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(54) **Lifter oil manifold assembly for v-type engines**

(57) A multiple-cylinder internal combustion engine including a lifter oil manifold assembly (LOMA) 100 positioned within the engine in an improved and beneficial manner is disclosed. In one embodiment, an engine includes an engine block 102 comprising a V-valley 112 in which the LOMA 100 is mounted such that longitudinal axes 106 of a plurality of solenoid control valves 108 therein are positioned essentially perpendicular to a vertical axis 110 centrally extending from an angle formed by the V-valley 112 of the engine block 102. In another embodiment, the V-valley 112 of such an engine includes both a LOMA 100 and a balance shaft 118.

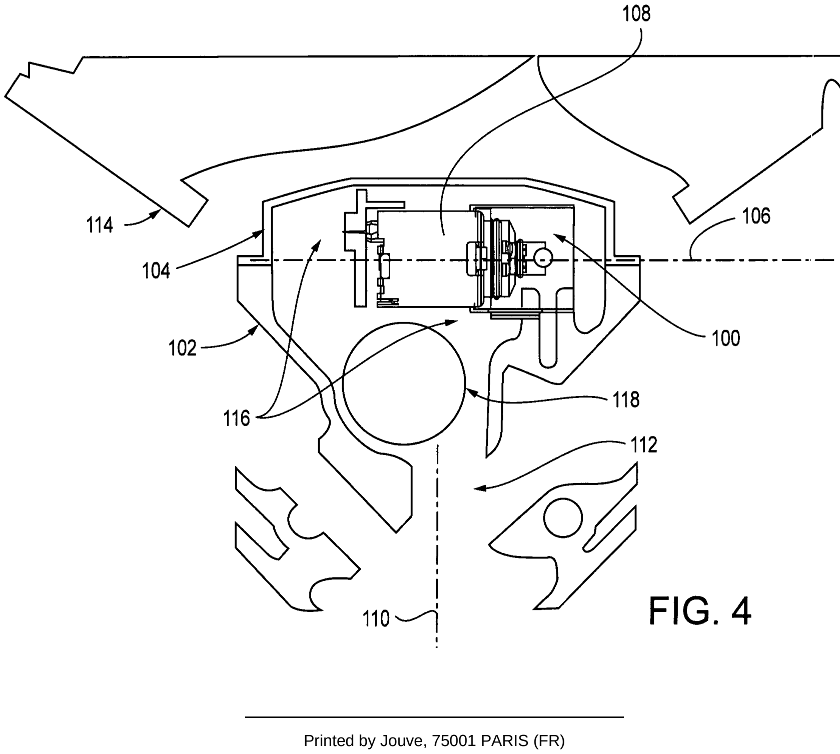

FIG. 4

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Description

BACKGROUND

[0001] The present invention relates to internal combustion engines and lifter oil manifold assemblies therein, which are particularly adapted for use with V-type engines.

[0002] Internal combustion engines are well known. Such an engine may include a plurality of combustion cylinders, each containing a reciprocable piston connected to a common crankshaft by a connecting rod. In so-called "four-stroke" or "four-cycle" engines, each cylinder is generally provided with one or more intake valves for admitting a fuel/air mixture to the cylinder, and one or more exhaust valves for exhausting burned mixture from the cylinder. A spark plug extending into each cylinder generally ignites the compressed fuel/air mixture at a predetermined time relative to the rotary position of the crankshaft. Typically, the intake valves are actuated by an intake camshaft that is operatively coupled to the crankshaft and that has a plurality of cam lobes radially disposed at varying predetermined angles to cause the intake valves to open and close at the proper preselected times during the rotation of the crankshaft. The exhaust valves are similarly controlled by an exhaust camshaft. In some engines, the intake and exhaust cam lobes are provided on a single, common camshaft.

[0003] In an overhead valve engine, the valves may be directly actuated by camshafts disposed on an engine head, or the camshaft(s) may be disposed within the engine block and may actuate the valves via a valve train wherein the valve train includes valve lifters, pushrods, and rocker arms. In V-style engines, alternate cylinders are typically disposed at an included central angle from the crankshaft bearing axis such that even-numbered cylinders are grouped into a first cylinder bank and odd-numbered cylinders are grouped into a second cylinder bank. According to this engine style, a single camshaft disposed within the engine block may actuate all the valves in both cylinder banks. The longitudinal depression between the banks of a V-style engine, and below the intake manifold, is known in the engine design and manufacturing arts as the engine "valley" or "V-valley."

[0004] In many traditional four-stroke internal combustion engines, the mutual relationships of the crankshaft, camshaft, and valves are mechanically fixed. That is, the valves are identically, and fully opened and closed with every two revolutions of the crankshaft. This identical and full opening and closing of the valves results in fuel/air mixture being drawn into each cylinder in a predetermined sequence, ignited by the spark plug, with the burned residue being discharged thereafter. This sequence generally occurs irrespective of the rotational speed of the engine or the load being placed on the engine at any given time.

[0005] It is well known that for much of the operating life of a multiple-cylinder engine, however, the load might be met by a functionally smaller engine having fewer firing cylinders, and that at low-demand times, fuel efficiency might be improved if one or more cylinders of a larger engine could be withdrawn from firing service. This can be accomplished by deactivating the valve train leading to preselected cylinders in any of various ways, such as by providing special valve lifters having internal locks that may be optionally switched on and off, either electrically or hydraulically. Such switching can be conveniently performed via a hydraulic manifold that utilizes electric solenoid control valves to selectively pass oil to the lifters on command from an engine control module (ECM). Such a manifold is referred to in the art as a lifter oil manifold assembly (LOMA). As described in U.S. Patent No. 6,439,176, it is well known to position a LOMA within the V-valley of a V-type engine such that the solenoid control valves therein are vertically interposed within the V-valley.

[0006] Such traditional positioning of LOMAs within V-type engines is problematic, however, as industry requirements demand increasingly tighter packaging of engine assemblies. For example, when engine assemblies having reduced height profiles are needed, or when assemblies include additional components, which operate to increase the existing height profiles, the vertical height requirements imposed by the solenoid control valves within LOMAs limit engine design flexibility in this regard.

[0007] One situation that challenges designers in this regard is the integration of balance shafts within V-type engine assemblies. Balance shafts are commonly used to reduce or cancel shaking forces and/or vibrations that result from residual imbalances inherent in the design architecture of machinery having rotating parts or mechanisms, such as, for example, motors. These balance shafts are sometimes referred to as "counterbalance" shafts. In internal combustion engines, balance shafts operate to absorb inertia forces and unbalanced moments of inertia in each of the engine cylinders so that vibration of the internal combustion engine can be sufficiently reduced. In certain V-type engines, a single engine balance shaft is positioned within the valley (*i.e.,* in the "V-valley") of the engine. The room or space for placement of such balance shafts in engines, however, is typically small or limited, particularly due to the fact that balance shafts usually are constrained to operate within specified radii, whether to clear mating parts or to enable installation. When the engine comprises a V-type engine, space constraints often pose an even greater challenge to engine designers. This challenge has often forced the difficult decision as to whether a balance shaft or a LOMA should be located in the V-valley, as past attempts to effectively integrate both components into the V-valley of V-type engines has proven difficult.

[0008] It is thus desirable to minimize the overall packaging space required in engine assemblies employing LOMAs. It is particularly desirable to minimize the overall packaging space in such assemblies employing a balance shaft in the V-valley. The disclosed apparatus and associated method overcomes the disadvantages in the prior art engine designing.

SUMMARY

[0009] The disclosed apparatus and associated method advantageously makes possible positioning of both a balance shaft and a lifter oil manifold assembly (LOMA) within the V-valley of V-type engines. According to one embodiment, a multiple-cylinder internal combustion engine comprising hydraulically-operable deactivation valve lifters comprises a LOMA including a plurality of solenoid control valves operable for activation and deactivation of lifters associated with one or more of the cylinders. The engine further comprises an engine block comprising a V-valley in which the LOMA is mounted. In this embodiment, longitudinal axes of the plurality of solenoid control valves are positioned essentially perpendicular to a vertical axis centrally extending from an angle formed by the V-valley of the engine block. Positioning of the LOMA in this manner provides a beneficial decrease in vertical height requirements of V-type engines in which they are incorporated.

[0010] While a balance shaft need not also be included within the V-valley according to the disclosed apparatus for beneficial advantages to be realized, according to an exemplary V-type engine of the present disclosed apparatus, V-valley therein not only comprises a LOMA, but also includes a balance shaft. According to this embodiment, a multiple-cylinder internal combustion engine comprises hydraulically-operable deactivation valve lifters, a LOMA comprising a plurality of solenoid control valves operable for activation and deactivation of lifters associated with one or more of the cylinders, an engine block comprising a V-valley in which the LOMA is mounted, and a balance shaft positioned within the V-valley between the engine block and the lifter oil manifold assembly. Further variations and details of the disclosed apparatus are described below.

[0011] During operation, LOMAs of the invention provide for selective modification of number of firing cylinders in multiple-cylinder internal combustion engines. Thus, the invention not only provides for design efficiencies, but also provides for more efficient engine operation. According to an exemplary method of the invention, a LOMA of the invention is provided in V-valley of an engine block for selectively activating and deactivating the hydraulically-operable deactivation valve lifters associated with one or more of the cylinders of the engine. One or more solenoid control valves of the LOMA are selectively energized to distribute pressurized oil thereto. In this manner, pressurized oil is selectively directed to the hydraulically-operable deactivation valve lifters. The number of firing cylinders is reduced accordingly. When an increase in the number of firing cylinders is desired, the solenoid control valves are selectively de-energized to redirect oil from the hydraulically-operable deactivation valve lifters in order to increase the number of firing cylinders. Further details of the invention are described below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIGURE 1 is a schematic drawing of a prior art oil system for an internal combustion engine showing the relationship in operation of a valve deactivation control system with a pressurized oil system.

[0013] FIGURE 2 is an exploded isometric view from above of a prior art lifter oil manifold assembly (LOMA).

[0014] FIGURE 3 is an exploded isometric view from the side of a V-type engine of the disclosed apparatus with a LOMA horizontally disposed in V-valley.

[0015] FIGURE 4 is a schematic cross-sectional view of a V-type engine of the disclosed apparatus with a LOMA horizontally disposed in the V-valley, with an adjacent balance shaft.

[0016] FIGURE 5 is partially cut out of a LOMA, illustrating positioning of a solenoid control valve within surrounding housing.

[0017] FIGURE 6 is an exploded perspective view of the partially cut out LOMA of FIG. 5.

[0018] FIGURE 7 is an exploded perspective view of a LOMA of the disclosed apparatus, wherein the LOMA has five solenoid control valves therein.

DETAILED DESCRIPTION

[0019] Referring to FIG. 1, engine oil circuits for an internal combustion engine are generally provided with a valve deactivation control circuit, schematically shown in FIG. 1. While only a single control valve and lifter are shown in the schematic of FIG. 1, it should be understood that valve deactivation is generally useful in multiple-cylinder engines for selectively reducing the number of combusting cylinders.

[0020] In FIG. 1, an oil pump 10 feeds oil from sump 12 to a juncture 14 where the flow of oil is split three ways. A first flow portion 16 provides conventional general lubrication to the engine. A second flow portion 18 provides oil conventionally to the hydraulic valve lifters 20, which also comprise valve deactivation lifters. A third flow portion 22 provides oil to a valve deactivation control system 24. An optional pressure relief valve 26 facilitates maintenance of oil pressure in control system 24 at a predetermined maximum level. Oil flowing to the valve deactivation control system 24 is filtered by strainer 28 and is then supplied to a solenoid control valve 30, wherein it is either diverted to the sump 12 if the control valve 30 is not energized, or diverted to the deactivation lifters 20 if the control valve 30 is energized, to cause the associated engine intake and exhaust valves to be deactivated. An engine control module (ECM) 32 receives input signals 33 from a pressure transducer 34 in the control system 24 and integrates such input signals 33 (using a predetermined algorithm) with other input operating data, such as oil temperature and engine speed, to provide output signals 36 directing the control valve 30 to energize or de-energize, as appropriate under the circumstances.

[0021] Referring now to FIG. 2, one example of a prior art lifter oil manifold assembly (LOMA) 38 includes a top plate 40, a bottom plate 42, and a gasket plate 44 sandwiched between the top and bottom plates 40 and 42, respectively. The three plates 40, 42, and 44 are held together by bolts 46 to form a complex oil distribution manifold as described in detail in U.S. Patent No. 6,439,176, and also as set forth briefly below.

[0022] When assembled, the LOMA 38 can be installed into an internal combustion engine, for example, via bolts 48 that extend through bores formed in the top plate 40, and through the gasket plate 44. The LOMA 38 can be secured, for example, onto engine block towers provided along opposite sides of the V-valley of a V-style engine for operative control of the deactivation lifters of the engine. Conventionally, such an assembly is secured in a V-style engine such that the control valves 30 are aligned longitudinally with a vertical axis 50 extending through the center of the angle formed by the V-valley. This vertical arrangement, however, decreases the amount of space within the V-valley of the V-type engines, making it difficult if not impossible to design V-type engines in an efficient and desirable manner.

[0023] Although many variations are known, in the embodiment illustrated in FIG. 2, a pattern of oil passages 52 is formed between the top plate 40 and the bottom plate 42 in cooperation with the gasket plate 44. The bottom plate 42 is also provided with a plurality of bores 56 extending completely therethrough at selected locations for receipt of control valves 30.

[0024] The upper surface 58 and the lower surface 60 of the gasket plate 44 are further provided with respective patterns of resilient gasketing material 62 based on the pattern of passages 52 and bores 56 formed in plates 40 and 42. Preferably, the gasketing material 62 is disposed in shallow grooves on the surfaces 58 and 60 into which the gasketing material 62 may be fully compressed upon assembly of the LOMA 38.

[0025] The oil passages 52 and gasketing material 62 in the plates 40, 42, and 44, cooperate together to define and form oil galleries of a complex three-dimensional hydraulic manifold for selectively distributing pressurized oil from an oil riser 70, through the strainer 28 (FIGURE 1) to each solenoid control valve 30 received in the bores 56 that are formed in the bottom plate 42. The solenoid control valves 30 extend through the bottom plate 42. The valve heads sealably seat against the underside of the gasket plate 44. As described above with reference to FIGURE 1, each of the control valves 30 controls the activation and deactivation of all of the valve lifters for a given cylinder of an eight-cylinder engine. Thus, four control valves 30 are required, for example, to deactivate the valves for four cylinders of an eight-cylinder engine. Four such control valves 30 are illustrated in FIG. 2.

[0026] Oil is distributed within the manifold from a global supply gallery through an oil riser 70 to the control valves 30. When a control valve 30 is energized to open, oil is admitted between the valve head that is seated on the underside of the gasket plate 44 and it is allowed to flow upwards into an individual supply gallery to supply two deactivation valve lifters. A variety of ports, including optional bypass ports, are generally provided throughout the manifold to facilitate this operation. When the control valve 30 is de-energized, oil flows through a passage in the control valve 30 and into a return gallery.

[0027] As shown in FIGURE 2, a connector/retainer 84 holds the solenoid control valves 30 in position within their respective bores 56 (only one set of four control valves are shown in FIG. 2) in the bottom plate 42. The connector/retainer 84 also provides electrical connection of the control valves 30 to the engine control module 32 (FIG. 1). In this regard, the connector/retainer 84 is typically insert-molded or cast of a high-temperature dielectric plastic. In the embodiment shown, the connector/retainer 84 supports the control valves 30 at their bases via a plurality of cups 86. Many variations in this supporting structure are known.

[0028] The connector/retainer 84 is provided with integral standoffs 92 through which the connector/retainer 84 is bolted, resulting in assembled LOMA 38. Electrical leads are cast into the connector/retainer 84, terminating distally at conductive slotted tabs into which connector tabs 96 on the control valves 30 are connectively inserted to provide power to the solenoid control valves 30 (FIGURE 1).

[0029] With reference to both FIG. 1 and FIG. 2, at engine start-up during operation, typically all valve lifters are activated, all engine valves are functional, and all control valves 30 are de-energized. The oil riser 70 fills the global oil gallery and individual oil galleries within the manifold. When a solenoid activation signal is transmitted from the engine control module 32 to any one or more control valves 30, such control valve(s) is (are) actuated or energized, permitting pressurized oil to flow from a global oil gallery past control valve 30, to outlet ports for passage via engine block towers to intake and exhaust valve deactivation lifters 20 (FIG. 1). Oil continues to flow via a return gallery to sump 12 (FIG. 1). Pressure is applied continuously to the intake and exhaust valve deactivation lifters 20 while the control valve 30 is actuated or energized. Conversely, when a solenoid deactivation signal is transmitted from the engine control module 32, the control valve 30 is closed (via an internal spring or other conventional means) shutting off further pressure to the intake and exhaust valve deactivation lifters 20. Excess oil in the lifters 20 is expelled to the sump 12, and the intake and exhaust valve deactivation lifters 20 resume activation of the intake and exhaust valves.

[0030] According to the improvements provided by the disclosed LOMA apparatus, a LOMA is positioned horizontally within the V-valley of a V-type engine. According to this arrangement, as illustrated in FIG. 3 and FIG. 4, such an inventive LOMA 100 is housed within a V-type engine block 102 and engine block cover 104 such that longitudinal axes 106 of a plurality of solenoid control valves 108 therein are essentially perpendicular to a vertical axis 110 centrally extending from an angle formed by a V-valley 112 of the engine block 102. The angle formed by the V-valley may vary according to the overall engine block design and its surrounding components as known to those of skill in the engine design and manufacture art. Generally, however, the angle is approximately 120° or less. In an exemplary embodiment, the vertical axis 110 centrally extends from and bisects the angle in a symmetrical manner. However, the vertical axis 110 can centrally extend from and bisect the angle formed by the V-valley in an asymmetrical manner according to other embodiments.

[0031] With further reference to FIG. 3 and FIG. 4, in one embodiment, an intake runner 114, or other components that are integral to the effective and efficient operation of the engine, are positioned above engine block cover 104. While inclusion of many components, such as intake runner 114, within engine block 102 is generally not desirable, housing of certain other components within engine block 102 is often desirable.

[0032] One particular component known to be best positioned within many engine blocks is advantageously capable of being housed within a V-type engine block according to the invention. This advantageous placement is possible, despite simultaneous placement of a LOMA therein. Thus, in accordance with this beneficial embodiment, surrounded by adequate clearance area 116 within V-valley 112 is a balance shaft 118, which is adapted for positioning within V-valley 112 of a V-type engine. In an exemplary embodiment of the invention, a balance shaft 118 is thus positioned between LOMA 100 and engine block 102. A wide variety of balance shafts 118 are known to those of skill in the art. So long as clearance area 116 within V-valley 112 is maintained as desired, any suitable balance shaft 118 can be so positioned according to the invention. Generally, clearance area 116 need only provide sufficient space to prevent undesirable physical interaction (*e.g.*, bumping) of balance shaft 118 and LOMA 100 during engine operation.

[0033] As illustrated in FIG. 5, each solenoid control valve 108 within a LOMA of the invention is seated within housing 120 of LOMA by longitudinal insertion of solenoid control valve 108 within a bore 122 traversing one or more subcomponents of the LOMA. The exact nature of the bore and subcomponents will vary as understood by those of skill in the art. In one embodiment, each solenoid control valve 108 is seated in a manner similar to that discussed with reference to FIG. 2, albeit with the LOMA positioned approximately perpendicular to that shown in FIG. 2 with respect to V-valley. As further illustrated in FIG. 5, connector tabs 124 on each solenoid control valve 108 are adapted for electrical connection with an engine control module. In an exemplary embodiment, connector tabs 124 are positioned on an opposite end of each solenoid control valve 108 with respect to the housing 120 into which the solenoid control valve 108 is inserted upon assembly. In one embodiment, connector tabs 124 are operatively coupled to a connector/retainer such as that described with reference to FIG. 2.

[0034] Each solenoid control valve 108 is seated within a corresponding bore 122 within housing 120 in any suitable manner. Depending on the embodiment, the manner of optimal seating may be impacted by different gravitational forces exerted on each solenoid control valve 108 as compared to conventional LOMA positioning within V-type engines. In conventional LOMA arrangements, components of solenoid control valves within move in the same or opposite direction as gravitational forces exerted thereon. In LOMA arrangements of the invention, gravitational forces operate perpendicular to directional movement of components of solenoid control valves therein. Hence, a frictional force is created during operation. Depending on the embodiment, this factor may be relevant in selection and adjustment of each solenoid control valve 108. If so, appropriate modifications are made as known to those skilled in the art.

[0035] LOMAs of the invention are mounted within surrounding engine blocks in any suitable manner. Many mounting mechanisms are known for use with conventional vertical mounting of LOMAs within V-type engines and are applicable to the present invention, albeit with orientation of the LOMA in a position perpendicular to its conventional positioning. In an exemplary embodiment, nuts and bolts secure the LOMA to the surrounding engine block.

[0036] Essentially horizontal positioning of LOMAs according to the invention advantageously decreases vertical height requirements associated with V-type engines. While such horizontal LOMA positioning enables simultaneous placement of a balance shaft within V-valley of such engines, in those embodiments of the invention that do not contain additional components such as balance shafts within V-valley, space-saving advantages are apparent nevertheless.

[0037] Many variations of the invention are thus possible and as such provide overall engine design flexibility. The invention is applicable to multiple-cylinder internal combustion engines of the V-type. For example, the invention is applicable to four-cycle engines and six-cylinder engines of this type. In addition, the invention is applicable to larger engines such as, for example, eight-cylinder engines, ten-cylinder engines, and twelve-cylinder engines. Various modifications and alterations of the invention will become apparent to those skilled in the art without departing from the spirit and scope of the invention, which is defined by the accompanying claims.

Claims

1. A multiple-cylinder internal combustion engine comprising hydraulically-operable deactivation valve lifters 20, the engine comprising:

a lifter oil manifold assembly 100 comprising a plurality of solenoid control valves 108 operable for activation and deactivation of lifters 20 associated with one or more of the cylinders; and
an engine block 102 comprising a V-valley 112 in which the lifter oil manifold assembly 100 is mounted;

wherein longitudinal axes 106 of the plurality of solenoid control valves 108 are positioned essentially perpendicular to a vertical axis 110 centrally extending from an angle formed by the V-valley 112 of the engine block 102.

2. The engine of claim 1, further comprising a balance shaft 118 positioned within the V-valley 112.

3. The engine of claim 1, further comprising a balance shaft 118 positioned between the engine block 102 and the lifter oil manifold assembly 100 and surrounded by adequate clearance area 116.

4. The engine of claim 1, comprising a deactivation valve lifter 20 for each valve to be deactivatable.

5. The engine of claim 1, further comprising an engine control module 32 for controlling the activation and deactivation of the valve lifters 20.

6. The engine of claim 1, further comprising a source of pressurized oil 12.

7. The engine of claim 1, wherein the vertical axis 110 centrally extends from and bisects the angle formed by the V-valley 112 in a symmetrical manner.

8. The engine of claim 1, wherein the vertical axis 110 centrally extends from and bisects the angle formed by the V-valley 112 in an asymmetrical manner.

9. A method of modifying number of firing cylinders in the multiple-cylinder internal combustion engine of claim 1, the method comprising:

providing the lifter oil manifold assembly 100 in the V-valley 112 of the engine block 102 for selectively activating and deactivating the hydraulically-operable deactivation valve lifters 20 associated with one or more of the cylinders of the engine;
selectively energizing one or more solenoid control valves 108 of the lifter oil manifold assembly 100;
distributing pressurized oil to the energized solenoid control valves 108, whereby the oil is selectively directed to the hydraulically-operable deactivation valve lifters 20 to reduce the number of firing cylinders; and
selectively de-energizing the solenoid control valves 108 to redirect oil from the hydraulically-operable deactivation valve lifters 20 to increase the number of firing cylinders.

10. A multiple-cylinder internal combustion engine comprising hydraulically-operable deactivation valve lifters 20, the engine comprising:

a lifter oil manifold assembly 100 comprising a plurality of solenoid control valves 108 operable for activation and deactivation of lifters 20 associated with one or more of the cylinders;
an engine block 102 comprising a V-valley 112 in which the lifter oil manifold assembly 100 is mounted; and
a balance shaft 118 positioned within the V-valley 112 between the engine block 102 and the lifter oil manifold assembly 100.

11. The engine of claim 10, wherein longitudinal axes 106 of the plurality of solenoid control valves 108 are positioned essentially perpendicular to a vertical axis 110 centrally extending from an angle formed by the V-valley 112 of the engine block 102.

12. The engine of claim 11, wherein the vertical axis 110 centrally extends from and bisects the angle formed by the V-valley 112 in a symmetrical manner.

13. The engine of claim 11, wherein the vertical axis 110 centrally extends from and bisects the angle formed by the V-valley 112 in an asymmetrical manner.

14. The engine of claim 10, further comprising an engine control module 32 for controlling the activation and deactivation of the valve lifters 20.

15. The engine of claim 10, further comprising a source of pressurized oil 12.

16. The engine of claim 10, wherein the engine is a four-cycle engine.

17. The engine of claim 10, wherein the engine is a six-cylinder engine.

18. The engine of claim 10, wherein the engine is an eight-cylinder engine.

19. A method of modifying number of firing cylinders in the multiple-cylinder internal combustion engine of claim 10, the method comprising:

providing the lifter oil manifold assembly 100 in the V-valley 112 of the engine block 102 for selectively activating and deactivating the hydraulically-operable deactivation valve lifters 20 associated with one or more of the cylinders of the engine;

selectively energizing one or more solenoid control valves 108 of the lifter oil manifold assembly 100;

distributing pressurized oil to the energized solenoid control valves 108, whereby the oil is selectively directed to the hydraulically-operable deactivation valve lifters 20 to reduce the number of firing cylinders; and

selectively de-energizing the solenoid control valves 108 to redirect oil from the hydraulically-operable deactivation valve lifters 20 to increase the number of firing cylinders.

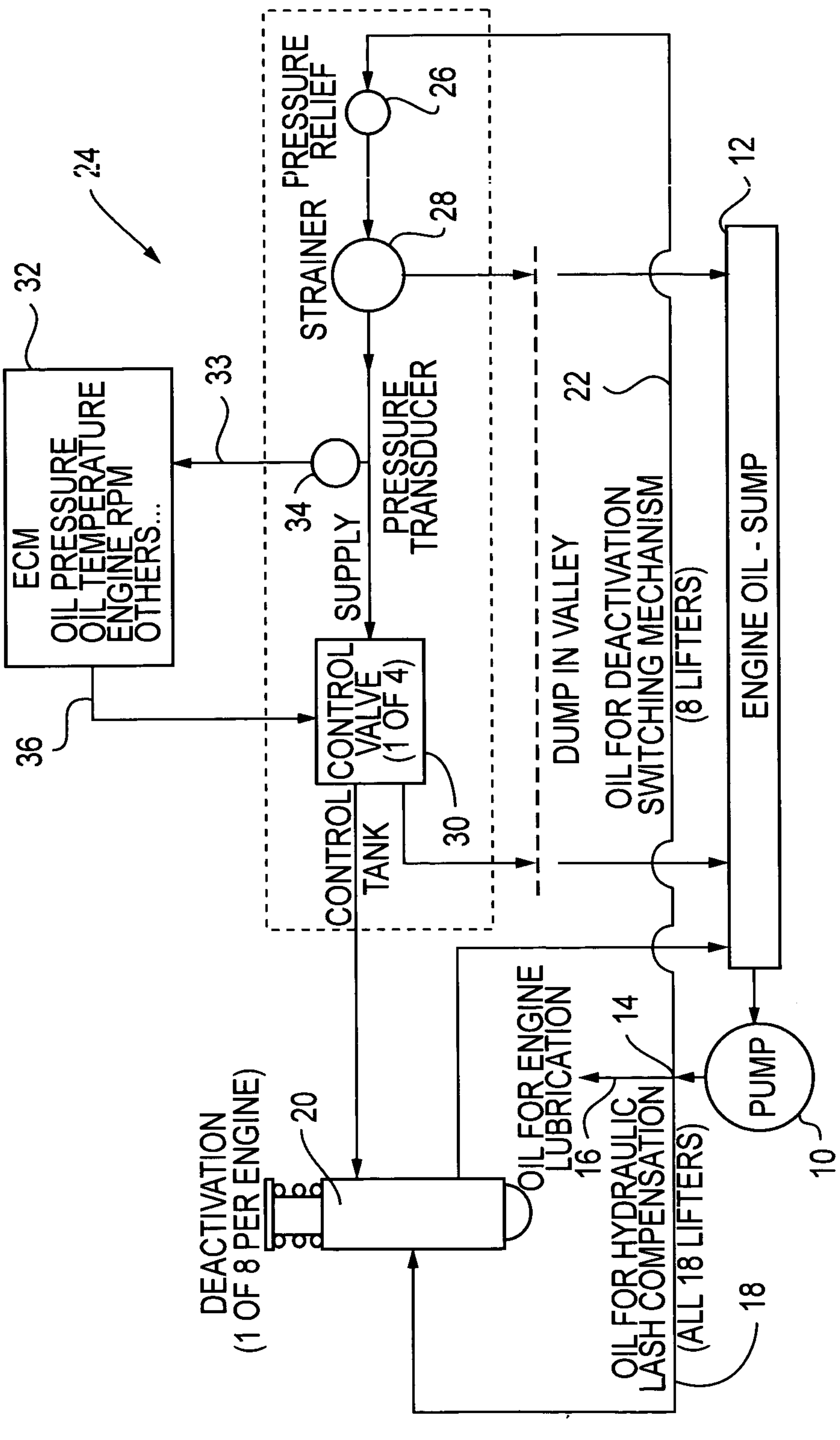

FIG. 1
PRIOR ART

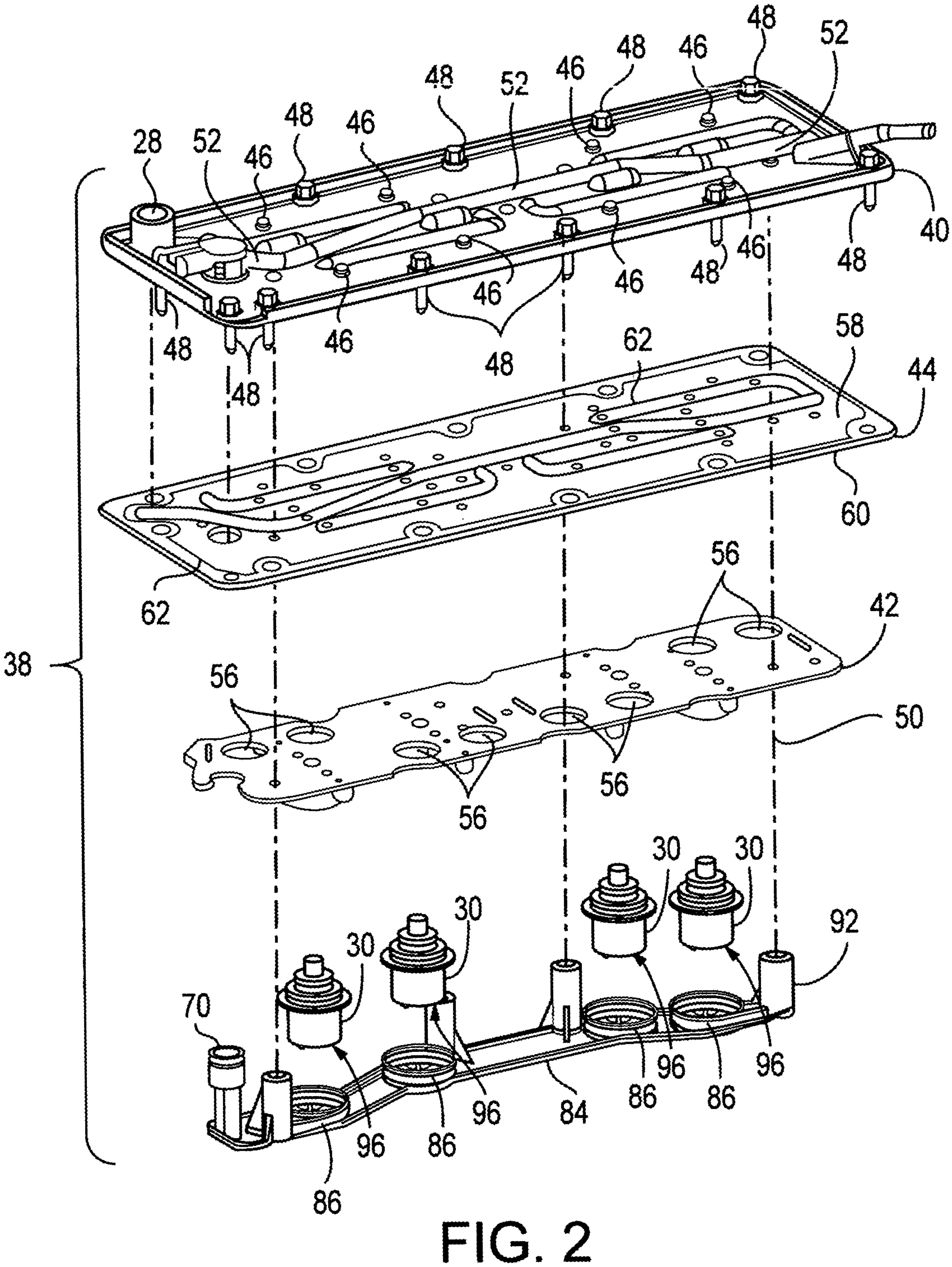

FIG. 2
PRIOR ART

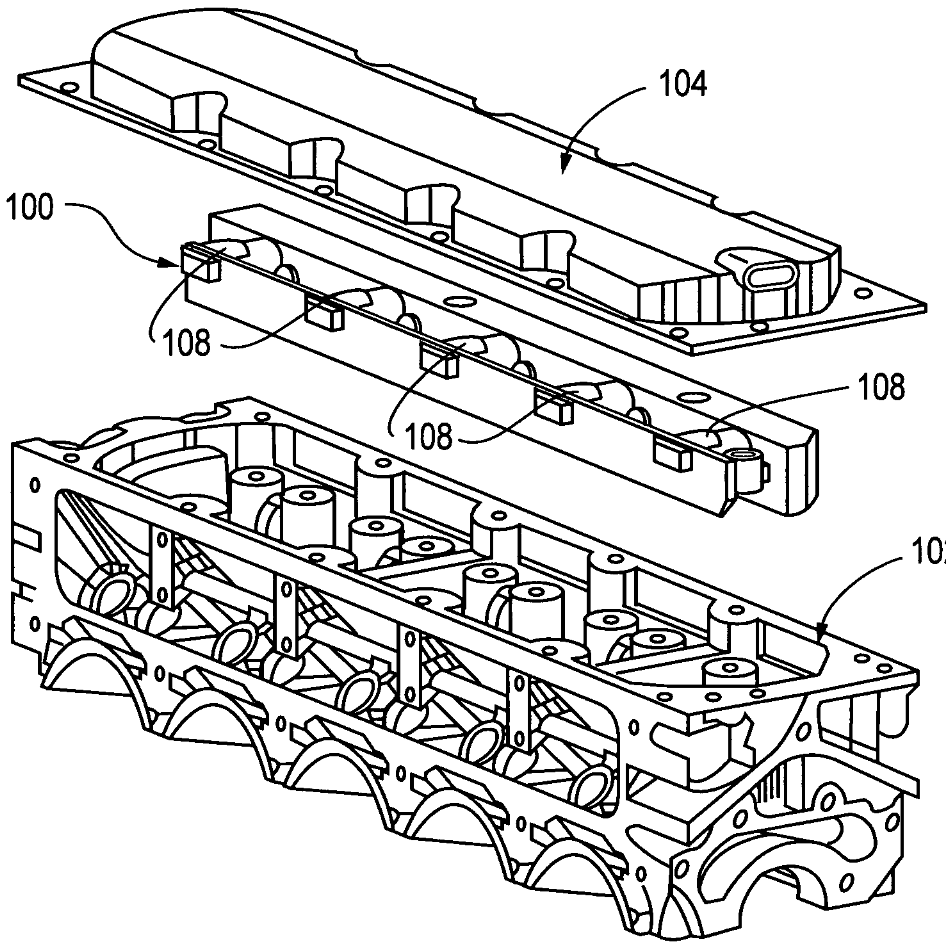

FIG. 3

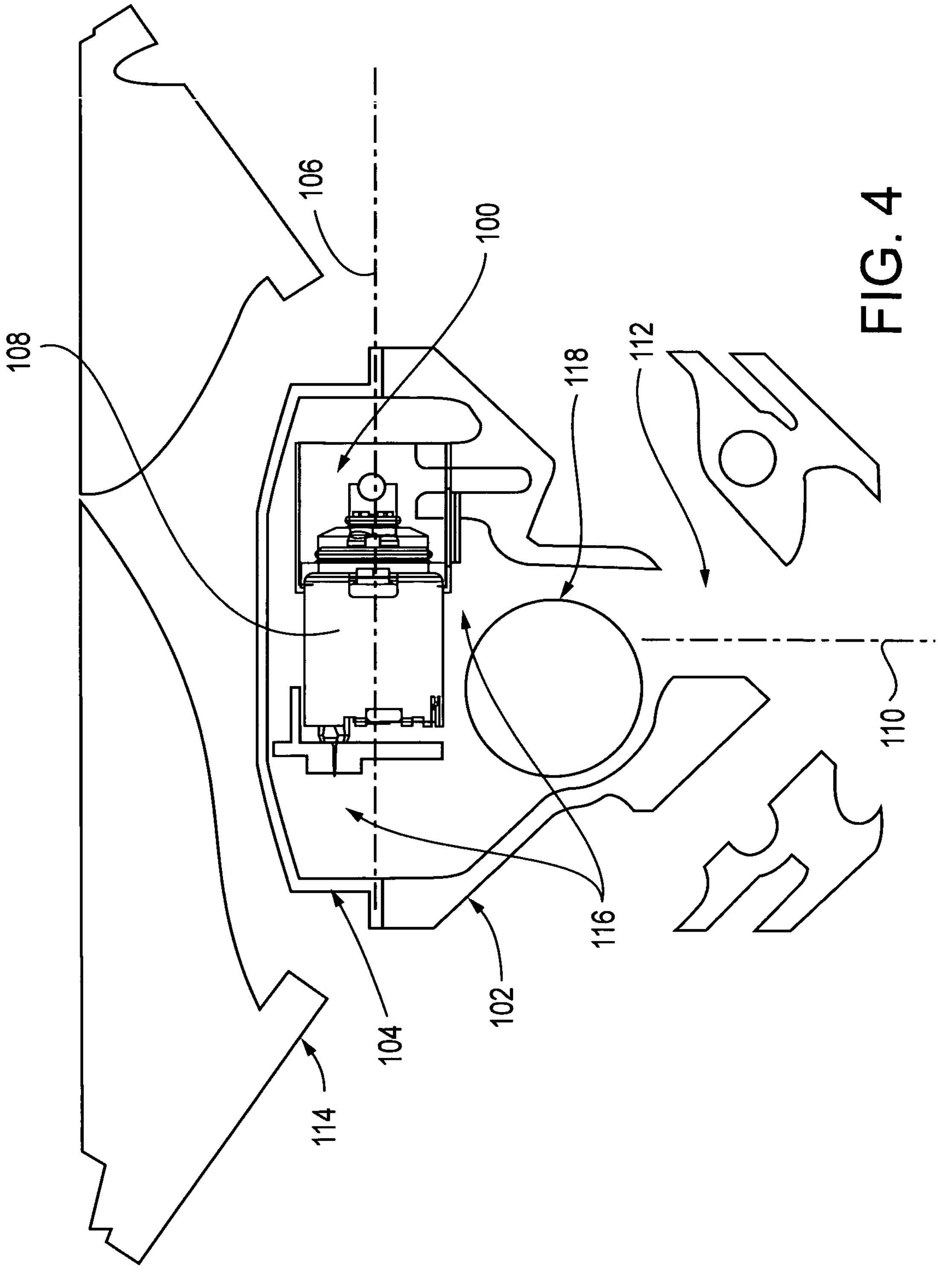

FIG. 4

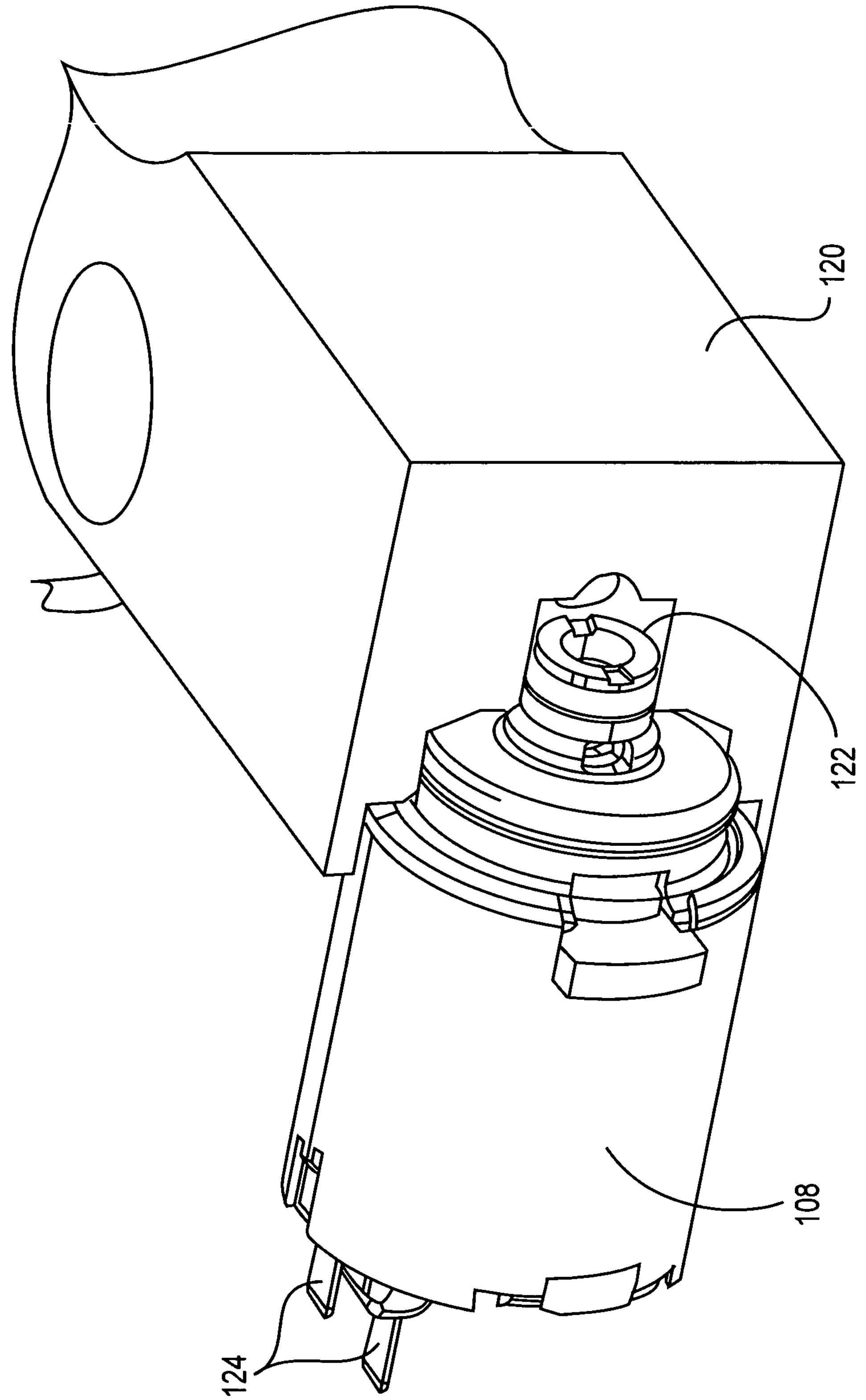

FIG. 5

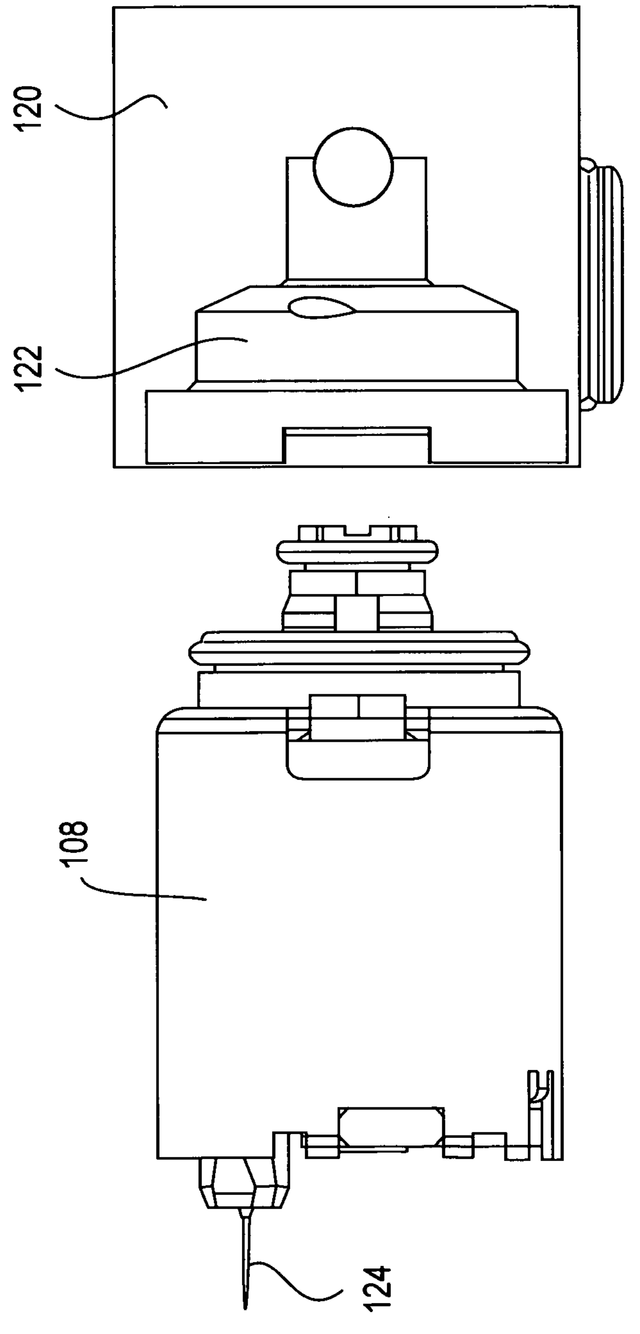

FIG. 6

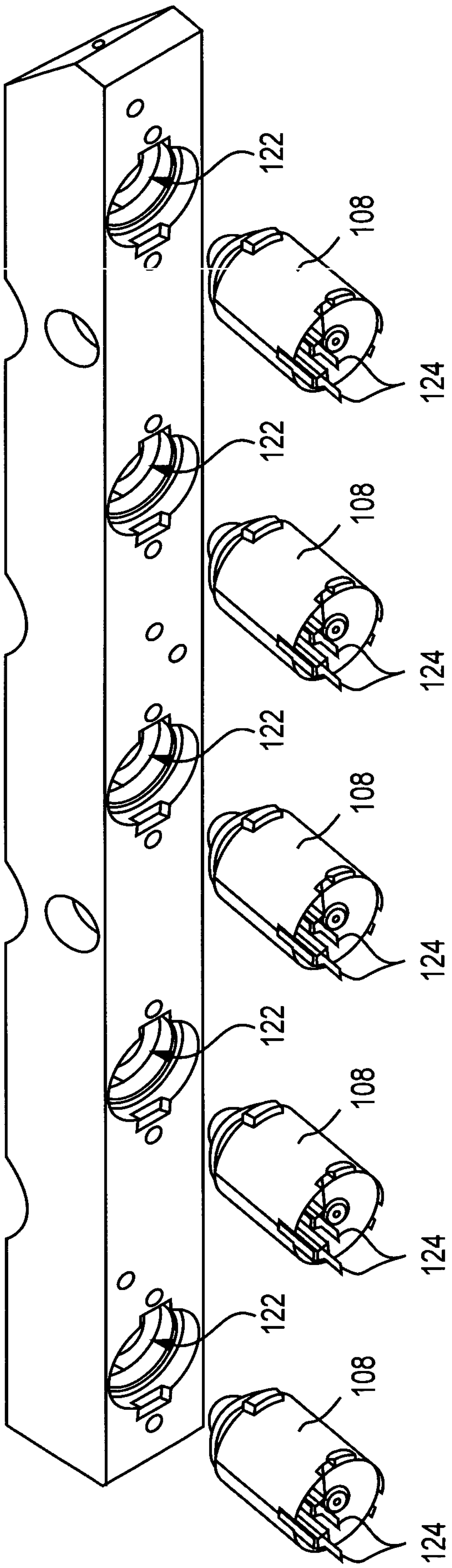

FIG. 7