

[54] **HYDRAULIC POWER TOOL**

[72] Inventors: **Fritz C. Catterfeld**, Canoga Park;
Sebastian B. Macaluso, Santa
Susana; **Lawrence D. Weber**,
Northridge, all of Calif.

[73] Assignee: **North American Rockwell Corpora-
tion**

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[58] Field of Search.....415/147, 150, 151, 211, 503,
415/163, 160, 162, 158, 167; 173/163, 159;
32/27, DIG. 1; 175/6

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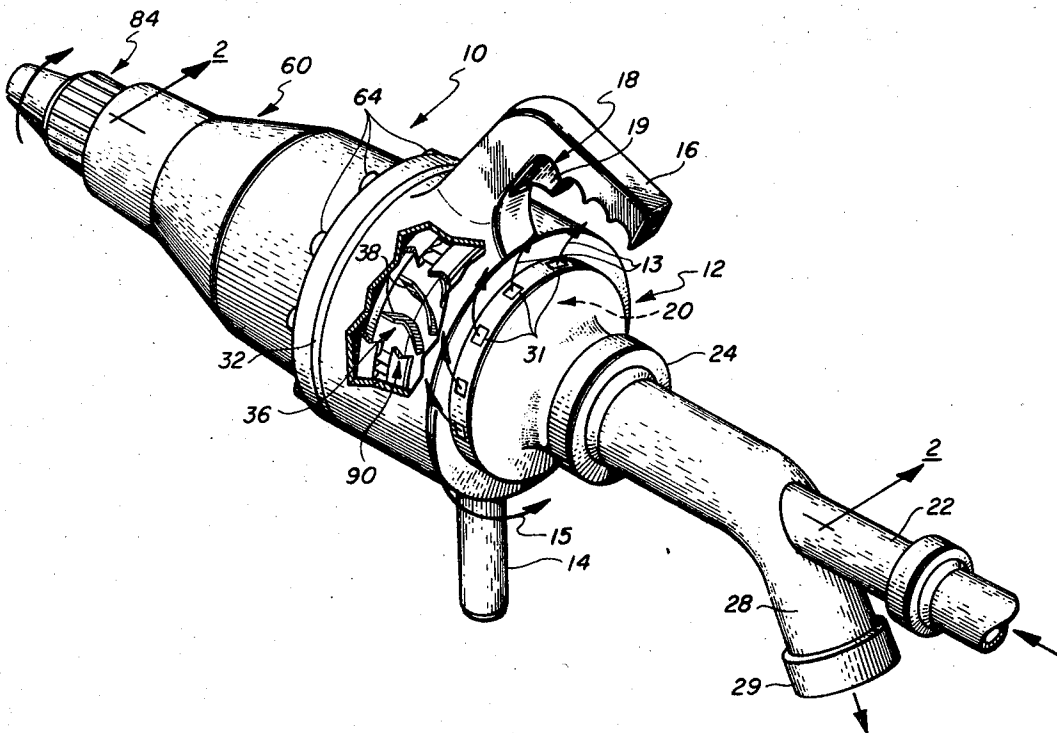
Primary Examiner—Henry F. Raduazo

Attorney—L. Lee Humphries and Thomas S. Mac-
Donald

[57] **ABSTRACT**

A hydraulically driven radial inflow turbine having power takeoff means attached thereto is actuated and controlled by an axially translatable nozzle ring. A manually actuatable trigger mechanism admits a small amount of control fluid which is tapped from a primary source of liquid under pressure into a chamber defined by the nozzle ring and the turbine housing to move the nozzle ring in registering alignment with the primary liquid inlet apertures to the turbine impeller blades. The trigger assembly proportionately supplies hydraulic pressure to the turbine to control the flow of fluid to the turbine thereby controlling the power output.

8 Claims, 8 Drawing Figures



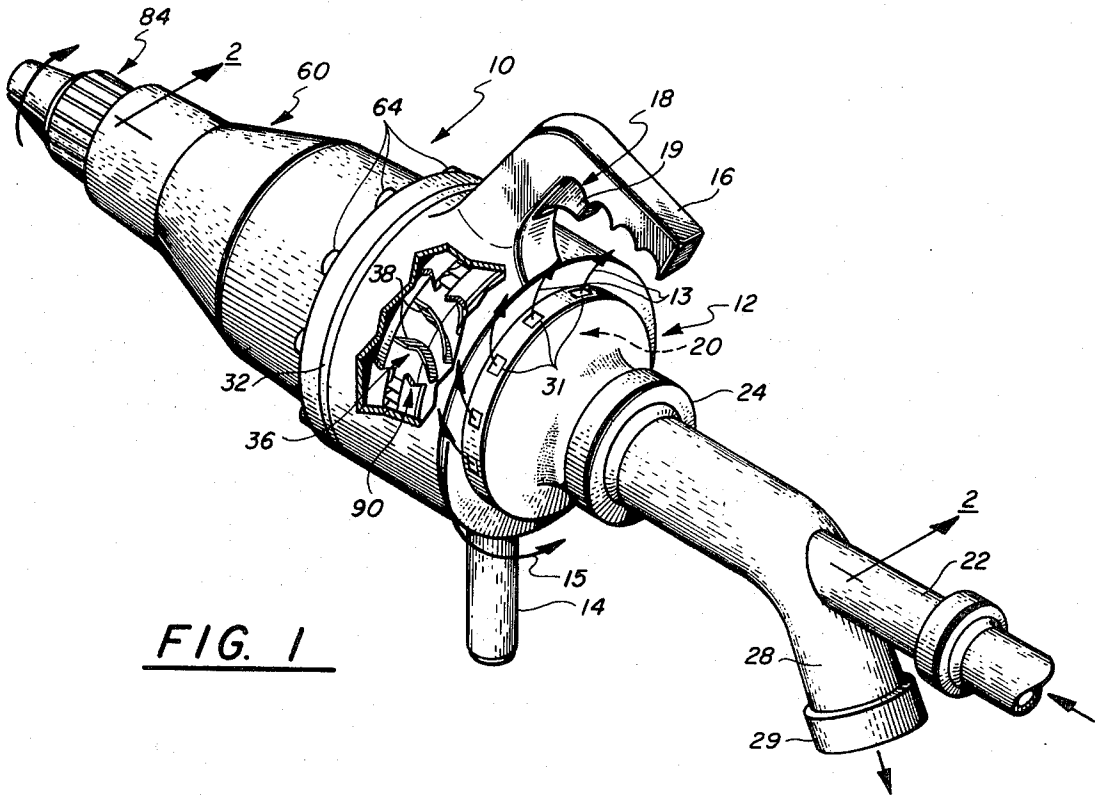


FIG. 1

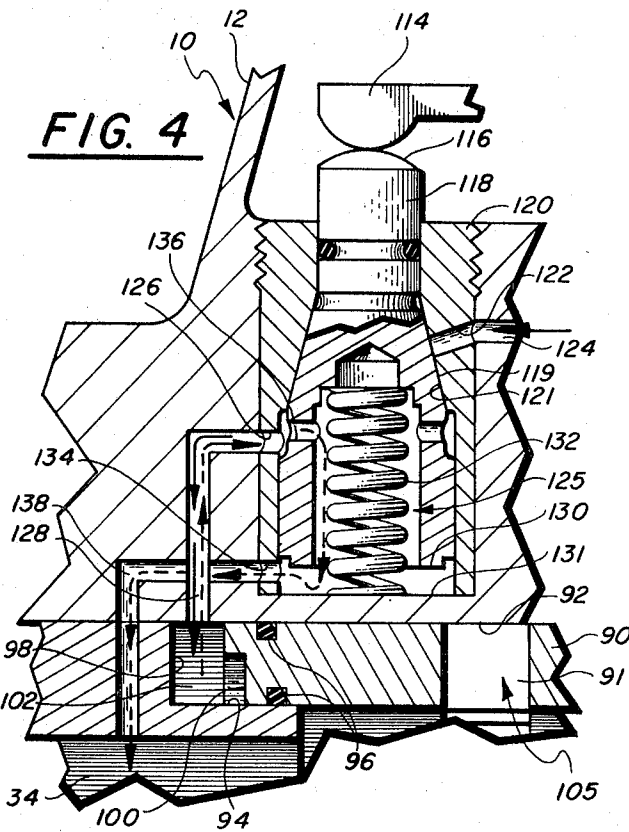


FIG. 4

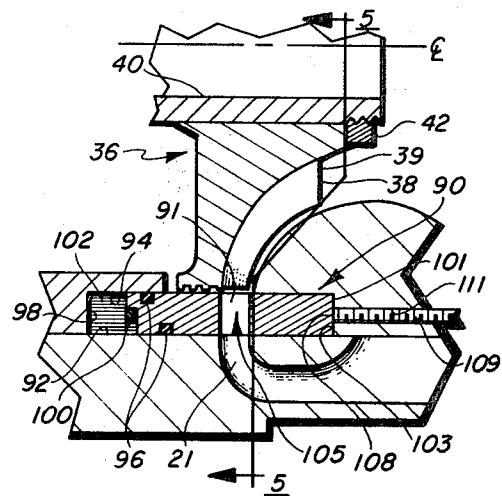


FIG. 3

INVENTORS.
FRITZ C. CATTERFELD
SEBASTIAN B. MACALUSO
BY LAWRENCE D. WEBER

Thomas S. MacDonald
ATTORNEY

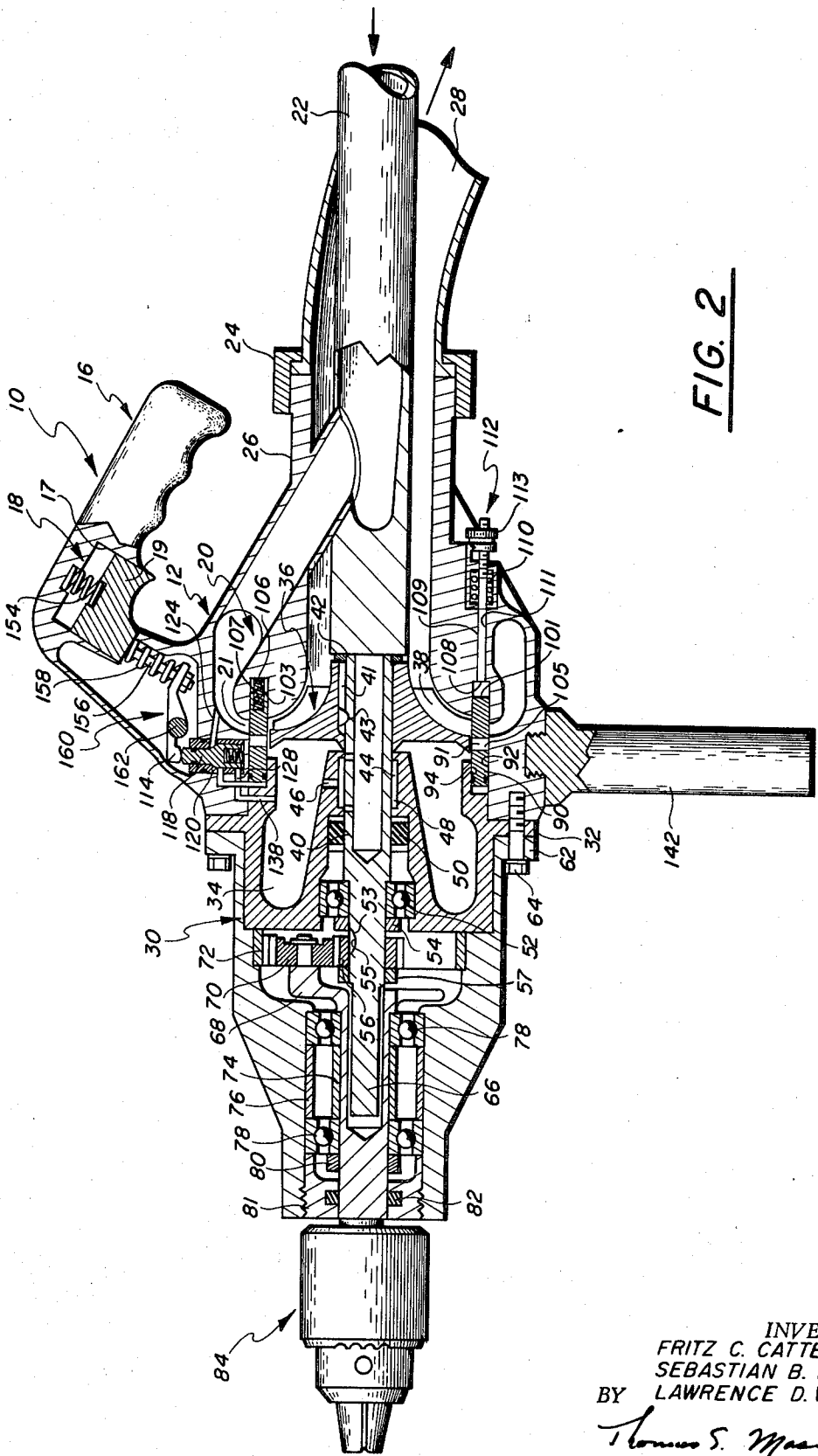


FIG. 2

INVENTORS
FRITZ C. CATTERFELD
SEBASTIAN B. MACALUSO
BY LAWRENCE D. WEBER
Thomas S. MacDonald
ATTORNEY

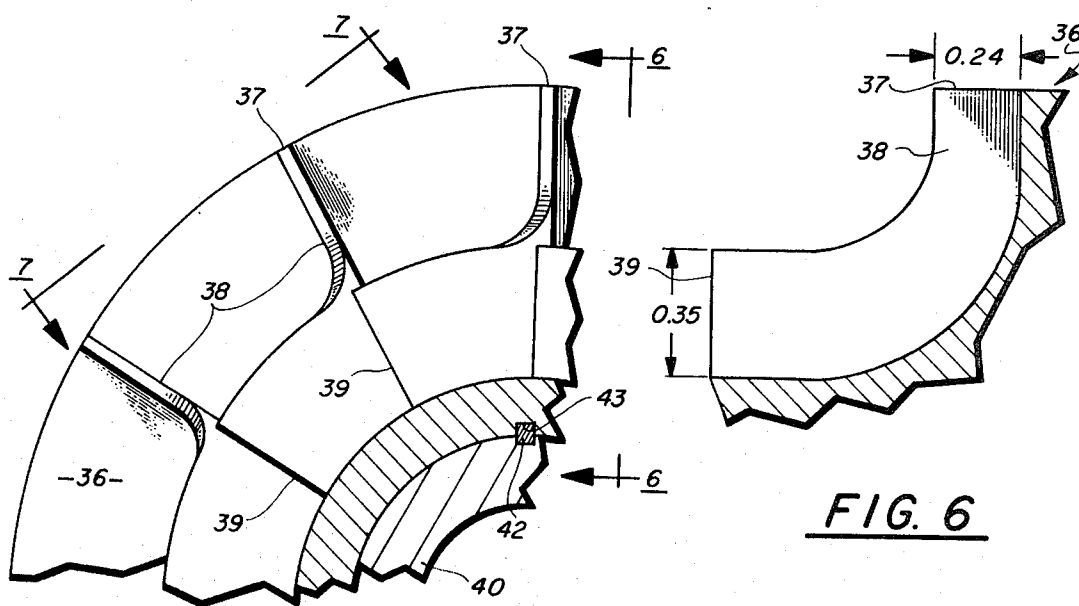


FIG. 6

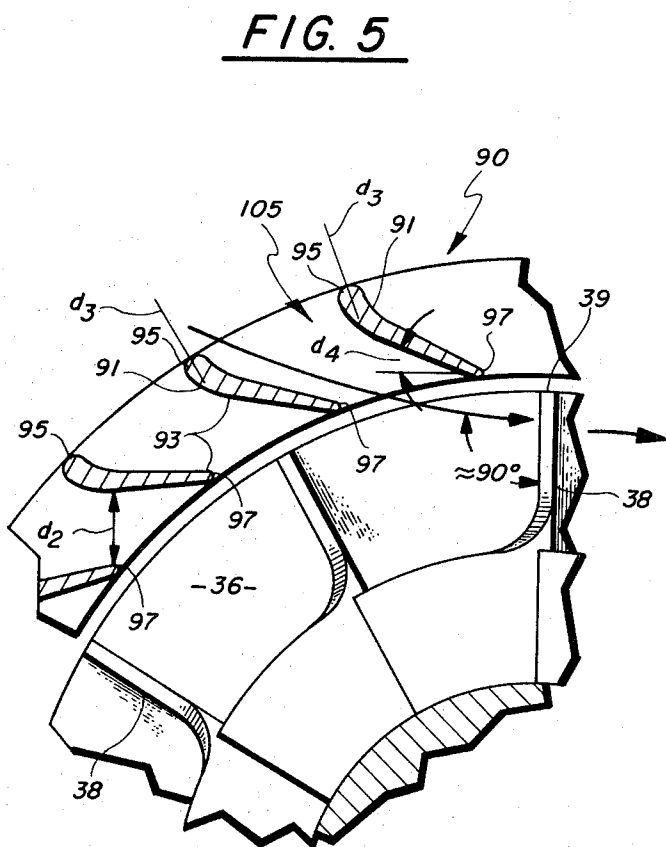


FIG. 5

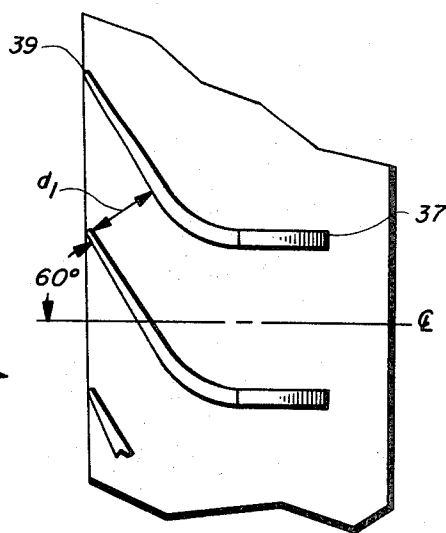


FIG. 7



INVENTORS.
FRITZ C. CATTERFELD
SEBASTIAN B. MACALUSO
LAWRENCE D. WEBER

BY LAWRENCE D. WEBER
Thomas S. MacDonald

ATTORNEY

HYDRAULIC POWER TOOL

BACKGROUND OF THE INVENTION

This invention is directed to the manipulation of hydraulic pressure to drive a turbine for use in power tools and the like.

Others have used a liquid under pressure to drive a wheel generating power therefrom. For example, U.S. Pat. No. 1,174,656 suggests the use of a water wheel for the purposes of driving a grinder which in turn grinds up refuse for disposal. This patent utilizes a "Pelton" type wheel which is driven by a jet of water.

Many other patented devices utilize the "Pelton" wheel, however, most of these prior art devices do not generate enough power to either shred refuse or perform efficiently any function that requires a large power output. The present invention differs from the "Pelton" type configuration because it is capable of providing working fluid flow to the turbine rotor for 360° of the nozzle circumference and flows a greater mass of working fluid for a given unit area. The nozzles used in "Pelton" type designs are not adaptable to small, high flow hydraulic turbine applications as intended for the hydraulic power tool described herein.

Other types of hydraulic rotating members have been utilized in bathroom shower heads to intermittently admit water therefrom. An example of this type of device is disclosed in U.S. Pat. No. 3,437,736 wherein a helical tooth rotor is rotated in a flow stream thereby admitting water to a shower head through a hole positioned in the hub of the rotor. This device is used primarily to pulsate a stream of water from a shower head.

One of the principal applications of this invention is for performing a plurality of jobs in underwater operations which are becoming more and more in demand as the seas are further explored and exploited. Obviously, power tool operating procedures take on a number of complexities under the sea, the deeper the dive, the more complex the tool manipulation problem is.

There are basically three types of power tools considered for use under the sea; electrical, pneumatic and hydraulic. Obviously electrical systems are dangerous in water and extra precautions must be considered to prevent electrical shocks. For example, safety circuits must be employed to shut down the equipment before the diver receives an electrical shock. The tool must be completely sealed, i.e., bearings, brushes, stator, commutators, as well as the electrical cable feeding into the tool. If open motor designs (free flooding) are considered then each component must be electrically isolated, one from the other and auxiliary equipment is necessary to convert dc to ac current when batteries are the primary power source.

Pneumatic systems, while they do not suffer from electrical problems, are disadvantaged by the necessity for leak tight seals. Since a compressible gas is utilized, an ever present danger of explosion is a reality. In addition, exhausted gas beneath the sea creates a confusion of noise and also causes vision problems due to the bursting gas bubbles near the vicinity of a workpiece.

Hydraulic systems using oil or the like as a working fluid are disadvantaged by the possibility of leaks which would contribute to contamination of the surrounding sea. Additionally, an oil hydraulic system must use a two-hose system whereby the oil is pumped back to the

pumping platform on the surface. Two line conduits are very cumbersome to manipulate beneath the sea.

The three tool driving means just described, to power a tool under water, suffer a common disadvantage in that they all create torque that offsets the physical force the diver is exerting against the tool and the workpiece. The diver's buoyancy in water works against him since his body can be moved with very little force. Therefore, the diver is limited as to the physical force he can apply to the tool.

A hydraulic system using sea water as the working fluid obviates most of the problems inherent in the foregoing power systems. A radial inflow turbine tool having a single conduit inlet leading to a sea water pumping station on the surface of the sea is the basic requirement for operation. The turbine tool need not be closely fitted, sealing out the surrounding sea water since sea water is the operating medium. No isolation from electrical shock is necessary and the need for safeguards is removed, i.e., methods to prevent explosions and sea water contamination are obviated. No noise or vision obstacles are encountered since sea water is exhausted into the sea as a liquid. Tool torque is minimized, if not altogether eliminated, by exhausting the sea water driving the turbine impeller in an opposite direction counteracting the torque generated by the tool against the workpiece.

Accordingly, it is an object of this invention to hydraulically drive and manipulate a turbine for the purposes of powering a tool.

More specifically, it is an object of this invention to hydraulically drive a turbine by proportionately admitting liquid into the turbine housing through a mechanical trigger mechanism thereby controlling the power output of the turbine tool.

SUMMARY OF THE INVENTION

The power generating unit of the present invention consists of a hydraulic turbine of radial inflow design having a power output spindle either rotating at the speed of the turbine or geared down to a desired rotational speed dependent upon the specific job to perform. The turbine is actuated by a trigger mechanism which consists of a valve body and a pressure operated movable nozzle ring. Depressing the trigger actuates a valve which allows a small flow of liquid from a primary source of hydraulic pressure, for example, water, to enter an annulus between the housing and the nozzle ring. As the pressure builds up in the annulus, the nozzle ring or stator which is normally in closed position, acts as a gate which is moved in line with the impeller inlet. The nozzle ring has a series of stator blades which direct hydraulic pressure onto the turbine impeller blades when the stator nozzle ring opening registers with the impeller inlet apertures, thereby starting the turbine. An adjustable stop is provided so that, when the trigger mechanism is depressed the nozzle ring moves against the stop thereby limiting the power output of the tool; i.e., limiting the volume of hydraulic flow which passes through the nozzle ring onto the impeller blades. The power takeoff spindle can be either directly driven, i.e., connected directly to the turbine shaft or it may be geared down to accomplish a number of useful tool operations. For example, the hydraulic turbine unit can be operated from the water supply

leading into a domestic dwelling from a water pumping fire truck for rescue operations or the tool can be operated by pumping sea water under pressure in undersea operations. The water pressure available to home dwellings is normally in the range of 90 to 125 psi. With the availability of water in the foregoing pressure ranges, the power output from the turbine unit is in the neighborhood of 4 to 5 HP at approximately 10,000 rpm. The hydraulic power unit can be utilized to drive, for example, a drill spindle, a cutting tool or a grinder.

An advantage over the previously discussed prior art includes an obvious gain in power to accomplish the specific objective by utilizing a radial inflow turbine unit.

Another advantage over the prior art is the positive proportional control of the hydraulic tool whereby the power output can be precisely controlled.

A further advantage is the ability to operate the tool without reliance on electricity. This advantage is particularly important when the hydraulic turbine is used as a cutting tool on shipboard or beneath the sea, for example, in the case of an emergency the hydraulically operated tool could be used to cut through shipboard compartment bulkheads, etc., without any danger of a fire that could be caused by the use of cutting torches or electrically powered cutting tools. The tool, being completely independent of electronics or pyrotechnics, is a safe tool to use in an emergency type of situation wherever it may be required.

A still further advantage over the prior art is the lack of noise generated when the hydraulic tool is operated under the sea.

Another advantage is the ability to operate the tool underwater free from vision obstructing exhaust products emanating from the tool.

Still another advantage is the minimization of torque generated by the reaction of the workpiece and the tool in underwater operations which can effect the amount of physical force the diver can exert against a workpiece.

DESCRIPTION OF THE DRAWINGS

The above noted objects and further advantages of the present invention will be more fully understood upon the study of the following detailed description in conjunction with the detailed drawings in which:

FIG. 1 is a partially cutaway perspective view of a hydraulic tool of the present invention, exposing a portion of the turbine wheel;

FIG. 2 is a cross-sectional view taken along lines 2—2 of FIG. 1;

FIG. 3 is an enlarged cross-sectional view of the turbine and the translatable nozzle ring wherein the aperture being bridged by the stator blades is in registering alignment with the inlet of the primary source of hydraulic pressure;

FIG. 4 is an enlarged cross-sectional view of the trigger assembly illustrating various flow passages for the hydraulic liquid;

FIG. 5 is a view taken along lines 5—5 of FIG. 3, illustrating the turbine blades;

FIG. 6 is a view taken along lines 6—6 of FIG. 5;

FIG. 7 is a view taken along lines 7—7 of FIG. 5 illustrating the blade curvature; and

FIG. 8 is a view through the aperture in the nozzle ring illustrating the stator blades and their relationship to the impeller blades.

Referring now to FIG. 1 and 2, the turbine tool generically designated as 10 consists of a rear housing assembly 12 having attached thereon a handle 14 and a hand grip 16 housing a trigger assembly 18. A water manifold 20 is located adjacent one end of the housing assembly 12 wherein an adaptor water inlet housing 22 is attached by flange nut 24. Surrounding and concentric with the water inlet housing 22 is a water outlet exhaust manifold 26 thereby providing a common input-output axial flow path for the hydraulic flow. The manifold 26 is adapted to exhaust depleted hydraulic pressure out of aperture 28. A stator housing assembly 30 is attached to rear housing 12 at flange 32 and a transmission housing 60 with attached drill spindle 84 connects adjacent the stator housing thereby completing the tool assembly.

Referring specifically to FIG. 2, the stator housing 30 includes a bearing liquid supply manifold or cavity 34 which surrounds a turbine drive shaft 40. A turbine impeller, generally designated as 36, includes turbine blades 38 and is attached to drive shaft 40 by key 43 in registering alignment with keyway 41. A turbine impeller lock nut 42 secures the turbine impeller 36 to shaft 40. Journal bearing 44 is lubricated from the liquid cavity 34 defined by stator housing 30, through water lubricating inlet aperture 46. An annulus 48 between the journal bearing 44 and the driveshaft 40 assures that the bearing receives sufficient lubricating liquid to maintain free movement to the shaft 40. Upstream of the hydraulic bearing 44 is a packing 50 made from, for example, a felt material to assure that the liquid lubricating medium (water) does not penetrate the bearings positioned upstream. A bearing 52 is located in the stator housing assembly 30 upstream of the wiper seal 50. The bearing 52 is retained on shaft 40 by retainer nut 54. Finally, an output drive sun gear 56 is affixed to shaft 40 adjacent retainer nut 54. The sun gear 56 is retained by lock nut 57 on the shaft 40 and is keyed thereto by key 53 retained in keyway 55.

A transmission housing 60 is mated to the stator adaptor flange 32 by transmission housing adaptor flange 62 and the whole assembly including the rear housing 12, the stator housing assembly 30 and the transmission housing 60 is connected by attachment bolts 64. The transmission housing 60 includes input shaft 66 which has at its inward end a planet gear support shaft 68 which supports at least one planet pinion gear 70. The planet gear meshes with the ring gear 72 and the output drive sun gear 56, thereby mechanically linking the transmission housing with the turbine wheel 36. A pair of bearings 78 are located by an inner spacer 74 and an outer spacer 76 which support input shaft 66. The input shaft is retained by the bearing inner races and the spacer by lock nut 80. The bearings, including the spacer, are retained in the transmission housing 60 by retainer 81 having a packing seal 82 therein, thereby assuring that the lubricating liquid is retained within the bearing assembly. Finally, at the outer end of input shaft 66, is attached, for example, a drill chuck 84.

Many different types of power output tools could be attached to the transmission housing and there may be

a direct drive from turbine impeller 36 to the output tool or, the output tool could be geared down as in the heretofore described embodiment.

Turning specifically to the turbine components which comprises the heart of the hydraulic tool, a cylindrically shaped axially aligned nozzle ring 90 is movable within an annular space or slideway defined by rear housing 12 and the stator assembly 30. The end face 100 (FIGS. 3 and 4) of the nozzle ring is defined by the rear housing 12 and the stator assembly 30 forming an annular chamber 102. The nozzle ring 90 is urged towards the chamber 102 by a plurality of equidistantly spaced nozzle return springs 106 (FIG. 2). The springs 106 are recessed in individual wells 107 in nozzle face 101 at one end and are adjacent an annular flange 103 of housing assembly 12 at the other end. The nozzle ring, when it is in its closed position, moves annulus 105, bridged by the stator blades 91 out of register with a turbine hydraulic water pressure inlet 21. The inlet 21 feeds primary hydraulic fluid to the turbine impeller blades 38 when the aperture 105 in nozzle 90 registers with the inlet.

Turning now to the trigger assembly 18 in hand grip 16, the trigger assembly includes a trigger 19 which fits into a recess 17 in the handle 16 and is biased outwardly by a trigger return spring 154. Opposite the actuator spring 154 is an actuator arm 156 which is affixed to the trigger at one end and to a rocker assembly generally designated as 160, at its other end. Surrounding the actuator arm 156 is a rocker arm override spring 158. The rocker assembly 160 is rotated at pivot 162 and includes a cam surface 114 which rests against an adjacent cam surface 116 which defines the top of a valve poppet 118. Actuation of the trigger 19 forces the rocker assembly to rotate which in turn forces the valve poppet 118 in a downward direction.

With reference to FIG. 4, an enlarged detail of the valve assembly is illustrated. The valve poppet 118 is confined and slidable within a valve body 120. The valve poppet includes a conically shaped surface 119 which mates with an identically shaped conical surface 121 in valve body 120, thereby assuring a leak tight fit when the valve poppet is seated within the valve body 120. A secondary hydraulic pressure inlet aperture 124 communicates with the primary water manifold 20 in rear housing assembly 12. An inlet aperture 122 in valve body 120 communicates with the secondary aperture 124. When the valve poppet 118 is depressed causing the valve poppet to move downwardly within valve body 120 the mating surfaces 119 and 121 separate causing liquid to pass from manifold 20 around poppet assembly 118 and out through aperture 126 leading into conduit 128. Liquid under pressure is routed down conduit 128 leading into annular chamber 102. Hydraulic pressure tapped from the primary source of liquid enters annular chamber 102 by depressing the trigger assembly causing the valve poppet 118 to come off its seat. Water pressure builds up in annular chamber 102 which sequentially causes the nozzle ring to move axially against the return springs 106 aligning the stator blades 91, bridging the opening in the nozzle ring 105, with the primary aperture 21 in the rear housing 12 thereby causing the primary liquid to be accelerated through the throats 93 defined by the stator blades 91 onto the turbine impeller blades 38 causing

the turbine to rotate. When poppet 118 is depressed, the poppet overcomes poppet return spring 132 causing the skirt 130 to mate with valve base surface 131. This action prevents liquid entering aperture 136 into chamber 125 (the chamber being defined by the poppet) from escaping through aperture 134 near the base of valve body 120. Thus, the liquid, taking the path of least resistance, exits through opening 126 down conduit 128 into annulus 102 as heretofore described. The flow path is shown in solid line arrows. When the trigger 19 (FIG. 2) is released, the poppet 118 reseats itself within valve body 120 via return spring 132 thereby shutting off the hydraulic pressure from chamber 20. Pressure within chamber 102 bleeds back through conduit 128 (dashed arrow) past opening 126 into aperture 136 thence to chamber 125. From chamber 125, the water pressure, again taking the path of least resistance, escapes out aperture 134 (the aperture being exposed when poppet skirt 130 was lifted off of valve base 131). The liquid then traverses conduit 138 eventually being dumped into chamber 34 defined by the stator housing 30. The relatively long bleed path traced by the dashed arrows into chamber 34 and out through exhaust 28, prevent "water hammer" normally associated with a rapid shutoff of hydraulic pressure. The relatively slow bleed of chamber 102 allows the nozzle ring 90 to slowly shutoff (via nozzle return spring 106) the main hydraulic pressure passing from chamber 20 through aperture 21 unto impeller blades 38 thus preventing "water hammer" or "chattering" in the hydraulic hose (not shown) feeding the tool.

Referring again to FIG. 2, a nozzle ring stop assembly 112 includes an adjustable shaft 109 which is retained within aperture 111 in the rear housing assembly 12. The nozzle ring stop includes a spring 110 and an adjustable stop nut 113 so that the nozzle ring stop assembly can be adjusted to control the maximum travel of the nozzle ring within its slidable chamber. Thus the maximum power output of the turbine impeller 36 can be controlled, thereby controlling the flow of liquid to the turbine tool.

Referring now to FIG. 3, an enlarged view of a portion of the rear housing 12, stator housing 30 and turbine impeller 36 is illustrated to show the nozzle ring 90 in its opened position, i.e., the chamber 102 is full of hydraulic fluid caused by the opening of the valve poppet 118. It can be seen that the nozzle ring shaft 109 in aperture 111 can control the maximum axial travel of the nozzle assembly 90.

With reference to FIGS. 5, 6 and 7, the impeller 36 is, for example, 3 inches in diameter and is comprised of 12 rotor vanes or blades 38 attached to the hub with an unshrouded front face. The rotor blade tip 37 inlet vane angle is radial and the outlet angle is 60° from the impeller axis as shown in FIG. 7. This angle is measured at the cerf 39 near the hub of the impeller 36. The inlet vane height 37 (FIG. 6) is approximately 0.240 inches and the rotor outlet vane or cerf 39 height is about 0.350 inches. The rotor throat d_1 (FIG. 7) near the cerf 39 is approximately 0.190 inches.

Referring to FIG. 8, the blades or vanes 91 bridging opening 105 in nozzle ring 90 number approximately 35. The vanes 91 at their inlet leading edges 95 have a radial inlet vane angle indicated as d_3 (a radial direction 90° to the axis) and a 15° outlet vane angle d_4 at trailing

edge 97. The nozzle throat opening 93 indicated as d_2 is approximately 0.079 inches measured at the narrowed opening between the vane blades 91.

The dimensions defined above for the turbine tool produce the following results: at 90 psid (pressure drop across the turbine) and a hydraulic liquid flow of 117 GPM (gallons per minute) the turbine unit will produce approximately 5 HP with 50 in/lbs. of torque with an operating efficiency of between 85 and 90 percent at approximately 5,500 RPM. At 120 psid and 127 GPM the tool will produce 8 HP with 75 in/lbs. of torque and at 240 psid, at 190 GPM, the turbine produces 22 HP with 155 in/lbs. of torque at approximately 10,000 RPM.

Maximum turbine efficiency is derived by accelerating the water flow through the nozzle throat 93 against the impeller vanes or blades 38. The jet of accelerated water strikes the blades at almost 90° to the face of the blades. By designing the throat as close as possible to the impeller blades, the maximum impact of the accelerated water is directed to the surface of the blades near the blade tips. The hydraulic energy, by the time it traverses the length of the blade 38 exiting at the cerf 39 of the blade is almost entirely depleted, thereby extracting almost all of the total hydraulic energy to impart rotation and torque to the turbine.

The exhausted water can be directed oppositely from the direction of rotation of the impeller thereby minimizing the working torque generated by the tool reacting against the workpiece in an underwater operation.

With reference to FIG. 1, the exhaust adapter housing 28 may be closed off by cap 29 and the exhausted liquid directed alternatively out of a plurality of equidistantly spaced apertures 31 in rear housing 12. Each of the apertures being designed to direct the liquid in a direction indicated by the arrows 13 which will counteract the torque underwater generated by the tool against the workpiece. Arrow 15 shows the counter torque. A closure band (not shown) may be placed over the apertures 31 and cap 29 removed for tool operation on the surface.

We claim:

1. A hydraulic turbine tool-driving apparatus comprising:

- a housing,
- means on said housing forming an inlet aperture and an outlet aperture,
- a source of hydraulic pressure connected to said inlet aperture,
- a turbine wheel having a series of outwardly extending turbine blades and including a shaft contained within said housing,
- a movable nozzle ring extending peripherally around the turbine wheel and interposed between said housing and said turbine wheel to direct said hydraulic pressure inwardly onto said turbine wheel, said nozzle ring comprising an axially aligned cylinder having a first end and a second end, means forming a peripheral aperture in said cylinder between said ends, said cylinder extending peripherally in a slide way around said turbine wheel, spring means for biasing one end of said cylinder so that said peripheral aperture is out of alignment with said inlet aperture,

a trigger mechanism to move said ring against said spring means bias so as to align said peripheral aperture with at least a portion said inlet aperture and in turn, to proportionately meter hydraulic flow past said nozzle ring onto said turbine wheel, and

a power takeoff means including said shaft to transmit rotational energy from said turbine wheel.

2. The invention as set forth in claim 1 wherein said inlet and outlet apertures are concentric, one within the other, thereby forming coaxially aligned inlet and outlet flow paths for the flow of water pressure.

3. The invention as set forth in claim 1 wherein said turbine wheel comprises a plurality of radially oriented turbine blades, each blade at its outer end, being oriented substantially 90° to the flow of water pressure and having a curved cerf at its inner end to extract substantially all of the water energy directed onto each of said blades before exhausting said water pressure through said outlet aperture.

4. The invention as set forth in claim 1 wherein said peripheral aperture is a continuous slot bridged by a series of fixed stator blades forming a plurality of injector throats so as to accelerate hydraulic pressure against said turbine blades when said nozzle ring is in registering alignment with said inlet aperture, each of the throats being positioned adjacent to the inner periphery of the nozzle ring so as to impact hydraulic flow at maximum velocity against the outer end of said turbine blades.

5. The invention as set forth in claim 1 wherein said trigger means includes a normally closed manually actuable poppet valve having a closed position and an open position, means forming an annular cavity between said housing and an end of said nozzle ring and conduit means extending between said hydraulic pressure source and said cavity, said poppet valve extending within said conduit means for metering hydraulic fluid from said source to said cavity so as to move said nozzle ring into alignment with said inlet aperture.

6. The invention as set forth in claim 5 including a second conduit means extending between the cavity and the interior of said poppet valve and a third conduit means communicating between the interior of said valve and said outlet aperture so as to provide a fluid bleed path for hydraulic fluid from within said cavity when said valve is moved to its closed position thereby preventing water hammering in the hydraulic system.

7. The invention as set forth in claim 1 further comprising an adjustable rod extendable into said housing, said rod being axially aligned with said nozzle ring, one end of said rod being in juxtaposition to an end of said nozzle ring so as to limit the extent of nozzle ring travel when said ring is moved into alignment with said inlet aperture thereby controlling the hydraulic flow to said turbine wheel.

8. A water turbine tool driving apparatus comprising: a housing, means on said housing forming an inlet aperture and an exhaust outlet aperture, a source of water pressure connected to said inlet aperture, a bladed turbine wheel including a shaft contained within said housing,

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means extending peripherally around the turbine wheel and interposed between said housing and said turbine wheel to direct said water pressure radially inwardly onto said turbine wheel,
means to move said last mentioned means and, in turn, to proportionately meter water flow through said last mentioned means onto said turbine wheel,
means to exhaust water through said outlet exhaust aperture after the water has traversed said turbine wheel,
a power take-off means including said shaft to trans-

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mit rotational energy from said turbine wheel, and means to close off said outlet exhaust aperture in said housing, said water being redirected to a plurality of apertures formed in a rear housing upstream of said outlet exhaust aperture, said plurality of apertures being aligned to exhaust water in a direction opposite to the direction of torque of a tool connected to said power take-off means when said tool is operated against a workpiece under water.

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