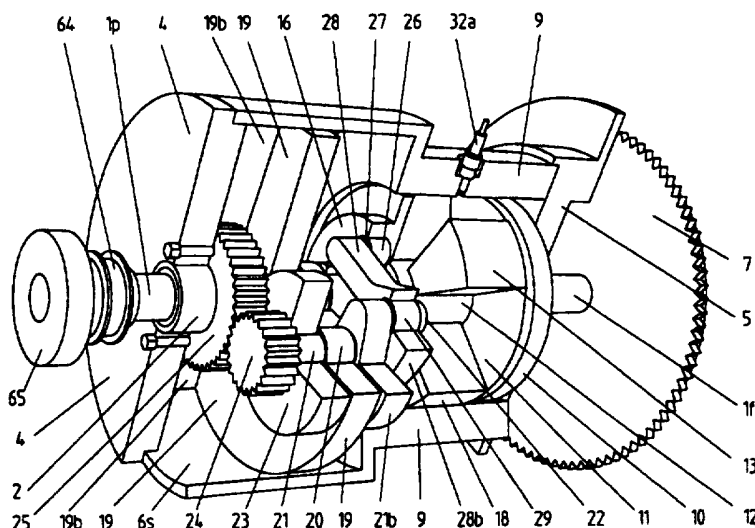


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**(54) Title:** SATELLITE ENGINE/MACHINE**(57) Abstract**

Coaxial stepped combined piston housing (9), satellite crank case (6s) has cover plates (4 and 5), containing bearings (2 and 3) supporting central rotor shaft (1) having flange (10), disc (11), rotor cylinder (12), and two arcuate, rectangular faced, double acting pistons (13), bonded by similar disc (14), supporting two similar pistons (18), and oscillator flange (16). Shaft (1) has a rotor wheel (19) in satellite case (6s) eccentrically carrying satellite crank shaft (21) on one side and on other side, satellite flywheel (23) and satellite pinion (24) having external gear teeth meshing with external teeth of stationary ring gear (25) bolted to cover plate (4). Oscillator flange (16) has eccentric bearings (26) engaging overhang gudgeon pin (27) of connecting rod (28) linked and actuated by Satellite crankshafts' crank pin (22). Uses: light prime mover for green, inexpensive propulsion of machinery, automotive vehicles, ships, overcraft and aircraft, including VTOL passenger aircraft.

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## **SATELLITE ENGINE/MACHINE**

**TECHNOLOGY FIELD:** The Intellectual Property covered by this Patent relates to engines, compressors and fluid driven motors, particularly to a Revolving/Oscillating piston Machine having a Satellite Crankshaft mechanism, specifically adapted for operation as a 4-Stroke Internal Combustion Engine for use on all manner of machinery/vehicles that can benefit from a prime mover that is compact, lightweight, quiet, vibration free, durable with low fuel consumption and almost zero pollution, including coupling to a propeller of an outboard motor, ship, hovercraft, and aircraft.

10

The Scope of the technology field also indisputably includes the enhanced claims of:-

**Multiple Back-Up Axially adjacent Ganging** of a plurality of machines as well as **Multiple Back-Up** plurality of axially adjacent independent sets of machines coupled to fans having a communal ducted fan casing, adapted for cold jet propulsion of aircraft, particularly VTOL (Vertical Take-Off and Landing) passenger aircraft, as this critical requirement has not yet been feasible with any state of the art prime mover due to excess weight and/or burning hot exhaust.

**PRESENT STATE OF THE ART PRIME MOVERS:** Most of the present successful prime movers are either Steam Turbines, Gas Turbines, Reciprocating Four Stroke and Two Stroke Engines or "Wankel" Engines.

### **DISADVANTAGES OF PRESENT STATE OF ART**

**Steam Turbine Installations** are large, costly, noisy and require huge boilers condensers and pipe work, which take a considerable amount of time to start up from cold. Their use is confined to giant power stations and ships.

**Gas Turbines** are unbearably noisy, run at exceedingly high speeds burning hot temperatures, requiring high temperature alloys, suffer from high exhaust pollution, and are too dangerous for use on land vehicles, or near people. Their use is mostly confined to power stations and aircraft. When used on helicopters, heavy, costly gear boxes are

required which limit range and work load. Gas turbines are still not powerful enough nor suitable for VTOL Passenger Airlines.

5 **Four Stroke Reciprocating Engines** are noisy, have many complex parts, including valve gear, cam shafts and multiple crankshafts, making them expensive, bulky, low power to weight ratio, due to only 27% PPAR (Piston/Port Area Ratio) low volumetric efficiency, and because of piston slap and friction short engine life. They suffer from vibration because perfect balance at all speeds is impossible, and exhaust pollution particularly at cold start, is a major problem not yet resolved, even with catalytic exhaust  
10 reactors.

**Two Stroke Reciprocating Engines** in addition to having vibration, are noisy, have greater exhaust pollution due to imperfect scavenge and lubrication pollution, and have an even shorter engine life due to ring pop-out in ports and inability to use long life  
15 inexpensive pressure lubricated plain bearings due to crankcase compression.

**Wankel Engines** (not strictly rotary) are prohibitively difficult to mass produce because they embody a tricorn rotor with internal gear teeth and an epitrochoidal cylinder, a profile that inspite of computer controlled machines, can not compete in price with  
20 costly reciprocating engines. There are numerous other inherent problems, including asymmetrical sealing, cooling, environmental pollution and design inability to cope with large power outputs.

**OBJECT** The object of the present invention is to not only overcome the drawbacks in  
25 the present state of the art but to provide a **Breakthrough Quantum Leap in Innovative Attributes** that go well beyond present state of the art limitations creating new embodiments for I.C. engines, compressors, pumps and fluid driven motors, previously not feasible. These embodiments include inexpensive, super efficient, green prime movers for Automotive Vehicles, Giant Power Stations. Ships and whisper quiet  
30 **Cold Jet Propulsion** units for VTOL Passenger Aircraft.

**Innovative Features Substantiating Breakthrough Attributes**

The following is a list of innovative features that provide and substantiate some of the Breakthrough Attributes of the present invention.

- 5     1.    Peripherally located Ports (claim 1m, Figs 1, 2, 3, 5, 10 & 11) allows more than  
         **86% PPAR** (Piston/Port Area Ratios). The best Multi valve PPAR is 27%. Providing  
         **300% Better Breathing** than the best Multi valve engines.
2.    **86% PPAR** allows for **later exhaust opening timings** (claim 1m, fig 10) - of up to  
10    100% of stroke (compared with 57% exhaust openings for multi-valve engines), lower  
         exhaust opening pressures, providing greater expansion of combustion gases, resulting in  
         **Colder, Wisperingly Low Exhaust Noise Levels, and Lower Fuel Consumption.**
3.    **Double acting** rotating/oscillating **pistons** provide **rotating combustion chambers**  
15    efficiently perform all phases of **four stroke cycle**, (claims 1e, h, l & m, fig 10) **without**  
         **valve gear, cam shafts or multiple crankshafts**, provides **Power to Weight Ratios**,  
         three times and eight times better than the best gas turbine and reciprocating engines  
         respectively.
- 20    4.    **Absence of multiple cylinders, cylinder head, & crankcase** (claims 1 & 12, fig  
         1), result in a **compact design** with a **High Power to Size Ratio.**
5.    **As few as 10** (purpose-made) **parts** of inexpensive materials (claim 1, fig 12) cost  
         **less than a Tenth the Price** of existing reciprocating and turboshaft engines.
- 25    6.    **Pistons can not touch the encompassing walls** (claims 1c, 1d, 1e, 1f, 1h & 1i, fig  
         1, 2 & 12) There is **no piston slap**, consequently **less friction, longer life.**
7.    **Rotating chambers move the combustion process past spark plugs** after ignition  
30    (claim 1m, fig 10) providing **longer life** for **plugs.**

8. **Rectangular sealing blades and port bridges** (claim 2, figs 3, 5, & 7) provide **Valveless Ported Performance without Seal Pop-out.**
9. All **moving parts fully balanced at all speeds** (claim 11, 1j, & 4, fig 12) - **No Vibration** (Important for Outboard Motors, large Motor Vessels and Aircraft).
10. **Thermostatically controlled full flow liquid cooled pistons** permit provision of thermally protected **internal catalytic implants** (claims 7 & 10, fig 16). **Pollutants burn inside chambers**, producing useful work, lowering fuel consumption with almost zero pollution, even during cold start.
11. **Four power impulses per revolution** (claim 1m, figs 2 & 10), provides **V8 Torque smoothness.**
12. **Rotor shaft speed one third crankshaft speed** (claim 1j, figs 10 & 12) providing **high torque at low engine speeds - faster acceleration.** important for low speed applications - helicopter rotors, large motor vessels, outboard motors, ducted fans and racing cars.
13. **Separate Auxiliary Module** for Output flywheel, starter motor, alternator and auxiliaries (claim 15, fig 11), provide **Quick Engine Change.**
14. **Centrifugal forces in rotating chambers** cause heavier fuel molecules in **lean mixtures** to move outwards **offering a rich mixture** to peripherally located **spark plugs** (claim 11, figs 2 & 10), providing **Excellent Combustion of Super Lean Mixtures** without knocking, enhanced by wedge-shaped combustion chamber for **optimum squish and quench.**
15. **Momentum of Rotor/Satellite Assembly** (claims 1c, d, e, i, j, 4 & 20, figs 1, 4, 5, 8 & 12) is self sufficient. **Separate Heavy Flywheel Not Required.** This is a significant feature for Outboard engines and Aircraft, where low weight is important.

16. Rotating chambers move compressing air past low pressure fuel injector nozzle and low pressure supercharging nozzle (claim 12 & 13, figs 2 & 10), allowing **low pressure fuel (including diesel fuel) injection and low pressure supercharging in closed chambers**, with Spark Ignition (and no Diesel Knock).

5

17. **Central rotor shaft allows ganging of multiple engines** for cold fan jet propulsion (claims 1a, 16 & 17, fig 17), provides **multiple back-up and smoother torque - two ganged Engines give 16 radial cylinder smoothness with small diametrical silhouette and short length**; ganging not possible with burning hot turbojet engines.

10

18. Plurality of **axially adjacent independent sets of cold exhaust quiet Satellite Engines** coupled to fans having a communal casing, (claim 17 and fig 18) produces a **wispingly quiet, cold jet propulsion unit with multiple backup and thrust augmentation** from dissipation of **waste heat from engine coolant and exhaust**.

15

19. **Multiple backup diesel fuel engine/fan units** having a communal duct case, plurality of cold air vectored thrust swivelling jet nozzle outlets, and fine gyroscopic, stabilising, digital control of pitch, roll and yaw outlet nozzles in wing tips, nose and tail (claims 12, 13 & 18, Fig 19), provide breakthrough VTOL passenger jet propulsion units with **almost 100% multiple back-up safety, and no fire hazard** - not possible with current heavy Kerosene burning hot turbojet engines.

20

#### **ESSENTIAL TECHNICAL FEATURES:**

25 (Figs 3 & 5) Essential features comprise a central revolving shaft, 1, in bearings, 2 & 3, contained in cover plates, 4 & 5, of a coaxial stepped combined piston housing, 9, and satellite crank case, 6s (figs 1, 2, 4 & 12). The shaft, 1, has a rotor flange, 10, disc, 11, coaxial rotor cylinder, 12, and two arcuate, rectangular faced, double acting pistons, 13, which are bounded by a separate oscillator disc, 14, supporting two similar double acting  
30 pistons, 18 and oscillator flange, 16 (figs 1, 4, 5, 6, 8 & 12). The shaft, 1, has a rotor wheel, 19, in the satellite case, 6s, eccentrically carrying a satellite crank shaft, 21, on one side and on the other side, a satellite flywheel, 23, and satellite pinion, 24, having

external gear teeth meshing with external teeth of a fixed ring gear, 25, bolted to inside of cover plate, 4. (Figs 1, 6, 8, 9 & 12) The oscillator flange, 16, has eccentric bearings, 26, engaging an integral overhang gudgeon pin, 27, of a connecting rod, 28, linked and actuated by Satellite crankshafts' crank pin, 22.

5

### **OPERATION:**

(Figs 10 & 12) Rotation of the rotor shaft, 1/rotor wheel, 23, causes orbiting of the satellite crankshaft, 21/pinion, 24, and spin on own axis, 21a, due to meshing with teeth of fixed ring gear, 25, actuating connecting rod, 28, to oscillate oscillator flange, 16/pistons, 18, relative to rotor pistons, 13, and four rotating chamber spaces, w, x, y & z (fig 10), to expand and compress within encompassing rotor cylinder, 12, and piston housing, 9, (figs 2, 10 & 12) which has an intake port, 30, exhaust port, 31, and two spark plugs, 32a & 32b, phased and timed to operate on the four stroke internal combustion engine cycle.

15

### **PRIOR ART Embodiments/Shortcomings/Unsolved Problems absent from the Present Invention and the Significant Novelty Distinctions:**

Patent Applications as early as 1884 have been filed for Revolving/Oscillating piston machines for use as Internal Combustion Engines. Compressors. Pumps and Motors and to date, none have been commercially successful. This is because of the below listed inherent non-viable embodiments and unsolved practical shortcomings, not embodied in the present invention:-

- a) "Circular Faced" arcuate pistons - difficult to mass machine - present invention rectangular faced, arcuate pistons, easier to mass machine;
- b) Half length radially attached pistons and Vanes, i.e. pistons radially attached by only half of inner arcuate face length to "half length" inner cylinders - unsolved sealing and stress problems - present invention pistons attached by larger, stronger end faces - inner cylinder is full length - no sealing or stress problems;
- c) "Stationary (pressurised) End Walls" prevent access for direct gudgeon pin link to oscillating pistons, resulting in Indirect complex rickety mechanisms - present invention has Moving (pressurised) End Walls, one rotating and one

oscillating/rotating, allowing Direct gudgeon pin link to oscillator pistons and simple Robust Satellite Beam and Crank Mechanism.

N.B. Exhaustive searches show no anticipations of the present invention. as all prior art  
5   comprise one or more of the above non-viable embodiments.

**REFERENCE TO DRAWINGS** An engine embodiment of the invention will now be described, with reference to the accompanying drawings, in which:-

- Fig 1** is a sectional General Assembly of an Internal Combustion Engine embodiment;  
**Fig 2** is a sectional radial view of an Internal Combustion Engine embodiment;  
 5 **Fig 3** is a cut-away perspective view of only the stationary components;  
**Fig 4** perspectively shows the Rotor Assembly, without the satellite sub-assembly;  
**Fig 5** is a cut-away perspective of the housing with part Rotor Assembly installed;  
**Fig 6** perspectively shows the Satellite Sub-Assembly meshing with fixed Sun Gear;  
**Fig 7** is an exploded and perspective view of the Piston Sealing blades and an Outer  
 10 Cylinder Sealing Ring;  
**Fig 8** perspectively shows the Satellite Sub-Assembly installed on the Rotor Assembly, as well as the fully balanced connecting rod and gudgeon pin;  
**Fig 9** is a perspective cut away of the Oscillator Sub-Assembly;  
**Fig 10** sequential diagrams a-l show one revolution of all 4 rotating chambers  
 15 completing the four stroke cycle - Suction, Compression, Expansion and Exhaust, and includes Stroke Commencements, Conclusions, and Ignition Firing Positions;  
**Fig 11** is a sectional general assembly of flywheel, starter motor and auxiliary pulley optionally contained in a separate modular housing, facilitating Quick Engine Change;  
**Fig 12** is a cut away perspective of the full assembly;  
 20 **Fig 13** is a close up view of location of piston seals and disc/cylinder seals;  
**Fig 14** shows the Bearing Pressure Lubrication and Internal Oil Cooling Circuits;  
**Fig 15** shows oil fog lubrication circuits for piston sealing blades and disc sealing rings;  
**Fig 16** shows optional catalytic implants coating areas on oscillator pistons;  
**Fig 17** is a GA of 2 ganged machines coupled to a fan having a ducted fan casing;  
 25 **Fig 18** is a GA of 2 axially adjacent independent sets of machines coupled to fans having a communal casing, giving multiple back-up without ganging;  
**Fig 19** is a plan view showing critically necessary multiple back-up of 3 pairs of axially adjacent machines coupled to fans having a communal casing, particularly adapted for VTOL passenger aircraft use.

**DESCRIPTION OF PREFERRED EMBODIMENTS**

Referring to figures 1, 2, 3, 4, 5, 6, 8, 9, 10 and 12 and/or additional figures where referred, a preferred embodiment of the present invention comprises:-

- 5 A long robust revolving shaft, 1, hereinafter called the "rotor shaft", 1, which is mounted in coaxial bearings, 2 & 3, contained in thick walled end cover plates, 4 & 5 respectively, of a stepped coaxially bored robust stationary housing, 6. The rotor shaft, 1, has extensions, 1f and 1p, beyond the cover plates, 4 & 5 respectively, with output coupling, 65, for mounting an output flywheel, 7 and auxiliary drive pulley, 8.

10

One of the coaxial bores, 9, of the stationary housing, 6, is a precision bore of specific diameter and length, hereinafter called the "piston housing", 9, and the other coaxial bore, 6s, is hereinafter called the "satellite crank case", 6s.

- 15 The rotor shaft, 1, is keyed to and rigidly supports a thick flat coaxial circular flange, 10, hereinafter called the "rotor flange", 10, which is located inside the piston housing, 9, near the piston housing cover plate, 5. The rotor flange, 10, has means provided on the rotor shaft, 1, to constrain it from outward axial movement, the constraining means including a circlip, 1c, and snap ring, located in a groove, 1g, provided in the rotor shaft,
- 20 1. The outer diameter of the rotor flange, 10, has a minimal running clearance inside the precision bore, 9.

- The rotor flange, 10, is rigidly attached to and supports a thick flat coaxial circular disc, 11, of equal outer diameter, hereinafter called the "rotor disc", 11. The rotor disc, 11, is
- 25 rigidly attached to and supports a thick walled coaxial inner cylinder, 12, of specific length and precision outer diameter, preferably one third of the precision bore, 9. The inner cylinder, 12 is hereinafter called the "rotor cylinder", 12.

- The rotor disc, 11, is rigidly attached to and supports the end faces of a set of two,
- 30 symmetrically located, coaxial, arcuate, rectangular faced, double acting pistons, 13, hereinafter called the "rotor pistons", 13. The rotor pistons, 13, have an outer radius equal to the outer radius of the rotor disc, 11, an inside radius equal to the outer radius of

the rotor cylinder, 12, and a specific length shorter than the length of the rotor cylinder, 12.

5 The unattached end faces of the rotor pistons, 13, are bounded by a thick walled flat coaxial circular disc, 14, hereinafter called the "oscillator disc", 14, which has an external diameter and thickness similar to the rotor disc, 11, and a bore with minimal running clearance on the rotor cylinder, 12, located so that the oscillator disc, 14, rotor disc, 11, rotor cylinder, 12, and piston housing, 9, form a rectangular sectioned annular enclosure within which the rotor pistons, 13, can rotate with minimal clearance and fluid  
10 leakage.

The oscillator disc, 14, is rigidly attached, including integrally attached to (fig 16), and supported by a thick flat coaxial circular flange, 16, of equal outside diameter, hereinafter called the "oscillator flange", 16. The oscillator flange, 16, has a coaxial bore  
15 containing bearings, 15, mounted on the middle section of the rotor shaft, 1. The oscillator flange external axial face, 16f, is provided with an axial thrust bearing, 17, and shoulder, 1s, located on the rotor shaft, 1, to restrain expanding axial thrust pressure loads between the oscillator disc, 14, and the rotor disc, 11.

20 The oscillator disc, 14, is rigidly attached to and supports the end faces of a set of two symmetrically located, coaxial, arcuate, rectangular faced double acting pistons, 18, hereinafter called the "oscillator pistons", 18. The oscillator pistons, 18, have an inner and outer arcuate radii equal to the inner and outer radii respectively of the oscillator disc, 14, and a length equal to the length of the rotor pistons, 13.

25

The rotor shaft, 1, is rigidly attached to and supports a robust coaxially balanced thick circular disc shaped revolving wheel, 19, hereinafter called the "rotor wheel", 19, which is located inside the crank case, 6s.

30 One end of the rotor wheel, 19, contains eccentric parallel axial bearings, 20, hereinafter called the "satellite bearings", 20, which are a specific distance from the axis, 1a, of the rotor shaft, 1. The satellite bearings, 20, support the journal, 21j, of a crank shaft, 21.

hereinafter called the "satellite crank shaft", 21. The satellite crank shaft, 21, has a counter balance weight, 21b, and a single overhang crank pin, 22, on one side of the satellite bearings, 20, and a keyed circular flywheel, 23, and a pinion, 24, on the other side of the satellite bearings, 20. The overhang crank pin, 22, the flywheel, 23, and the pinion, 24, are hereinafter called the "satellite crank pin", 22, the "satellite flywheel", 23, and the "satellite pinion", 24, respectively. The satellite pinion, 24, has external gear teeth meshing with external gear teeth of a fixed ring gear, 25, which is coaxial and separate from the rotor shaft, 1, and rigidly secured by bolts, 25b, to the inside face of the crank case cover plate, 4. The gear ratio of the ring gear, 25/satellite pinion, 24, is 2:1 so that one rotation of the rotor shaft, 1, causes three axial rotations of the satellite crankshaft, 21.

The unattached face of the oscillator flange, 16, is provided with eccentric parallel axial bearings, 26, which engage an integral overhang gudgeon pin, 27, provided on a robust balanced connecting rod, 28, having crank pin bearings, 29, engaging the satellite crank pin, 22.

The crank radius of the satellite crank shaft, 21, centre distance between crank shaft journal axis, 21a, and rotor axis, 1a, distance between the connecting rod, 28, centres, centre distance between rotor shaft axis, 1a, and gudgeon pin bearing axis, 26a, and specific dimensions, clearances and timing of all the aforesaid moving parts are so provided that rotation of the rotor shaft, 1, causes relative oscillating movement between the rotor pistons, 13, and the oscillator pistons, 18, to provide four rotating chambers, w, x, y, & z, expanding and compressing to specific desired swept volumes, clearance volumes and compression ratios.

The piston housing, 9, contains peripherally located apertures serving as an inlet port, 30, an exhaust port, 31, and inlet piping, 35, and exhaust piping, 34, respectively, two peripherally located spark plugs, 32a and 32b, including fuel/ignition handling management and equipment specifically phased, located and adapted with means including starter motor, 36, to operate the machine on the four stroke internal combustion engine cycle.

Referring to figure 7. to minimise leakage through clearances between the pistons, 13/18, and the annular enclosure, piston sealing means is provided comprising a plurality of spring loaded overlapping axially and radially displaced thin rectangular shaped sealing blades, 37, 38 & 39, located in at least one group of three continuous connected rectangular shaped channels, 37c, 38c & 39c (not shown), provided in the outer arcuate face, 37f, the unattached end face, 38f, and the inner arcuate face, 39f, respectively, of the pistons, 13/18. Perpendicular spring loading comprises a leaf spring, 40, located beneath each set of the blades, 37, 38 & 39. Lengthwise spring loading comprises a helical spring, 41, located in staggered cut-outs, 42, provided in the middle of the blades to seal the four corners of the pistons, 13/18.

Preferably, the inlet and exhaust ports, 30 & 31 respectively, include end support lands, 30l & 31l, and central peripheral bridges, 30b & 31b, to support and prevent outer axial sealing blades, 37, from popping out when moving across the ports, 30 & 31.

Referring to figure 13, stepped shoulders, 43a & 43b, are provided on the inside inner peripheral surface of the oscillator disc, 14, containing stationary, snugly fitting inward sprung split sealing rings, 44a & 44b, to minimise fluid leakage between the inner periphery of the oscillator disc, 14, and outer periphery of the rotor cylinder, 12.

Stepped shoulders, 45a, 45b, 46a & 46b, are also provided on the inside outer peripheral surface of the discs, 11/14 respectively, each containing stationary, snugly fitting outward sprung split sealing rings, 47a & 47b/48a & 48b, to minimise fluid leakage between the periphery of the discs, 11/14, and the bore of the piston housing, 9.

The rings, 44a, 44b, 47a, 47b, 48a & 48b, comprise flat rectangular sectioned spring steel having tolerances and finish to minimise fluid escaping past the clearance gaps under all operating conditions of the machine.

30

To minimise out of balance forces on the machine when operating, a void, 16v is provided on the oscillator flange, 16, to counter balance the gudgeon pin bearing hole.

26h, about the centre of the oscillator flange axis, 1a. A balance weight, 28b, is provided on the connecting rod, 28, to counter balance the masses of the connecting rod, 28, and the integral gudgeon pin, 27, about the axis of the satellite crank pin, 22. A balance weight, 21b, is provided on the satellite crank shaft, 21, to counter balance the masses of the satellite crank pin, 22, connecting rod, 28, gudgeon pin, 27, and connecting rod balance weight, 28b, about the axis, 21a, of the satellite crank shaft journal, 21j, and a balance weight, 19b, is provided on the rotor wheel, 19, to counter balance the masses of the rotor wheel, 19, satellite pinion, 24, satellite flywheel, 23, satellite crank shaft, 21, crank shaft balance weight, 21b, satellite crank pin, 22, gudgeon pin, 27, connecting rod, 28, and connecting rod balance weight, 28b, about the axis, 1a, of the rotor shaft, 1.

Referring to figure 14, wet lubrication oil sumps, 50 & 51, are provided in the satellite crank case, 6s, and in the piston housing, 9 (in the gap between rotor flange, 10, and adjacent cover plate, 5) respectively, to serve as reservoirs for lubrication oil and oil coolant.

Preferably the bearings in the machine are plain oil pressure lubricated bearings provided with oil pressure lubrication, supplied via a net work of oil pressure galleries, 52n & 53n, by oil pressure pumps, 52 & 53, having rotors, 52r & 53r, driven by the rotor shaft, 1, with oil galleries, 52g & 53g, connected to the sumps, 50 & 51.

Also referring to figure 14, thermostatically controlled cooling means is provided, comprising:-

coolant passages 13c/18c, contained within the rotor pistons, 13, and oscillator pistons, 18, respectively;

coolant passages, 10c/16c, contained between the rotor disc, 11, and rotor flange, 10, and oscillator disc, 14, and oscillator flange, 16;

coolant passages, 12c, on the inside of the rotor cylinder, 12;

preferably all the above coolant passages are connected to and provided with coolant pumping means, including communal pumping means, 52 & 53, for oil lubrication and oil coolant; and.

water coolant passages, 9c, in the piston housing walls, 9, in areas subjected to excessive heat, serviced by a coolant inlet, 9i, and a coolant outlet, 9o, connected to and provided with a water coolant pump means (not shown), driven by the rotor shaft, 1.

- 5 The cooling means includes, at least one air cooled fin, (not shown), provided on at least one component of the machine requiring cooling.

Referring to figure 15, lubrication means is provided to lubricate the piston sealing blades, 37/38/39, and disc sealing rings, 44a/44b/47a/47b/48a & 48b, including oil fog  
10 lubrication induced through a network of oil fog lubrication galleries, 54, communicating with the oil fog in oil sumps, 50 & 51, and gaps between piston sealing blades, 37, 38 & 39, when the gaps are subject to suction pressure.

The oil fog lubrication galleries, 54, include centrifugally controlled metering means, 55,  
15 to automatically meter oil fog lubrication to increase proportionately with the speed of the machine, and include the provision of non-return valves, 56, located in the lubrication galleries, 54, to prevent combustion gases from entering the sumps, 50 & 51.

Referring to fig 16, optionally, exhaust pollution reduction means are provided  
20 comprising catalytic material implants, 57, located in a significant portion of piston surface areas exposed to incomplete combustion and pollutants, particularly piston headland surface areas. The catalytic material, 57, comprise Platinum, Rhodium and Palladium. Preferably, implant operating temperature control means is provided, comprising thermostatic flow control of piston/encompassing wall coolant to maintain  
25 temperatures sufficiently high for catalytic reaction, without thermal damage to catalyst at all engine loads and speeds (not shown);

Optionally, the ring gear, 25/satellite pinion, 24, gear ratio is other than 2:1, preferably 3:1, 4:1, 6:1 and 8:1 (not shown).

30

Optionally, at least one low pressure injector nozzle means is provided in wall of the piston housing, 9, including an air/fuel fog injection nozzle, 33, air/lubricant fog injector

nozzle (not shown) and supercharged air non-return connection, 67, for injection into the rotating chambers w, x, y and z, after the inlet port, 30, is closed.

Optionally, high compression ratio means is provided sufficient to operate the engine on the compression ignition diesel cycle, including, instead of spark plugs, the provision of diesel fuel injection nozzles located in the piston housing and diesel fuel injection handling management and equipment means provided to inject diesel fuel at the end of each compression stroke (not shown).

Optionally, the set of two rotor pistons, 13, and set of two oscillator pistons, 18, also includes at least three rotor pistons and at least three oscillator pistons, with corresponding increases in the number of ports, spark plugs and injectors (not shown).

Optionally, (fig 11), modular construction means are provided to facilitate quick assembly and disassembly, consisting at least two modules:-

a power module containing the piston housing, 9, and satellite crank case housing, 6s, and

an auxiliary module containing the main output flywheel, 7m, starter motor, 36m, and an auxiliary drive pulley, 64. The auxiliary module comprises a supporting flange, 59, having bearings, 60, which supports an adapter shaft, 63, attached to and supporting the main output flywheel, 7m, and the auxiliary pulley, 64. A splined fit, 65, is provided between the adapter shaft, 63 and one end of the rotor shaft, 1.

Optionally, referring to fig 17, a coupling, 71, is provided to enable the rotor shafts, 1x & 1y, of two machines, 72x & 72y, to be ganged in series for multiple back-up and increased power output, including off-setting of power phases of said machines for smoother torque, for applications including coupling the rotor shaft, 1, of the ganged machines, 72x and 72y, to the hub, 68, of a fan, 69, having a duct case, 70, adapted for cold air jet propulsion.

Preferably, the machines are provided with coolant heat exchangers, 73x & 73y, exhaust piping, 34x & 34y, and exhaust silencers, 74x & 74y, located inside the duct case, 70, so as to dissipate waste heat into the airflow for thrust augmentation.

- 5    Optionally referring to fig. 18, multiple back-up independent sets of axially adjacent machines, 75 & 76, coupled to a fan, 75f & 76f, having a communal duct casing, 77, with means to operate each set singly, jointly, and as back-ups, as desirable, each machine having its coolant heat exchangers, 75h & 76h., exhaust piping, 75p & 76p, and exhaust silencers, 75s & 76s, dissipating their waste heat inside the duct casing, 77, for  
10    thrust augmentation.

- Optionally, referring to fig. 19, a multiple back-up means is provided, including six axially adjacent independent sets of machines, 79, each coupled to a fan, 80, including means to operate each of said sets singly, jointly, and as back-ups, the fans, 80, having a  
15    communal coaxial ducted fan cold jet propulsion casing, 78, also provided with a plurality of cold air vectored thrust swivelling jet nozzle outlets, 81, including provision of outlet piping, 82, for wing tip jet nozzles, 83, nose jet nozzles, 84, and tail jet nozzles, 85, with means adapted for providing gyroscopic stabilising digitally controlled nozzle actuating means for fine control of pitch, roll and yaw, specifically for VTOL aircraft  
20    propulsion.

- Alternatively the rotor wheel, 19, embodies a starting ring gear with coupling mechanism and starter motor (not shown), instead of a separate flywheel provided with a starting ring gear.

25

Alternatively to an internal combustion engine, the machine is adapted for use as a fluid pump, including a compressor, including the use of non-return valves, including reed valves and spring loaded poppet valves, provided in the inlet and outlet ports (not shown).

30

Alternatively internal and external auxiliary equipment, handling and management means is provided to specifically adapt the machine for use as a pump **instead** of an internal combustion engine (not shown).

- 5 Alternatively means is provided to specifically adapt the machine for use as a fluid driven motor **instead** of an internal combustion engine (not shown).

**CLAIMS:**

1. A Revolving/Oscillating Piston Machine comprising in combination:
- 5 a) a long robust revolving shaft, hereinafter called the "rotor shaft", mounted in coaxial bearings contained in thick walled end cover plates of a stepped coaxially bored robust stationary housing, said rotor shaft having extensions beyond said cover plates, said extensions having output coupling means including a flywheel and auxiliary drive means, including pulleys and belts for driving auxiliary equipment;
- 10 b) said stationary housing having coaxial bores on end of precision specific diameter and length, hereinafter called the "piston housing" and the other coaxial bore, hereinafter called the "satellite crank case";
- 15 c) said rotor shaft keyed to and rigidly supporting a thick flat coaxial circular flange, hereinafter called the "rotor flange", located inside said piston housing near said piston housing cover plate, said rotor flange outer diameter having a minimal running clearance inside said precision bore, said rotor flange having means provided on said rotor shaft to constrain against outward axial movement, said constraining means including a circlip and snap ring, located in a groove provided in said rotor shaft;
- 20 d) said rotor flange rigidly attached, including integrally attached to and supporting a thick flat coaxial circular disc, of equal outer diameter, hereinafter called the "rotor disc", said rotor disc rigidly attached, including integrally attached to and supporting a thick walled coaxial inner cylinder of specific length and precision outer diameter, preferably one third of said precision bore, said inner cylinder hereinafter called the
- 25 "rotor cylinder";
- 30 e) said rotor disc rigidly attached, including integrally attached to and supporting the end faces of a set of two, symmetrically located, coaxial, arcuate, rectangular faced, double acting pistons, hereinafter called the "rotor pistons", said rotor pistons having an outer radius equal to outer radius of said rotor disc, an inside radius equal to outer radius of said rotor cylinder and a specific length shorter than said rotor cylinder length;

- 5 f) said rotor pistons' unattached end faces, bounded by a thick walled flat coaxial circular disc, hereinafter called the "oscillator disc", having an external diameter and thickness similar to said rotor disc, and a bore with minimal running clearance on said rotor cylinder, located so that said oscillator disc, rotor disc, rotor cylinder and piston housing form a rectangular sectioned annular enclosure within which said rotor pistons can rotate with minimal clearance and fluid leakage;
- 10 g) said oscillator disc rigidly attached, including integrally attached to and supported by a thick flat coaxial circular flange of equal outside diameter, hereinafter called the "oscillator flange", said oscillator flange having a coaxial bore containing bearings mounted on a matching middle section of said rotor shaft, said oscillator flange external axial face provided with an axial thrust bearing means located on said rotor shaft, to restrain expanding axial thrust pressure loads between said oscillator disc and said
- 15 rotor disc;
- 20 h) said oscillator disc rigidly attached, including integrally attached to and supporting the end faces of a set of two symmetrically located, coaxial, arcuate, rectangular faced double acting pistons, hereinafter called the "oscillator pistons", said oscillator pistons having an inner and outer arcuate radii equal to the inner and outer radii respectively of said oscillator disc, and a length equal to the length of said rotor pistons;
- 25 i) said rotor shaft rigidly attached, including integrally attached to and supporting a robust coaxially balanced thick circular disc shaped revolving wheel, hereinafter called the "rotor wheel", located inside said crank case;
- 30 j) one end of said rotor wheel containing eccentric parallel axial bearings, hereinafter called "satellite bearings", a specific distance from axis of rotor shaft, said satellite bearings supporting the journal of a crank shaft, hereinafter called the "satellite crank shaft", said satellite crank shaft having a counter balance weight and a single overhang crank pin on one side of said satellite bearings and a keyed circular flywheel and a pinion on the other side of said satellite bearings, said overhang crank pin.

- flywheel and pinion hereinafter called the “satellite crank pin”, “satellite flywheel” and “satellite pinion” respectively, said satellite pinion having external gear teeth meshing with external gear teeth of a fixed ring gear, said ring gear coaxial and separate from said rotor shaft and rigidly secured to the inside face of said rear cover plate, teeth gear ratio of said ring gear/satellite pinion being 2:1, so that one rotation of said rotor shaft causes three axial rotations of said satellite crankshaft;
- 5
- k) said oscillator flange unattached face provided with an eccentric parallel axial hole containing bearings, said bearings engaging an integral overhang gudgeon pin provided on a robust balanced connecting rod, having crank pin bearings engaging said satellite crank pin of said satellite crank shaft;
- 10
- l) crank radius of said satellite crank shaft, the centre distance between crank shaft journal axis and rotor axis, distance between connecting rod centres, centre distance between rotor shaft axis and gudgeon pin bearing axis, and specific dimensions, clearances and timing of all aforesaid moving parts so provided that rotation of said rotor shaft causes relative oscillating movement between said rotor pistons and said oscillator pistons, to provide four rotating chambers expanding and compressing to specific desired swept volumes, clearance volumes and compression ratios;
- 15
- 20
- m) said piston housing contains peripherally located apertures serving as intake and exhaust ports, with connections for inlet and exhaust piping, respectively, and at least one, but preferably two spark plugs, including fuel/ignition handling, management and equipment means, specifically phased, located and adapted with means, including starter motor means, to operate said machine on the four stroke internal combustion engine cycle.
- 25
2. A machine, as in claim 1, characterised in that piston fluid pressure sealing means is provided to minimise leakage through clearances between said pistons and said annular enclosure, said piston sealing means including a plurality of spring loaded overlapping axially and radially displaced thin rectangular shaped
- 30

sealing blades located in at least one group of three continuous connected rectangular shaped channels provided in the outer arcuate face, the unattached end face and the inner arcuate face respectively, of said pistons, perpendicular spring loading including a leaf spring located beneath each set of said blades, lengthwise spring loading of said blades including a helical spring located in staggered cut-outs provided in the middle of said blades to seal the four corners of said pistons; and preferably said inlet and exhaust ports mentioned in claim 1m include end support lands and central peripheral bridges to support and prevent said outer axial sealing blades from popping out when moving across said ports.

10

3. A machine, as in claim 2, characterised in that disc peripheral fluid pressure sealing means is provided:

15

a) including a stepped shoulder located on the inside inner peripheral surface of said oscillator disc, said shoulder including at least one stationary snugly fitting inward sprung split sealing ring to minimise fluid leakage between inner periphery of said oscillator disc, and outer periphery of said rotor cylinder; and

20

b) including stepped shoulders located on the inside outer peripheral surface of said discs, containing at least one stationary snugly fitting outward sprung split sealing ring to minimise fluid leakage between said clearance gap between the outer periphery of said rotor disc/said oscillator disc and said bore of said piston housing;

25

said rings including flat rectangular sectioned spring steel having tolerances and finish to minimise fluid escaping past said clearance gaps under all operating conditions of said machine.

4. A machine as in claim 3, characterised in that said counter balancing means, mentioned in claims 1d, 1e and 1g to minimise out of balance forces on said machine when operating including:-

30

a) a void - located on said oscillator flange to counter balance said gudgeon pin hole in said oscillator flange about the centre of its axis;

- 5                   b)     a balance weight located on said connecting rod to counter balance the masses of said connecting rod and said integral gudgeon pin about axis of said satellite crank pin;
- c)     a balance weight located on said satellite crank shaft to counter balance the masses of said satellite crank pin, connecting rod, gudgeon pin and connecting rod balance weight about axis of journal of said satellite crank shaft, and
- 10               d)     a balance weight located on said rotor wheel to counter balance the masses of said rotor wheel, satellite pinion, satellite flywheel, satellite crank shaft, crank shaft balance weight, satellite crank pin, gudgeon pin, connecting rod, and connecting rod balance weight about axis of said rotor shaft.
- 15               5.     A machine as in claim 4, characterised in that at least one wet lubrication oil sumps means is included in said satellite crank case and in said piston housing, in gap between said rotor flange and adjacent cover plate, to serve as reservoirs for lubrication oil and oil coolant.
- 20               6.     A machine as in claim 5, characterised in that at least one of said bearings in said machine includes a plain oil pressure lubricated bearing with means for oil pressure lubrication, including at least one oil pressure pump having a rotor driven by said rotor shaft.
- 25               7.     A machine as in claim 6, characterised in that thermostatically controlled cooling means is provided, including:-
- a)     coolant passages contained within said rotor and oscillator pistons;
- b)     coolant passages contained between said rotor disc and rotor flange and said oscillator disc and oscillator flange;
- 30               c)     coolant passages on inside of said rotor cylinder;
- d)     all said coolant passages being connected and provided with coolant pumping means including communal pumping means for oil lubrication and oil coolant;

- 5 e) water coolant passages in said piston housing cylinder wall, in areas subjected to excessive heat, serviced by at least one coolant inlet and at least one coolant outlet connection, said coolant passages being connected to and provided with water coolant pumping means, including a coolant pump having a rotor driven by said rotor shaft. and,
- f) the provision of at least one air cooled fin located on at least one component of said machine requiring cooling.
- 10 8. A machine as in claim 7, characterised in that lubrication means is provided to lubricate said piston sealing blades and said disc sealing rings, including oil fog lubrication induced through a network of oil fog lubrication galleries communicating with oil fog in said oil sump and peripheral gaps between piston sealing blades when said gaps are subject to suction pressure.
- 15 9. A machine as in claim 8, characterised in that optionally at least one said oil fog lubrication galleries includes centrifugally controlled metering means to automatically meter oil fog lubrication to increase proportionately with the speed of said machine, said control means including the provision of non-return valves located in said lubrication galleries to prevent combustion gases from entering
- 20 said sumps.
10. An engine as in claim 9, characterised in that optionally exhaust pollution reduction means are provided including:
- 25 a) catalytic material implants located in a significant portion of piston surface areas exposed to incomplete combustion and pollutants, particularly piston headland surface areas;
- b) said catalytic material including Platinum, Rhodium and Palladium;
- 30 c) implant operating temperature control means including thermostatic control of piston/encompassing wall coolant to maintain temperatures sufficiently high for catalytic reaction, without thermal damage to catalyst at all engine loads and speeds;

11. A machine as in claim 10, characterised in that optionally said ring gear/satellite pinion teeth gear ratio mentioned in claim 1j, also includes ratios of 3:1, 4:1, 6:1 and 8:1.
- 5 12. A machine as in claim 11, characterised in that optionally included in wall of said piston housing is at least one low pressure injector nozzle means, including means for injection of air/fuel fog, air/lubricant fog and supercharged air into said rotating chambers after said inlet port is closed.
- 10 13. A machine as in claim 12, characterised in that optionally included in said machine is means for high compression ratio, sufficient to operate said machine on the compression ignition diesel cycle, including instead of spark plugs, the provision of diesel fuel injection nozzles located in piston housing, and diesel fuel injection handling, management and equipment means to inject diesel fuel  
15 into said rotating chambers at the end of each compression stroke.
14. A machine as in claim 13, characterised in that optionally said set of two rotor pistons and said set of two oscillator pistons mentioned in claims 1e and 1h, also includes at least three rotor pistons and at least three oscillator pistons with  
20 corresponding increases in the number of said ports, spark plugs and injectors.
15. A machine as in claim 14, characterised in that optionally included in said machine are modular construction means to facilitate quick and easy assembly and disassembly including at least two modules:-
- 25 a) a power module including said piston housing and satellite crank case housing, and
- b) an auxiliary module including a main output flywheel, starter motor, and at least one auxiliary drive pulley, said auxiliary module including a supporting flange including bearings, supporting an adapter shaft, including said adapter shaft attached to and supporting said main output  
30 flywheel, and at least one auxiliary pulley including said adapter shaft

having an internal spline to match an external spline provided at end of said rotor shaft.

16. A machine as in claim 15, characterised in that optionally included in said machine are coupling means to enable the rotor shafts of a plurality of said machines to be ganged in series for multiple backup and increased power output, including offsetting of power phases of said machines for smoother torque.
17. A machine as in claim 16, characterised in that a multiple backup means is provided, comprising a plurality of axially adjacent independent sets of at least one machine coupled to at least one fan, including means to operate each of said sets singly, jointly and as backups said fans having a communal coaxial ducted fan cold jet propulsion casing adapted for propulsion of aircraft including VTOL passenger aircraft, said machines having coolant heat exchangers, exhaust silencers, and exhaust piping located inside said communal casing so as to dissipate waste heat into propulsion air flow for thrust augmentation.
18. A machine as in claim 17, characterised in that optionally, said communal duct case is provided with a plurality of cold air vectored thrust swivelling jet nozzle outlets, including provision of outlet piping for wing tip jet nozzles, nose jet nozzles and tail jet nozzles with means adapted for providing gyroscopic stabilising digitally controlled nozzle actuating means for fine control of pitch, roll and yaw, specifically for VTOL aircraft propulsion.
19. A machine as in any one or more of claims 1 to 18, characterised in that said rotor wheel has peripheral starting ring gear teeth with coupling means to a starter motor as an alternative to dispense with a separate flywheel provided with ring gear teeth.
20. A machine as in any one or more of claims 1 to 9, characterised in that said machine is adapted for use as a fluid pump, including compressors, having non-

return valves, including reed valves and spring loaded poppet valves, provided in said inlet and outlet passages.

21. A machine as in any one or more of claims 1 to 9 characterised in that internal  
5 and external auxiliary equipment, handling and management means is provided to specifically adapt said machine for use as a pump **instead** of an internal combustion engine.
22. A machine as in any one or more of claims 1 to 9 characterised in that means is  
10 provided to specifically adapt said machine for use as a fluid driven motor **instead** of an internal combustion engine.
23. A machine as characterised substantially in the detailed description and the accompanying drawings.

FIGURE 1

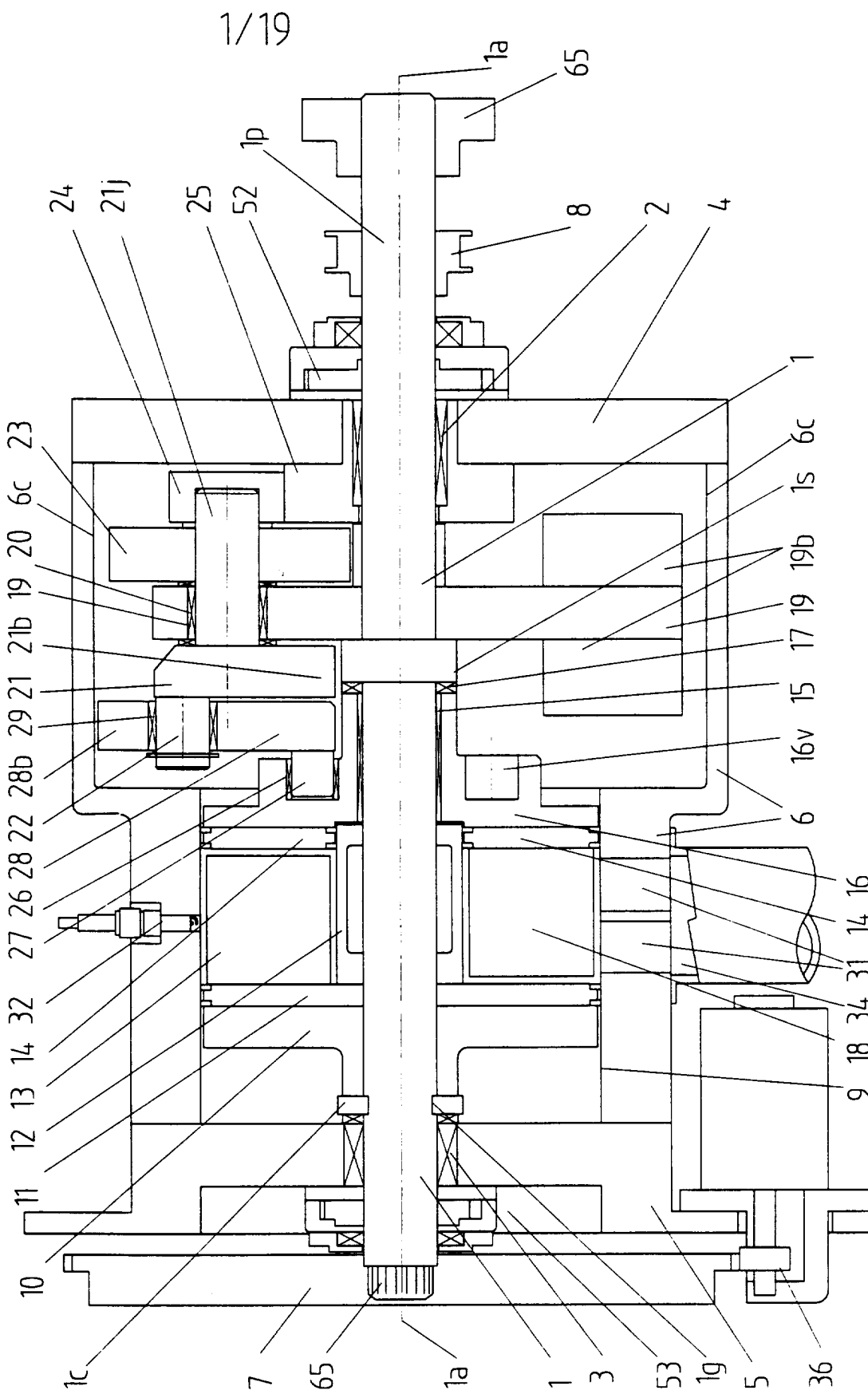
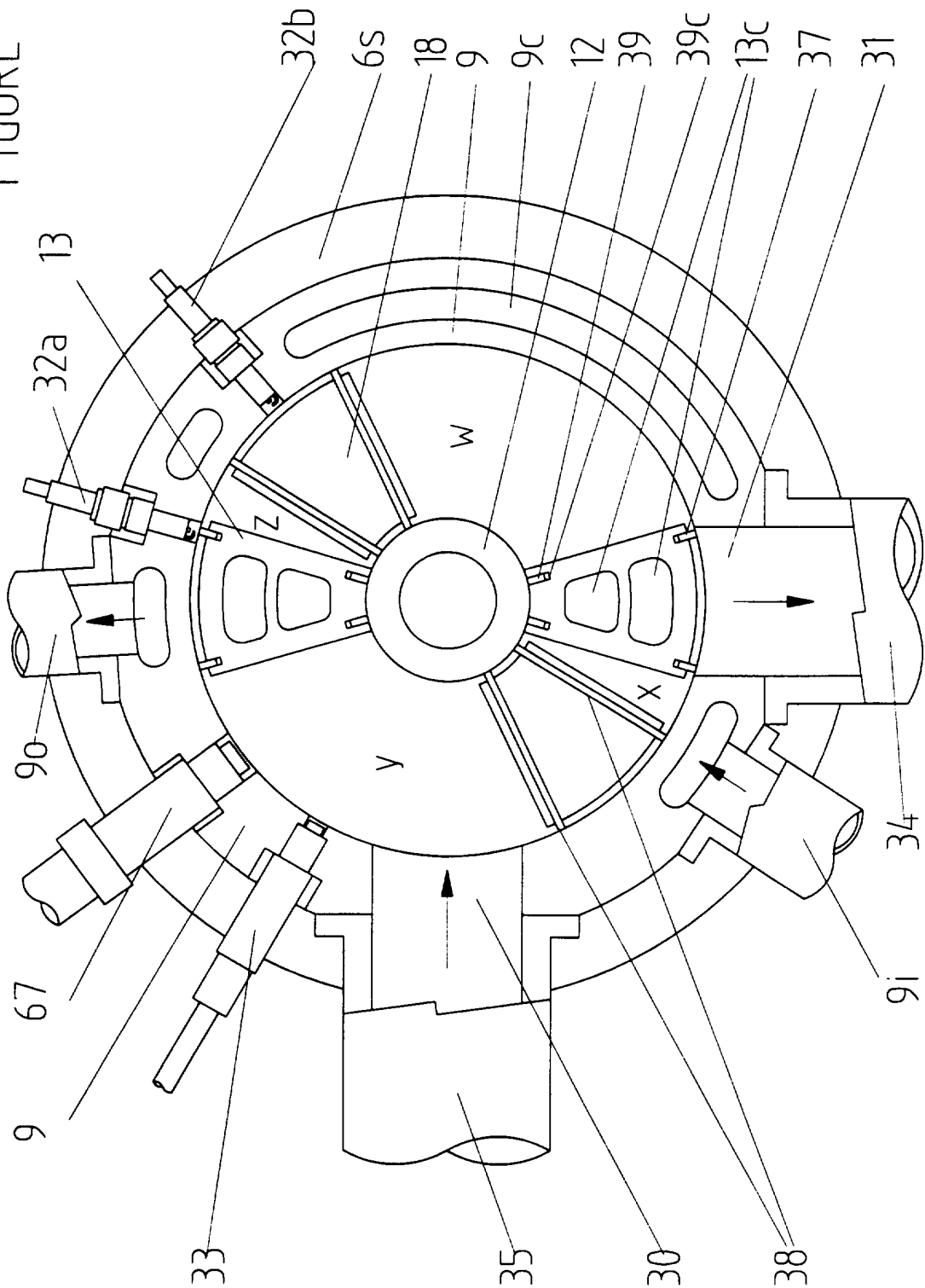
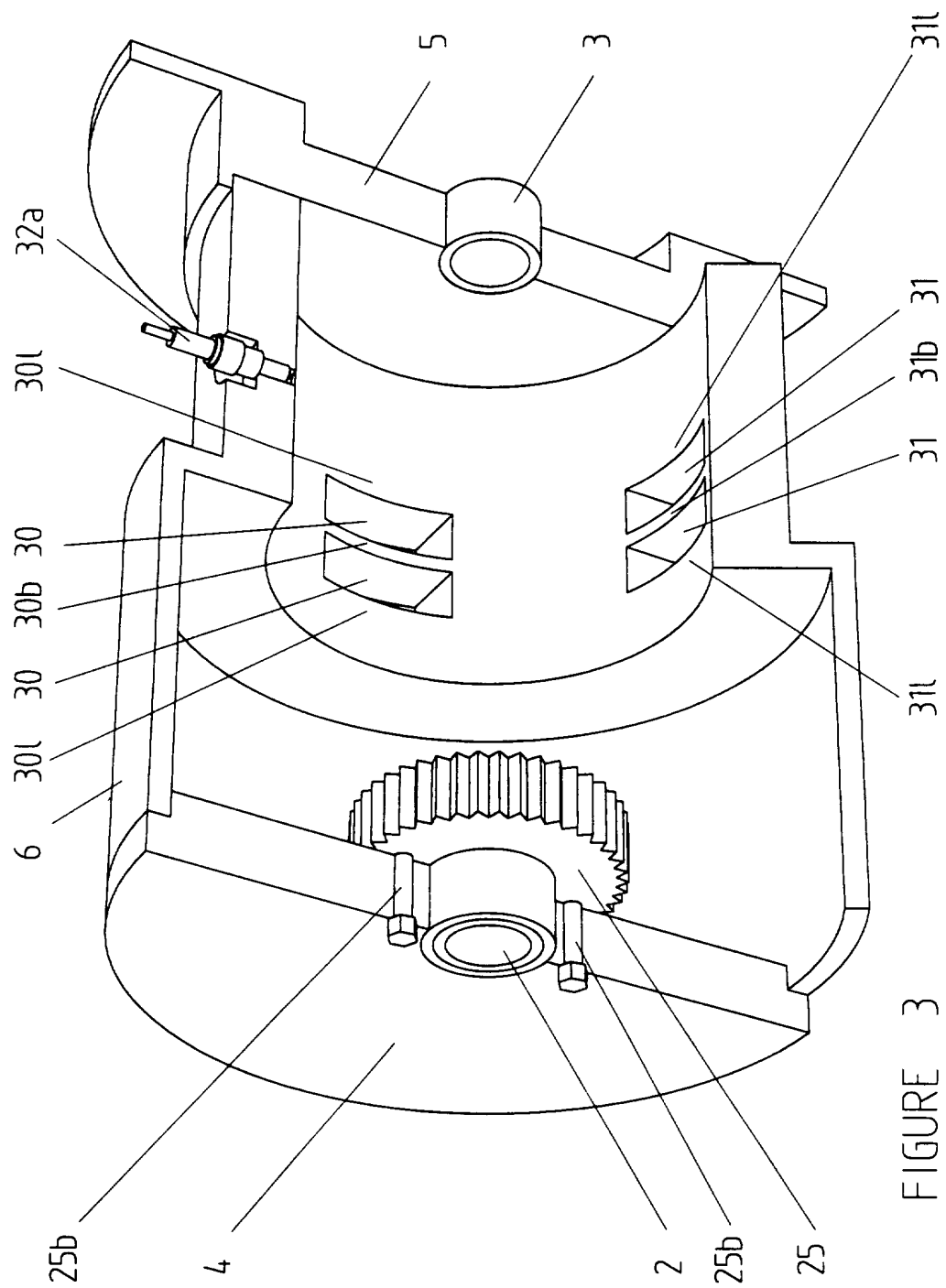


FIGURE 2



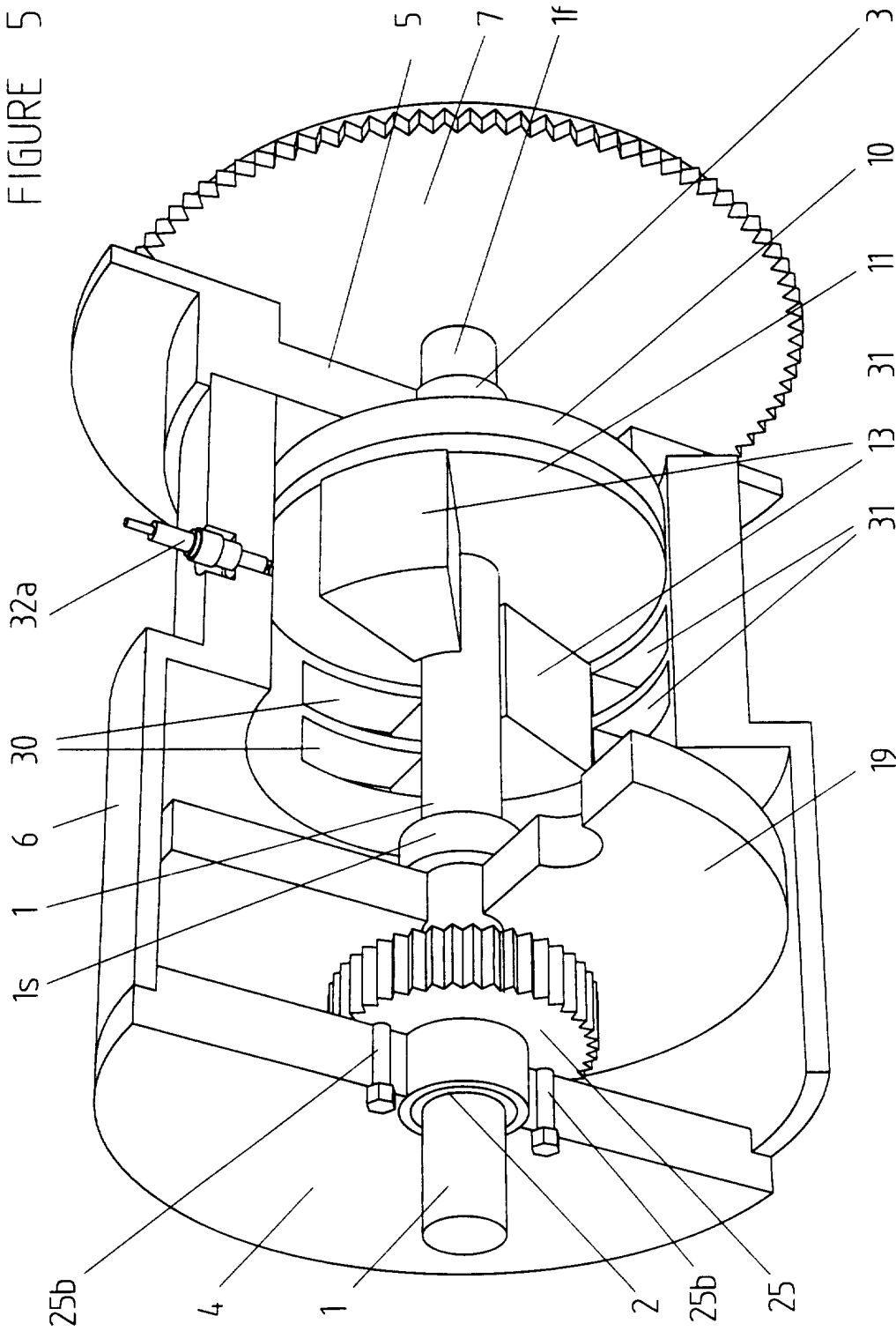
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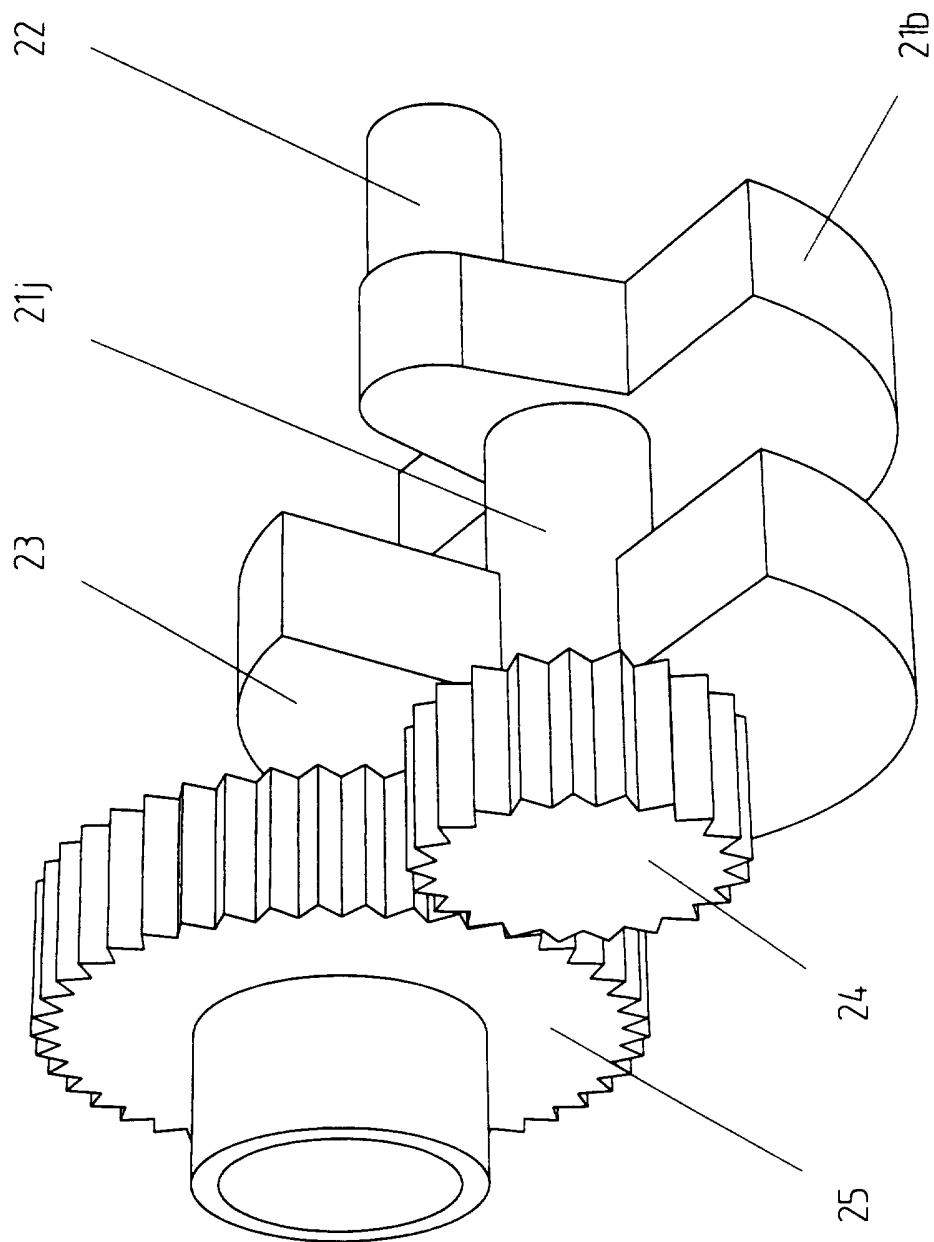
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FIGURE 5



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FIGURE 6



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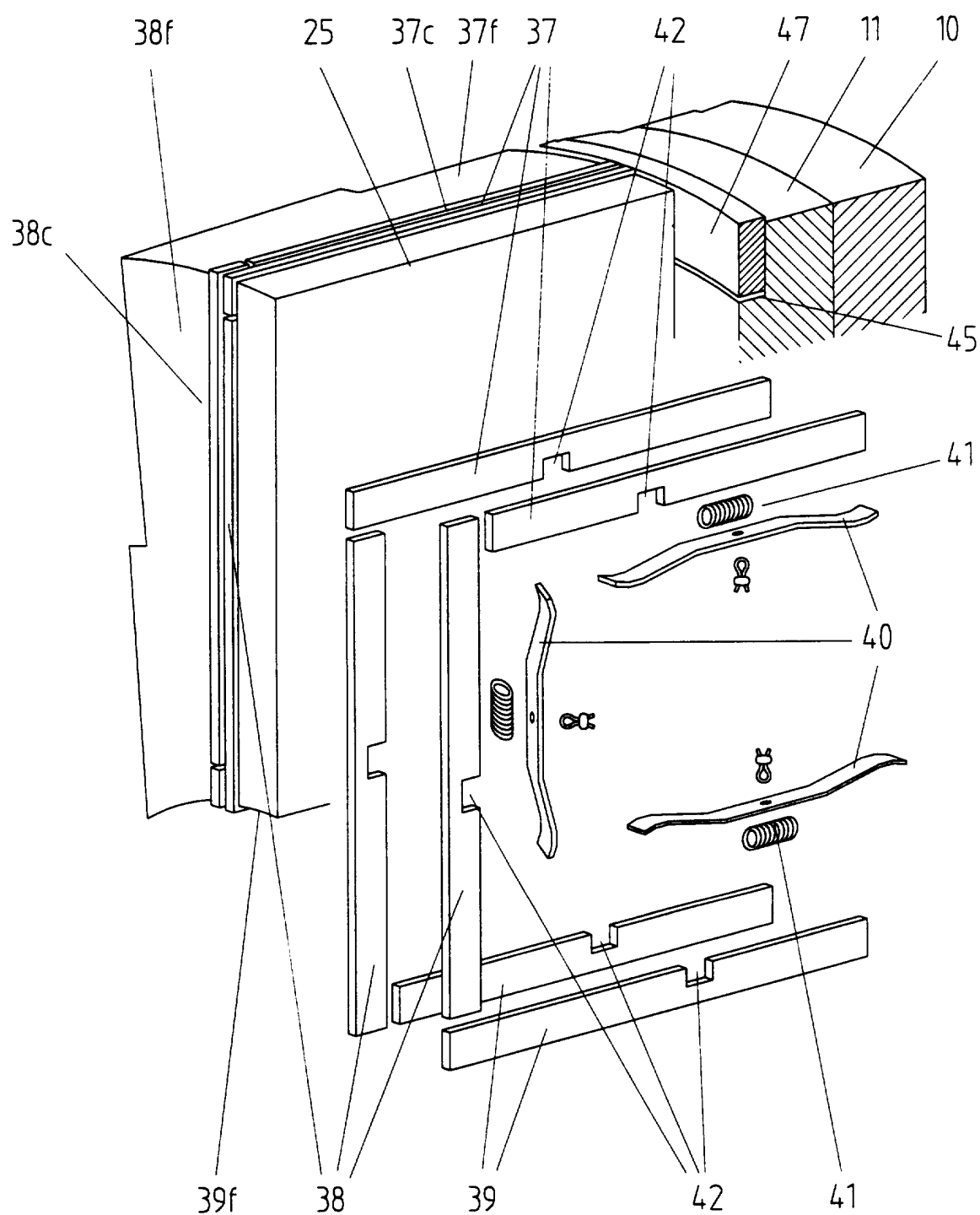
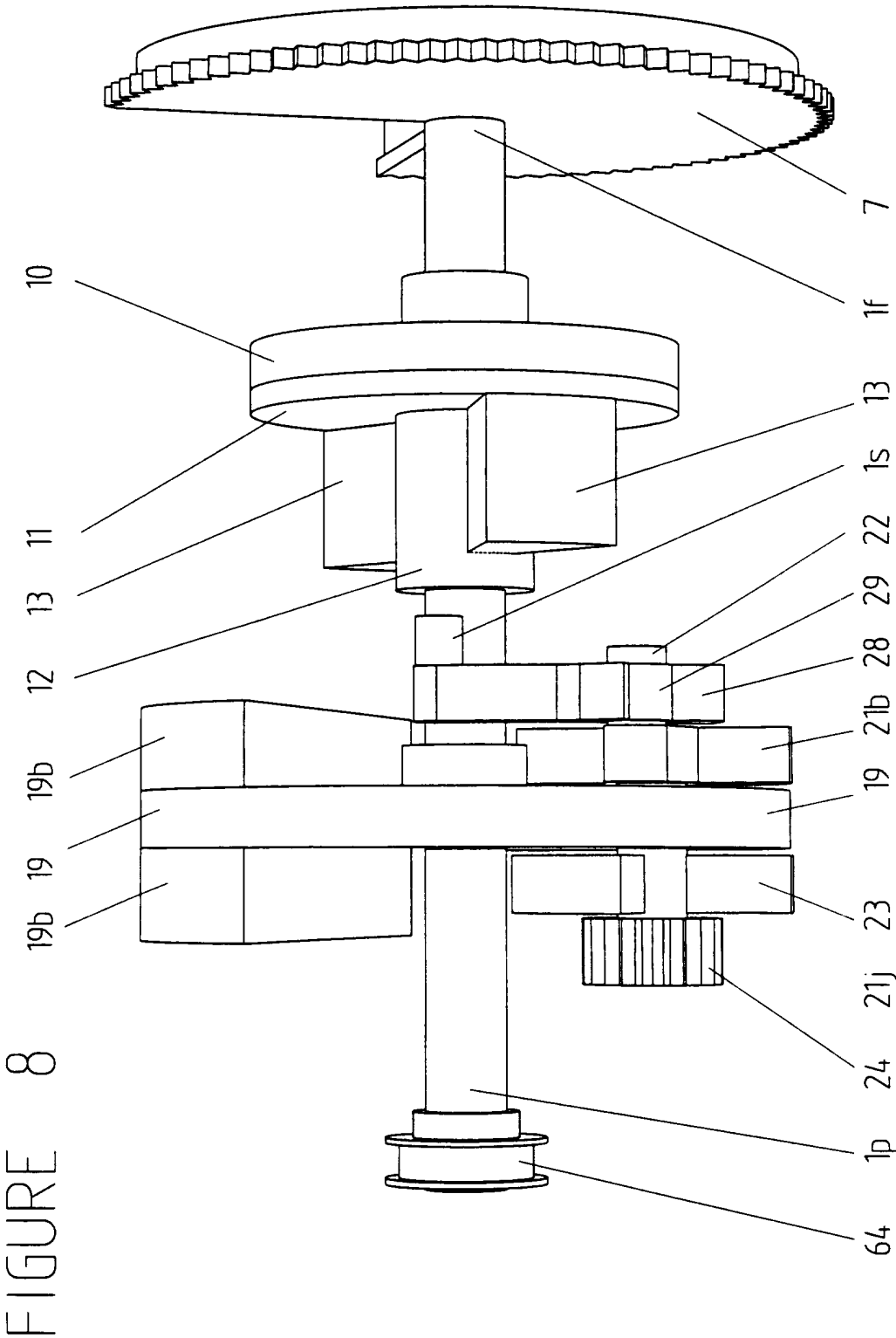
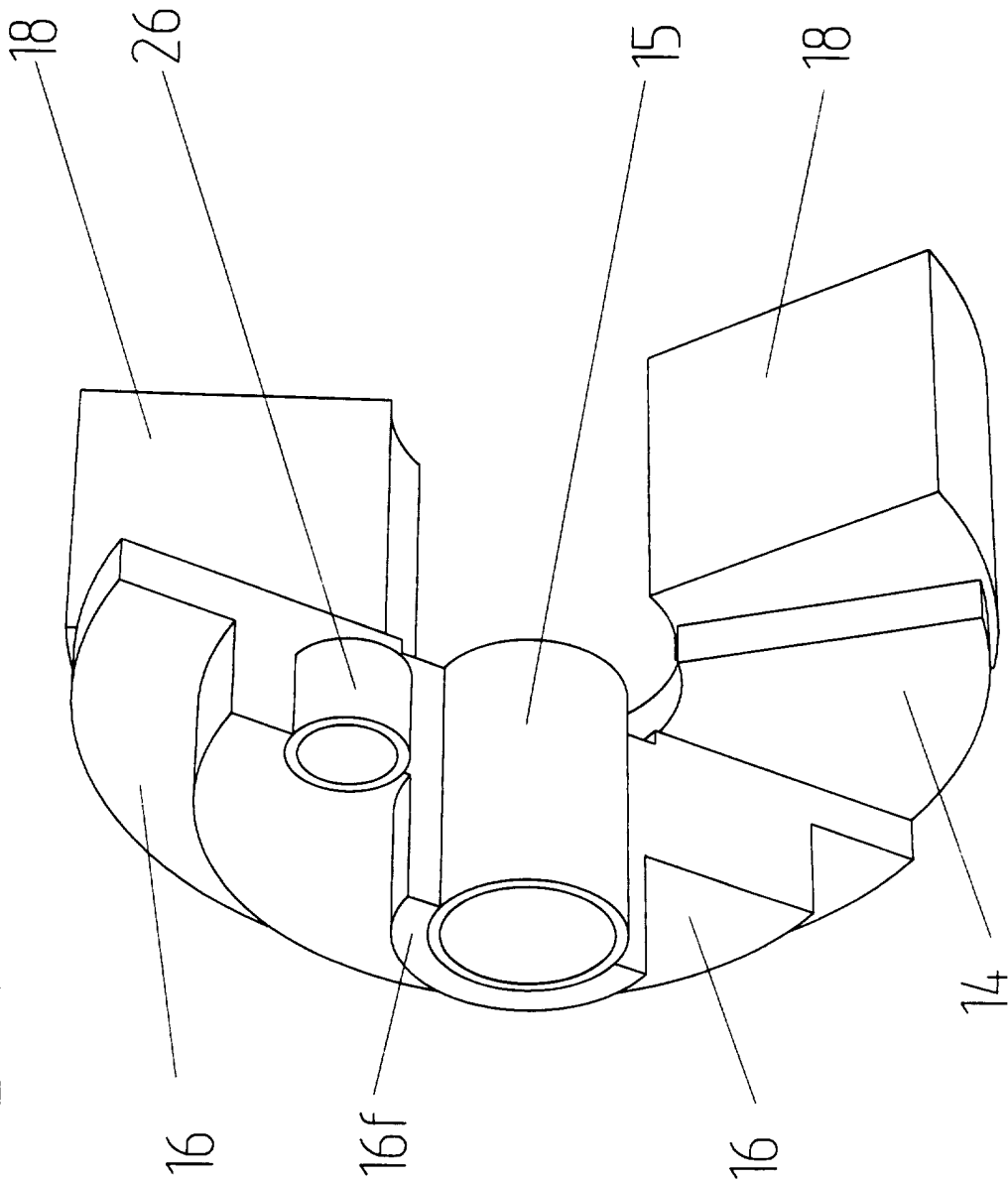


FIGURE 7



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FIGURE 9



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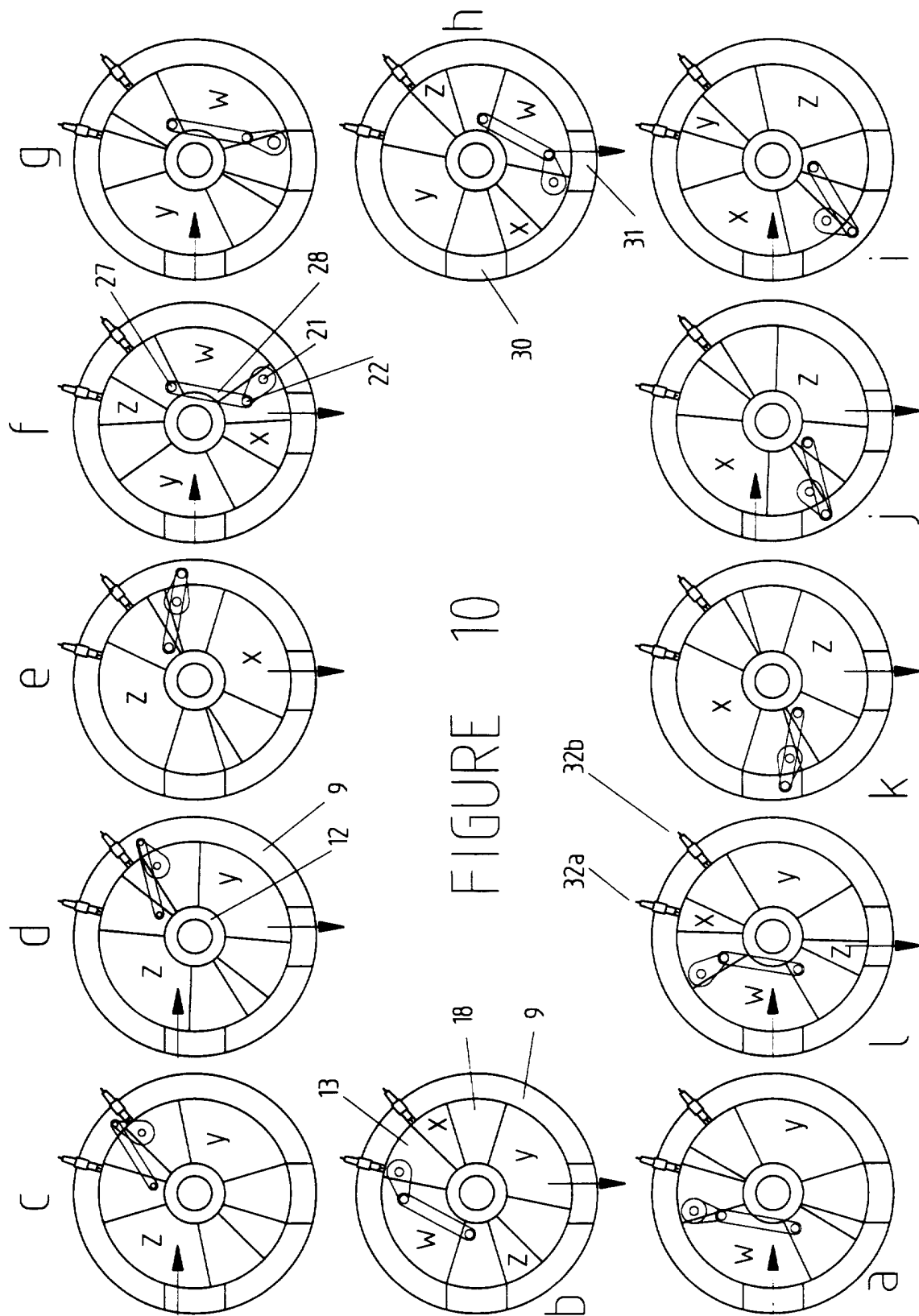
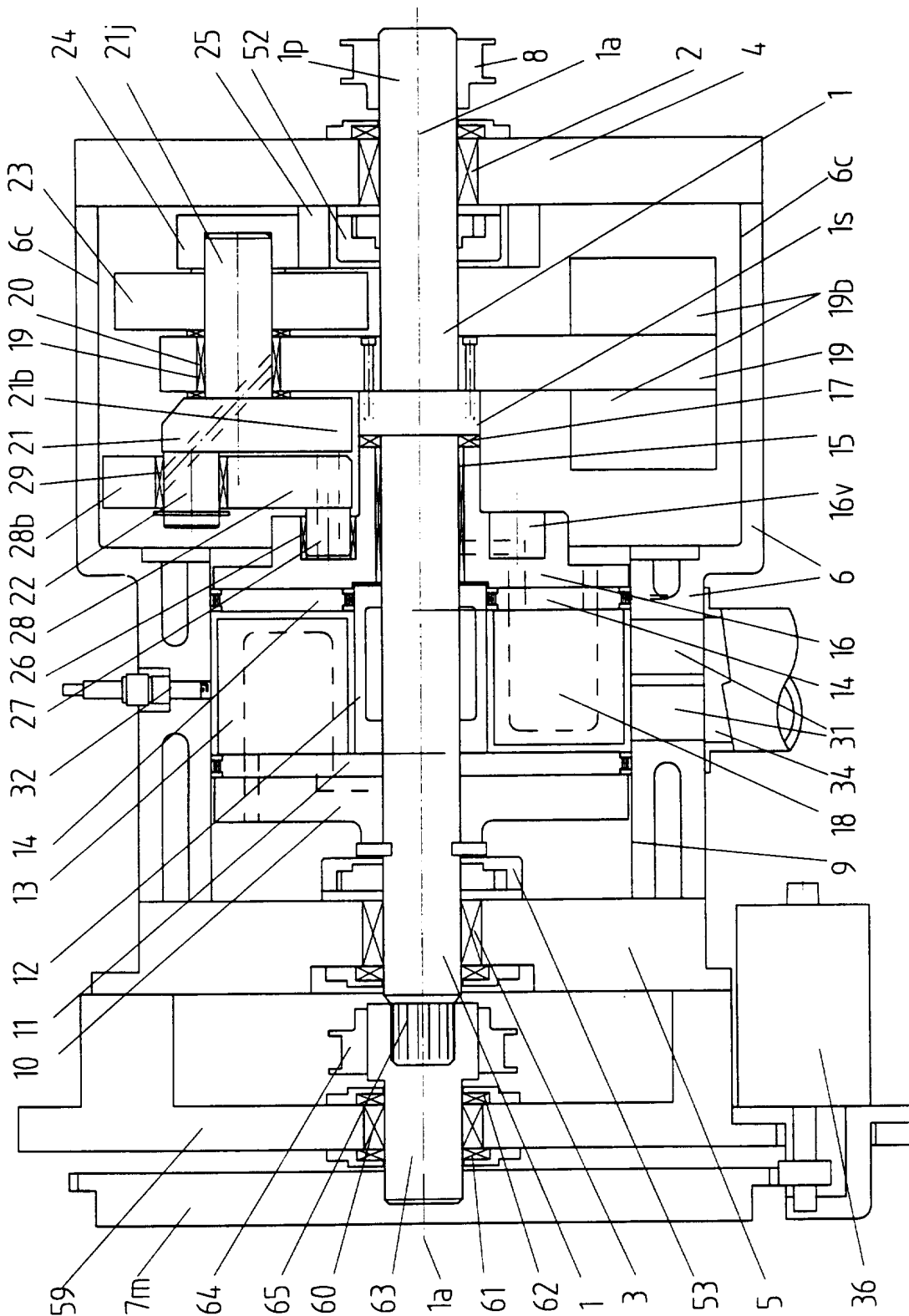


FIGURE 10

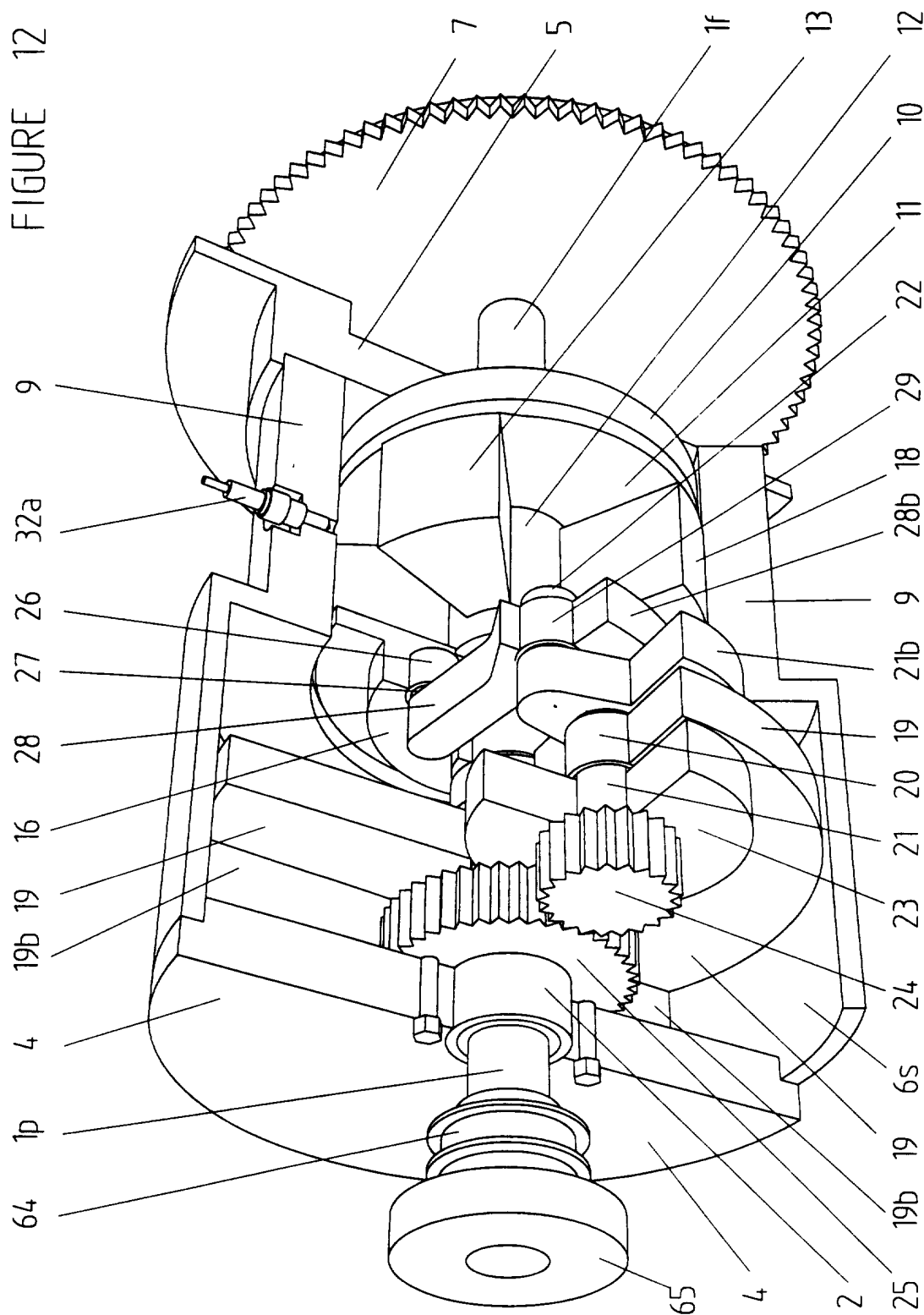
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FIGURE 11



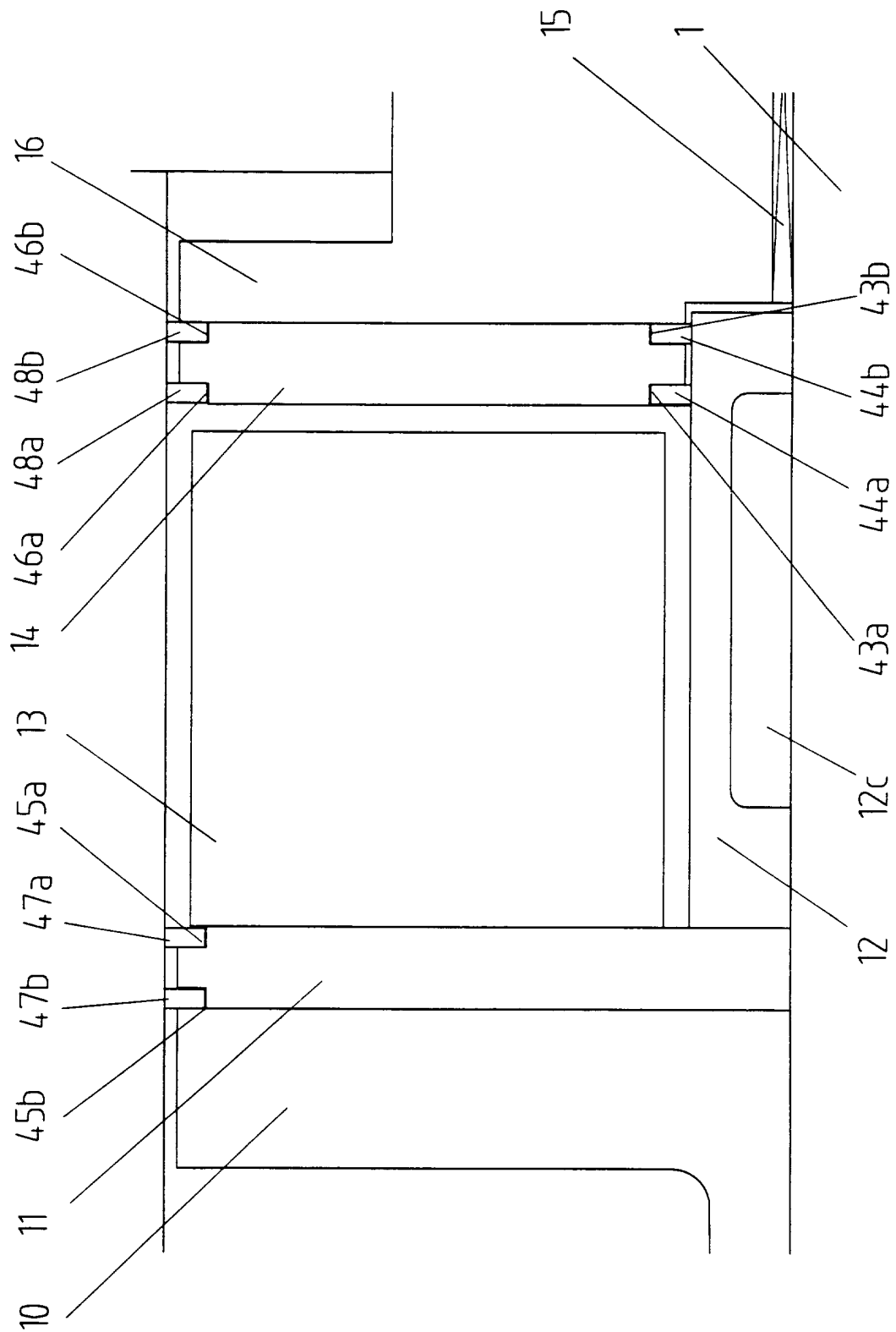
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FIGURE 12



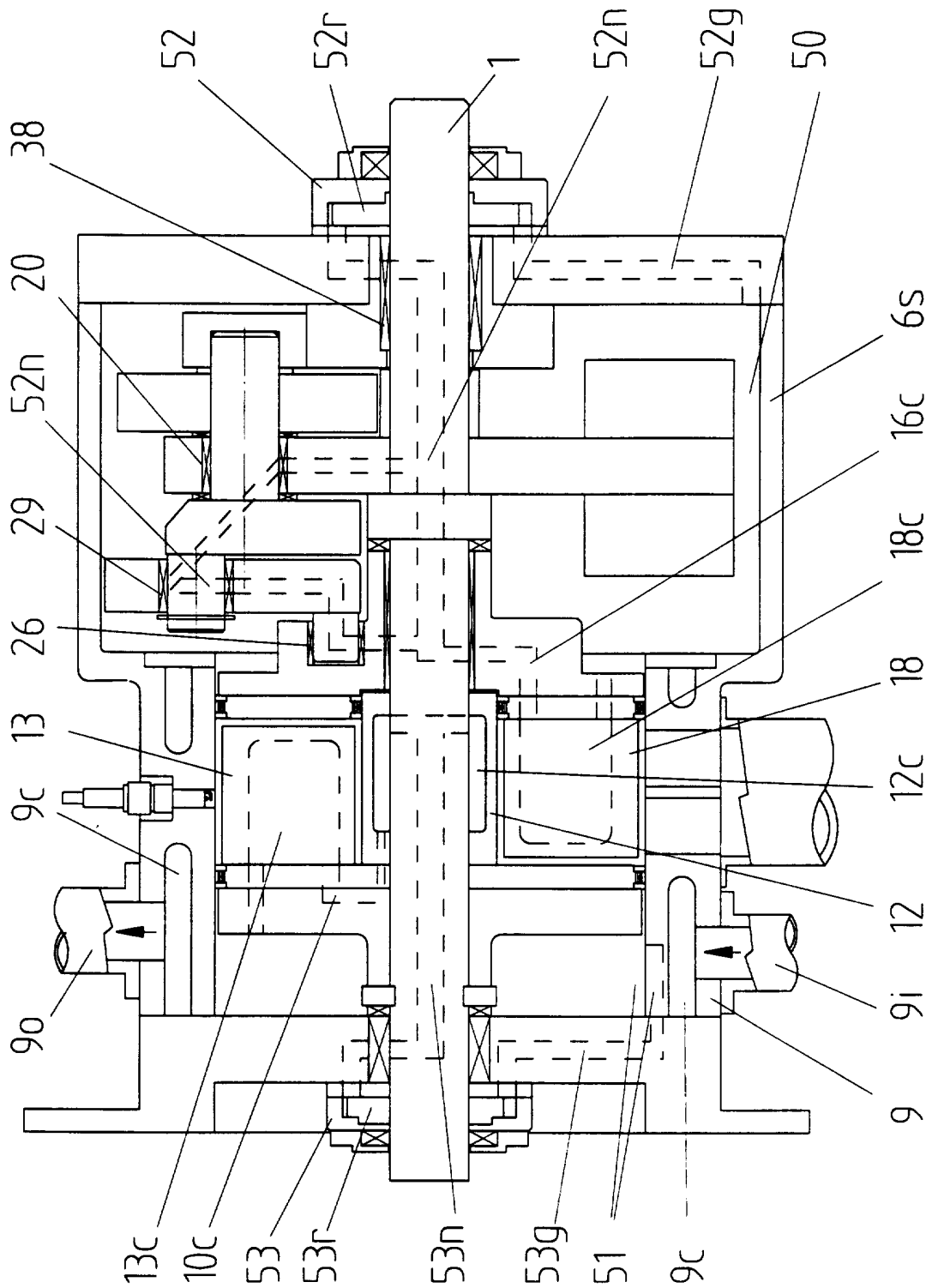
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FIGURE 13



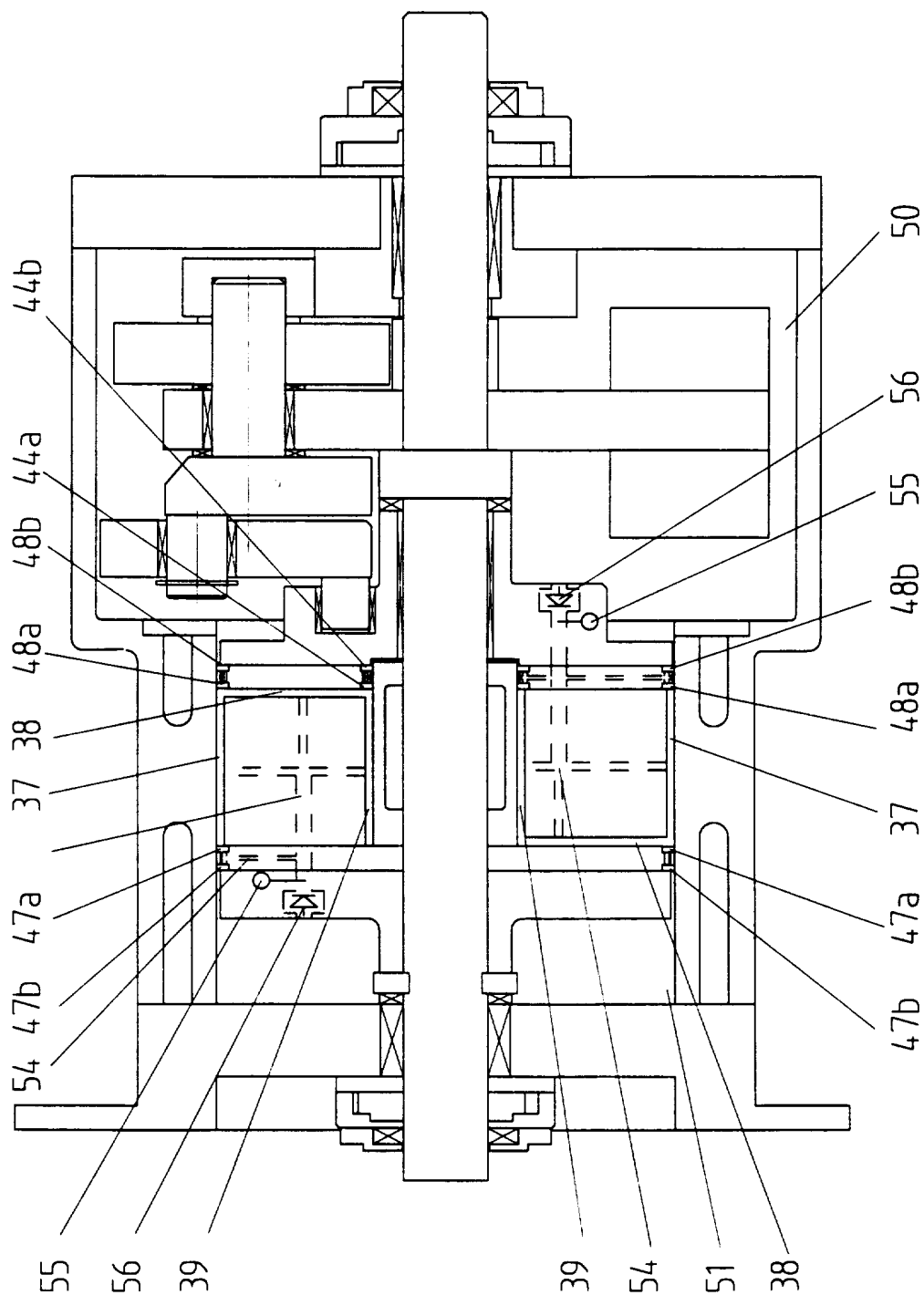
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FIGURE 14



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FIGURE 15



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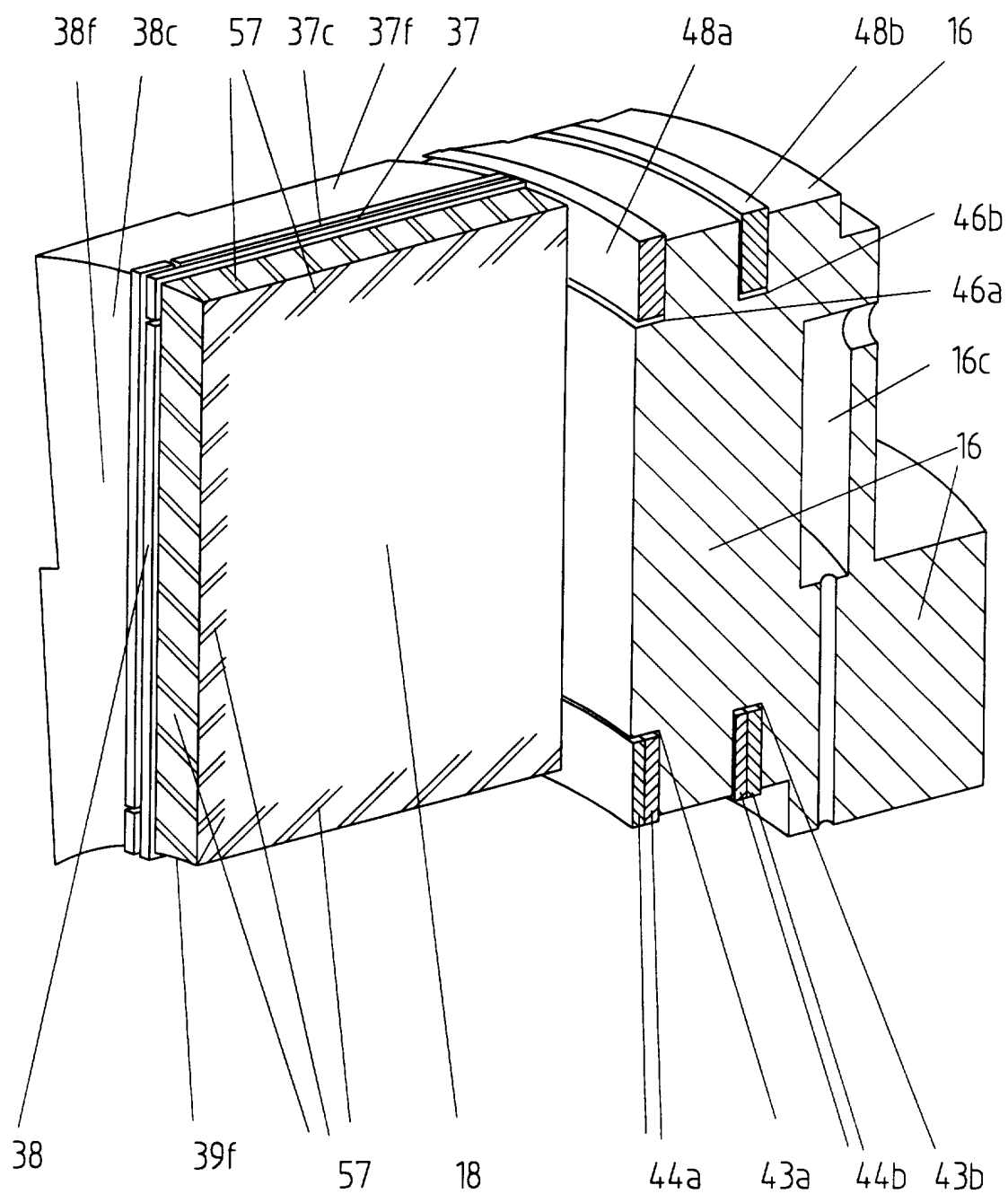


FIGURE 16

FIGURE 17

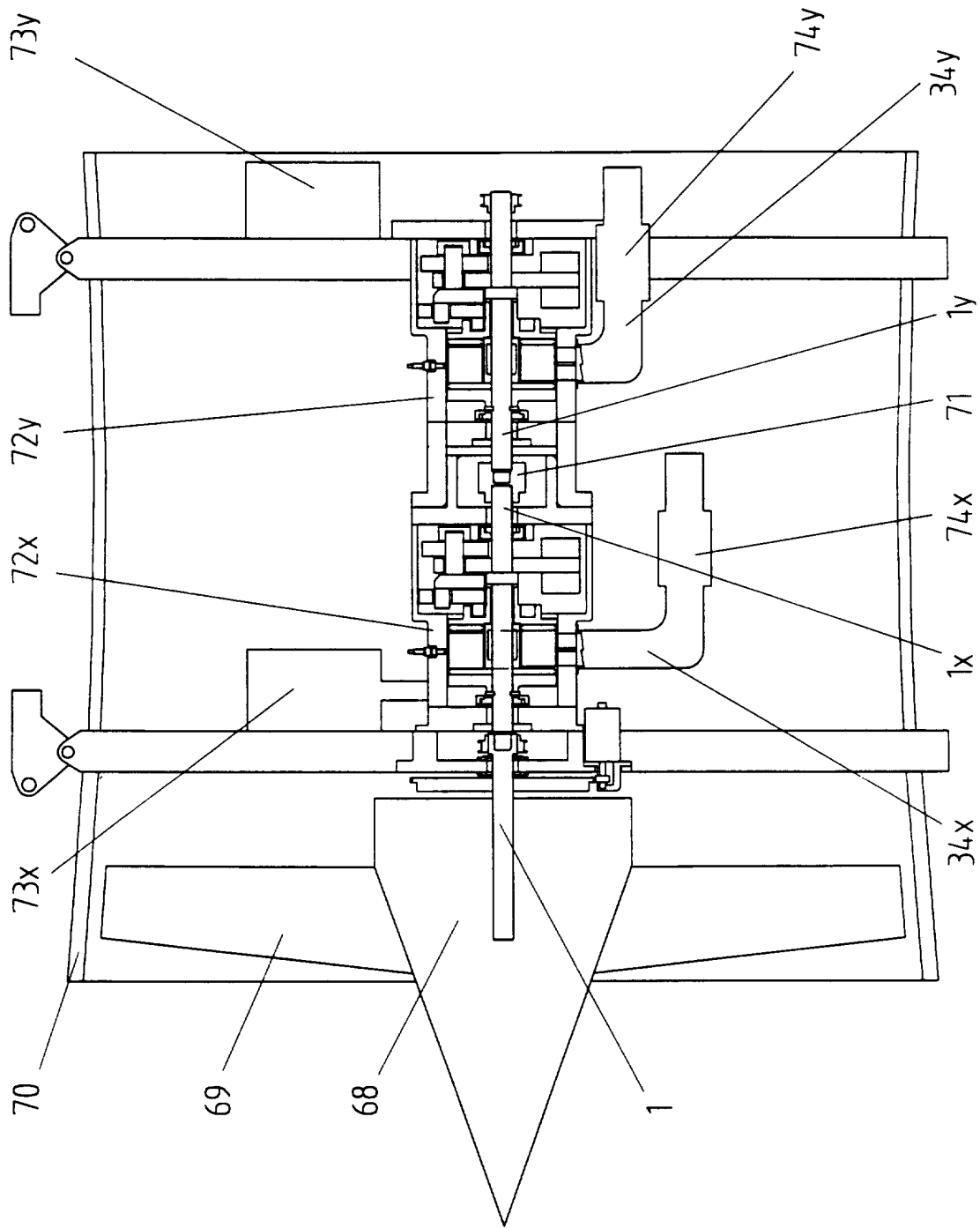
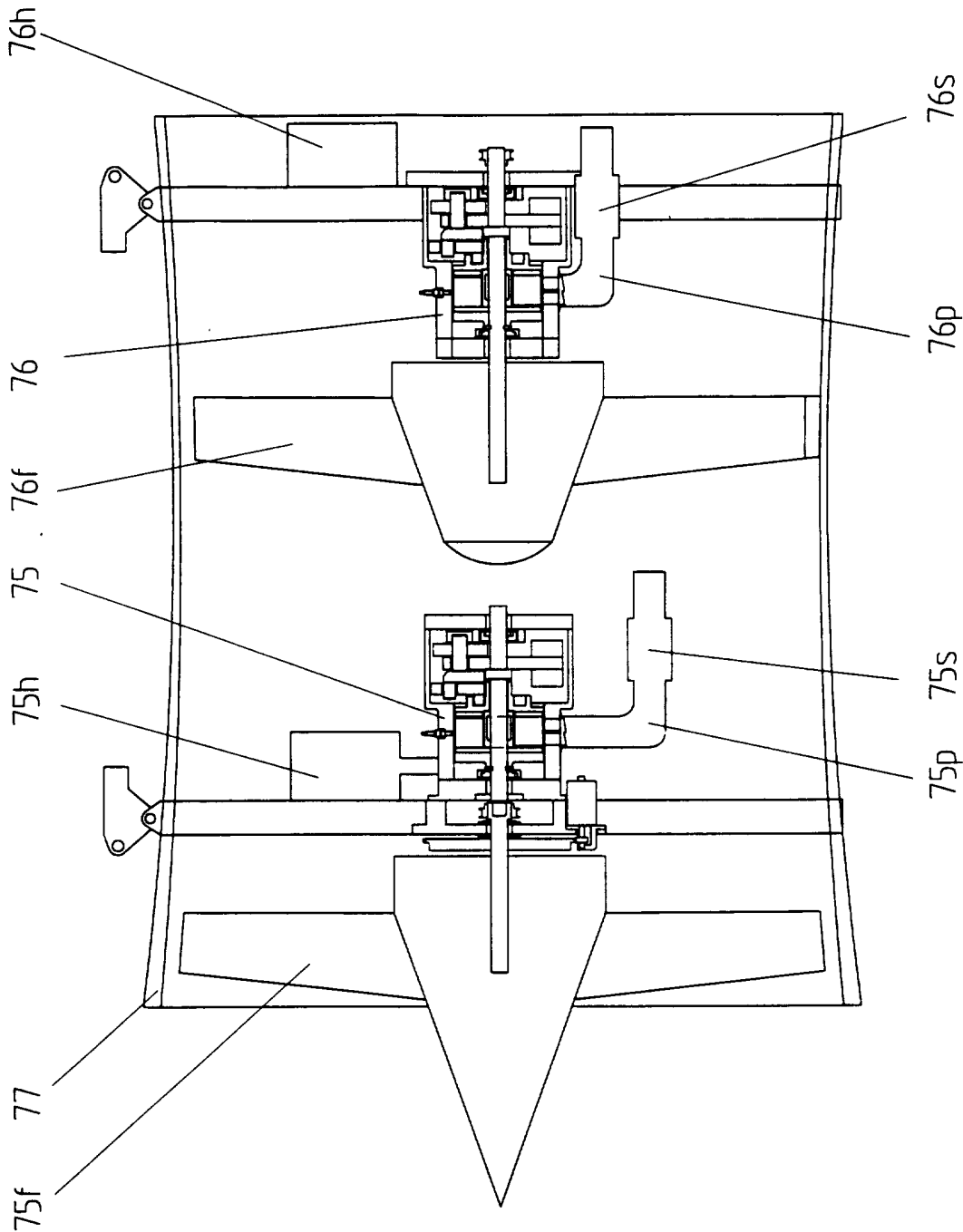
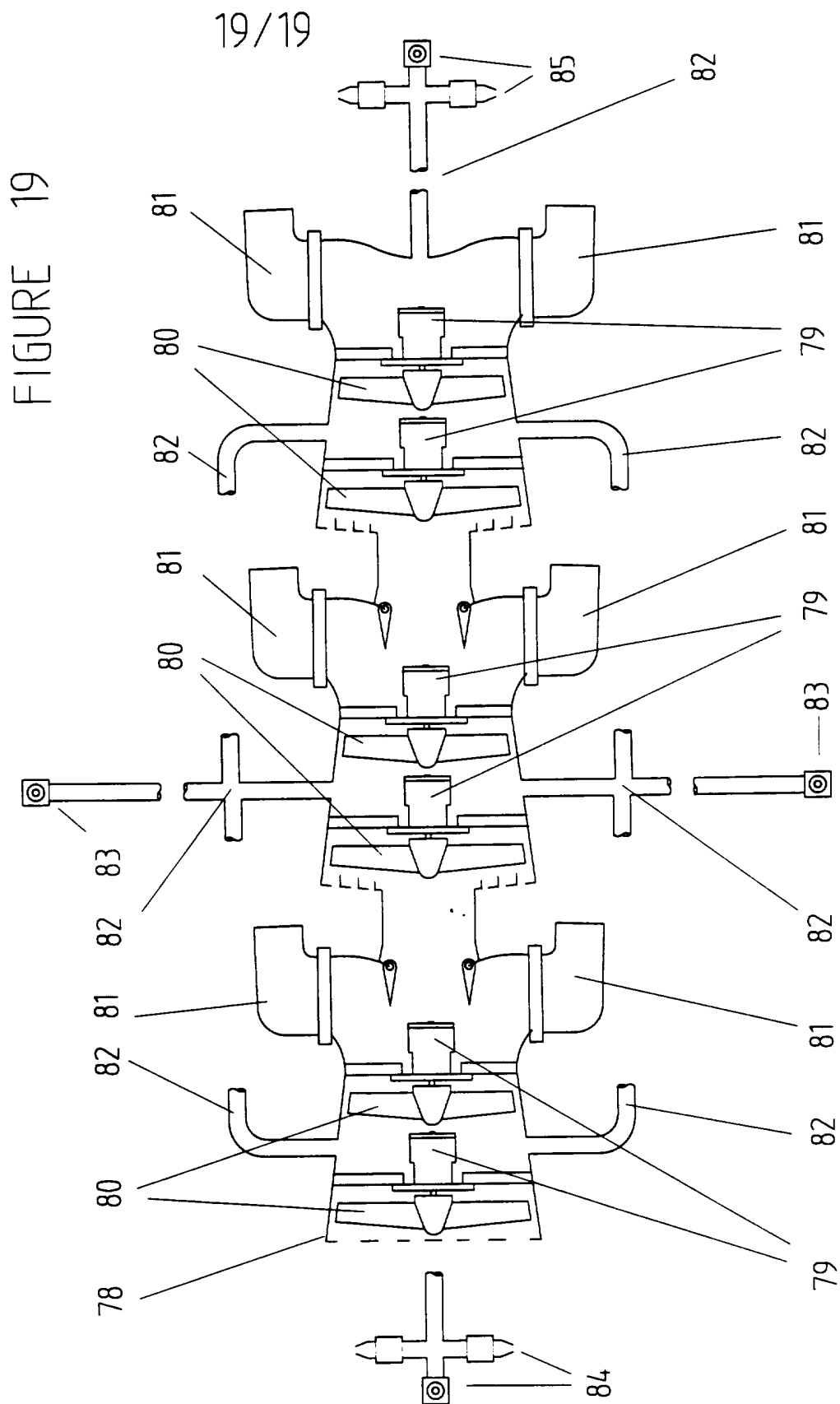


FIGURE 18





## INTERNATIONAL SEARCH REPORT

International Application No

PC 1/GB 95/02764

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 6 F01C1/07

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

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC 6 F01C

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

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

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages                       | Relevant to claim No. |
|------------|----------------------------------------------------------------------------------------------------------|-----------------------|
| X          | EP,A,0 554 227 (DOVERI NICOLO ;TAMBURINI ALESSANDRO (IT)) 4 August 1993<br>see the whole document<br>--- | 1-3,15                |
| X          | US,A,3 483 578 (HARRISON THOMAS R) 16 December 1969<br>see the whole document<br>---                     | 1-4                   |
| X          | US,A,3 356 079 (ROLFSMEYER) 5 December 1967<br>see the whole document<br>---                             | 1                     |
| A          | ---                                                                                                      | 2-4                   |
| X          | WO,A,91 15659 (JAGUAR CARS) 17 October 1991<br>see the whole document<br>---                             | 1-3,15                |
|            | ---<br>-/--                                                                                              |                       |

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

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- \* "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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Date of the actual completion of the international search

25 January 1996

Date of mailing of the international search report

08.02.96

Name and mailing address of the ISA

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Authorized officer

Wassenaar, G

## INTERNATIONAL SEARCH REPORT

Int. onal Application No  
PC1/GB 95/02764

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|------------|------------------------------------------------------------------------------------|-----------------------|
| X          | GB,A,2 074 652 (WATSON C D) 4 November 1981                                        | 1                     |
| A          | see the whole document<br>-----                                                    | 2-6                   |

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 95/02764

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s) | Publication<br>date |
|-------------------------------------------|---------------------|----------------------------|---------------------|
| EP-A-0554227                              | 04-08-93            | NONE                       |                     |
| US-A-3483578                              | 16-12-69            | NONE                       |                     |
| US-A-3356079                              | 05-12-67            | NONE                       |                     |
| WO-A-9115659                              | 17-10-91            | EP-A- 0523129              | 20-01-93            |
| GB-A-2074652                              | 04-11-81            | NONE                       |                     |