

(12) STANDARD PATENT
(19) AUSTRALIAN PATENT OFFICE

(11) Application No. **AU 2004250089 B2**

(54) Title
Sonic heads and assemblies and uses thereof

(51) International Patent Classification(s)
E02D 3/054 (2006.01) **E21B 28/00** (2006.01)
E21B 7/24 (2006.01)

(21) Application No: **2004250089** (22) Date of Filing: **2004.06.18**

(87) WIPO No: **WO04/113668**

(30) Priority Data

(31) Number	(32) Date	(33) Country
531833	2004.03.18	NZ
532050	2004.03.30	NZ
526639	2003.06.20	NZ

(43) Publication Date: **2004.12.29**

(44) Accepted Journal Date: **2008.06.26**

(71) Applicant(s)
Flexidrill Limited

(72) Inventor(s)
Pfahlert, Roger

(74) Agent / Attorney
A J PARK, PO Box 565, Auckland

(56) Related Art
WO 1997/046787 A
SU 1116138 A
EP 0333484 A

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
29 December 2004 (29.12.2004)

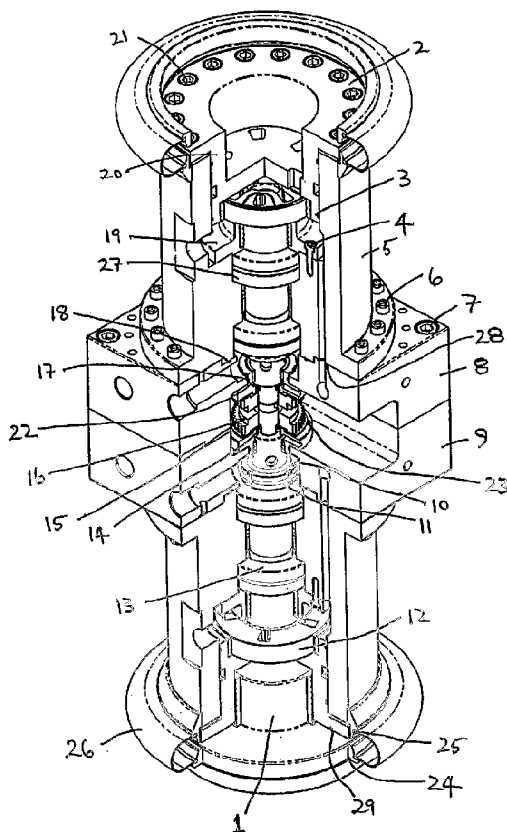
PCT

(10) International Publication Number
WO 2004/113668 A1

- (51) International Patent Classification⁷: E21B 7/24
- (72) Inventor; and
- (75) Inventor/Applicant (for US only): PFAHLERT, Roger [NZ/NZ]; 28 Princess Street, Temuka (NZ).
- (21) International Application Number: PCT/NZ2004/000128
- (74) Agents: ADAMS, Matthew, D et al.; A J Park, 6th Floor Huddart Parker Building, PO Box 949, Wellington, 6015 (NZ).
- (22) International Filing Date: 18 June 2004 (18.06.2004)
- (25) Filing Language: English
- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.
- (26) Publication Language: English
- (30) Priority Data:
- | | | |
|--------|----------------------------|----|
| 526639 | 20 June 2003 (20.06.2003) | NZ |
| 531833 | 18 March 2004 (18.03.2004) | NZ |
| 532050 | 30 March 2004 (30.03.2004) | NZ |
- (71) Applicant (for all designated States except US): FLEX-IDRILL LIMITED [NZ/NZ]; 220 Lake Road, Takapuna, AUCKLAND (NZ).
- (84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH,

[Continued on next page]

(54) Title: SONIC HEADS AND ASSEMBLIES AND USES THEREOF



(57) Abstract: A sonic head assembly suitable for generating an output, said assembly having a frame, a sonic head carrying, carried by, substantially locating or substantially being located by the frame, wherein the sonic head has a spaced pair of pistons each located within a head cylinder, and wherein each headed cylinder has a valving arrangement whereby a variable volume can be defined by the piston relative to the headed cylinder as a consequence of fluid supply into and/or fluid release from the variable volume chamber reliant on the valving arrangement, and wherein the valving arrangement of one headed cylinder is out of phase with the other such that as one chamber increases in volume as a consequence of fluid supply thereto, the other correspondingly decreases, and vice versa.

WO 2004/113668 A1



GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCI Gazette.

NEW ZEALAND
PATENTS ACT, 1953

No: 526639/533724/533726

Date: 20 June 2003/18 March 2004/30 March 2004

COMPLETE SPECIFICATION

SONIC HEADS AND ASSEMBLIES AND USES THEREOF

We, FLEXIDRILL LIMITED, a company duly incorporated under the laws of New Zealand of 220 Lake Road, Takapuna, Auckland, New Zealand, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

The present invention relates to vibration or sound ("sound") generation as might be useful, *inter alia*, in sonic drilling. The invention relates to related apparatus, methods, systems and procedures.

There is frequently a need to provide vibration.

Examples of use of vibration includes separation procedures reliant on the buoyancy of particulate materials in amongst other particulate materials, stripping of sand from a cast item, ground or other compaction, pile driving and drilling (including directional and/or rotary drilling).

Usually vibration is generated reliant upon the spinning of an eccentric weight or counter rotating weights. See for example, US Patent 3,866,480 which discloses an orbital vibrator. Such orbiting mass oscillators may employ orbiting rollers which are rotatably driven around the inner race wall of a housing, as disclosed in US Patent No. 4815328 to Bodine, or an unbalanced rotor, the output of which is coupled to a drill bit as disclosed in US Patent No. 4261425 to Bodine.

Other methods of creating and utilising sonic energy for application to a mandrel are also disclosed in US Patent Specifications 3375884 (Bodine), 3379263 (Bodine), 4836299 (Bodine), 4527637 (Bodine); 5549170 (Barrow) and 5562169 (Barrow) and WO01/83933 (Bar-Cohen).

Japanese Patent Specification 57-179407 of Kawasaki Heavy Ind Ltd discloses a pile hammer employing a fluid actuator to operate in accordance to the resonance of the pile for the inherent frequency of the soil by providing a relief valve and a bypass circuit. Amplitudes of movement beyond those purely attributable to the liquid volumes are stated as being obtainable.

Another device that uses hydraulic fluid to create vibratory impact is shown in Australian Patent 479534 (A/S Moelven Brug) (see US 3747694).

A preferred use of interest to ourselves for vibrational apparatus, but not one to which the vibrational apparatus needs be restricted, is in support of down hole drilling or boring equipment. Other uses include those hereinafter discussed.

A variety of different prior art procedures have been disclosed including our own patent specifications reliant upon down hole directional drilling apparatus capable of being controlled through the drill string. It is advanced and/or rotated from the prime mover above ground or in an excavated region of the ground.

In some applications however there is a preference to subject the drill string and the drill head to rapid vibrations thereby allowing the movement through the ground by breaking up encountered rock structures and compacting the surrounds thereby reducing the materials to be removed from down hole. Such procedures, whether reliant on resonance within the drill string or not, is referred to as sonic drilling or boring.

Sonic drilling methods and apparatus are disclosed, *inter alia*, in US Patent Nos. 4836299, 4548281 and 5417290 which are herein incorporated by reference.

Sonic drilling is accomplished by vibrating a drill string to produce compressive and expansive waves in the drill string. The vibrations are induced in a longitudinal direction of the drill string and the drill string is preferably vibrated at a resonant frequency. The resonant frequency is dependent upon a number of factors including the length of the drill string.

The vibrational forces on the drill string causes the drill string to contract and expand in the longitudinal direction. The vibrational forces at the bottom of the drill string shear, displace and/or otherwise fracture apart the soil and/or rock particles thereby cutting through the formation.

It has also been disclosed in the art that drilling systems which employ cycloidal sonic energy as a method of drilling cause a highly effective action on the bottom and particularly the adjacent side walls of the bottom portion of a well bore by virtue of the cycloidal drilling action.

The present invention recognises an advantage is derivable in the area of sonic drilling where it is possible to commence the generation of the sonic head whilst in its operative connection (directly or indirectly) with the drill string. For many prior art forms of sonic head re-starts are difficult owing to the need to retract the drill string from against a rock face and other structure that might be binding the drill string as a whole.

It is therefore an object of one or some embodiments of the present invention to provide a sonic head assembly and/or a sonic head for such assembly which will provide the option of start-up without a need for retraction in such circumstances and/or separation of the sonic head in the drill string.

It is an object of one or some aspects of the present invention to provide a sonic head assembly and/or sonic head for such an assembly which enables the generation of vibrations including sonic vibrations into a structure without a requirement for tuning to a resonant frequency of the structure for it to be vibrative. In some aspects of the present invention is envisaged that start-up can commence without a need for resonance being achieved but in some embodiments of the present invention such resonance can still be achievable by adjustment of control parameters as the sonic head assembly is being used.

In one or some other embodiments of the present invention, it is an object to provide a sonic head and/or a sonic head assembly not reliant upon the rotation of eccentrics but which imparts a useful sonic output that can be used in many situations or which at least provides the public with a useful choice.

It is an object of one or some other embodiments of the present invention to provide constructions of a fluid driven sonic head for a sonic head assembly which confers some measure of isolation of key components from the affect of excessive vibration and/or by omission of a component or components avoids difficulty from any such vibration.

It is an object of one or more embodiments of the present invention to provide a sonic head and/or related sonic head assembly reliant upon separate fluid feeds, one for imparting the vibration and at least one for controlling, other input parameters e.g. amplitude, frequency, the valving, etc.

It is an object of one or more other embodiments of the present invention to provide a sonic head and/or sonic head assembly which has a fluid supply and retrieval system that takes the fluid to ambient or near ambient pressures (preferably prior to return to the sonic head).

It is an object of one or more other embodiments of the present invention to provide sonic head support arrangements and/or buffers and/or linkages which provide some freedom(s) of movement between at least part of the sonic head and a supporting frame yet allows some relativity of movement therebetween.

The present invention is also directed to vibrational apparatus and to the related methods of operation and use which will at least provide a useful choice.

In one aspect the invention is a **vibrational apparatus capable of providing a vibrational output**, said apparatus comprising or including

a shuttle having first and second ends,

a first complementary structure associating with the first end of said shuttle,

and

a second complementary structure associating with the second end of said shuttle,

wherein there is a drive or drives to move the shuttle alternately in each shuttling direction so that, in one direction, the shuttle moves away from the first complementary structure and, in the other direction, the shuttle moves away from the second complementary structure,

and wherein the output of the vibration is from one or other, or both, of said complementary structures and not directly from the shuttle itself.

Preferably said first and second complementary structures are fixed relative to each other insofar as distance is concerned.

Preferably there is a separate positive drive for the shuttle in each of the two directions.

Preferably at least one drive is selected from a direct mechanical drive through pivot links, a magnetic drive, a hydraulic drive, a pneumatic drive and a combustive drive.

Optionally the separate positive drives relies on fluid pressure.

Preferably the drive type for the shuttle in each of its directions is the same.

Preferably the shuttling is without solid to solid impact.

Preferably said shuttle co-acts at least at one end with its complementary structure so as to provide a cushioning affect by squeezing a fluid.

Preferably said cushioning affect is at both ends.

Preferably the vibrational output is from one of the complementary structures.

Preferably there is reliance upon the provision of an externally pressurised fluid as the sole means of empowerment of shuttle movement by being timingly introduced so as to pressurise alternately chambers each defined between a complementary structure and said shuttle.

Preferably in said apparatus:

said first complementary structure coacts with the shuttle to define a first pressurisable chamber,

said a second complementary structure to coact with the shuttle to define a second pressurisable chamber,

there is a first valving arrangement to control fluid flow into and out of the first pressurisable chamber,

a second valving arrangement to control fluid flow into and out of the second pressurisable chamber,

at least one supply of pressurisable fluid, or adaption(s) therefor, to the shuttle whereby each of the first and second valving arrangements can allow or not allow fluid entry to the respective chamber, and

at least one outtake of fluid, or adaption(s) therefor, whereby each of the first and second valving arrangements can allow or disallow fluid egress from its respective chamber;

wherein the valving arrangements and shuttle movement relative to the complementary member(s) is such that as the first valving arrangement allows fluid entry to the first chamber thereby to expand both the first chamber and volume of fluid therein, the second valving arrangement allows fluid egress from the second chamber thereby to allow both compression of both the second chamber and the volume of fluid therein, and so forth in an alternating shuttle moving manner.

Preferably the valving arrangement in each instance involves a rotary valve member having ports to open or close a fixed port or fixed ports to the chamber,

Preferably each valving arrangement includes a different or the same rotary valve member which includes an axial passageway to allow fluid outtake or supply.

Preferably each valving arrangement includes a rotary valving member, such rotary valving members being operated on a common rotational axis and out of phase one with the other.

Preferably the timing provided by the valving arrangements can allow some overlap of supply or exhaust flows between the respective chambers.

Preferably each valving arrangement is driven independently of the fluid supply and fluid outtake

Optionally it is possible to regulate amplitude of movement of the shuttle independently of the frequency of shuttling by having a control of the valving arrangements that is independent of at least one of pressure and volume of supply to and outtake of fluid from the valving arrangements.

Preferably each valving arrangement is proximate to its chamber thereby to optimise to a small distance between valving by the valving arrangement and the action of fluid being introduced into the proximate chamber.

Preferably the fluid supply or outtake involves an accumulator.

Preferably the apparatus is supported by a frame relative to which the vibrational apparatus has at least in part some freedom to move.

Optionally the vibrational apparatus is linked to a frame by articulating or other linkages to allow some movement of each complementary structure relative to the frame.

Preferably the vibrational apparatus is supported at least in part by gas bags in a frame.

Preferably the apparatus is supported from a frame capable of being manipulated directly or indirectly to control the disposition of the sonic head.

Preferably the drive is, or drives are, or the or any motor thereof, at least to some extent and at least in part, is substantially isolated from the vibration(s) of the head, (e.g. standoff mounts being provided therefor, belt drives, etc.).

The apparatus is preferably carried directly or indirectly by a frame which directly or indirectly has mounted at least part of an endless drive assembly for the valving arrangement(s) and/or a fluid motor for use in driving the valving arrangement(s).

In another aspect the invention is **apparatus for generating a vibrational output**, said apparatus comprising or including

a shuttle,

a first complementary member to coact with the shuttle to define a first pressurisable chamber,

a second complementary member to coact with the shuttle to define a second pressurisable chamber,

a first valving arrangement to control fluid flow into and out of the first pressurisable chamber,

a second valving arrangement to control fluid flow into and out of the second pressurisable chamber,

one or more supply of pressurisable fluid, or adaption(s) therefor, to the shuttle whereby each of the first and second valving arrangements can allow or not allow fluid entry to the respective chamber,

one or more outtake of fluid, or adaption(s) therefor, whereby each of the first and second valving arrangements can allow or disallow fluid egress from the respective chamber;

wherein the valving arrangements and shuttle movement relative to the complementary member(s) is such that as the first valving arrangement allows fluid entry to the first chamber thereby to expand both the first chamber and volume of fluid therein, the second valving arrangement allows fluid egress from the second chamber thereby to allow both compression of both the second chamber and the volume of fluid therein, and so forth in an alternating shuttle moving manner,

and wherein at least one valving arrangement involves a rotary valve member.

Preferably at least one complementary member is or provides a piston for a shuttle provided cylinder.

Preferably it is possible to regulate amplitude of movement of the shuttle independently of the frequency of shuttling by having a control of the valving arrangement that is independent of the pressure and/or volume of supply to and/or outtake of fluid from the valving arrangement,

wherein the valving arrangement is proximate to the chamber thereby to optimise to a minimal distance between valving by the valving arrangement and the action of fluid being introduced into the proximate chamber.

Preferably it is possible to regulate amplitude of movement of the shuttle independently of the frequency of shuttling by having a control of the valving arrangement that is independent of the pressure and/or volume of supply to and/or outtake of fluid from the valving arrangement,

wherein the outtake of fluid from a chamber is not used to power the movement of the shuttle.

Preferably it is possible to regulate amplitude of movement of the shuttle independently of the frequency of shuttling by having a control of the valving arrangement that is independent of the pressure and/or volume of supply to and/or outtake of fluid from the valving arrangement,

wherein the outtakes of fluid is (are) to substantially ambient pressures prior to, if desired, such fluid being made available (e.g. by pumping) for a return to the vibrational head.

Preferably it is possible to regulate amplitude of movement of the shuttle independently of the frequency of shuttling by having a control of the valving arrangement that is independent of the pressure and/or volume of supply to and/or outtake of fluid from the valving arrangement,

wherein the fluid is primarily a liquid but may include some entrained gas (e.g. air) so as to confer some cushioning effect in the chamber.

Preferably the output is (directly or indirectly) from one or other (or both) complementary member(s) rather than the shuttle.

Preferably there is no drill rod nor rod extension through the shuttle or vibrational head (thereby to enable, if desired, multiple vibrational heads to be used in delivering power to a drill string or other means to be subjected to vibration).

Optionally the first and second complementary members are or include pistons provided with circumferential or peripheral grooves that each may or may not carrying a piston rings or seal.

Preferably the valving arrangement in each instance involves a rotary valve member having ports to open or close a fixed port or fixed ports to the chamber.

Preferably each (or a common) valving arrangement includes a rotary valve member which includes an axial passageway to allow fluid outtake or supply.

Preferably each valving arrangement includes a rotary valving member, such rotary valving members being operated on a common rotational axis and out of phase one with the other.

Preferably each valving arrangement is driven independently of the fluid supply and fluid outtake.

Preferably the shuttle can be caused to move even if there is no initial movement of one or other or both of said first and second complementary means (e.g. as is the case if attached to a bound drill string).

Preferably the vibrational head, irrespective of whether or not its operation is tuned to provide resonance in a body or device (such as a drill string) directly or indirectly attached to one or other, or both, of the complementary means, can be operated with a jack hammer effect.

Preferably the fluid supply and/or outtake involves an accumulator,

Preferably the vibrational head is supported by a frame relative to which the vibrational head has at least in part some degree(s) of freedom to move,

Optionally the vibrational head is linked to the frame by articulating or other linkages to allow some movement of a complementary means relative to the frame.

Preferably the vibrational head is supported by a frame and is buffered so as not to pass unnecessary shock into the frame reliant at least in part on gas bag support from the frame.

Preferably the apparatus supported from the frame is capable of being manipulated directly or indirectly to control the disposition of the sonic head.

Preferably the drive is, or drives to both valving arrangements are, or the or any motor thereof, at least to some extent and at least in part is substantially isolated from the vibration(s) of the vibrational head.

Preferably the apparatus as a vibrational head is carried directly or indirectly by a frame which directly or indirectly has mounted at least part of an endless drive assembly for the valving arrangement(s) and/or a fluid motor for use in driving the valving arrangement(s).

In another aspect the invention is a **vibrational head assembly** suitable for generating an output (e.g. suitable for direct or indirect vibrational input into a structure (e.g. a drill string), or other medium capable of transmitting/absorbing the vibrational input, said assembly having

a frame, and

a vibrational head carrying, carried by, substantially locating and/or substantially being located by the frame,

wherein the vibrational head has at least some freedom(s) to move relative to the frame, and/or vice versa,

and wherein the vibrational head has a shuttle and two components each component with the shuttle defining one of two variable volume chambers, the shuttle being moveable relative to each component under the action of a fluid under pressure being supplied into one variable volume chamber and being released from the other variable volume chamber, and vice versa,

and wherein the vibrational output is not or is not to be directly or indirectly from the frame nor the shuttle,

and wherein it is adapted so that if driving a drill string with the vibrational output each cycle provides a drive in and a drive out of the drill bit carried by the drill string.

In still another aspect the invention is a **vibrational head assembly** for generating an output (e.g. for direct or indirect vibrational input into a drill string), said assembly having

a frame,

as a vibrational head carrying, carried by and/or substantially locating the frame,

wherein the vibrational head has (preferably at least within bounds) at least some freedom(s) to move relative to the frame, and/or vice versa,

and wherein at least some of the mass ("the shuttle") of the vibrational head (inclusive of at least some of said fluid) under the action of valves and a pressurised fluid supply or pressurised fluid supplies for opposing variable volume chambers defined in part in each case by the shuttle, in use, is able to shuttle with respect to two other masses of the vibration head each of which defines in part a said chamber,

and wherein it is from at least one of these other masses from which there is to be the vibrational output.

In yet another aspect the invention is a **vibrational apparatus** comprising or including

a piston,

a chamber assembly defining a chamber in which the piston is adapted to shuttle rectilinearly between stroke limits, said chamber having a chamber end region at and/or beyond each stroke limit of the piston, there being an inlet port into and an outlet port out of each chamber end region,

a fluid supply assembly associated with said chamber assembly capable of supplying a pressurised fluid or any pressurised fluid it may receive in use to the inlet ports of the chamber,

a fluid collection assembly associated with said chamber assembly to collect fluid from the outlet ports (and preferably capable of supplying that collected fluid for reuse via a said source of pressurised fluid),

a first rotary valve capable of an out of phase allowing or disallowing of fluid movement from the fluid supply assembly into each said inlet port by opening or closing same,

a second rotary valve capable of an out of phase disallowing or allowing of fluid movement from the chamber out of each said outlet port by closing or opening same,

a first drive to rotate the first rotary valve,

a second drive to rotate the second rotary valve, and

a timing link between the first and second drives such that, for each chamber end region, an inlet port will generally be open when its associated outlet port is closed, and vice versa, and such that, each state of the opening and closing of each end chamber end region is generally out of phase with the condition of the other,

wherein in use, there is or will be a vibrational output via the chamber assembly and/or an output member of or carried by the piston as a consequence of rapid piston shuttling within the chamber.

The invention also is, **in combination or assembly, (I) a rotatable drill string and (II) apparatus** as aforesaid when adapted or adapted to allow vibrational drilling.

The invention also is **pile driving, boring and/or drilling** involving the use of vibrational apparatus in accordance with any one of claims 1 to 34.

The invention also is **a method for generating vibrations** using

a vibrational head having a housing from which the vibrational output is to be taken directly or indirectly,

a shuttle to reciprocate within the housing thereby to vibrate the housing, and

a drive to cause the reciprocation of the shuttle within the housing and thereby to vibrate the housing.

The invention also is **a method for drilling using** a vibrational head connectable to a rotatable drill string, the vibrational head having a housing, a shuttle and a drive,

wherein the shuttle is able to be reciprocated within the housing under the action of a drive, and

wherein the vibrational output into the drill string is directly from or indirectly from the housing rather than the shuttle.

Preferably said method involves the steps of

engaging a drill string having a down hole lead assembly to the vibrational head, the engagement not being carried by the shuttle,

vibrating and rotating the drill string and its down hole assembly to advance drilling progress,

detaching the drill string from the vibrational head,

adding to the top of the drill string thereby to extend the drill string,

engaging the extended drill string to the vibrational head, the re-engagement not being carried by the shuttle; and

vibrating and rotating the extended drill string and its down hole assembly to further advance drilling progress.

In another aspect the present invention consists in **apparatus for generating a vibrational (e.g. sonic) output**, said apparatus comprising or including

a shuttle,

a first complementary member to coact with the shuttle to define a first pressurisable chamber,

a second complementary member to coact with the shuttle to define a second pressurisable chamber,

a first valving arrangement to control fluid flow into and out of the first pressurisable chamber,

2004250089 21 Feb 2008

a second valving arrangement to control fluid flow into and out of the second pressurisable chamber,

one or more supply (supplies) of pressurisable fluid, or adaption(s) therefor, to the shuttle whereby each of the first and second valving arrangements can allow or not allow fluid entry to the respective chamber,

one or more outtake (outtakes) of fluid, or adaption(s) therefor, whereby each of the first and second valving arrangements can allow or disallow fluid egress from the respective chamber;

wherein the valving arrangements and shuttle movement relative to the complementary member(s) is such that as the first valving arrangement allows fluid entry to the first chamber thereby to expand both the first chamber and volume of fluid therein, the second valving arrangement allows fluid egress from the second chamber thereby to allow both compression of both the second chamber and the volume of fluid therein, and so forth in an alternating shuttle moving manner,

and wherein the output is (directly or indirectly) from one or other (or both) complementary member(s) rather than the shuttle.

The “shuttle” in some embodiments may be perceived as substantially static yet moving relative to the other componentry. The opposite may also be the case as many hybrids of the two.

Accordingly “shuttle” as used herein throughout should be understood as shuttling relative to other aspects of the assembly.

In another aspect the present invention consists in **apparatus for generating a vibrational (e.g. sonic) output**, said apparatus comprising or including

a shuttle,

a first complementary member to coact with the shuttle to define a first pressurisable chamber,

a second complementary member to coact with the shuttle to define a second pressurisable chamber,

a first valving arrangement to control fluid flow into and out of the first pressurisable chamber,

a second valving arrangement to control fluid flow into and out of the second pressurisable chamber,

one or more supply (supplies) of pressurisable fluid, or adaption(s) therefor, to the shuttle whereby each of the first and second valving arrangements can allow or not allow fluid entry to the respective chamber,

one or more outtake (outtakes) of fluid, or adaption(s) therefor, whereby each of the first and second valving arrangements can allow or disallow fluid egress from the respective chamber;

wherein the valving arrangements and shuttle movement relative to the complementary member(s) is such that as the first valving arrangement allows fluid entry to the first chamber thereby to expand both the first chamber and volume of fluid therein, the second valving arrangement allows fluid egress from the second chamber thereby to allow both compression of both the second chamber and the volume of fluid therein, and so forth in an alternating shuttle moving manner,

and wherein one, some or all of the following features are present:

- (a) the first and second components and shuttle relate to each other on the same axis,
- (b) the output is (directly or indirectly) from one or other (or both) complementary member(s) rather than the shuttle,
- (c) the sonic head when used for sonic drilling (or some equivalent) has the shuttle independent of the drill string or equivalent means to be vibrated),
- (d) there is no drill rod nor rod extension through the shuttle or sonic head (thereby to enable, if desired, multiple sonic heads to be used in delivering power to a drill string or other means to be subjected to vibration),
- (e) the first and second complementary members are pistons or include pistons,
- (f) the first and second complementary members are or include pistons provided with circumferential or peripheral grooves but not carrying piston rings,
- (g) the valving arrangement in each instance involves a rotary valve member having ports to open or close a fixed port or fixed ports to the chamber,

- (h) each (or a common) valving arrangement includes a rotary valve member which includes an axial passageway to allow fluid outtake or supply (preferably outtake),
- (i) each valving arrangement includes a rotary valving member, such rotary valving members being operated on a common rotational axis and out of phase one with the other,
- (j) each valving arrangement is driven independently of the fluid supply and fluid outtake,
- (k) it is possible to regulate amplitude of movement of the shuttle independently of the frequency of shuttling by having a control of the valving arrangement that is independent of the pressure and/or volume of supply to and/or outtake of fluid from the valving arrangement,
- (l) the valving arrangement is proximate to the chamber thereby to optimise to a minimal distance between valving by the valving arrangement and the action of fluid being introduced into the proximate chamber, (i.e. to enable a shorter time for the shock wave of the input fluid to energise the piston and/or piston (preferably to enable operation at higher frequency when desired, to enable resonance at shorter stroke or amplitude, to provide higher efficiency and/or provide greater flexibility and versatility)),
- (m) the outtake of fluid from a chamber is not used to power the movement of the shuttle,
- (n) the outtakes of fluid is (are) to substantially ambient pressures prior to, if desired, such fluid being made available (e.g. by pumping) for a return to the sonic head,
- (o) the fluid is primarily a liquid but may include some entrained gas (e.g. air) so as to confer some cushioning effect in the chamber,
- (p) the supply arrangement is or is to be of a high flow at constant or (e.g. relatively) low pressure (e.g. unlike some prior art systems that require increasing pressure of fluid supply to operate when the device to be vibrated is under increasing load),

- (q) the shuttle can be caused to move even if there is no movement of one or other or both of said first and second complementary means e.g. as is the case if attached to a bound drill string,
- (r) the sonic head irrespective of whether or not its operation is tuned to provide resonance in a body or device (such as a drill string) directly or indirectly attached to one or other, or both, of the complementary means, can be operated with a jack hammer effect,
- (s) the fluid supply and/or outtake involves or is to involve an accumulator,
- (t) the sonic head is supported by a frame relative to which the sonic head has at least in part some degree(s) of freedom to move,
- (u) the sonic head is linked to a frame by articulating (e.g. dog bones) or other linkages to allow some movement of a complementary means relative to the frame,
- (v) the sonic head is supported by a frame and is buffered so as not to pass unnecessary shock into the frame (preferably such buffering including, in conjunction with any optional suitable linkage or linkages, the use of cushioning gas bags or the equivalent) (preferably as air bags as opposed to air springs are utilised),
- (w) the sonic head is supported from a frame capable of being manipulated directly or indirectly to control the disposition of the sonic head,
- (x) the sonic head is carried or supported directly or indirectly by a frame which directly or indirectly [e.g. a carried carriage or slide, or support(s) for the frame as a carriage or slide] (but not linked to the sonic head by any rigid member) has mounted at least part of an endless drive assembly for the valving arrangement(s) and/or a fluid motor for use in driving the valving arrangement(s),
- (y) a carriage or slide, or support(s) for a frame as a carriage or slide, carries a hydraulic motor and/or drive component (e.g. to be via a flexible drive) for rotating a drill string and/or a mandrel therefor, the sonic head being locatable but with some freedom(s) to move by said frame,

2004250089 21 Feb 2008

- (z) drives and/or motors are to be or are, at least to some extent, substantially isolated from the vibration(s) of the sonic head, (e.g. standoff mounts being provided therefor, belt drives, etc.).

Reference hereinafter to energising the "piston" includes alternatively and/or as well the energising of the reactive structure of the piston. Likewise reference to "piston grooves" refers also and/or instead to grooves of the piston surrounding structure.

Preferably the apparatus is substantially as hereinafter described but versions (less desired) may have substituted for the second complementary member (or second piston) some other arrangement to provide a driven return of the shuttle in use.

Accordingly in another aspect the present invention consists in **a sonic head assembly** for generating an output (e.g. suitable for direct or indirect sonic input into a drill string), said assembly having

a frame, and

a sonic head carrying, carried by, substantially locating and/or substantially being located by the frame;

wherein the sonic head has (**preferably at least within bounds**) at least some freedom(s) to move relative to the frame, and/or vice versa;

and wherein the sonic head has at least one piston in a complementary cylinder moveable relative to each other to define a variable volume chamber expandable in volume under the action of a valved fluid supply into the variable volume chamber when it is at less than its full volume;

and wherein the cylinder for part of a shuttle is to shuttle (i.e. move relatively) in an away direction as the variable volume chamber expands;

and wherein means is provided to return the shuttle and thus the headed cylinder to express fluid from the variable volume chamber via a valve arrangement.

In another aspect the invention consists in **a sonic head assembly** suitable for generating an output (e.g. suitable for direct or indirect sonic input into a drill string), said assembly having

a frame, and

a sonic head carrying, carried by, substantially locating and/or substantially being located by the frame;

wherein the sonic head has at least some freedom(s) to move relative to the frame, and/or vice versa;

and wherein the sonic head has componentry defining variable volume chambers, such componentry involving a piston in a complementary headed cylinder, moveable relative to each other such that each chamber is under the action of a fluid under pressure supplied into one variable volume chamber whilst previously supplied fluid is being released from the other variable volume chamber, and *vice versa*.

and wherein part of the componentry defining each chamber is of a shuttle that shuttles.

In another aspect the invention consists in a **sonic head assembly** suitable for generating an output (e.g. for direct or indirect sonic input into a drill string), said assembly having

a frame,

a sonic head carrying, carried by, substantially locating or substantially being located by the frame,

wherein the sonic head has a spaced pair of pistons each located within a headed cylinder,

and wherein each headed cylinder has a valving arrangement whereby a variable volume can be defined by the piston relative to the headed cylinder as a consequence (at least in part) of fluid supply into and/or fluid release from the variable volume chamber reliant on the valving arrangement,

and wherein the valving arrangement of on headed cylinder is out of phase with the other such that as one chamber increases in volume as a consequence (at least in part) of fluid supply thereto, the other correspondingly decreases, and vice versa.

In another aspect the invention consists in a **sonic head assembly** suitable

2004250089 21 Feb 2008

for generating an output (e.g. for direct or indirect sonic input into a drill string), said assembly having

a frame,

a sonic head carrying, carried by, substantially locating, and substantially being located by the frame,

wherein the sonic head has (preferably at least within bounds) at least some freedom(s) to move relative to the frame, and/or vice versa

and wherein the sonic head has at least one piston in a complementary headed cylinder, moveable relative to each other, to define a variable volume chamber under the action of a fluid under pressure supplied into or being released from the variable volume chamber,

and wherein the supply status, into or from the variable volume chamber is under the control of a rotary valve (or some equivalent).

In another aspect the invention consists in a **sonic head assembly** suitable (for generating an output for direct or indirect sonic input into a drill string), said assembly having

a frame,

a sonic head carrying, carried by, substantially locating and/or substantially being located by the frame,

wherein the sonic head has at least some freedom(s) to move relative to the frame, and/or vice versa

and wherein the sonic head has at least one piston in a complementary headed cylinder, moveable relative to each other, to define a variable volume chamber under the action of a fluid under pressure supplied into or being released from the variable volume chamber under the control of a valving arrangement,

and wherein

- (i) feed for such fluid prior to valving into the variable volume chamber, or
- (ii) outtake for such fluid after valving from the variable volume chamber,

involves a passageway in a rotatable valve member of the valving arrangement.

In another aspect the invention consists in **a sonic head assembly** for generating an output (e.g. for direct or indirect sonic input into a drill string), said assembly having

a frame,

a sonic head carrying, carried by, substantially locating and/or substantially being located by the frame,

wherein the sonic head has (preferably at least within bounds) at least some freedom(s) to move relative to the frame, and/or vice versa

and wherein the sonic head has at least one piston in a complementary cylinder moveable relative to each other to define a variable volume chamber under the action of a fluid under pressure supplied into or released from the variable volume chamber,

In another aspect the invention consists in **a sonic head assembly** for generating an output (e.g. for direct or indirect sonic input into a drill string), said assembly having

a frame,

a sonic head carrying, carried by, substantially locating and/or substantially being located by the frame,

wherein the sonic head has (preferably at least within bounds) at least some freedom(s) to move relative to the frame, and/or vice versa

and wherein the sonic head has at least one piston in a complementary cylinder moveable relative to each other to define a variable volume chamber under the action of a fluid under pressure supplied into or released from the variable volume chamber,

and wherein the supply into and/or release from the variable volume chamber is under the action of a controllable rotary valve.

In another aspect the invention consists in **a sonic head assembly** for generating an output (e.g. for direct or indirect sonic input into a drill string), said assembly having

a frame,

as a sonic head carrying, carried by and/or substantially locating the frame,

wherein the sonic head has (preferably at least within bounds) at least some freedom(s) to move relative to the frame, and/or vice versa,

and wherein at least some of the mass of the sonic head (inclusive of at least some of said fluid) under the action of at least one valve and a pressurised fluid supply, in use, is able to shuttle with respect to some of the mass of the sonic head from which a drill line is to receive directly or indirectly the sonic output.

In another aspect the invention consists in a **sonic head assembly** for generating an output (e.g. for direct or indirect sonic input into a drill string), said assembly having

a frame,

a sonic head carrying, carried by, substantially locating and/or substantially being located by the frame,

wherein the sonic head has (**preferably at least within bounds**) at least some freedom(s) to move relative to the and vice versa,

and wherein the sonic head has at least one part in a complementary receiver moveable relative to each other to define a variable volume chamber expandable in volume under the action of a valved fluid supply into the variable volume chamber when it is at less than its full volume,

and wherein the receiver or said part is of a shuttle which moves (relatively) in an “away” (as opposed to its “towards”) direction as the variable volume chamber expands,

and wherein means is provided to return the shuttle (relatively) by causing a towards direction motion thereof thereby to express fluid from the variable volume chamber via a valve arrangement, and wherein the sonic output is or is to be not from the frame nor the shuttle.

In another aspect the invention consists in a **sonic head assembly** suitable for generating an output for direct or indirect sonic input into a structure (e.g. a drill

string), or other medium capable of transmitting/absorbing the sonic input said assembly having

a frame,

a sonic head carrying, carried by, substantially locating and/or substantially being located by the frame,

wherein the sonic head has at least some freedom(s) to move relative to the frame, and/or vice versa,

and wherein the sonic head has a shuttle and two components, each component with the shuttle defining one of two variable volume chambers, the shuttle being moveable relative to each component under the action of a fluid under pressure being supplied into one variable volume chamber and being released from the other variable volume chamber, and *vice versa*,

and wherein the sonic output is not or is not to be directly or indirectly from the frame nor the shuttle.

In another aspect the invention consists in **a sonic head assembly** for generating an output (e.g. for direct or indirect sonic input into a drill string), said assembly having

a frame,

a sonic head carrying, carried by, substantially locating or substantially being located by the frame,

wherein the sonic head has a spaced pair of parts or components (“parts”) each associating with a shuttle,

and wherein the shuttle has a valving arrangement whereby a variable volume chamber can be defined by each part with the shuttle as a consequence of shuttle position relative to each part, such that when one chamber is at its allowed maximum volume the other is at its allowed minimum volume, and *vice versa*,

and wherein the shuttle is caused to move from rest with respect to said parts thereafter to shuttle by fluid applied into a first chamber whilst being released from the

second, by fluid applied into the second chamber whilst being released from first, and so forth,

and wherein

- (a) the first and second components and shuttle relate to each other on the same axis,
- (b) the output is (directly or indirectly) from one or other (or both) complementary member(s) rather than the shuttle,
- (c) the sonic head when used for sonic drilling (or some equivalent) has the shuttle independent of the drill string or equivalent means to be vibrated),
- (d) there is no drill rod nor rod extension through the shuttle or sonic head (thereby to enable, if desired, multiple sonic heads to be used in delivering power to a drill string or other means to be subjected to vibration),
- (e) the first and second complementary members are pistons or include pistons,
- (f) the first and second complementary members are or include pistons provided with circumferential or peripheral grooves but not carrying piston rings, [and/or vice versa e.g. cylinder has the grooves],
- (g) the valving arrangement in each instance involves a rotary valve member having ports to open or close a fixed port or fixed ports to the chamber,
- (h) each (or a common) valving arrangement includes a rotary valve member which includes an axial passageway to allow fluid outtake or supply (preferably outtake),
- (i) each valving arrangement includes a rotary valving member, such rotary valving members being operated on a common rotational axis and out of phase one with the other,
- (j) each valving arrangement is driven independently of the fluid supply and fluid outtake,
- (k) it is possible to regulate amplitude of movement of the shuttle independently of the frequency of shuttling by having a control of the valving arrangement that is independent of the pressure and/or volume of supply to and/or outtake of fluid from the valving arrangement,

- (l) the valving arrangement is proximate to the chamber thereby to optimise to a minimal distance between valving by the valving arrangement and the action of fluid being introduced into the proximate chamber, (i.e. to enable a shorter time for the shock wave of the input fluid to energise the piston (preferably to enable operation at higher frequency when desired, to enable resonance at shorter stroke or amplitude, to provide higher efficiency and/or provide greater flexibility and versatility)),
- (m) the outtake of fluid from a chamber is not used to power the movement of the shuttle,
- (n) the outtakes of fluid is (are) to substantially ambient pressures prior to, if desired, such fluid being made available (e.g. by pumping) for a return to the sonic head,
- (o) the fluid is primarily a liquid but may include some entrained gas (e.g. air) so as to confer some cushioning effect in the chamber,
- (p) the supply arrangement is or is to be of a high flow at constant or (relatively) low pressure (e.g. unlike some prior art systems that require increasing pressure of fluid supply to operate when the device to be vibrated is under increasing load),
- (q) the shuttle can be caused to move even if there is no movement of one or other or both of said first and second complementary means e.g. as is the case if attached to a bound drill string,
- (r) the sonic head irrespective of whether or not its operation is tuned to provide resonance in a body or device (such as a drill string) directly or indirectly attached to one or other, or both, of the complementary means, can be operated with a jack hammer effect,
- (s) the fluid supply and/or outtake involves or is to involve an accumulator,
- (t) the sonic head is supported by a frame relative to which the sonic head has at least in part some degree(s) of freedom to move,
- (u) the sonic head is linked to a frame by articulating (e.g. dog bones) or other linkages to allow some movement of a complementary means relative to the frame,

- (v) the sonic head is supported by a frame and is buffered so as not to pass unnecessary shock into the frame (preferably such buffering including, in conjunction with any optional suitable linkage or linkages, the use of cushioning gas bags or the equivalent) (preferably as air bags as opposed to air springs are utilised),
- (w) the sonic head is supported from a frame capable of being manipulated directly or indirectly to control the disposition of the sonic head,
- (x) the sonic head is carried directly or indirectly by a frame which directly or indirectly [e.g. a carried carriage or slide, or support(s) for the frame as a carriage or slide] (but not linked to the sonic head by any rigid member) has mounted at least part of an endless drive assembly for the valving arrangement(s) and/or a fluid motor for use in driving the valving arrangement(s),
- (y) a carriage or slide, or support(s) for a frame as a carriage or slide, carries a hydraulic motor and/or drive component (e.g. to be via a flexible drive) for rotating a drill string and/or a mandrel therefor, the sonic head being locatable but with some freedom(s) to move by said frame,
- (z) drives and/or motors are to be or are, at least to some extent, substantially isolated from the vibration(s) of the sonic head, standoff mounts being provided therefore.

Preferably the apparatus is substantially as hereinafter described but versions (less desired) may have substituted for the second complementary member (or second piston) some other arrangement to provide a driven return of the shuttle in use.

In another aspect the invention consists in **a sonic head assembly** for generating an output (e.g. for direct or indirect sonic input into a drill string), said assembly having

a frame,

a sonic head carrying, carried by, substantially locating, and substantially being located by the frame,

wherein the sonic head has (preferably at least within bounds) at least some freedom(s) to move relative to the frame, and/or *vice versa*,

and wherein the sonic head has at least one component received by another, and moveable relative to each other, to define a variable volume chamber expandable under the action of a fluid under pressure supplied into the variable volume chamber when at less than its largest volume or compressible as fluid previously supplied is enabled to be released from the variable volume chamber when it is at more than its smallest volume

and wherein the fluid status insofar as pressure and immediately available volume is concerned is independent of the instantaneous volume of the chamber,

and wherein a rotary valve controls ingress and egress of the fluid into and from the chamber.

In another aspect the invention consists in a **sonic head assembly** for generating an output (e.g. for direct or indirect sonic input into a drill string), said assembly having

a frame,

a sonic head carrying, carried by, substantially locating and/or substantially being located by the frame,

wherein the sonic head has at least some freedom(s) to move relative to the frame, and/or *vice versa*,

and wherein the sonic head has at least two components moveable relative to each other, to define a variable volume chamber moveable from a condition which has the chamber less than at its maximum volume under the action of a fluid under pressure supplied under the control of a valving arrangement into the chamber and being returned by other means from that maximum volume condition while fluid is being released from the variable volume chamber under the control of a valving arrangement,

and wherein

- (i) feed for such fluid prior to valving into the variable volume chamber, or

- (ii) outtake for such fluid after valving from the variable volume chamber, involves a passageway in a rotatable valve member of the valving arrangement.

In another aspect the invention consists in **a sonic head assembly** for generating an output (e.g. for direct or indirect sonic input into a drill string), said assembly having,

a frame,

a sonic head carrying, carried by, substantially locating and/or substantially being located by the frame,

wherein the sonic head has (preferably at least within bounds) at least some freedom(s) to move relative to the frame, and/or vice versa

and wherein the sonic head has at least one piston in a complementary cylinder moveable relative to each other to define a variable volume chamber

(i) expandable under the action of a fluid under pressure supplied into the variable volume chamber when at less than its maximum allowed volume, and

(ii) compressible from its maximum allowed volume under the action of a mechanical input whilst fluid is allowed to egress from the chamber,

and wherein the output is directly or indirectly not from the frame but rather is directly or indirectly from that component selected from the cylinder and piston not providing said mechanical input.

In another aspect the invention consists in **a sonic head assembly** for generating an output (e.g. for direct or indirect sonic input into a drill string), said assembly having, *inter alia*,

a frame,

a sonic head carrying, carried by, substantially locating and/or substantially being located by the frame,

wherein the sonic head has (preferably at least within bounds) at least some freedom(s) to move relative to the frame, and/or vice versa,

and wherein the sonic head has at least one piston in a complementary cylinder moveable relative to each other to define a variable volume chamber,

and wherein one, some or more of the following

- (a) the first and second pistons and cylinders forming part of a shuttle relate to each other on the same axis,
- (b) the output is (directly or indirectly) from the, or one or other (or both) pistons (s) (rather than the shuttle),
- (c) the sonic head when used for sonic drilling (or some equivalent) has the or a shuttle independent of the drill string or equivalent means to be vibrated),
- (d) there is no drill rod nor rod extension through the shuttle or sonic head (thereby to enable, if desired, multiple sonic heads to be used in delivering power to a drill string or other means to be subjected to vibration),
- (e) pistons is (are) provided with circumferential or peripheral grooves but not carrying piston rings,
- (f) a valving arrangement to the chamber(s) involves a rotary valve member having ports to open or close a fixed port or fixed ports to the chamber,
- (g) each (or a common) valving arrangement includes a rotary valve member which includes an axial passageway to allow fluid outtake or supply (preferably outtake),
- (h) each valving arrangement includes a rotary valving member, such rotary valving members being operated on a common rotational axis and out of phase, one with the other,
- (i) each valving arrangement is driven independently of the fluid supply and fluid outtake,
- (j) it is possible to regulate amplitude of movement of the shuttle independently of the frequency of shuttling by having a control of the valving arrangement that is independent of the pressure and/or volume of supply to and/or outtake of fluid from the valving arrangement,
- (k) the valving arrangement is proximate to the chamber thereby to optimise to a minimal distance between valving by the valving arrangement and the action of fluid being introduced into the proximate chamber, (i.e. to enable

a shorter time for the shock wave of the input fluid to energise the piston (preferably to enable operation at higher frequency when desired, to enable resonance at shorter stroke or amplitude, to provide higher efficiency and/or provide greater flexibility and versatility)),

- (l) the outtake of fluid from a chamber is not used to power the movement of the shuttle,
- (m) the outtakes of fluid is (are) to substantially ambient pressures prior to, if desired, such fluid being made available (e.g. by pumping) for a return to the sonic head,
- (n) the fluid is primarily a liquid but may include some entrained gas (e.g. air) so as to confer some cushioning effect in the chamber,
- (o) the supply arrangement is or is to be of a high flow at constant or low pressure (e.g. unlike some prior art systems that require increasing pressure of fluid supply to operate when the device to be vibrated is under increasing load),
- (p) the shuttle can be caused to move even if there is no movement of piston(s) e.g. as is the case if attached to a bound drill string,
- (q) the sonic head irrespective of whether or not its operation is tuned to provide resonance in a body or device (such as a drill string) directly or indirectly attached to one or other, or both, of the piston(s), can be operated with a jack hammer effect,
- (r) the fluid supply and/or outtake involves or is to involve an accumulator,
- (s) the sonic head is supported by a frame relative to which the sonic head has at least in part some degree(s) of freedom to move,
- (t) the sonic head is linked to a frame by articulating (e.g. dog bones) or other linkages to allow some movement of a complementary means relative to the frame,
- (u) the sonic head is supported by a frame and is buffered so as not to pass unnecessary shock into the frame (preferably such buffering including, in conjunction with any optional suitable linkage or linkages, the use of cushioning gas bags or the equivalent) (preferably as air bags as opposed to air springs are utilised),

- (v) the sonic head is supported from a frame capable of being manipulated directly or indirectly to control the disposition of the sonic head,
- (w) the sonic head is carried directly or indirectly by a frame which directly or indirectly [e.g. a carried carriage or slide, or support(s) for the frame as a carriage or slide] (but not linked to the sonic head by any rigid member) has mounted at least part of an endless drive assembly for the valving arrangement(s) and/or a fluid motor for use in driving the valving arrangement(s),
- (x) a carriage or slide, or support(s) for a frame as a carriage or slide, carries a hydraulic motor and/or drive component (e.g. to be via a flexible drive) for rotating a drill string and/or a mandrel therefor, the sonic head being locatable but with some freedom(s) to move by said frame,
- (y) drives and/or motors are to be or are, at least to some extent, substantially isolated from the vibration(s) of the sonic head, standoff mounts being provided therefore.

In another aspect the invention consists in **a sonic head assembly** for generating an output (e.g. for direct or indirect sonic input into a drill string), said assembly having

a frame,

as a sonic head carrying, carried by and/or substantially locating the frame,

wherein the sonic head has (preferably at least within bounds) at least some freedom(s) to move relative to the frame, and/or vice versa,

and wherein at least some of the mass (“the shuttle”) of the sonic head (inclusive of at least some of said fluid) under the action of valves and a pressurised fluid supply or pressurised fluid supplies for opposing variable volume chambers defined in part in each case by the shuttle, in use, is able to shuttle with respect to two other masses of the sonic head each of which defines in part a said chamber,

and wherein it is from at least one of these other masses from which there is to be the sonic output.

Accordingly in another aspect the present inventions consists in a **sonic head** for generating an output (e.g. suitable for direct or indirect sonic input into a drill string),

and wherein the sonic head has at least one piston in a complementary cylinder moveable relative to each other to define a variable volume chamber expandable in volume under the action of a valved fluid supply into the variable volume chamber when it is at less than its full volume;

and wherein the cylinder for part of a shuttle to shuttle is an away direction as the variable volume chamber expands;

and wherein means is provided to return the shuttle and thus the headed cylinder to express fluid from the variable volume chamber via a valve arrangement.

In another aspect the invention consists in a **sonic head** suitable for generating an output (e.g. suitable for direct or indirect sonic input into a drill string),

and wherein the sonic head has componentry defining variable volume chambers, such componentry involving a piston in a complementary headed cylinder, moveable relative to each other such that each chamber is under the action of a fluid under pressure supplied into one variable volume chamber whilst previously supplied fluid is being released from the other variable volume chamber, and *vice versa*.

and wherein part of the componentry defining each chamber is of a shuttle that shuttles.

In another aspect the invention consists in a **sonic head** suitable for generating an output (e.g. for direct or indirect sonic input into a drill string),

wherein the sonic head has a spaced pair of pistons each located within a headed cylinder,

and wherein each headed cylinder has a valving arrangement whereby a variable volume can be defined by the piston relative to the headed cylinder as a consequence (at least in part) of fluid supply into and/or fluid release from the variable volume chamber reliant on the valving arrangement,

and wherein the valving arrangement of on headed cylinder is out of phase with the other such that as one chamber increases in volume as a consequence (at least in part) of fluid supply thereto, the other correspondingly decreases, and *vice versa*.

In another aspect the invention consists in **a sonic head** suitable for generating an output (e.g. for direct or indirect sonic input into a drill string),

and wherein the sonic head has at least one piston in a complementary headed cylinder, moveable relative to each other, to define a variable volume chamber under the action of a fluid under pressure supplied into or being released from the variable volume chamber,

and wherein the supply status, into or from the variable volume chamber is under the control of a rotary valve.

In another aspect the invention consists in **a sonic head** suitable (for generating an output for direct or indirect sonic input into a drill string),

and wherein the sonic head has at least one piston in a complementary headed cylinder, moveable relative to each other, to define a variable volume chamber under the action of a fluid under pressure supplied into or being released from the variable volume chamber under the control of a valving arrangement,

and wherein

- (i) feed for such fluid prior to valving into the variable volume chamber, or
- (ii) outtake for such fluid after valving from the variable volume chamber, involves a passageway in a rotatable valve member of the valving arrangement.

In another aspect the invention consists in **a sonic head** for generating an output (e.g. for direct or indirect sonic input into a drill string),

wherein the sonic head has at least one circumferentially or peripherally grooved piston (preferably without any piston rings) in a complementary cylinder moveable relative to each other to define a variable volume chamber under the action of a fluid under pressure supplied into or released from the variable volume chamber.

In another aspect the invention consists in **a sonic head** for generating an output (e.g. for direct or indirect sonic input into a drill string),

and wherein the sonic head has at least one piston in a complementary cylinder moveable relative to each other to define a variable volume chamber under the action of a fluid under pressure supplied into or released from the variable volume chamber,

and wherein one, some or all of the following features are present:

the sonic head when used for sonic drilling (or some equivalent) has the shuttle independent of the drill string or equivalent means to be vibrated), there is no drill rod nor rod extension through the shuttle or sonic head (thereby to enable, if desired, multiple sonic heads to be used in delivering power to a drill string or other means to be subjected to vibration),

the outtake of fluid from a chamber is not used to power the movement of the shuttle,

the outtakes of fluid is (are) to substantially ambient pressures prior to, if desired, such fluid being made available (e.g. by pumping) for a return to the sonic head,

the fluid is primarily a liquid but may include some entrained gas (e.g. air) so as to confer some cushioning effect in the chamber,

the sonic head irrespective of whether or not its operation is tuned to provide resonance in a body or device (such as a drill string) directly or indirectly attached to one or other, or both, of the complementary means, can be operated with a jack hammer effect,

the fluid supply and/or outtake involves or is to involve an accumulator,

the sonic head is supported by a frame relative to which the sonic head has at least in part some degree(s) of freedom to move,

the sonic head is linked to a frame by articulating (e.g. dog bones) or other linkages to allow some movement of a complementary means relative to the frame,

the sonic head is supported by a frame and is buffered so as not to pass unnecessary shock into the frame (preferably such buffering including, in conjunction with any optional suitable linkage or linkages, the use of cushioning gas bags or the equivalent) (preferably as air bags as opposed to air springs are utilised),

the sonic head is supported from a frame capable of being manipulated directly or indirectly to control the disposition of the sonic head,

the sonic head is carried directly or indirectly by a frame which directly or indirectly [e.g. a carried carriage or slide, or support(s) for the frame as a carriage or slide] (but not linked to the sonic head by any rigid member) has

mounted at least part of an endless drive assembly for the valving arrangement(s) and/or a fluid motor for use in driving the valving arrangement(s),

a carriage or slide, or support(s) for a frame as a carriage or slide, carries a hydraulic motor and/or drive component (e.g. to be via a flexible drive) for rotating a drill string and/or a mandrel therefor, the sonic head being locatable but with some freedom(s) to move by said frame,

drives and/or motors are to be or are, at least to some extent, substantially isolated from the vibration(s) of the sonic head, standoff mounts being provided therefore.

In another aspect the invention consists in a sonic head for generating an output (e.g. for direct or indirect sonic input into a drill string),

wherein the sonic head has an adaption to provide some freedom(s) to move relative to a frame, and/or vice versa,

and wherein at least some of the mass of the sonic head (inclusive of at least some of said fluid) under the action of at least one valve and a pressurised fluid supply, in use, is able to shuttle with respect to some of the mass of the sonic head from which a drill line is to receive directly or indirectly the sonic output.

In another aspect the invention consists in **a sonic head** for generating an output (e.g. for direct or indirect sonic input into a drill string),

and wherein the sonic head has at least one part in a complementary receiver moveable relative to each other to define a variable volume chamber expandable in volume under the action of a valved fluid supply into the variable volume chamber when it is at less than its full volume,

and wherein the receiver or said part is of a shuttle which moves in an “away” (as opposed to its “towards”) direction as the variable volume chamber expands,

and wherein means is provided to return the shuttle by causing a towards direction motion thereof thereby to express fluid from the variable volume chamber via a valve arrangement, and wherein the sonic output is or is to be not from the frame nor the shuttle.

In another aspect the invention consists in **a sonic head** for generating an output for direct or indirect sonic input into a structure (e.g. a drill string), or other medium capable of transmitting/absorbing the sonic input,

and wherein the sonic head has a shuttle and two components, each component with the shuttle defining one of two variable volume chambers, the shuttle being moveable relative to each component under the action of a fluid under pressure being supplied into one variable volume chamber and being released from the other variable volume chamber, and *vice versa*,

and wherein the sonic output is not or is not to be directly or indirectly from any associated carrying slide or frame nor the shuttle.

In another aspect the invention consists in **a sonic head** for generating an output (e.g. for direct or indirect sonic input into a drill string),

wherein the sonic head has at least one component received by another, and moveable relative to each other, to define a variable volume chamber expandable under the action of a fluid under pressure supplied into the variable volume chamber when at less than its largest volume or compressible as fluid previously supplied is enabled to be released from the variable volume chamber when it is at more than its smallest volume

and wherein the fluid status insofar as pressure and immediately available volume is concerned is independent of the instantaneous volume of the chamber,

and wherein a rotary valve controls ingress and egress of the fluid into and from the chamber.

In another aspect the inventions consists in **a sonic head** for generating an output (e.g. for direct or indirect sonic input into a drill string),

wherein the sonic head has at least two components moveable relative to each other, to define a variable volume chamber moveable from a condition which has the chamber less than at its maximum volume under the action of a fluid under pressure supplied under the control of a valving arrangement into the chamber and being returned by other means from that maximum volume condition while fluid is being

released from the variable volume chamber under the control of a valving arrangement,

and wherein

- (i) feed for such fluid prior to valving into the variable volume chamber, or
- (ii) outtake for such fluid after valving from the variable volume chamber, involves a passageway in a rotatable valve member of the valving arrangement.

In another aspect the invention consists in **a sonic head** for generating an output (e.g. for direct or indirect sonic input into a drill string),

wherein the sonic head has at least one piston in a complementary cylinder moveable relative to each other to define a variable volume chamber

- (i) expandable under the action of a fluid under pressure supplied into the variable volume chamber when at less than its maximum allowed volume, and
- (ii) compressible from its maximum allowed volume under the action of a mechanical input whilst fluid is allowed to egress from the chamber,

and wherein the output is directly or indirectly from that component selected from the cylinder and piston not providing said mechanical input.

In another aspect the invention consists in **a sonic head** for generating an output (e.g. for direct or indirect sonic input into a drill string),

wherein at least some of the mass ("the shuttle") of the sonic head (inclusive of at least some of said fluid) under the action of valves and a pressurised fluid supply or pressurised fluid supplies for opposing variable volume chambers defined in part in each case by the shuttle, in use, is able to shuttle with respect to two other masses of the sonic head each of which defines in part a said chamber,

and wherein it is from at least one of these other masses from which there is to be the sonic output.

The present invention also consists in **a sonic head** of or suitable for a sonic head assembly of any of aforementioned kinds i.e. without a said frame.

In still a further aspect the present invention consists in **the use of a sonic head or a sonic head assembly** of the present invention for the purpose of providing a vibrational input into a body, media or device.

In yet a further aspect the present invention consists in **a method of drilling** which involves the operative use of a sonic head or sonic head assembly in accordance with the present invention.

In yet a further aspect the present invention consists in, **in combination, a drill string, a sonic head assembly** (or components therefor) and (optionally) related linkages, hydraulic supplies etc.

In a further aspect the present invention consists in **vibrational apparatus** comprising or including

a piston,

a chamber assembly defining a chamber in which the piston is adapted to shuttle between stroke limits, said chamber having a chamber end region at and/or beyond each stroke limit of the piston, there being an inlet port into and an outlet port out of each chamber end region, and

a fluid supply assembly or assemblies associated with said chamber assembly capable of supplying a pressurised fluid to the inlet ports of the chamber,

wherein there is at least one rotary valve capable of an out of phase allowing or disallowing of fluid movement from the fluid supply assembly or assemblies into each said inlet ports by opening or closing same,

and wherein each chamber end region has an inlet port and an outlet port adapted

- i) such that each inlet port when opened by the rotary valve(s) is larger as an inlet than its associated outlet provided by the outlet port which is at least substantially always open, or vice versa, and/or
- ii) such that each outlet port is valved to open to allow discharge of fluid from its chamber end region at least substantially out of phase to the inlet port opening of that same chamber end region (e.g. completely or partially closed out of phase),

and wherein in use, there is or will be a vibrational output via the first assembly, the second assembly and/or an output member of or carried by the piston as a consequence of rapid piston shuttling within the chamber.

Preferably the rapid cycling envisaged is from 20 to 500 cycles/second.

As used herein "fluid" includes a liquid (such as a hydraulic liquid – usually an oil but not necessarily so), a gas (for example, nitrogen or air) and, or mixtures of liquids and air or liquids and particulate solids or gas and particulate solids or any other suitable combination, e.g. emulsions of different liquids, mixtures of gases, etc.

Optionally a single rotary valving unit (preferably with a rotational axis substantially perpendicular to a rectilinear stroke axis of the piston) can be provided.

Preferably such a rotary valve member has a single radiused array of openings, such openings allowing the opening of an inlet port and the regions of the valving member between such openings closing the inlet ports.

Preferably the effect for each inlet port is to "open", "close" and "open" the inlet port with sequential openings whilst the out of phase other inlet port is respectively "closed", "opened" and "closed" by the respective diametrically opposed closing regions of the valve member and the opening sandwiched thereby.

In another aspect the present invention consists in **vibrational apparatus** comprising or including

a piston,

a chamber assembly defining a chamber in which the piston is adapted to shuttle between stroke limits, said chamber having a chamber end region at and/or beyond each stroke limit of the piston, there being an inlet port into and an outlet port out of each chamber end region,

a fluid supply assembly associated with said chamber assembly capable of supplying a pressurised fluid or any pressurised fluid it may receive in use to the inlet ports of the chamber,

a fluid collection assembly associated with said chamber assembly to collect fluid from the outlet ports (and preferably capable of supplying that collected fluid for reuse via a said source of pressurised fluid),

a first rotary valve capable of an out of phase allowing or disallowing of fluid movement from the fluid supply assembly into each said inlet port by opening or closing same,

a second rotary valve capable of an out of phase disallowing or allowing of fluid movement from the chamber out of each said outlet port by closing or opening same,

a first drive to rotate the first rotary valve,

a second drive to rotate the second rotary valve, and

a timing link between the first and second drives such that, for each chamber end region, an inlet port will generally be open when its associated outlet port is closed, and vice versa, and such that, each state of the opening and closing of each end chamber end region is generally out of phase with the condition of the other,

wherein in use, there is or will be a vibrational output via the first assembly, the second assembly and/or an output member of or carried by the piston as a consequence of rapid piston shuttling within the chamber.

The term “drive” includes a dedicated or undedicated drive and can amount to no more than some transmission element or assembly capable of being driven (e.g. by a hydraulic or electric motor) [directly or indirectly] thereby to rotate the rotary valve(s).

The “timing link” can be and preferably is a driving link such that the drive into one drive in turn drives the other.

Preferably preferments are as previously stated.

Preferably the timing link between the drives is a belt or chain linking pulleys, sprockets, or the like.

Preferably the fluid supply assembly receives the pressurised fluid and does not itself pressurise fluid.

Preferably the vibrational apparatus is adapted to be linked into a remote hydraulic circuit to supply said pressurised fluid.

Preferably the vibrational apparatus is capable of being “tuned” so as to provide desired amplitudes of movement and/or resonance outputs reliant upon a control of the pressure and/or volume of the pressurised fluid being supplied and/or a control of the timing link and drives.

Preferably the stroke axis is rectilinear.

Preferably the piston has two journaled extensions (not necessarily required to rotate but capable of sliding in the bearing or other surround).

Preferably one extension being the output member.

Preferably the inlet ports are laterally of the chamber with respect to the stroke axis.

Preferably the outlet ports are laterally of the chamber with respect to the stroke axis.

Preferably the piston (irrespective of whichever aspect of the present invention is involved) carries an output member.

In some forms of the present invention the output member can be an extension of the piston or piston assembly such that the piston proper is rectilinearly guided but there is at least one protruding end of that assembly to provide the output.

In some forms of the present invention such protruding end(s) and/or indeed the piston itself can act as a conduit for a quite separate fluid supply, e.g. it may be desirable to duct a gas, liquid or other material down and/or up from the drill string with which the output member might be associated in use, such fluids being kept distinct from the operating fluid of the vibrational apparatus.

In yet a further aspect the present invention consists in **a method of vibrating a structure, assembly or member** which involves associating vibrational apparatus of the present invention therewith and operating that vibrational apparatus so as to induce vibration thereof.

In yet a further aspect the present invention consists in **pile driving, boring and/or drilling** involving the use of vibrational apparatus in accordance with the present invention.

The present invention also consists in **pile driving and/or drilling or boring assemblies** of any suitable kind which includes vibrational apparatus of the present invention, e.g. can include a drill head, a drill string and a vehicle or other prime mover to supply a hydraulic fluid as the working fluid.

As used herein "shuttle" and "piston" have the broadest meanings envisaged herein with respect to what moves and what does not, etc.

As used herein the term “and/or” means “and” or “or”, or, where the context allows, both.

As used herein the term “comprises” or “comprising” can mean “includes” or “including”.

As used herein the term “(s)” following a noun can mean both the singular and plural versions of that noun.

As used herein the term “stroke limit of the piston” can refer to limits of a rectilinear stroke or any curved stroke (e.g. can include a stroke of a piston that swings about a pivot axis or other support, whether fixed or moving).

Reference herein to “out of phase” in respect of the allowing or disallowing of fluid movement from the fluid supply assembly(s) means substantially registering an opening of the rotary valve(s) to allow entrance of fluid into one end region whilst the other end region has its inlet port substantially closed by the or a rotary valve(s).

Reference herein to “out of phase” with respect to the inlet and outlet ports of the same chamber end region refers preferably, but not necessarily so, to the inlet port being closed by the or a rotary valve(s) whilst the outlet port is open.

The term “out of phase”, in any of its defined forms, is inclusive of both no overlap (i.e. no partial opening with partial closing) and some overlap.

As used herein the term “rapid” with respect to piston shuttling within the chamber refers to any speed of operation of the shuttle that will provide an output vibration of use to the application at hand and, in the case of “sonic drilling or boring”, includes at least several cycles per second. By way of example, and without limitation, the cycles/sec are preferably above 20 cycles/sec. Many hundreds of cycles/second are envisaged, e.g. up to, for example, one or several thousand cycles/second. Vibrational apparatus of the present invention operating with, for example, a hydraulic liquid as the fluid, at for example, about 200 bar (as is common for hydraulic fluid of excavators) can operate the shuttle at about 200 cycles/second.

Preferably the rapid cycling envisaged is from 20 to 500 cycles/second.

As used herein “fluid” includes a liquid (such as a hydraulic liquid – usually an oil but not necessarily so), a gas (for example, nitrogen or air) and, or mixtures of liquids and air or liquids and particulate solids or gas and particulate solids or any other suitable combination, e.g. emulsions of different liquids, mixtures of gases, etc.

The term “excavator” may mean quite in addition to apparatus normally considered as an excavator any power source such as hydraulic, electric, pneumatic, or other.

The term “head” or “headed” in respect of any cylinder or chamber envisages a chamber closed by the stationary and/or movable “piston” irrespective of whether or not valving is via any one or more of a head, the cylinder and the piston.

A preferred form of the present invention will now be described with reference to the accompanying drawings in which

Figure 1 is a three dimensional cutaway (the top complementary member or piston not being shown) of a sonic head in accordance with the present invention having rotary valve members as part of the valving arrangement for each chamber and having them aligned axially,

Figure 2 is a top view of the apparatus of Figure 1 showing at the centre line the device cutaway by the quarter sector as shown in Figure 1,

Figure 3 is a front view of the apparatus of Figure 2 shown in elevation,

Figure 4 is the end view AA of the apparatus of Figure 3,

Figure 5 is a section of the sonic head shown in Figures 1 to 4, such section being along the centre line yet showing the device in elevation,

Figure 6 shows a preferred frame and ancillary apparatus assembly in accordance with the present invention, there being shown an outtake mandrel for connection into the body to be vibrated by the first complementary means or directly from the first complementary means (e.g. for powering by way of example a drill string).

Figure 7 is for an opposed piston variant (i.e. having complementary variable volume chambers) a timeline against shuttle movement under the two scenarios (A) Fig 8', Fig 9', and so forth cycling and (A) Fig 8, Fig 8A, Fig 9, Fig 9A, Fig 8, Fig 8A, Fig 9, 9A, Fig 8, and so forth cycling,

Figure 8' is a flow diagram of the apparatus shuttling to the right,

Figure 9' is a flow diagram of the apparatus shuttling to the left,

Figure 8 is a flow diagram as in Fig 8',

Figure 8A is a flow diagram where oil feed pressures momentarily match and reliance is placed on an accumulator in the oil system (not shown), but where the shuttle movement is a momentary precursor to the condition of Fig 9,

Figure 9 is a flow diagram as in Fig 9',

Figure 9A is a flow diagram as in Fig 8A also where reliance is placed on an accumulator (the same or different – preferably different) but where the shuttle movement is a momentary precursor to the condition of Fig 8.

Figure 10 is an exploded cut away drawing of an embodiment to the present invention, this embodiment having a single rotary valve adapted to control the opening and closure of inlet ports but having an always open outlet port structure but of lesser opening than the inlet ports when open,

Figure 11 is a form of the present invention having two rotary valves, one for the inlet port set and one for the outlet port set thereby not requiring any differential in size of the inlet and outlet ports,

Figure 12 shows another broken away view of the embodiment of Figure 11, and

Figure 13 shows how in one other embodiment but relying on the mechanism typified by Figure 11, there can be a sprocket or other drive of each rotary valve timed relative to each other by a timing belt or belts and/or an idle shaft such that input by, for example, an electric or hydraulic motor as shown has the capability of controlling the speed of rotation of both rotary valves.

In the preferred form of the present invention there are two variable volume chambers and each operates in an out of phase manner with respect to the other such that there is a positive powering of each chamber to a larger volume under the valve controlled pressure and volume of supplied fluid thereby avoiding the need for outtakes of the fluids to provide any direct drive to diminish the volume of that same chamber otherwise than from an expanding effect on the other variable volume chamber. Preferably in use neither chamber is ever to be devoid of liquid/fluid therein.

In the arrangement as shown in Figure 1,

1 denotes a piston assembly,

2 denotes a stationary valve block assy,

3 denotes an O-Ring

2004250089 21 Feb 2008

- 4 denotes a cap screw
- 5 denotes a bearing block
- 6 denotes a cap screw
- 7 denotes a cap screw
- 8 denotes a top center block
- 9 denotes a bottom center block,
- 10 denotes a nut,
- 11 denotes a washer
- 12 denotes a valve shaft
- 13 denotes a spherical roller thrust bearing
- 14 denotes a single lip seal
- 15 denotes a synchronous drive pulley
- 16 denotes a taper lock bush
- 17 denotes an O-ring
- 18 denotes an O-ring
- 19 denotes a valve shaft bush housing assy
- 20 denotes a stationary valve block spacer
- 21 denotes a cap screw
- 22 denotes a valve shaft bush assy
- 23 denotes a cap screw
- 24 denotes a piston seal rim
- 25 denotes a bearing block seal rim
- 26 denotes a tire
- 27 denotes a bearing cage
- 28 denotes an O-ring , and
- 29 denotes a plastic piston spacer.

With reference to the arrangement as shown in Figure 5 it can be seen that there is a first variable volume chamber 30 and a second variable volume chamber 31 and whilst a tire like flexible connection 32 and 33 respectively links each piston including part 34 and 35 with the shuttle 36, the amplitude of movement envisaged is relatively small during most operations. Preferably they range from a fraction of a

millimetre to several centimetres but could be more the larger the sonic head is. The frequency can be from a few Hertz to thousands.

Each chamber is bounded by the piston part of its component 34 or 35 which preferably each includes peripheral pressure drop grooves without piston rings. This is to avoid ring damage as a result of the vibration and to allow the supplied fluid the prospect of some lubricating effect between the piston and the stationary valve blocks 37 and 38 respectively. As can be seen each stationary valve block 37 or 38 is ported and coacts with a rotating valve member or rotating valve shaft 39 and 40 respectively to either allow fluid into or fluid from its proximate variable volume chamber 30 or 31.

Axially within each rotating valve member 39 is a passageway which ports radially therefrom which is used preferably for the outtake of fluid back to a collection chamber from whence it can be returned (e.g. by pumping) as shown in Figure 5. The oil inlet lines are shown supply via passageways to the valving arrangement exteriorly of the rotating valving member 39 or 40.

A separate fluid supply (not shown in Figure 5) is utilised for a hydraulic motor 41 which is to operate via the member 42 and endless drive belt or the equivalent 43 for each of rotating valve members 39 and 40. Such a hydraulic motor receives a fluid supply preferably provided separately from the volume of fluid being supplied for the purpose of energising the sonic head insofar as the shuttle movement is concerned.

As can be seen, preferably the arrangement which includes 41, 42 and 43, is on a slide 44 relative to a frame 45 which directly or indirectly supports the sonic head. The frame 45 itself can be arranged as a slidable carriage on a support rail or other structure 46 such that preferably it operates relative thereto within limits.

If desired the slide 44 and the rail or other structure 46 can be linked.

Shown in Figure 6 is the sonic head having a drill string mandrel or the equivalent 47 adapted to be rotated by an endless drive belt/chain or the equivalent 48 driven by a hydraulic motor 49 (separate hydraulic feed again). Optional rotation of the mandrel 47 will rotate or manoeuvre a drill string attached thereto whilst the mandrel or the equivalent 47 is vibratable (directly or indirectly) under the action of the proximate piston or complementary means of the sonic head.

Such a proximate piston, piston assembly, or complementary means is preferably supported so as to be moveable at least in a longitudinal sense to some extent relative to the frame 45 and for this purpose some guided linkages are preferably provided. For example, links 50 and 51 on either side of the sonic head can link by a pivot 52 or 53 to the sonic head and by 54 and 55 to the frame 45. At the same time limits of movement can be imposed by compression springs 56 and 57 (or air bags) in conjunction preferably with airbags 58 and 59 which provide a cushioning or damping effect between the sonic head and the frame 45 and in turn the carriages or supports 44 and 46.

It can be seen therefore that the linkages allow some semblance of rotation of the dog bone links whilst at the same time allowing some axial displacement of the sonic head as a whole, yet the shuttle 36 is free of direct contact with the frame and/or the slides or carriages 44 and 46 otherwise than as a consequence of the flexible drives and the hose and/or other linkages not shown in the attached drawings.

Preferably all connections (including of hydraulics) are of flexible vibration resistance hoses connected so as to avoid involuntary disconnection.

The sonic head of the present invention can start with a jackhammer effect even without drill string tuned for resonance. Control thereafter can be (a) speed of rotating valves (rotor) and/or (b) volume of fluid (e.g. oil). This can alter frequency yet still allow power to be added independent of drill string length. The drill string can have torque and pressure placed on it without affecting the resonator or shuttling sonic head shuttle. This affords huge drilling control.

The independent systems for rotor control from that of the shuttle oil supply, the vibrational isolation of the sonic head save primarily for sonic shock, the frame within a frame arrangements, and the short distance of oil shock travel bestow significant advantages.

Operation of cycles as in Figures 7 to 9A will now be described with apparatus having the flow capabilities previously described. Please appreciate where such a device as shown in Figures 1 to 9A is, say, about 1.5m long the shuttle movement is of the order of, say, 0.1mm to 15mm (the amplitude), the parameters of operation affecting amplitude.

The operation can be a direct millisecond range movement as in scenario (A) referred to in respect of Figure 7 (i.e. Fig 8', Fig 9', etc) but can instead be scenario (B) where conditions as in Figures 8A and 9A each requires an accumulator in the oil circuit to allow the momentary movement required to the following Figure 9 and Figure 8 instantaneous condition respectively.

It is envisaged that apparatus in accordance with forms of the present invention as shown in Figures 10 to 13 will preferably be driven by a hydraulic system from, for example, an excavator (or other vehicle or a standing prime mover) and therefore the various sources of pressurised liquid and the reservoirs referred to herein are preferably those of such a supply excavator, etc. to which the apparatus can be linked. Preferably also there can be a diversion in the inflow to the apparatus of such pressurised hydraulic fluid through such closure and/or choke valves etc. as may be required separately to provide a hydraulic drive to the or one of the rotary valves (and thus by the timing or synchronising link in turn to the other) as well as separately the charging of the fluid alternately to each chamber end region.

In the embodiment shown in Figure 10 the piston 60 has extensions 61 journaled so as to allow axial movement. It matters not if the piston and the journals are circular in cross section and/or whether or not they are allowed to rotate within the chamber defined by the chamber assembly 62.

As can be seen in the embodiment of Figure 10 there is a first chamber end region 63 and a second chamber end region 64 each accessible to an inlet port 65 and 66 respectively.

Positioned so as to rotate substantially about an axis normal to the stroke axis of the piston 60 is a rotary valve 95 having on a same radius areas of no opening 67 and openings 68.

As can be seen one of these openings 68 (designated 68A) is opening the pressurised liquid supply chamber 69 of the fluid supply assembly into communication with the chamber end region 63 whilst there is no such access via the second inlet port 66 into the chamber end region 64 owing to the out of phase state, i.e.; there is a region 67 holding the second inlet port 66 closed whilst the first inlet port 65 is open. The vice versa situation onwards will allow alternate charging to each chamber end region.

As shown in Figure 10 there is a first exhaust or outlet port 70 for the chamber end region 63 and a second outlet port 71 for the chamber end region 64. In a situation as shown in Figure 10 where these ports are always kept open preferably means (in this case a plate having openings 72 and 73) other than a second rotary valve ensures that the inflow of liquid via an opening 68 and a port 65 or 66 will always be at a greater rate than there is any exhausting out via the corresponding opening 72 or 73 as part of a hydraulic return circuit.

Persons skilled in the art will appreciate how the fluid supply assembly 74 can be supplied with an infeed of a hydraulic fluid into the chamber 69 with the fluid finding its own way from there into one or other of the chamber end regions 63 and 64 and from thence via the exit ports (70 and 72 in one instance and 71 and 73) in the other instance back to the pumping system of, for example, the excavator with which the apparatus might be linked for return of that same hydraulic liquid back to the chamber 69 or such diversion thereof, as might be considered desirable, to a hydraulic motor for driving the rotary valve 95.

A more preferred form of the present invention is that shown in Figure 12. This has similar to Figure 10 a piston 75 and journaled extensions 76 and 77 thereby defining chambers 78 and 79 bounded at least in part by chamber end regions 78A and 79A with each chamber controllable by, for example, the rotary valve 80 with its openings and non openings similarly arrayed to the manner shown by reference to the embodiment of Figure 10. The assembly 81 with its chamber 82 is adapted to receive pressurised hydraulic liquid and to selectively allow its movement into first one and then the other of the chambers 78 and 79.

Timed to the rotation of the rotary valve 80 is a rotary valve member 83 which has the role of allowing the exhausting of hydraulic liquid from first one and then the other of the chambers 78 and 79 in an out of phase relationship to that of injection thereby to reciprocate the piston. The exhaust rotary valve 83 preferably rotates at the same speed as the rotary valve 80 and the spacings of its openings is appropriate for each outlet from the chambers 78 and 79.

Figure 11 best shows the arrangement of these openings with a port 84 being closed by not being aligned with an opening 85 of the input rotary valve 80 whilst an outlet port 85A of that same chamber end region 86 is aligned with an opening 87 to

2004250089 21 Feb 2008

allow outflow into the chamber 88 of the fluid collection assembly 79 from whence it is ducted back via, for example, the excavator, for pumped recycled use.

The arrangement of Figure 13 shows in a bench test form an electric motor 90 (ideally it would be a hydraulic motor in use) driving directly a drive assembly adapted to rotate a first rotary valve (not shown) whilst a link belt 91 through an idle shaft 92 in turn through a second link belt 93 drives the other rotary valve (not shown) thereby providing the appropriate vibrational movement (caused by reciprocation of the piston) that extends into the journaled output member 94.

In operation therefore appropriate tuning can occur of the vibrations required. If we assume that an excavator has a capability of providing a substantially constant hydraulic flow and pressure into the apparatus of the present invention and there is a division of the flow so that one flow can supply a hydraulic motor to achieve rotary valve rotation whilst the other flow is to charge selectively either side of the piston under the action of the rotary valve timed or synchronised movement, a very simple control regime applies. This is far less complicated with far fewer moving parts and requiring lower tolerances than for any of the prior art procedures previously disclosed.

For example, if the inlet port at one end is shut by its rotary valve then the hydraulic liquid cannot go anywhere and nothing will happen by way of charging into that end region. Contrarily however the same will not be the case at the other end if that is in part or wholly open.

Accordingly when an input rotary valve is turned (spun) the hydraulic oil flows into the piston chamber end region and forces the piston to the end of its stroke. The rotary valve continues to turn and through its timing or synchronism with the other rotary valve, the "spent" hydraulic oil is allowed to release to exhaust. At the same time or subsequently (or both) the first rotary valve diverts oil to the other end of the piston in turn forcing the piston back.

The hydraulic drive through timing belts means that if the rotary valves in unison rotate slowly (say 10 rpm) the piston will shuttle very slowly but if both rotary valves are rotated at say 1000 rpm the piston could be moving, say, at approximately 200 times per second. Thus tuning for the various ground conditions can be achieved

by the simple expediency of manipulating the speed of the synchronised rotary valves by the control of the fluid input to the hydraulic motor.

2004250089 21 Feb 2008

2004250089 21 Feb 2008

WHAT WE CLAIM IS:

1. **Vibrational apparatus capable of providing a vibrational output**, said apparatus comprising or including

a shuttle having first and second ends,

a first complementary structure associating with the first end of said shuttle,

and

a second complementary structure associating with the second end of said shuttle,

wherein there is a drive or drives to move the shuttle alternately in each shuttling direction so that, in one direction, the shuttle moves away from the first complementary structure and, in the other direction, the shuttle moves away from the second complementary structure,

and wherein the output of the vibration is from one or other, or both, of said complementary structures and not directly from the shuttle itself.,

and wherein at least one of the drives is that of a rotary valve controlled inflow of a pressurised fluid.

2. Apparatus of claim 1 wherein said first and second complementary structures are fixed relative to each other insofar as distance is concerned.

3. Apparatus of claim 1 or 2 wherein there is a separate positive drive for the shuttle in each of the two directions.

4. Apparatus of claim 3 wherein at least one drive is selected from a direct mechanical drive through pivot links, a magnetic drive, a hydraulic drive, a pneumatic drive and a combustive drive.

5. Apparatus of claim 4 wherein both the separate positive drives relies on fluid pressure.

6. Apparatus of claim 4 or 5 wherein the drive type for the shuttle in each of its directions is the same.

7. Apparatus of claim 1 wherein the shuttling is without solid to solid impact.

8. Apparatus of claim 7 wherein said shuttle co-acts at least at one end with its complementary structure so as to provide a cushioning affect by squeezing a fluid.

9. Apparatus of claim 8 wherein said cushioning affect is at both ends.

2004250089 21 Feb 2008

10. Apparatus of claim 1 wherein the vibrational output is from one of the complementary structures.

11. Apparatus of claim 3 wherein there is reliance upon the provision of an externally pressurised fluid as the sole means of empowerment of shuttle movement by being timely introduced so as to pressurise alternately chambers each defined between a complementary structure and said shuttle.

12. Apparatus of claim 1 wherein

said first complementary structure coacts with the shuttle to define a first pressurisable chamber,

said a second complementary structure ~~to~~coacts with the shuttle to define a second pressurisable chamber,

there is a first valving arrangement to control fluid flow into and out of the first pressurisable chamber,

a second valving arrangement to control fluid flow into and out of the second pressurisable chamber,

at least one supply of pressurisable fluid, or adaption(s) therefor, to the shuttle whereby each of the first and second valving arrangements can allow or not allow fluid entry to the respective chamber, and

at least one outtake of fluid, or adaption(s) therefor, whereby each of the first and second valving arrangements can allow or disallow fluid egress from its respective chamber;

wherein the valving arrangements and shuttle movement relative to the complementary member(s) is such that as the first valving arrangement allows fluid entry to the first chamber thereby to expand both the first chamber and volume of fluid therein, the second valving arrangement allows fluid egress from the second chamber thereby to allow both compression of both the second chamber and the volume of fluid therein, and so forth in an alternating shuttle moving manner.

13. Apparatus of claim 12 wherein the valving arrangement in each instance involves a rotary valve member having ports to open or close a fixed port or fixed ports to the chamber,

14. Apparatus of claim 13 wherein each valving arrangement includes a different or the same rotary valve member which includes an axial passageway to allow fluid outtake or supply.

15. Apparatus of claim 13 wherein each valving arrangement includes a rotary valving member, such rotary valving members being operated on a common rotational axis and out of phase one with the other.

16. Apparatus of claim 15 wherein the timing provided by the valving arrangements can allow some overlap of supply or exhaust flows between the respective chambers.

17. Apparatus of claim 12 wherein each valving arrangement is driven independently of the fluid supply and fluid outtake

18. Apparatus of claim 16 wherein it is possible to regulate amplitude of movement of the shuttle independently of the frequency of shuttling by having a control of the valving arrangements that is independent of at least one of pressure and volume of supply to and outtake of fluid from the valving arrangements.

19. Apparatus of claim 13 wherein each valving arrangement is proximate to its chamber thereby to optimise to a small distance between valving by the valving arrangement and the action of fluid being introduced into the proximate chamber.

20. Apparatus claim 12 wherein the fluid supply or outtake involves an accumulator.

21. Apparatus of claim 12 when supported by a frame relative to which the vibrational apparatus has at least in part some freedom to move.

22. Apparatus of claim 21 wherein the vibrational apparatus is linked to a frame by articulating or other linkages to allow some movement of each complementary structure relative to the frame.

23. Apparatus of claim 21 or 22 wherein the vibrational apparatus is supported at least in part by gas bags in a frame.

24. Apparatus of claim 1 when is supported from a frame capable of being manipulated directly or indirectly to control the disposition of the sonic head.

25. Apparatus of claim 1 wherein the drive is, or drives are, or the or any motor thereof, at least to some extent and at least in part, is substantially isolated from the

vibration(s) of the head, (e.g. standoff mounts being provided therefor, belt drives, etc.).

26. Apparatus of claim 12 when carried directly or indirectly by a frame which directly or indirectly has mounted at least part of an endless drive assembly for the valving arrangement(s) and/or a fluid motor for use in driving the valving arrangement(s).

27. **Apparatus for generating a vibrational output**, said apparatus comprising or including

a shuttle,

a first complementary member to coact with the shuttle to define a first pressurisable chamber,

a second complementary member to coact with the shuttle to define a second pressurisable chamber,

a first valving arrangement to control fluid flow into and out of the first pressurisable chamber,

a second valving arrangement to control fluid flow into and out of the second pressurisable chamber,

one or more supply of pressurisable fluid, or adaption(s) therefor, to the shuttle whereby each of the first and second valving arrangements can allow or not allow fluid entry to the respective chamber,

one or more outtake of fluid, or adaption(s) therefor, whereby each of the first and second valving arrangements can allow or disallow fluid egress from the respective chamber;

wherein the valving arrangements and shuttle movement relative to the complementary member(s) is such that as the first valving arrangement allows fluid entry to the first chamber thereby to expand both the first chamber and volume of fluid therein, the second valving arrangement allows fluid egress from the second chamber thereby to allow both compression of both the second chamber and the volume of fluid therein, and so forth in an alternating shuttle moving manner,

and wherein at least one valving arrangement involves a rotary valve member.

28. Apparatus of claim 27 wherein at least one complementary member is or provides a piston for a shuttle provided cylinder.

29. Apparatus of claim 27 or 28 wherein it is possible to regulate amplitude of movement of the shuttle independently of the frequency of shuttling by having a control of the valving arrangement that is independent of the pressure and/or volume of supply to and/or outtake of fluid from the valving arrangement,

wherein the valving arrangement is proximate to the chamber thereby to optimise to a minimal distance between valving by the valving arrangement and the action of fluid being introduced into the proximate chamber.

30. Apparatus of claim 27 or 28 wherein it is possible to regulate amplitude of movement of the shuttle independently of the frequency of shuttling by having a control of the valving arrangement that is independent of the pressure and/or volume of supply to and/or outtake of fluid from the valving arrangement,

wherein the outtake of fluid from a chamber is not used to power the movement of the shuttle.

31. Apparatus of claim 27 or 28 wherein it is possible to regulate amplitude of movement of the shuttle independently of the frequency of shuttling by having a control of the valving arrangement that is independent of the pressure and/or volume of supply to and/or outtake of fluid from the valving arrangement,

wherein the outtakes of fluid is (are) to substantially ambient pressures prior to, if desired, such fluid being made available (e.g. by pumping) for a return to the vibrational head.

32. Apparatus of claim 27 or 28 wherein it is possible to regulate amplitude of movement of the shuttle independently of the frequency of shuttling by having a control of the valving arrangement that is independent of the pressure and/or volume of supply to and/or outtake of fluid from the valving arrangement,

wherein the fluid is primarily a liquid but may include some entrained gas (e.g. air) so as to confer some cushioning effect in the chamber.

33. Apparatus of claim 27 or 28 wherein the output is (directly or indirectly) from one or other (or both) complementary member(s) rather than the shuttle.

34. Apparatus of claim 27 or 28 wherein there is no drill rod nor rod extension through the shuttle or vibrational head (thereby to enable, if desired, multiple

vibrational heads to be used in delivering power to a drill string or other means to be subjected to vibration).

35. Apparatus of claim 27 or 28 wherein the first and second complementary members are or include pistons provided with circumferential or peripheral grooves that each may or may not carrying a piston rings or seal.

36. Apparatus of claim 27 or 28 wherein the valving arrangement in each instance involves a rotary valve member having ports to open or close a fixed port or fixed ports to the chamber.

37. Apparatus of claim 27 or 28 wherein each (or a common) valving arrangement includes a rotary valve member which includes an axial passageway to allow fluid outtake or supply.

38. Apparatus of claim 27 or 28 wherein each valving arrangement includes a rotary valving member, such rotary valving members being operated on a common rotational axis and out of phase one with the other.

39. Apparatus of claim 27 or 28 wherein each valving arrangement is driven independently of the fluid supply and fluid outtake.

40. Apparatus of claim 33 wherein the shuttle can be caused to move even if there is no initial movement of one or other or both of said first and second complementary means (e.g. as is the case if attached to a bound drill string).

41. Apparatus of claim 27 or 28 wherein the vibrational head, irrespective of whether or not its operation is tuned to provide resonance in a body or device (such as a drill string) directly or indirectly attached to one or other, or both, of the complementary means, can be operated with a jack hammer effect.

42. Apparatus of claim 27 or 28 wherein the fluid supply and/or outtake involves an accumulator,

43. Apparatus of claim 27 or 28 wherein the vibrational head is supported by a frame relative to which the vibrational head has at least in part some degree(s) of freedom to move,

44. Apparatus of claim 43 wherein the vibrational head is linked to the frame by articulating or other linkages to allow some movement of a complementary means relative to the frame.

2004250089 21 Feb 2008

45. Apparatus of claim 43 or 44 wherein the vibrational head is supported by a frame and is buffered so as not to pass unnecessary shock into the frame reliant at least in part on gas bag support from the frame.

46. Apparatus of claim 43 when supported from the frame is capable of being manipulated directly or indirectly to control the disposition of the sonic head.

47. Apparatus of claim 27 or 28 wherein the apparatus is a vibrational head a drive is, or drives to both valving arrangements are, or the or any motor thereof, at least to some extent and at least in part is substantially isolated from the vibration(s) of the vibrational head.

48. Apparatus of claim 27 or 28 wherein the apparatus as a vibrational head is carried directly or indirectly by a frame which directly or indirectly has mounted at least part of an endless drive assembly for the valving arrangement(s) and/or a fluid motor for use in driving the valving arrangement(s).

49. **A vibrational head assembly** suitable for generating an output (e.g. suitable for direct or indirect vibrational input into a structure (e.g. a drill string), or other medium capable of transmitting/absorbing the vibrational input, said assembly having
a frame, and

a vibrational head carrying, carried by, substantially locating and/or substantially being located by the frame,

wherein the vibrational head has at least some freedom(s) to move relative to the frame, and/or vice versa,

and wherein the vibrational head has a shuttle and two components each component with the shuttle defining one of two variable volume chambers, the shuttle being moveable relative to each component under the action of a fluid under pressure being supplied into one variable volume chamber and being released from the other variable volume chamber, and vice versa, at least one of the fluid flows being controlled by a rotary valve,

and wherein the vibrational output is not or is not to be directly or indirectly from the frame nor the shuttle,

and wherein it is adapted so that if driving a drill string with the vibrational output each cycle provides a drive in and a drive out of the drill bit carried by the drill string.

50. **A vibrational head assembly** for generating an output (e.g. for direct or indirect vibrational input into a drill string), said assembly having

a frame,

as a vibrational head carrying, carried by and/or substantially locating the frame,

wherein the vibrational head has (preferably at least within bounds) at least some freedom(s) to move relative to the frame, and/or vice versa,

and wherein at least some of the mass (“the shuttle”) of the vibrational head (inclusive of at least some of said fluid) under the action of valves, at least one valve being a rotary valve, and a pressurised fluid supply or pressurised fluid supplies for opposing variable volume chambers defined in part in each case by the shuttle, in use, is able to shuttle with respect to two other masses of the vibration head each of which defines in part a said chamber,

and wherein it is from at least one of these other masses from which there is to be the vibrational output.

51. **Vibrational apparatus** comprising or including

a piston,

a chamber assembly defining a chamber in which the piston is adapted to shuttle rectilinearly between stroke limits, said chamber having a chamber end region at and/or beyond each stroke limit of the piston, there being an inlet port into and an outlet port out of each chamber end region,

a fluid supply assembly associated with said chamber assembly capable of supplying a pressurised fluid or any pressurised fluid it may receive in use to the inlet ports of the chamber,

a fluid collection assembly associated with said chamber assembly to collect fluid from the outlet ports (and preferably capable of supplying that collected fluid for reuse via a said source of pressurised fluid),

a first rotary valve capable of an out of phase allowing or disallowing of fluid movement from the fluid supply assembly into each said inlet port by opening or closing same,

a second rotary valve capable of an out of phase disallowing or allowing of fluid movement from the chamber out of each said outlet port by closing or opening same,

a first drive to rotate the first rotary valve,

a second drive to rotate the second rotary valve, and

a timing link between the first and second drives such that, for each chamber end region, an inlet port will generally be open when its associated outlet port is closed, and vice versa, and such that, each state of the opening and closing of each end chamber end region is generally out of phase with the condition of the other,

wherein in use, there is or will be a vibrational output via the chamber assembly and/or an output member of or carried by the piston as a consequence of rapid piston shuttling within the chamber.

52. **In combination or assembly, (I) a rotatable drill string and (II) apparatus of any one of the preceding claims when adapted or adapted to allow vibrational drilling.**

53. **Pile driving, boring and/or drilling** involving the use of vibrational apparatus in accordance with any one of claims 1 to 34.

54. ~~**A method for generating vibrations**~~ using

~~— a vibrational head having a housing from which the vibrational output is to be taken directly or indirectly,~~

~~— a shuttle to reciprocate within the housing thereby to vibrate the housing, and~~

~~— a drive to cause the reciprocation of the shuttle within the housing and thereby to vibrate the housing.~~

55. ~~**A method for drilling using**~~ a vibrational head connectable to a rotatable drill string, the vibrational head having a housing, a shuttle and a drive,

~~— **wherein** the shuttle is able to be reciprocated within the housing under the action of a drive, and~~

~~— **wherein** the vibrational output into the drill string is directly from or indirectly from the housing rather than the shuttle.~~

2004250089 21 Feb 2008

56. ~~A method as claimed in claim 55 wherein said method involves the steps of~~
A method of drilling using apparatus of any one of claims 1 to 51 as the vibrational head, said method involving the steps of:

engaging a drill string having a down hole lead assembly to the vibrational head, the engagement not being carried by the shuttle,

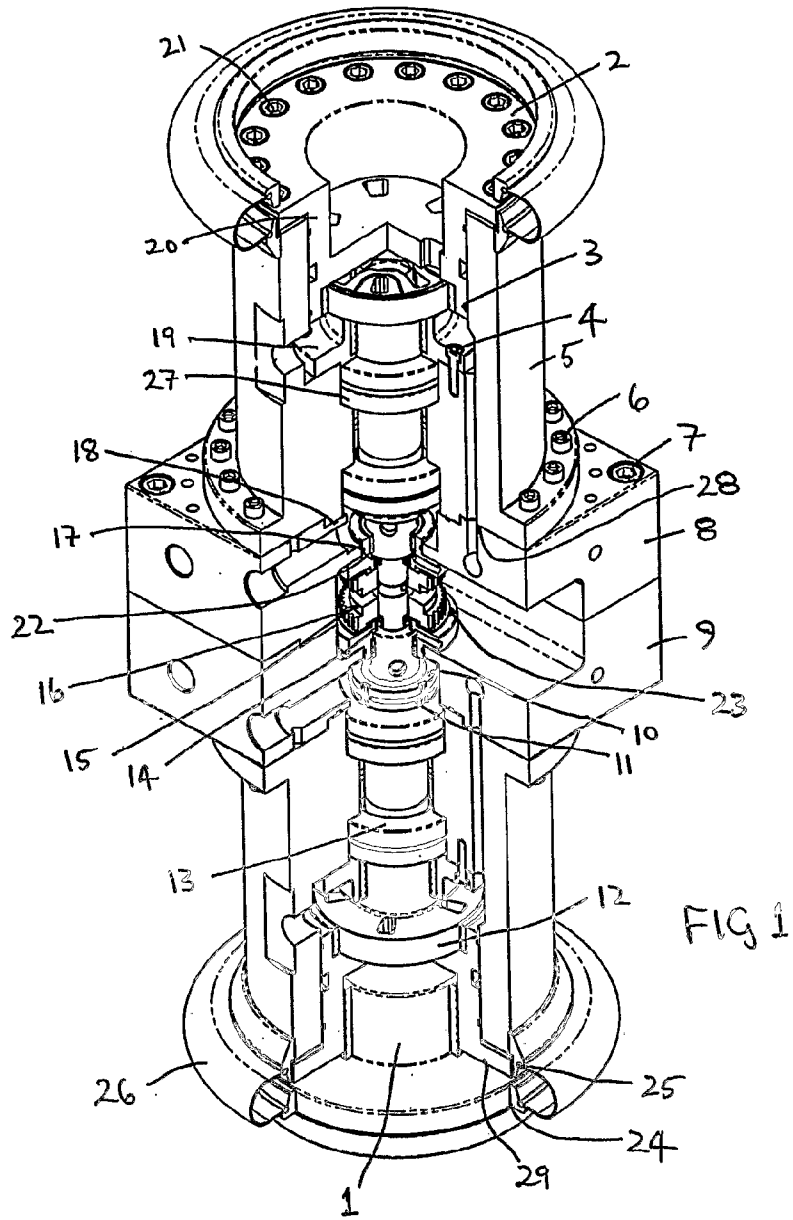
vibrating and rotating the drill string and its down hole assembly to advance drilling progress,

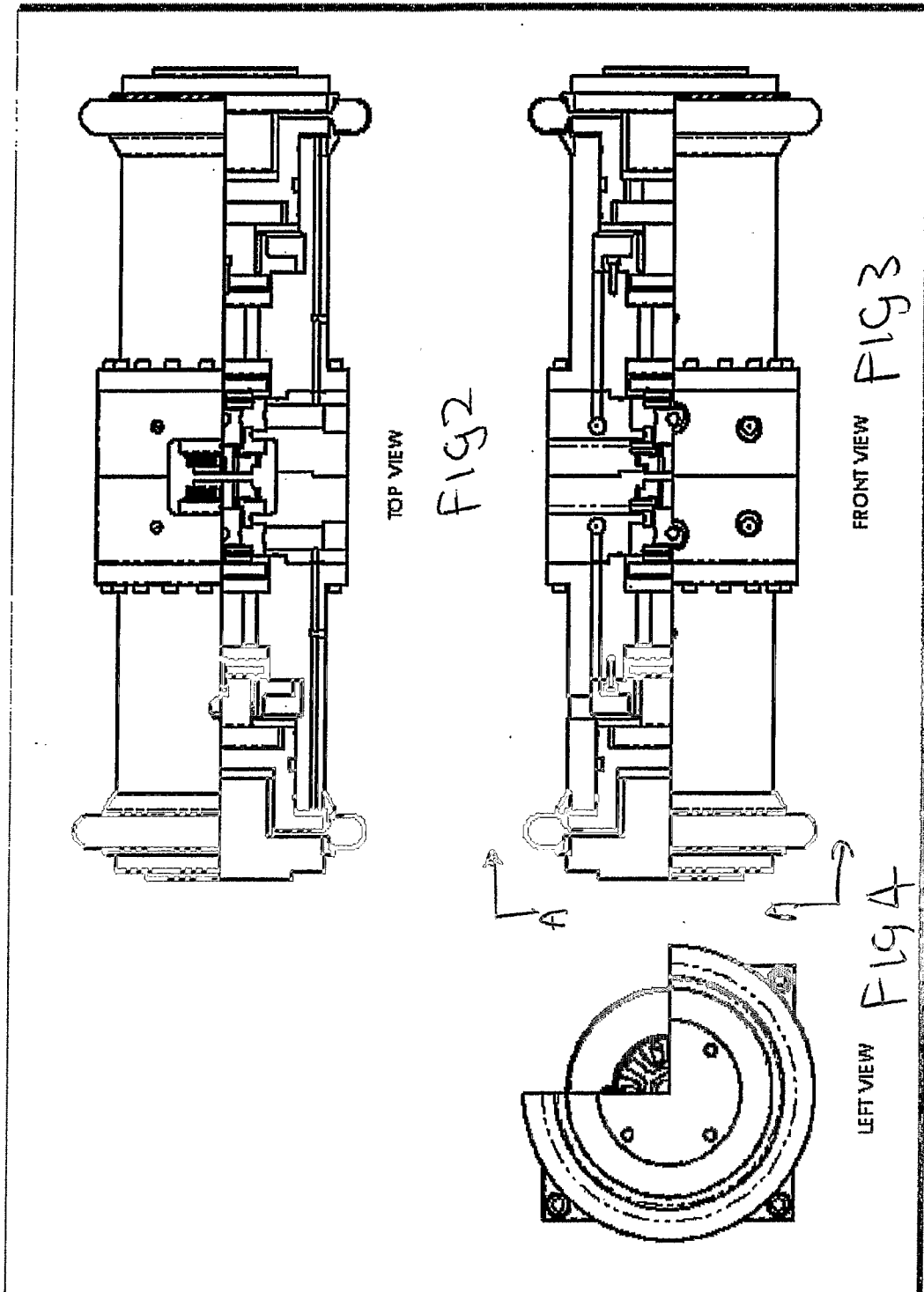
detaching the drill string from the vibrational head,

adding to the top of the drill string thereby to extend the drill string,

engaging the extended drill string to the vibrational head, the re-engagement not being carried by the shuttle; and

vibrating and rotating the extended drill string and its down hole assembly to further advance drilling progress.





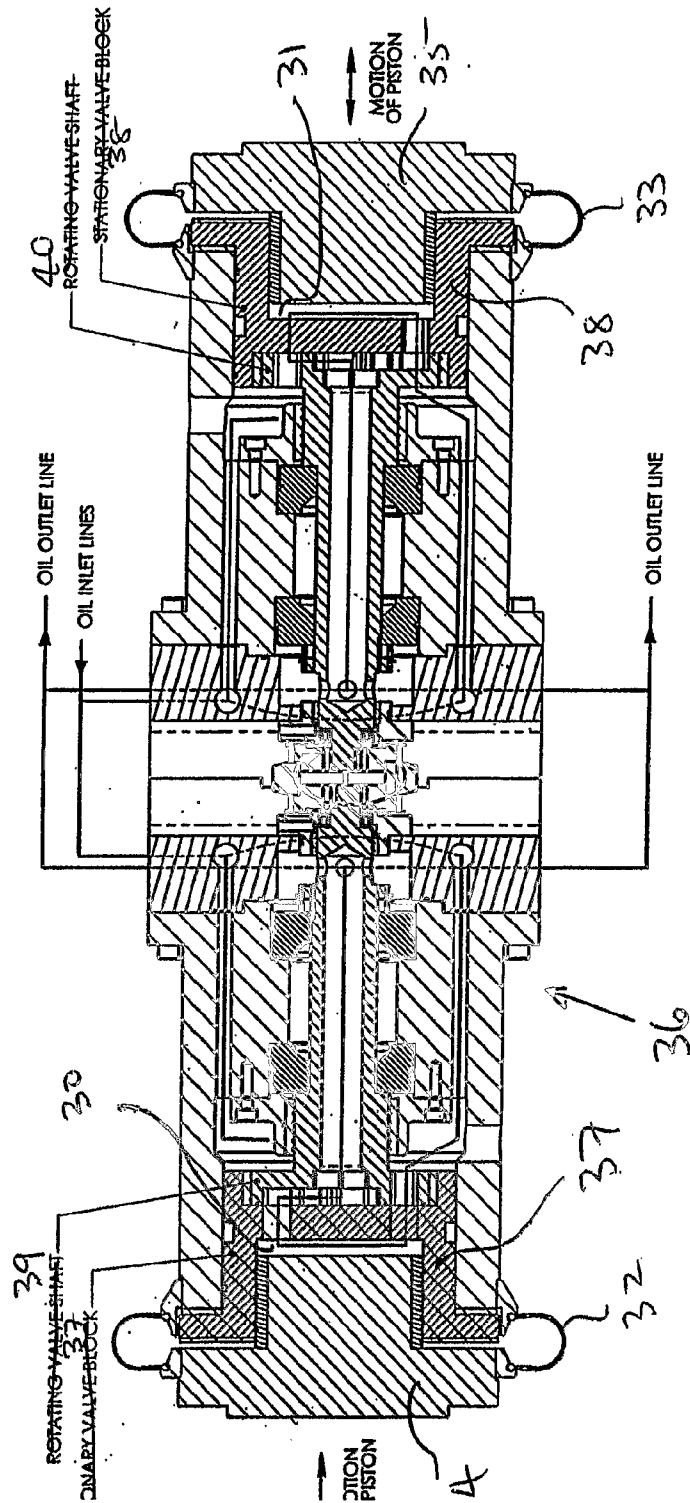
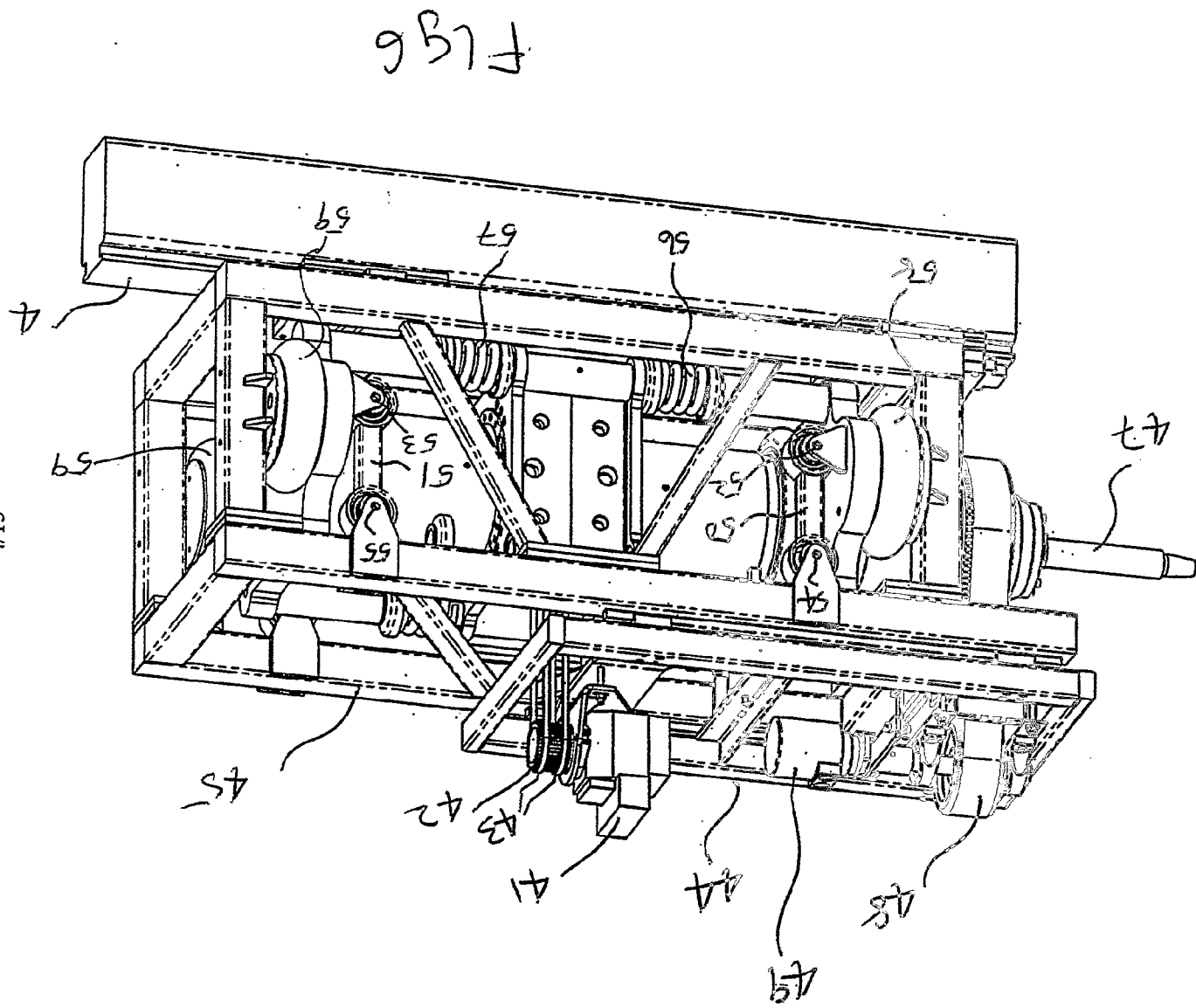


FIG 5

4/15



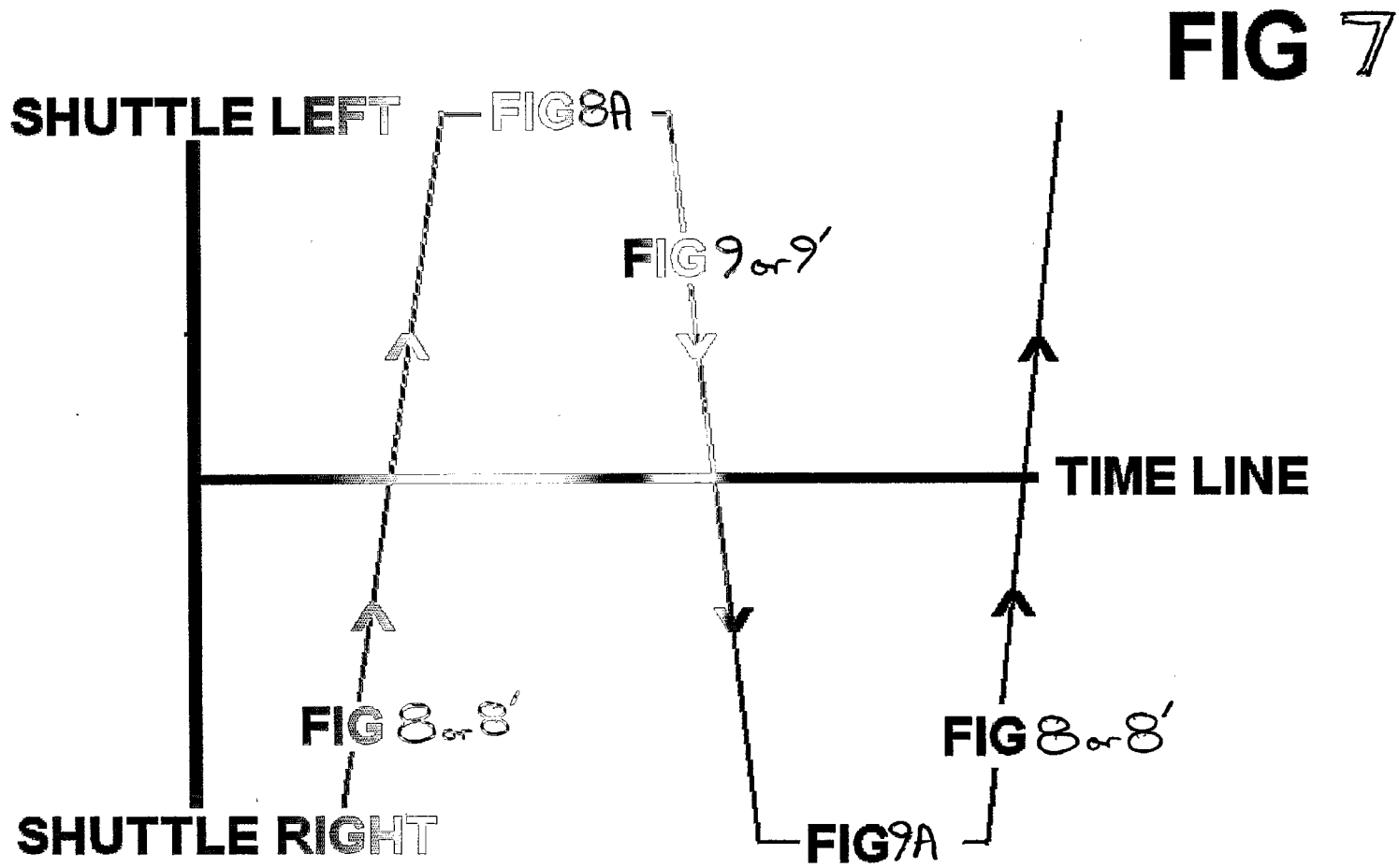


FIG 7

FIG 8'

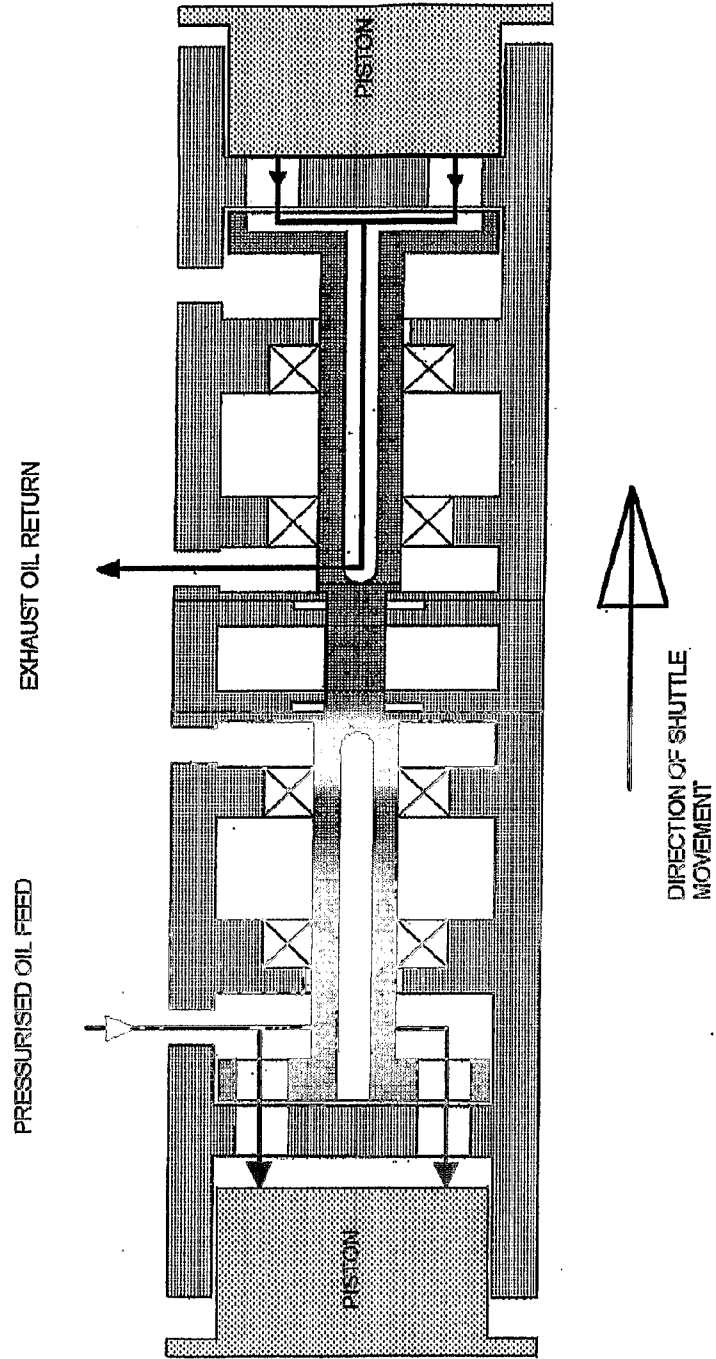


FIG 9'

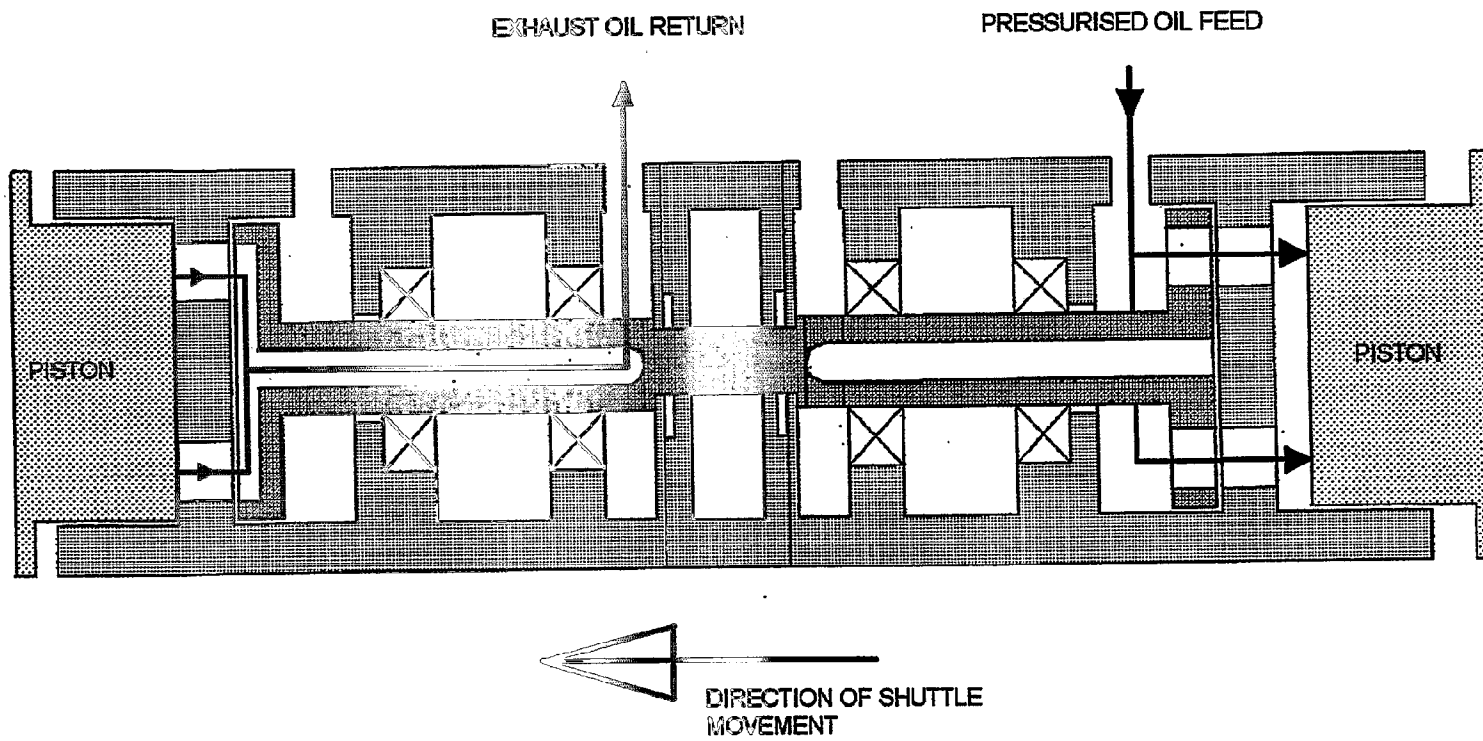


FIG 8

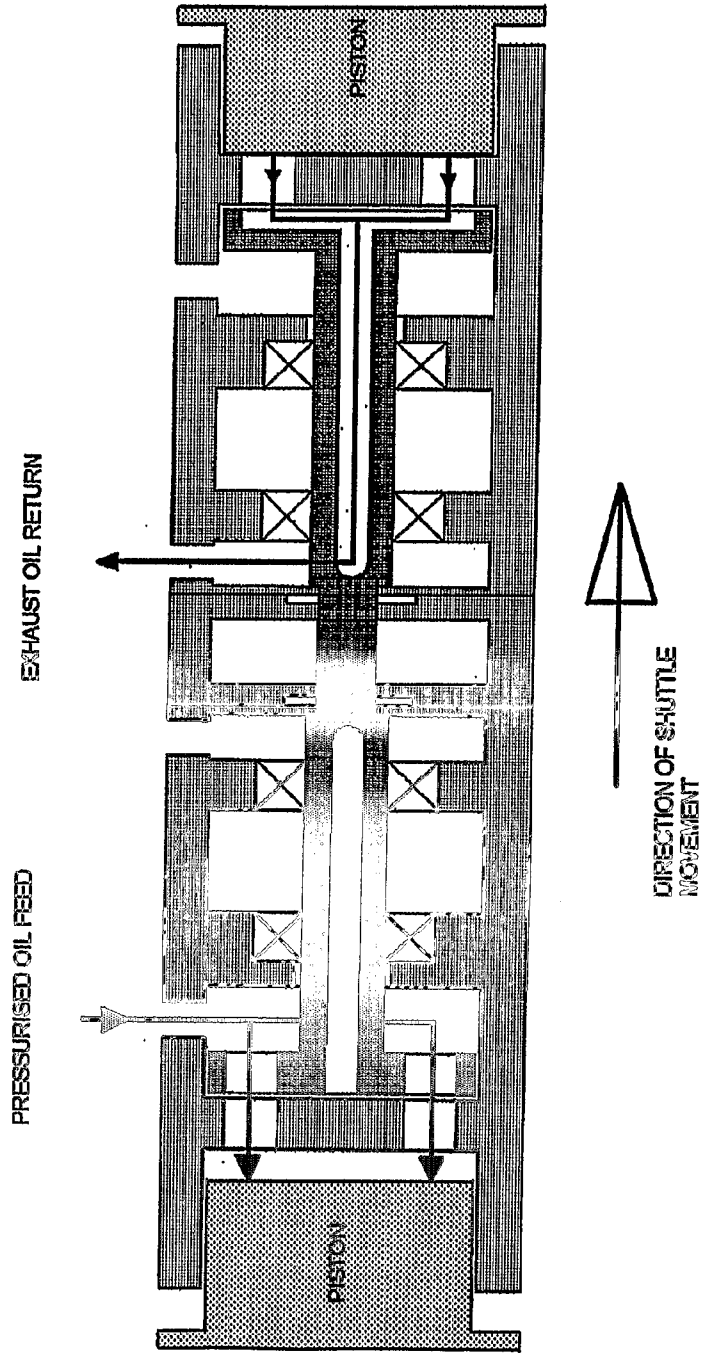


FIG 8A

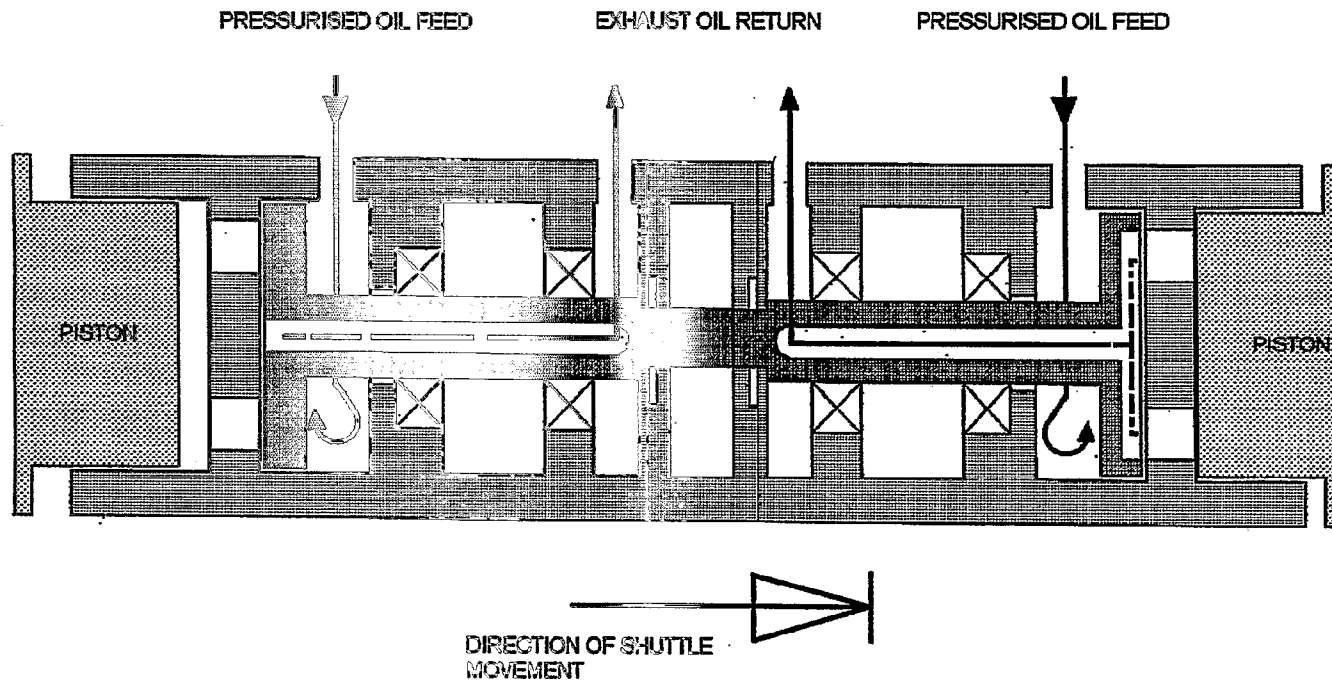
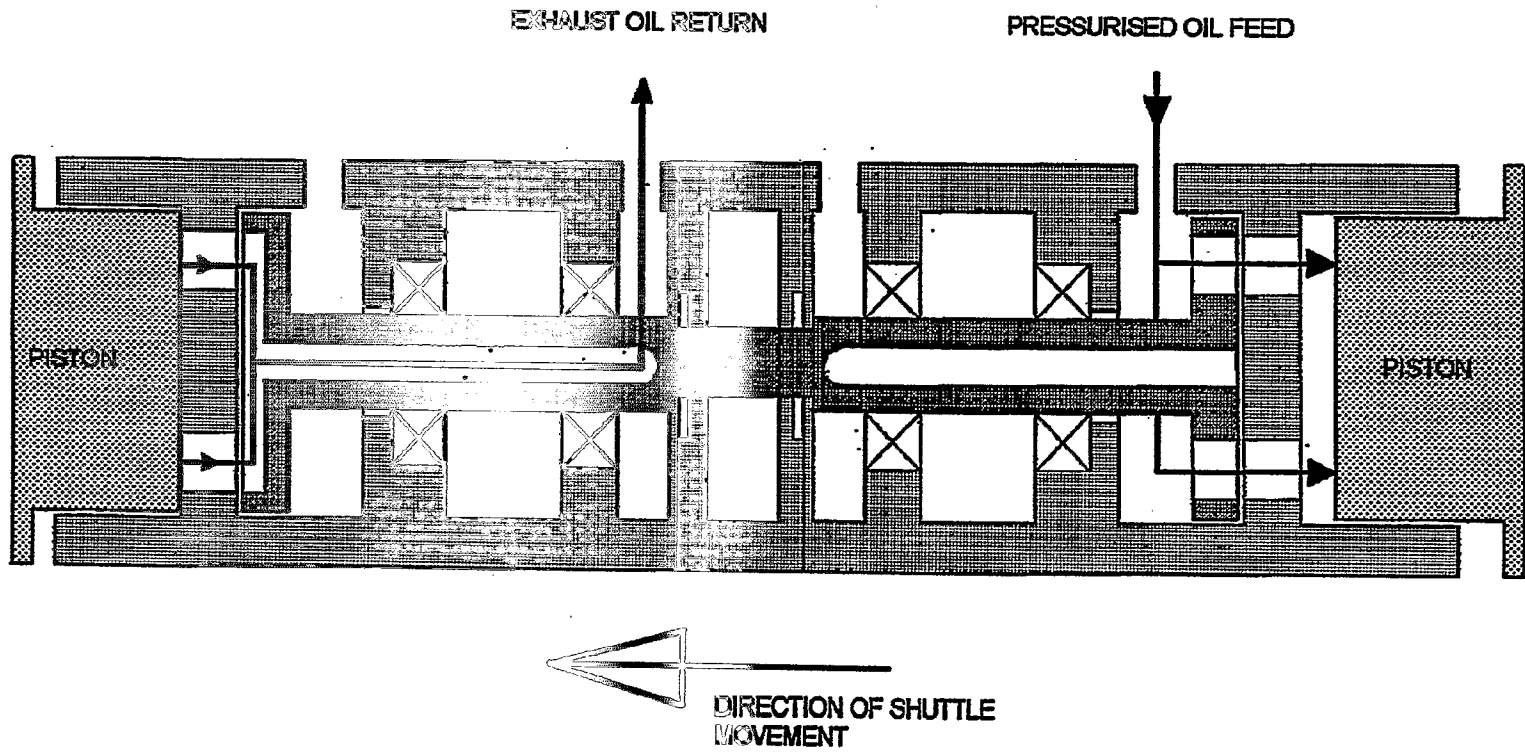
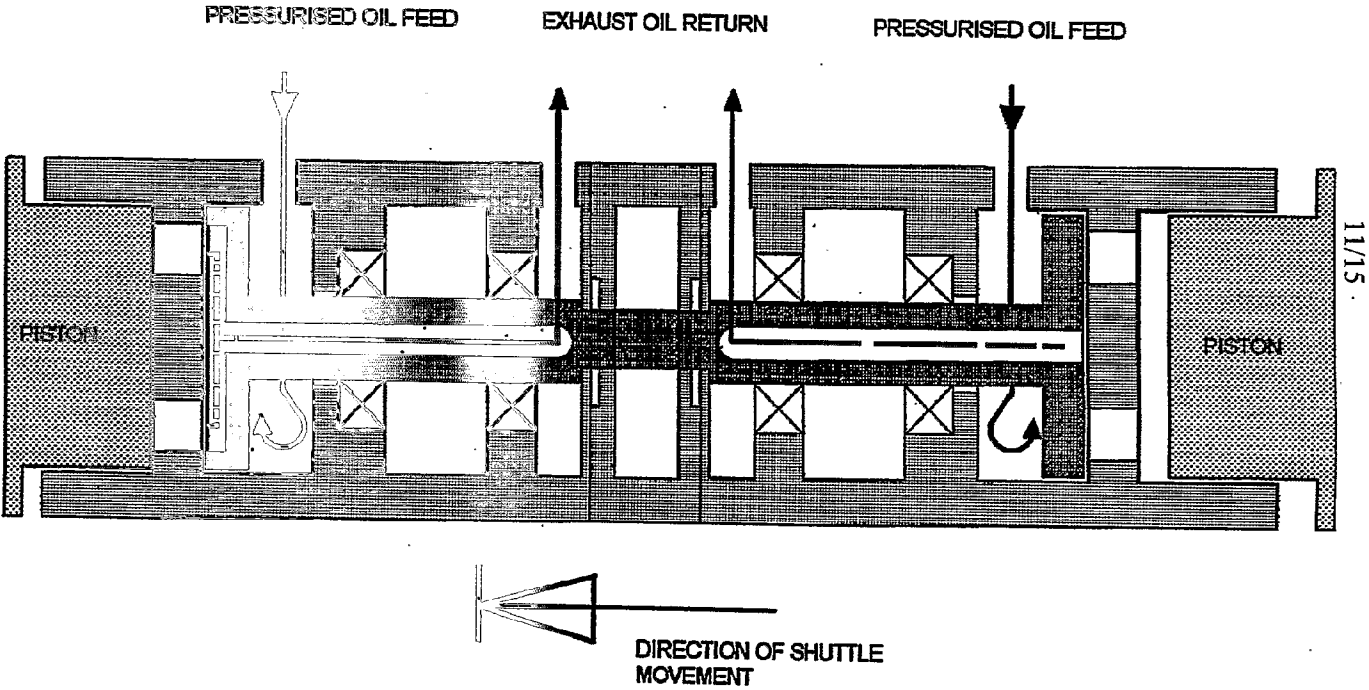


FIG 9



10/15

FIG 9A



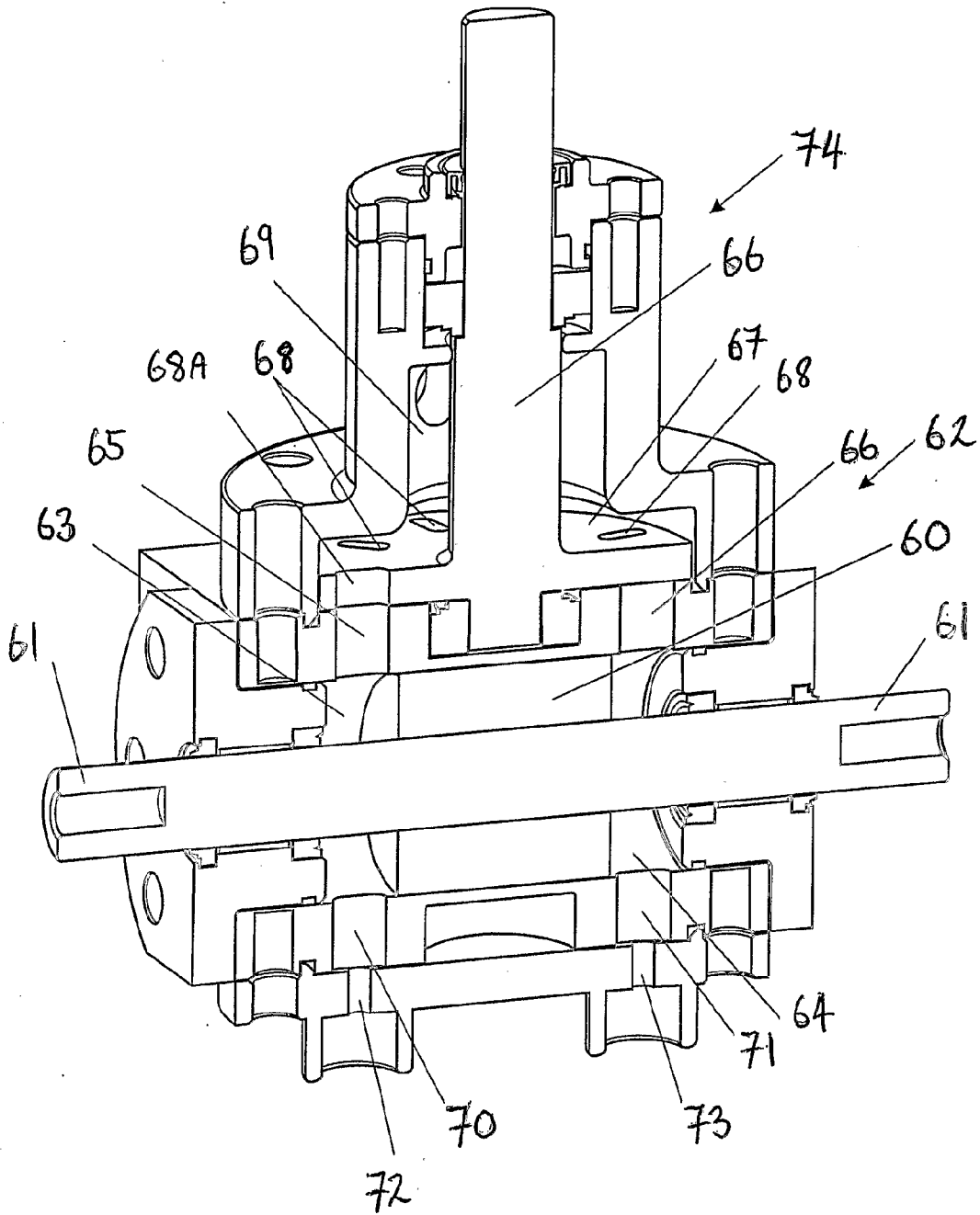


FIGURE 10

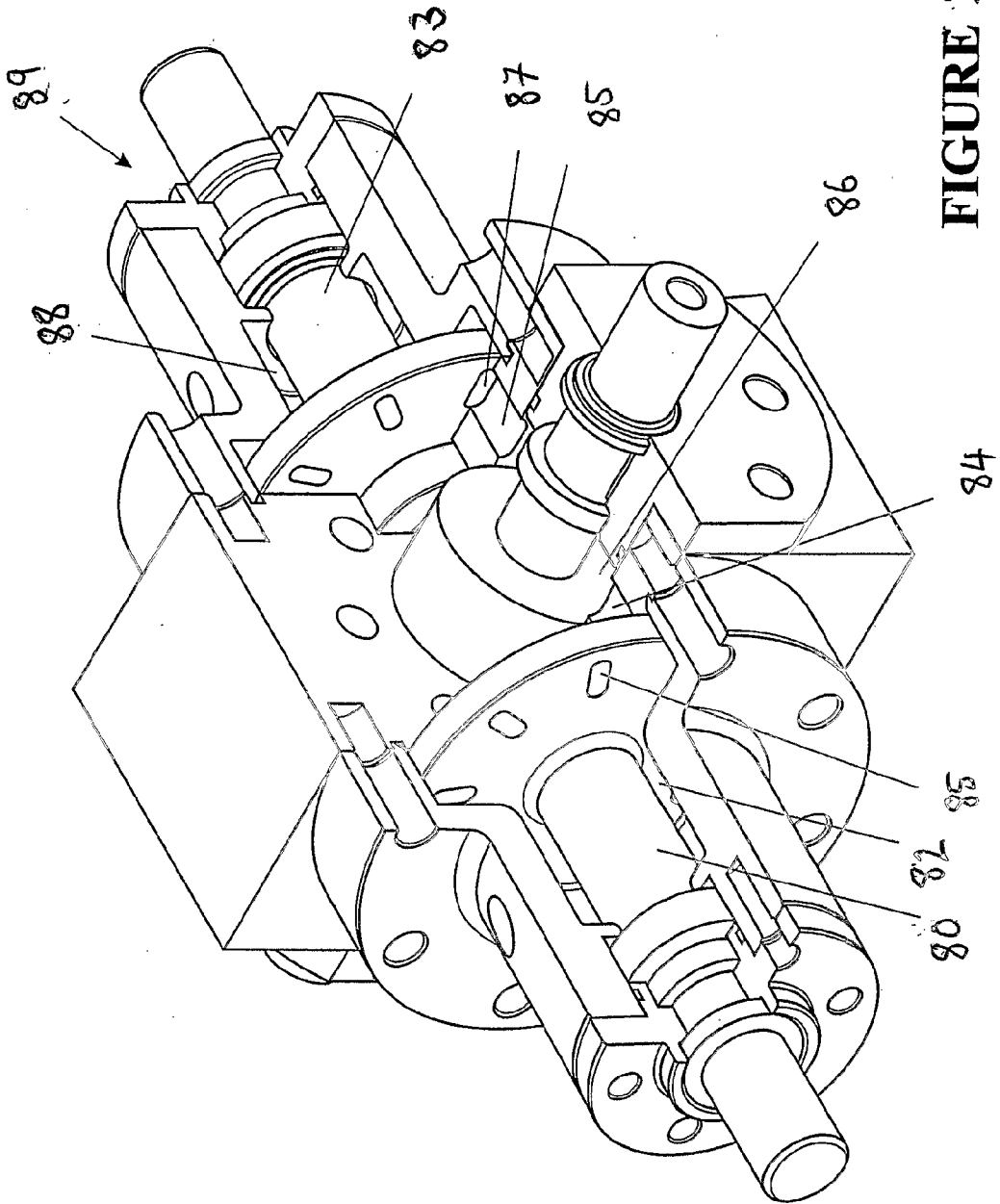


FIGURE 11

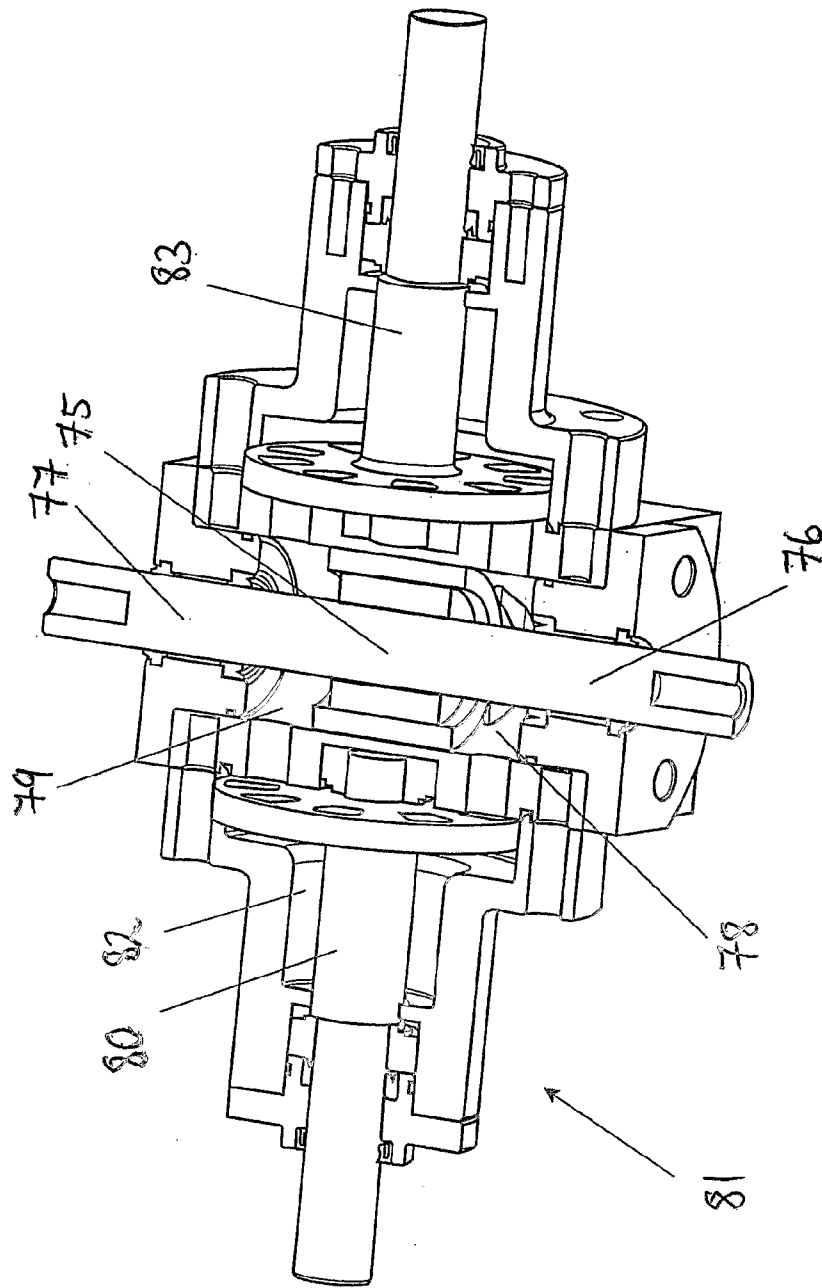


FIGURE 12

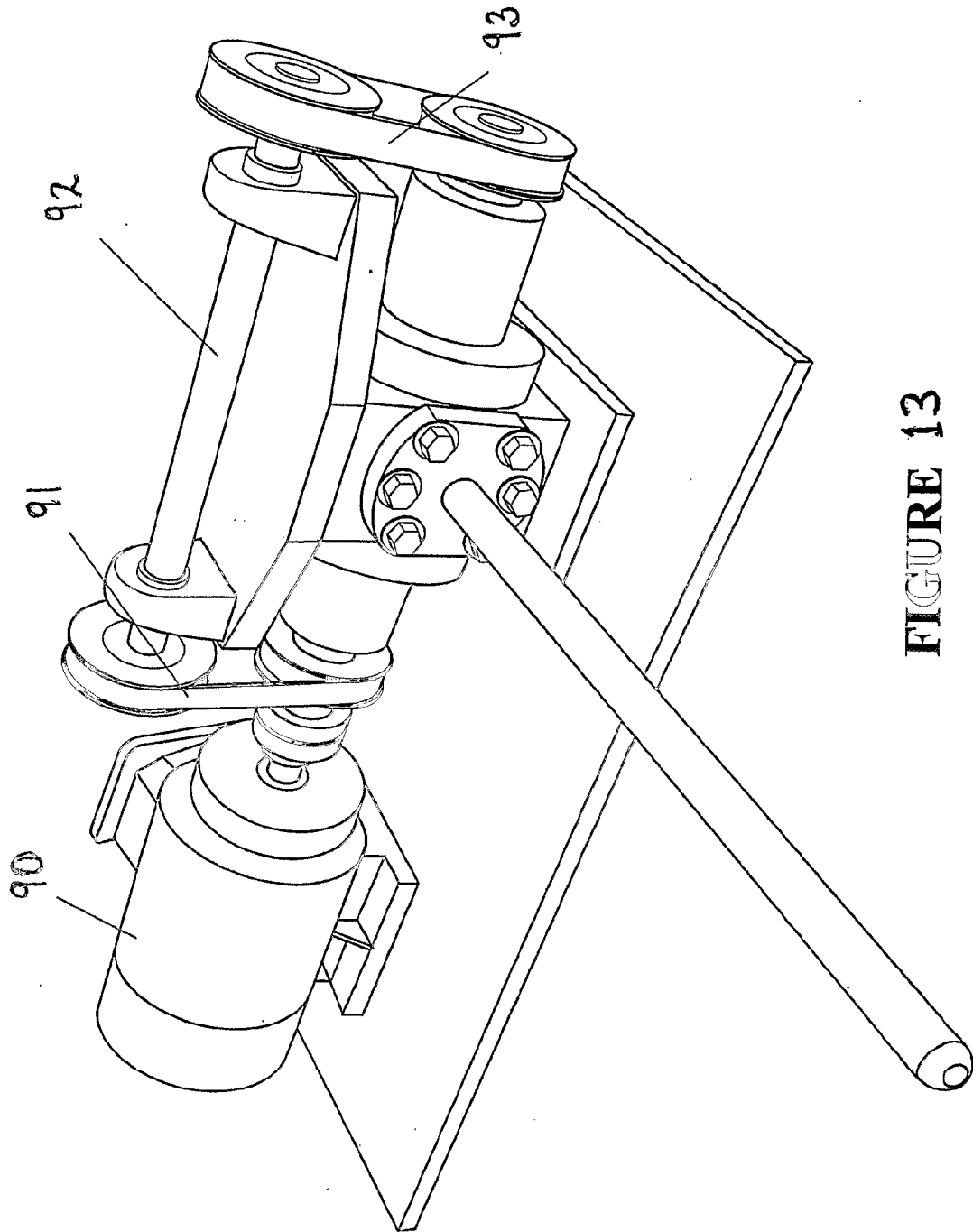


FIGURE 13