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(54) **CONTROLLED VARIABLE COMPRESSION RATIO INTERNAL COMBUSTION ENGINE**
BRENNKRAFTMASCHINE MIT GESTEUERTEM VARIABLEN DICHTUNGSVERHÄLTNIS
MOTEUR A COMBUSTION INTERNE A TAUX DE COMPRESSION VARIABLE COMMANDE

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Description**BACKGROUND OF THE INVENTION**Field of the Invention

[0001] This invention relates to the internal combustion engine art and, more particularly, to an improved arrangement for controlling the compression ratio of the engine.

Description of the Prior Art

[0002] The theory of internal combustion engines states that thermal efficiency, which is directly related to fuel economy, is directly proportional to compression ratio.

[0003] Compression ratio (CR) is defined as the ratio of the total internal volume of the cylinder when the piston is at bottom dead centre (BDC), to the clearance volume of the cylinder when the piston is at top dead centre (TDC). The space between the piston and the cylinder head at TDC is also known as the combustion chamber.

$$CR = \text{Total vol. at BDC} / \text{Clearance vol. at TDC}$$

[0004] There is always a clearance space enclosed by the piston top surface and the inner surface of the cylinder head when the piston is at TDC.

[0005] It is important to differentiate between compression ratio and compression pressure (CP), although they are directly related. Typical compression ratios of modern spark ignition engines are anywhere from 8 to 9.5. The compression ratio for a particular spark ignition internal combustion engine design is selected after a determination of what safe compression pressures the engine can handle without the fuel mixture detonating prematurely.

[0006] The CP at part throttle will be lower than at full throttle. Thus, CR is limited by the maximum (full throttle) CP. This limitation, a) hinders the use of very lean mixtures for emission control, and b) places an undesirable limitation on the theoretical efficiency of the engine.

[0007] But an automobile is driven mostly at part throttle. During partial throttle operation, the CR may be safely increased without exceeding maximum safe CP. An increase in engine efficiency and a decrease in emissions may be realised if the CR is varied in a manner so that CP remains constant near a preselected value. To keep the CP level, the engine compression system must adapt to changing operation and external conditions such as load, speed, etc. and change the compression ratio therein.

[0008] A solution to providing variable CR is to somehow control the clearance volume at TDC.

[0009] Several variable compression ratio systems have attempted to provide a quiet, stable, controllable

arrangement for changing the compression ratio in internal combustion engines. U.S. Patent 4,516,537 teaches the use of a variable position sub-piston under hydraulic control. The `537 patent describes the inherent problem of a number of prior solutions of the back-flow of the hydraulic fluid under the intense back pressure of the internal explosion of fuel and air. The prior art systems did not work as expected because the regulation of the compression ratio is accompanied by too large an error imposed by the intense explosion pressure.

[0010] The `537 patent attempts to solve the problems by only moving the sub-piston during the intake and exhaust strokes of the engine. The opening and closing of a check valve is used to activate the movement of the sub-piston. However, `537 discloses that the sub-piston will be forced to a slightly rearward position during the intense power explosion. Such intermittent movement results in noise, vibration and control instability.

[0011] A disclosure in the Japanese patent No. 88926/81 attempts to solve some of the problems by introducing a hydraulic cylinder with a plunger mounted to be co-axial with the piston rod of the sub-piston used to vary the compression ratio. However, the system results in a step wise control of the compression ratio which introduces a large error resulting in knock and erratic performance.

[0012] Other attempts such as U.S. Patent 2,163,015, and similar U.S. Patents 2,040,652 and 2,970,581, have attempted to replace the hydraulic control with a mechanical cam (which in this case was still under hydraulic control). However, the cam does not solve the problem of providing a "solid" configuration under ignition pressure. The geometric design of a cam introduces a lever and fulcrum into the physics of the system. The axis upon which the cam is mounted is never in line with the force vector. Thus there is always a moment force around the axis contributing to movement, noise, error and inoperability.

[0013] Thus, there has long been a need for an improved arrangement for controlling the compression ratio of the engine which provides positioning of a means to vary the clearance volume of the cylinder at TDC.

[0014] It is also desired that the control means be continuously variable and vibration resistant to provide noise free and error free efficient operation of the engine.

[0015] WO91/14860 of the present applicant seeks to provide a solution to the above-stated problems associated with the earlier disclosures. In this document, a secondary cylinder is formed in the cylinder head and a piston is located therein. The position of the piston is controlled by an involute surface mounted upon a rotatable shaft such that the torque generated upon the involute and shaft by the explosion in the cylinder is reduced to a very low value. Since the present application is an improvement upon the disclosure of WO91/14860,

several of the drawings and much of the description of the earlier application is included herein. WO91/14860 represents the closest prior art to the present application, and the preamble of the claim 1 is derived therefrom.

SUMMARY OF THE INVENTION

[0016] It is an object of the present invention to provide an improved arrangement for changing the TDC clearance volume of a cylinder in a vehicle while the engine is operating.

[0017] Thus, in the present invention, the involute is supported by a shaft but driven by a sleeve surrounding the shaft. The sleeve communicates with the involute by means of a spring to advance the involute only during periods of low back pressure. The involute communicates with the shaft by means of a ratchet whereby the involute will advance in only one direction and only during low pressure. The ratchet prevents movement in the other direction. The involute is repositioned by means of moving the shaft.

[0018] Any such control device responding to the preselected variables of air temperature, pressure, octane rating of the fuel, engine temperature, etc. may be incorporated in the algorithm used by the control device to determine the rotational position and achieve the preselected engine efficiency by changing the compression ratio.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] Figures 1-12 and the detailed description thereof are taken from WO91/14860, and are therefore marked as "prior art". These drawings, which are themselves by way of example only, are included herein so as to facilitate the understanding of the present invention, an embodiment of which is shown, again by way of example, in Figs. 13-17.

[0020] For simplicity, similar reference characters refer to similar elements throughout.

Figure 1 is a cross sectional view of an engine which shows a secondary cylinder positioned by an involute;

Figure 2 illustrates the placement of the secondary piston;

Figure 3 is a perspective view of the involute/shaft arrangement with control device;

Figure 4 is a cross sectional view of an engine which illustrates the cap of the secondary cylinder as a wedge;

Figure 5 is a perspective view of the shaped cap wedge arrangement;

Figure 6 illustrates another design according to WO91/14860;

Figure 7 illustrates a cross sectional view of another design according to WO91/14860;

Figure 8 illustrates another design according to WO91/14860;

Figure 9 illustrates a block diagram of the position control;

Figure 10 illustrates the ideal curve;

Figure 11 illustrates another design according to WO91/14860;

Figure 12 illustrates yet another design according to WO91/14860;

Figure 13 illustrates a base shaft with ratchet according to the present invention;

Figure 14 illustrates a sleeve for the base shaft shown in Figure 13;

Figure 14A is a cross section of a partially assembled mounting for an involute according to the present invention;

Figure 15 illustrates an involute used with the base shaft and sleeve embodiment according to the present invention;

Figure 16 illustrates a mount for the embodiment according to the present invention using a base shaft and sleeve; and,

Figure 17 illustrates the relationship of Figures 13 through 16.

DETAILED DESCRIPTION OF THE DRAWINGS

[0021] The purpose of this invention, which is shared by the invention described in WO91/14860, is to provide an arrangement which may be used to increase internal combustion engine thermal efficiency. The efficiency is a function of the compression ratio and the fuel-air ratio.

[0022] Unleaded gas and smog control devices have been introduced to reduce undesirable emissions. High octane gas is used to prevent knocking. The compression ratio of most engines is fixed at a range of 8 to 9.

[0023] The quantities of fuel and air may be controlled to try to provide an ideal lean mixture which runs hotter. However, with low compression ratios, the lean mixture burns slower resulting in serious loss of power and sometimes may even fail to ignite. If it is too slow, the burning is incomplete and creates pollutants. The engine controls may increase the fuel to create a richer mixture which burns faster. However, the rich mixture burns cooler and still creates pollutants.

[0024] The desired control is to increase compression pressure to the maximum for the current load. With increased pressure, the mixture burns faster. Thus, the ideal mix may be used and pollutants reduced.

[0025] Two distinct advantages are achieved at the same time, pollutants are reduced and economy of operation is improved. The theoretical efficiency is enhanced by reducing the combustion chamber volume with a corresponding rise in compression ratio. This also results in a fully compressed charge at all times; enabling leaner mixtures to burn faster and more completely. This invention teaches an improved arrangement to control an increase in the pressure of an internal com-

bustion engine while the engine is operating.

[0026] The objective is to maintain a constant pressure of the charge in the combustion chamber prior to ignition regardless of engine load, speed or environmental conditions.

[0027] The compression is varied by means of a secondary piston. Under part throttle conditions, the secondary piston moves down to increase the compression ratio.

[0028] Under cruising conditions or part throttle conditions, the engine compression ratio is raised to run in a more fuel efficient manner. Since the charge density is made constant at all throttle conditions, it becomes possible to use extremely lean mixtures reducing pollutants and improving economy. Under heavy load conditions or full throttle acceleration, the engine compression ratio is lowered.

[0029] Another significant result of use of the arrangement is that the high charge density attainable maintains a high flame propagation speed. The ignition timing can then be significantly retarded. This in turn reduces the "negative" work of the rising piston acting against the expanding gases which further improves the fuel economy.

[0030] Figure 10 is a graph showing the effect of compression ratio on the efficiency of a constant-volume engine. The fuel-air-cycle efficiency is seen to increase with compression ratio. The ratio of fuel-air-cycle efficiency to air-cycle efficiency is roughly constant for a given fuel-air ratio. Efficiency is increased as the compression ratio is increased. The objective is to squeeze the maximum mileage from a given amount of fuel by running the engine at the highest possible compression ratio.

[0031] The elegance of the design of the arrangement, and of the improved arrangement disclosed herein, is that it produces a method of attaining step-less variable compression ratio which is virtually maintenance free, stable, noise free, easy to implement and cost effective.

[0032] Referring now to the drawings, there is illustrated in Figure 1 a cross sectional view of an internal combustion engine generally designated 10. The engine has a primary cylinder 101, a cylinder head 102, and a primary piston 103. Other items necessary for the function of the engine such as intake, exhaust valves, rocker arms, rocker arm camshaft, piston rings, crank shaft, connecting rod, etc. are illustrated but not integral to the invention.

[0033] A secondary cylinder 201 is formed in the cylinder head 102 and positioned so that the opening of the secondary cylinder 201 corresponds with a selected part of the volume which comprises the clearance volume at TDC. As illustrated, the opening of the secondary cylinder 201 is fully enclosed within the upper portion of the cylinder head 102 which is opposite the upper surface of the primary piston 103. A secondary piston 203 is mounted within the secondary cylinder 201. The

space within the secondary cylinder 201 and below the secondary piston 203 is added to the clearance volume of the engine 10 in computing the compression ratio. As the secondary piston 203 is lowered along the secondary cylinder 201, the clearance volume is reduced and the compression ratio is increased.

[0034] Cooling of the secondary cylinder 201 and piston 203 may be provided by means of an oil flow which is well known in the art.

[0035] A return spring 204 is attached to the secondary piston 203 to return the secondary piston 203 to the upper-most position of the secondary cylinder 201 and keep it firmly pressed to the surface of the involute. The shaft of the actuator (electric motor) incorporates a spring return mechanism to rotate the shaft in the direction of minimum CR in case of loss of power or control signals to the actuator. The minimum CR position is the configuration utilised upon starting and stopping the engine.

[0036] The secondary piston 203 must incorporate compression rings, lubrication channels, etc. to function but such items are well known in the art, are not part of the invention herein and therefore not shown in detail.

[0037] In the design of Figure 1, the spark plug 104 is illustrated as mounted within the secondary piston 203 with the spark gap between the electrodes extending into the combustion chamber 110 of the primary cylinder 101, cylinder head 102 and primary piston 103. This configuration allows the secondary piston 203 to be as large as possible. This arrangement is more clearly shown by the diagram of Figure 2.

[0038] The spark plug may be mounted elsewhere given a different arrangement of the secondary cylinder 201 and the intake and exhaust valves incorporated in the design. Multiple intake and exhaust valves may be used to increase the efficiency of the engine. But these items are well known in the art.

[0039] Figure 4 shows the spark plug wire 105 from the distributor being connected to the spark plug 104 by means of a connector fitted on the camshaft cover. This could also be performed by providing a service access, hinged door on the camshaft cover. The size, placement and sealing requirements of the door to provide easy access to the spark plugs mounted inside the secondary piston is well known in the art. Alternatively, the camshaft cover could be fitted with cable connectors for passage of cables to the outside of the cover.

[0040] The shaft 301 shown in perspective in Figure 3 may be mounted in bearings on towers and positioned so that the surface of a plurality of involutes 302 are in contact with a plurality of caps 205 for multi-cylinder engines. The shaft 301 is similar to a camshaft which is well known in the art.

[0041] A control device is connected to one end of the shaft 301 and rotates the shaft 301 to a preselected position. As shown in Figure 4, under the condition of the shaft 301 being rotated counter clockwise, the outside surface of the involute 302 will push down upon the cap

205 which lowers the secondary piston 203 thereby decreasing the clearance volume and increasing the compression ratio of the engine 10 to a preselected value for the present operating conditions.

[0042] Fuel and air is input into the cylinder through the intake valve and ignited by the spark plug 104. The resulting explosion places an upward force upon the secondary piston 203 and the primary piston 103. The primary piston 103 will move down and transmit the force through the connecting rod 109 to the crankshaft of the engine 10. The secondary piston 203 will transmit its force through the cap 205 and the involute 302 to the shaft 301. However, because the contact point between the involute 302 and the cap 205 is in line with the axis of the shaft 301, there is very little, if any, torque applied to the shaft 301 to cause the shaft to change position. It is this stability which provides much of the benefit of the prior application WO91/14860 and also the present application. The earlier prior art is very vulnerable to the back pressure changing the control setting. The changes cause the system to vibrate between the desired position and the back pressure position resulting in noise, inefficiency, and wear on the arrangement.

[0043] As described in WO91/14860, what little torque, which may be experienced during periods of high stress, may be further isolated from the control device through the worm gear 502 and drive gear 501 arrangement between the shaft and the servo control device 503 shown in Figure 3. The servo control device 503 is illustrated to be an electric motor but may be a hydraulic drive device.

[0044] The shaft 301 is rigidly mounted on bearings in towers to the cylinder head. Thus the upward force generated on the secondary piston 203 and transmitted through the cap 205 and the involute 302 to the shaft 301 is controlled.

[0045] Figure 4 is another design showing a shaped cap 405 mounted above the secondary piston 203. The secondary piston 203 is kept in rotational alignment within the secondary cylinder 201 by means of a guide 407 and key 406. This keeps the wedge shaped end 408 of the shaped cap 405 of the secondary piston 203 in normal alignment with the surface of the involute. Figure 5 shows the detail of the wedge 408 and the alignment of the cap 408 on the surface of the involute 302. By use of this alignment, the force vector of the shaped cap 405 acts through the centre of the shaft 301 with a resultant zero torque force acting on the shaft 301.

[0046] The control of the position of the shaft may utilize an electric servo motor. As the mechanical positioning apparatus reduces the torque of the back pressure to zero, a hydraulic position control actuator may be used.

[0047] The control means may utilise automatic braking to eliminate overshoot and backlash. The position of the control means may have a simple correspondence to the intake manifold vacuum.

[0048] The intake manifold butterfly may incorporate

a dash pot to damp the throttle response to allow the control system to follow the motion of the intake manifold butterfly valve.

[0049] Figure 9 illustrates a block diagram of a control method. Because it is impractical to measure the pressure in a cylinder while it is in operation, an indirect method to compute the relative amount of charge present in a cylinder is used. A fairly accurate indication is the inlet manifold vacuum. A vacuum manifold sensor produces a signal for input to the logic unit.

[0050] When the vehicle is accelerating or climbing an incline or moving at a very high rate of speed, the manifold vacuum will be relatively low. Intake manifold vacuum is a direct parameter for establishing engine load and a fairly accurate means for determining the amount of charge entering the cylinders.

[0051] Alternatively, the logic unit could combine inputs from several variables such as atmospheric pressure, engine RPM, throttle position, engine temperature, etc. to evaluate current compression ratio.

[0052] Figure 9 illustrates that RPM sensor 920 is another input which may be utilised by the logic unit.

[0053] The position sensor 925 of the actuator 926 indicates to the logic unit 915 the present position of the involute 302 and thus the compression ratio of the engine.

[0054] The reference 927 contains a table established for the engine and vehicle type to allow the logic unit 915 to compare current engine charge, RPM and compression ratio to the desired compression ratio established to produce top efficiency. The logic unit will then calculate a clockwise or counter clockwise position control signal and communicate that signal to the actuator 926. The position sensor 925 provides the feed back to allow the logic unit 915 to determine when the actuator has turned the involute 302 to the position to achieve the desired compression ratio. Upon arrival at the desired position, the logic unit 915 will disengage the actuator 926. A switch may be provided to lock the actuator in its present position to further stiffen the tolerance of the system to backpressure.

[0055] The objective of both the prior disclosure of WO91/14860 and the present invention is to maintain the compression ratio at the highest possible level for the conditions. The only limiting factor is that the pre-ignition pressure does not exceed a maximum tolerable value.

[0056] This process of achieving the optimum compression ratio for the present operation of the engine is essentially continuous. The position of the involute 302 may stay essentially the same for a period of time depending upon the driving conditions.

[0057] As the actuator 926 will require a finite time to position the involute 302, a damping mechanism may be utilised on the main throttle butterfly valve to ensure that it cannot be opened or closed too quickly. The damping action should closely follow the response time of the actuator 926 to allow the system time to "catch

up".

[0058] Alternately, an additional throttle plate under the control of the logic unit may be utilised. Such control systems are well known in the art.

[0059] Figure 6 and 7 show another design of the prior disclosure WO91/14860 having threaded bolts 603 driven by a worm gear 502 moving a drive gear 501 on the shaft 301. The bolt 603 replaces the action of the involute 302. A second worm gear 602 mounted on the shaft 301 engages a second drive gear 601, it pushes down on the cap 205 mounted on the secondary cylinder 203. The back pressure of the secondary cylinder 203 against the bolt 603 will create some torque force on the bolt 603 and tend to unscrew it. However, the torque on the second drive gear 601 against the second worm gear 602 transmitted as torque on the drive gear 501 to the worm gear 502 is significantly reduced by a pre-selected gearing ratio so that any rearward movement of the bolt 603 is controlled.

[0060] The gear head portion of the bolt 603 may be attached to the threaded portion of the bolt 603 by means of a key inserted into a guide. This may increase the strength of the arrangement over a one-piece moulded or machined part.

[0061] Figure 8 illustrates yet another prior art design in which the position of each involute 815 is independently controlled by a separate logic unit 816 or one channel of a multi channelled control unit.

[0062] The control unit 816 is connected to the servo motor actuator 810 and directs it to rotate in the desired direction. A worm gear 813 is mounted on the shaft 817 of the servo motor actuator 810 and engaged with gear 814. Gear 814 is formed as part of the involute 815 and rotatably mounted to the cylinder head of the motor to be controlled. The servo motor position sensor 811 provides input to the logic unit 816. The control signal from the logic unit 816 to the servo motor actuator is terminated when the position sensed by the servo motor position sensor 811 indicates that the involute 815 has moved the secondary piston 203 to the pre-selected position. The servo limit switch 812 protects the control system from rotating beyond pre-selected limits by disengaging the servo motor actuator 810. The limit switch 812 may be incorporated into a fail safe position circuit to allow the servo motor actuator 810 to move the involute 815 to the minimum compression ratio position upon loss of the logic unit 816 or selected inputs to the logic unit 816.

[0063] Figure 11 illustrates yet another prior art design in which the position of each involute 1115 is independently controlled by a separate logic unit 1116 or one channel of a multi channelled control unit. The involute 1115 which controls the position of a cap 205 as described above is mounted on the shaft 1117 of the servo motor actuator 1110 in the same manner as described above.

[0064] Figure 12 illustrates yet another prior art design in which the position of each threaded bolt 1206 is

independently controlled by a separate logic unit 1216 or one channel of a multi-channelled control unit. The rotated position of the threaded bolt 1206 which controls the position of the cap 205, as described above, corresponds to the rotation of the worm gear 1202 mounted on shaft 1217 of the servo motor actuator 1210 in the same manner as described above.

[0065] Figures 13 through 17 illustrate an embodiment according to the present invention, which may incorporate some of the features of the prior designs if desired. According to the invention, the positioning of the involute is achieved with minimum power because the involute is advanced only during times of low pressure in the combustion chamber.

[0066] Subsequent to the filing of the application, it has been noted that Figures 13-17 do not show all of the features described below in relation thereto. A supplementary sheet of drawings showing the features referred to below which are not expressly shown in Figures 13-17 have been prepared and are open to public inspection in the official file. The sheet is entitled "Supplementary Drawings" and has been filed with the representative's letter dated 26 August 1998.

[0067] Figure 13 depicts a base shaft 1301 on which is formed a ratchet 1302.

[0068] Figure 15 depicts an involute 1501 in which a plurality of notches 1503 are formed at a pre-selected radius. A first wall 1504 is formed in the centre of the involute and a click/lock mechanism 1502 is mounted in the inside surface of the first wall 1504. One involute 1501 with click/lock mechanism 1502 is mounted onto the base shaft 1301 over each ratchet 1302.

[0069] Now referring to Figure 14, a sleeve 1401 has a preselected inside diameter to fit over the base shaft 1301. The sleeve 1401 is formed with fingers 1402 which can be mounted through the notches 1503 of the involute 1501. A spring 1403 is mounted on the sleeve 1401 to communicate torque from the sleeve 1401 to the involute 1501 upon the rotational movement of the sleeve 1401. The position of the sleeve 1401 is controlled by a servo motor actuator or hydraulic actuator as described above in relation to certain of the prior art designs. A gear 1404 is formed on a selected portion of the sleeve 1401 to allow rotational information to be communicated between the actuator and the sleeve 1401 by such means as a worm gear or directly coupled gear transmission.

[0070] Upon movement of the shaft 1401 in the desired direction and the loading of the spring 1403, the arrangement is primed to have the involute move in the desired direction upon the occurrence of pressure in the combustion chamber, as communicated to the involute 1501 by the secondary cylinder described above, being lower than the spring 1403 coefficient. This movement of the involute 1501 relieves the tension on the spring 1403. The involute 1501 is prevented from rotating in the opposite direction by a click/lock mechanism 1502 mounted in the involute 1501 and engaging the ratchet

1302 on the base shaft 1301. The granularity of the teeth in the ratchet 1302 is of a pre-selected size. In the preferred embodiment, the granularity is small to allow the rotation of the involute 1501 to appear essentially continuous even though it is actually step wise.

[0071] Since many individual involutes 1501 may be mounted along the arrangement, a "double" or two-stage bearing may be used in the middle for greater support. Such a bearing is depicted in Figure 16. The bearing may be of the oil pressure type or a roller/ball bearing type. The bearing is comprised of a rotating inner bearing 1601 mounted within an outer bearing 1602 mounted on a journal 1603 which is positioned to support the arrangement. The inner bearing supports the base shaft 1301 while sections of the sleeve 1401 are attached to the outer bearing 1602.

[0072] Figure 17 shows the entire embodiment assembled into arrangement 17. A stepper motor 1702 is depicted as having a transmission gear 1703 engaging the drive gear 1404 of the sleeve 1401. The involute 1501 is rotated into the desired forward position under a controller connected to the stepper motor 1702. To reverse the position of the involute 1501, a clutch mechanism 1701 at one end of the base shaft 1301 is released which will cause the base shaft 1301 to rotate in the direction of lower compression.

[0073] Since certain changes may be made in the above apparatus without departing from the scope of the invention herein involved, it is intended that all matter contained in the above description, as shown in the drawing Figs. 13-17, shall be interpreted in an illustrative, and not a limiting sense.

Claims

1. An improved arrangement for a variable compression internal combustion engine (10) having a plurality of primary cylinders (101) in each of which a primary piston (103) slides, each piston being driven by a crank shaft by means of a connecting rod, the engine having a cylinder head (102), the arrangement comprising:

a plurality of secondary cylinders (201) carried by the cylinder head in a position communicating with respective ones of said primary cylinders;

a secondary piston (203) slidably mounted within each said secondary cylinder and having a first end with a cap (205,405) and a second end adjacent said primary piston (103), said second end and the primary piston forming a combustion chamber of a volume which may be varied and which can be subjected to fuel explosion pressure;

actuating means (926) mounted on said cylinder head for reciprocating said secondary piston within said secondary cylinder, said actuating means comprising a control means and a rotational shaft positioned by said control means;

a plurality of involute surfaces (302, 602, 815, 1115, 1501) associated with said shaft, one said involute surface (302, 602) being adjacent each said cap;

a return spring mounted between said secondary piston and said cylinder head whereby said cap is urged against said involute surface forming a region of contact between said cap and said involute surface, said contact region being positioned to be on a line normal to the axis of said shaft,

drive means communicating drive from the control means to the involutes whereby the involutes may be rotated in a preselected direction under the influence of said control means;

characterised in that

said shaft is a base shaft which has a plurality of ratchets having a preselected granularity;

said involute surfaces each have a plurality of notches formed at a preselected radius, have a first wall formed at a second preselected radius and incorporate click/lock means mounted in said first wall, said click/lock means engaging a respective ratchet whereby to prevent rotation of said involute in the direction opposed to said preselected direction;

a sleeve with a preselected inside diameter larger than said base shaft is mounted over said base shaft;

a plurality of fingers is formed in said sleeve and are engagable with said notches;

a spring having a preselected coefficient is mounted on at least one of said fingers between the sleeve and a respective involute notch whereby upon the rotation of said sleeve said spring is loaded to rotate said involute in the preselected direction at least one step along said ratchet granularity under the condition of the pressure in said combustion chamber being lower than said preselected coefficient.

2. An arrangement according to claim 1 characterised in that the means inhibiting movement of said sec-

ondary piston in a direction to increase the volume of the combustion chamber includes a clutch mechanism (1701).

3. An arrangement according to claim 1 or claim 2 characterised in that said control means comprises a servo motor actuator (926) and a logic unit (925) responsive to signals from engine sensors such that said servo motor can be activated to move said secondary piston to a selected position and such that said servo motor actuator can be disengaged upon the selected position being reached.
4. An arrangement according to any of claims 1-3 characterised in that the cap (205,405) of said secondary piston is formed as a wedge (408), in that a key (406) is mounted in the side of said secondary piston, and in that walls forming a slot in said secondary cylinder are engageable by said key whereby said secondary piston is aligned within said secondary cylinder.
5. An arrangement according to claim 1 or claim 2 characterised in that said control means comprises a servo motor actuator (810), servo motor position sensor (811), a position limit switch (812) whereby said servo motor actuator is disengaged under the condition of said shaft being rotated to pre-selected limit positions, an intake manifold pressure sensor (910) mountable in the intake manifold of the engine being controlled, and further including an RPM sensor (920) connected to said logic unit whereby said logic unit selects the position of said secondary piston based upon the additional information of the RPM of the engine being controlled.
6. An arrangement according to claim 1 or claim 2 characterised in that said control means comprises an hydraulic drive actuator, an hydraulic drive position sensor, a position limit switch whereby said hydraulic drive actuator is disengaged under the condition of said shaft being rotated to preselected limit positions, an intake manifold pressure sensor mountable in the intake manifold of the engine being controlled, and a logic unit responsive to signals from said manifold pressure sensor and said hydraulic drive position sensor whereby said hydraulic drive actuator is activated to move said secondary piston to a preselected position within said secondary cylinder, and further including an RPM sensor connected to said logic unit whereby said logic unit selects the position of said secondary piston based upon the additional information of the RPM of the engine being controlled.

Patentansprüche

1. Verbesserte Anordnung für einen Verbrennungsmotor (10) mit veränderbarer Verdichtung mit einer Vielzahl von Primärzylindern (101), bei denen in jedem jeweils ein Primärkolben (103) gleitend angeordnet ist, jeder Kolben über eine Pleuelstange von einer Kurbelwelle getrieben wird und der Motor einen Zylinderkopf (102) aufweist, wobei sich die Anordnung aus folgenden Teilen zusammensetzt:

einer Vielzahl von Sekundärzylindern (201), die vom Zylinderkopf in einer Lage gehalten werden, in der sie mit den jeweiligen Primärzylinder kommunizieren;

einem gleitend in jedem der besagten Sekundärzylinder angeordneten Sekundärkolben mit einer Kappe (205, 405) an einem Ende und einem an dem besagten Primärkolben (103) anliegenden zweiten Ende, wobei besagtes zweites Ende und der Primärkolben eine Brennkammer mit einem Volumen bilden, das veränderbar ist und durch eine Brennstoffexplosion druckbeaufschlagt werden kann;

am besagten Zylinderkopf montierte Mittel (926) für die Einstellung der Kolbenbewegung des besagten Sekundärkolbens in besagtem Sekundärzylinder, wobei besagte Mittel für die Einstellung aus einem Mittel für die Regelung und einer umlaufenden, von dem besagtem Mittel zur Regelung verstellten Welle bestehen;

einer Vielzahl von der besagten Welle zugeordneten Evolventenflächen (302, 602, 815, 1115, 1501), wobei je eine der besagten Evolventenflächen (302, 602) an jeder besagten Kappe liegt;

einer zwischen besagtem Sekundärkolben und besagtem Zylinderkopf montierten Rückstellfeder, mit der die besagte Kappe gegen die besagte Evolventenfläche gedrückt wird und dabei einen Kontaktbereich zwischen der besagten Kappe und der besagten Evolventenfläche bildet der auf einer Linie liegt, die lotrecht zur Achse der besagte Welle verläuft;

Antriebsmittel für die Übertragung von Leistung vom Mittel zur Regelung zu den Evolventenflächen, so daß sich diese unter Einfluß der besagten Mittel zur Regelung in einer vorgegebenen Drehrichtung drehen können;

dadurch gekennzeichnet, daß

es sich bei der Welle um eine Hauptwelle mit

einer Vielzahl von Zahnsperren mit vorgegebener Körnigkeit handelt;

besagte Evolventenflächen jeweils eine Vielzahl von Kerben, die auf einem vorgegebenen Radius ausgebildet sind, eine erste Wand, die an einem zweiten, vorgegebenen Radius ausgebildet ist, sowie in der ersten besagte Wand angebrachte Rasten/Verriegelungsmittel aufweisen, wobei besagte Rasten/Verriegelungsmittel eine entsprechende Klinke einrasten lassen, die ein Drehen der besagten Evolventenfläche in einer der besagten vorgewählten Drehrichtung entgegengesetzten Richtung verhindert;

eine Muffe mit einem vorgegebenen Innendurchmesser, der größer ist als der der besagten Hauptwelle, über der besagten Hauptwelle angebracht ist;

in der besagten Muffe eine Vielzahl von Fingern gebildet werden, die in die besagten Kerben eingreifen können;

eine Feder mit vorgegebenem Federkoeffizienten an wenigstens einem der besagten Finger zwischen der Muffe und einer entsprechenden Evolventenkerbe angebracht ist, wodurch bei Drehung der besagten Muffe die besagte Feder so vorgespannt wird, daß besagte Evolventenfläche entlang den besagten, körnigen Zahnsperren um wenigstens einen Schritt in der vorgewählten Drehrichtung gedreht wird, wozu jedoch der Druck in der besagten Brennkammer niedriger sein muß als der besagte, vorgewählte Federkoeffizient.

2. Anordnung gemäß Anspruch 1, dadurch gekennzeichnet, daß die Mittel zur Verhinderung einer Bewegung des besagten Sekundärkolbens in einer das Volumen der Brennkammer vergrößern Richtung eine Kupplungsmechanik (1701) mit einbeziehen.
3. Anordnung gemäß Anspruch 1 oder Anspruch 2, dadurch gekennzeichnet, daß besagtes Mittel zur Regelung einen Servomotor-Stellantrieb (926) und ein Logikteil (925) aufweist, die auf Signale von Motoren Sensoren so ansprechen, daß der besagte Servomotor zur Verstellung des besagten Sekundärkolbens in eine vorgegebene Position aktiviert werden kann, und so daß der besagte Servomotor-Stellantrieb nach Erreichen der gewählten Position ausgeklinkt werden kann.
4. Anordnung gemäß einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß die Kappe (205, 405)

des besagten Sekundärkolbens durch Anbringen eines Keils (406) in der Seite des besagten Kolbens eine keilförmige Form (408) erhält und der besagte Keilteil in eine im besagten Sekundärzylinder durch die Wände ausgebildete Nut eingreifen kann, wodurch der besagte Sekundärkolben in dem besagten Sekundärzylinder ausgerichtet bleibt.

5. Anordnung gemäß Anspruch 1 oder Anspruch 2, dadurch gekennzeichnet, daß besagtes Mittel zur Regelung einen Servo-Stellmotor (810), einen Servomotor Positionssensor (811) und einen Positionsendschalter (812) zum Ausrücken des Servo-Stellmotors beim Drehen der besagten Welle in vorgegebene Endstellungen, sowie einen im Ansaugkrümmer des zu regelnden Motors montierbaren Ansaugkrümmer-Drucksensor (910) aufweist, sowie des weiteren einen an den besagten Logikteil angeschlossenen Drehzahlsensor (920), wobei der besagte Logikteil die Position des besagten Sekundärkolbens anhand der weiteren Information über die Drehzahl des geregelten Motors wählt.
6. Anordnung gemäß Anspruch 1 oder Anspruch 2, dadurch gekennzeichnet, daß besagtes Mittel zur Regelung einen hydraulischen Stellantrieb, einen Sensor für die Stellung des hydraulischen Stellantriebs, einen Grenzscharter zur Abschaltung des besagten Hydraulikstellteils nach dem Drehen der besagten Welle in vorgegebene Grenzstellungen, einen Ansaugkrümmer-Drucksensor zur Montage im Ansaugkrümmer des geregelten Motors und einen auf Signale des besagten Ansaugkrümmer-Drucksensors und des Positionssensors für den besagten Hydraulik-Stellantrieb ansprechenden Logikteil aufweist, wobei der besagte Hydraulik-Stellantrieb aktiviert wird, um den besagten Sekundärkolben im besagten Sekundärzylinder in eine vorgegebene Position zu bewegen, sowie des weiteren einen an den besagten Logiksensor angeschlossenen Drehzahlsensor, wobei besagter Logikteil die Position des besagten Sekundärkolbens anhand der zusätzlichen Information über die Drehzahl des geregelten Motors wählt.

Revendications

1. Un agencement amélioré pour un moteur à combustion interne à compression variable (10) ayant plusieurs cylindres primaires (101) dans chacun desquels coulisse un piston primaire (103), chaque piston étant mû par un vilebrequin au moyen d'une bielle, le moteur ayant une culasse (102), l'agencement comprend :

plusieurs cylindres secondaires (201) portés

par la culasse dans une position communiquant respectivement avec chacun desdits cylindres primaires ;

un piston secondaire (203) coulissant monté dans chacun desdits cylindres secondaires et ayant la première extrémité munie d'une calotte (205, 405) et la seconde extrémité adjacente audit piston primaire (103), ladite seconde extrémité et ledit piston primaire formant une chambre de combustion d'un volume qui peut varier et qui est soumis à la pression de l'explosion de fuel ;

connecteurs de manoeuvre (926) montés sur ladite culasse pour animer d'un mouvement de va-et-vient ledit piston secondaire à l'intérieur dudit cylindre secondaire, lesdits connecteurs de manoeuvre comprenant un dispositif de commande et un arbre de rotation positionné par ledit dispositif de commande ;

plusieurs surfaces à développante (302, 602, 815, 1115, 1501) associées audit arbre, l'une desdites surfaces à développante (302, 602) étant adjacente à chacune desdites calottes ;

un ressort de rappel monté entre ledit piston secondaire et ladite culasse tandis que ladite calotte est pressée contre ladite surface à développante formant ainsi une zone de contact entre ladite calotte et ladite surface à développante, ladite zone de contact étant placée de façon à être alignée normalement sur l'axe dudit arbre ;

des éléments d'entraînement transmettant l'entraînement du dispositif de commande aux développantes tandis que les développantes peuvent être pivotées dans une direction prédéterminée sous l'action dudit dispositif de commande ;

caractérisé par le fait que

ledit arbre est un arbre de base qui a plusieurs rochets ayant une granulation prédéterminée ;

chacune desdites surfaces à développante a plusieurs encoches formées selon un angle prédéterminé, une première paroi formée selon un second angle prédéterminé et est pourvue d'un dispositif de cliquet-verrou monté sur ladite première paroi, ledit dispositif de cliquet-verrou s'engrangent respectivement dans une encoche, pour empêcher la rotation de ladite développante dans la direction opposée à ladite direction prédéterminée ;

une chemise d'arbre d'un diamètre intérieur prédéterminé inférieur a celui dudit arbre de base est montée sur ledit arbre de base ;

plusieurs ergots sont formés sur ladite chemise d'arbre et s'engrangent dans lesdites encoches ;

un ressort d'un coefficient prédéterminé est monté sur au moins l'un desdits ergots entre la chemise d'arbre et l'encoche respective de la développante, tandis que sur rotation de ladite chemise, ledit ressort est armé pour faire pivoter ladite développante dans ladite direction prédéterminée au moins d'un degré le long de la granulation dudit rochet à condition que la pression dans ladite chambre de combustion soit plus basse que ledit coefficient prédéterminé.

2. Un agencement conformément à la requête 1, caractérisé par le fait que le dispositif bloquant le mouvement dudit piston secondaire dans une direction pour augmenter le volume de la chambre de combustion comprend un mécanisme d'embrayage (1701)

3. Un agencement conformément à la requête 1 ou 2, caractérisé par le fait que ledit dispositif de commande comprend un actionneur de servomoteur (926) et une unité logique (925) réagissant aux signaux des capteurs du moteur de telle sorte que ledit servomoteur puisse être actionné pour placer ledit piston secondaire dans une position déterminée et de telle sorte que ledit actionneur de servomoteur puisse être débrayé par ladite clef, ce par quoi ledit piston secondaire est aligné dans ledit cylindre secondaire.

4. Un agencement conformément à l'une des requêtes 1 à 3, caractérisé par le fait que la calotte (205, 405) dudit piston secondaire est en forme de coin (408) sur lequel est montée une clef (406) du côté dudit piston secondaire, et dans lequel des parois formant une rainure dans ledit cylindre secondaire peuvent être engrangées par ladite clef tandis que ledit piston secondaire est aligné à l'intérieur dudit cylindre secondaire.

5. Un agencement conformément à la requête 1 ou 2, caractérisé par le fait que ledit dispositif de commande comprend un actionneur de servomoteur (810), un capteur de position du servomoteur (811), un interrupteur de fin de course (812), au moyen de quoi ledit actionneur de servomoteur est débrayé à condition que ledit arbre soit pivoté dans les positions limite prédéterminées, un capteur de pression de la tubulure d'admission (910) à monter dans la

tubulure d'admission du moteur à commande,
 et en outre, comprenant un capteur de régime du
 moteur (920) relié à ladite unité logique, ce par quoi
 ladite unité logique sélectionne la position dudit pis-
 ton secondaire sur la base de l'information supplé- 5
 mentaire du capteur de régime du moteur comman-
 dé.

6. Un agencement conformément à la requête 1 ou 2,
 caractérisé par le fait que ledit dispositif de com- 10
 mande comprend un actionneur d'entraînement hy-
 draulique, un capteur de position de l'entraînement
 hydraulique, un interrupteur de fin de course, au
 moyen de quoi ledit actionneur de l'entraînement 15
 hydraulique est débrayé à condition que ledit arbre
 soit pivoté dans les positions limite prédéterminées,
 un capteur de pression de la tubulure d'admission
 à monter dans la tubulure d'admission du moteur
 commandé, et une unité logique réagissant aux si- 20
 gnaux des capteurs de pression de la tubulure d'ad-
 mission et dudit capteur de position de l'entraîne-
 ment hydraulique de telle sorte que ledit actionneur
 de l'entraînement hydraulique soit actionné pour
 placer ledit piston secondaire dans une position 25
 prédéterminée à l'intérieur dudit cylindre secondai-
 re.
 et en outre, comprenant un capteur de régime du
 moteur relié à ladite unité logique, ce par quoi ladite
 unité logique sélectionne la position dudit piston se- 30
 condai-
 re sur la base de l'information supplémen-
 taire du capteur de régime du moteur commandé.

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Fig. 1.

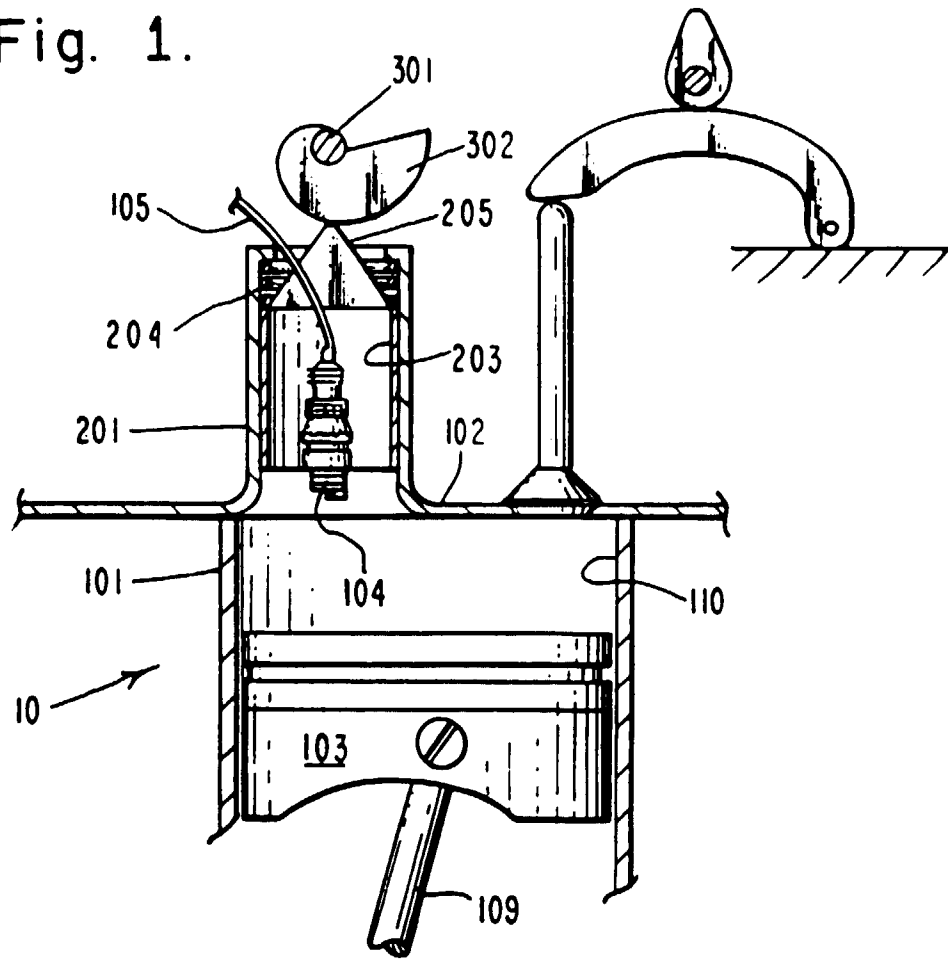
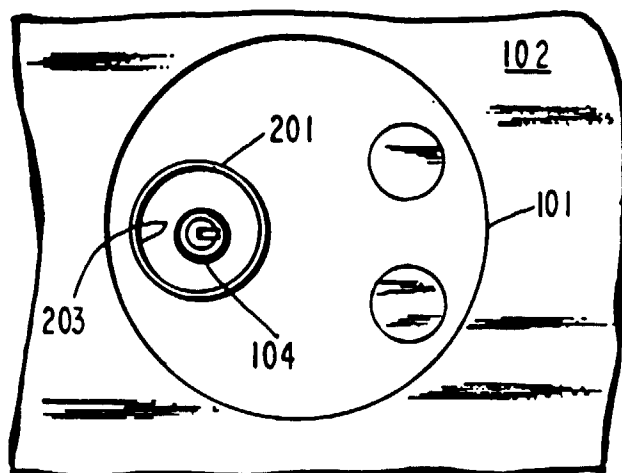


Fig. 2.



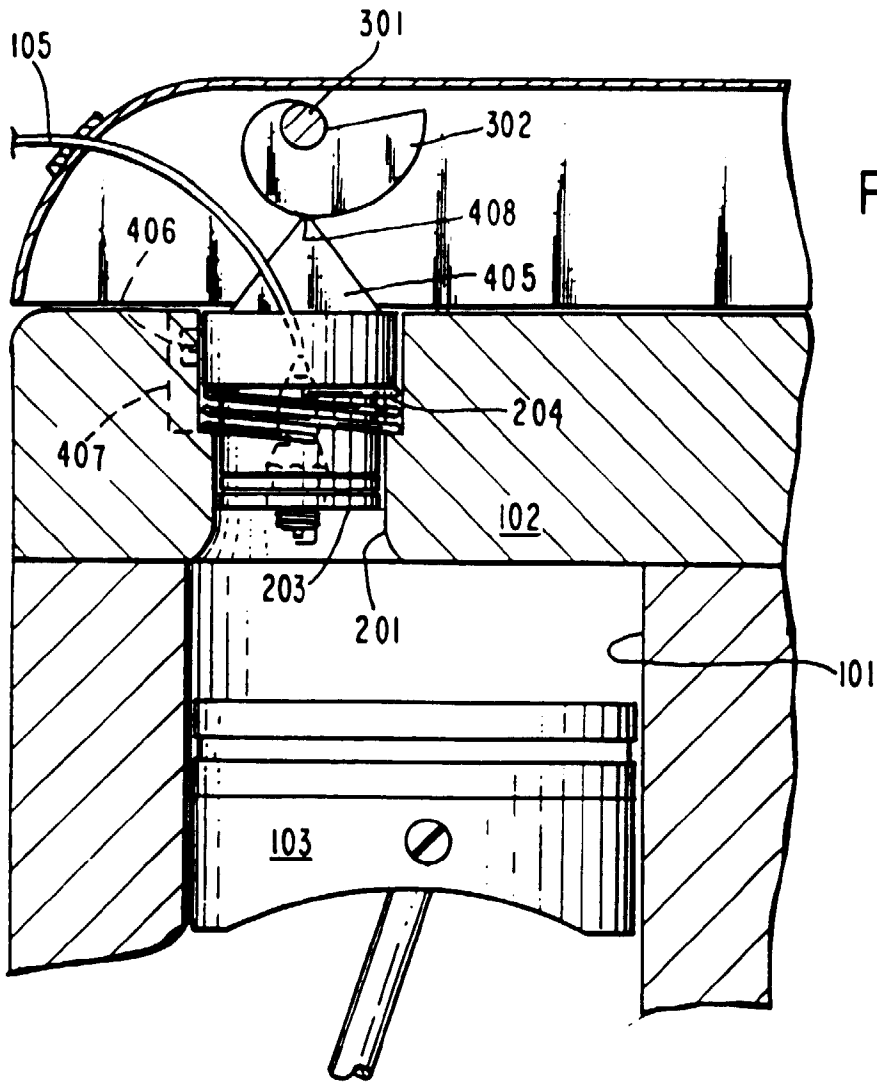


Fig. 4.

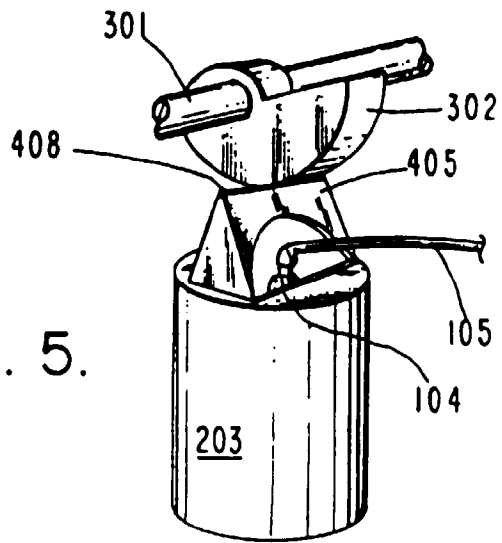


Fig. 5.

Fig. 6.

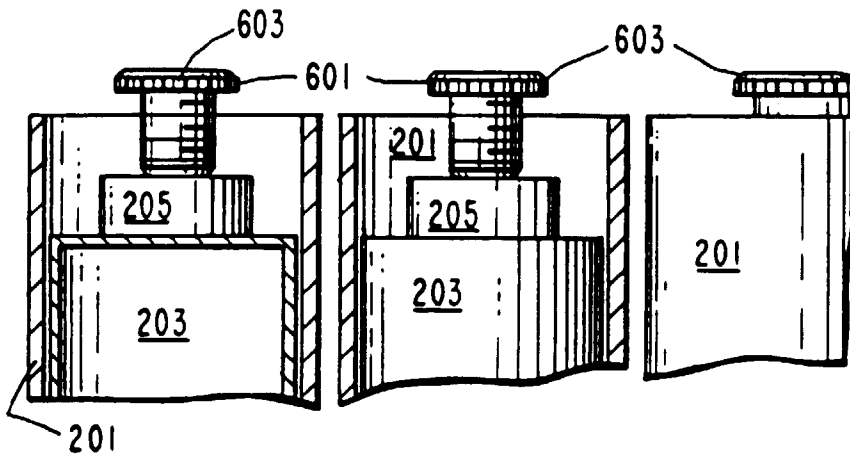
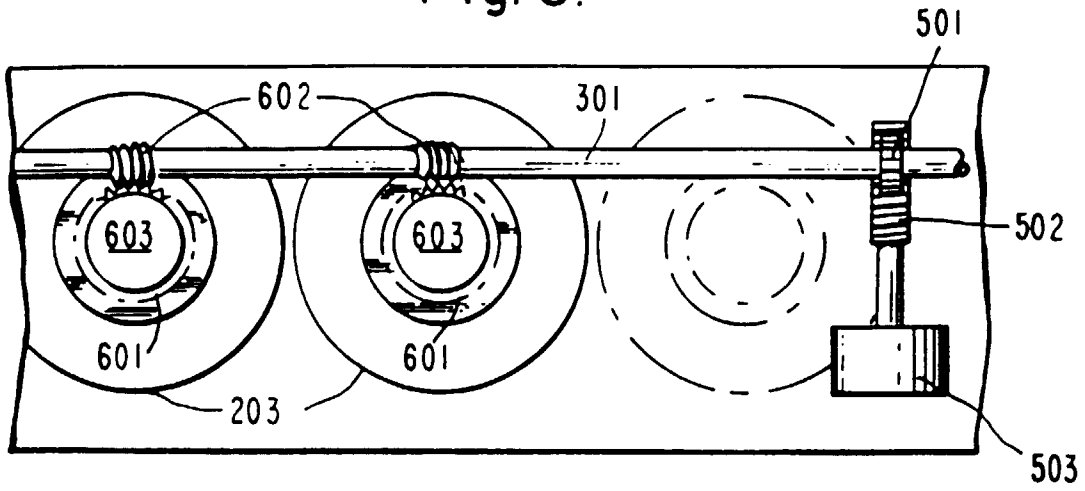


Fig. 7.

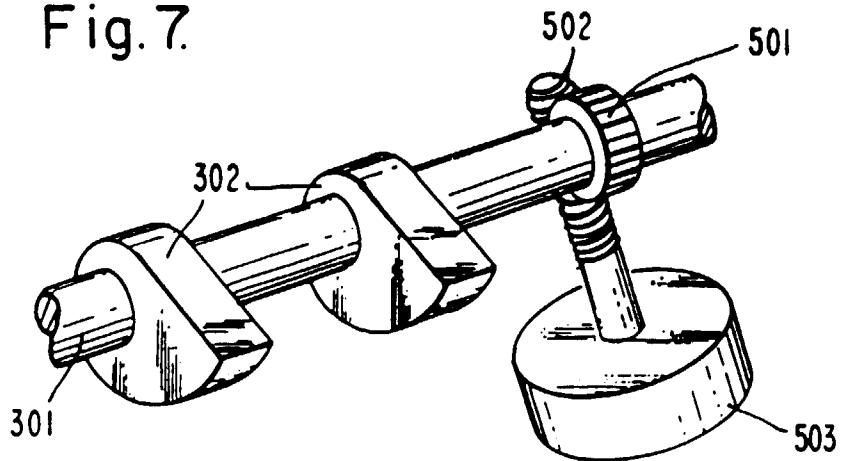


Fig. 3.

Fig. 9.

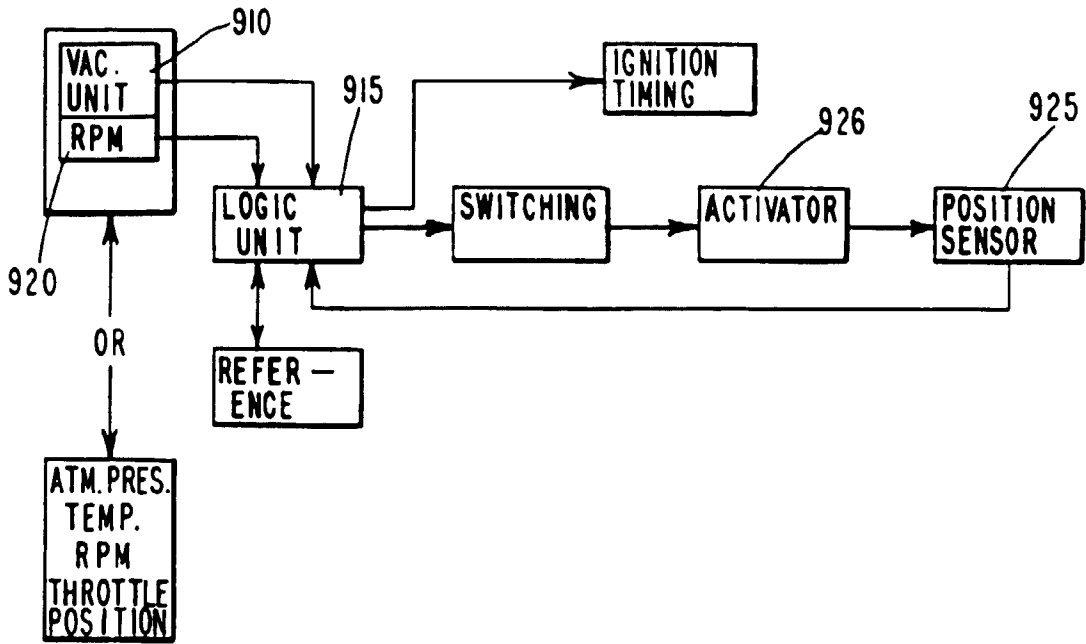


Fig. 10.

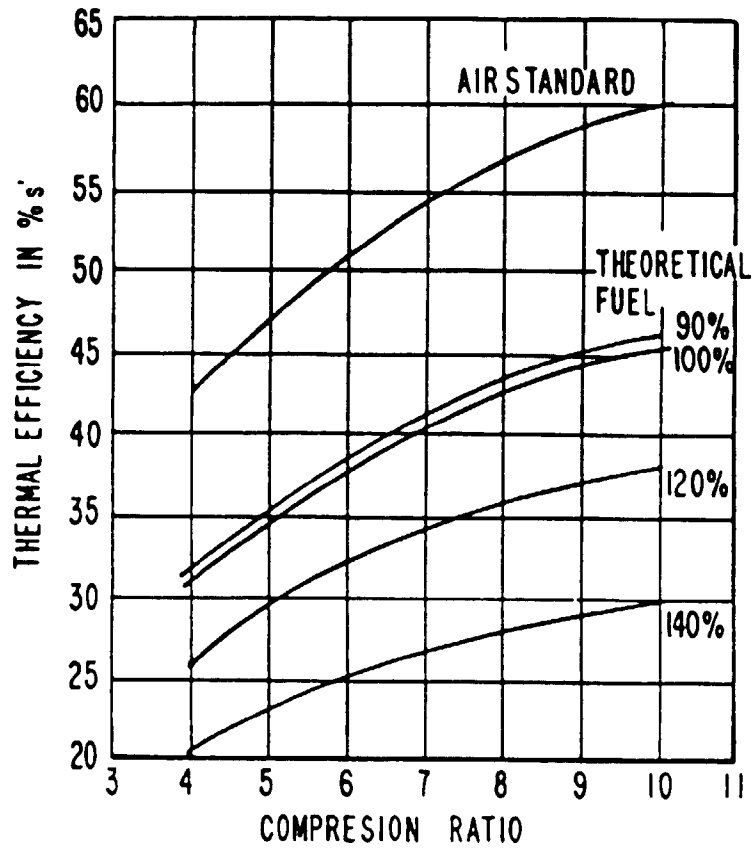


Fig. 8.

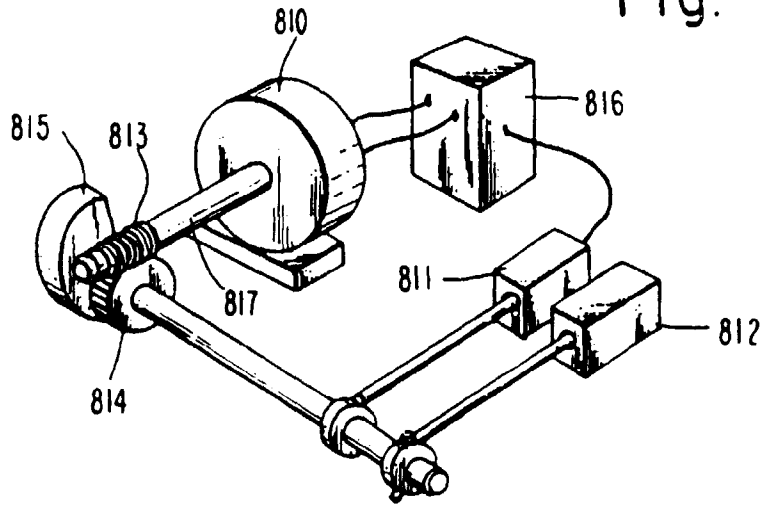


Fig. 11.

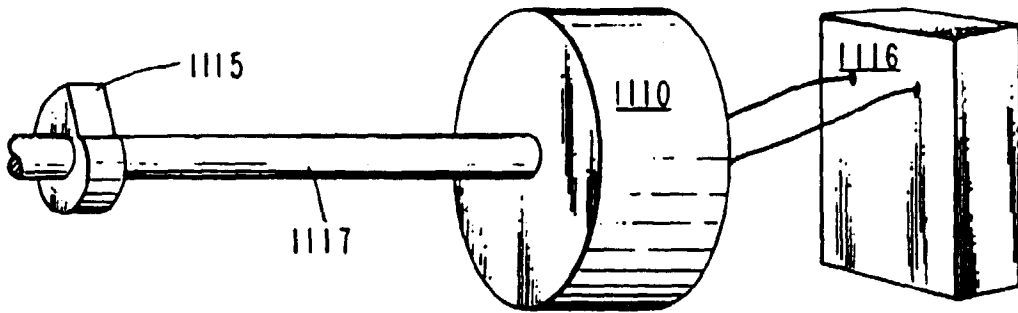


Fig. 12.

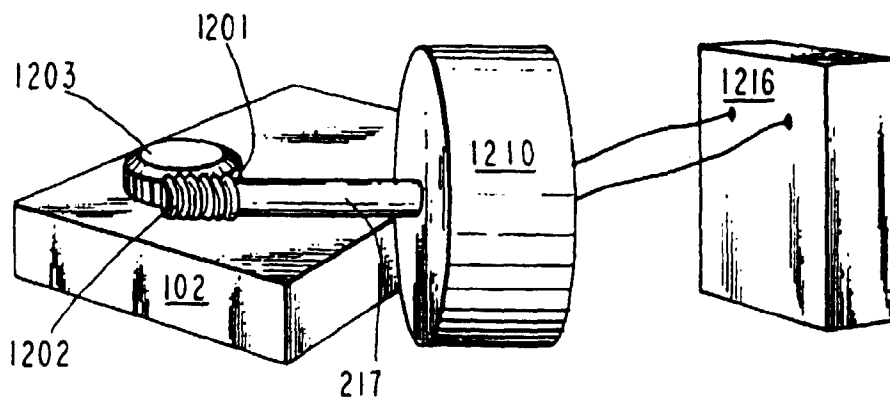


Fig. 13.

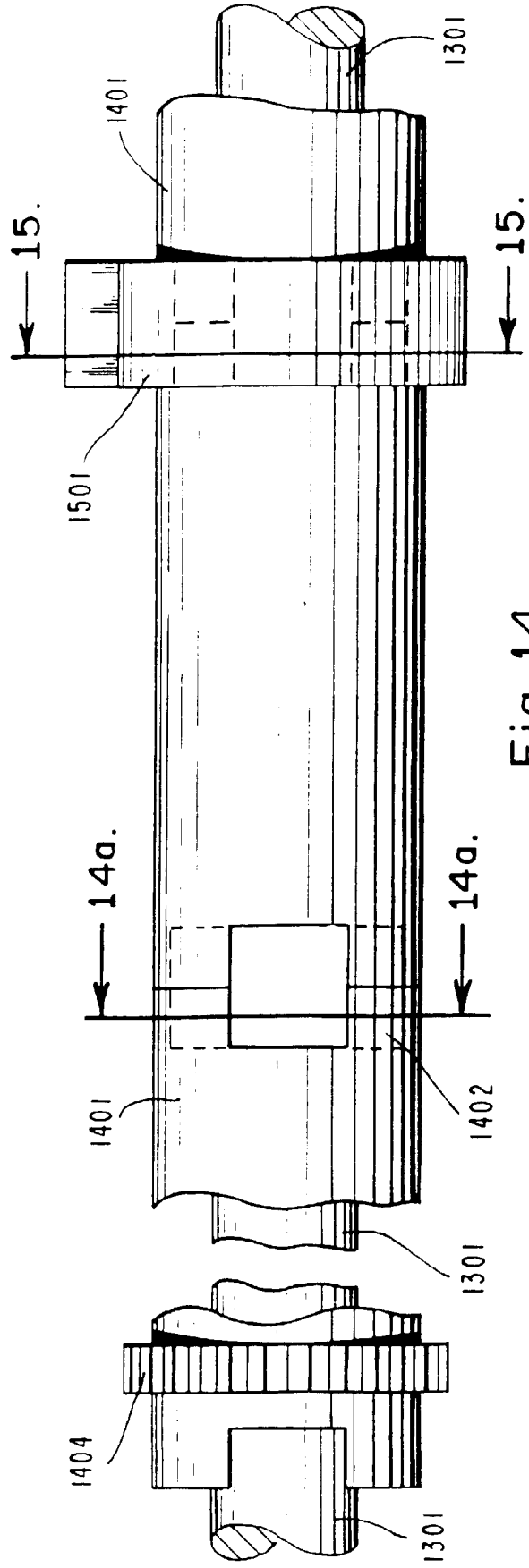
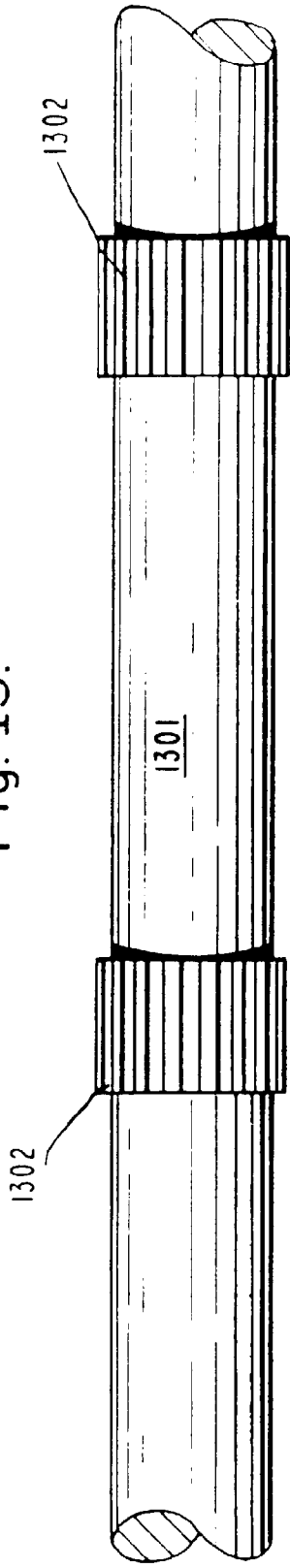


Fig. 14.

Fig. 15.

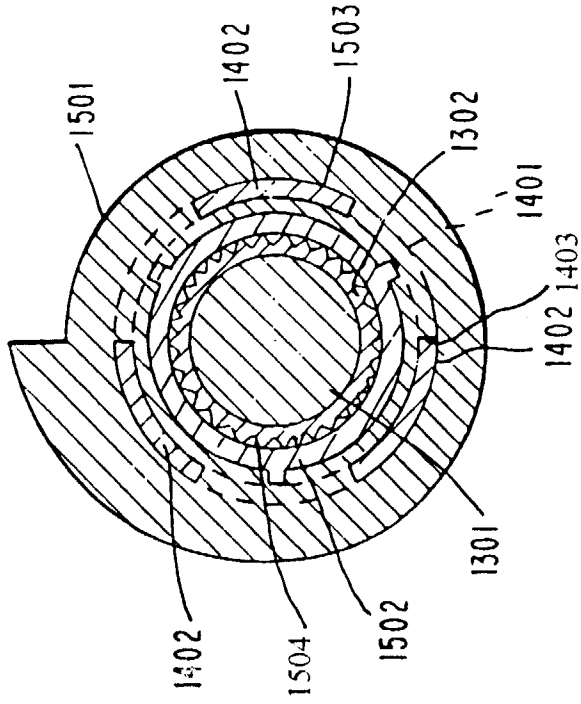


Fig. 14a.

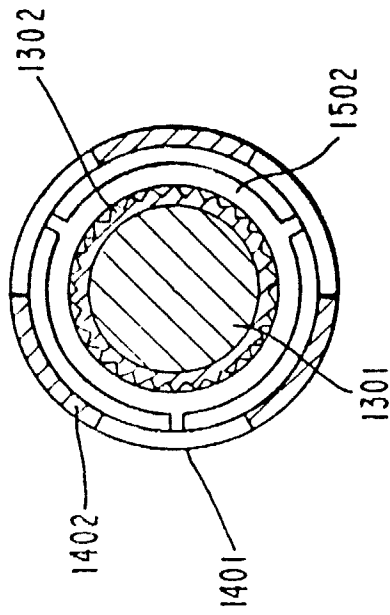
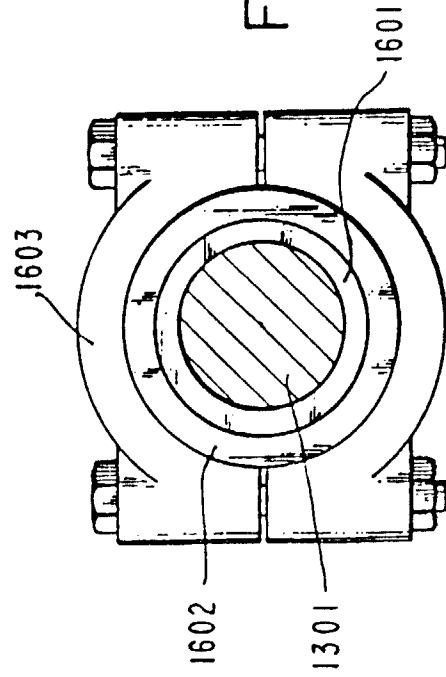


Fig. 16.



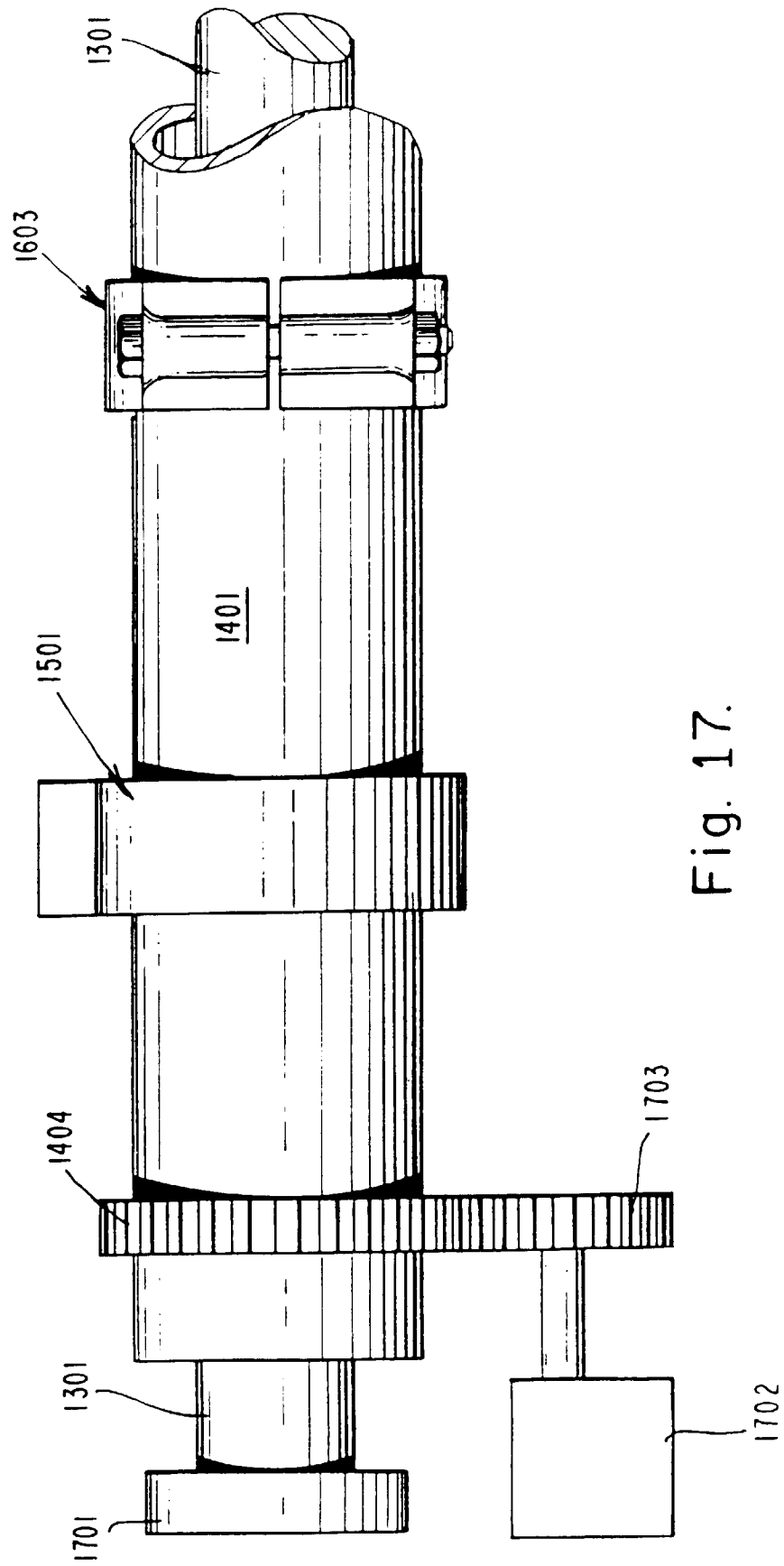


Fig. 17.