(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 037 269**
A1

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 81301342.2

(22) Date of filing: 27.03.81

(51) Int. Cl.³: F 01 L 13/00
F 02 D 17/02

(30) Priority: 28.03.80 CA 348753
14.11.80 CA 348753

(43) Date of publication of application:
07.10.81 Bulletin 81/40

(84) Designated Contracting States:
AT BE CH DE FR GB IT LI LU NL SE

(71) Applicant: ENGINE CONTROL INDUSTRIES LTD.
1 Place Ville Marie Suite 2707 P.O. Box 1631 Station A
Montreal Quebec H3C 3A2(CA)

(72) Inventor: Tamas, Jozsef
3610 MacTavish Street
Apt. 16, Montreal(CA)

(72) Inventor: Petrillo, Gino
7447 Comb Street
St. Leonard, Quebec(CA)

(72) Inventor: Tamas, Laszlo
3610 MacTavish Street
Apt. 16, Montreal(CA)

(74) Representative: Hartley, David et al,
c/o Withers & Rogers 4 Dyer's Buildings Holborn
London, EC1N 2JT(GB)

(54) Engine cylinder cutout system.

(57) A novel engine cylinder cutout system for internal combustion engines, e.g., gasoline engines, or diesel engines, is provided herein. The system may be operated either by fluids, e.g., pneumatic or hydraulic, or mechanically. The system includes a plurality of uncoupling devices (20) (equal in number to the number of cylinders or valves in the engine) for selectively coupling or uncoupling valve operators (14) from their respective driving member (23). Fluid or mechanical shifting mechanisms (37, 47) are selectively actuated to provide variation of valve operation from normal cycles allowing the valves (15) to be opened or closed as required, to cut off operation (to uncouple selective one or ones of the operators) so that selected exhaust valves are open while the associated selected intake valves are closed. A retentive control means (39, 49) is provided responsive to the status of vehicle operating parameters for randomly initiating operation of shifting mechanism (37, 47) associated with each such uncoupling device (20) for random initial activation thereof, thereby selectively cutting out one or more cylinders to assure operation of the cylinders in the engine a substantially even average amount of time.

This cutout system can desirably operate independently of the oil pressure system of the engine, although it can also use such system. The retentive control means also assures even cutout of the cylinders during different sequences of operation so that engine wear is reduced, and any such wear is even.

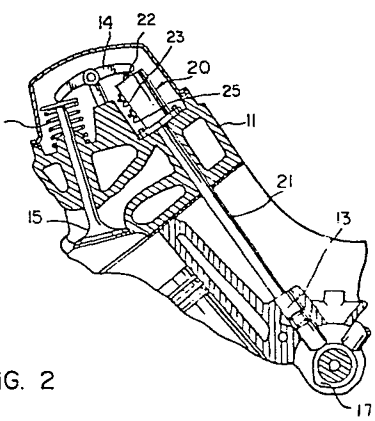

FIG. 2

EP 0 037 269 A1

(a) Title of the Invention

An engine cylinder cutout system and control therefor

(b) Technical Field to Which the Invention Relates

This invention relates to an improvement in an engine cylinder cutout system including (a) a plurality of uncoupling devices for selectively coupling or uncoupling associated valve operators from respective driven members, the cutout devices being selectively operable for normal operation enabling the normal cycle of operation of the valve operators and for cutout operation interrupting the normal cycle in any phase of its operation, the plurality of cutout devices being equal in number to the number of cyclinders or valves in the engine, and (b) shifting mechanism for selectively operating the cutout devices to provide variation of valve operation from normal cycles, allowing the valves to be opened or closed as required, and cutout operation, uncoupling selective one or ones of the valve operators so that selected exhaust valves are open while associated selected intake valves are closed. More particularly, it relates to an improved control means to enable selective operation of the cylinder cutout system which is functional by fluid pressure or by mechanical means.

(c) Relevant Background Art

Internal combustion engines that operate on less than full cylinder complement to achieve fuel economy have been under development since the beginning of the 1900's. Their commercial implementation has been impractical due to the complexity and corresponding high costs of existing systems, as well as unimpressive reliability records.

Cylinder cutout systems are intended to be used to enable multiple cylinder engines to function with fewer than all of their cylinders, thereby to conserve fuel when less than full power operation of the engine is necessary. Thus, a larger displacement engine in effect can be converted in service to a smaller displacement engine, with the power loss incidental to such reduction being acceptable under light load conditions. Cylinder cutout systems of the prior art operate to modify the operation of the valves of the engine. The usual objective of these devices is to disable one or more of the cylinders of the engine by cutting off fuel thereto or otherwise affecting the cylinder operation so that the cylinder is dead as far as fuel consumption and power output are concerned.

Typical of the prior art engine cylinder cutout systems and controls therefor is the system provided, for example, in Jones, United States Patent No. 1,201,055, granted October 10, 1961. Jones taught a cylinder cutout system wherein fuel was cut off to a single bank of six cylinders in a V-12 engine, with the intake valve of the cutoff bank being held closed and the exhaust valves being held open. The valve control system was an electro-mechanical arrangement adapted to work directly on the rocker arm of the valve train to hold the valve elements in the desired open or closed position when it was desired to deactivate the cylinders associated with the valves.

Fuller, Jr. et al, United States Patent No. 4,050,435 issued September 27, 1977, was alleged to provide an improved device to control the valves for enabling intake and exhaust valves of the cylinders of an internal combustion engine to be held respectively closed and open to disable some of the cylinders and thus to conserve fuel and energy. In the invention as taught in United States Patent No. 4,050,435, a fluid-operated valve pushrod elongating or shortening device was provided that could be installed as an accessory in an existing engine using a pushrod and rocker arm valve train system. The system was said to be controllable, in effect to elongate the exhaust valve pushrods and to deactivate the intake valve pushrods for each cylinder to be cut out from engine operation. This system was also said to be controllable so that the intake and exhaust valves could operate in the normal manner in response to the reciprocating movement of the pushrods. Engine oil pressure preferably served as the actuating medium. The device was alleged to permit full or partial engine operation under any control set up desired.

(d) Assessment of the Prior Art

The prior art was silent in respect of a suitable control means to enable selective operation of the cutout device. Since, moreover, United States Patent No. 4,050,435 taught the use of the oil pressure of the engine to control the operation of the device, the device was only operable when the oil pressure was at a predetermined minimum. Consequently, any disruption in a constant oil pressure would render the device, and hence the internal combustion engine itself, inoperable. Moreover, the normal dirt and grime which accumulate in the oil from normal engine wear tends to hinder the working of this and any other such mechanism relying on engine oil pressure. Consequently, it is preferable to use brake or transmission fluid as the operating fluid. Furthermore, no means were taught for any sequencing of the intake and exhaust valve controls or selective controlling of the cylinders to be cut out to enable even wear of the engine.

(e) Disclosure of the Invention

The invention as claimed is intended to provide a remedy. This invention now aims to provide an internal combustion engine control system having three essential segments therein, namely, the uncoupling devices or mechanisms of cylinder control, improved solenoid-controlled shifting mechanisms, and improved retentive control means, i.e., information processing. The invention thus provides for the integrated actuation of these three essential segments with the end result of allowing selectivity, either manual or automatic, in the functioning of the cylinders of an internal combustion engine. By this invention, mechanisms are provided to effect control of cylinder valves through interruption of their normal actuation pulses by the controlled alteration of the function of normal pushrods. By this invention, means are also provided for cylinder firing patterns to be altered to minimize vibration and to provide for substantially even cylinder use and wear while responding to sensor-monitored load conditions.

Thus, the present invention solves the problem by means of a retentive control means responsive to the status of vehicle operating parameters for randomly initiating operation of shifting mechanism associated with each of the uncoupling devices for random initial activation thereof, thereby selectively cutting out one or more cylinders in the engine a substantially even average amount of time, so that engine wear is balanced.

(f) Advantageous Effects of the Invention

By the use of the retentive control means of this invention, a control system whereby an average sequencing of the cutoff of the cylinders is provided in order to provide balanced engine wear. In the invention, the uncoupling devices are operated by fluid (preferably not the engine oil pressure system) under substantially constant desired pressure and in which the fluid pressure may be maintained substantially constant regardless of the state of operation of the engine. In addition, normal valve operation may be selectively interrupted in order to assist in start-up of the engine through temporary reduction of piston compression and fuel intake (thus preventing flooding).

This invention has therefore provided improved shifting mechanisms, improved solenoid mechanism, uncoupling devices, and cylinder control mechanisms, and improved retentive control means or information processing mechanisms which are simple in design, easy to manufacture, provide fast, reliable control of valve function and do not interfere with normal pushrod functions of reliable valve actuation (when so desired) and with normal rocker arm/engine head lubrication. Such mechanisms are designed for use with standard internal combustion engines, involving only minor pushrod modification. Such mechanisms are designed to be fully compatible with any standard internal combustion engine regardless of fuel used or number of cylinders. The principles involved in the mechanisms of aspects of this invention can be adapted to the valves directly for use with an overhead-cam type engine.

(g) Disclosure of Further Features of the Invention

In one further feature of the invention, the uncoupling devices are operated by fluid under substantially constant pressure, or are operated mechanically.

In a second further feature of the invention, the uncoupling device is specially constructed for selectively coupling or uncoupling a reciprocating pushrod member from a driven member, and for holding such driven member at a controlled position with respect to the pushrod member while the pushrod member motion itself is uninterrupted, with the driven member having a return stroke driving means, the uncoupling device comprising: (a) a support means disposed between a selected pushrod member and a selected driven member; (b) a variable length member connected to the support means and relatively movable with respect thereon; (c) coupling means on the variable length member for engaging the selected pushrod member; (d) means for selectively operating or deactivating the coupling means, whereby the variable length member may be selectively driven by the pushrod member when coupled thereto or, when uncoupled, not driven by the pushrod member throughout its normal cycle while the motion of the pushrod is unimpeded with respect to the variable length member; (e) length-varying means movable attached to the variable length member for permitting relative motion between first and second limit positions, the variable length member being at minimum and maximum lengths, respectively, when the length-varying means is disposed at its first and second limit positions respectively, the length-varying means being drivingly connected to the driven member; and (f) extension-actuating means for selectively extending the length-varying means to its second limit position relative to the variable length member, and for holding the length-varying member at such position.

In a third further feature of the invention, the uncoupling device for controlling the valve of the internal combustion engine of the engine cylinder cutout system comprises: (1) a casing; (2) a composite operating mechanism comprising an inner pushrod and outer tappet rod telescopically assembled together and slidably mounted within the casing; and (3) controlled means actuatable for automatically (i) permitting the inner pushrod to slide with respect to the outer tappet rod so that the outer tappet rod is immovable with respect to the casing, and (ii) locking the inner pushrod to the outer tappet rod, thereby to cause the inner pushrod to move the outer tappet rod slidably with respect to the casing.

By a variant thereof, the inner pushrod includes a major cylindrical portion slidably disposed within a major hollow cylindrical portion of the outer tappet rod.

By a variation thereof, the major hollow cylindrical portion includes a minor central projecting pin, slidably disposed within a minor central bore at one end of the outer tappet rod.

By another variation, one end of the outer tappet rod includes a plurality of bores extending longitudinally therethrough, and the inner pushrod includes a central bore extending longitudinally therethrough.

In a fourth further feature of the invention, the means (3) comprises: (a) a first semi-toroidal groove in the inner pushrod; (b) a plurality of discrete slits around the circumference of the outer tappet rod; (c) a plurality of balls disposed within the discrete slits; (d) a slidable member within the casing, the slidable member including a second semi-toroidal groove on the inner face thereof; and (e) means for moving the slidably member (d) between (i) a first position, where the second groove is aligned with the first groove, thereby to permit the inner pushrod to slide with respect to the outer tappet rod, and (ii) a second position, where the second groove is not aligned with the first groove, thereby to lock the inner pushrod with respect to the outer tappet rod.

By a variation thereof, the slidable member comprises: a piston having a head portion and a rod portion, the second groove being disposed on the rod portion of the piston; and the moving means comprises: a pressure fluid injectable into selected associated pressure chambers within the casing for acting against selected surfaces of the head portion of the piston.

By another variation, the device includes a lower pressure chamber within the casing for filling with the pressure fluid for urging the lower face of the head of the piston upwardly.

By a further variation, the device includes an intermediate pressure chamber within the casing for filling with the pressure fluid for urging the upper face of the head of the piston downwardly.

By a still further variation, the device includes an upper pressure chamber within the casing for filling with the pressure fluid for urging the upper face of the rod of the piston downwardly.

By yet another variation, the piston rod includes a shoulder engageable with the casing to limit the extent of the lower movement of the piston.

By a still further variation, the casing includes an inner shoulder engageable with the upper face of the head of the piston to limit the extent of the upper movement of the piston.

By another variant, the inner pushrod includes: (a) an inner cylindrical rod; (b) an intermediate hollow cylindrical bushing; and (c) an outer hollow cylindrical slidable member, the outer member including a circumferential encircling first groove around the outer face thereof.

By a variation thereof, the outer tappet rod includes: (a) a hollow cylindrical main portion, the main portion including a plurality of discrete encircling slits therearound; and (b) an outer upper projecting rod.

By yet another variation, the device includes a second slidable member disposed between the inner wall of the casing and the outer wall of the outer tappet rod, the second slidable member including a circumferential encircling second groove around the inner face thereof.

In a fifth further feature of the invention, the means (3) comprises: (d) a plurality of balls disposed within the discrete encircling slits; and (e) means for moving the slidable member between (i) a first position where the second groove is aligned with the first groove, (ii) a second position where the second groove is not aligned with the outer hollow cylindrical slidable member with the first groove thereon in its upper position, and (iii) a third position where the second groove is not aligned with the first groove when the outer hollow cylindrical slidable member with the first groove thereon is in its lower position.

By another variation, the moving means comprises a pressure fluid injectable into selected pressure chambers within the casing for acting against selected surfaces of respective such movable members.

By yet another variation, the hollow cylindrical main portion of the outer tappet rod includes a lower head portion.

By still another variation, the fluid pressure chambers include a lower pressure chamber for filling with the pressure fluid for urging the lower face of the lower head portion to move the member upwardly.

By a still further variation, the fluid pressure chambers include a lower intermediate chamber for filling with the pressure fluid for urging the upper face of the lower head portion to move the member downwardly.

In a fifth further feature of the invention, the means (3) comprises: (d) a plurality of balls disposed within the discrete encircling slits; and (e) means for moving the slidable member between (i) a first position where the second groove is aligned with the first groove, (ii) a second position where the second groove is not aligned with the outer hollow cylindrical slidable member with the first groove thereon in its upper position, and (iii) a third position where the second groove is not aligned with the first groove when the outer hollow cylindrical slidable member with the first groove thereon is in its lower position, and the fluid pressure chambers include an upper intermediate chamber for filling with the pressure fluid for urging the lower face of the second slidable member upwardly.

By a variation thereof, the fluid pressure chambers include an upper intermediate chamber for filling with the pressure fluid for urging the lower face of the second slidable member upwardly.

By another variation, the fluid pressure chambers include an upper chamber for filling with the pressure fluid for urging the upper face of the second slidable member downwardly.

By yet a further variation, the casing includes an upper inner shoulder for restricting the upper movement of the second slidable member.

By a further variation, the casing includes a false floor between the lower intermediate chamber and the upper intermediate chamber for simultaneously restricting lower movement of the second slidable member and upper movement of the head of the slidable member.

By another variant, the inner pushrod includes a main lower cylindrical portion and a minor upper central projection of lesser diameter than the lower cylindrical portion.

By a variation thereof, the outer tappet rod includes a main inner cylindrical portion and a hollow core within which the minor upper central projection is adapted to slide.

By a further variation, the outer tappet rod includes means to restrict lower movement thereof.

By yet another variation, the inner pushrod includes a main lower cylindrical portion and a minor upper central projection of lesser diameter than the lower cylindrical portion, and the outer tappet rod includes a further main inner cylindrical portion and a hollow core within which the minor central projection of the pushrod is adapted to slide, and an outer slidable cylinder slidably disposed between the inner wall of the casing and the outer wall of the further main cylindrical portion.

By still another variation, the device includes cooperating shoulders on the outer tappet rod and the further cylindrical portion.

In a sixth further feature of the invention, the means (3) comprises: (e) means (i) for urging the slidable member downwardly to require the outer tappet rod to move in unison with the inner pushrod with respect to the casing, and (ii) for urging the slidable member upwardly to permit the inner pushrod to slide with respect to the outer tappet rod.

In a seventh further feature of the invention, the means (3) comprises: (e) means (i) for urging the slidable member downwardly to require the outer tappet rod to move in unison with the inner pushrod with respect to the casing, and (ii) for urging the slidable member upwardly to permit the inner pushrod to slide with respect to the outer tappet rod, and the means (e) includes a pressure chamber for filling with pressure fluid below the lower face of the base of the further cylindrical portion for urging the face upwardly, or above the upper face of the base of the further cylindrical portion for urging the face downwardly.

By a variant thereof, the means (e) includes a pressure chamber for filling with pressure fluid below the lower face of the base of the further cylindrical portion for urging the face upwardly, or above the upper face of the base of the further cylindrical portion for urging the face downwardly.

By yet another variant, the inner pushrod comprises a main lower cylindrical portion slidably disposed within the lower portion of the casing, the cylindrical portion including an upper central extension rod; the outer tappet rod comprises a main lower cylindrical portion slidably disposed within the upper portion of the casing, a central lower well within which the upper extension rod is adapted to slide, and an upper pushrod engagement ball.

In a seventh further feature of the invention, the means (3) comprises a lower chamber in the casing between the pushrod and the tappet rod and a means for filling the chamber with a pressure fluid so that, (i) when the chamber is filled with fluid, reciprocation of the pushrod provides corresponding reciprocation of the tappet rod; and (ii) when the chamber is empty of fluid, reciprocation of the pushrod does not provide corresponding reciprocation of the tappet rod.

By a variation, the inner pushrod and the outer tappet are longitudinally bored therethrough for normal oil lubrication.

By still another variant, the casing includes a lower portion of a first internal diameter, and an upper portion of a second larger internal diameter.

By a variation thereof, the inner pushrod comprises a lower cylindrical portion adapted to slide reciprocatingly within the lower portion of the casing, a lower countersunk pushrod engagement face, and an upper reduced diameter upstanding extension rod; and the outer tappet rod comprises an upper portion of larger diameter adapted to slide reciprocatingly within the upper portion of the casing, a lower portion of lesser diameter adapted to slide reciprocatingly within the lower portion of the casing, a lower well within which the extension rod is adapted to slide reciprocatingly, and an upper pushrod engagement ball.

By another variation thereof, the upper portion of the outer tappet rod is adapted to abut on an inner shoulder on the casing to restrict lower movement thereof.

By yet another variation, the inner pushrod and the outer tappet rod are longitudinally bored therethrough for normal oil lubrication.

By a further variation, the casing includes an upper chamber, fed with pressure fluid through a pair of unimpeded flow conduits, and a lower chamber, fed with pressure fluid through a positive controlled flow conduit, whereby (i) when the lower chamber is filled with pressure fluid, reciprocation of the inner pushrod provides a corresponding reciprocation of the outer tappet rod; (ii) when the lower chamber is emptied of the pressure fluid and when the upper chamber is emptied of pressure fluid, reciprocation of the outer tappet rod does not provide a corresponding reciprocation of the outer tappet rod, with the outer tappet rod at its lower limit position; and (iii) when the lower chamber is emptied of the pressure fluid, reciprocation of the outer tappet rod does not provide a corresponding reciprocation of the outer tappet rod, with the outer tappet rod at a slightly elevated position to provide a slight bleed-off of the exhaust valve.

By yet another variation, the device includes an additional unimpeded flow conduit from the upper portion of the lower pressure chamber to provide emergency pressure relief to the lower chamber.

In an eighth further feature of the invention, the uncoupling device includes inner and outer pushrods, in which the inner pushrod includes a cylindrical portion slidably dispoosed with its base within the casing and within a coextensive major bore within the outer tappet rod.

By a variant thereof, the inner pushrod includes a control projecting pin slidably disposed within a minor central bore communicating with the major bore within the outer tappet rod..

By another variant thereof, the device includes a first pressure fluid inlet port to an upper portion of a first internal fluid pressure chamber for operation of the outer pushrod by the reciprocation of the inner pushrod.

By yet another variant thereof, the device includes a pressure fluid inlet port in the outer pushrod leading to a second internal fluid pressure chamber.

By a still further variant thereof, the device includes a second pressure fluid inlet selectively operable as a free-flow port and as a one way inlet port, leading to a lower portion of a first internal fluid pressure chamber.

In a ninth further feature of the invention, the uncoupling device for controlling the valve for the internal combustion engine comprises: (1) a mounting bushing; (2) an inner and an outer coaxially assembled tappet rod assembly slidably mounted within the mounting bushing; and (3) tappet rod length adjusting means operatively associated with the tappet rod assembly and actuatable to change the tappet rod length between a first preselected long length and a second preselected short length.

By a variation thereof, the tappet rod assembly includes: an outer cylindrical member, the lower end of which is connected to a lower tappet rod, with the outer cylindrical member being centrally bored; and an inner tappet rod slidably mounted within the central bore, the inner tappet rod including a tappet-engaging projection ball thereon.

By another variation, the tappet rod length adjusting means comprises: an engagement member at the end of the outer cylindrical member, the engagement member including two different height shoulders connected by a spiral ramp so that the shoulders are 180° apart; and an enlarged engagement member along the inner tappet rod, the enlarged engagement member including two different height shoulders connected by a spiral ramp so that the shoulders are 180° apart.

By still another variation, the engagement means on the inner cylinder comprises an integral enlargement.

By yet another variation, the engagement means on the inner cylinder comprises a sloped end thereof.

By another variation, the device includes directly driven means to rotate only the inner tappet rod and its engagement member through 180° thereby to fix the tappet rod at an upper position independent of the operation of the pushrod.

By a variation thereof, the means includes a bushing having a polygonal inner face slidably engageable with a congruent polygonal outer face of the outer enlargement and operating means to rotate the bushing.

By a further variation thereof, the operating means comprises a rack and pinion device.

By yet another variation thereof, the operating means comprises an hydraulic ram.

In an eleventh further feature of the invention, the shifting mechanism comprises solenoid control mechanism comprising: (a) a block; (b) a central longitudinal control well therein; (c) a first and a second transverse, fluid conducting valved bores therein each being provided with a fluid flow conduit; (d) a central, transverse fluid conducting bore therein, provided with open conduit connections to the transverse valved bores and valved conduit connections to the valved bores, and connecting to a main supply conduit; and (e) actuated control means disposed in the control well for (i) providing fluid connection between the first valved conduit, the open conduit connection, the central bore and the main supply conduit while blocking off fluid connection between the open conduit connection and the second valved conduit; (ii) providing fluid connection between the second valved conduit, the open conduit connection, the central bore and the main supply conduit while blocking off fluid connection between the open conduit connection and the first valved conduit; and (iii) providing fluid connection between the first valved conduit, the open conduit connection, the central bore and the main supply conduit while blocking off fluid connection between the open conduit connection and the second valved conduit and providing fluid connection between the second valved conduit, the open conduit connection, the central bore and the main supply conduit while blocking off fluid connection between the open conduit connection and the first valved conduit.

By a variant thereof, the actuated control means comprises an electromagnetically actuated solenoid having a body portion with an access gap and a blocking portion thereon.

By another variant, the first valved conduit is connected to the exhaust mechanism.

By another variant, the second valved conduit is connected to the intake mechanism.

By a further variant, the first valved conduit is connected to the exhaust mechanism, the second valved conduit is connected to the intake mechanism and the exhaust conduit is at a lower level than the intake conduit.

By yet another variant, the valved bores are each controlled by spring actuated ball check valves.

By a still further variant, the actuated control means is positively actuated to provide flow from main supply conduit at a sufficient pressure to flow through valved bores and then through the fluid flow conduit associated with each valved bore.

By another variant, the actuated control means is positively actuated to provide fluid flow through the open conduit connection only to the first valved bore, allowing fluid exhaust from the exhaust mechanism to relieve fluid pressure and allowing normal exhaust valve function.

By a further variant, the actuated control means is positively actuated to provide fluid flow through the open conduit connection to both the first valved bore and the second valved bore, thereby closing the intake valve while allowing the exhaust valve to function normally.

By still another variant, the actuated control means is positively actuated to provide fluid flow through the open conduit connection only to the second valved bore, thereby disconnecting the intake valve mechanism.

In a twelfth further feature of the invention, the shifting mechanism comprises: (a) an open tubular casing; (b) a control body slidably disposed within the tubular casing, the control body including a head portion, adapted to abut with a rim in the tubular casing, thereby to limit movement of the control body in one direction; (c) a lesser diameter tubular rod connected between the control body and a second captive slidable plug fully disposed within the tubular casing; and (d) two pairs of ports adapted to lead hydraulic fluid into and out of the interior of the tubular casing.

By a variant thereof, the mechanism includes means for applying an activating force to the head portion of the control body.

By a variation thereof, the actuating force is derived from a solenoid, a permanent magnet, an electromagnet, a spring, hydraulic means, or pneumatic means.

By yet another variant thereof, the mechanism includes means adapted to act upon an exposed face of the captive plug selectively to act against the means for applying the activating force.

By a variation thereof, that means is a return spring.

By another variant thereof, the ports are so disposed that the control body is adapted to close off a pair of diametrically opposed ports while the captive plug is adapted to open the other pair of diametrically opposed ports.

By a variation thereof, the mechanism includes spacing grooves or gates to adjust the proper distance between the control body and the captive plug.

In a thirteenth further feature of the invention, the retentive control means includes a memory system operatively associated with the retentive control means which serves to assure a substantially even cutout of all the cylinders of the engine during different sequences of operation so that engine wear is balanced.

By a variant thereof, the retentive control means controls a solenoid for each of the shifting mechanism, thereby causing fluid pressure to actuate selected one or ones of the uncoupling devices.

By other variants, the retentive control means may be either manually programmable or atuomatically programmable.

(h) Description of Ways of Carrying Out the Invention

Several ways of carrying out the invention are described in detail below with reference to the drawings which illustrate specific embodiments in which:

Figure 1 shows a partial cut-away segment of a typical valve train in an internal combustion engine, the valve train using hydraulic lifters, pushrods and rocker arms, conventionally referred to as tappets;

Figure 2 shows a typical installation of an uncoupling device mounted in the engine of Figure 1;

Figures 3, 4 and 5 show one variant of a cylinder control mechanism of an embodiment of the present invention for an intake valve in various stages of its operation;

Figures 6, 7, 8 and 9 show one variant of a cylinder control mechanism of an embodiment of the present invention for an exhaust valve in various stages of its operation;

Figures 10 and 11 show another variant of a cylinder control mechanism of an embodiment of the present invention for an intake valve in various stages of its operation;

Figures 12, 13 and 14 show yet another variant of a cylinder control mechanism of an embodiment of the present invention for an exhaust valve in various stages of its operation;

Figures 15, 16, 17 and 18 show other variants of a cylinder control mechanism of an embodiment of the present invention in which Figures 15, 16 and 17 are for an exhaust valve in various stages of its operation, and in which Figure 18 is for an intake valve;

Figures 19 and 20 show in full view and in partial view, respectively, another variant of a cylinder control mechanism of an embodiment of the present invention for an intake valve;

Figures 21 and 22 show in full view and in partial view, respectively, another variant of a cylinder control mechanism of an embodiment of the present invention for an exhaust valve;

Figure 23 is a top view, partly in section of the body of a solenoid control mechanism forming part of another variant of the present invention;

Figure 24 is a front view of the solenoid control mechanism of Figure 23;

Figure 25 is a rear view of the solenoid control mechanism of Figure 23;

Figure 26 is a side view of the solenoid control mechanism of Figure 23;

Figure 27 is a side view of the armature mechanism and coil core forming a part of the solenoid control mechanism of Figure 23;

Figure 28 is a schematic longitudinal section through another variant of a control mechanism forming part of another variant of the present invention;

Figure 29 is a functional block diagram showing the electronic control component;

Figure 30 is a first portion of the control logic shown in Figure 29; and

Figure 31 is a second portion of the control logic shown in Figure 29.

As seen in Figures 1 and 2, a valve-in-head internal combustion engine 10 of typical configuration and known in the prior art includes a cylinder head 11 through which extend pushrods 12 disposed between hydraulic valve lifters 13 and rocker arms or tappets 14. Valves 15 are moved to an open position by rocker arms 14 in a conventional manner and are seated by means of valve springs 16. Cam 17 drives the pushrod 12 (or the pushrods directly if a mechanical pushrod system is used) in timed sequence in a manner well known in the art. This cam drive of the pushrods is not interfered with in the uncoupling device used in the cutout system of aspects of this invention.

A valve uncoupling device 20 is installed in the valve actuating train between the pushrods (which are modified slightly from the factory installed pushrods) and the rocker arm, as shown in Figure 2. Thus, the modified pushrod is installed and the valve uncoupling device 20 is placed between the top end of the pushrod 21 and the rocker arm 14 to provide a tappet rod 22 to operate the rocker arm 14. Fluid connections 23 and 24 are made to the uncoupling device 20 and to the shifting mechanism of a suitable control system of an aspect of the present invention to be described hereinafter for controlling the flow of dluid under pressure to the uncoupling device 20. A valve uncoupling device 20 is installed at each intake valve and at each exhaust valve of each cylinder of the engine desired to be cut out upon demand.

The valve uncoupling device 20 may be the one disclosed and claimed in United States Patent No. 4,050,435, and so its structure and operation will not be described herein, or it may be the one or ones disclosed and described hereinafter.

For normal engine operation on all cylinders, activation of the intake valves and the exhaust valves by the valve uncoupling devices 20 operatively situated in their valve trains is accomplished by supplying fluid pressure through lines 22 and 23 in order not to interfere with the normal cam timed operation of the valves. When it is desired to operate the engine with less than all cylinders, the valve uncoupling device 20 is selectively actuated in association with a selected exhaust valve to hold the selected exhaust valve open by admitting fluid under pressure through suitable line 22. At the same time, the associated selected intake valve is held closed by admitting fluid under pressure through line 23 of an associated valve uncoupling device.

It is not necessary that the shifting mechanism be placed remote from the uncoupling device 20 as contemplated by Figure 2. Various other embodiments of a shifting mechanism are shown in subsequent Figures (to be described hereafter and to be read in conjunction with Figures 1 and 2).

As seen in Figures 3, 4 and 5, the cylinder control mechanism 120 for an intake valve comprises a hollow cylindrical casing 130 having a greater diameter lower end 131. Disposed within case 130 is a modified inner pushrod 121 and modified outer tappet rod 122. Inner pushrod 121 is modified by the provision of an encircling semi-toroidal ball race groove 132 within which a plurality of balls 133 are freely rotatably placed. Inner pushrod 121 also includes a smaller diameter upper cylindrical pin 134 projecting therefrom. Outer tappet rod 122 includes a lower hollow cylindrical portion 125 telescopically slidably mounted with respect to inner pushrod 121. Portion 125 of outer tappet rod 122 includes a discontinuous circumferential encircling slit 136 therein of slightly greater width than the diameter of the balls 133. The number of discontinuities in slit 136 is equal to the number of balls 133. The upper part of outer tappet rod 122 is also provided with a central well 137, within which pin 134 is adapted to oscillate or reciprocate. A plurality of longitudinally extending vent bores 138 is also provided in the upper portion of outer tappet rod 122. A dead space 148 is provided between an end face of inner pushrod 121 and the base of portion 125 of outer tappet rod 122. Outer tappet rod 122 is provided with a conventional pushrod engagement ball 122a.

Slidably disposed within casing 130 between the inner wall of the casing 130 and the outer wall of the lower portion 125 of outer tappet rod 122 is a piston 139 including a rod end 140 and a head end 141. The piston 139 thus provides three discrete chambers within casing 130, namely lower chamber 142, intermediate chamber 143 and upper chamber 144, having conduits 145, 146, 147 therefrom respectively, to allow inflow or outflow of a fluid under pressure, e.g., a hydraulic fluid or a pneumatic fluid. Rod 139 is provided with an interior encircling semi-toroidal ball race groove 149 therein.

In operation, in the configuration shown in Figure 3, with fluid under pressure in chambers 143 and 144 and with chamber 142 evacuated, reciprocating movement of the inner pushrod 121 (e.g., by operator 13 and cam 17 as described for Figure 2) results in corresponding reciprocating movement of outer tappet rod 122, since the balls 133 are captured in the race between the grooves 132 and the slits 136. In this configuration, normal valve operation is provided.

In the configuration shown in Figures 4 and 5, with fluid under pressure in chamber 142, and with chambers 143 and 144 evacuated, piston 139 is pushed upwardly so that groove 149 is aligned with slits 136. Thus, as inner pushrod 121 is pushed upwardly, balls 133 escape to the race between slits 136 and groove 149. This permits inner pushrod 121 to oscillate within well 137 without a corresponding oscillation of outer tappet rod 122. In this configuration , the intake valve always remains closed when disabled.

Thus, the mechanism shown in these Figures is a device designed such that, when activated through a control mechanism, the normal reciprocating function of a(n intake) valve is interrupted, with the bottom half of the inner pushrod 121 following the contour of the cam shaft through the action of a spring (not shown) in cavity 137 while the top piece 122 remains at the bottom of stroke position. Thus, this embodiment shows a mechanism designed to alter the operation of a pushrod for an intake valve such that the cam-induced motion can be selectively disconnected from its normal valve train operation, in such a manner as to maintain the valve at its end-of-pushrod stroke position with the valve closed regardless of pushrod motion.

The small size of the slits compared to the size of the balls is to ensure fast, secure deactivation with a minimum of wear on the parts. Drilling of the push and tappet rods also ensures that the secondary role of the normal rod is maintained, namely, that of lubrication. Since all the parts are cylindrical (except, of course, for the balls), the pushrod and tappet rod are free to rotate, in the normal pushrod manner, to distribute wear evenly and to compensate for pushrod deformation which otherwise tends to curve the rod with repeated impact. This cylindrical design allows all parts to rotate about the pushrod axis while not interfering with the intended valve actuation process.

As seen in Figures 6, 7, 8 and 9, the cylinder control mechanism 220 for an exhaust valve includes a casing 230 within which are slidably mounted inner pushrod 221 and outer tappet rod 222. Inner pushrod 221 is a normal pushrod merely modified to have a flat head 255, and has its conventional lubrication bore 237 longitudinally therethrough. Concentrically disposed around inner pushrod 221 is a cylindrical housing 251 to support inner pushrod 221 while allowing inner pushrod 221 to oscillate therewithin, and yet permitting relative rotation thereof.

Outer tappet rod 222 includes a lower hollow cylindrical portion 235 which is provided with a plurality of discontinuous slits 236. Disposed between the inner wall of portion 235 and the outer wall of housing 251 is a piston 239 including a rod portion 240 and a head portion 241. On the outer circumferential wall of the rod portion 240 is an encircling semi-toroidal ball race groove 232, within which a plurality of balls 233 is freely rotatably positioned. The width of slits 236 is slightly greater than the diameter of the balls 233, and the number of discontinuous slits 236 is equal to the number of balls 233. Mounted in the casing 230 between the inner wall thereof and the outer wall of portion 235 is a governing cylinder 252, whose inner wall is provided with a cylindrical groove 249. Outer tappet rod 222 is also provided with a normal pushrod engagement ball 222a.

The placement of the various components within casing 230 provides a number of discrete fluid chambers therein, namely, lower chamber 242, lower intermediate chamber 243, upper intermediate chamber 253 and upper chamber 244, provided with valved pressure fluid conduits 245, 246, 254 and 247, respectively.

In operation, as shown in Figure 6, inner pushrod 221 contained within cylinder housing 251 is caused to oscillate by cam 17 (see Figure 2) and forces outer tappet rod 222 to its top-of-stroke position, opening valve 15 through activation of the rocker arm 14. Fluid under pressure is provided in chambers 242 and 244, while chambers 243 and 253 are evacuated. Thus, balls 233 are allowed to run freely along the ball race provided by groove 232 and cylindrical guide 249. This then provides normal valve operation.

As seen in Figure 7, fluid under pressure is admitted to chamber 244 via conduit 247, which forces governing cylinder 252 downward. This permits balls 233 to run along groove 232 and in cylindricalguide 249, i.e., releasing the balls 233 from their locked positions (as shown in Figures 8 and 9). Fluid under pressure is forced to leave chamber 253 via conduit 254. Fluid is then injected into chamber 242 via conduit 245, raising piston head

243/piston rod 240 and evacuating chamber 243 via port 246 (as shown in Figure 6).

As seen in Figures 8 and 9, fluid pressurization of chamber 243 through conduit 246 forces head end 241 downwardly and evacuates chamber 242 via conduit 245, and with rod end 240 sliding downwardly with respect to casing 251. Then, hydraulic or electronic sequencing by fluid pressurization of chamber 253 via conduit 254 pushes governing piston 252 upward, and consequently cylindrical guide 249 is also pushed upward. Chamber 244 is also evacuated via conduit 247. This, then, eliminates the alternate guide race for the balls 233 which are therefore forced into the race defined by the groove 232 and the slits 236. Inner pushrod 221 is kept following the motion of the cam 17 by reaction of the spring 16 (see Figure 2) but the valve is kept at its end-of-stroke position.

Thus, the embodiment shown in Figures 6 - 9 provides a mechanism designed to maintain a valve in an open position when activated or to allow system functioning as a normal pushrod as desired. Thus, the embodiment shown here provides a mechanism designed to alter the operation of the pushrod for an exhaust valve such that the rod effectively is maintained at the top-of-stroke position, maintaining the valve open. By lengthening the height of the pushrod assembly, the rod is effectively maintained at its top-of-stroke position, with the valve remaining propped open with no further energy expenditure. Since this inner pushrod/outer tappet rod assembly is drilled for lubrication, the system maintains normal rocker arm lubrication.

The embodiment shown here in Figures 10 and 11 provides a simple form of cylinder control mechanism 520 for an intake valve. The mechanism 520 includes a casing 530 within which are independently slidably mounted a modified inner pushrod 521 and a modified outer tappet rod. The lower end of inner pushrod 521 is operatively engaged by a valve lifter mechanism 513, and the upper end is provided by a reduced diameter extension 525. The modified outer tappet rod includes a restraining shoulder 523 and an internal bore 524. Extension 525 is adapted to slide within bore 524. In its at-rest position, there is a dead head 540 within bore 524 between the end of the bore 524 and the end of the extension 525, the length of the dead head 540 being slightly longer than the stroke of the extension rod 525. Outer tappet rod 522 is provided with a normal pushrod engagement ball 522a.

A fluid pressure chamber 531 provided with conduit 532 is formed between the end of the outer tappet rod 522 and the larger diameter end of inner pushrod 521.

In operation, in the configuration shown in Figure 10, chamber 531 is evacuated. Thus, oscillation of the inner pushrod 521 merely results in oscillation of the extension 525 within bore 540, and so there is no oscillation of the outer tappet rod 522. Thus, the tappet 14 is not actuated and the valve 15 remains closed. The valve is in its inactive position. The intake valve always remains closed when disabled.

In normal operation as shown in Figure 11, chamber 531 is filled with fluid under pressure via conduit 532. Oscillation of the inner pushrod 521 is transmitted to the outer tappet rod 522 via the fluid under pressure acting as a bridge and produces normal valve operation.

This embodiment thus shows a mechanism designed to maintain a valve in its substantially closed position, isolated from the normal pushrod induced reciprocation when activated, or to allow the pushrod/rocker arm assembly to function in a normal manner valve-activating manner when so desired. One-way valves and springs ensure that the chamber cavity is maintained at its fullest level. Lubrication is again maintained. In addition, both inner and outer pushrod and tappet rod sections are free to rotate, in order to distribute wear on the sections within the housing, which remains fixed with respect to the engine head. Thus, this embodiment shows a mechanism designed to alter the operation of a pushrod for an intake valve such that the cam-induced motion can be selectively disconnected from its normal valve train operation, in such a manner as to maintain the valve at its end-of-pushrod-stroke position with the valve substantially closed regardless of pushrod motion.

As seen in Figures 12, 13 and 14, the cylinder control mechanism 620 for an exhaust valve includes a casing 630, a modified inner pushrod 621 and a modified outer tappet rod 622. Modified inner pushrod 621 includes a reduced diameter extension 625 projecting therefrom. Modified outer tappet rod 622 includes a central bore 650 within which extension 625 is adapted to slide, and a reduced diameter extension 627 providing an abutment shoulder 628. Between the outer tappet rod 622 and the casing 630 is a piston 639 including a rod portion 640 and a head portion 641. The elements are disposed within casing 630 so as to provide a pressure chamber 651 including a pair of conduits 652, 653 thereto. Outer tappet rod 622 is provided with a normal pushrod engagement ball 622a.

In normal operation as shown in Figure 12, with lower portion of chamber 651 evacuated through conduit 653, but with the upper portion of chamber 651 filled with fluid under pressure through conduit 652, piston 640 is pushed down with fluid under pressure on the top face of head 641. Thus, when the inner pushrod 621 oscillates, the outer tappet rod 622 similarly oscillates since it is urged upwardly by direct contact with cooperating shoulders on the respective rods. The rods are urged downwardly by a spring in chamber 650.

In the locked position as shown in Figures 13 and 14, the lower chamber 651 is filled with fluid under pressure through conduit 653 simultaneously removing fluid through, and partially sealing off, conduit 652. Thus, inner pushrod 621 is free to oscillate within bore 650, both in the upstroke (not shown) and in the down-stroke (as shown in Figure 13).

Deactivation of the system, to allow resumption of normal pushrod function can be accelerated by the addition of a second fluid port (not shown) placed so as to provide pressure to be placed so as to provide force to lower the piston, allowing inner and outer rod sections 621/622 to return to their normal pattern of contact.

Thus, in this embodiment, a mechanism is shown which is designed to maintain a valve in an open position, isolated from the normal pushrod reciprocation, when activated, or to allow the pushrod to function normally when so desired. Thus, the embodiment shown here provides a mechanism designed to alter the operation of the pushrof for an exhaust valve such that the rod effectively is maintained at any desired position, e.g., at the top-of-stroke position, maintaining the valve open. By lengthening the height of the pushrod assembly, the rod is effectively maintained at its top-of-stroke position, with the valve remaining propped open with no further energy expenditure. Since this inner pushrod/outer tappet rod assembly is drilled for lubrication, the system maintains normal rocker arm lubrication.

As seen in Figures 15 and 16, the exhaust valve control mechanism 720 comprises a hollow cylindrical casing 730 having a greater diameter upper end 731. Disposed within casing 730 is a modified pushrod 721 and a modified tappet rod 722. Pushrod 721 is modified with the lower end having a pushrod engagement countersunk circular face 714 into which a normal pushrod fits after being cut to size. The bottom part of the pushrod 721 consists of a tight-fitting piston head 715, with the top portion comprising a reduced-diameter extension rod 716 fitting snugly and slidably inside a receptor well 724 in the bottom part of tappet rod 722. Elements 715, 716 and 722 of the pushrod 721 are centrally drilled at 735 for normal oil lubrication provision. The tappet rod 722 slides reciprocatingly inside the upper portion 731 of cylindrical casing 720. The upper face 728 comprises a normal pushrod engagement ball 729 for rocker arm contact/activation. The lower face 732 of the upper portion 733 of tappet rod 722 rests, at bottom of its stroke, on lip 734 of the cylindrical casing 730 where enlarged upper end 731 begins. The tappet rod terminates in protrusion 726 which fits slidingly into main bore 736 of casing 730. Receptive well 724 extends far enough to allow full motion of pushrod extension rod 716 through any phase of operation.

Various conduits are provided in cylindrical casing to be connected to pressure-fluid carrying conduits (not shown). Thus, there are two upper apertures, namely upper left hand unimpeded flow conduit 752 connected between lip 734 and upper hydraulic chamber 750; lower left hand conduit 754 connected to lower chamber 751 of casing 730; upper right hand unimpeded flow conduit 753 connected to upper hydraulic chamber 750; and lower right hand conduit 755 connected to the upper portion of bore 734.

In normal operation, the upper hydraulic chamber 750 (see Figure 16) is allowed both to fill with fluid and to empty of fluid through unimpeded flow through conduits 752 and 753. At the same time, fluid is trapped in chamber 751 through impeded fluid flow from conduit 754, creating a hydraulic extension/bridge for the cam-induced impulses and producing normal valve actuation. Conduit 755 is unregulated and provides an emergency relief valve to guard against overextension of the pushrod and resulting damage to valves, rocker arms, etc.

When deactivated, normal fluid flow is permitted through conduit 753, while such flow is blocked through conduit 752. This creates a hydraulic jack which does not allow the rocker arm assembly to return to its neutral position, leaving it only slightly open such that the normal, uninterrupted piston action would not damage the valves. At the same time, pressure is relieved from chamber 751 by opening conduit 754. In this way, tappet rod 722 is held stationary through pressure in the bottom section of chamber 750, while pushrod 721 reciprocates freely inside chamber 751, with reduced diameter extension rod 716 sliding oscillatingly and normally inside receptor well 724. Again, conduit 755 is a relief valve to prevent valve damage..

Reactivation occurs through de-pressurization of chamber 750 through conduit 752 and re-pressurization of chamber 751 through the allowing of inlet fluid through conduit 754. All of these changes are preferably solenoid-induced, but may satisfactorily be mechanically controlled.

It should be noted that relief conduit 755 can be run vertically instead of horizontally. In this case, its access to the interior of casing 730 is by means of a semi-circular groove leading from chamber 750 with no loss of function.

Thus, the embodiment shown here provides a mechanism designed to alter the operation of the pushrod for an exhaust valve such that the rod effectively is maintained at any desired position, e.g., at the top-of-stroke position, maintaining the valve open. By lengthening the height of the pushrod assembly, the rod is effectively maintained at its top-of-stroke position, with the valve remaining propped open with no further energy expenditure. Since this inner pushrod/outer tappet rod assembly is drilled for lubrication, the system maintains normal rocker arm lubrication.

Figure 17 shows a companion intake control valve mechanism to the exhaust valve control mechanism in Figures 15 and 16. The intake valve control mechanism includes a simple hollow cylindrical casing 830. Within casing 830 is slidably disposed a modified pushrod 831 and a modified tappet rod 822. Modified pushrod 831 is provided with a lower extension means (not shown) for engagement with, and operation by, a normal pushrod (not shown), and with an upper extension lesser-diameter rod 816 fitting snugly and slidably inside a receptor well 833 in the bottom part of modified tappet rod 822. Elements 831, 816 and 822 are drilled at 835 for normal oil lubrication provision. The modified tappet rod 822 slides reciprocatingly inside the upper portion of the hollow cylindrical casing 830. The upper face 828 of modified tappet rod 822 is provided with a normal pushrod-engagement ball 829 for normal rocker arm contact/activation.

The lower portion of cylindrical casing is provided with a lower chamber 851, adapted to be fed with fluid under pressure through controlled conduit 854.

In normal intake valve operation, chamber 851 is filled with fluid under pressure through conduit 854. This creates a hydraulic extension/bridge for the cam-induced impulses to pushrod 831 and provides normal valve actuation, i.e., reciprocation of pushrod 831 causes a corresponding reciprocation of tappet rod 832 with a corresponding operation of the rocker arm through ball 829.

When deactivated, fluid under pressure is drained from chamber 851 through conduit 854. This allows pushrod 831 to reciprocate with its extension rod 816 sliding within well 833, without any corresponding reciprocation of tappet rod 832. The intake valve always remains closed when disable

Re-activation occurs through re-pressurization of chamber 851.

Thus, this embodiment shows a mechanism designed to alter the operation of a pushrod for an intake valve such that the cam-induced motion can be selectively disconnected from its normal valve train operation, in such a manner as to maintain the valve at its end-of-pushrod stroke position with the valve substantially closed regardless of pushrod motion.

As seen in Figure 18, the exhaust valve control mechanism 775 comprises a hollow cylindrical casing 776 having a greater diameter upper end 777. Disposed within casing 776 is a modified pushrod 778 and a modified tappet rod 779. Pushrod 778 has its lower end 778a which engages with the normal hydraulic valve lifter (not shown). The bottom portion of the pushrod 778 acts like a tight-fitting piston head 780a sliding within core 780 with the top of pushrod portion 778 comprising a reduced-diameter extension rod 781 fitting snugly and slidably inside a receptor well 782 in the tappet rod 779. Tappet rod 779 has a major lower bore 782 coextensive with core 780. Elements 778 and 779 are centrally drilled at 783 for normal oil lubrication provision. The tappet rod 779 slides reciprocatingly inside the upper portion 777 of cylindrical casing 776. The upper face 783 comprises a normal pushrod engagement ball 784 for rocker arm contact/activation. The tappet rod 779 terminates in chamber 785 which abuts chamber 786 in casing 776. Receptive well 782 extends far enough to allow full motion of pushrod extension rod 781 through any phase of operation. The lower portion of tappet rod 779 is provided with a through bore 787 to the annular chamber 788 within casing 776. A partial circumferential channel 789 is provided in tappet rod 779 for a purpose to be described.

Apertures are provided in cylindrical casing 776 to be connected to pressure-fluid carrying conduits (not shown). Thus, there is an upper aperture 790 provided with conduit 791, and lower aperture 792 provided with conduit 793.

In operation in its activated state, with fluid in chamber 788, upward movement of pushrod 778 first seals aligned ports 790 and 787. This provides a hydraulic extension/bridge between pushrod 778 and tappet rod 779. This in turn causes upward movement of tappet rod 779. This upward movement allows hydraulic fluid to enter chamber 788 via free-flow port 792 and conduit 793. Now, at the bottom of the stroke, hydraulic fluid in chamber 788 is permitted to exit via free-flow port 792 and conduit 793.

A modification of the operation can enable the exhaust valve to be maintained in its partially-opened state. The modification involves operating port 792 and conduit 793 in a one-way check valve fashion, allowing hydraulic fluid only to enter chamber 788. In such event, hydraulic fluid trapped in chamber 788 will maintain tappet rod 779 in a selected upper orientation. Such orientation is at the time when ports 790 and 787 are aligned. This permits the correct amount of hydraulic fluid to be disposed in front of the pushrod 778.

Thus, the embodiment shows here provides a mechanism designed to alter the operation of the pushrod for an exhaust valve such that the rod effectively is maintained in any desired position, maintaining the valve open. By lengthening the height of the pushrod assembly, the rod is effectively maintained at its top-of-stroke position, with the valve remaining propped open with no further energy expenditure. Since this inner pushrod/outer tappet rod assembly is drilled for lubrication, the system maintains normal rocker arm lubrication.

As seen in Figures 19 and 20, a cylinder control mechanism 320 for an intake valve is provided including an inner pushrod 321, an outer tappet rod 322, an hydraulic valve lifter 313, a rocker or tappet arm 314 and a valve spring 316. Outer tappet rod 322 is modified by the provision of an upper bi-level engagement member 330 including a lower engagement shoulder 331 and an upper engagement shoulder 332. Engagement member 330 is of a cross-sectional shape (e.g., hexagonal) allowing it to be held non-rotatably but slidably within guide element 333 (of similar cross-section). Guide element 333 is positively rotatable by means of a worm gear assembly 334 secured to the engine block. Surrounding the outer tappet rod 322 is a hollow control cylinder 340 provided with a bottom floor 341 upon which the lower end 335 of the outer tappet rod 322 rests. The lower end 342 of control cylinder 340 is secured to the upper end of the inner pushrod 321. The upper end of the control cylinder 340 is provided with an upper engagement member 343 having a lower engagement shoulder 345 and an upper engagement shoulder 344. Control cylinder 340 is slidably and rotatably mounted within control bushing 346 whose outer surface 349 is within aperture 348 in the engine block. In order to maintain the modified unit 320 in its "at-rest" position, a coil spring 351 is disposed between ring 352 on pushrod 321 and retainer 353 secured to the engine block. Pushrod 321/tappet rod 322 are longitudinally drilled at 337 for normal oil lubrication function.

In use, in one configuration (not shown), with faces 331/344 and 332/345 in engagement, the inner pushrod 321/outer tappet rod 322 act as a normal rod. Thus, oscillation of the inner pushrod 321 by the hydraulic valve lifter 313 causes similar oscillation of the outer tappet rod 322, causing alternate opening and closing of the valve (15 - see Figure 2).

Rotation of the guide element 333 by worm gear assembly 334 through 180 degrees (see Figure 20) causes faces 331/345 to be engaged only at top-of-the-stroke of outer tappet rod 322. At other times, inner pushrod 322 rests on the lip of control cylinder 333. This realignment causes inner pushrod 321/outer tappet rod 322 to become a short rod, thereby maintaining intake valve 15 (see Figure 2) closed at all times. The intake valve always remains closed when disabled.

Rotation of guide member 333 through 180 degrees again by worm gear assemblv 343 causes engagement member 330 to rotate again and have faces 331/344 and 332/345 in engagement. This brings the inner pushrod 321/outer tappet rod 322 back to its original normal operation (not shown).

As seen in Figures 21 and 22,the cylinder control mechanism 420 for an exhaust valve includes an inner pushrod 421 and an outer tappet rod 422, as well as conventional valve lifter mechanism 413, and tappet rod 424. The valve and valve springs are not shown herein, but are shown as 15 and 16 in Figure 2.

The outer tappet rod 422 is modified by including an operator member 430 thereon, of a shape which can be gripped, e.g., hexagonal or octagonal, which is secured for slidable movement but fixed against rotation within control element 433, rotatably mounted by worm gear mechanism 434 to the engine block. Operator member 430 includes upper engagement face 460 and lower engagement face 461.

Modified outer tappet rod 422 is freely rotatably mounted within the elongated tubular bushing 440, so that the lower end 435 thereof abuts the upper end 436 of the pushrod 421. Bushing 440 passes through bore 448 in engine block member 449 and rests with its cylindrical protuberance 456 on that portion of the engine block. The upper end of bushing 440 is provided with upper engagement surface 463 and lower engagement surface 464.

Inner pushrod 421/outer tappet rod 422 is maintained in its fixed relation to bushing 440 by means of coil spring 451 between retainers 452 on pushrod 421 and 453 on bushing 440. Pushrod 421/tappet rod 422 are longitudinally drilled at 437 for normal oil lubrication function.

In use, in the configuration shown in Figure 21, surfaces 461/464 and 460/463 are in engagement. Consequently, the inner pushrod 421/outer tappet rod 422 combination act as a normal rod, and oscillation of the rod 421 by the cam 17 (see Figure 2) causes opening and closing of the valve 15 (see Figure 2). The rod 421 returns to its "at-rest" position by the action of the spring 451.

Rotation of the control member 433 by the worm gear mechanism 434 through 180° causes operator member 430 to be rotated through 180° and moved upwardly. Surfaces 461/463 are only in engagement at the top-of-stroke. Thus, as shown in Figure 22, a "long" rod 421/422 is provided whereby the valve 15 is always open. In this configuration, the pushrod 421 returns to its "at-rest" position by the action of spring 451. Face 463 rests at the top of stroke position on protrusion 438.

An essential element of the engine cylinder cutout system is the shifting mechanism which can be either mechanically operated or may be solenoid controlled. An improved single coil solenoid mechanism is now provided which allows control of the modified mechanisms for both the intake valves and the exhaust valves in a safe and ordered manner through the magnetically-induced motion of a single armature and this will be described hereinafter.

The importance of sequencing the engagement and disengagement of the modified mechanisms is due to the fact that partial charges can occur. There is also the possibility of combustion occurring with no provision for gas release. The intake valve must first then be removed from its normal operative cycles followed by the removal of the exhaust valves from its normal operative cycles. When the reverse is desired, the exhaust valve must first be engaged fully before the intake valve allows combustion to take place.

The solenoid control mechanism provides for this sequencing through the control of the fluid-controlled exhaust from the modified mechanisms. The two modified mechanisms, i.e., for the intake valve and for the exhaust valve, use the fluid flow patterns during their normal cycles set forth in the following table.

TABLE

Intake Valve Inlet	Intake Valve Outlet	Exhaust Valve Inlet	Exhaust Valve Outlet
(A) Working:			
Flow	No Flow	Flow	Flow
(B) Non-Working:			
Flow	Flow	Flow	No Flow

From the above table, it is apparent that the flow of fluid into the modified mechanisms is not interfered with, but that the allowing of fluid flow out of the modified mechanism is the key to their functions.

An embodiment of a solenoid control mechanism within the scope of this invention is shown in Figures 23 - 27. The mechanism 900 includes a block 910 provided with numerous channels and ports therein. It includes a central longitudinal well 911, provided with a rounded undercut floor 912 and an outlet bore 913. A pair of identical right and left transverse cylindrical chambers 914, 915 are provided, which are longitudinally offset to provide upper right hand 914 and lower left hand 915 channels. Upper right hand channel 914 is connected to well 911 by bored conduit 916, and lower left hand channel 915 is connected to well 911 by means of bored conduit 917. Inlet to channel 914 is by conduit 918 connected to the intake mechanism, while inlet to channel 915 is by conduit 919 connected to the exhaust mechanism. Exhaust conduit 919 is at a lower level than intake conduit 918, which allows for the sequencing.

Longitudinal well 911 is connected to intersecting, transverse outlet bore 920 which leads to right hand and left hand internal chambers 921, 922, and then to outlet conduit 923. Right hand channel 914 vents to right hand chamber 921 via outlet port 924, while left hand channel 915 vents to left hand chamber 922 via outlet port 925. Fluid control is provided by check valves 926, 927 in channels 914, 915, respectively.

Check valves 926, 927 comprise a ball 928, 929, normally held against port 924, 925 by spring 930, 931, respectively. A governing mechanism, comprising a cylindrical base 932, 933, three transverse arms 934, 935, and an upright port 936, 937, respectively, is secured within conduit 918, 919, respectively. The governing mechanism restricts the forward motion of the balls 928, 929, in order to minimize damage to the springs 930, 931 through repeated compression. These two check valves 926, 927 thus allow the intake of fluid by the modified mechanisms at all times when the pressure differential permits such fluid flow.

A solenoid armature 950 is provided at the bottom of central well 911, and this armature is described with reference to Figure 27. The armature 950 includes a main cylindrical body 951 having an upper bored well 952 therein, with a coiled spring 953 trapped therein. The lower portion of body 951 is provided with an encircling governing gap 954, and a lower cylindrical block 955. The upper portion of the body is provided with a larger diameter pillar 956 which is drawn by a conventional armature coil core 957 when activated. Conventional armature components and a coil winding (not shown) are also associated with the armature block 951 and the armature coil 957.

In operation, fluid under pressure which may come from the engine oil supply, although an independent source of fluid under pressure may be provided for fail-safe operation, enters the modified mechanisms through conduit 923. The inlet flow is provided through branches 921 and 922 which feed check valves 926 and 927, respectively, through check valve ball seats and ports 924 and 925.

Fluid leaving the modified mechanisms enters through conduit 923, but instead of branching off, flows straight through bore 920, the flow through which is controlled by solenoid armature 950 (see Figure 27) in well 911. Armature 950 provides control of fluid flow through governing gap in block 951. When in normal operation, i.e., with the intake outlet closed, and with the exhaust outlet open, the spring 952 in the top well 953 forces the armature block 951 to its normal, bottom position. In this position, fluid flow through bore 920 is guided through governing gap 954 in block 951 into conduit 917 allowing fluid exhaust from the exhaust mechanism to by-pass the check valve 927 and to relieve fluid pressure, allowing normal exhaust valve function. When the coil 957 (shown here without its winding) is activated, the armature block 951 is lifted, to a point where fluid outlet is provided first to both the exhaust mechanism (through conduit 917) and the intake mechanism (through conduit 916) is allowed simultaneously. This effectively closes the intake valve while the exhaust valve is still functioning normally. As the armature block 951 is raised further by means of the coil 957, the intake mechanism is fully disconnected by fluid directed through conduit 916 as a by-pass to check valve 926. While this situation is established, the fluid flow through conduit 917 is effectively blocked through the raising of lower block 955 of armature block 951 to block the opening of conduit 917, which formerly opened on armature gap 954.

When the cylinder is re-activated, the electromagnet in coil 957 is de-activated, the armature is forced down by the force of gravity and by spring 951, to a point where conduits 916, 917 are again both in contact with fluid directed by armature gap 954. Thus, the exhaust is re-activated while the intake remains disabled. As the armature returns to its resting position, the fluid is again sealed off at conduit 916, providing no intake outlet for fluid and re-activating the intake mechanism. Similarly, the exhaust mechanism which has already been re-activated, continues to function in a normal manner.

Another simplified embodiment of a control mechanism is shown in Figure 28. Here, the mechanism 975 includes a tubular casing 976 having one closed end 977 and an open flanged end 978. A pair of diametrically opposed ports 980,981 (exhaust ports) 979,982 (intake ports) are provided through the wall of the tubular casing 976 to which are attached fluid-carrying conduits 984, 985, 983 and 986, respectively.

Slidably disposed within casing 976 is a control body 987 having a cap 988 at one end and terminating in a longitudinally extending shaft 989. Shaft 989 connects to captive plug 990, slidably disposed within casing 976. The cap 988 of control body 987 is acted on by a force shown by arrow 992, which may be a solenoid, a permanent magnet, an electromagnet, a spring, a hydraulic pneumatic or mechanical means. The interior of the casing is thus provided with hydraulic chamber 993.

For cut-out operation, the intake 980 closes first, while the exhaust 979 remains slightly open after the regular stroke. In the cut-in operation, the exhaust 979 closes first. Deactivation of the intake 980 is stopped and normal operation is then reinstated. The opening and closing of the ports 979, 982, 980 and 981 is achieved by the activation of the control body either to open or to close ports 979, 982, 980 and 985. This control may be facilitated by setting the proper distances, i.e., by grooves or gates, in front of the ports.

Turning now to Figure 29, a block diagram is shown of the organization of the control components, which explains how the sensed parameters of the vehicle are processed in a control logic 1, which controls electronically-actuated solenoid groupings 1 to 4 (only solenoid groupings 1 and 2 being shown) via solenoid drivers 2 . The vehicle-sensing functions themselves are preferably divided into two categories, the first being primary sensors for parameters of a higher prioerity, e.g., engine temperature and vehicle brake actuation. For safety reasons, it is desirable that such primary parameters override the logic control decisions developed from the set of secondary parameters, e.g., acceleration position and speedometer reading. Each sensor output, which is generally an analog voltage proportional to the particular parameter sensed, is converted to a digital representation by means of an analog-to-digital converter or encoder. Four such A/D converters 3, 4, 5 and 6 are shown, one for each sensor. For engine temperature and brake actuation status, a single status bit for each is sufficient. For instance, if the engine temperature is below the operational value, the output is a logic "0". Similarly, upon brake actuation the output of the A/D 4 changes from "1" to "0". As will be seen later in conjunction with Figure 31, a logic "0" from either A/D 3 or 4 immediately inhibits the actuation of all the solenoid groups 1 to 4, which in turn disable the uncoupling devices 20 associated with each cylinder, and the engine returns to normal operation.

Figures 30 and 31 show in detail the circuit of the control logic 1. The circuit 1 has, as shown in Figure 30, four inputs. Two inputs designated A_0 and A_1 from the A/D 6, and two inputs designated S_0 and S_1 from the A/D 5 in Figure 29. In other words, each accelerator and speedometer position is digitized by the respective A/D into four regions represented by two bits A_0 and A_1 and S_0 and S_1. For instance, should the accelerator remain unactivated and the speedometer reading be zero, A_0, A_1, S_0 and S_1 would each be a logic "0". On the other hand, should the accelerator be fully depressed, A_0 and A_1 would change to logic "1". The four possibilities for A_0/A_1 and S_0/S_1 are, of course, 00, 01, 10 and 11.

The four variables A_0, A_1, S_0 and S_1 are processed on the first portion of the logic circuit 1 shown in Figure 30 to yield two variables 1_0 and 1, which are fed to the second portion by the logic circuit 1, shown in Figure 31. The circuit of Figure 30 comprises inverters 101 to 104, which seem to develop the complement (or negation) of each variable. A suitable multiple inverter integrated circuit is Texas Instruments' TTL logic IC SN74040 which has 6 inverters, only four of which would be used. The circuit in Figure 30 further comprises NAND gate circuits 105, 106 and 107. The NAND circuits 105 and 107 are 3-input positive NAND circuits, while the circuit 106 has two 4-input positive NAND gates. TI's SN7410 is a suitable circuit, being a triple 3-input gate IC, for the gates 105 and 107, while for gates 106, SN7420 is a suitable dual 4-input IC. The basic logical relationship between the variables A_0, A_1, S_0 and S_1 and the outputs 1_0 and 1 is as follows:

$$1_0 = \overline{A}_1 \overline{A}_0 S_0 + \overline{A}_1 S_1 S_0; \text{ and}$$

$$1_1 = \overline{A}_. \overline{A}_0 \overline{S}_1 + A_0 S_1 S_0 + A_0 S_1 \overline{S}_0.$$

Thus, it follows that for all variables at logic "0", for instance zero speed with engine idling, both 1_0 and 1_1 would be a logic "1". Should S_0 and S_1 be a logic "1", (i.e., high speed), but the accelerator be unactivated (i.e., vehicle coasting at high speed), 1_0 would be a logic "0" and 1_1 a logic "1".

Turning now to the second portion of the control logic 1 , shown in Figure 31, the two outputs 1_0 1_1 are applied thereto as sole inputs from the secondary (lower priority) sensors. In addition, the outputs B and T, from the high priority sensors for brake actuation and low temperature, are applied directly to the final AND gates controlling the activation of the respective output devices 2 with the solenoid groupings 1 to 4. As mentioned before, brake actuation or insufficient temperature would immediately cause the final AND gates to have a logic "0" at their outputs Z_0 Z_1 Z_2 and Z_3. Two J-K flip-flop circuits 201 and 202 serve as latches to remember the previous status of the two variables 1_0 and 1_1 prior to a change therein. The logic gate symbols shown in Figure 31 are those conventionally used in the art, and it is believed that a detailed individual designation of each such gate would be superfluous. Suffice it to give the basic logic functions performed by the circuit shown in Figure 31, which functions may be simplifiable and implementable by other (possibly more efficient) circuits other than that shown in Figure 31. These functions, relating the solenoid drivers' outputs Z_0, Z_1, Z_2 and Z_3 to the variables 1_0 and 1_1 and ultimately to A_0, A_1, S_0 and S_1, are:

$$Z_0 = (\overline{Q}_1\overline{Q}_2 1 + \overline{Q}_1\overline{Q}_2 1_0 + Q_1 1_0 1_1)BT$$

$$Z_1 = (\overline{Q}_1 1_0 + Q_1 Q_2 1_1 + Q_2 1_0 1_1)BT$$

$$Z_2 = (Q_1\overline{Q}_2 1_1 + Q_1\overline{Q}_2 1_0 + \overline{Q}_1 Q_2 1_1 + \overline{Q}_1 1_0 1_1)BT$$

$$Z_3 = (Q_1 1_0 + Q_1 Q_2 1_1 + Q_2 1_0 1_1)BT.$$

The variables Q_1 and Q_2 in the above functions are internally developed within the circuit of Figure 31 and are, of course, dependent on the previous history of the engine and speed. Indeed, Q_1 and Q_2 and their complements $\overline{Q}_1$ and $\overline{Q}_2$ are outputs of the flip-flops 201 and 202. The inclusion of the variables B and T in the above logic functions expresses the override capability of these two inputs; both must be logic "1" for the activation of any cutout device to be possible. (Note that the B bit is only logic "0" is the brake is actuated while the car is moving).

The meaning of the above logic functions in terms of operational characteristics is summarized in the following table. The table gives the corresponding number of groups or pairs of cylinders cut out, given a certain combination of accelerator position and speedometer indication. Since the present control logic provides the random mitiatron of the flip-flops 201 and 202 (Figure 31) each time the engine is started anew, the groups of cylinders cut out are also random. This, as is obvious, provides for even distribution of the cylinders cut out over longer periods of time, such that normal wear is evenly distributed over all the cylinders.

A_0 A_1	S_0 S_1 / Speed Range: / Corresponding Accelerator Displacement Range	0,0 0-10 kmph	0,1 10-30 kmph	1,0 30-70 kmph	1,1 70 kmph
0,0	0-0.6 cm	3	2	3	3
0,1	0.6-1.8 cm	1	2	2	2
1,0	1.8-4.2 cm	0	1	2	1
1,1	4.2-7.2 cm	0	0	0	0

As an example, the table shows that with the spread between 0-10 kmph and the accelerator displacement between 0.6 cm (assuming a total displacement of 7.3 cm), three groups of cylinders are cut out, since the car is idling. For an eight cylinder engine, this means that six cylinders are cut out. For a four cylinder engine, it would means that three cylinders are cut out. Of course, such table is not the only possible arrangement. Its basic purpose is to take account of the torque requirements placed on the engine, and as such is dependent on the choice of the designer within limits. For instance, one may always choose to operate more cylinders than is minimally required. It is also understood that other parameters may be sensed, e.g., vacuum, tachometers with transmission, fuel flow, oil pressure and choke.

The retentive control means, or "brain", of the engine cylinder cutout system of this invention as described above, consists of two parts. The role of the first part is to determine the correct number of cylinders to be used in response to sensor output.

On a normal 8-cylinder car traveling on a level road, at constant speed, the system automatically determines the driver (i.e., throttle) controlled input as to power demand. It next compares the normal load, i.e., expected speed, at engine output with the actual load, along with potential speed variations caused by additional weight, drag, other forces, and speed. It then determines the correct state of operation for the system, disengaging cylinders as required. In one example, the 8 cylinders are automatically cut to 4 at 90 kmph with a fully-loaded car, flat road, ideal weather conditions, and minimal drag forces. As the car climbs a hill, the speed varies (i.e., dS), and the rate of dS/dt determines the additional load on the engine. The brain deduces from dS/dt what an adequate engine response would be needed to maintain speed, if any change is needed at all (slight hills involve almost no speed fluctuation). The engine then responds to the signals from the "brain" and modifies the output accordingly. Its responses are simplified in the following chart:

SENSOR INPUT VS. OUTPUT RESPONSE

Condition	dS/dT	dT/dt	Response
Stable	0	0	0
Acceleration			
i) Voluntary	0	*	Threshold * increase
	0	**	Threshold ** increase
	0	***	Threshold *** increase
ii) Involuntary	#	0	Threshold # decrease
	##	0	Threshold ## decrease
	###	0	Threshold ### decrease

* indicates a slight increase in throttle setting
** indicates a moderate increase in throttle setting
*** indicates a large increase in throttle setting
\# indicates a slight increase in speedometer reading
\## indicates a moderate increase in speedometer reading
\### indicates a large increase in speedometer reading
Threshold * increase indicates an increase in number of cylinders active when a predetermined power demand is sensed.
Threshold # decrease indicates a decrease in number of cylinders active once a predetermined power surplus is apparent.

The degree of response is dependent on the degree of the sensed load variation. This chart is simplified, as all vehicles have unique and characteristic parameters, which vary according to speed.

Both signals are analog based, with voltage variations between minimum (0) and maximum (1) initiating coded digital signals describing the zero throttle (0) and maximum throttle (1) settings through analog/digital converters. The two signals are then compared with reference levels, i.e., a depression of 0.25 normally produces a speed of 30 kmph ,initiating a normal response of shifting to 4 cylinders. Should a speed of 40 kmph be indicated, then the response would be a shifting to 2 cylinders. Should a speed of 20 kmph be recorded, the response would involve shifting to 6 cylinders. There is, after every switch, a slight delay before any further switching occurs, with the exception of the throttle override response which cuts all cylinders in for emerging power situations.

Once the correct number of cylinders is chosen, then the firing pattern is chosen to allow for (1) minimal harmonic resonance (in the engine it supports); (2) provide for random selection of cut-in and cut-out cylinder in use.

As an additional variant, it is possible to provide a manual electrical control for the initial operation of the engine in order to cut out the intake of fuel and to relieve compression in selected cylinders to facilitate start up. Once the engine is started, the manual electrical cut-out is overrun and the retentive control means responsive to the status of a selected vehicle operating parameter (i.e. temperature) becomes dominant.

Claims:

1. An engine cylinder cutout system including (a) a plurality of uncoupling devices (20) for selectively coupling or uncoupling associated valve operators (14) from respective driven members (23), said cutout devices (20) being selectively operable for normal operation enabling the normal cycle of operation of the valve operators (14) and for cutout operation interrupting said normal cycle in any phase of its operation, the plurality of cutout devices (20) being equal in number to the number of cylinders or valves in the engine; and (b) shifting mechanism (37, 47) for selectively operating said cutout devices (20) to provide variation of valve operation from normal cycles, allowing the valves to be opened or closed as required, and cutout operation, uncoupling selective one or ones of the valve operators (14) so that selected exhaust valves can be maintained open in a controlled manner while associated selected intake valves can be maintained closed; characterized in the provision of (c) retentive control means (39, 49) responsive to the status of vehicle operating parameters for randomly initiating operation of shifting mechanism (37, 47) associated with each said uncoupling device for random initial activation thereof; thereby selectively cutting out one or more cylinders in said engine a substantially even average amount of time, so that engine wear is balanced.

2. The engine cylinder cutout system of claim 1 characterized in that said uncoupling device is specially constructed for selectively coupling or uncoupling a reciprocating pushrod member from a driven member, and for holding such driven member at a controlled position with respect to said pushrod member while said pushrod member motion itself is uninterrupted, with said driven member having a return stroke driving means, said uncoupling device comprising: (a) a support means disposed between a selected pushrod member and a selected driven member; (b) a variable length member connected to said support means and relatively movable with respect thereon; (c) coupling means on said variable length member for engaging said selected pushrod member; (d) means for selectively operating or deactivating said coupling means, whereby said variable length member may be selectively driven by said pushrod member when coupled thereto or, when uncoupled, not driven by said pushrod member throughout its normal cycle while the motion of said pushrod is unimpeded with respect to said variable length member; (e) length-varying means movably attached to said variable length member for permitting relative motion between first and second limit positions,

said variable length member being at minimum and maximum lengths, respectively, when said length-varying means is disposed at its first and second limit positions, respectively, said length-varying means being drivingly connected to said driven member; and (f) extension-actuating means for selectively extending said length-varying means to its second limit position relative to said variable length member and for holding said length-varying member at said position.

3. The engine cylinder cutout system of claim 1 characterized in that said uncoupling device for controlling the valve for said internal combustion engine comprises: (1) a casing; (2) a composite operating mechanism comprising an inner pushrod and outer tappet rod telescopically assembled together and slidably mounted within said casing; and (3) controlled means actuatable for automatically (i) permitting said inner pushrod to slide with respect to said outer tappet rod so that said outer tappet rod is immovable with respect to said casing, and (ii) locking said inner pushrod to said outer tappet rod, thereby to cause said inner pushrod to move said outer tappet rod slidably with respect to said casing.

4. The device of claim 3 characterized in that said means (3) comprises: (a) a first semi-toroidal groove in the inner pushrod; (b) a plurality of discrete slits around the circumference of the outer tappet rod; (c) a plurality of balls disposed within said discrete slits; (d) a slidable member within said casing, said slidable member including a second semi-toroidal groove on the inner face thereof; and (e) means for moving said slidable member (d) between (i) a first position, where said second groove is aligned with said first groove, thereby to permit said inner pushrod to slide with respect to said outer tappet rod; and (ii) a second position, where said second groove is not aligned with said first groove, thereby to lock said inner pushrod with respect to said outer tappet rod.

5. The device of claim 3 characterized in that said means (3) comprises: (d) a plurality of balls disposed within said discrete encircling slits; and (e) means for moving said slidable member between (i) a first position where said second groove is aligned with said first groove, (ii) a second position where said second groove is not aligned with said outer hollow cylindrical slidable member with the first groove thereon in its upper position, and (iii) a third position where said second groove is not aligned with said first groove when said outer hollow cylindrical slidable member with the first groove thereon is in its lower position.

6. The device of claim 3 characterized in that said means (3)

comprises: (d) a plurality of balls disposed within said discrete encircling slits; and (e) means for moving said slidable member between (i) a first position where said second groove is aligned with said first groove, (ii) a second position where said second groove is not aligned with said outer hollow cylindrical slidable member with the first groove thereon in its upper position, and (iii) a third position where said second groove is not aligned with said first groove when said outer hollow cylindrical slidable member with the first groove thereon is in its lower position.

7. The device of claim 3 characterized in that said means (3) comprises: (e) means (i) for urging said slidable member downwardly to required said outer tappet rod to move in unison with said inner pushrod with respect to said casing, and (ii) for urging said slidable member upwardly to permit said inner pushrod to slide with respect to said outer tappet rod.

8. The device of claim 3 characterized in that said means (3) comprises: (e) means (i) for urging said slidable member downwardly to require said outer tappet rod to move in unison with said inner pushrod with respect to said casing, and (ii) for urging said slidable member upwardly to permit said inner pushrod to slide with respect to said outer tappet rod.

9. The device of claim 3 characterized in that said means (3) comprises a lower chamber in said casing between said pushrod and said tappet rod and a means for filling said chamber with a pressure fluid so that, (i) when said chamber is filled with fluid, reciprocation of said pushrod provides corresponding reciprocation of said tappet rod; and (ii) when said chamber is empty of fluid, reciprocation of said pushrod does not provide corresponding reciprocation of said tappet rod.

10. The engine cylinder cutout system of claim 1 characterized in that said uncoupling device for controlling the valve for said internal combustion engine comprises: (1) a mounting bushing; (2) an inner and an outer coaxially assembled tappet rod assembly slidably mounted within said mounting bushing; and (3) tappet rod length adjusting means operatively associated with said tappet rod assembly and actuatable to change the tappet rod length between a first preselected long length and a second preselected short length.

11. The engine cylinder cutout system of claim 1 characterized in that said shifting mechanism comprises solenoid control mechanism comprising: (a) a block; (b) a central longitudinal control well therein; (c) a first and a second transverse, fluid conducting valved bores therein each

being provided with a fluid-flow conduit; (d) a central, transverse fluid conducting bore therein, provided with open conduit connections to said transverse valved bores and valved conduit connections to said valved bores, and connecting to a main supply conduit; and (e) actuated control means disposed in said control well for (i) providing fluid connection between said first valved conduit, said open conduit connection, said central bore and said main supply conduit while blocking off fluid connection between said open conduit connection and said second valved conduit; (ii) providing fluid connection between said second valved conduit, said open conduit connection, said central bore and said main supply conduit while blocking off fluid connection between said open conduit connection and said first valved conduit; and (iii) providing fluid connection between said first valved conduit, said open conduit connection, said central bore and said main supply conduit while blocking off fluid connection between said open conduit connection and said second valved conduit and providing fluid connection between said second valved conduit, said open conduit connection, said central bore and said main supply conduit while blocking off fluid connection between said open conduit connection and said first valved conduit.

12. The engine cylinder cutout system of claim 1 characterized in that said shifting mechanism comprises: (a) an open tubular casing; (b) a control body slidably disposed within said tubular casing, said control body including a head portion, adapted to abut with a rim in said tubular casing, thereby to limit movement of said control body in one direction; (c) a lesser diameter tubular rod connected between said control body and a second captive slidable plug fully disposed within said tubular casing; and (d) two pairs of ports adapted to lead hydraulic fluid into and out of the interior of said tubular casing.

13. The engine cylinder cutout system of claim 1 characterized in that said retentive control means includes memory means operatively associated with said retentive control means and serving to assure a substantially even cutout of all the cylinders of the engine during different sequences of operation so that engine wear is balanced.

14. The engine cylinder cutout system of claim 1 characterized in that said retentive control means is provided with means for retaining the status of the immediately preceding change of operating parameters.

15. The engine cylinder cut-out system of claim 1 characterized by including initial manual control means for cutting out the intake of fuel and to relieve compression in selected cylinders to facilitate start-up, and means, operative when the engine is running, to overrun said manual control means, thereby rendering the retentive control means (39, 49) responsive to a selected vehicle operating parameter dominant.

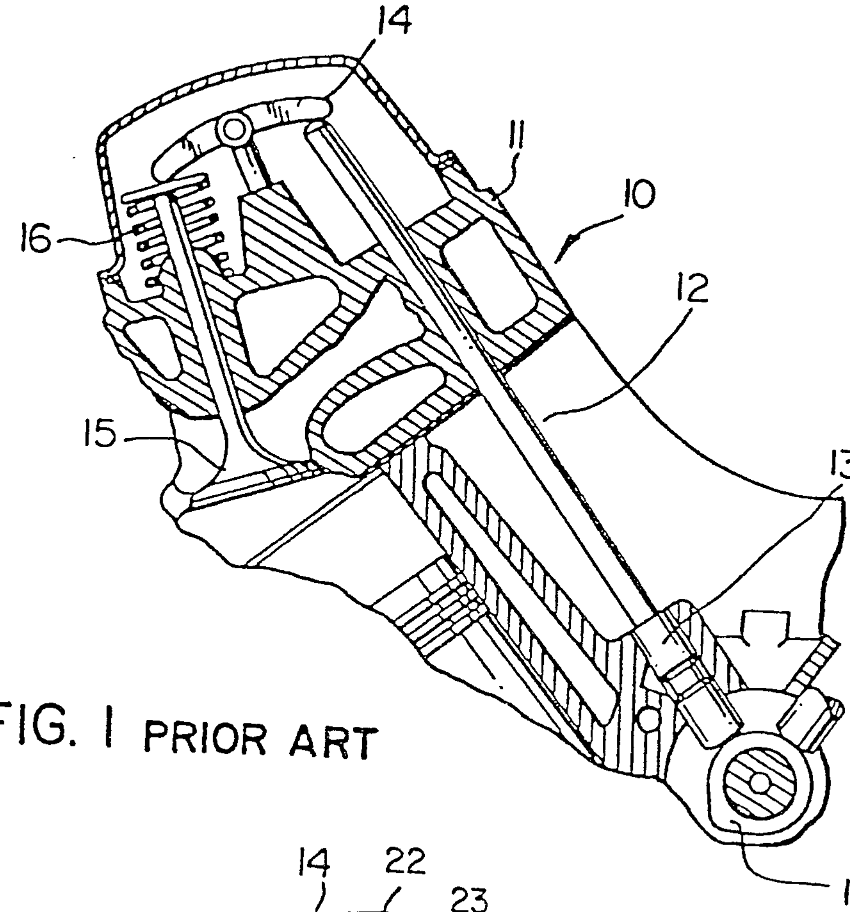

FIG. 1 PRIOR ART

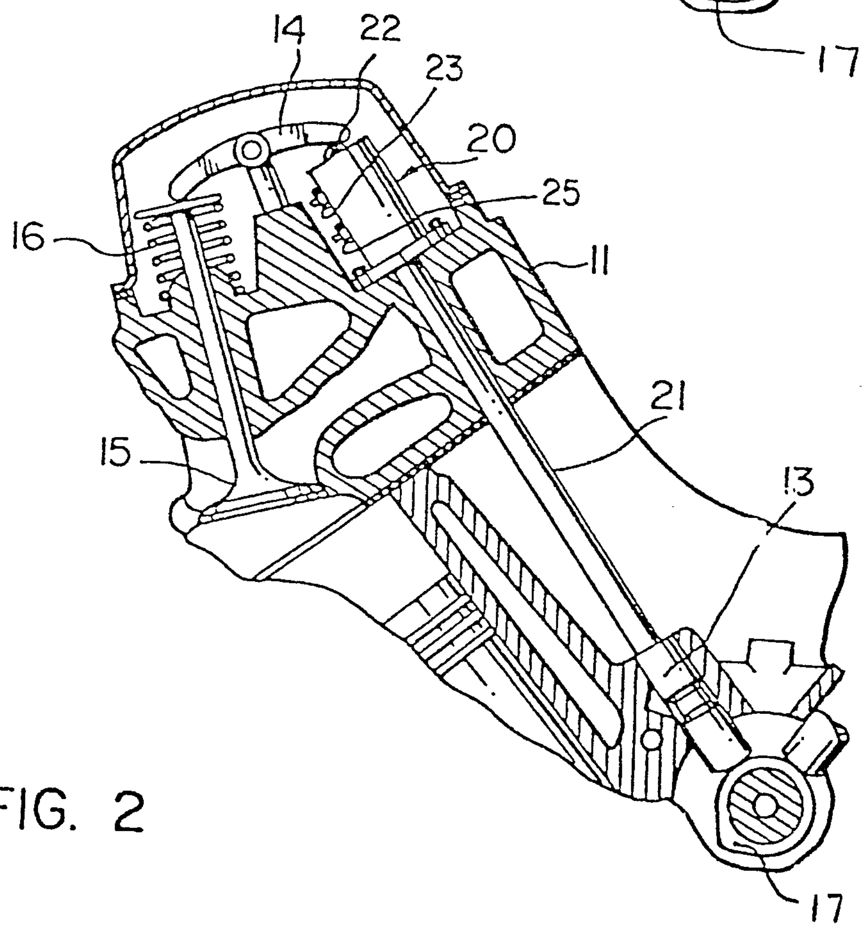

FIG. 2

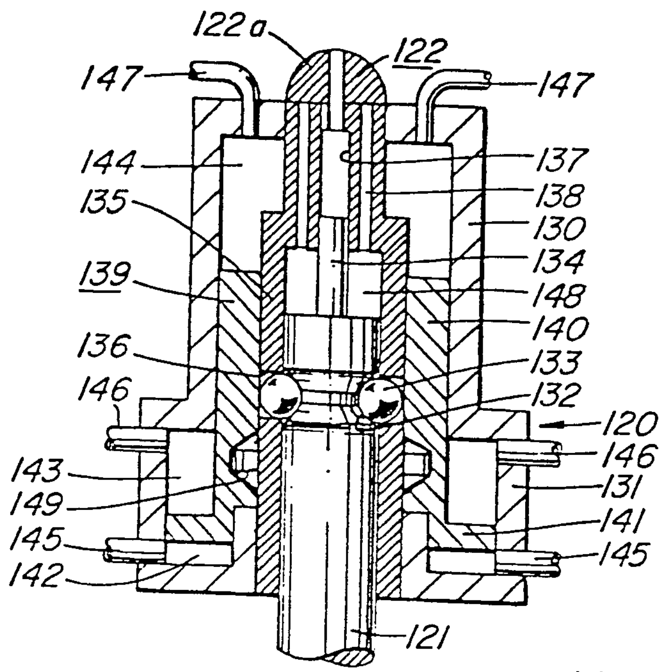

FIG. 3

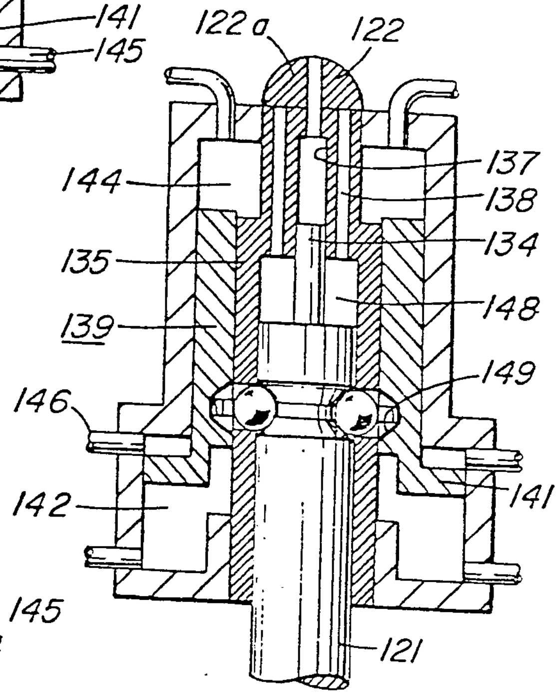

FIG. 4

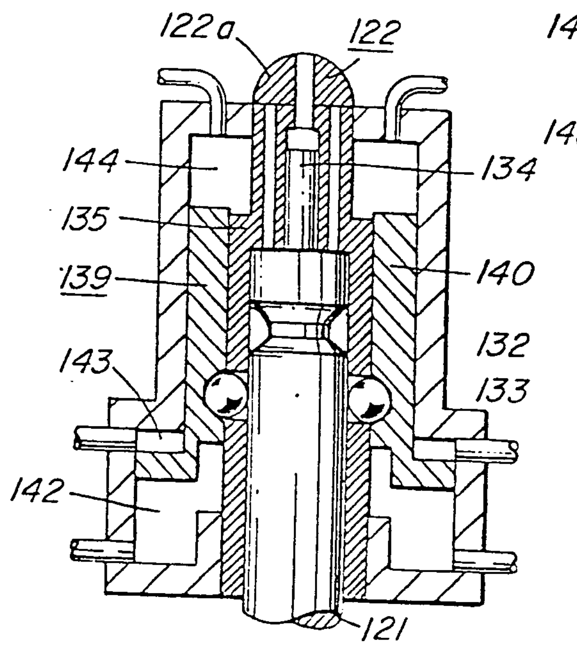

FIG. 5

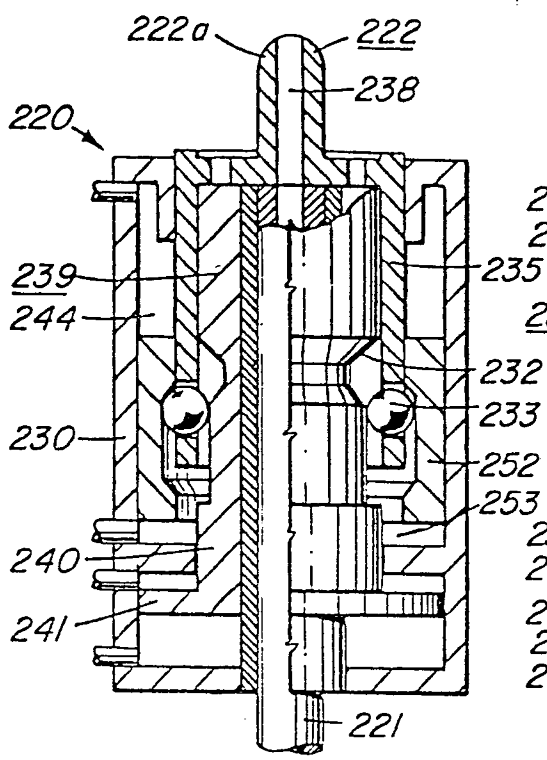

FIG. 6

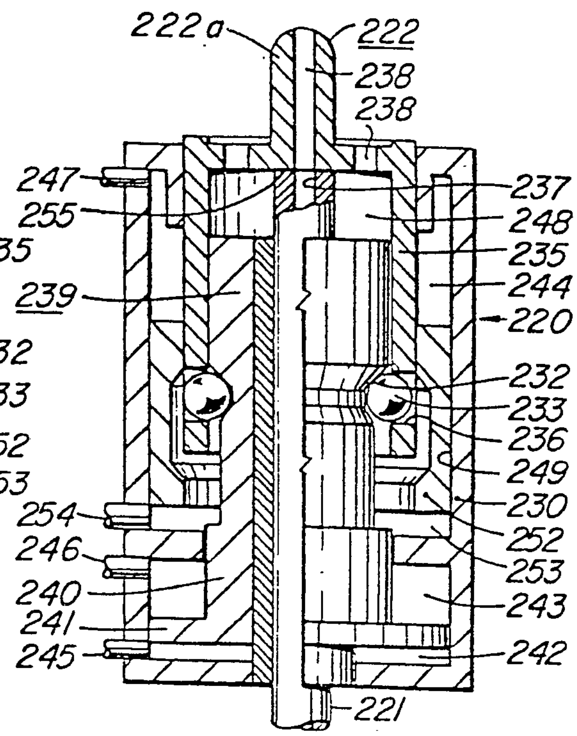

FIG. 7

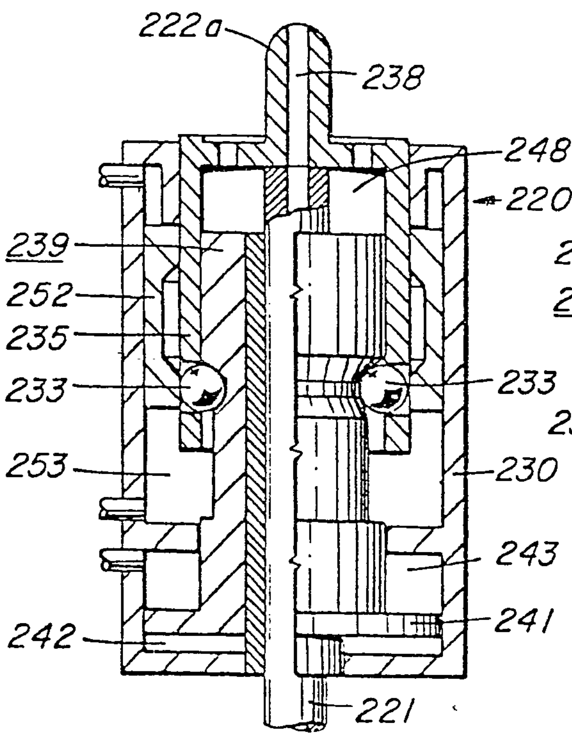

FIG. 8

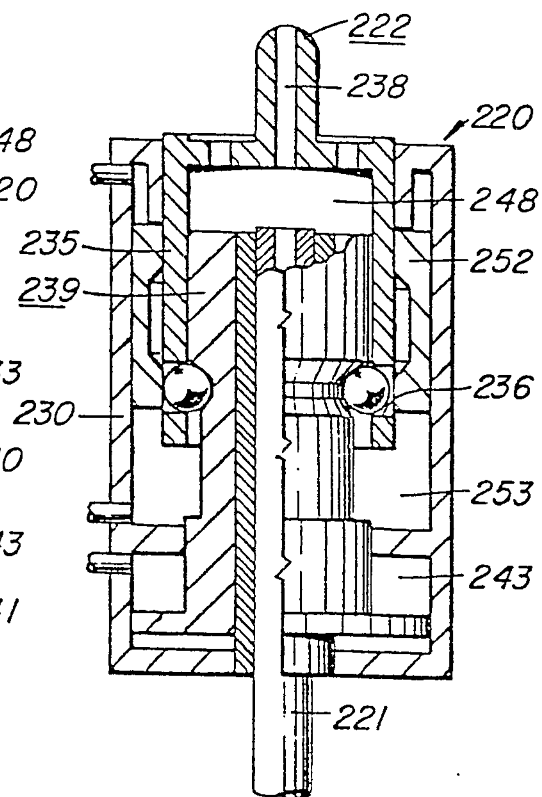

FIG. 9

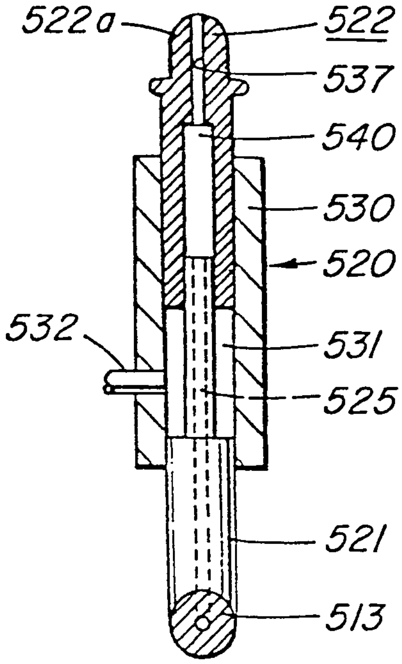

FIG. 10

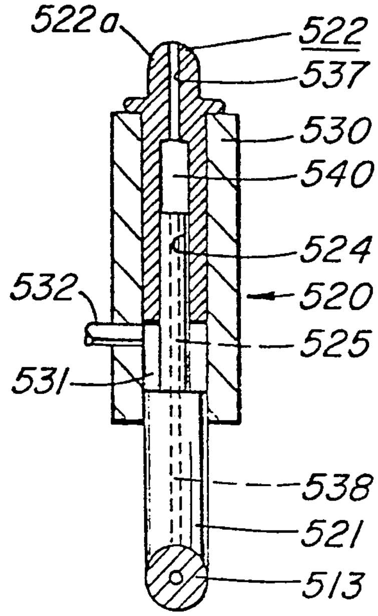

FIG. 11

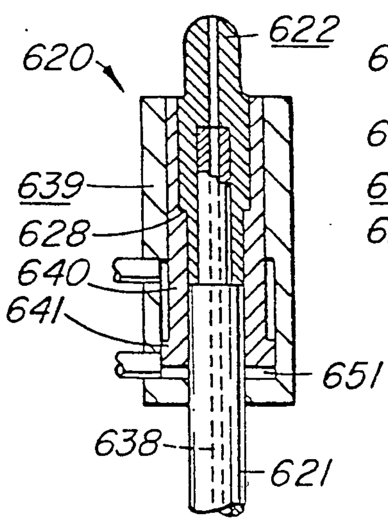

FIG. 12

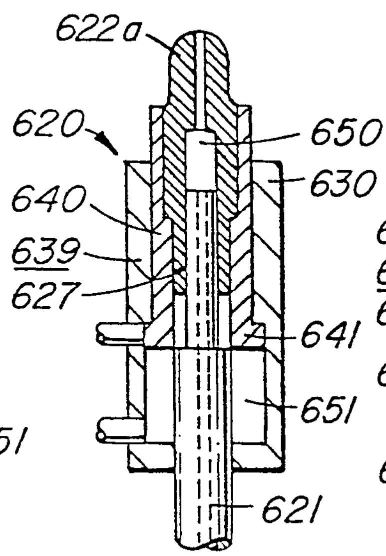

FIG. 13

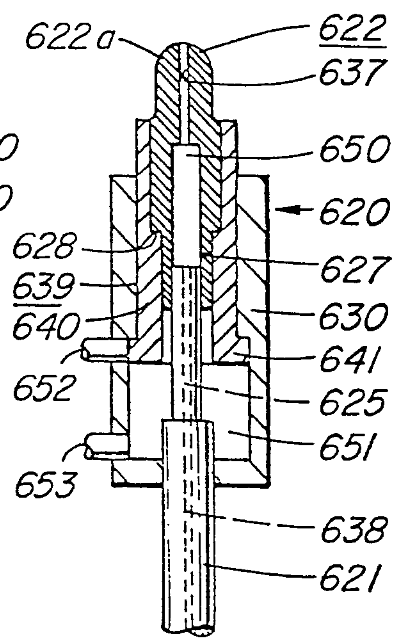

FIG. 14

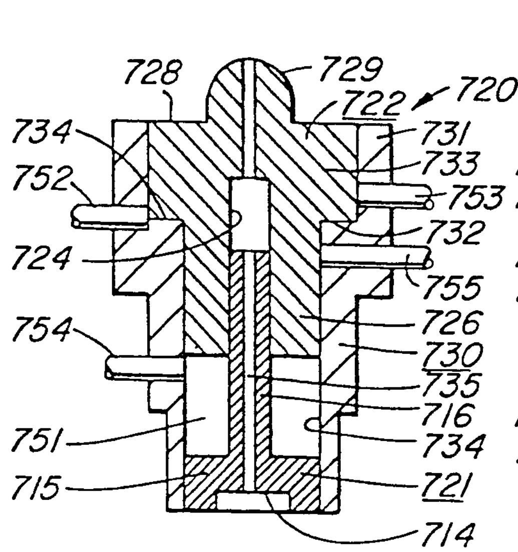

FIG. 15

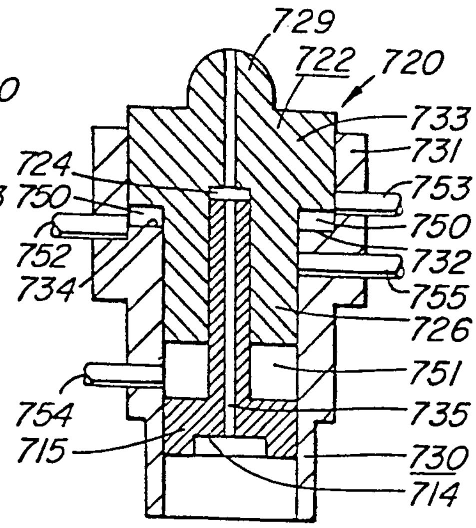

FIG. 16

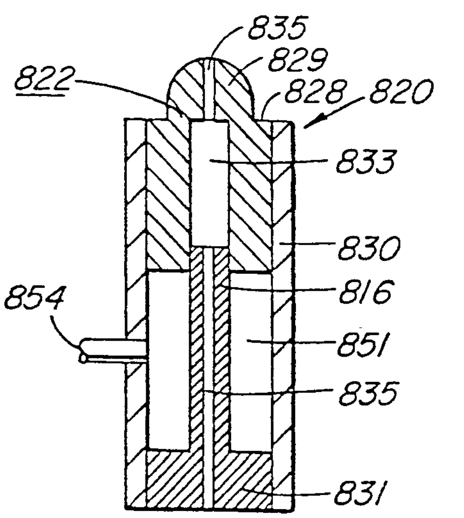

FIG. 17

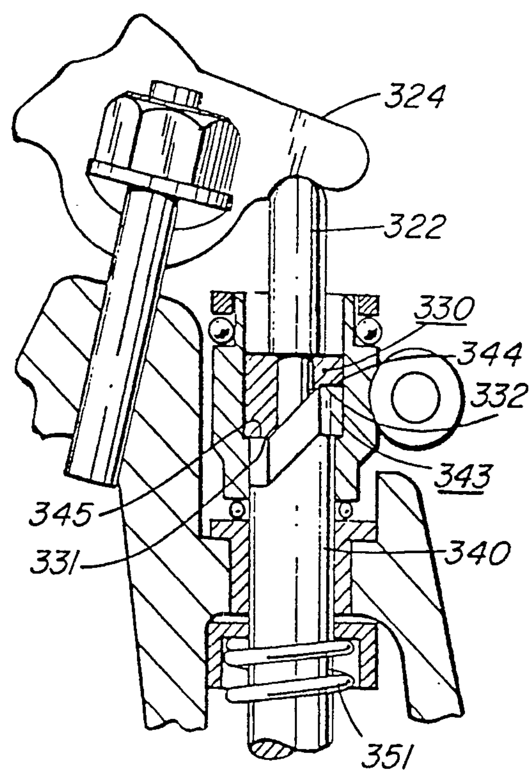

FIG. 20

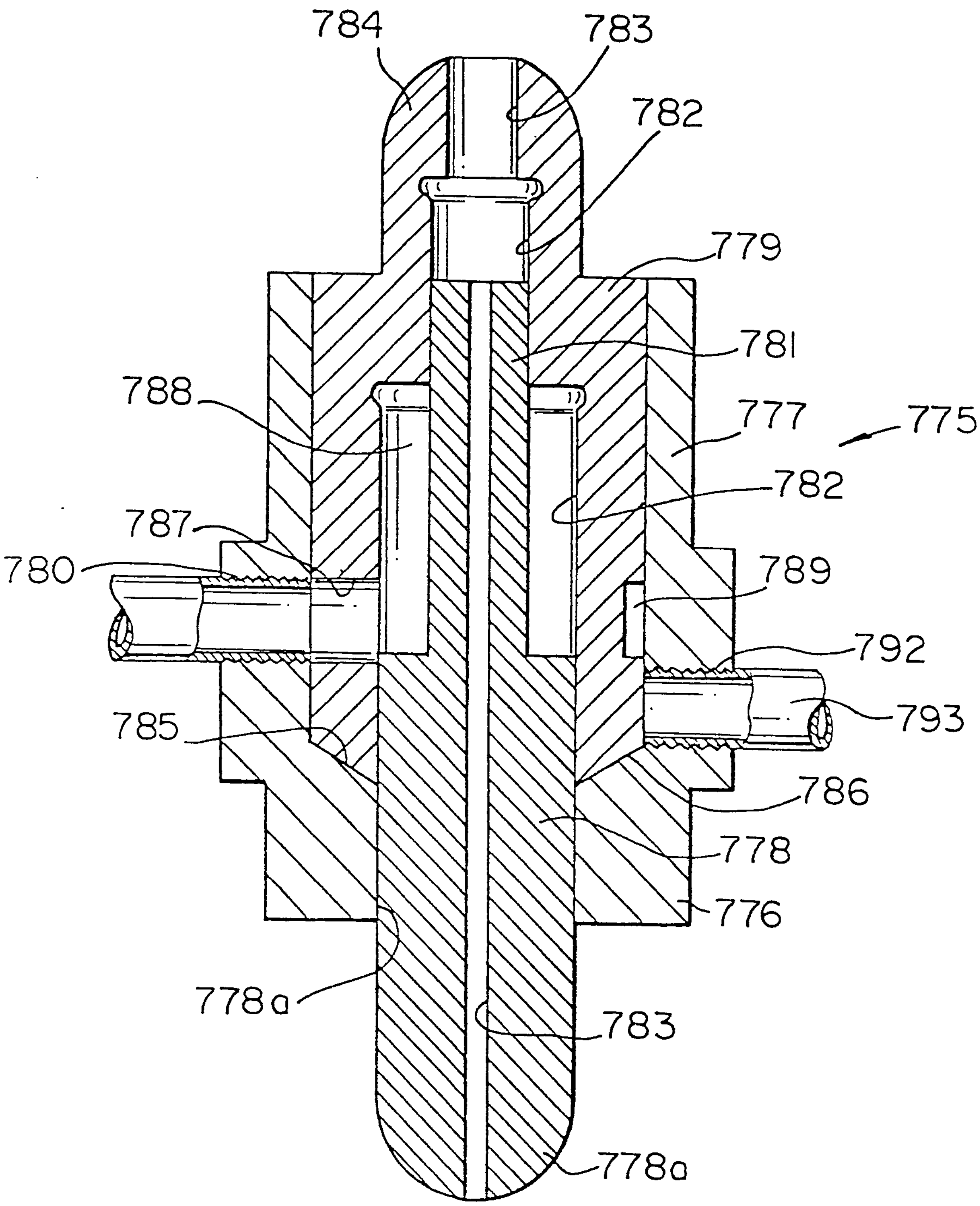
784
783
782
779
781
788
777
775
782
787
780
789
792
785
793
786
778
776
778a
783
778a

FIG.18

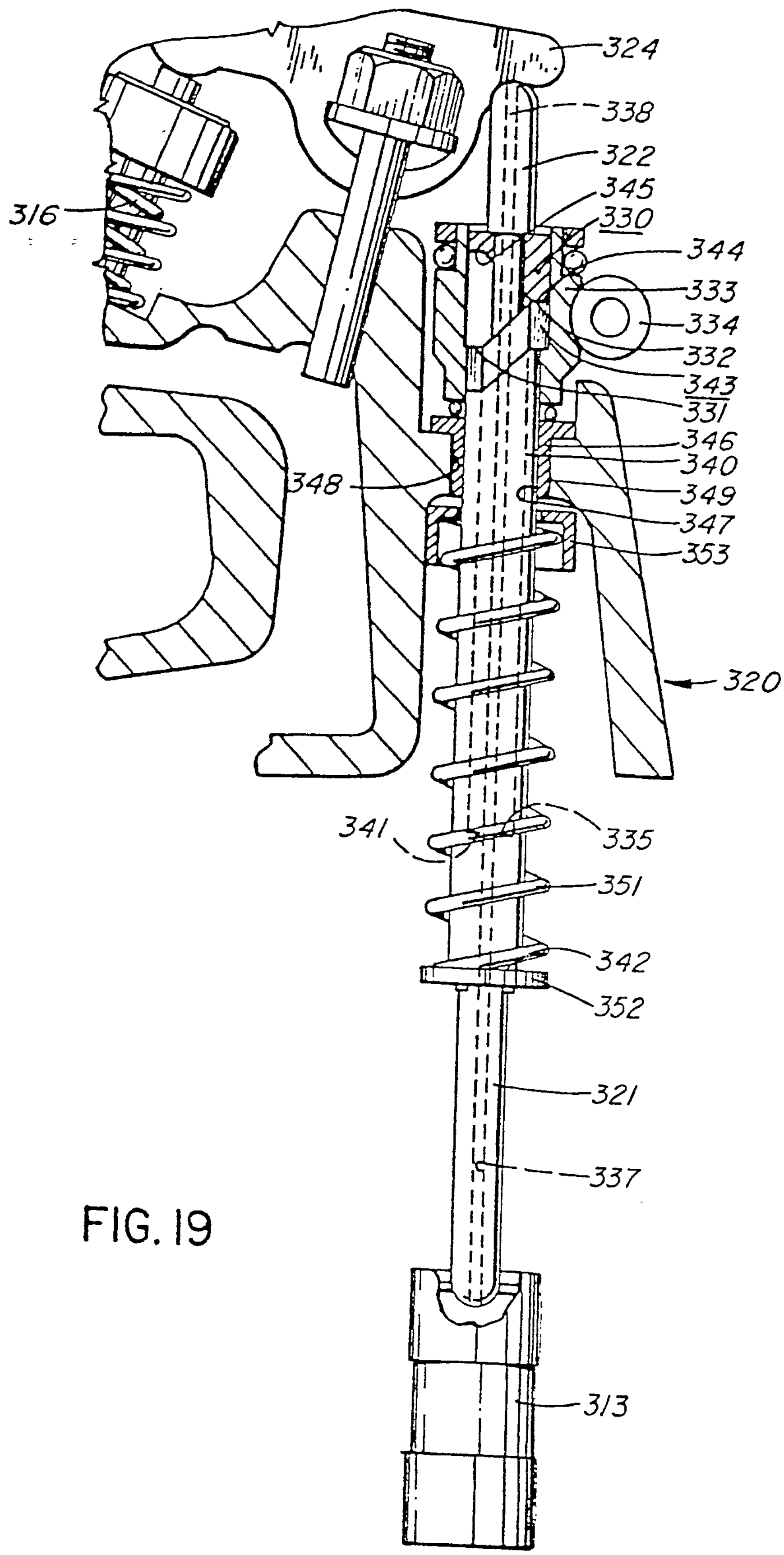
324
338
322
345
330
316
344
333
334
332
343
331
346
340
348
349
347
353
320
341
335
351
342
352
321
337
313

FIG. 19

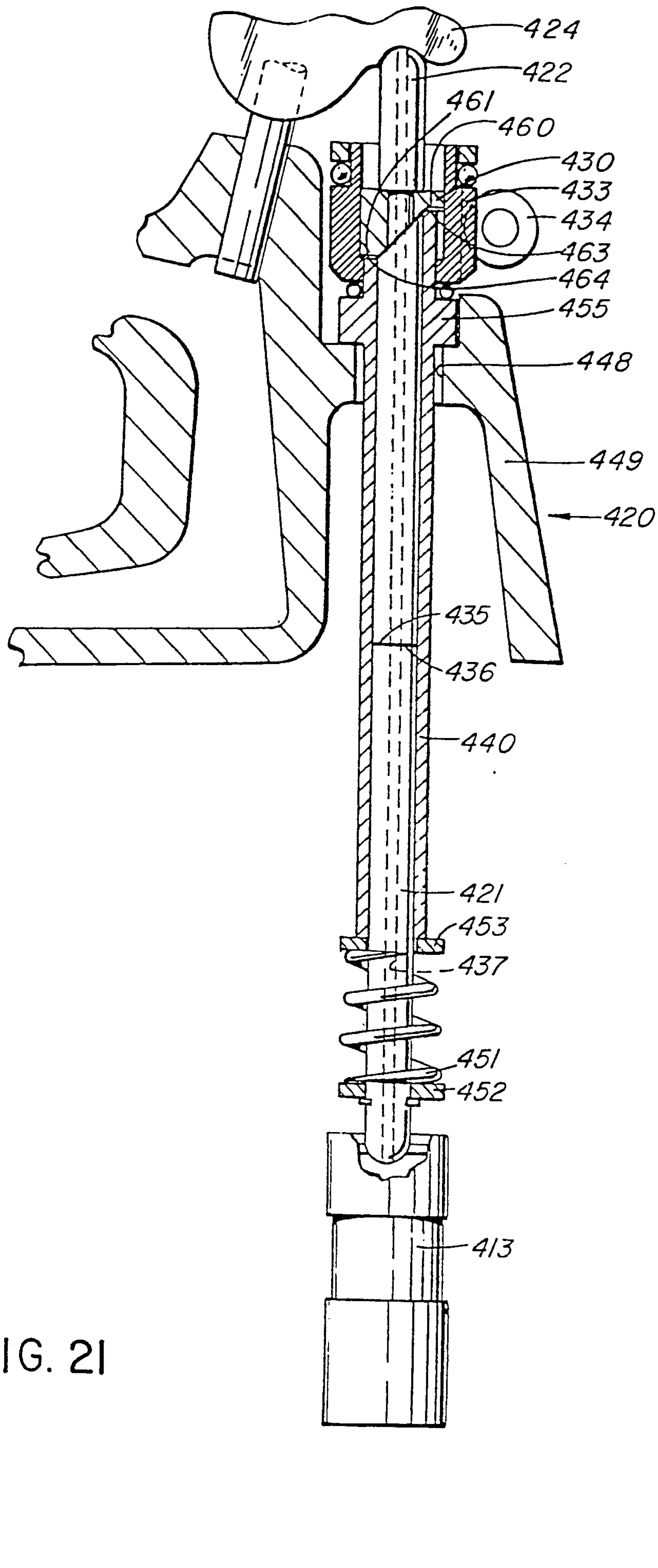
424
422
461
460
430
433
434
463
464
455
448
449
420
435
436
440
421
453
437
451
452
413

FIG. 21

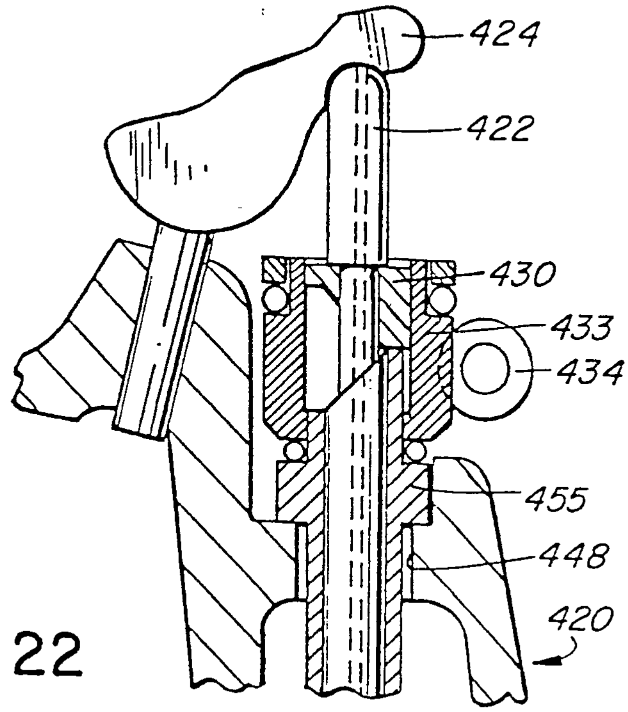

FIG. 22

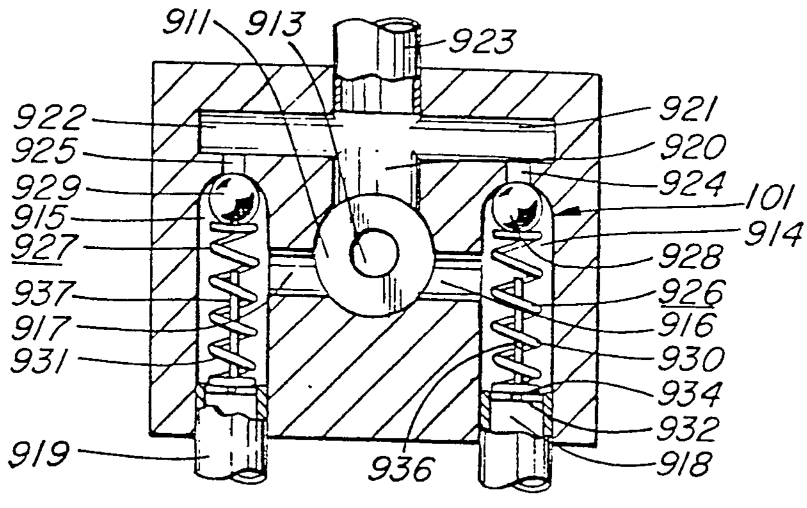

FIG. 23

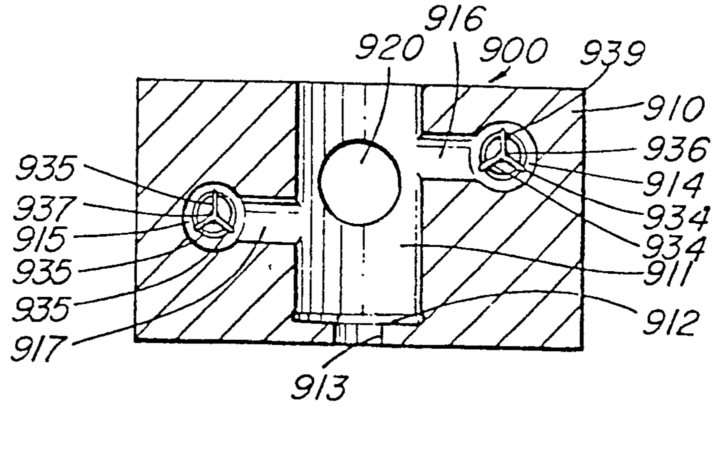

FIG. 24

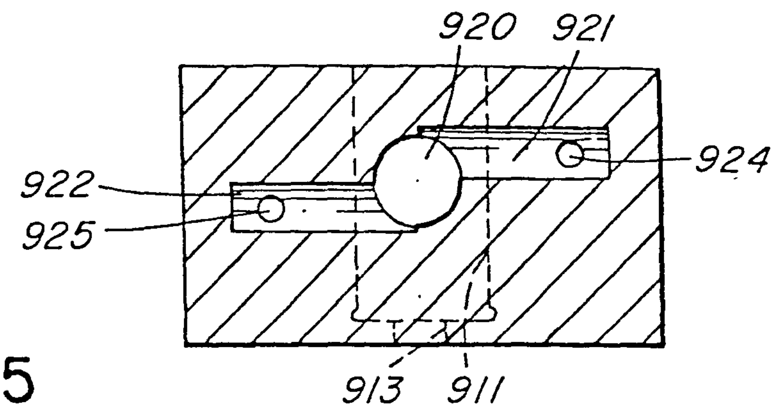

FIG. 25

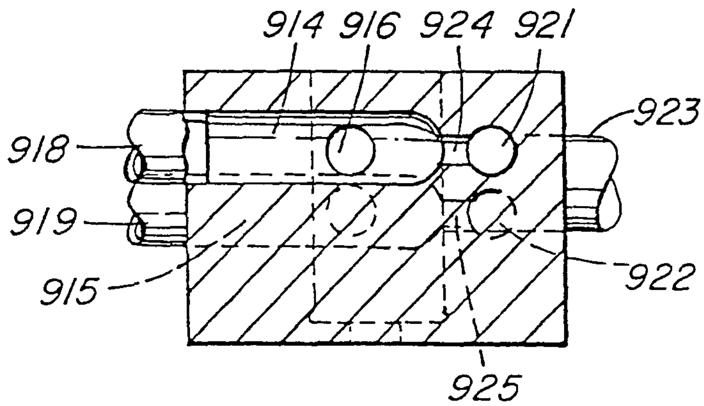

FIG. 26

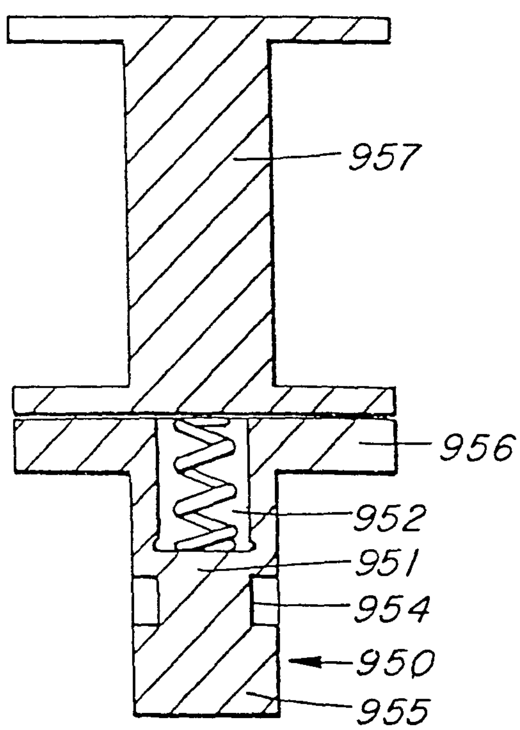

FIG. 27

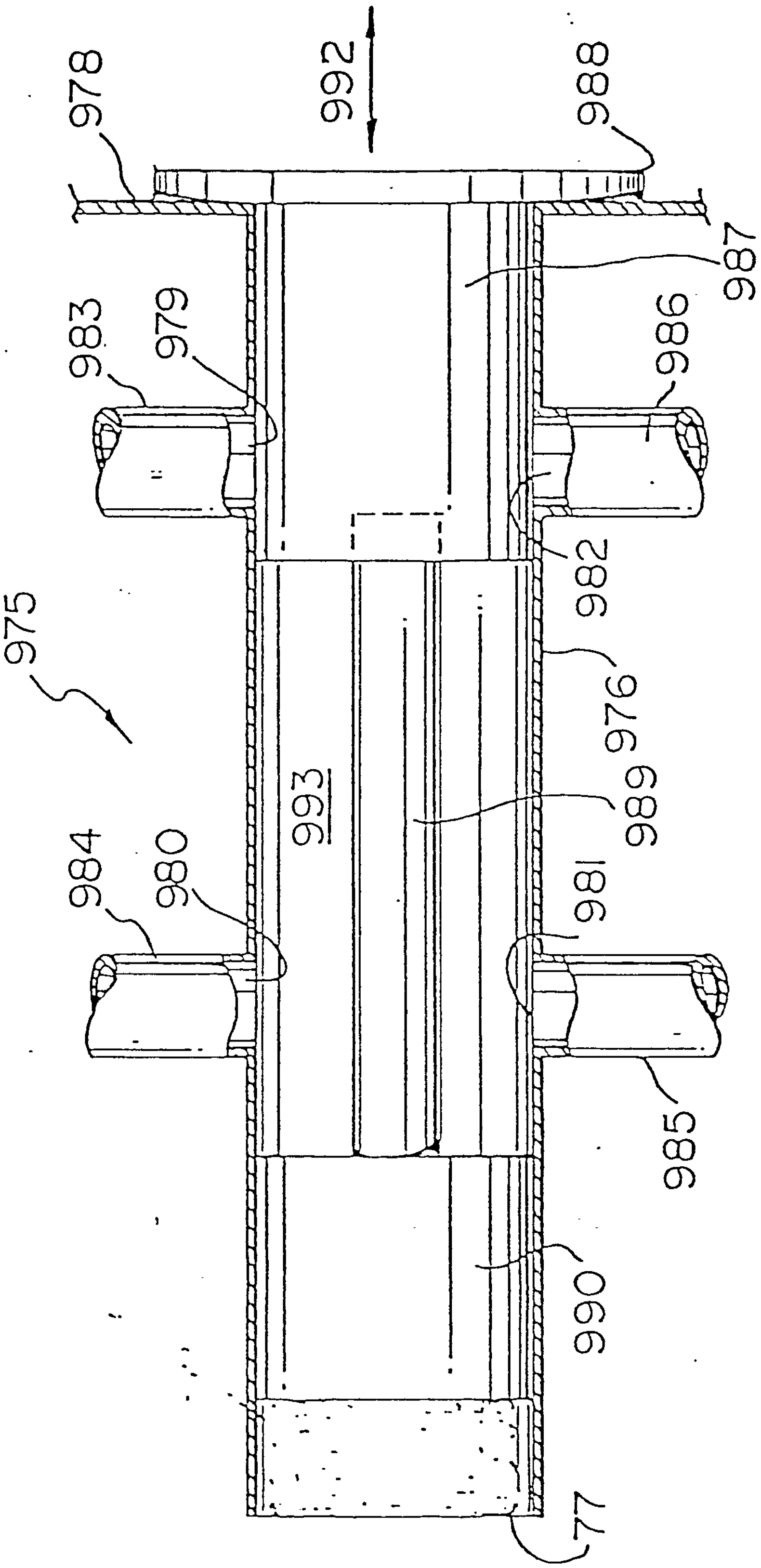
992
978
988
987
983
979
986
982
975
976
993
989
984
980
981
985
990
77

FIG. 28

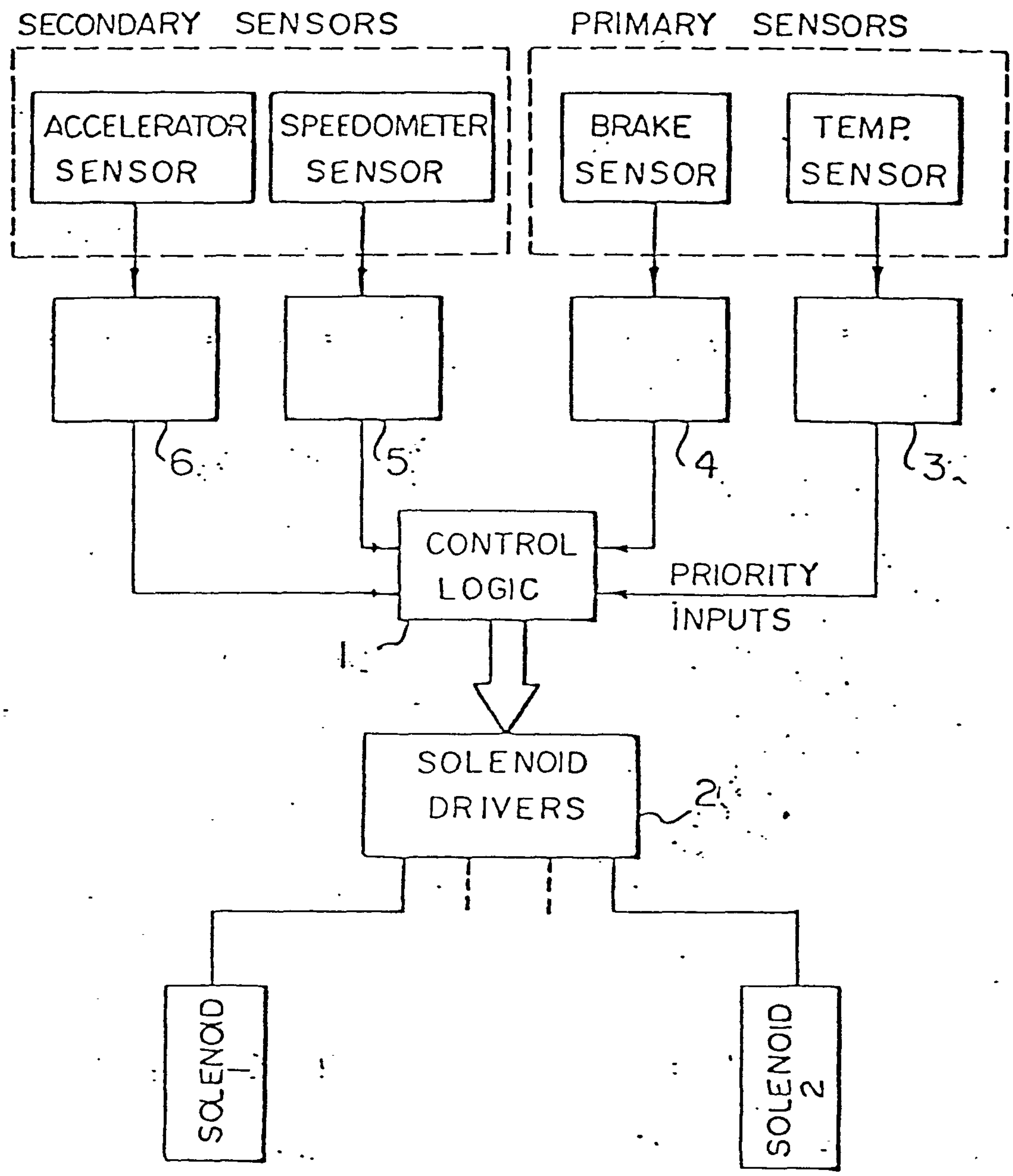
SECONDARY SENSORS
PRIMARY SENSORS
ACCELERATOR SENSOR
SPEEDOMETER SENSOR
BRAKE SENSOR
TEMP. SENSOR
6
5
4
3
CONTROL LOGIC
PRIORITY INPUTS
1
SOLENOID DRIVERS
2
SOLENOID 1
SOLENOID 2

FIG. 29

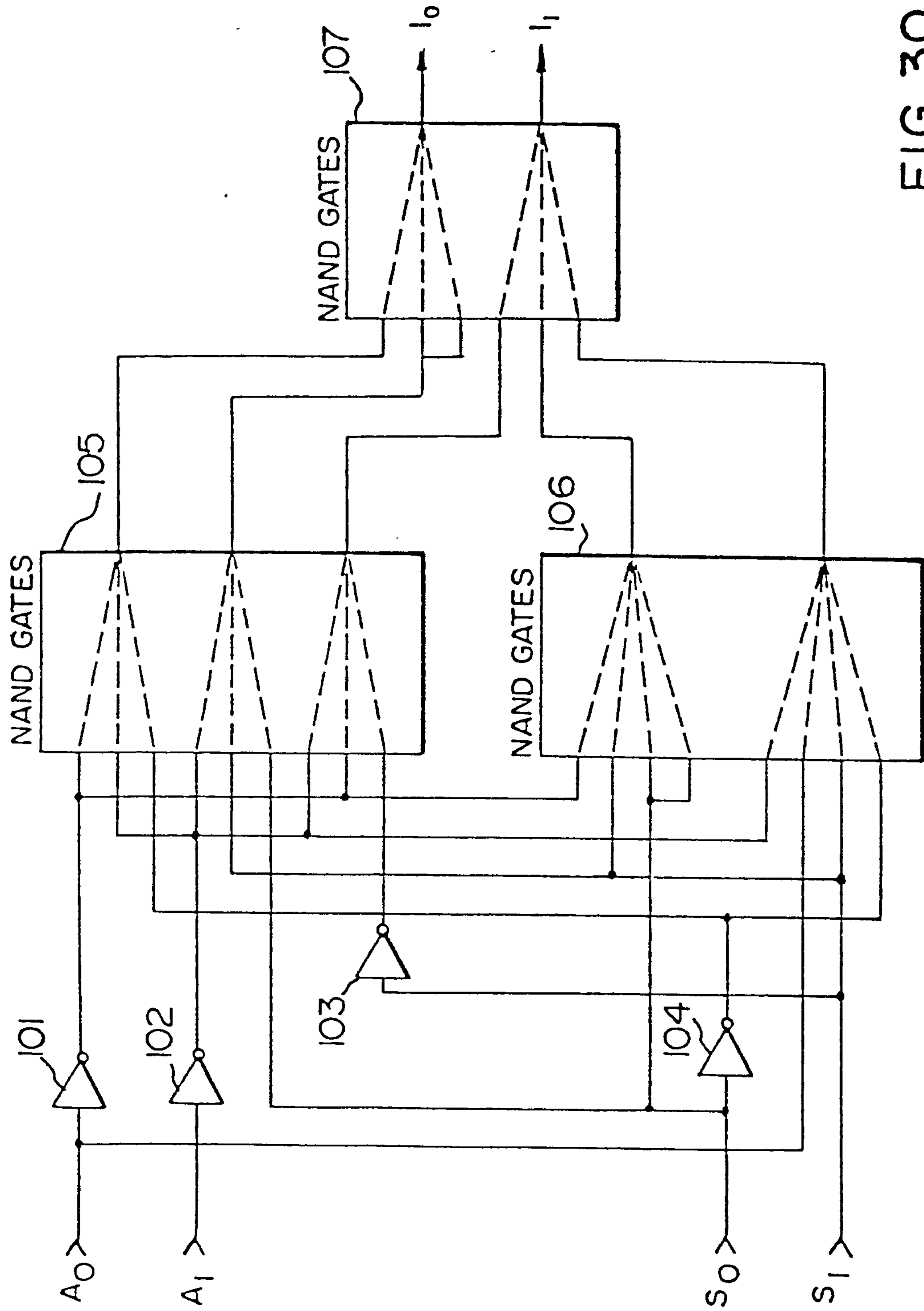
NAND GATES
NAND GATES
NAND GATES
105
106
107
101
102
103
104
A_0
A_1
S_0
S_1
I_0
I_1

FIG. 30

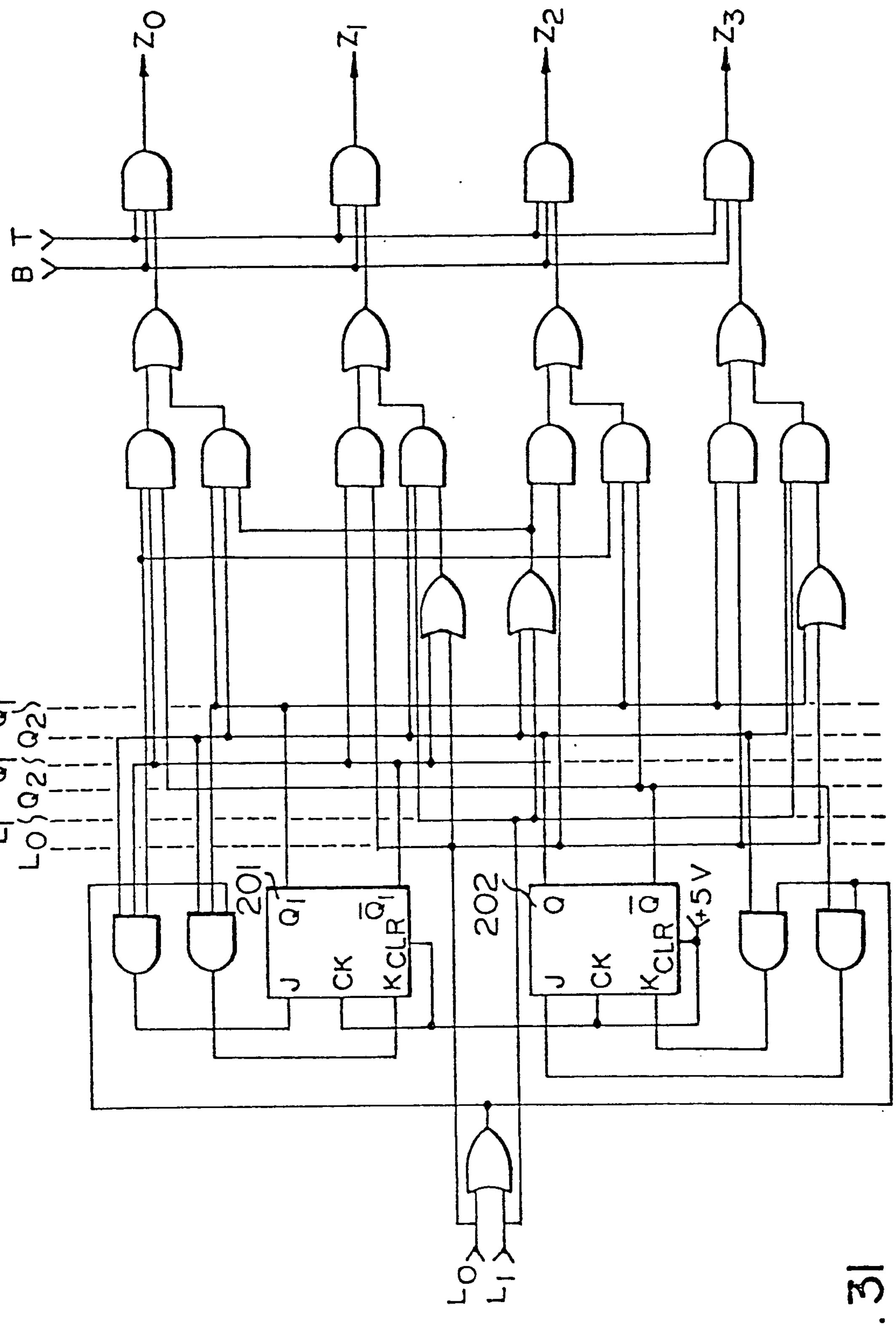
Z0
Z1
Z2
Z3
B
T
Q1
Q2
Q1
Q2
L1
L0
201
Q1
$\overline{Q}_1$
J
CK
K
CLR
202
Q
$\overline{Q}$
J
CK
K
CLR
+5 V
L0
L1

FIG. 31

0037269

European Patent Office

EUROPEAN SEARCH REPORT

Application number
EP 81 30 1342

Category	DOCUMENTS CONSIDERED TO BE RELEVANT Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int Cl ³)
X	US - A - 4 146 006 (GARABEDIAN) * Column 1, line 46 to column 2, line 54 * --	1,15, 13,14	F 01 L 13/00 F 02 D 17/02
D	US - A - 4 050 435 (FULLER) * Column 1, line 5 to column 2, line 30 * --	2,3	
	US - A - 4 151 824 (GILBERT) * Column 1, line 25 to column 3, line 45; column 4, line 59 to column 9, line 66 * --	2,3,4, 5-12	TECHNICAL FIELDS SEARCHED (Int Cl ³) F 02 D F 01 L
	US - A - 4 129 109 (NISSAN) * Column 1, line 6 to column 2, line 16 * --	1	
	US - A - 4 161 166 (ROZNOVSKY) * Column 2, line 6 to column 5, line 31 * --	2-12	
	US - A - 2 948 274 (WOOD) * Column 1, line 15 to column 6, line 39 * --	2-12	CATEGORY OF CITED DOCUMENTS X: particularly relevant A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons
	US - A - 3 518 976 (THUESEN) * Column 1, line 39 to column 3, line 8 * -----	2-12	
✓	The present search report has been drawn up for all claims		&: member of the same patent family, corresponding document

Place of search	Date of completion of the search	Examiner
The Hague	24-06-1981	WASSENAAR