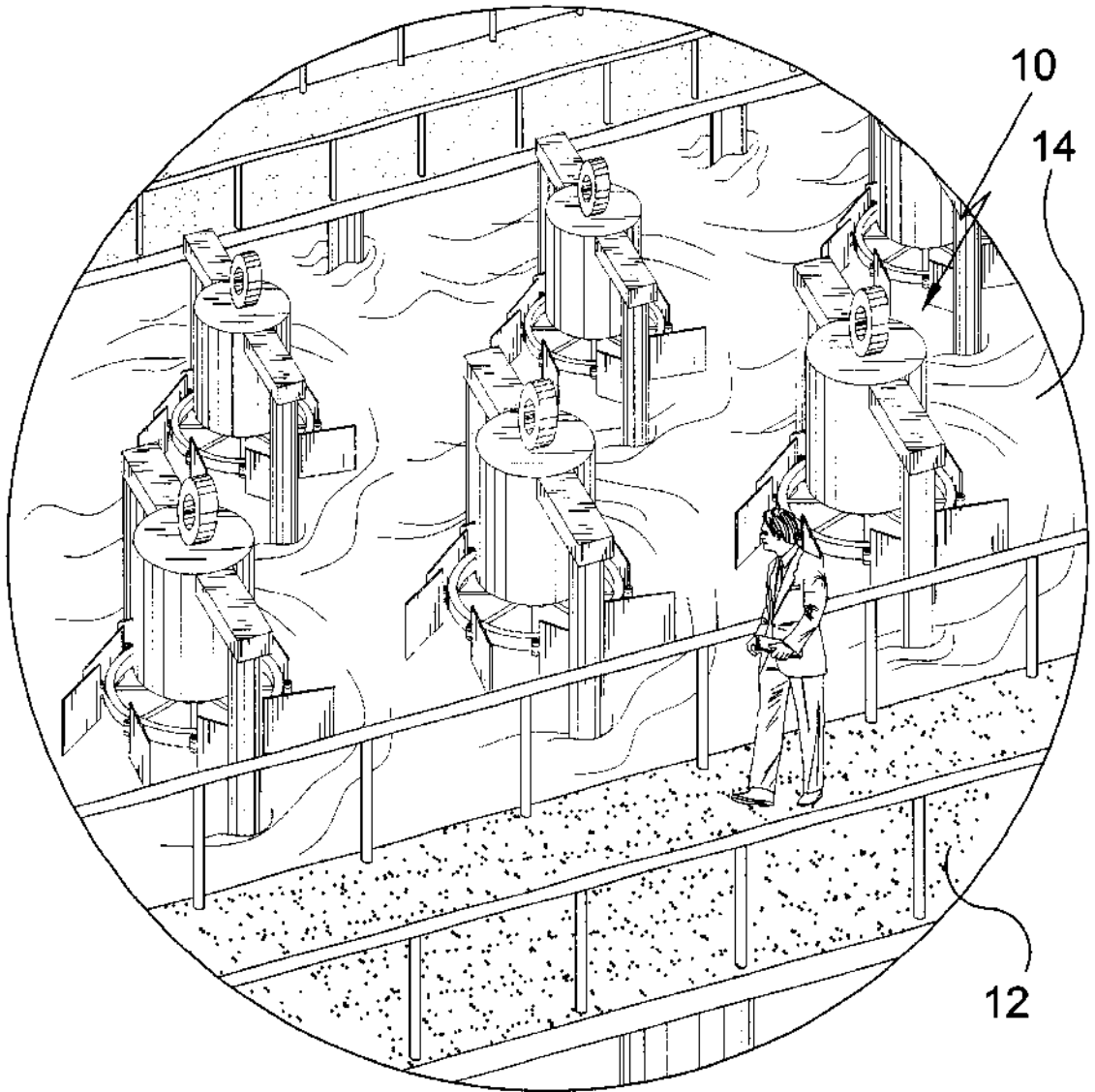
(56) **References Cited**

**U.S. PATENT DOCUMENTS**

X000,001 I1 \* 4/1831 Coney ..... 416/119  
4,517 A \* 5/1846 Hand ..... 416/119 X  
4,843 A \* 11/1846 Rowand ..... 415/3.1  
98,891 A \* 1/1870 Sovy ..... 416/119  
113,284 A \* 4/1871 Folsom ..... 416/119  
203,382 A \* 5/1878 Smith ..... 416/117  
302,769 A \* 7/1884 Pallausch ..... 416/119  
4,156,580 A \* 5/1979 Pohl ..... 415/4.2  
4,424,451 A \* 1/1984 Schmidt ..... 416/119 X  
5,051,059 A \* 9/1991 Rademacher ..... 415/3.1 X

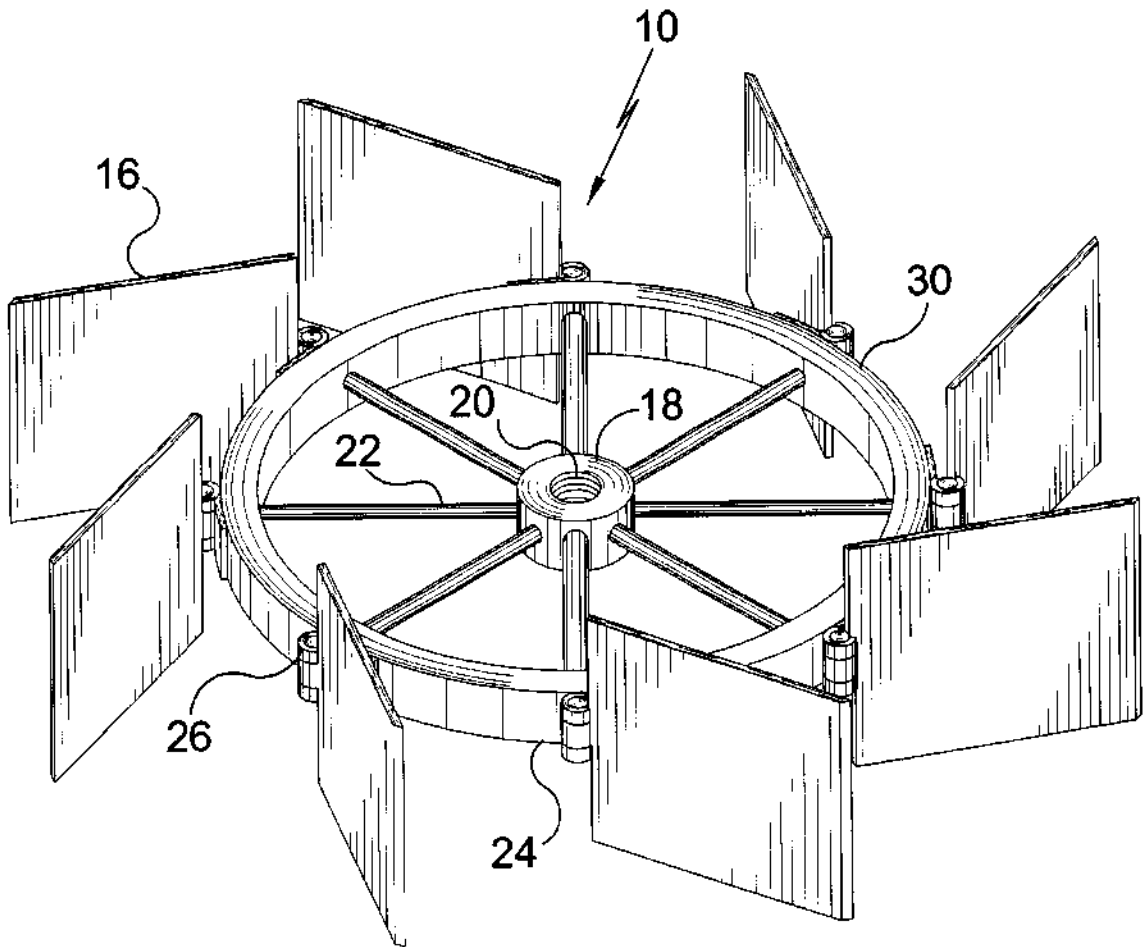
**1 Claim, 15 Drawing Sheets**



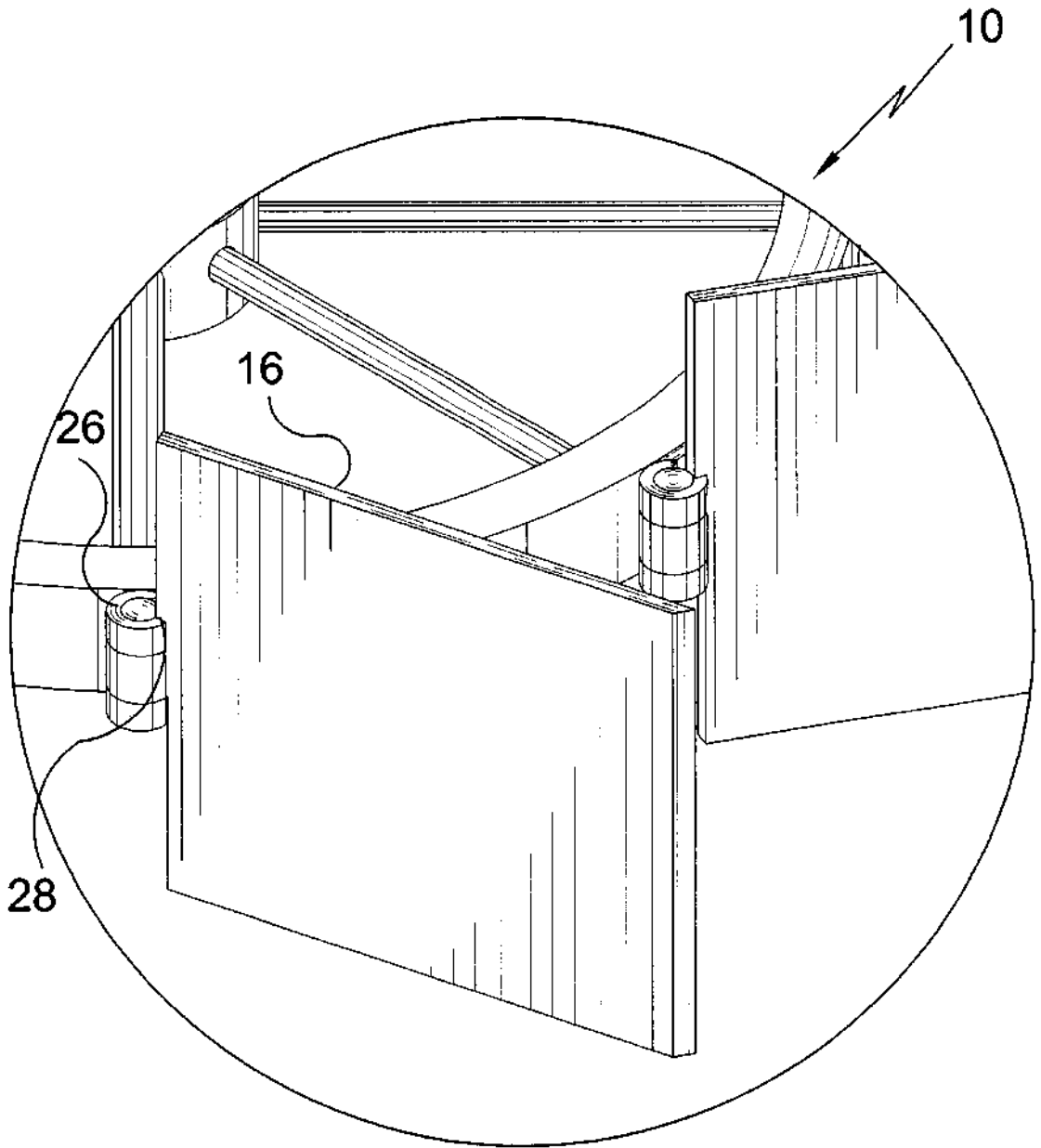


**FIG. 1**

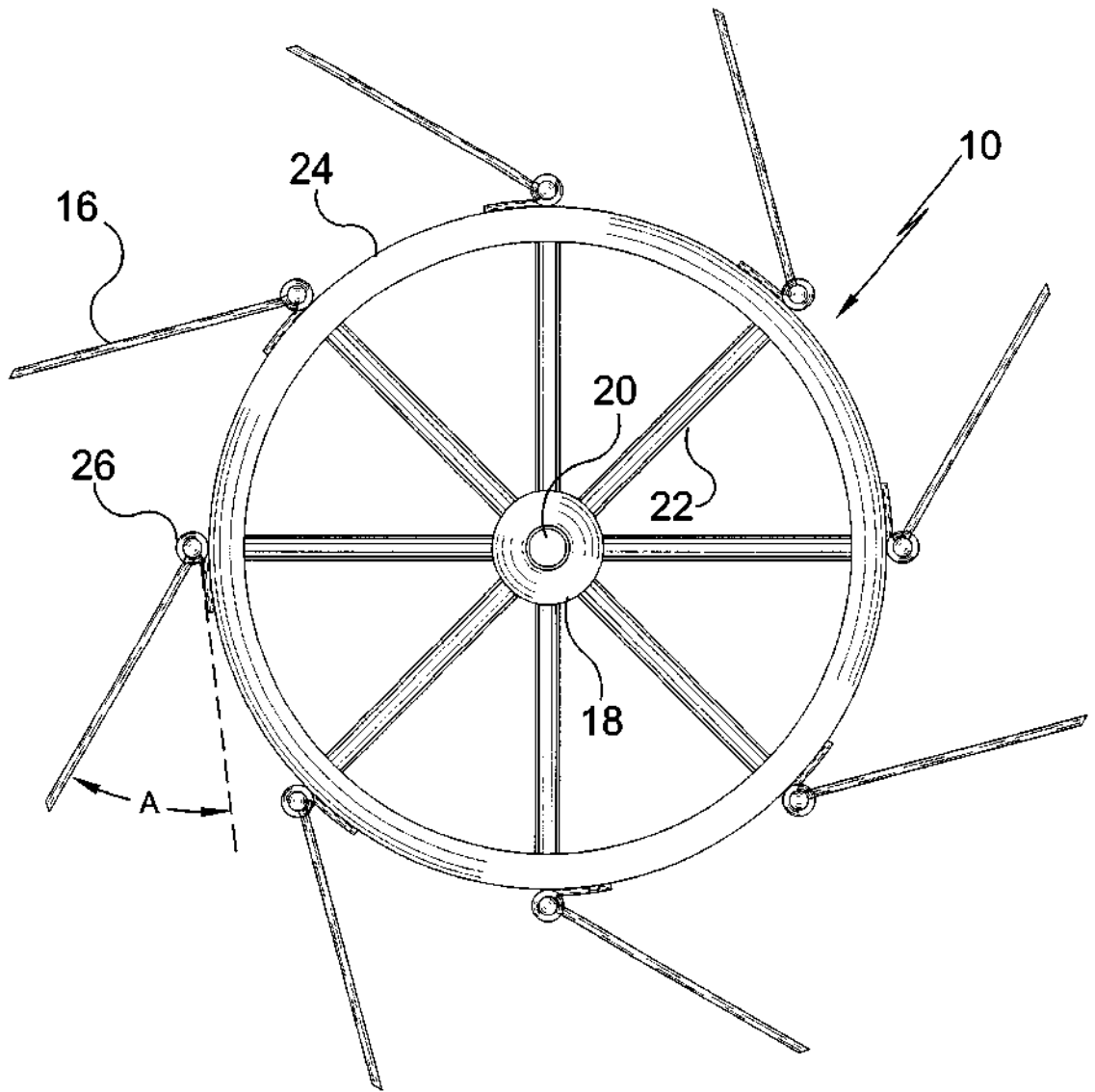




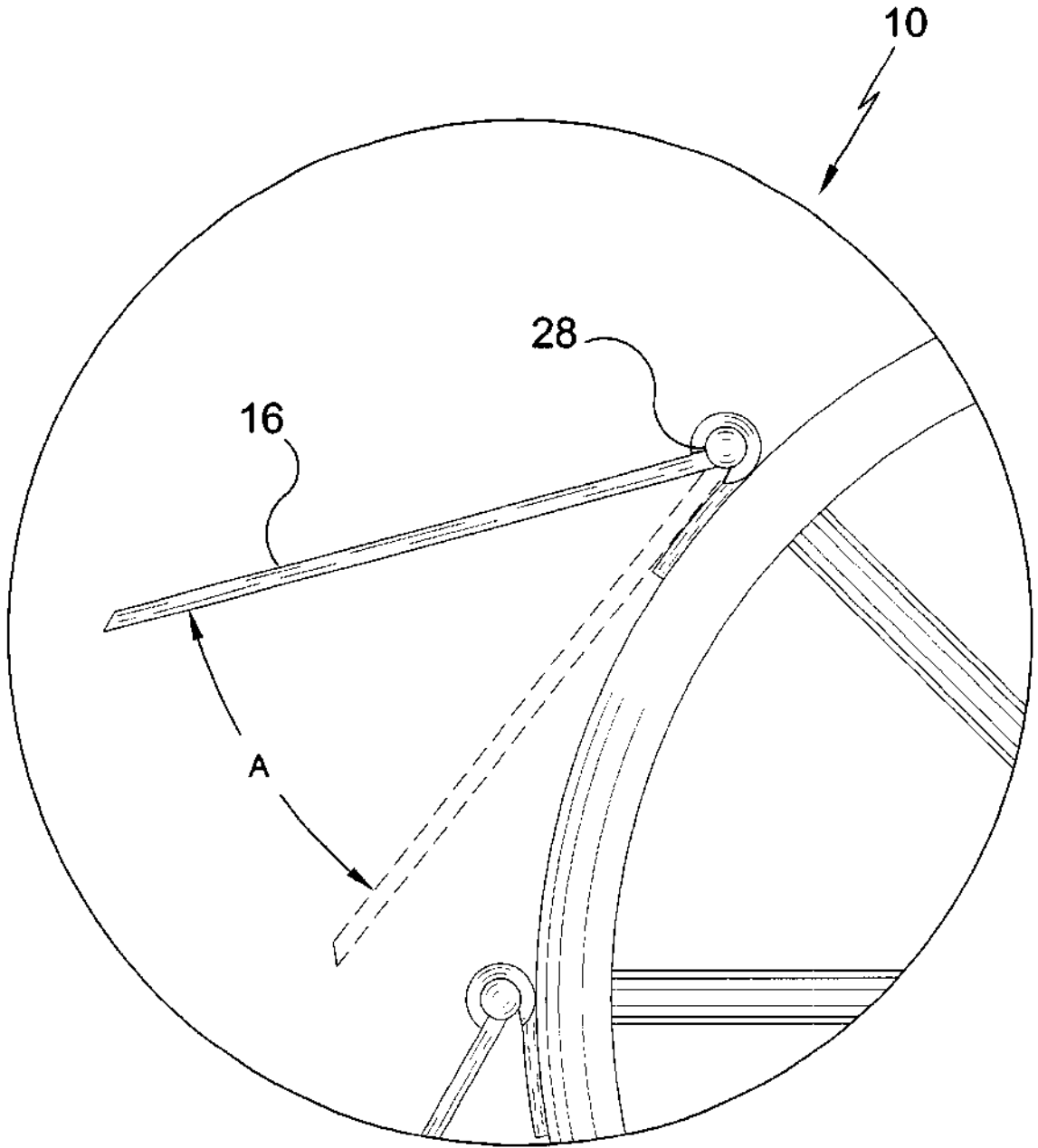
**FIG. 2**



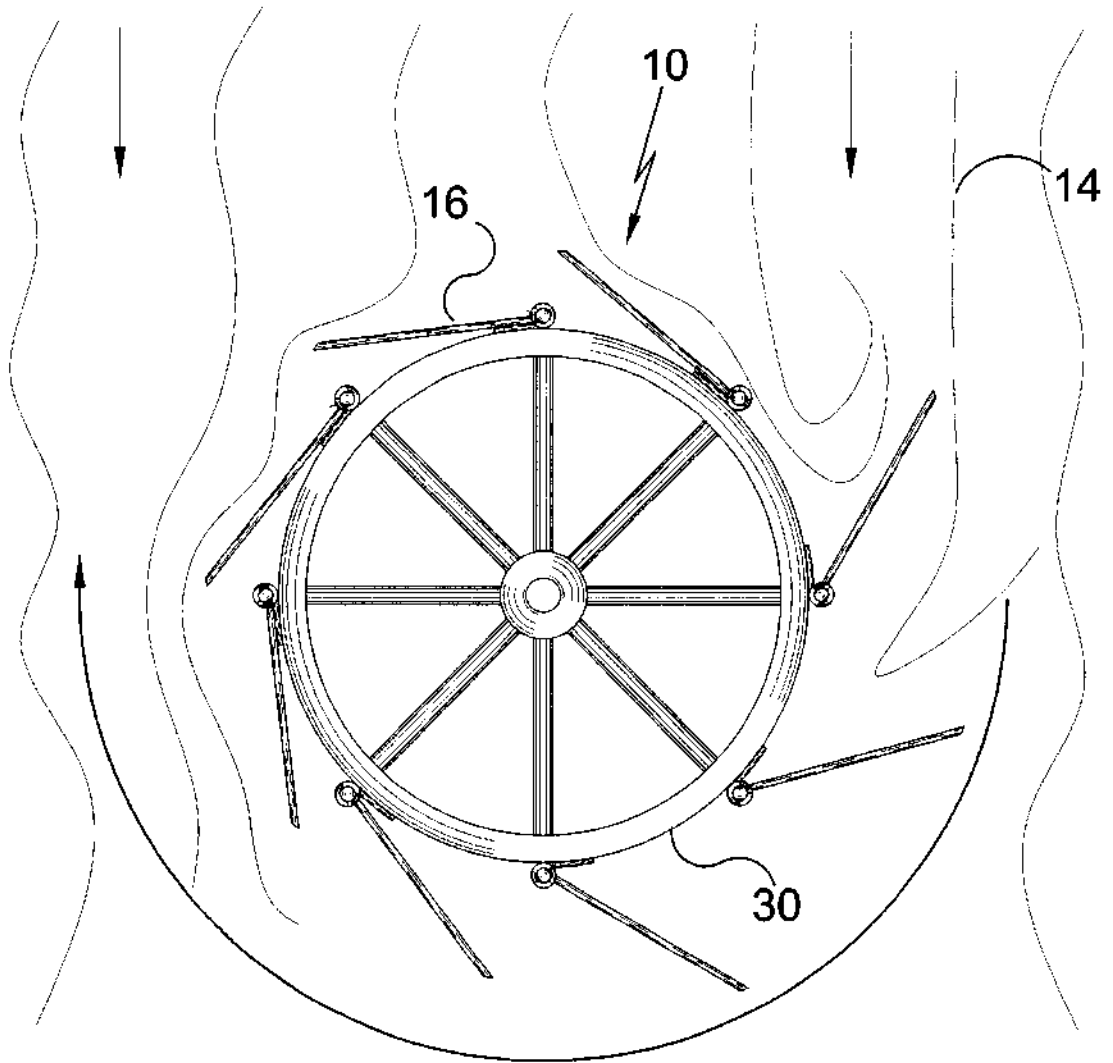
**FIG. 3**



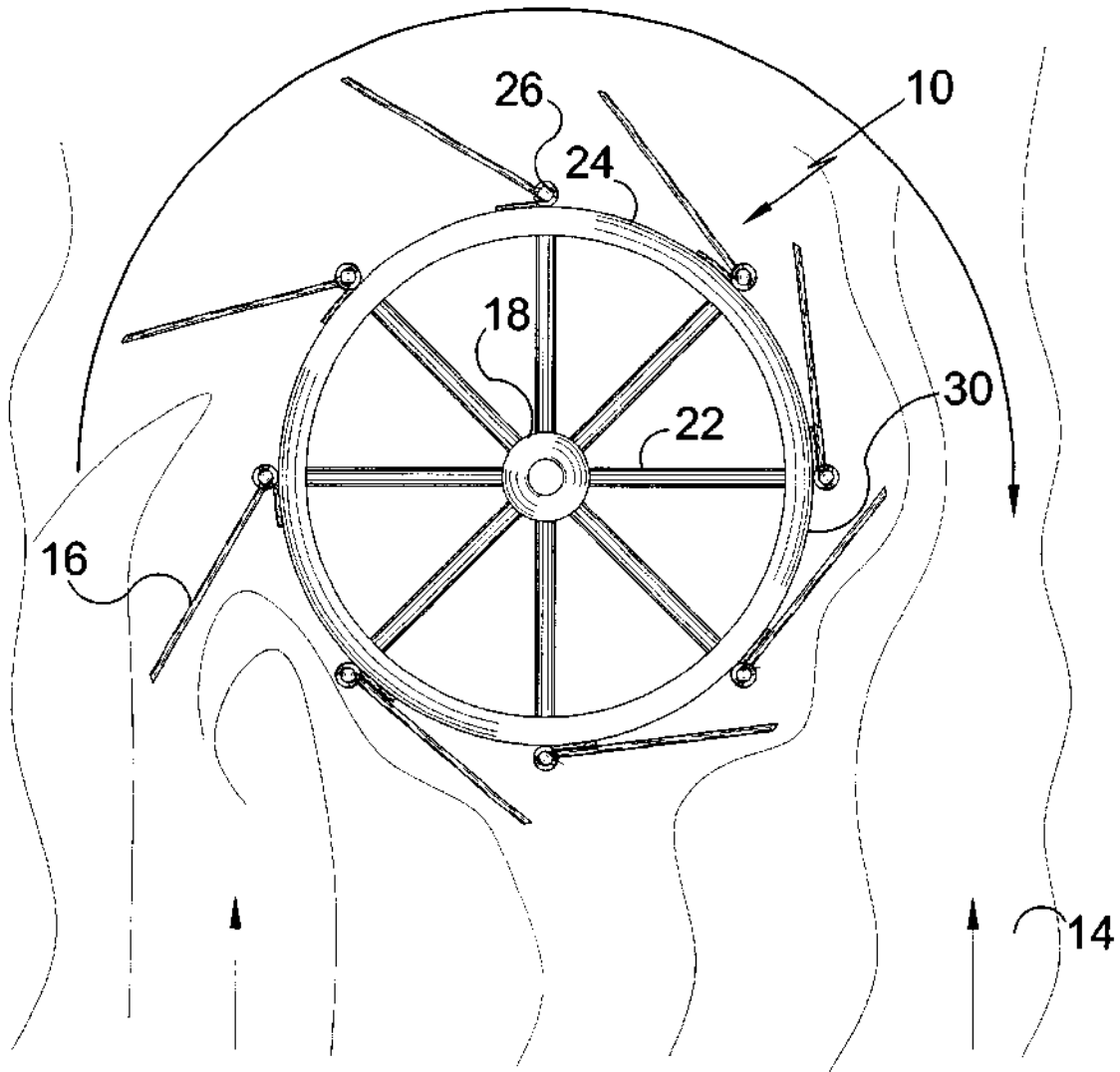
**FIG. 4**



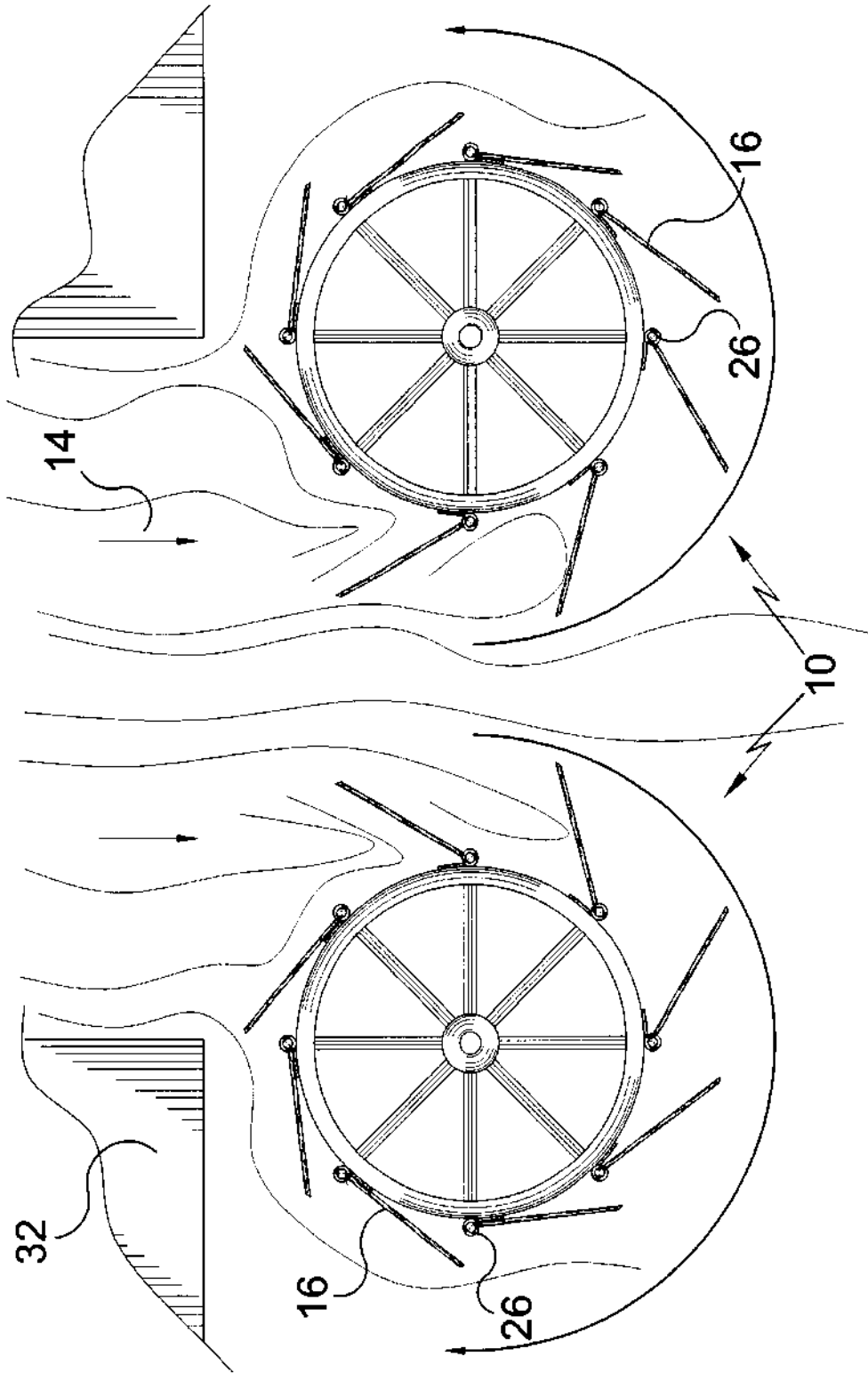
**FIG. 5**



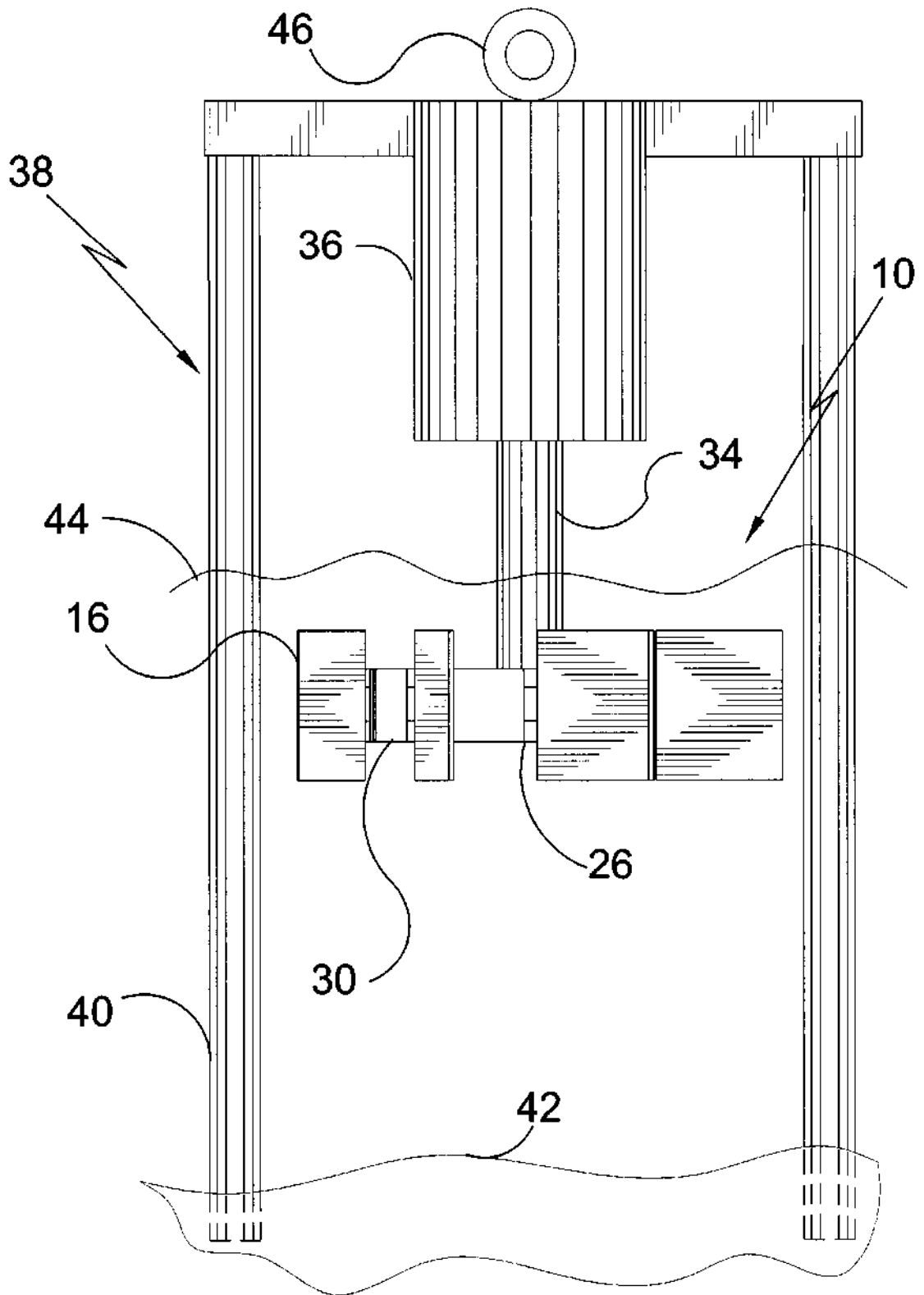
**FIG. 6**



**FIG. 7**

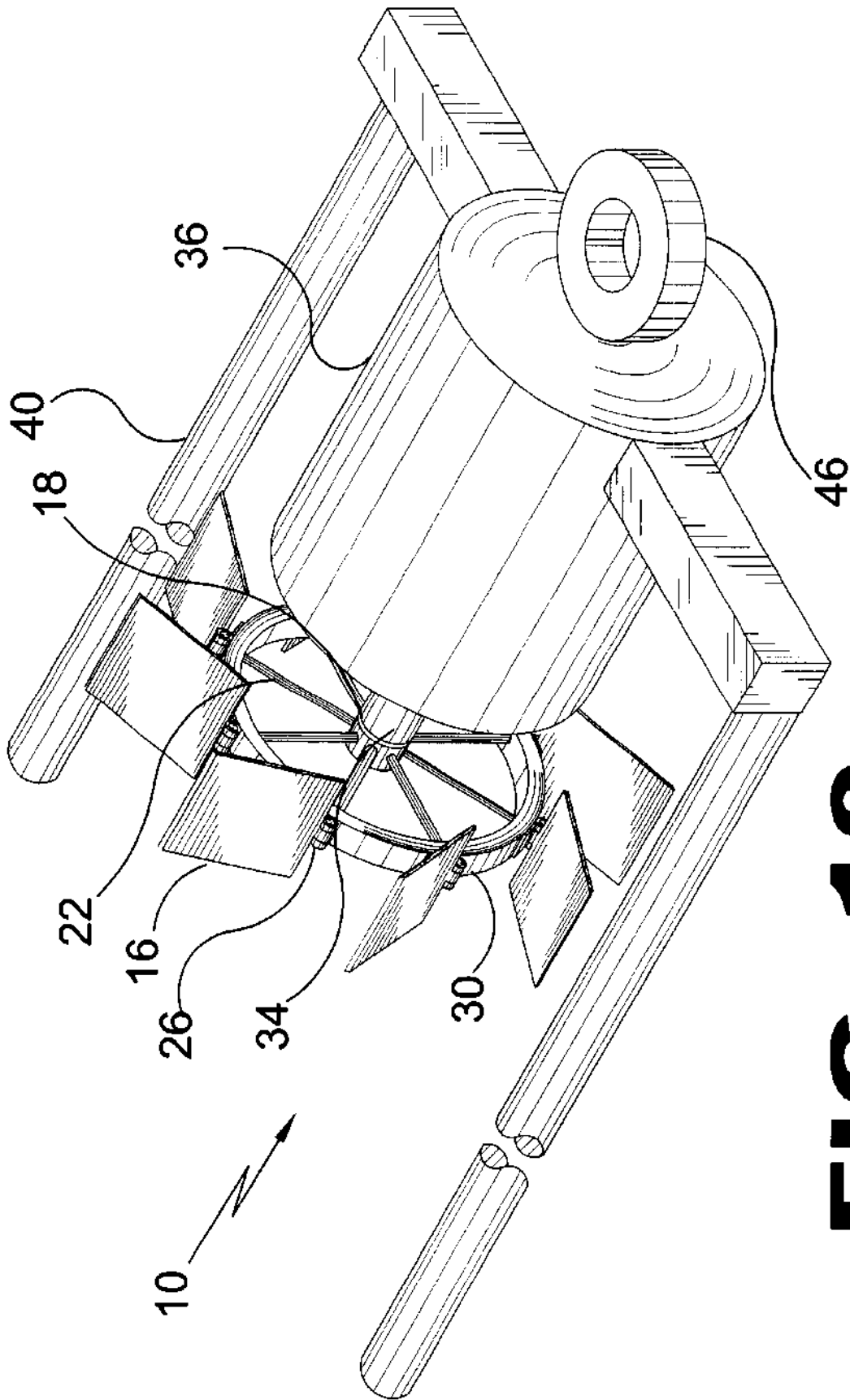


**FIG. 8**

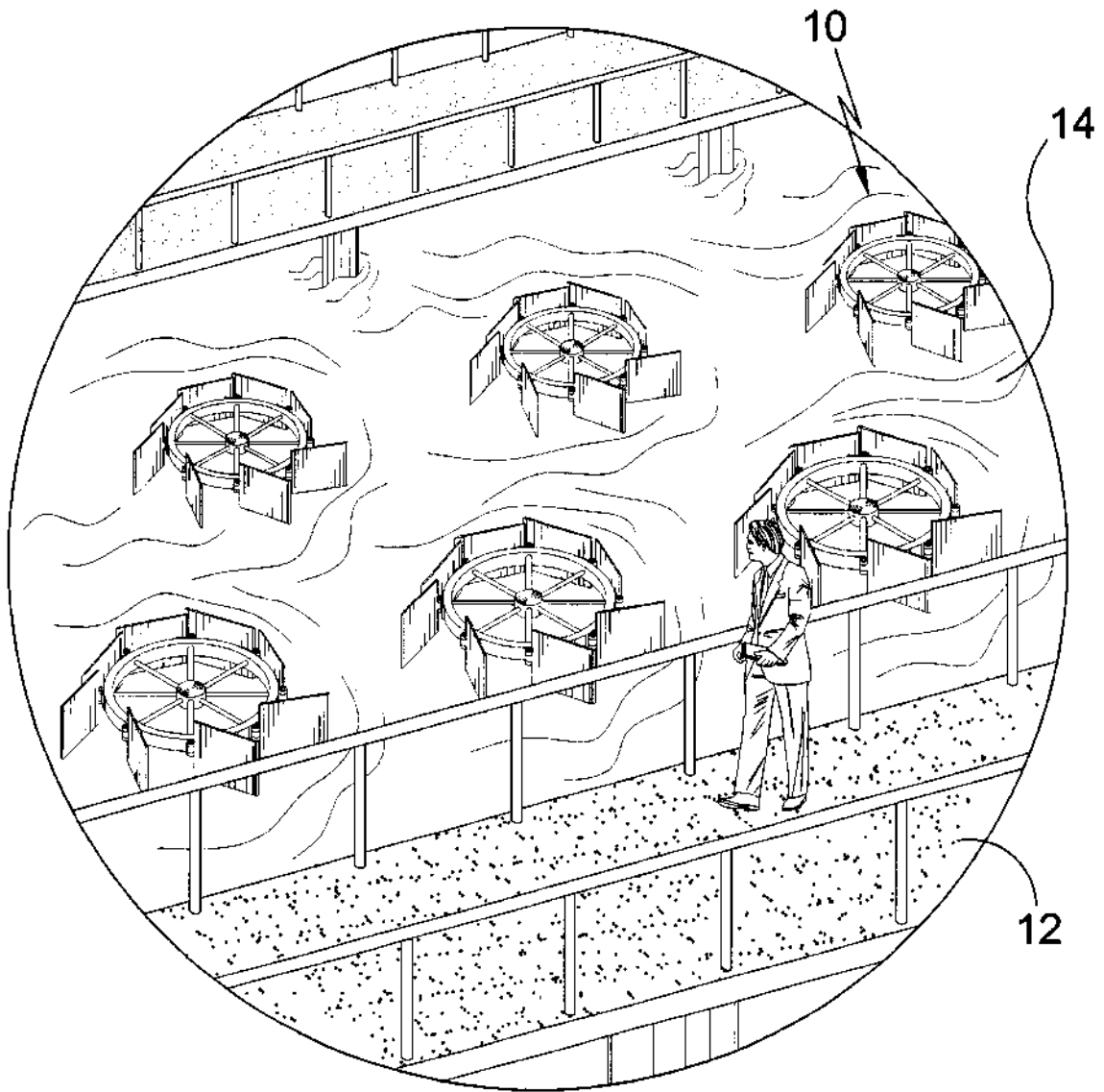


**FIG. 9**

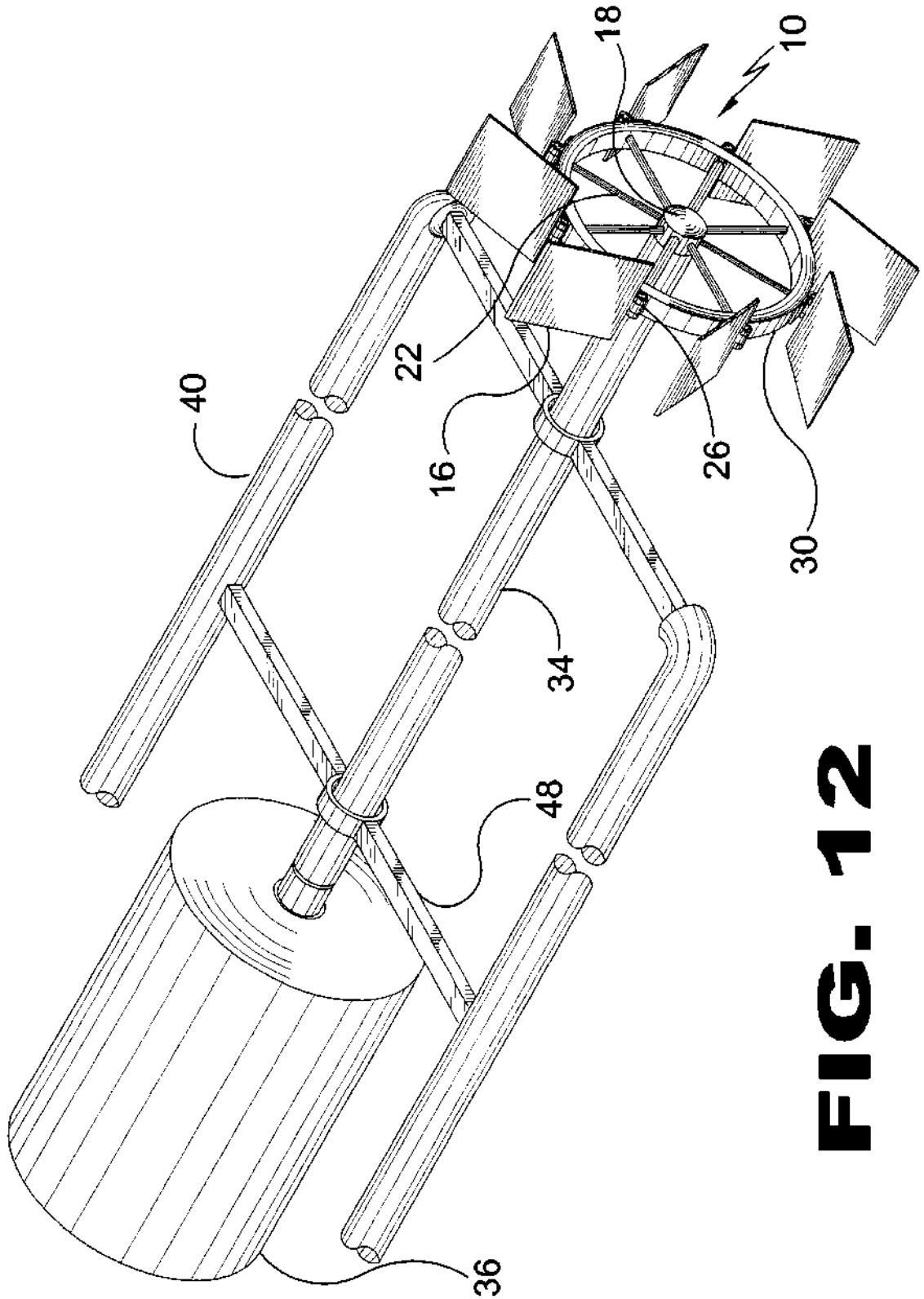




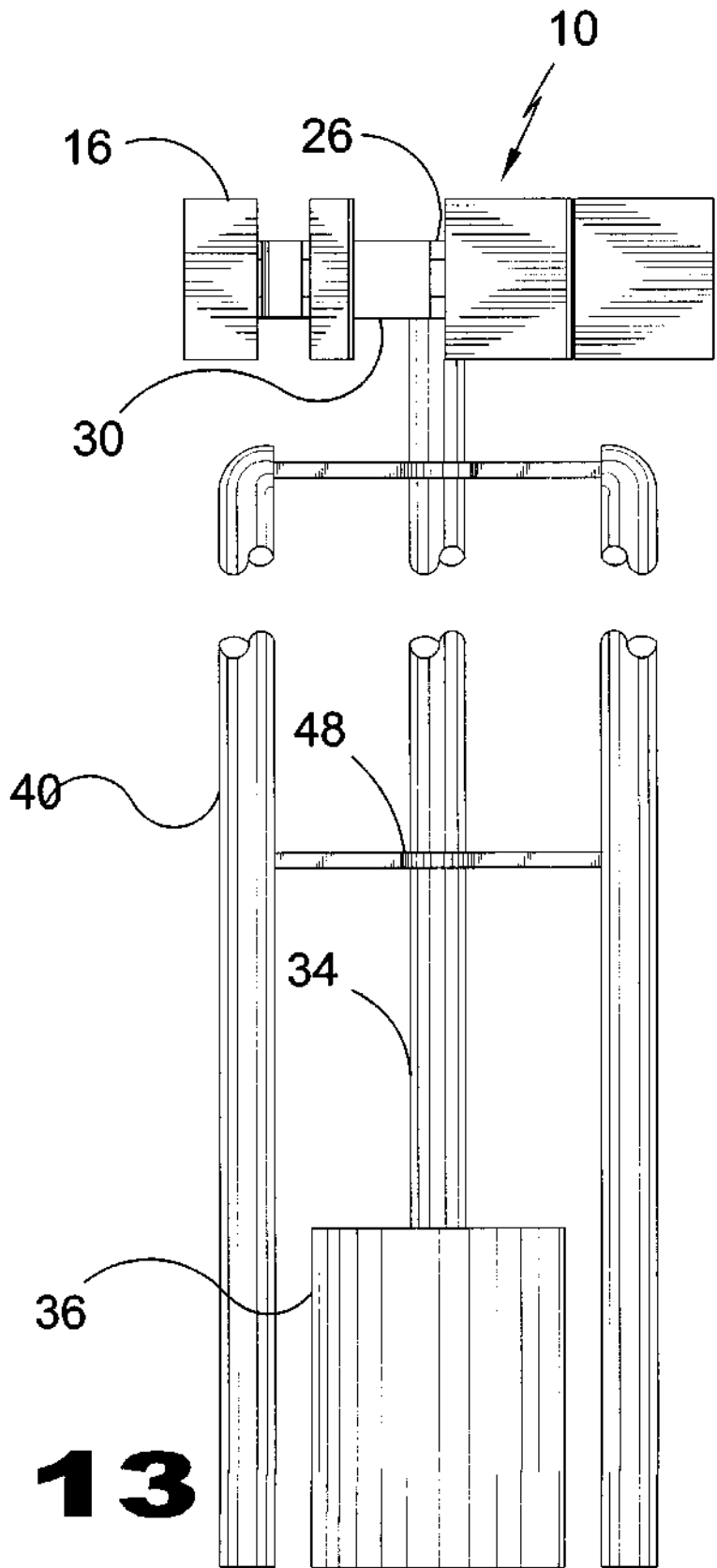
**FIG. 10**



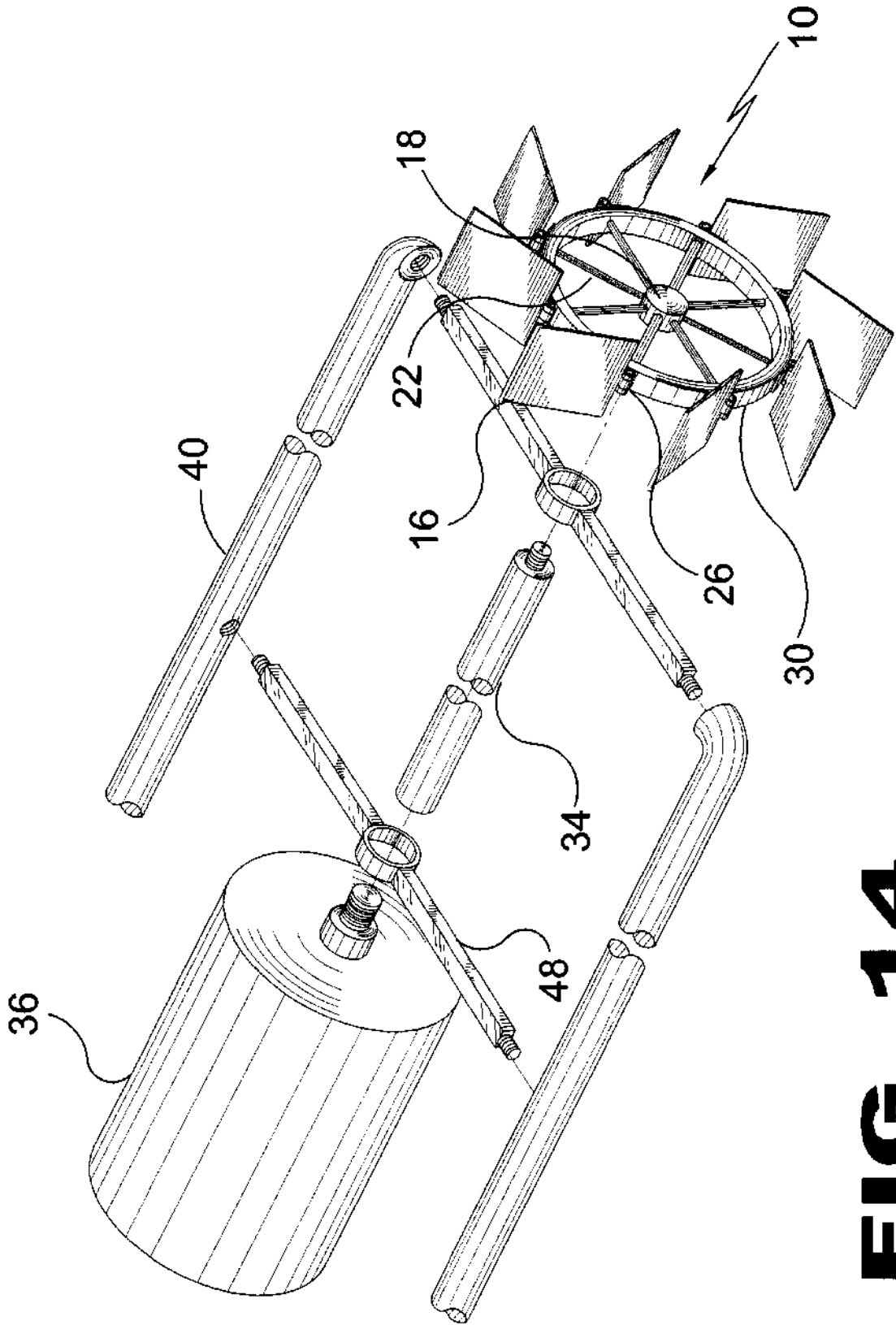
**FIG. 11**



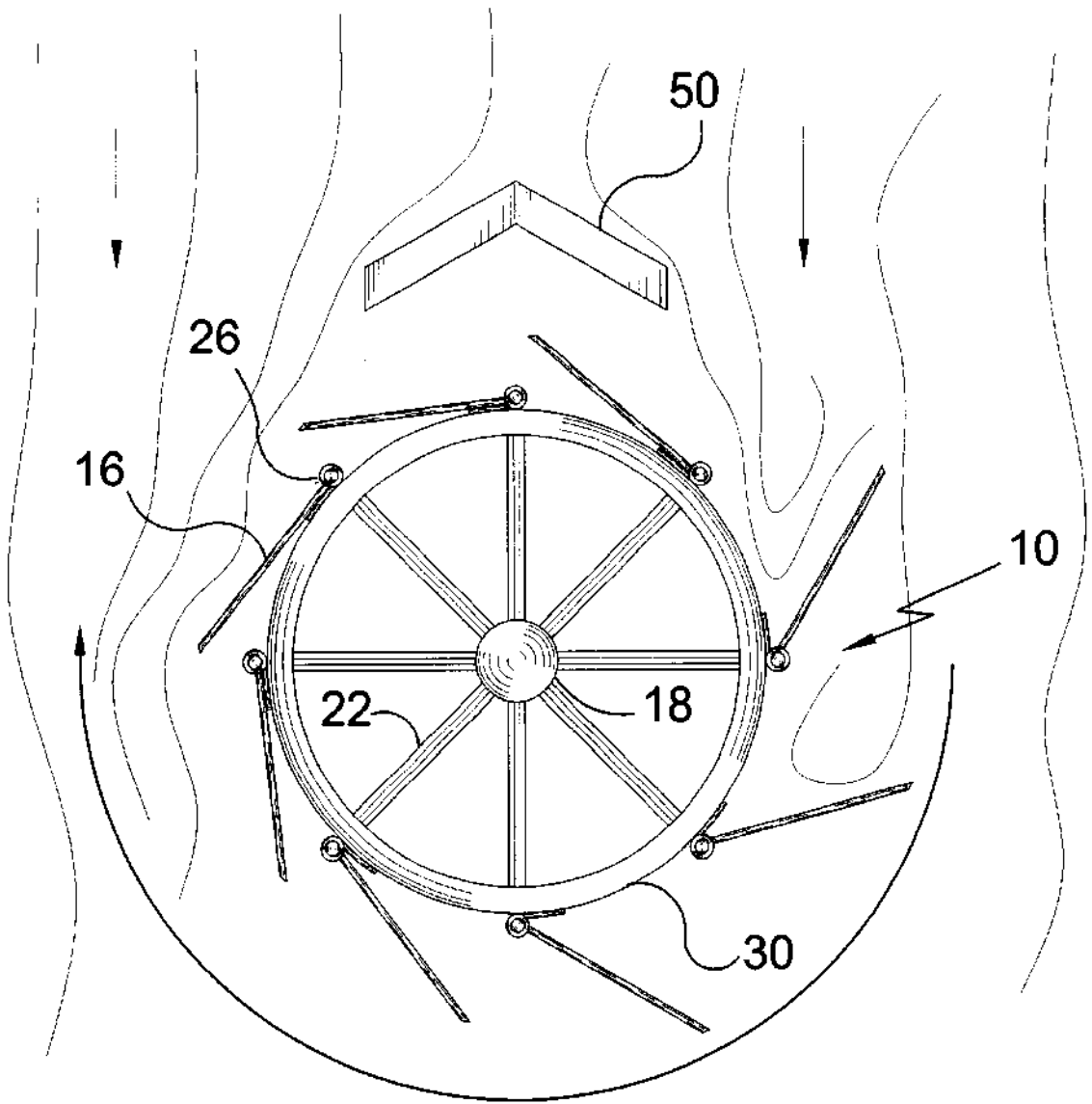
**FIG. 12**



**FIG. 13**



**FIG. 14**



**FIG. 15**

**1**  
**WATER WHEEL**

**BACKGROUND OF THE INVENTION**

**1. Field of the Invention**

The present invention relates generally to a water wheel and, more specifically, to a water wheel that gains its power and momentum through water current acting upon a plurality of paddles attached to hinges that open to a pre determined angle that are attached to the outer perimeter of a wheel. The wheel consists of a central circular body member with a plurality of spokes radiating from its outside perimeter that attach to the inside perimeter of an outer circular body member. On the outside perimeter of the outer circular body member a plurality of hinges with paddles are attached that can only open to a pre determined angle from the wheel that ensures water current is caught by the paddles on only one side of the wheel which causes it to rotate. The kinetic energy stored in the wheel while rotating is harnessed through a drive shaft connected to the central circular body member that connects to a generator placed perpendicular to the central circular body member. To keep the generator and drive shaft in place a plurality of support members, with couplers for the drive shaft, are dug into the bed of the river or ocean that the device is used in.

**2. Description of the Prior Art**

There are other water wheel devices designed for energy production but while these water wheels may be suitable for the purposes for which they were designed, they would not be as suitable for the purposes of the present invention, as hereinafter described.

**SUMMARY OF THE PRESENT INVENTION**

The present invention discloses a wheel-like member consisting of a central circular body member having a plurality of spokes radiating from its outside perimeter that attach to the inside perimeter of an outer circular body member. On the outside perimeter of the outer circular body member a plurality of hinges with paddles are attached thereto that can only open to a pre-determined angle "A" from the wheel that ensures water current is caught by the paddles on only one side of the wheel which causes the wheel to rotate in only one direction. The kinetic energy stored in the wheel while rotating is harnessed through a drive shaft connected to the central circular body member that connects to a generator placed perpendicular to the central circular body member. To keep the generator and drive shaft in place a plurality of support members, with cross-member support couplers are disposed into the bed of the river or ocean that the device is being used in.

A primary object of the present invention is to provide a water wheel that may be used in an environment with multiple water currents.

Another object of the present invention is to provide a water wheel with a plurality of paddles with hinges attached to its outside perimeter that only open to a predetermined angle from the wheel.

Yet another object of the present invention is to provide a water wheel that does not harm the wildlife or block current greatly where it is used.

Still yet another object of the present invention is to provide a water wheel that when paddles are closed may direct water into open paddles.

Yet another object of the present invention is to provide a water wheel with a drive shaft and generator that produces power.

**2**

Additional objects of the present invention will appear as the description proceeds.

The present invention overcomes the shortcomings of the prior art by providing a water wheel that when influenced by current can rotate and produce power by usage of a plurality of paddles with hinges that open to a predetermined angle from the wheel, so that water current can be directed into and caught by the open paddles. The present invention also provides a water wheel that can be used in an environment with multiple and alternating currents without blocking water or harming the environment and wildlife.

The foregoing and other objects and advantages will appear from the description to follow. In the description reference is made to the accompanying drawings, which form a part hereof, and in which is shown by way of illustration specific embodiments in which the invention may be practiced. These embodiments will be described in sufficient detail to enable those skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized and that structural changes may be made without departing from the scope of the invention. In the accompanying drawings, like reference characters designate the same or similar parts throughout the several views.

The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the present invention is best defined by the appended claims.

**BRIEF DESCRIPTION OF THE DRAWINGS**

In order that the invention may be more fully understood, it will now be described, by way of example, with reference to the accompanying drawings in which:

- FIG. 1 is a perspective view of the present invention.
- FIG. 2 is a top view of the present invention.
- FIG. 3 is an isometric view of the present invention.
- FIG. 4 is a top view of the present invention.
- FIG. 5 is a top view of the present invention.
- FIG. 6 is a top view of the present invention.
- FIG. 7 is a top view of the present invention.
- FIG. 8 is a top view of the present invention.
- FIG. 9 is a side view of the present invention.
- FIG. 10 is an isometric view of the present invention.
- FIG. 11 is a perspective view of the present invention.
- FIG. 12 is an isometric view of the present invention.
- FIG. 13 is a side view of the present invention.
- FIG. 14 is an exploded view of the present invention.
- FIG. 15 is a top view of the present invention.

**LIST OF REFERENCE NUMERALS**

With regard to reference numerals used, the following numbering is used throughout the drawings.

- 10 present invention
- 12 plant
- 14 flowing water
- 16 paddle
- 18 central body member
- 20 connection means
- 22 spokes
- 24 outer body member
- 26 hinge
- 28 stop member
- 30 wheel
- 32 obstruction

34 drive shaft  
 36 generator  
 38 frame  
 40 support legs  
 42 bed  
 44 water line  
 46 crane loop  
 48 cross support member  
 50 debris deflector

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following discussion describes in detail one embodiment of the invention and several variations of that embodiment. This discussion should not be construed, however, as limiting the invention to those particular embodiments. Practitioners skilled in the art will recognize numerous other embodiments as well. For a definition of the complete scope of the invention, the reader is directed to the appended claims.

FIG. 1 is a perspective view of the present invention showing the present invention 10 in use in a large-scale power plant or the like 12 with a plurality of the devices being generally horizontally disposed and operating in a river 14 or other body of flowing water.

FIG. 2 is a top view of the present invention showing the present invention 10 having a plurality of paddles 16 with which to capture the energy from the water current. Shown therein is a central circular body member 18 which forms a hub-like central member having a means for rotatable connection 20 centrally disposed therein having a plurality of spokes 22 radiating radially therefrom to an outer, wheel-like, circular, ring-like body member 24 which may also be referred to hereinafter as a wheel 30. It can be seen that the panels 16 having means for connection or hinges 26 disposed about the outer periphery of the outer circular body member 24.

FIG. 3 is an isometric view of the present invention showing the present invention 10 having a stopper member 28 to prevent the paddle 16 from opening more than the predetermined angle. Hinge member 26 is also shown.

FIG. 4 is a top view of the present invention showing the present invention 10 having a central circular body member 18 fixedly attached to an outer circular body member 24 by multiple spokes 22. Also shown is a plurality of hinges 26 surrounding the outside perimeter of outer member 24 for attachment of multiple paddles 16 thereto. A central connection member 20 is also shown. Angle "A" indicates the maximum angular opening of the paddles 16 with respect to the tangent line of outer member 24.

FIG. 5 is a top view of the present invention 10 showing the paddle 16 open to "A" degrees before engaging the paddle opening delimiter or stop 28. It is believed that the preferred embodiment angle "A" is about 30 degrees for optimal performance being in the range of 25-35 degrees; however, it is believed that other angles could also be successfully utilized.

FIG. 6 is a top view of the present invention showing the present invention 10 in operation with the current 14 coming from a forward direction. Also shown are the paddles 16 opening to a predetermined angle to catch or capture the current 14 on one side of wheel 30 while on the opposing side the paddles are closed to deflect the current. Other elements previously disclosed are also shown.

FIG. 7 is a top view of the present invention 10 showing the present invention in operation with the current 14

coming in the reverse direction. Also shown is the wheel 30 not changing its direction of rotation but instead conforming to the change in current direction by having the paddles 16 open on the opposite side of outer member 24. Other elements previously disclosed are also shown.

FIG. 8 is a top view of the present invention showing the present invention 10 in operation with a plurality of devices 10 placed on the sides of existing obstructions 32 that water flows 14 around. Other elements previously disclosed are also shown.

FIG. 9 is a side view of the present invention showing the present invention 10 having a drive shaft 34 with a generator 36 connected at its opposing side from the wheel 30 to harness the kinetic energy produced by the wheel 30 while it rotates. Also shown is a generally upright standing frame member 38 having support members or legs 40 which are mounted by penetration into the bed 42 of the river or the like further showing the water line 44 of the water body. Also shown is a crane loop 46 for lifting the present invention. Other elements previously disclosed are also shown.

FIG. 10 is an isometric view of the present invention 10 showing the present invention having a generator 36 mounted on the top portion of the wheel 30. Other elements previously disclosed are also shown.

FIG. 11 is a perspective view of the present invention 10 showing the devices 10 in use in a large scale power plant or the like 12 with a plurality of devices 10 operating in a river or other body of flowing water 14.

FIG. 12 is an isometric view of the present invention 10 showing the present invention having a plurality of support cross members or couplers 48 to hold the drive shaft 34 steady while in operation. Other elements previously disclosed are also shown.

FIG. 13 is a side view of the present invention showing the present invention 10 having a drive shaft 34 with a generator 36 connected at its opposing side from the wheel 30 to harness the kinetic energy produced by the wheel 30 while it rotates. Other elements previously disclosed are also shown.

FIG. 14 is an exploded view of the present invention showing the present invention 10 with all of its main structural components exploded into their individual elements as previously disclosed.

FIG. 15 is a top view of the present invention showing the present invention 10 having an addition of a debris deflector 50 that may be used to prevent damage to the wheel 30 that may occur due to drifting debris. Other elements previously disclosed are also shown.

I claim:

1. An apparatus for a water wheel for use in a flowing body of water, comprising:
  - a) a wheel, said wheel being rotatable, said wheel being generally horizontally disposed;
  - b) a central body member disposed internal of said wheel;
  - c) a shaft upon which said wheel rotates;
  - d) a first means for connecting said wheel to said shaft;
  - e) an outer body member disposed about said central body member;
  - f) a second means for connecting said outer body member to said central body member;
  - g) means for a plurality of paddles disposed on the perimeter of said outer body member whereby energy from the flowing body of water is captured;



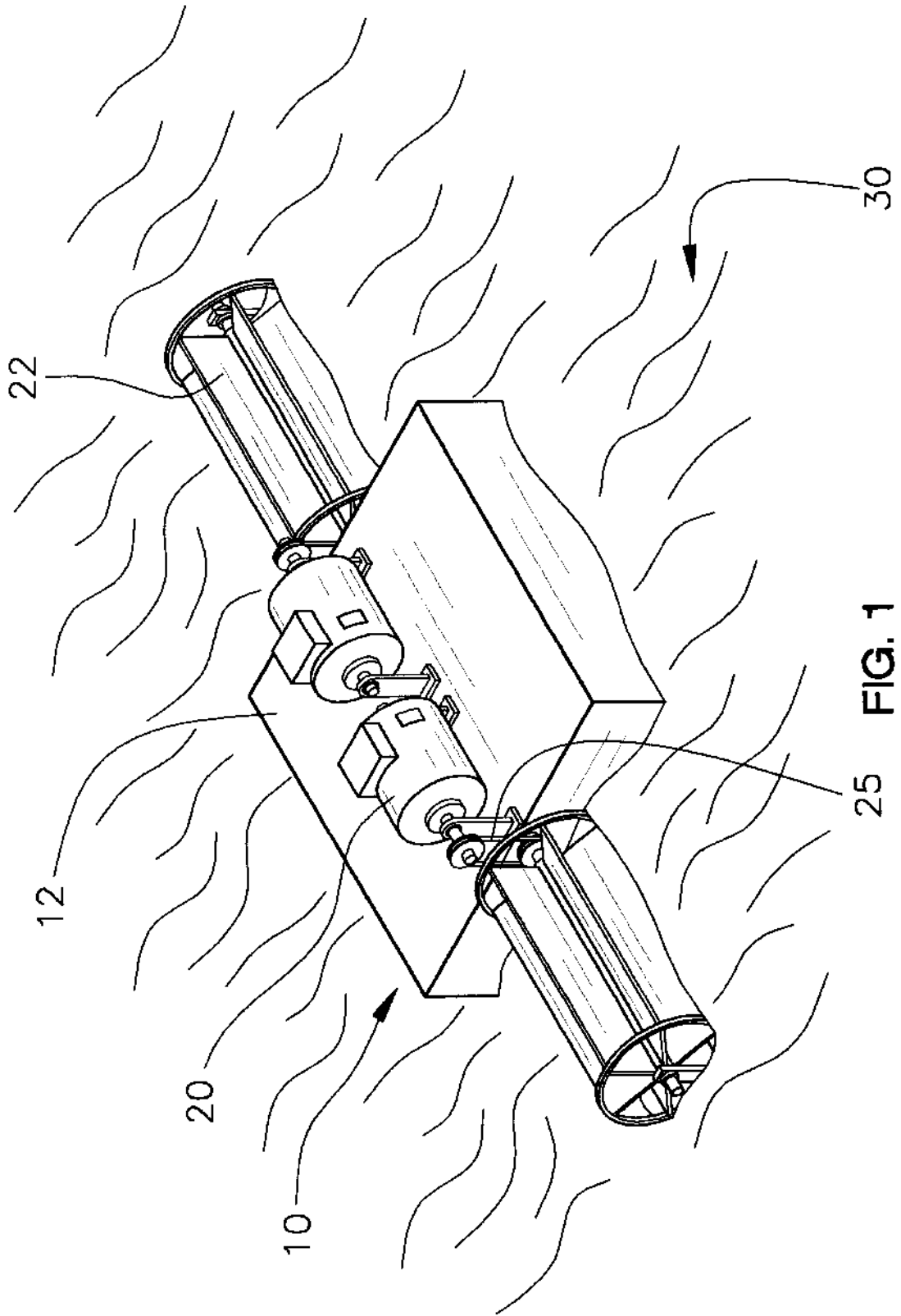
5

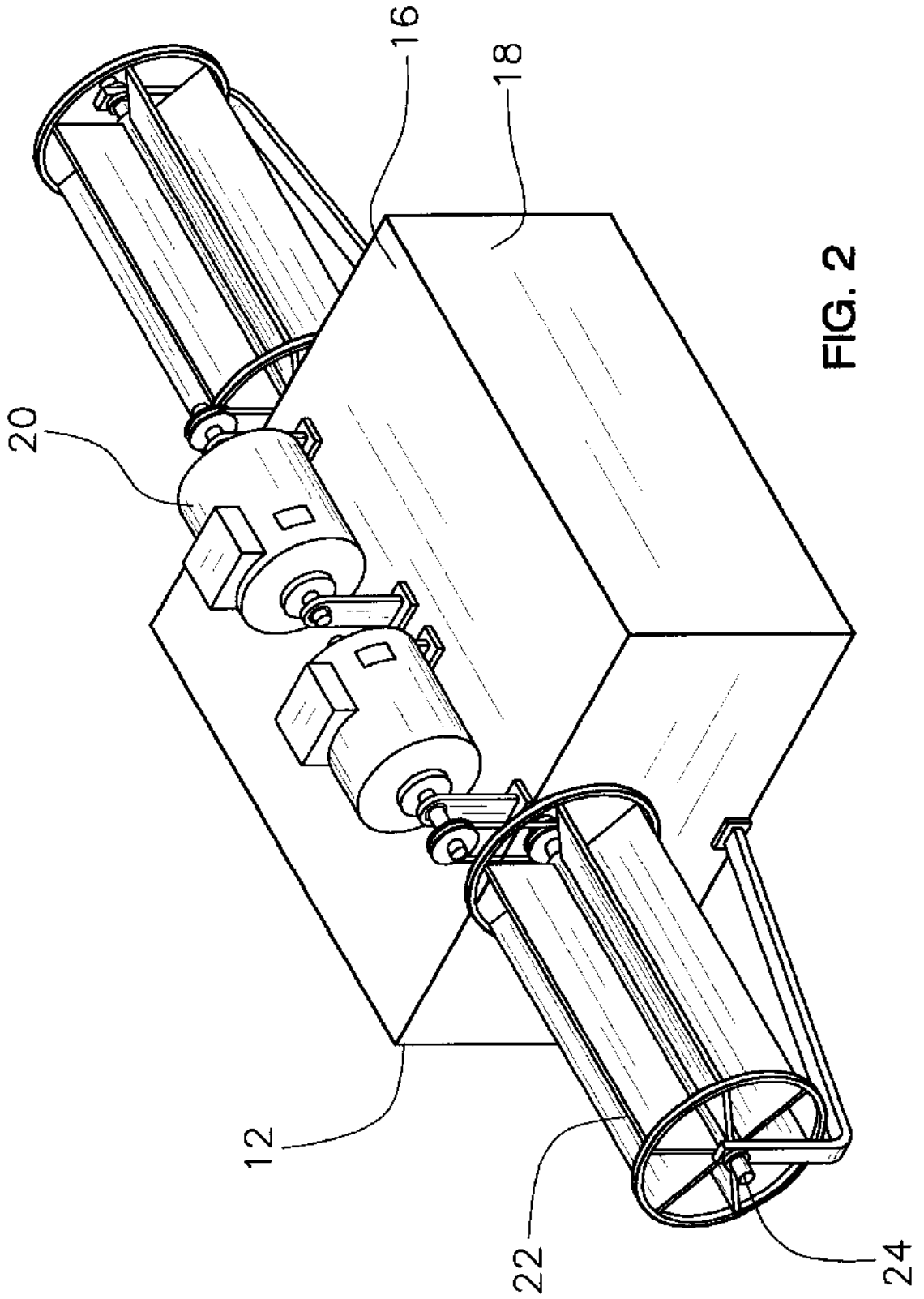
- h) means for mounting the apparatus in a flowing body of water whereby the apparatus is securely supported;
- i) a hinge for connecting said paddles to said outer body member, said hinge being disposed on the outer periphery of said outer body member; 5
- j) a stop being disposed on said hinge so that said paddles open to a fixed maximum degree relative to a tangent line of said outer body member;
- k) means for a generator disposed on said shaft whereby electricity is generated by the rotation of said wheel by the body of water; 10
- l) means for deflecting debris disposed proximate to said wheel whereby contact with debris in the water body is prevented; and 15
- m) a crane loop being disposed on said top end of said frame member, wherein said central body member is a hub, said hub having an aperture therein, said aperture receives said shaft, said first means for connecting said wheel to said shaft further comprises said shaft con-

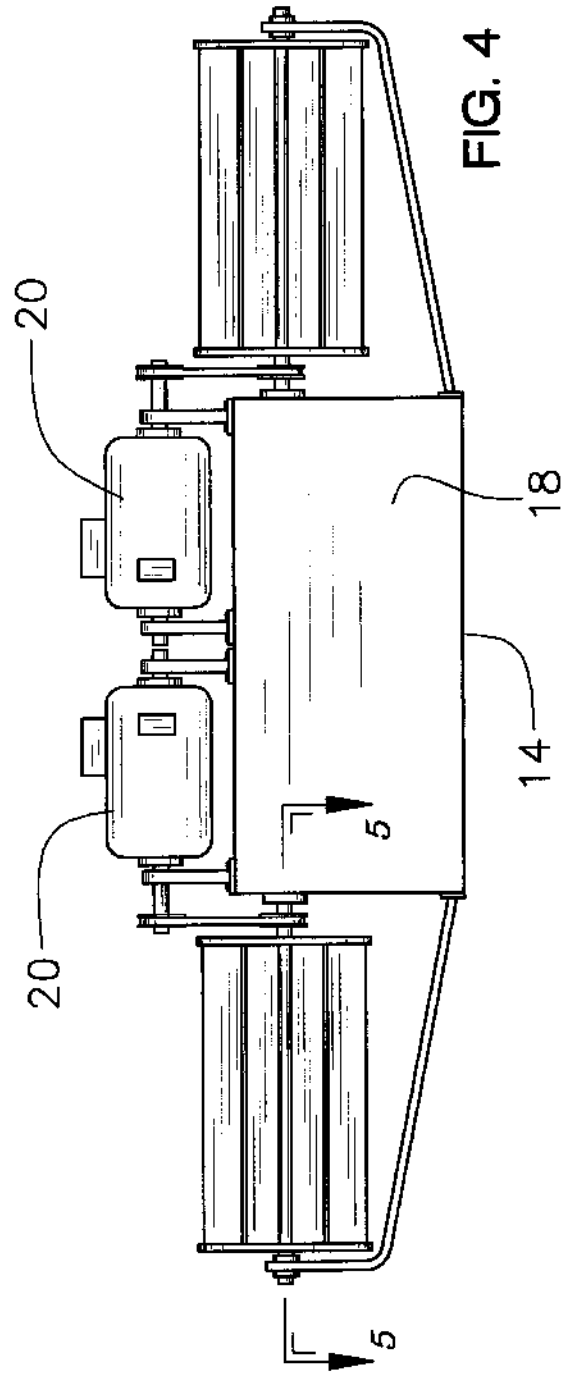
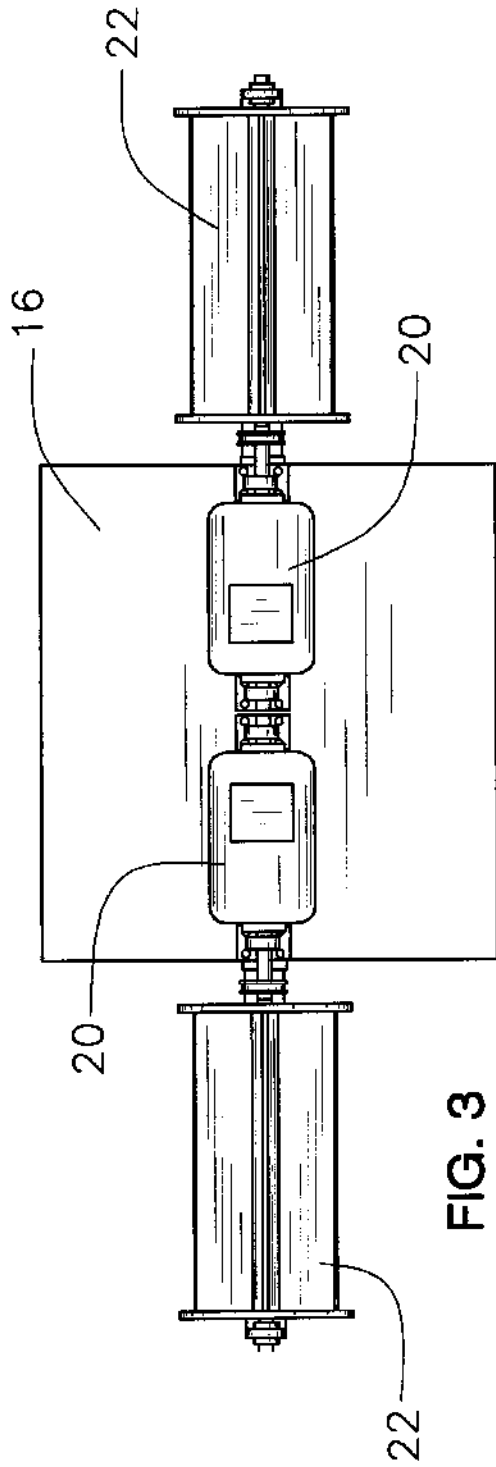
6

necting to said hub by using said aperture, said shaft is disposed perpendicular to said wheel, said outer body member is a ring disposed about said central body member, said second means for connecting said outer body member to said central body member further comprises a plurality of spokes, said means for a plurality of paddles further comprises said paddles being generally perpendicular to said outer body member, said paddles open to an angle of about 30 degrees relative to a tangent line of said outer body member, said means for mounting further comprises a generally upright standing frame member having the apparatus disposed thereon, said frame member having an upper end and a lower end, said lower end of said frame member being disposed into the bed of the body of water, said frame member further comprises at least one supporting cross member.

\* \* \* \* \*







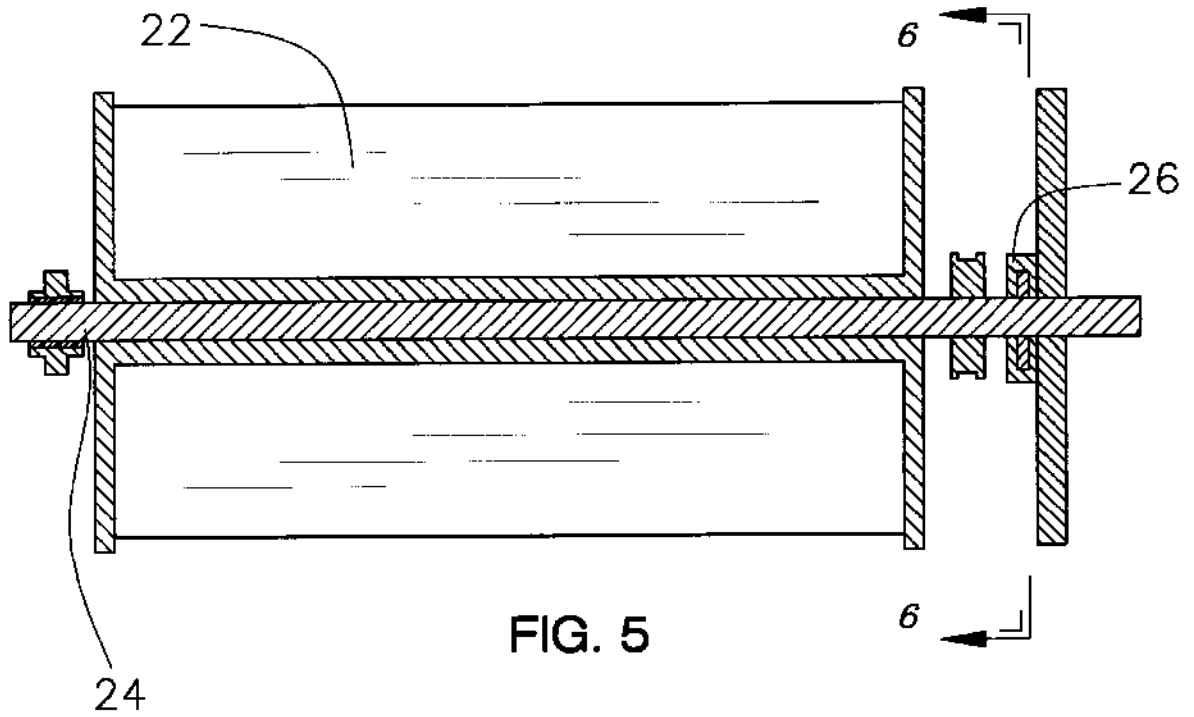


FIG. 5

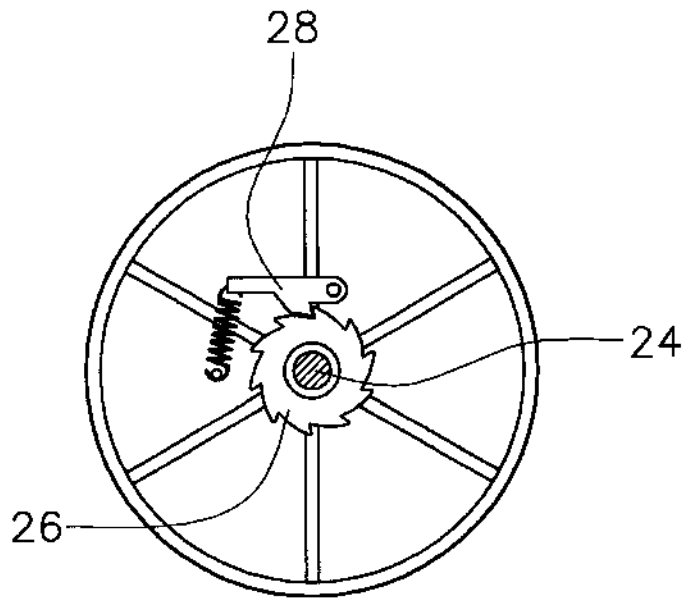


FIG. 6

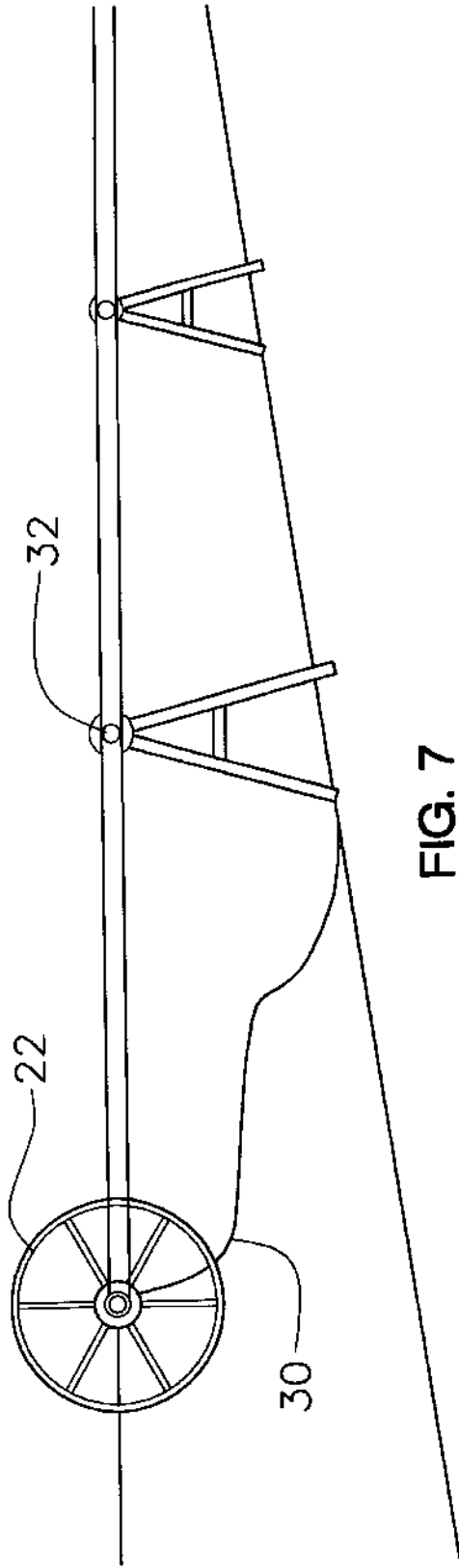


FIG. 7

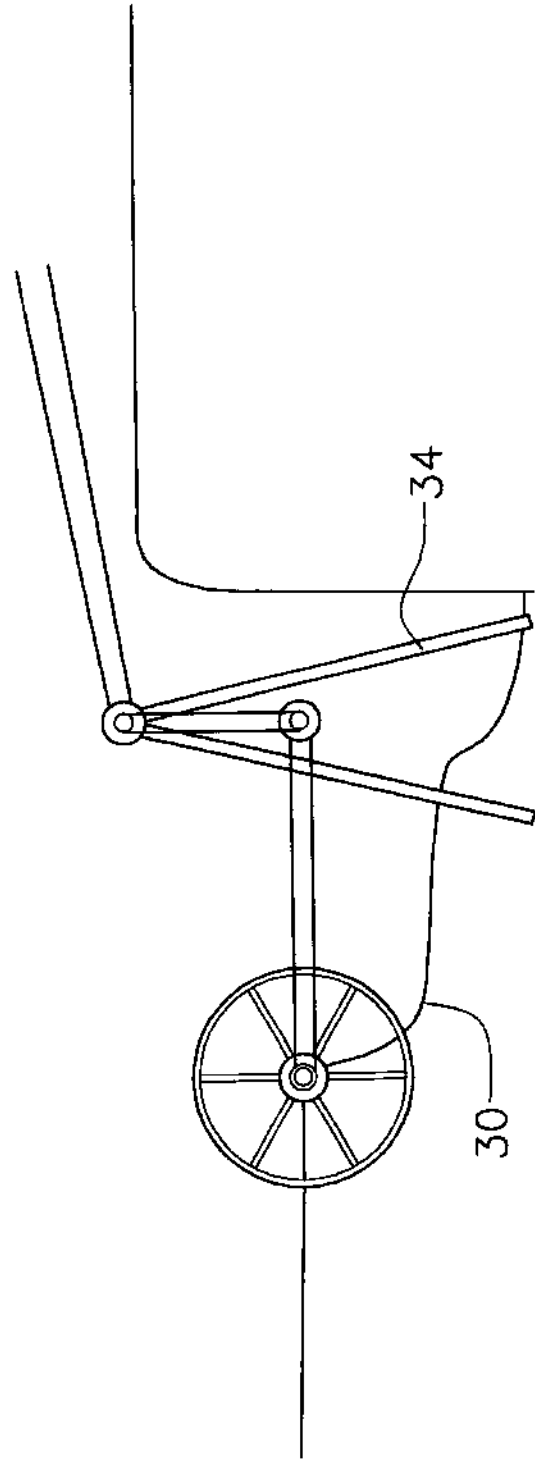


FIG. 8

**HYDRO-ELECTRIC GENERATOR**

**BACKGROUND OF THE INVENTION**

1. Field of the Invention

The present invention relates to electricity generating devices and more particularly pertains to a new hydro-electric generator for producing electricity in areas of flowing water.

2. Description of the Prior Art

The use of electricity generating devices is known in the prior art. U.S. Pat. No. 3,644,052 describes a device for producing electricity from the motion of waves. Another type of electricity generating devices is U.S. Pat. No. 6,133,644 which utilizes the ocean's surf to produce electricity.

While these devices fulfill their respective, particular objectives and requirements, the need remains for a device which is portable and can be positioned in any area where water flow can be used for producing electricity.

**SUMMARY OF THE INVENTION**

The present invention meets the needs presented above by using a barge type floatation device to mount generators on to produce electricity where needed.

To this, the present invention generally comprises a floatation device. An electric generator is mounted on the floatation device. A paddle wheel is rotatably mounted to the floatation device. The paddle wheel is mechanical coupled to the electric generator. The floatation device is anchored in an area of flowing water such that a current rotates the paddle wheel and electricity is produced.

There has thus been outlined, rather broadly, the more important features of the invention in order that the detailed description thereof that follows may be better understood, and in order that the present contribution to the art may be better appreciated. There are additional features of the invention that will be described hereinafter and which will form the subject matter of the claims appended hereto.

The objects of the invention, along with the various features of novelty which characterize the invention, are pointed out with particularity in the claims annexed to and forming a part of this disclosure.

**BRIEF DESCRIPTION OF THE DRAWINGS**

The invention will be better understood and objects other than those set forth above will become apparent when consideration is given to the following detailed description thereof. Such description makes reference to the annexed drawings wherein:

FIG. 1 is a schematic perspective view of a new hydro-electric generator according to the present invention.

FIG. 2 is a schematic perspective view of the present invention.

FIG. 3 is a schematic top view of the present invention.

FIG. 4 is a schematic side view of the present invention.

FIG. 5 is a schematic cross-sectional view taken along line 5—5 of the present invention.

FIG. 6 is a schematic cross-sectional view taken along line 6—6 of the present invention.

FIG. 7 is a schematic view of the present invention.

FIG. 8 is a schematic view of the present invention.

**DESCRIPTION OF THE PREFERRED EMBODIMENT**

With reference now to the drawings, and in particular to FIGS. 1 through 8 thereof, a new hydro-electric generator

embodying the principles and concepts of the present invention and generally designated by the reference numeral 10 will be described.

As best illustrated in FIGS. 1 through 8, the hydro-electric generator 10 generally comprises providing a floatation device 12 having a bottom wall 14, a top wall 16 and a peripheral wall 18 extending between the top 16 and bottom 14 walls.

Each of a pair of electric generators 20 for producing electricity is mounted on the top wall 16 of the floatation device 12. The generators 20 are conventional generators.

Each of a pair of paddle wheels 22 is rotatably mounted to the peripheral wall 18 of the floatation device 12. The paddle wheels 22 are positioned on opposite sides of the floatation device 12. Each of the paddle wheels 22 is mounted on lone of a pair of axles 24. Each of a pair of belts 25 is positioned on and extends between one of the axles 24 and one of the generators 20. The generators 20 produce electricity when the paddle wheels 22 turn the axles.

Each of a pair of gears 26 is positioned on one of the axles 24. Each of a pair of detents 28 is mechanically coupled to one of the gears 26 such that the axles 24 are rotational in only one direction.

The floatation device 12 is positioned in water 30 in an area needing electricity. The water 30 needs to be moving water such that a current is produced. The floatation device 12 is anchored in the water 30. The current causes the paddle wheels to rotate. When the paddle wheels 22 rotate, the generators 20 create electricity. Relays 32 are set up for transferring the electricity produced over distances. Towers 34 may be built to accommodate for cliffs or other changes in elevations.

With respect to the above description then, it is to be realized that the optimum dimensional relationships for the parts of the invention, to include variations in size, materials, shape, form, function and manner of operation, assembly and use, are deemed readily apparent and obvious to one skilled in the art, and all equivalent relationships to those illustrated in the drawings and described in the specification are intended to be encompassed by the present invention.

Therefore, the foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly, all suitable modifications and equivalents may be resorted to, falling within the scope of the invention.

I claim:

1. A portable hydro-electric generator device comprising: a floatation device having a bottom wall, a top wall and a peripheral wall extending between said top and bottom walls;
- a pair of electric generators for producing electricity, each of said electric generators being mounted on said top wall of said floatation device;
- a pair of paddle wheels, each of said paddle wheels being rotatably mounted to said peripheral wall of said floatation device, said paddle wheels being positioned on opposite sides of said floatation device, each of said paddle wheels being mounted on an axle, each of a pair of belts being positioned on and extending between one of said axles and one of said generators, wherein said generators produce electricity when said paddle wheels turn said axles;
- a pair of gears, each of said gears being positioned on one of said axles, each of a pair of detents being mechani-

3

cally coupled to one of said gears such that said axles are rotational in only one direction; and  
wherein said floatation device is anchored in an area of flowing water such that a current rotates said paddle wheels and electricity is produced. 5  
2. A method of producing electricity comprising the steps of:  
providing a floatation device having a bottom wall, a top wall and a peripheral wall extending between said top and bottom walls; 10  
providing a pair of electric generators for producing electricity, each of said electric generators being mounted on said top wall of said floatation device;  
providing a pair of paddle wheels, each of said paddle wheels being rotatably mounted to said peripheral wall of said floatation device, said paddle wheels being positioned on opposite sides of said floatation device, 15

4

each of said paddle wheels being mounted on an axle, each of a pair of belts being positioned on and extending between one of said axles and one of said generators, wherein said generators produce electricity when said paddle wheels turn said axles;  
providing a pair of gears, each of said gears being positioned on one of said axles, each of a pair of detents being mechanically coupled to one of said gears such that said axles are rotational in only one direction; and  
positioning said floatation device in an area of water;  
anchoring said floatation device; and  
rotating said paddle wheels with a current of water such that a current rotates said paddle wheels and electricity is produced.

\* \* \* \* \*





US006655919B2

(12) **United States Patent**  
**Rossi et al.**

(10) **Patent No.:** **US 6,655,919 B2**  
(45) **Date of Patent:** **Dec. 2, 2003**

(54) **METHOD FOR ASSEMBLING A PELTON TURBINE WHEEL**

4,573,870 A \* 3/1986 Moussa ..... 415/202  
4,950,130 A \* 8/1990 Erlach ..... 415/202  
6,210,113 B1 \* 4/2001 Ihrenberger ..... 416/116

(75) **Inventors:** **Georges Rossi**, Saint-Ismier (FR);  
**Louis Finet**, Vif (FR); **Francis Freynet**, Grenoble (FR); **Bernard Michel**, Vaulnaveys le Bas (FR)

**FOREIGN PATENT DOCUMENTS**

EP 0843092 5/1998  
FR 570124 4/1924  
FR 2776341 9/1999  
GB 688577 3/1953

(73) **Assignee:** **Alstom Power Hydro**, Grenoble (FR)

(\*) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 48 days.

\* cited by examiner

(21) **Appl. No.:** **10/129,792**

(22) **PCT Filed:** **Dec. 6, 2000**

(86) **PCT No.:** **PCT/FR00/03412**

§ 371 (c)(1),  
(2), (4) **Date:** **May 10, 2002**

(87) **PCT Pub. No.:** **WO01/42645**

**PCT Pub. Date:** **Jun. 14, 2001**

(65) **Prior Publication Data**

US 2002/0176779 A1 Nov. 28, 2002

(30) **Foreign Application Priority Data**

Dec. 10, 1999 (FR) ..... 99 15637

(51) **Int. Cl.<sup>7</sup>** ..... **F03B 1/02**

(52) **U.S. Cl.** ..... **416/197 BOD**; 416/116;  
416/214 A; 415/202; 29/889.21

(58) **Field of Search** ..... 416/197 B, 197 A,  
416/214 A, 190, 192, 116; 415/202, 3.1,  
6, 141; 29/889.21

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

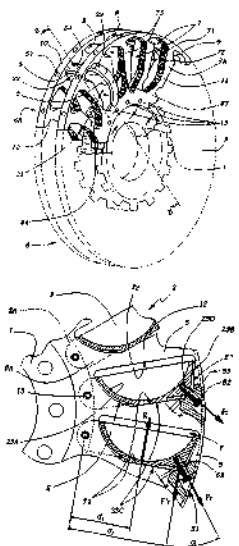
1,361,467 A \* 12/1920 Kincaid

*Primary Examiner*—Edward K. Look  
*Assistant Examiner*—J. M. McAleenan  
(74) *Attorney, Agent, or Firm*—Dowell & Dowell, P.C.

(57) **ABSTRACT**

The invention concerns a method which consists in: pre-positioning, in a housing (7) of a flange (5), a bucket (2) supported by part (23) of its outer surface (23) against an edge (71) of the housing (7) providing a space (E') between the convex surface (23B) of the outer radial part (2B) of the bucket (2) and said edge (71); producing an articulated linkage (15) of the bucket (2) on the rim (1) and/or the flange (5) on the inside (2A) of the bucket (2); exerting on the outer radial part (2B) of the bucket (2) a first calibrated force to bring it closer to the edge (71); determining the distance (e) between said outer radial part (2B) and said edge (71) under said force; slackening said force; arranging, between said outer radial part (2B) and said edge (71), a wedge (53) having a thickness substantially equal to said distance (e); and exerting on the outer radial part (2B) of the bucket a second force (F<sub>2</sub>) to bringing it closer to the edge and maintaining said second force (F<sub>2</sub>) which has an intensity not less than that of the first force.

**11 Claims, 5 Drawing Sheets**



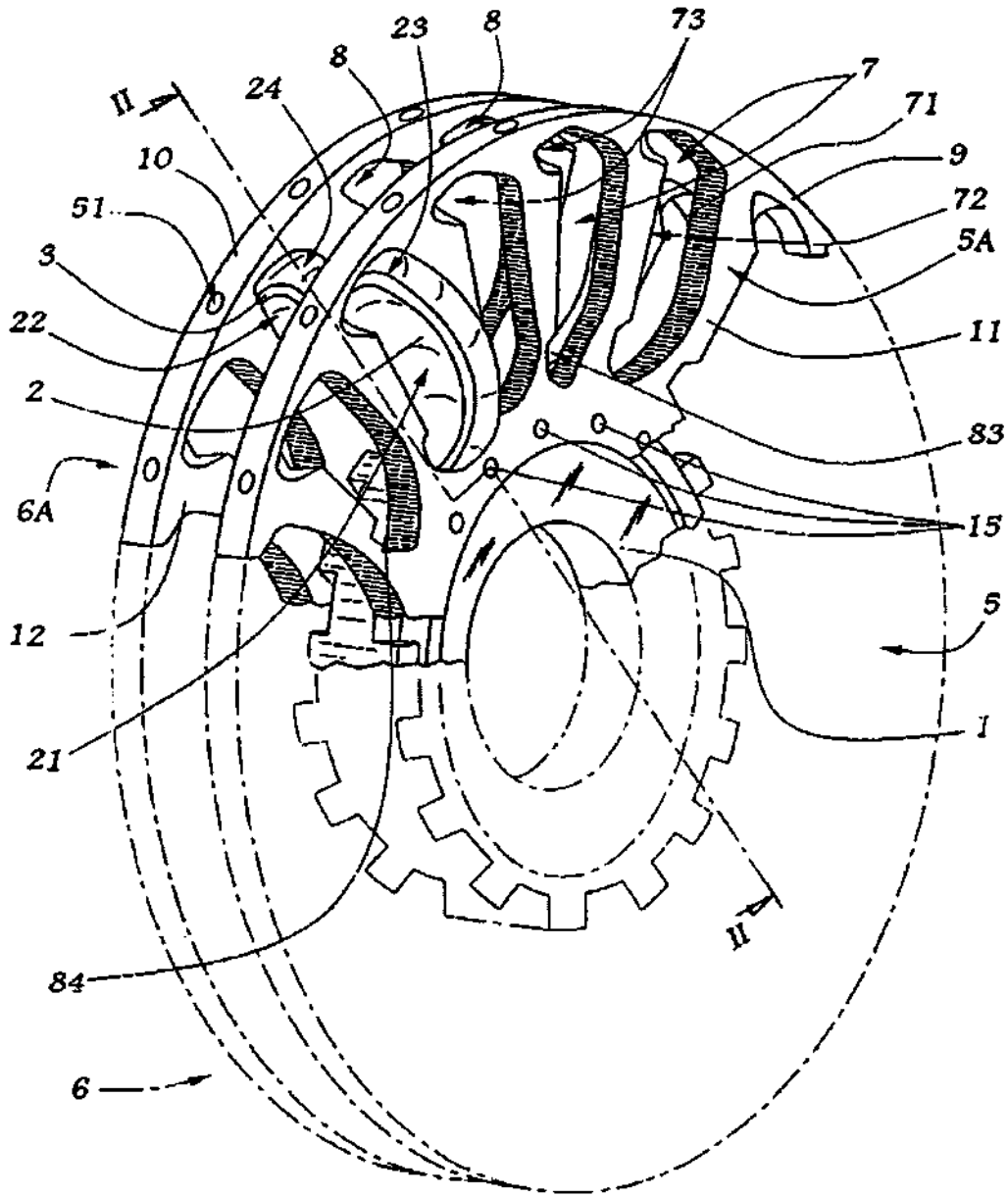
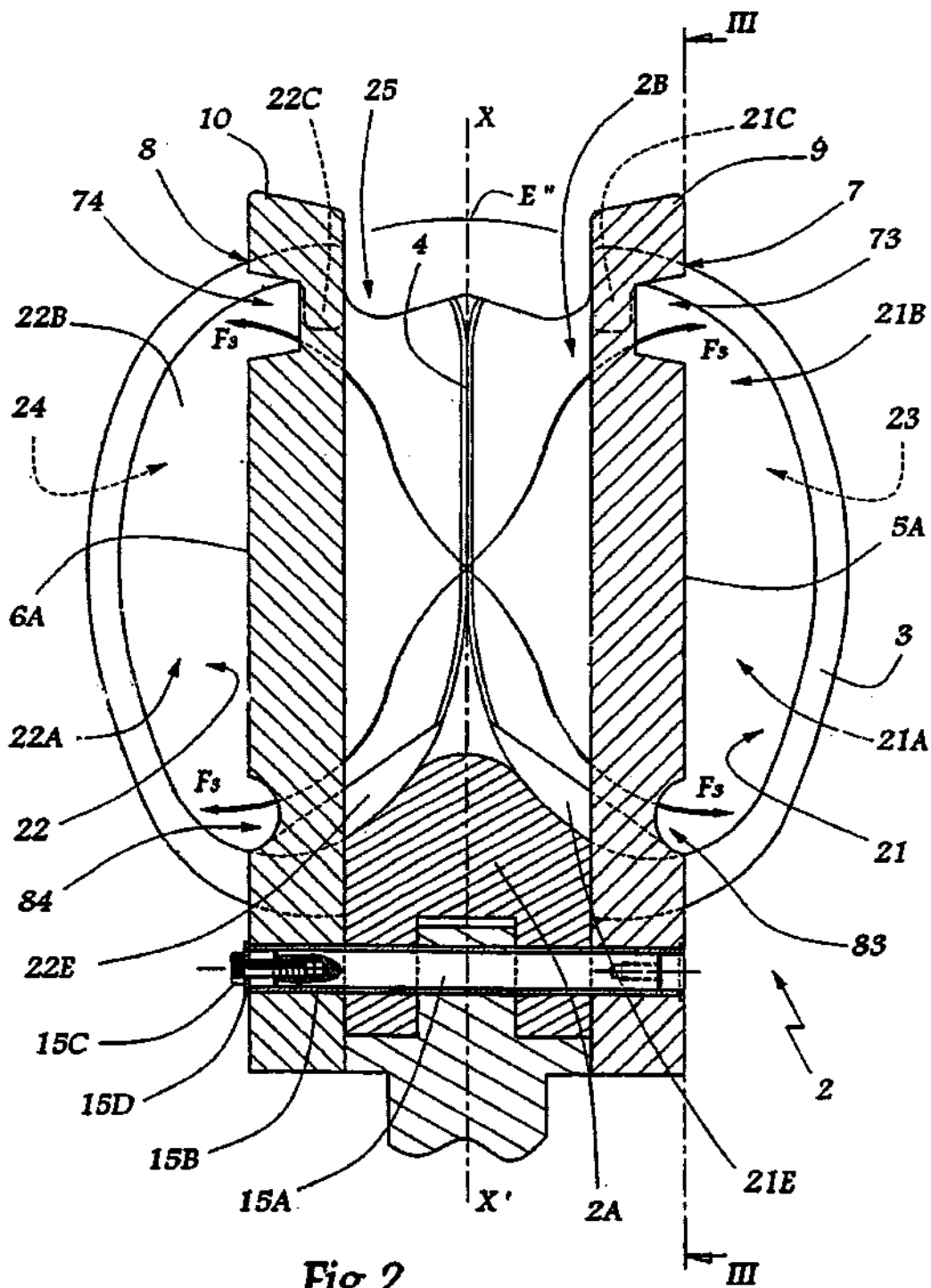


Fig. 1



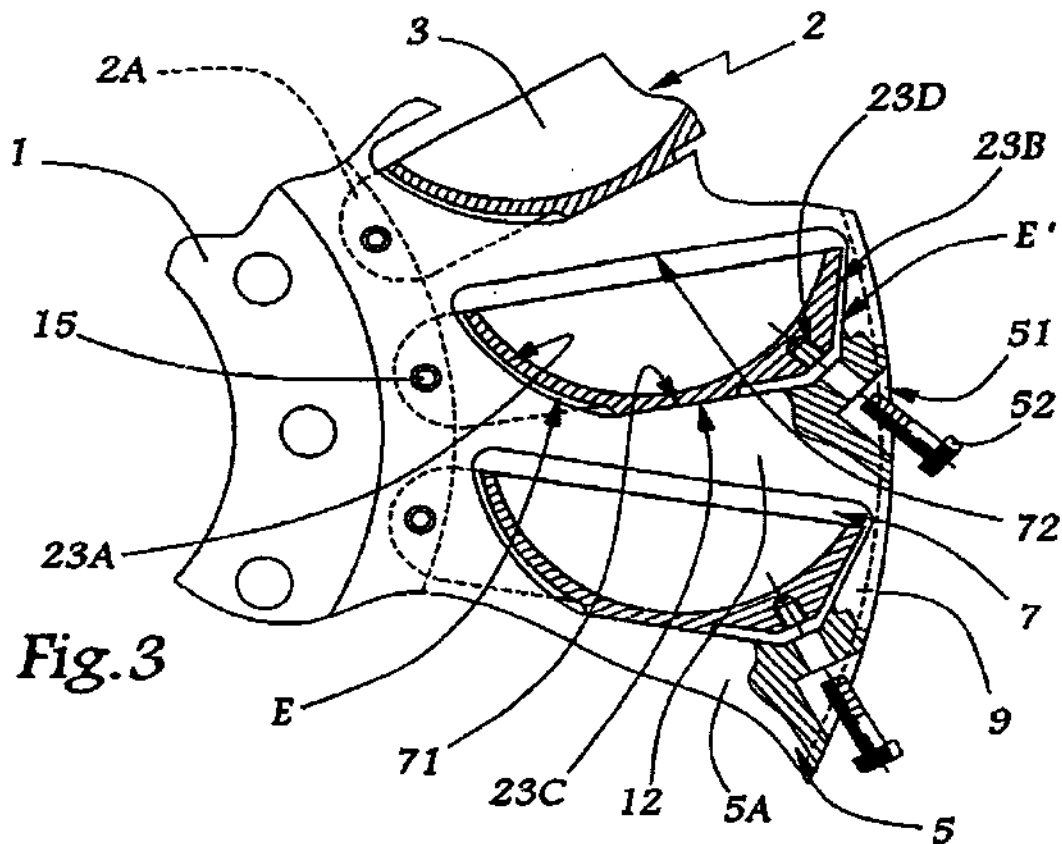


Fig. 3

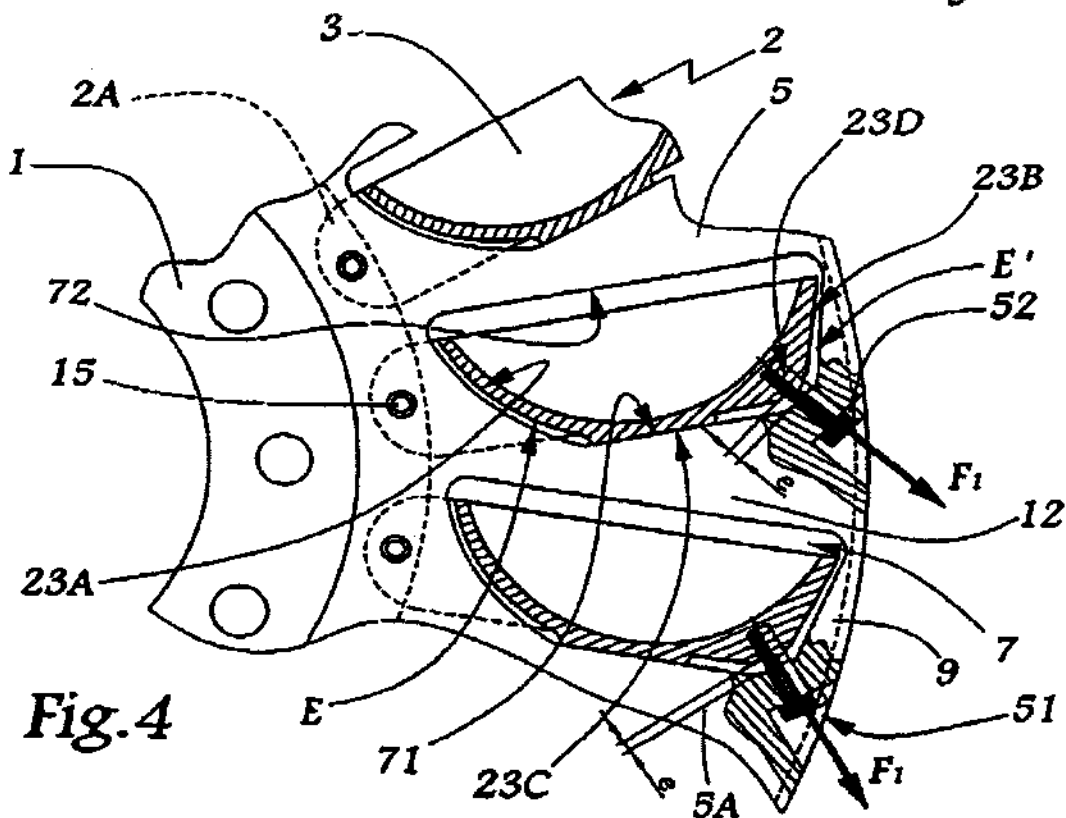


Fig. 4



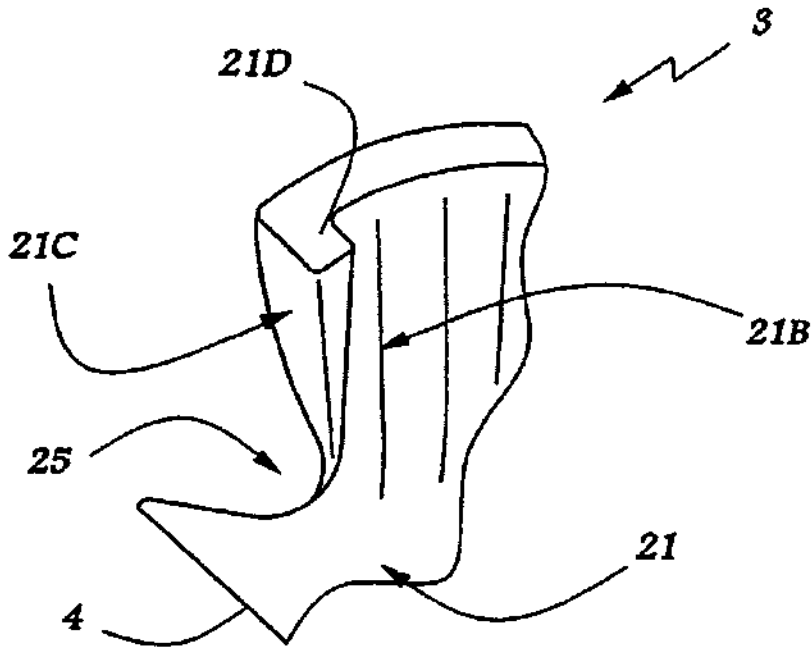


Fig. 6

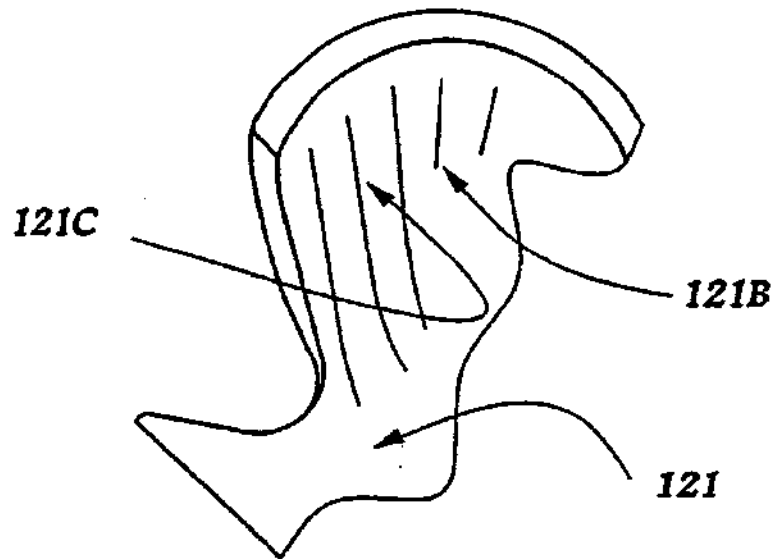


Fig. 7

## METHOD FOR ASSEMBLING A PELTON TURBINE WHEEL

The invention relates to a method for assembling a Pelton turbine wheel, to a bucket for such a wheel and to a wheel equipped with such a bucket.

Pelton turbines are conventionally used for transforming the kinetic energy of a fluid, such as the water of a waterfall, into mechanical energy. Such transformation is effected by rotating the turbine wheel under the effect of a tangential force exerted, on buckets arranged on the periphery of a rim, by a jet of water emerging from one or more injectors distributed around the wheel.

International Patent Application WO-A-99/49213 discloses using two annular flanges fast with the rim for supporting the buckets of a Pelton turbine wheel, which allows an optimized distribution of the forces undergone by the buckets, the mechanical stresses in that case no longer being concentrated in a zone of fastening of the bucket on the rim. In this known device, each bucket is in abutment, by a convex surface, against radial arms of the flanges and immobilized with respect to each flange thanks to a locking screw.

The buckets of such a turbine wheel undergo a large number of impacts due to the jets of driving fluid coming from the injectors. The effect of these impacts is to apply each bucket alternately on the radial arms against which it is in abutment, which results in an alternate stressing of the materials constituting the buckets and the flanges. In addition, the surface abutment of the buckets on the flanges necessitates a precise adjustment of the outer dimensions of each bucket and of the corresponding housings provided in the flanges. Such an adjustment does not allow interchangeability of the buckets, which accordingly renders manufacture and maintenance of such a wheel complex.

It is a more particular object of the invention to overcome these drawbacks by proposing a method for assembling a wheel, as known from WO-A-99/49213, which makes it possible to avoid that the impacts of the jets of driving fluid generate alternate fatigue and/or stressing of the bucket with respect to the rim or to the flanges.

This method consists in:

- pre-positioning, in a housing of a flange, a bucket supported by a part of its outer convex surface against an edge of this housing, providing a space between the convex surface of the outer radial part of this bucket and this edge;
- producing an articulated linkage of this bucket on the rim and/or the flange on the inside of the bucket;
- exerting on the outer radial part of the bucket a first calibrated force to bring it closer to the flange;
- determining the distance between this outer radial part and this edge under this calibrated force;
- slackening this calibrated force;
- arranging, between this outer radial part and this edge, a wedge having a thickness substantially equal to the distance mentioned above, and
- exerting on this outer radial part and maintaining a second force to bring it closer to the edge, this second force having an intensity greater than or equal to that of the first force.

Thanks to the invention, the bucket mounted on the wheel is subjected to a pre-stress formed by the second calibrated force which has the effect of immobilizing it firmly with respect to the flange and of compensating, with the wedge, the spacing existing between the outer radial part of the

bucket and the flange. After establishment of the pre-stress, the wedge makes it possible to "filter" the dynamic forces exerted on the bucket, particularly at the level of its outer radial part. The use of a wedge, of thickness determined as a function of the exact geometry of the bucket and of the flange and of the reaction of the bucket to the first calibrated force of bringing closer, makes it possible to envisage an interchangeability of the buckets, only the thickness of each wedge having to be adjusted precisely to the geometry of the surrounding parts.

According to a first advantageous aspect of the invention, the method consists in exerting the calibrated forces by means of a locking screw received in a housing made in the flange and penetrating in a tapping made in the outer radial part of the bucket. The calibrated force may thus be exerted by means of a torque wrench or any other controlled tightening means and have a considerable intensity, particularly in the case of a wheel of large diameter.

According to another advantageous aspect of the invention, the afore-mentioned first and second calibrated forces for bringing closer are substantially of the same intensity. Thus, when the wheel is in mounted configuration, each bucket is in abutment against the corresponding wedge under the effect of the calibrated force used for determining the thickness of this wedge. This assembly makes it possible to obtain a constant force in the locking screws by filtering the alternate forces due to the impacts of the jets of fluid.

The invention also relates to a turbine wheel bucket carrying out the method as described hereinbefore and, more specifically, to a bucket comprising a bi-concave surface for flow of a fluid for driving the wheel and a convex surface adapted to cooperate with at least one annular flange fast with a rim of the wheel. This bucket is characterized in that its convex surface forms at least one abutment zone located against the flange and at least one zone distant from the flange in an outer radial part of the bucket, this zone distant from the flange being adapted to be brought closer to a part of the flange located opposite by a calibrated force.

According to advantageous but non-obligatory aspects of the invention, this bucket incorporates one or more of the following characteristics:

The convex surface of the bucket also forms a zone distant from the flange in an inner radial part of the bucket.

Thus, the localized abutment zone on the face is formed solely in a central part of this convex surface, which allows a certain displacement of the bucket in a radial direction.

The bucket comprises, at the level of the outer radial part and/or the inner radial part of its concave surface, at least one guide adapted to give to the flow of the afore-mentioned fluid a divergent component which is accentuated with respect to a median edge of the bucket. This guide makes it possible to avoid the fluid in the course of flow striking a radial arm of the flange disposed opposite the concave surface of the bucket. This guide may be provided to be adapted to direct the flow up to the level of a recess made in a radial arm of the flange disposed opposite this concave surface. This guide is advantageously formed by a rib extending, from an outer radial end zone of the bucket, in the direction of an inner radial part of the bucket, this rib bordering the outer notch of the bucket.

Finally, the invention relates to a Pelton turbine wheel which comprises a rim, at least one annular flange, fast with the rim and provided with housings for receiving buckets, and at least one bucket as described hereinbefore.

Such a wheel advantageously comprises, for this bucket or for each bucket, a wedge disposed between the afore-

mentioned distant zone and the flange, the bucket or each of the buckets being subjected to a calibrated force of bringing this distant zone and the flange closer.

According to another advantageous aspect of the invention, the or each flange is provided with recesses for flow of the fluid driving the turbine from the concave surface of each bucket, the recesses being formed on an outer lateral surface of the flange.

The invention will be more readily understood and other advantages thereof will appear more clearly in the light of the following description of two embodiments of a Pelton turbine wheel in accordance with its principle, given solely by way of example and made with reference to the accompanying drawings, in which:

FIG. 1 is a view in partial perspective of a Pelton turbine wheel according to the invention.

FIG. 2 is a section along line II—II in FIG. 1.

FIG. 3 is a section along line III—III in FIG. 2 during a first step of assembly of the wheel of FIG. 1, a plurality of buckets being shown.

FIG. 4 is a view similar to FIG. 3 during a second step of the method of assembly.

FIG. 5 is a view similar to FIG. 3 during a third step of the method of assembly.

FIG. 6 is a view in partial perspective of the bucket of the wheel of FIGS. 1 to 5.

FIG. 7 is a view similar to FIG. 6 for a bucket according to a second embodiment of the invention.

The turbine wheel shown in FIGS. 1 to 6 comprises a rim 1 and buckets 2, eighteen in number in the example shown, distributed on the periphery of the rim 1. Each bucket comprises two ladles or bowls 3 separated by a median edge 4 intended to be arranged opposite one or more water or vapour injectors (not shown). The rim 1 is provided to be mounted on a shaft for transferring the movement (likewise not shown).

In order to render the drawing clearer, only one bucket has been shown in FIG. 1.

Two ring-shaped flanges 5 and 6 are mounted on the rim 1 and contribute to holding the buckets 2 with respect to this rim. The flanges 5 and 6 are respectively provided with housings 7 and 8 in which the bowls 3 of the buckets 2 may be inserted. Two bands 9 and 10 of continuous matter are respectively formed in the outer peripheral zones of the flanges 5 and 6. These bands 9 and 10 join radial arms 11 and 12 formed by the flanges 5 and 6, respectively between adjacent housings 7 and 8.

Each bucket 2 is mounted on the rim 1 and the flanges 2 thanks to a pin 15 installed as a so-called "compound" assembly and appearing more clearly in FIG. 2. This pin comprises a slightly conical principal body 15A inserted in a split sleeve 15B, itself introduced in corresponding bores in flanges 5 and 6 and the rim 1. A locking screw 15C cooperates with a washer 15D for tightening the pin 15 in position.

Each bucket 2 defines two concave surfaces 21 and 22 between which extends the edge 4 along a radial axis X—X' forming axis of symmetry of the bucket 2. The bucket 2 also defines two convex surfaces 23 and 24 together forming the outer surface of each bowl 3. Each bucket 2 comprises an inner radial part 2A at the level of which it is connected with the rim 1 and the flanges 5 and 6 by the pin 15. Each bucket 2 also comprises an outer radial part 2B located in the vicinity of the bands 9 and 10 when the wheel is in mounted configuration and in which there is defined an outer notch 25 allowing the injection of the jet of water in the bucket 2.

23A and 23B respectively denote the inner and outer radial parts of the surface 23.

As is more clearly visible in FIGS. 3 to 5, a heel or projecting part 23C projects beyond the surface 23 with respect to parts 23A and 23B, the heel 23C being formed in an intermediate zone of the bucket 2.

The geometry of the surface 24 is similar to that of the surface 23 and also comprises a projecting part or heel.

Each housing 7 is defined by a concave edge 71 and a substantially rectilinear edge 72 between which is inserted a bowl 3 of a bucket 2, the surface 23 of this bowl going alongside the edge 71. Similarly, each housing 8 receives the bowl 3 of the bucket 2 located on the left of axis X—X' in FIG. 2.

As is more particularly visible in FIG. 3, the geometry of the edge 71 and of the surface 23 is such that the surface 23 is in abutment against the edge 71 solely at the level of its central zone or heel 23C, two spaces E and E' being respectively formed between the part 23A and the edge 71, on the one hand, and between the part 23B and the edge 71 on the other hand.

During the step of assembly of the wheel shown in FIG. 3, each bucket 2 is positioned in the corresponding housings 7 and 8 and the pin 15 is inserted in the corresponding bores of the buckets of the rim and the flanges, without tightening this pin, so that an articulated linkage is produced of each bucket on the rim and the flanges.

There is then inserted in a housing 51 provided in the band 9 of the flange 5, a screw 52 whose shank traverses the housing 51 and may be inserted in a tapping 23D provided in the part 23B of the surface 23. The screw 52 is then screwed with a torque wrench or other controlled tightening means such as a pre-stress jack or a heating pipe, so as to obtain a calibrated force for bringing closer the part 2B of the bucket 2 and the edge 71 of the housing 7. One proceeds in the same way concerning the second bowl of the bucket 2.

One is then in the position of FIG. 4 where a calibrated force  $F_1$  is exerted on the part 2B by the screw 52 and the equivalent screw provided in the second flange 6. In this configuration, the distance  $e$  existing between the part 23B of the surface 23 and the edge 71 of the housing 7 is measured. This distance  $e$  may be different from one bucket to the other taking into account the manufacturing tolerances of the rim, the flanges and the buckets. The equivalent distance between the outer part of the surface 24 and the concave edge of the housing 8 is measured.

In practice, all the buckets 2 are positioned in the housings 7 and 8 and all the screws 52 and equivalent are progressively tightened in logical order, in order to place all the buckets under pre-stress  $F_1$  for bringing closer their respective outer radial parts 2B with respect to the flanges 5 and 6 in order to ensure an overall symmetry. The distances  $e$  are then measured, as these distances depend in particular on the distribution of forces in the flanges 5 and 6.

When the distances  $e$  have been determined, wedges 53 are fashioned, of which each has a thickness equal to the distance  $e$  between a bucket and the flange as defined hereinbefore. Then, after having loosened the screws 52, i.e. released the force  $F_1$ , each of the wedges 53 is positioned between the bucket 2 and the edge 71 or equivalent of the housing 7 or 8 in which it is inserted and for which the wedge 53 has been fashioned. In other words, each wedge 53 is intended for a couple formed by a bucket 2 and a housing 7 or 8.

When the wedge 53 is in place, the screws 52 and equivalent are tightened again, with a calibrated force  $F_2$  of intensity greater than or equal to that of the force  $F_1$  used previously. The outer radial part 2B of each bucket 2 is thus



5

subjected to a force  $F_2$  for bringing closer this part with respect to the edge **71** or equivalent of the housing.

As the force  $F_2$  is at least as intense as the force  $F_1$ , one is sure that the part **23B** of the surface **23** is in firm abutment against the wedge **53** which is itself in firm abutment against the edge **71** of the housing **7** or equivalent. Each bucket is thus subjected to a pre-stress  $F_2$  which applies it efficiently against the flange, in pivoting about the axis of the pin **15**. Each bucket **2** is therefore firmly maintained in position and does not risk oscillating under the effect of the impacts of the fluid issuing from the injectors.

The pins **15** are then tightened so that the articulated linkage created at their level is locked.

At the end of assembly, the bucket **2** may be modeled like a beam articulated towards the pin and in abutment on the central zones **23c** and equivalent while it is subjected to a force of application against the edge **71**.

As is more particularly visible in FIG. 5, each bucket **2** is subjected to a force of reaction  $R$  by the flange **5** or **6** and to the force  $F_2$ , the force  $F_2$  having an intensity equal to the section of the screw **52** multiplied by the force of tightening.

In the case of a screw of type M16 tightened to 200 MPa, the force  $F_2$  has a value defined as follows:

$$F_2 = 144 \text{ mm}^2 \times 200 \text{ MPa} = 28\,800 \text{ N}$$

The tangential component  $F'_2$  of the force  $F_2$  is equal to  $F'_2 = F_2 \times \cos(\alpha)$  where  $\alpha$  is the angle of the force  $F_2$  with respect to the reaction  $R$ . Assuming  $\alpha$  to be equal to  $30^\circ$ , one obtains:

$$F'_2 = 24\,940 \text{ N.}$$

At equilibrium, the pre-stress exerted by the force of reaction  $R$  on the bucket **2** which results from the component  $F'_2$  may be expressed as a function of the distances  $d_1$  and  $d_2$  defined respectively between the pin **15** and a point of application of the reaction  $R$  and between the pin **15** and the point of application of the force  $F_2$  such that

$$R = F'_2 \times d_2 / d_1.$$

Furthermore, the force of the impact exerted by the jet on each bucket **2** may be determined by calculation and it suffices to choose the force of tightening of the screws **52** and equivalent and the ratio  $d_2/d_1$  for the force  $R$  to be permanently greater than or equal to the force undergone by the bucket under the effect of the impact mentioned above. A safety coefficient of the order of 1.5 may, for example, be used.

Thus, each bucket is firmly maintained in position with respect to its environment and the material constituting it is not stressed in fatigue by the impacts that it undergoes.

The method of the invention is efficient as long as the force  $F_2$  is greater in value than the force  $F_1$ , which makes it possible to ensure that each bucket **2** is effectively applied against the adjacent wedge **53** or equivalent.

According to an advantageous variant of the invention, the forces  $F_1$  and  $F_2$  may be substantially equal, in which case the screws **52** and equivalent are not subjected to a high elongation force while each bucket is efficiently maintained in position.

The fact that a space  $E$  is provided between the part **23A** of the surface **23** and the edge **71** ensures that the system formed by a bucket **2** and a flange **5** or **6** is isostatic.

As is more particularly visible in FIGS. 2 and 6, the outer radial parts **21B** and **22B** of the concave surfaces **21** and **22** are each provided with a rib **21C** or **22C** adjacent the notch **25**. The function of these ribs is to deviate the flow of water

6

represented by arrow  $F_3$  in FIG. 2 towards the outside of the space  $E$  defined between the flanges **5** and **6**.

In order to avoid the flow of water deviated by the ribs **21C** and **22C** striking the rectilinear edges **72** and equivalent of the housings **7** and **8**, these edges are provided, on the outer faces **5A** and **6A** of the flanges **5** and **6**, with recesses, **73** for the edges of housings **7** and **83** for the edges of housings **8**. Thanks to these recesses **73** and **83**, the flow of water  $F_3$  may be evacuated without generating a force of braking of the wheel which might occur if the water flowing over the surfaces **21** and **22** struck the edges **72** and equivalent of the housings **7** and **8**.

As is more particularly visible in FIG. 6, the rib **21c** has a depth and a thickness which decrease on moving away from the edge **21D** of the surface **21**.

As shown in FIG. 7, the function of the rib **21c** may also be obtained by a concave zone **121C** provided in the outer radial part **121B** of the concave surface **121** of a bucket in accordance with a second embodiment.

Towards the inner part **21A** or **22A** of the surfaces **21** and **22**, the latter are provided with a lining **21E** or **22E** making it possible also to divert the flow  $F_3$  towards the outside of the flanges **5** and **6**, without interference with the rectilinear edges of the housings **7** and **8**.

As before, recesses **74** and **84** may be provided on the flanges **5** and **6**, at the level of the edges of the housings **7** and **8**, to avoid an interference between the flow  $F_3$  and these edges. In a variant, the linings **21E** and **22E** extend up to outside the flanges **7** and **8**, with the result that it is not necessary to provide recesses in the inner parts of the arms **11** and **12**.

The invention has been described with a turbine wheel comprising a rim and two flanges added on this rim. It is also applicable to the case of the rim being formed by two half-rims each integrating an annular part forming flange, as described in the second embodiment of WO-A-99/49213 and, more generally, to any turbine wheel comprising a rim and at least one flange.

What is claimed is:

1. Method for assembling a turbine wheel of Pelton type comprising a rim (**1**), a plurality of buckets (**2**) distributed over the periphery of this rim and at least one annular flange (**5**, **6**) fast with said rim and provided with housings (**7**, **8**) for receiving said buckets, characterized in that it consists in:

pre-positioning, in a housing (**7**) of said flange, a bucket (**2**) supported by a part (**23C**) of its outer convex surface (**23**) against an edge (**71**) of said housing, providing a space ( $E$ ) between the convex surface (**23B**) of the outer radial part (**2B**) of said bucket and said edge (**71**);

producing an articulated linkage of said bucket (**2**) on the rim and/or said flange (**5**) on the inside (**2A**) of said bucket;

exerting on said outer radial part (**2B**) of said bucket a first calibrated force ( $F_1$ ) to bring it closer to said flange;

determining the distance ( $e$ ) between this outer radial part (**2B**) and this edge (**71**) under said force ( $F_1$ );

slackening said force ( $F_1$ );

arranging, between said outer radial part (**2B**) and said edge (**71**), a wedge (**53**) having a thickness substantially equal to said distance ( $e$ ), and

exerting on said outer radial part (**2B**), and maintaining a second force ( $F_2$ ) to bring it closer to said edge (**71**), said second force ( $F_2$ ) having an intensity greater than or equal to that of said first force ( $F_1$ ).

2. Method according to claim 1, characterized in that it consists in exerting said calibrated forces ( $F_1$ ,  $F_2$ ) by means

of a locking screw (52) received in a housing (51) made in said flange (5, 6) and penetrating in a tapping (23D) made in the outer radial part (2B) of said bucket (2).

3. Method according to claim 1, characterized in that said first and second calibrated forces ( $F_1$ ,  $F_2$ ) for bringing closer are substantially of the same intensity.

4. Pelton turbine wheel bucket comprising a bi-concave surface (21, 22) for flow ( $F_3$ ) of a fluid for driving said wheel and a convex surface (23, 24) adapted to cooperate with at least one annular flange (5, 6) fast with a rim (1) of said wheel, characterized in that said convex surface (23) forms at least one abutment zone (23C) located against said flange (5, 6) and at least one zone (23B) distant from said flange in an outer radial part (2B) of said bucket (2), said zone (23B) distant from said flange being adapted to be brought closer to a part of the flange located opposite, by a calibrated force ( $F_1$ ,  $F_2$ ).

5. Bucket according to claim 4, characterized in that said convex surface (23, 24) forms a zone (23A) distant from said flange (5, 6) in a radial part (2A) inside said bucket (2).

6. Bucket according to claim 4, characterized in that it comprises, at the level of the outer radial part (21B, 22B) and/or the inner radial part (21A, 22A) of its concave surface (21, 22), at least one guide (21C, 22C, 21E, 22E) adapted to give the flow ( $F_3$ ) of said fluid a divergent component accentuated with respect to the median edge (94) of said bucket (2).

7. Bucket according to claim 6, characterized in that said guide (21C, 22C, 21E, 22E) is adapted to direct said flow ( $F_3$ ) up to the level of a recess (73, 74, 83, 84) made in a radial arm (11, 12) of said flange (5, 6) disposed opposite said concave surface (21, 22).

8. Bucket according to claim 7, characterized in that said guide is formed by a rib (21C, 22C) extending, from an outer radial end zone (2B) of said bucket (2), in the direction of an inner radial part (2A) of said bucket, this rib bordering an outer notch (25) of said bucket.

9. Pelton turbine wheel comprising a rim (1) and at least one annular flange (5, 6) fast with said rim and provided with housings (7, 8) for receiving buckets, characterized in that it comprises at least one bucket (2) according to claim 4.

10. Turbine wheel according to claim 9, characterized in that it comprises, for said bucket (2) or each of said buckets, a wedge (53) disposed between said distant zone (23B) and said flange (5, 6), said bucket or each of said buckets being subjected to a calibrated force ( $F_2$ ) for bringing said distant zone and said flange closer.

11. Turbine wheel according to claim 10, characterized in that said or each flange (5, 6) is provided with recesses (73, 74, 83, 84) for flow of the fluid driving the turbine from the concave surface (21, 22) of each bucket (2), said recesses being formed on an outer lateral surface (5A, 6A) of said flange (5, 6).

\* \* \* \* \*



US006877968B2

(12) **United States Patent**  
**Godsall et al.**

(10) **Patent No.:** **US 6,877,968 B2**  
(45) **Date of Patent:** **Apr. 12, 2005**

(54) **LOW HEAD WATER TURBINE**

4,923,368 A \* 5/1990 Martin ..... 415/202  
6,554,596 B1 \* 4/2003 Patterson et al. .... 418/260

(75) **Inventors:** **Terrence Gordon Godsall**, Tamworth (CA); **Donald Eric Innes**, Tamworth (CA); **Matthew Christopher Innes**, Montreal (CA)

\* cited by examiner

*Primary Examiner*—Christopher Verdier  
(74) *Attorney, Agent, or Firm*—Nixon Peabody LLP; Jeffrey L. Costellia

(73) **Assignee:** **The Salmon River Project Limited**, Ontario (CA)

(57) **ABSTRACT**

(\*) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 28 days.

A low head water turbine comprising a runner having a cylindrical outer surface and a plurality of similar blades similarly pivotably secured along their inner sides to the outer surface of the runner so as to pivot in the direction of rotation of the runner between a closed position lying adjacent the outer surface of the runner and an open position at an angle thereto. A housing having end walls and a rounded side wall extending therebetween, completely encases the runner and its blades. The runner is eccentrically mounted to end walls of the housing for rotation about a horizontal axis so that the cylindrical outer surface is spaced closer to an upper portion of the housing side wall and farther from a lower portion. A water inlet opening is located in a lower, forward portion of the housing, below the axis of rotation of the runner. A water outlet opening is located in a lower, rearward portion of the housing. During operation of the turbine, the blades will be constricted by the side wall of the housing and thereby moved to the closed position as they approach and pass the upper portion of the housing side wall, and will move to the open position under force of gravity, water and centrifugal force acting on them as they move below the axis of rotation of the runner to the lower position, all the time the housing side wall acting on the outer sides of the blades.

(21) **Appl. No.:** **10/305,360**

(22) **Filed:** **Nov. 27, 2002**

(65) **Prior Publication Data**

US 2004/0101397 A1 May 27, 2004

(51) **Int. Cl.**<sup>7</sup> ..... **F03B 7/00**

(52) **U.S. Cl.** ..... **418/268**; 415/3.1; 415/141; 415/185; 415/186; 415/125; 415/906

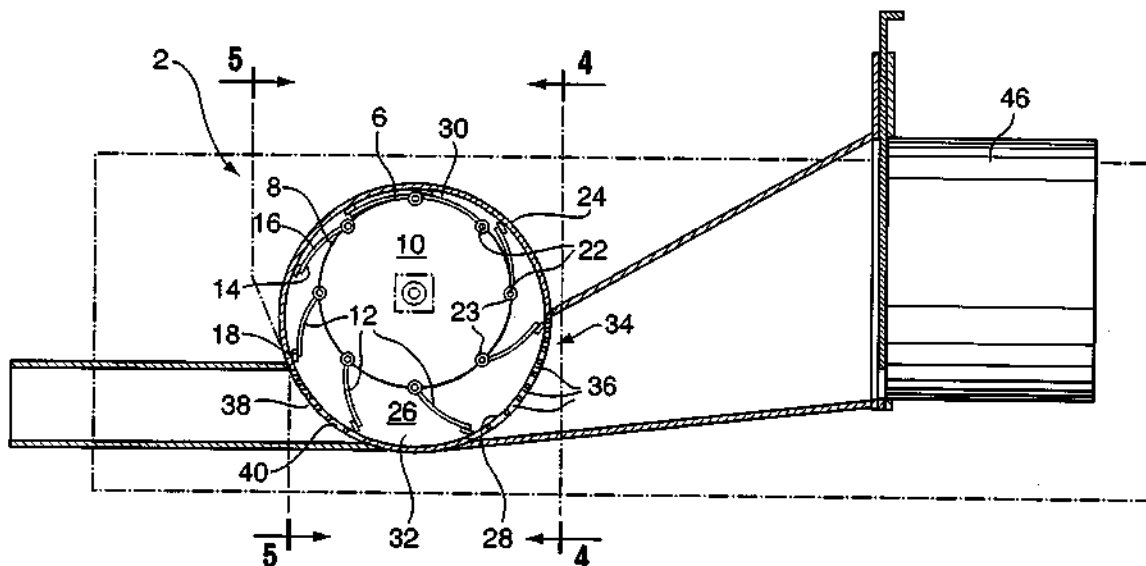
(58) **Field of Search** ..... 415/3.1, 140, 141, 415/202, 125, 906, 183, 185, 186, 208.5; 416/240, 134 R, 135, 88, 89, 111–112, 116, 117, 119; 418/268

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

109,335 A \* 11/1870 Morgan ..... 415/141  
227,576 A \* 5/1880 Read ..... 415/141  
3,983,404 A \* 9/1976 Sherrard ..... 415/3.1  
4,263,516 A \* 4/1981 Papadakis ..... 415/3.1

**10 Claims, 5 Drawing Sheets**



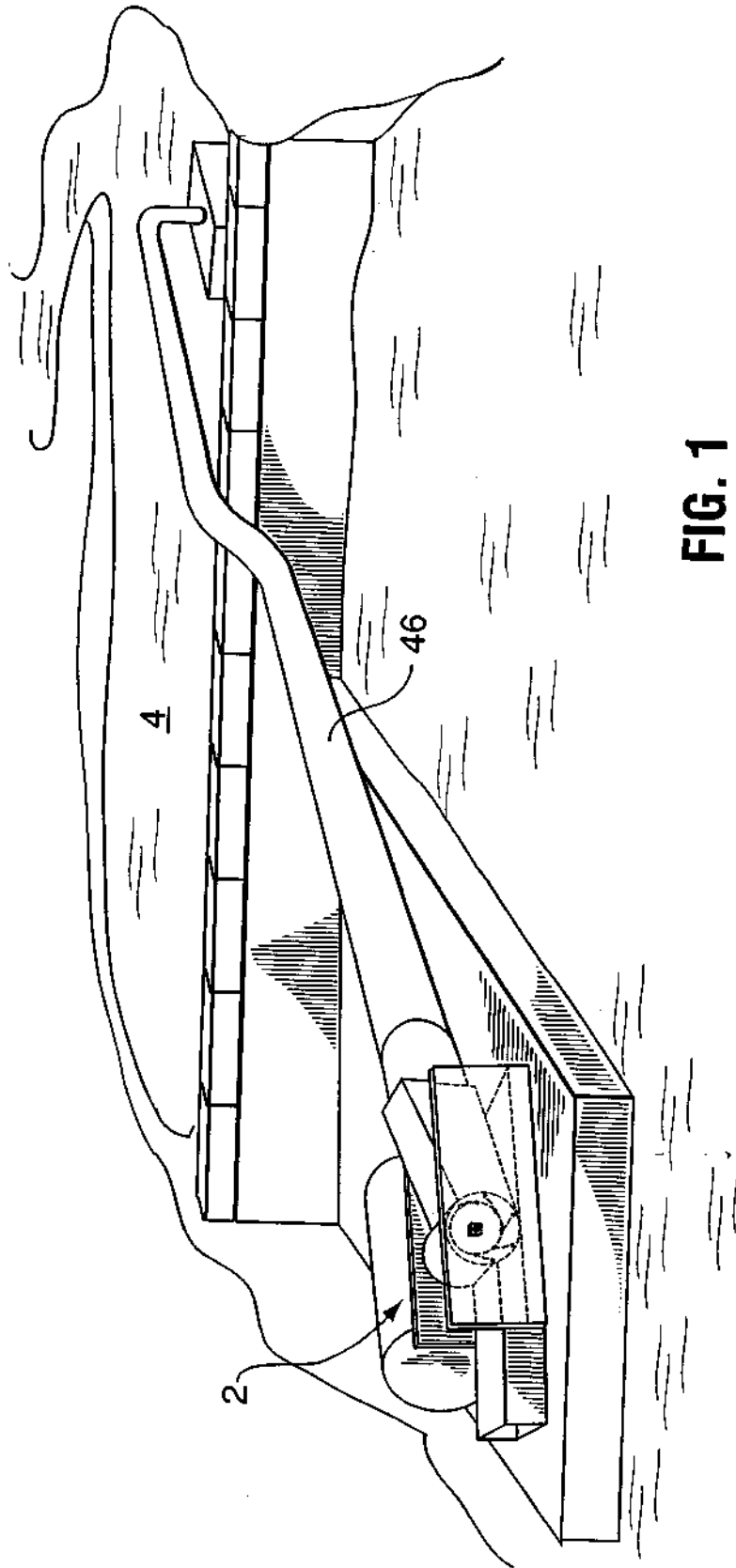


FIG. 1

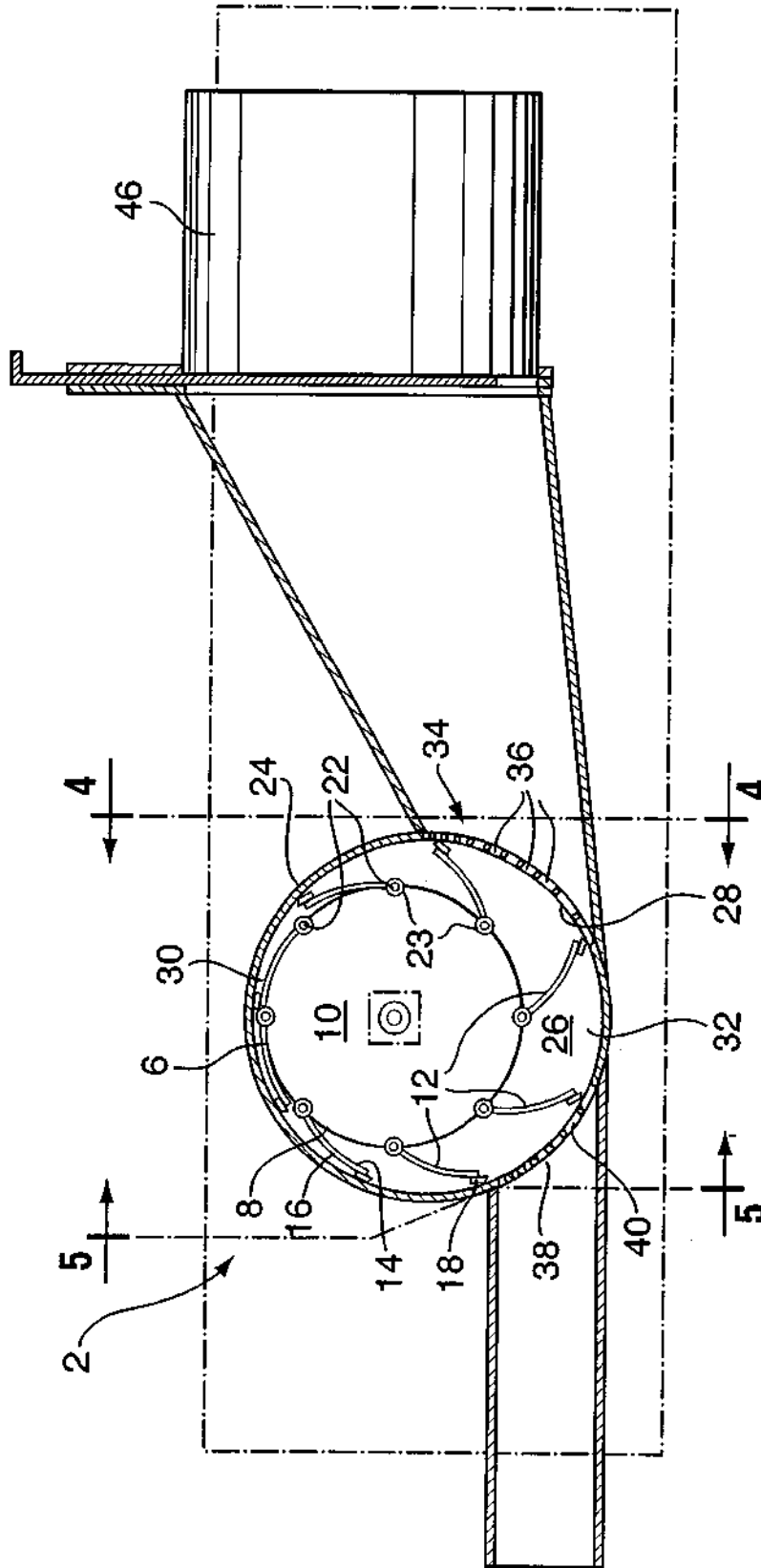


FIG. 2

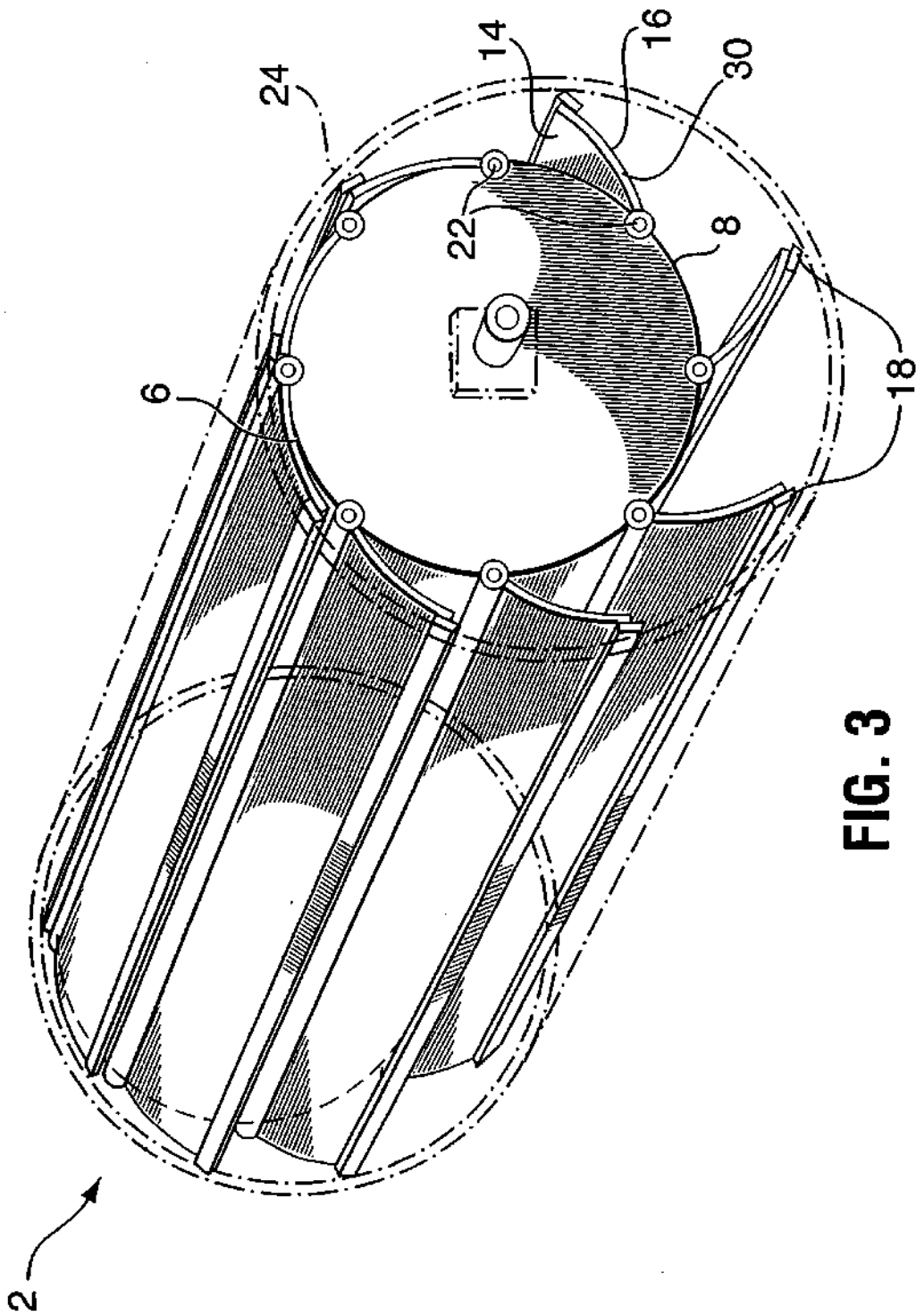


FIG. 3

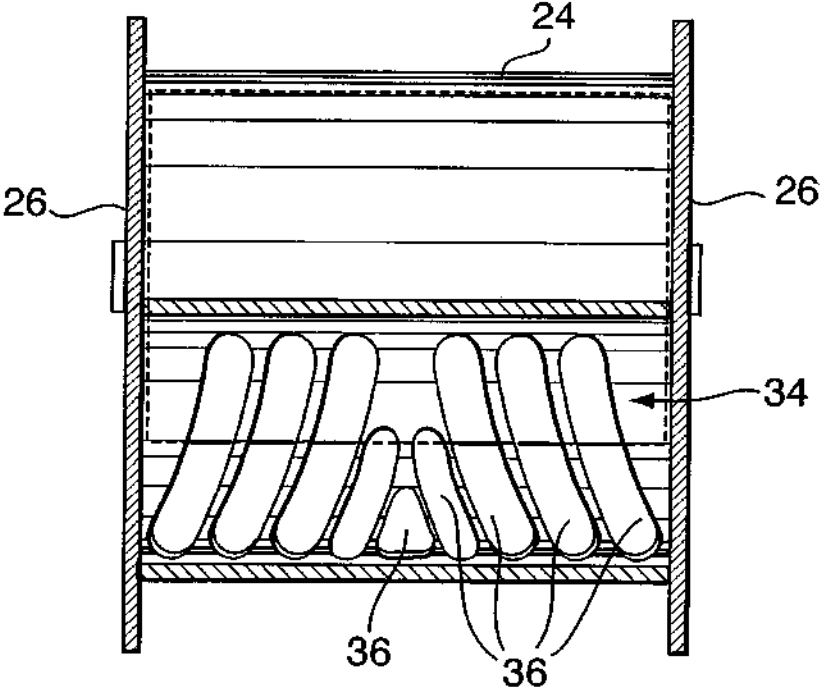


FIG. 4

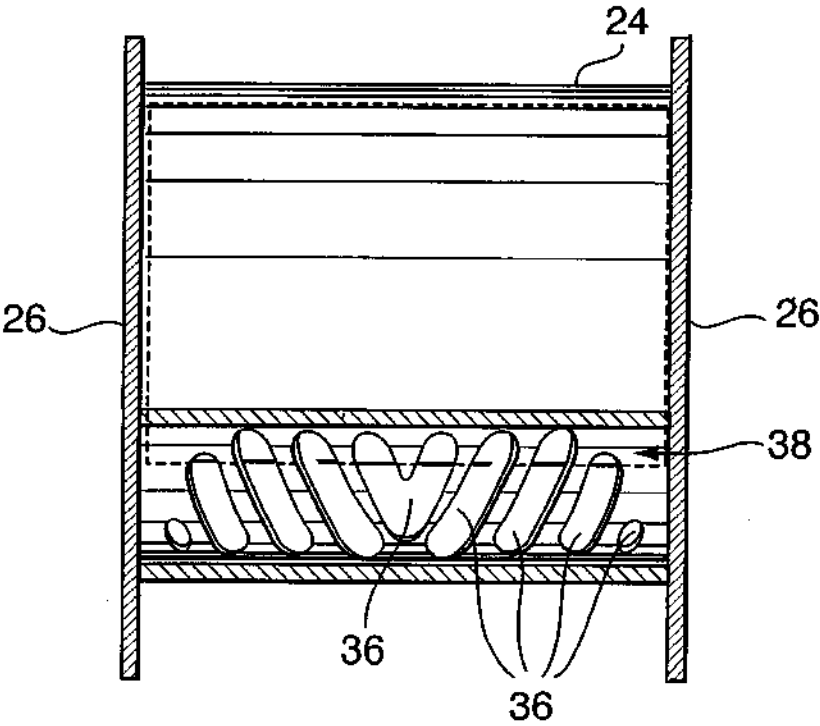


FIG. 5

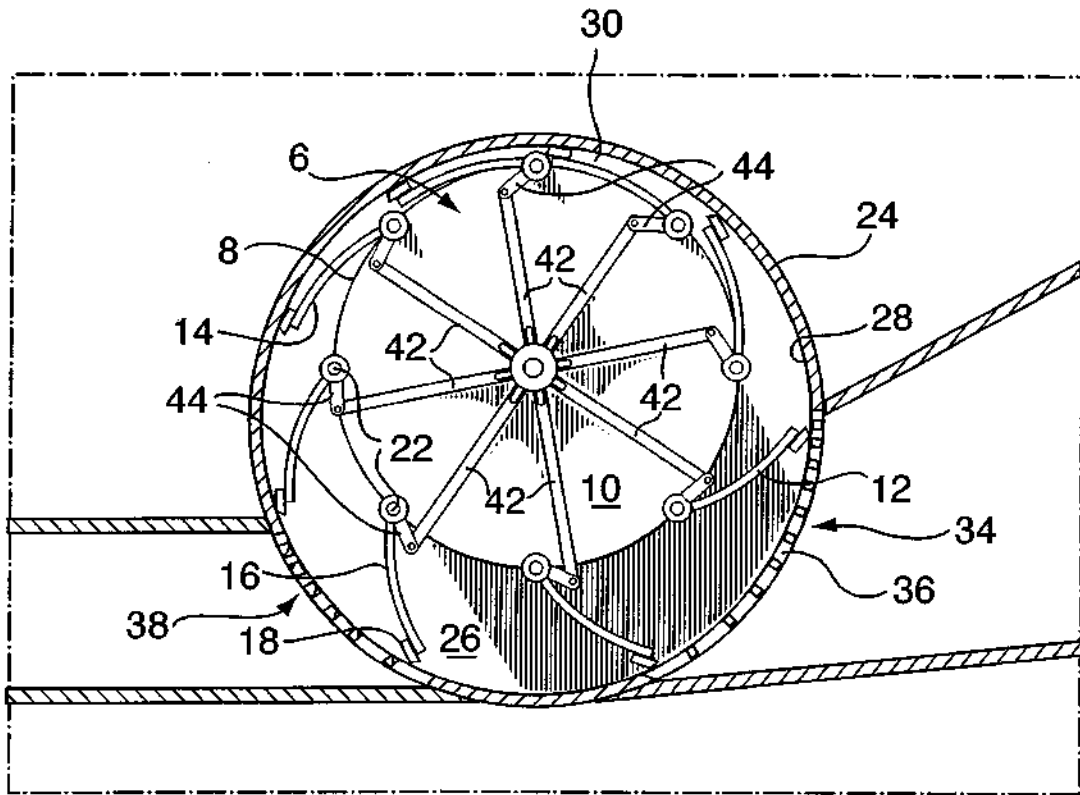


FIG. 6



1

**LOW HEAD WATER TURBINE****FIELD OF THE INVENTION**

The present invention relates to an improvement in low head water turbines, and more particularly to turbines which can capture energy from heads of water from about six meters, down to about one meter, for use, for example, in generating electricity.

**BACKGROUND OF THE INVENTION**

Traditionally, low head water turbines have been of an open type, as exemplified for example by conventional water wheels, and have had extremely low efficiency. This has meant, for example, that sections of small rivers having a low head or drop, have been unsuitable for generation of hydro electric power. Conventional power generation turbines such as Francis turbines, Kaplan turbines and Pelton turbines traditionally require high heads of water to generate the water pressure and velocity required to move the turbine blades. Such arrangements have necessitated large dams, construction of flumes and the like, necessitating, often, massive capital expenditure.

The present invention is intended to provide a more efficient construction of turbine which can be economically constructed, and which will operate at higher efficiency, making it suitable for low head electric power generation applications.

**SUMMARY OF THE INVENTION**

In accordance with the present invention there is provided a low head water turbine comprising a runner having a cylindrical outer surface extending between opposite ends and a plurality of similar blades having inner and outer sides extending to the ends. The blades are evenly spaced about the surface of the runner and extend to the ends of the runner. The blades are similarly pivotably secured along their inner sides to the outer surface of the runner so as to pivot in the direction of rotation of the runner between a closed position lying adjacent the outer surface of the runner and an open position at an angle thereto. A housing having end walls and a rounded side wall extending therebetween, completely encases the runner and its blades. End walls of the housing are proximal to the ends of the runner. The runner is eccentrically mounted to the end walls of the housing for rotation about a horizontal axis so that the cylindrical outer surface of the runner is spaced closer to an upper portion of the housing side wall and farther from a lower portion. A water inlet opening is located in a lower, forward portion of the housing, below the axis of rotation of the runner. A water outlet opening is located in a lower, rearward portion of the housing. The blades are constructed and positioned so that, during operation of the turbine, the blades will be constricted by the side wall of the housing and thereby moved to the closed position as they approach and pass the upper portion of the housing side wall, and will move to the open position under centrifugal force and the force of gravity and water acting on them as they move below the axis of rotation of the runner to said lower position, all the time the housing side wall acting on the outer sides of the blades.

The turbine of the present invention, in tests, has proven to operate at about 85 percent efficiency, an efficiency which is far higher than conventional low head water turbines. Unlike conventional low head turbines which must be constructed on a site-specific basis, the turbine of the present

2

invention may be made in modular form to a uniform design and size. A plurality of similar turbines may be placed in a stream in series or parallel fashion to generate additional power.

**BRIEF DESCRIPTION OF THE DRAWINGS**

These and other objects and advantages of the invention will become apparent upon reading the following detailed description and upon referring to the drawings in which:

FIG. 1 is a schematic view of a water turbine according to the present invention in a low head stream arrangement;

FIG. 2 is a schematic side view, in section, of the turbine according to the present invention;

FIG. 3 is a schematic perspective partial view of the runner of the turbine of FIG. 2;

FIG. 4 is a section view along the line 4—4 of FIG. 2 showing the up stream, entrance to that turbine;

FIG. 5 is a section view along the line 5—5 of FIG. 2 showing the down stream exit of the turbine of the present invention;

FIG. 6 is a schematic side section view of an alternative embodiment of runner for a turbine according to the present invention.

While the invention will be described in conjunction with its illustrated embodiments, it will be understood that it is not intended to limit the invention to such embodiments. On the contrary, it is intended to cover all alternatives, modifications and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

**DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

In the following description, similar features in the drawings have been given similar reference numerals.

Turning to FIGS. 1 and 2 there is illustrated a low head turbine (2) according to the present invention receiving water input from a stream (4).

Turbine (2) comprises a runner (6) having a cylindrical outer surface (8) extending between opposite ends (10). A plurality of similarly shaped and sized blades (12), having inner sides (14) and outer sides (16) extending between ends (10) are spaced evenly about the surface (8) of runner (6) as illustrated, and extend between the ends (10) of runner (6). Along the outer side (16) are preferably secured strips (18) of a low friction plastic. The inner sides (14) of blades (12) are pivotally secured at pivots (22) to the outer surface (8) of runner (6), in such a manner that the blades can pivot in the direction of rotation of the runner, between a closed position lying adjacent the outer surface (8) of the runner and an open position at an angle thereto. Appropriate biasing means (23) in the form of a spring, resilient cushion or counter weights (not illustrated), may be associated with each blade (12) and cylindrical outer surface (8) so as to normally urge the blades to open position.

A housing (24), having end walls (26) and a rounded side wall (28), which may be of circular or irregularly rounded shape in cross section, completely encases runner (6), with the end walls (26) of the housing being proximal to the ends (10) of the runner (6). Runner (6) is eccentrically mounted, as can be seen in FIG. 2, to housing end walls (26), within the housing for rotation about a horizontal axis so that, in operation, runner (6) is spaced closer to an upper portion (30) of the housing side wall (28) and further from a lower

portion (32) of that housing side wall. A water inlet (34) is provided in housing sidewall (28) as illustrated (FIG. 4), instead of being a single large opening, inlet (34) is formed by a plurality of slots (36) which thus act like a grating which can support blades (12), as will be described subsequently, during operation of the device. Slots (36) may be formed as illustrated so that the area thereof increases progressively from top to bottom of inlet (34) so as to permit progressively greater inflow of water from the top to bottom, although this construction is optional. Water inlet opening (34) is located, as can be seen in FIG. 3, in a lower, forward portion of side wall (28) of housing (24), below the axis of rotation A of the runner, although the opening may also extend above that axis.

A water outlet opening (38) is provided in a lower, rearward portion of side wall (28) of housing (24) as illustrated (FIG. 5), outlet (38) similarly formed by a plurality of spaced slots (40) in the side wall (28) of housing (24).

In the alternative embodiment illustrated in FIG. 6, blades (12) are secured to the runner in diametrically opposite pairs and mechanical links (42) are provided between arms (44) connected to the diametrically opposed pairs of blades (12), in such a manner that movement of one blade (12) from open to closed position, in each such pair, causes movement of the diametrically opposed blade from closed to open position. In this way, opening of blades (12) is facilitated.

In operation, because of the eccentrically mounted runner (6) within housing (24), as water from inlet (34) flows against opening blades (12) in the lower, forward (upstream) portion of housing (24), runner (6) is moved about axis A in a clockwise motion. Blades (12), with their outer sides (or strips (18) attached thereto) being constricted by the inner surfaces of side wall (28) of housing (24), are moved to closed position as they approach and pass the upper portion (30) of housing side wall (24) and are moved to open position under centrifugal force and the force of gravity and water (and action of links (42) and arms (44) or counterweights (not illustrated) if they are present), as the blades move below the axis of rotation A to the lower portion (32) of housing (24).

Because the flow of water into housing (24) through inlet opening (34) is directed at the blades in the lower portion of housing (24), and because there is little opportunity for water to escape between the ends of the blades and the ends of the housing, and between the outer edges of the blades and the corresponding inner surface of the side wall of the housing in the lower portion of the housing, most of the water flowing into the housing is able to effectively and efficiently bear against blades (12) in their open position in this lower section of the housing, thereby causing rotation of runner (6). It is essentially the eccentric mounting of runner (6) within housing (24), and the pivoting blades, necessitated by the eccentric mounting of runner (6) which leads to the increased efficiency of operation of this turbine.

In some arrangements of turbine (2), a flow of water may have to be brought into inlet openings (34) by way of a pipe (46) (FIG. 1).

A plurality of turbines (2) as described may be placed in a waterway in either down stream (series) or side-by-side (parallel) arrangement. The series and parallel arrangements are suitable for different applications and provide different advantages, depending upon the characteristics of a particular stream location.

Conventional means of converting the mechanical energy from the rotation of the runner (6) to electrical energy may be combined with the turbine for production of electricity.

Thus, it is apparent that there has been provided in accordance with the invention a low head water turbine device that fully satisfies the objects, aims and advantages set forth above. While the invention has been described in conjunction with illustrated embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art in light of the foregoing description. Accordingly, it is intended to embrace all such alternatives, modifications and variations as fall within the spirit and broad scope of the invention.

What we claim as our invention:

1. A low head water turbine comprising:

- (a) a runner having a cylindrical outer surface extending between opposite ends;
- (b) a plurality of similar blades having inner and outer sides extending to the ends, the blades evenly spaced about the surface of the runner and extending to the ends of the runner, the blades similarly pivotably secured along their inner sides to the outer surface of the runner so as to pivot in the direction of rotation of the runner between, closed position lying adjacent the outer surface of the runner and an open position at an angle thereto;
- (c) a housing having end walls and a rounded side wall extending therebetween, completely encasing the runner and its blades, the end walls of the housing being proximal to the ends of the runner, the runner eccentrically mounted to the end walls of the housing for rotation about a horizontal axis so that the cylindrical outer surface of the runner is spaced closer to an upper portion of the housing side wall and farther from a lower portion thereof;
- (d) a water inlet opening located in a lower, forward portion of the housing and below the axis of rotation of the runner; and
- (e) a water outlet opening located in a lower, rearward portion of the housing;

the blades constructed and positioned so that, during operation of the turbine, the blades will be constricted by the side wall of the housing and thereby moved to the closed position as they approach and pass said upper portion of the housing side wall, and will move to the open position under centrifugal force and the force of gravity and water acting on them as they move below the axis of rotation of the runner to said lower position, all the time the housing side wall acting on the outer sides of the blades.

2. A turbine according to claim 1, wherein the blades are curved along a transverse axis so as, when in the closed position, to conform to the surface of the runner.

3. A turbine according to claim 1, wherein the inlet opening is formed by series of spaced slots in the wall of the housing.

4. A turbine according to claim 3, wherein the total area of the spaced slots progressively increases from top to bottom of the inlet opening so as to permit progressively greater inflow of water from top to bottom of said inlet opening.

5. A turbine according to claim 3, wherein the outlet opening is formed by a series of spaced slots in the wall of the housing.

6. A turbine according to claim 4, wherein the outlet opening is formed by a series of spaced slots in the wall of the housing.

7. A turbine according to claim 1, wherein elongated flexible strips are secured to the outer sides of the blades, during operation so as to reduce passage of water between the outer sides of the blades and the housing wall.

**5**

**8.** A turbine according to claim 7, wherein the strips are made of a low friction plastic.

**9.** A turbine according to claim 1, wherein the blades are secured to the runner in diametrically opposed pairs and linkage means are provided between the diametrically opposed pairs, whereby movement of one blade progressively from the open to the closed position causes corre-

**6**

sponding progressive movement of the diametrically opposed blade from the closed to the open position.

**10.** A turbine according to claim 1, wherein the blades are provided with means to bias them towards the open position.

\* \* \* \* \*



US00D331563S

# United States Patent [19]

[11] Patent Number: Des. 331,563

Drake

[45] Date of Patent: \*\* Dec. 8, 1992

[54] PADDLE WHEEL

4,241,688 12/1980 Mansoll et al. .... 440/90  
4,473,358 9/1984 Viosca, Jr. .... 440/90

[76] Inventor: Joel S. Drake, 5723 Lake St., Glen Arbor, Mich. 49636

### OTHER PUBLICATIONS

[\*\*] Term: 14 Years

"Young Sailors Operate Hand Cranks to Turn Paddles on Boat", Jun. 1954, p. 116, Popular Mechanics.

[21] Appl. No.: 691,092

Primary Examiner—Kay H. Chin  
Attorney, Agent, or Firm—Varnum, Riddering, Schmidt & Howlett

[22] Filed: Apr. 25, 1991

### Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 443,643, Nov. 29, 1989, Pat. No. Des. 317,286.

[52] U.S. Cl. .... D12/317; D12/306

[58] Field of Search .... D12/306, 317; 440/90, 440/31; 114/58; 416/111, 108, 197 B, 197 A

### [57] CLAIM

The ornamental design for a paddle wheel, as shown and described.

### DESCRIPTION

FIG. 1 is a front perspective view of a paddle wheel showing my new design;

FIG. 2 is a rear elevational view thereof;

FIG. 3 is a side elevational view thereof, the opposite side elevational view being a mirror image of that shown;

FIG. 4 is a front elevational view thereof;

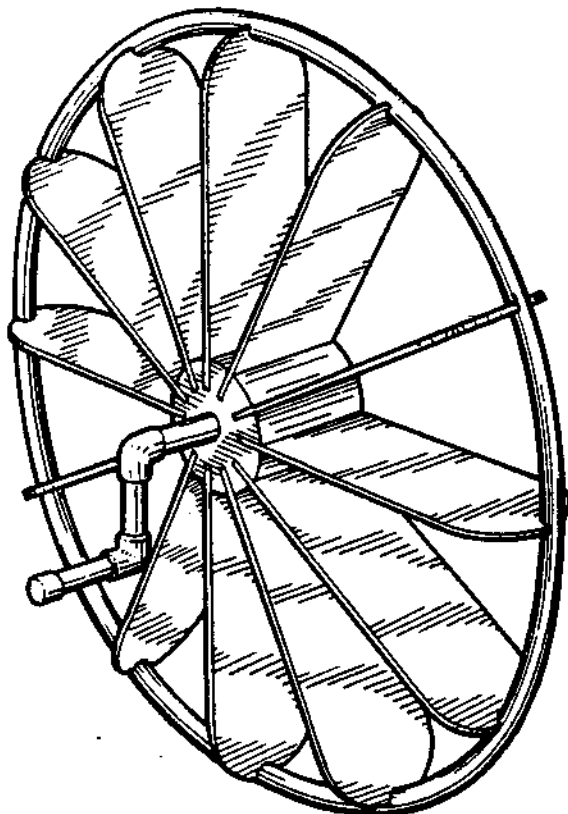
FIG. 5 is a rear perspective view of a second embodiment of the paddle wheel; and,

FIG. 6 is a side elevational view of FIG. 5, the opposite side elevational view being a mirror image of that shown.

### [56] References Cited

#### U.S. PATENT DOCUMENTS

|            |         |                     |         |
|------------|---------|---------------------|---------|
| D. 192,714 | 5/1962  | Thomas et al. ....  | D12/306 |
| D. 230,349 | 2/1974  | Kyryluk et al. .... | D12/306 |
| D. 317,286 | 6/1991  | Drake .....         | D12/306 |
| 1,024,419  | 4/1912  | Resch .....         | 440/31  |
| 1,691,396  | 10/1927 | Lindstrom .....     | 114/283 |
| 3,006,310  | 10/1961 | Penland et al. .... | 440/26  |
| 3,045,636  | 7/1962  | Thomas et al. ....  | 440/26  |
| 4,171,675  | 10/1979 | Thompson .....      | 440/90  |



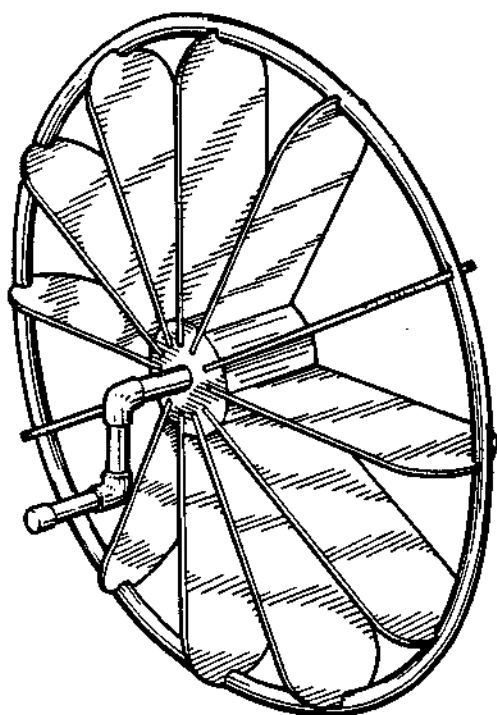


FIG. 1

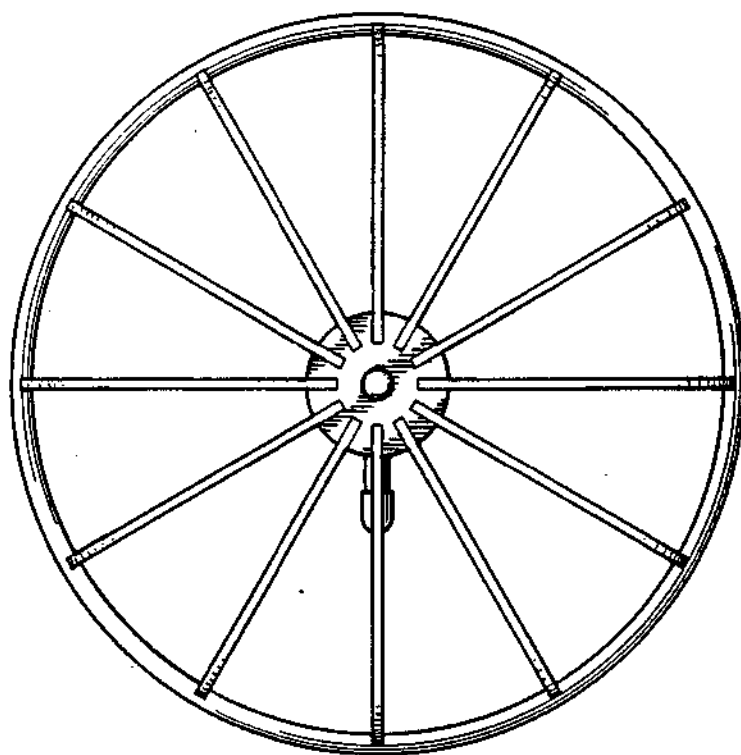


FIG. 2

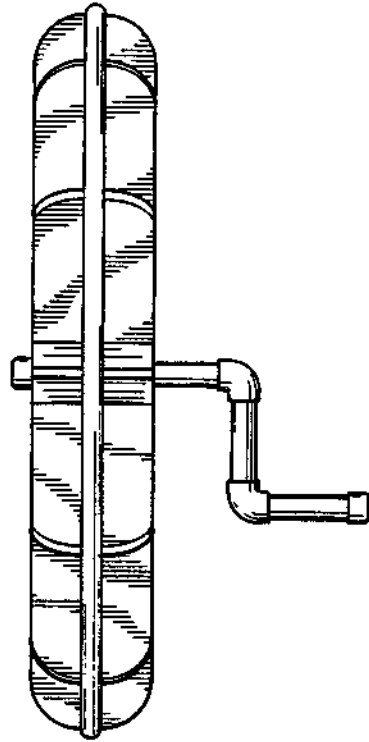


FIG. 3

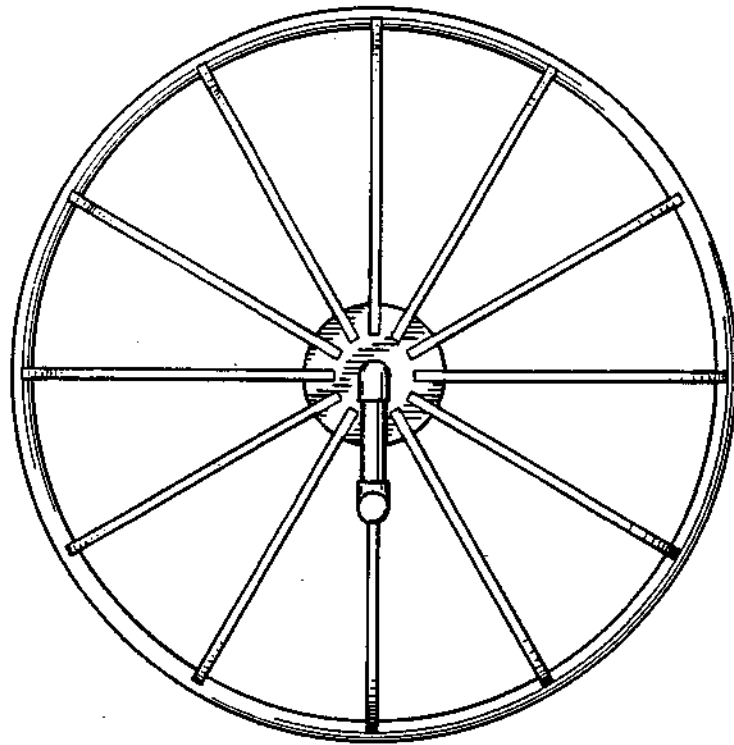


FIG. 4

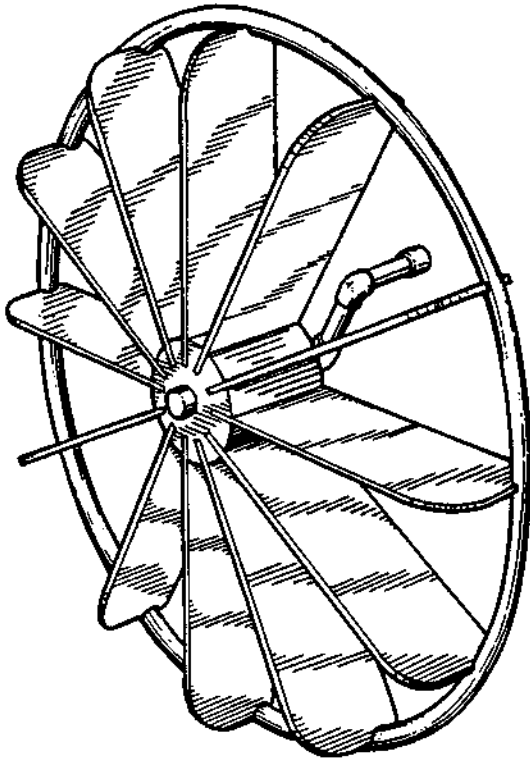


FIG. 5

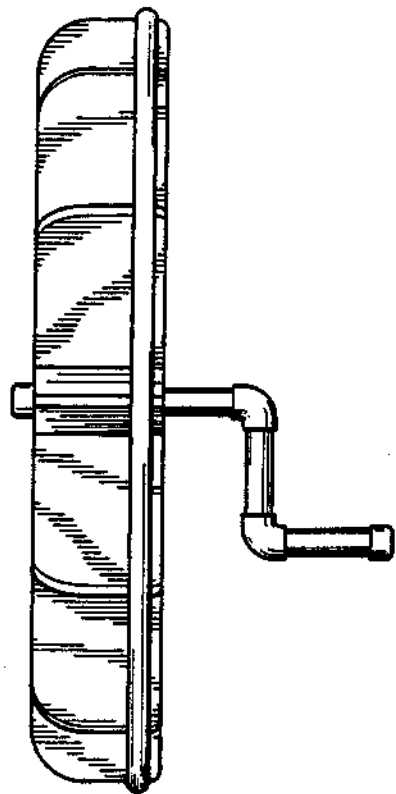


FIG. 6