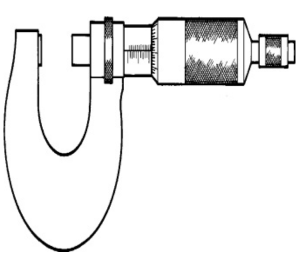
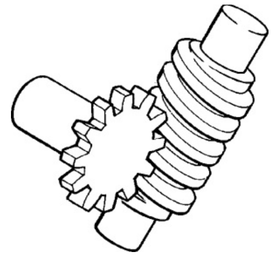


METRO DETROIT METALWORKING CLUB SEPTEMBER 2013



Club website: www.metrodetroitmetalworkers.com

Treasury report:

Balance: $929.43

Next meeting:
October 9, 2013, 7p.m.
Macomb County
Community College
Room S140

Contacts:

President: Rick Chownyk

Vice Pres: Emil Cafarelli

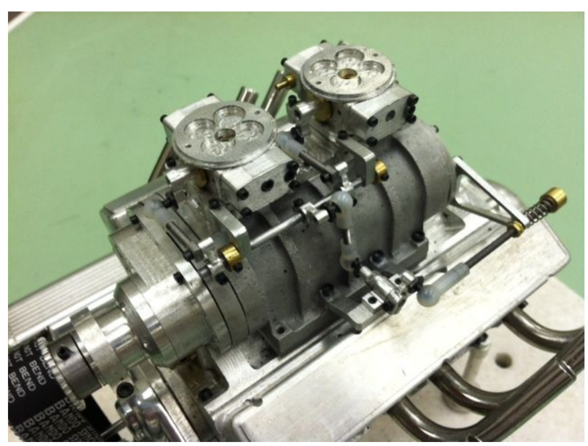
Treasurer: Ken Hunt

Secretary: Bob Farr

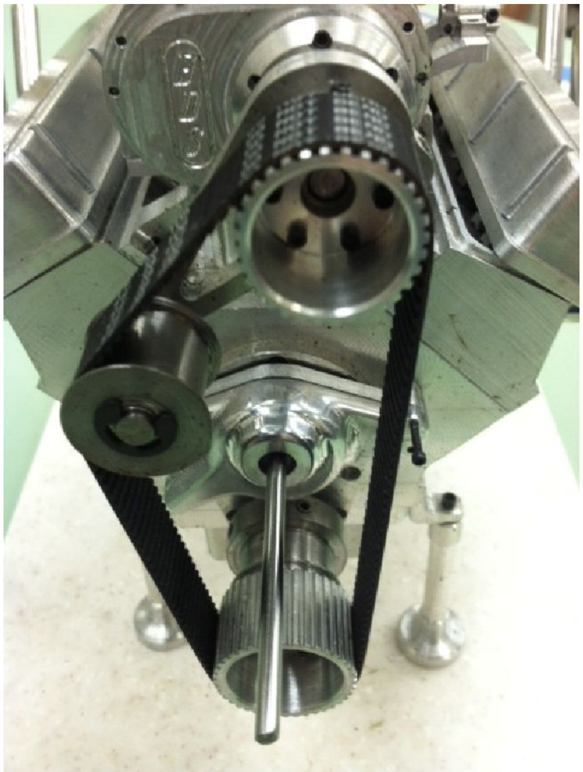
Webmaster: Steve/Doug Huck

Show-&-Tell: Steve Huck continues to make swift progress on his latest V8 project.

This version includes a Roots-style blower and twin carburetors:



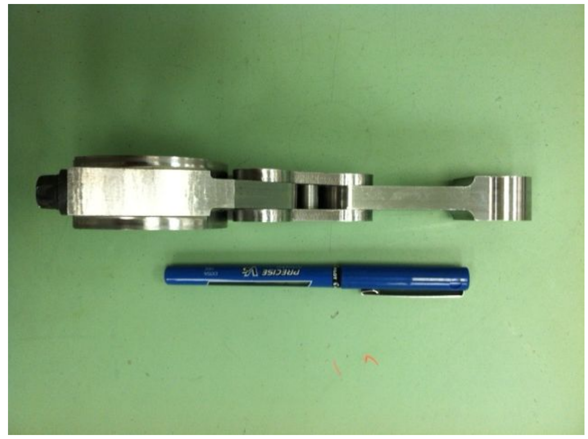
Steve has managed to source a drive belt and machine matching pulleys which are a perfect scale for the motor and blower:



Nice job Steve, we look forward to hearing this one run soon!

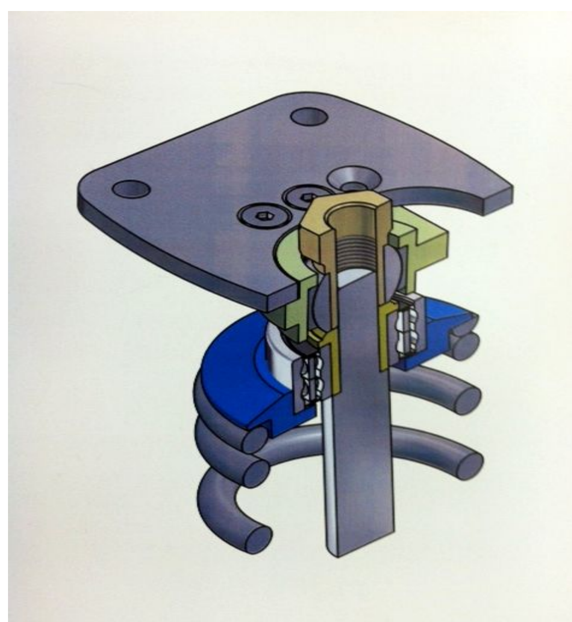
Jay Drouillard shared another interesting engine-related part, this time an adjustable length connecting rod:

The length adjustment was designed to allow variable compression ratios to accommodate boosted or normally aspirated engines:



Jay also shared several patents related to variable length rods and systems for controlling them. Those patents are reprinted at the back of this newsletter for those interested.

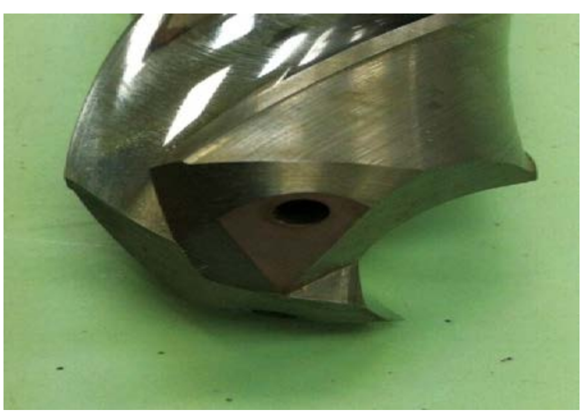
Ted Zillich reported some progress on his updated Volkswagen suspension project. He included some very nice CAD drawings in his presentation:



Ted’s design is an adjustable camber plate for his Super Beetle:

Ted also brought along an impressive 2lb solid carbide drill to show:

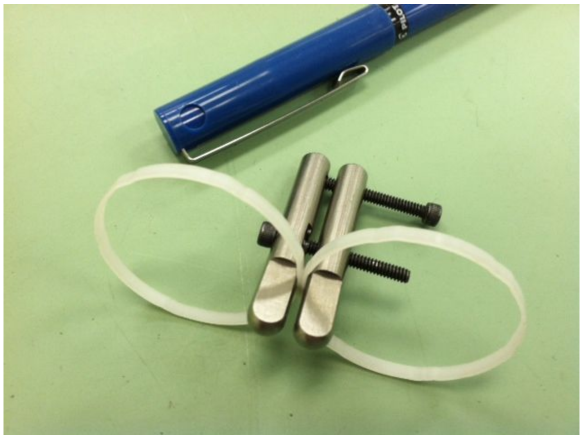
The flutes were polished with leather and diamond paste, and the drill also had coolant feed exiting at the nose:



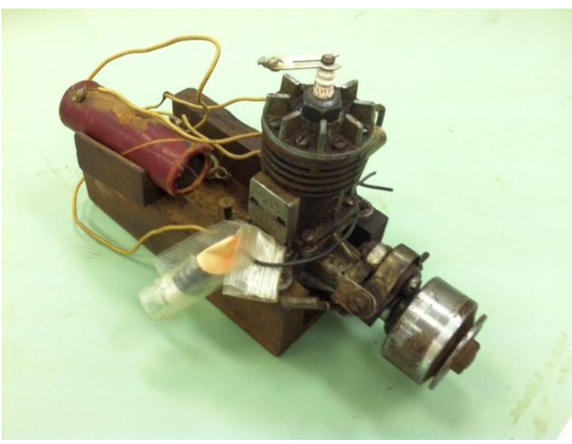
Ron Schmidt brought in a “glare gear assembly” used to keep proper pressure on a grinding wheel without hammering the traditional nuts:

This assembly is made by William Sopko Company in Cleveland, Ohio. It comes in several sizes, and Sopko makes a variety of products – www.wmsopko.com

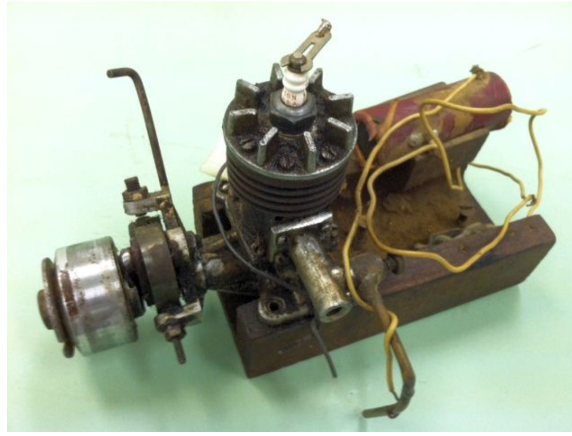
Kurt Schulz shared his design for a small clamp/fixture used to hold rings in which the ends were to be joined:



Mark Wyatt presented this interesting "GHQ Aero" motor which has been in his family for many years:



Mark's engine rests on a nice wooden stand and even has a spare spark plug stored in the bag shown. Here is another view of the engine:



A bit of online research turned up an interesting article from 2008 in the "Duration Times", a publication of Australian Chapter No.1788 of the Society of Antique Modelers. The author – Mr. Roy Bourke of Toronto, Canada – notes that the GHQ Aero engines did not have a reputation for running reliably. A copy of Mr. Bourke's article is attached at the back of this newsletter. Wish Mark some luck with reviving his GHQ: he may need it! Thanks for sharing your model engine Mark – whether it ever runs or not.

Dr. Mike Jostock gave a short presentation about developments in navigation technology for airplanes of passenger-carrying size. A series of 800 beacons have been placed around the U.S. which communicate with in-flight commercial aircraft having a compatible receiver on board. Those planes, and smaller privately owned planes such as Mike's, will soon be able to add transmitters which will supplant traditional ground-based radar to provide aircraft separation and navigation assistance.

The system outputs its data to various handheld tablets like the Apple iPad and can include real-time weather and moving map features. What will they think of next?

For Sale: Mr. Jerry Mate (who is not a member of the club) stopped in at the beginning of the meeting to drop off some information about a few machines he is selling that may be of interest to our members. His phone number is (248) 647-0088 and he is located in Birmingham, Michigan. The pictures are attached (please contact Mr. Mate for prices).

This first machine is a table saw of unknown make:

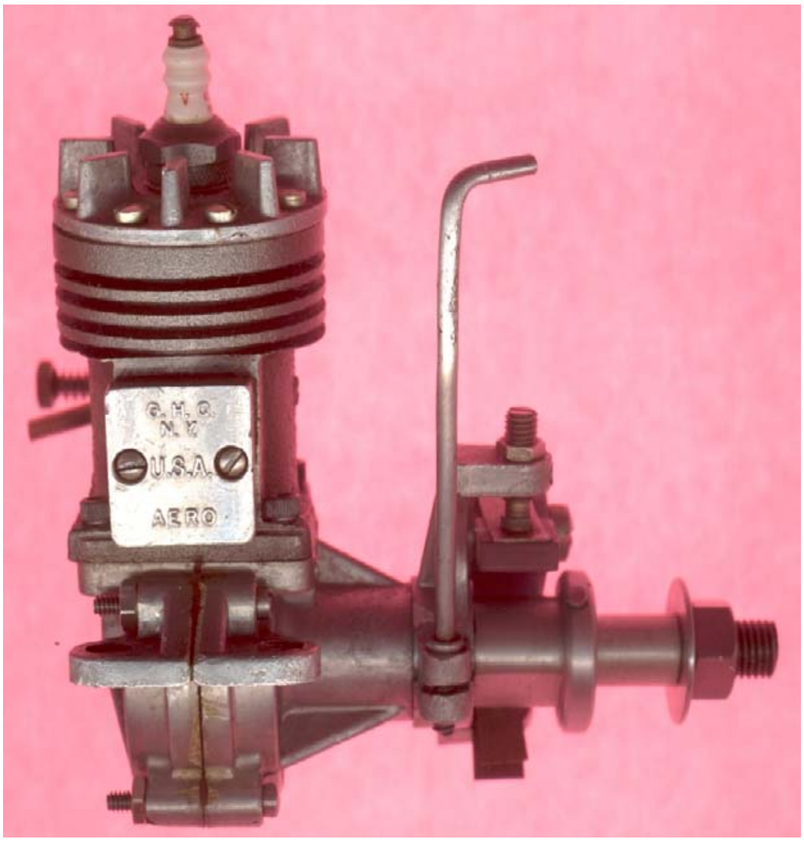
This is a 9-inch South Bend thread cutting lathe with some accessories:

Joiner:

Sander:

Mill/drill machine:

Bob Farr, Secretary



The Infamous GHQ Engine

From Roy Bourke, Canada.

It is ironic that, of the thousands of designs of model aircraft engines that have been produced worldwide, one of the most famous is the GHQ Aero .52 cid. This was a spark ignition engine that outsold the pioneer of all model engines, the Brown Junior. Over 100,000 of these heavy cast-iron GHQ's were produced. It was the only American engine that was continuously manufactured and available throughout World War II. And today, any engine collector that wants one should have little problem in finding one in mint condition. GHQ's have a reputation of never wearing out because so few were ever made to run, much less to successfully fly a model airplane.

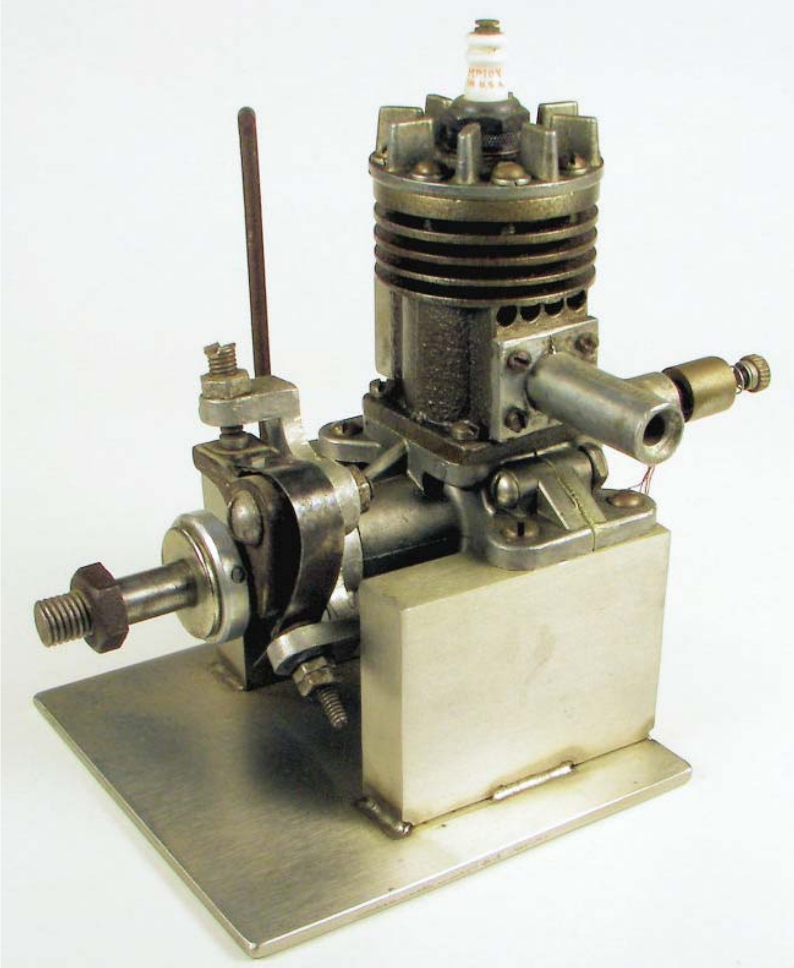
The GHQ was born the Loutrel in the early 1930's, quite a decent engine for the time but not really in mass production. In 1934 its designer, Pete Loutrel, sold the design to the GHQ Model Company, a subsidiary of *Americas Hobby Center,* one of the oldest and largest mail order hobby houses in the United States. GHQ manufactured quite a decent and extensive line of flying scale rubber kits in successful competition with Comet, Cleveland and other famous kit manufacturers. But the company's reputation started its downward plunge when the GHQ engine was introduced in 1936.

The GHQ simply wouldn't run, or at least was very difficult to get running. Some say the engine was ported to run clockwise (in fact some claim it wasn't ported at all, as a fuel saving measure!). Others claim the problem was the timer, which offered too much resistance when run counter-clockwise.

Whatever the reason, one can just imagine 100,000 modellers each flipping a prop endlessly in the vain hope of converting the occasional hard-earned "pop" coaxed from the engine into a continuous burst of energy that lasted long enough to propel his model skyward. But it was amazing what low price and wartime availability did for sales of this cantankerous engine. If you had lived in the 1930's, when $20.00 represented two weeks' wages, which engine would you have bought? A Brown Junior at $21.95 or a GHQ at $12.50? And if you were really frugal, you could get a kit to make the GHQ engine for $8.50 ! Then as word started to get around about the GHQ's reluctance to run, the price was dropped to $5.00 for the kit, and thousands of gullible buyers believed GHQ's advertised performance claims (truth in advertising didn't exist in the 1930's!!)


GHQ Guts

American involvement in WW-II came along in 1942, and with it severe shortages and restrictions on the supply of metals (even pot metals) that were needed for arms production. Virtually every US model engine manufacturer ceased production, every one that is except GHQ! So it was pretty easy for the engine-buying public to conveniently forget the GHQ's growing reputation, and succumb to the hopes of getting a gas model flying with an available engine (whose price had now climbed back up to $20.00!). And the GHQ remained in continuous production throughout, except for a brief period when the entire staff of the GHQ production shop (a garage in the Bronx) was fired. (GHQ's were assembled by members of a motorcycle gang hired for the purpose, who were caught spiriting engines out the side door in their lunch buckets and were immediately fired *en masse*!)



With the end of the war came a huge resurgence in manufacture of model engines by reputable companies that were quick to respond to the needs of the multitude of engine-hungry modellers at home or returning from wartime duty overseas. These were good engines, engines that actually ran, and their success and popularity soon sounded the death knoll to sales of the now-infamous GHQ.

If you ever see a modeller wearing a hat with the lettering "GHQ Racing Team", don't laugh too hard! There are modern modellers who have taken on the challenge not only of getting GHQ's to run, but to actually use them in a special class of R/C pylon racing! And if you really want to get some performance out of a GHQ, and have access to machining facilities, I understand that replacing its piston and cylinder with the piston and sleeve of a Veco .61 will make an engine that really smokes! Wouldn't that be something! A Lanzo Bomber screaming skyward, powered by a customized GHQ !!!!!

US006371062B1

(12) **United States Patent**
Rao et al.

(10) **Patent No.: US 6,371,062 B1**
(45) **Date of Patent: Apr. 16, 2002**

(54) **VARIABLE COMPRESSION RATIO CONNECTING RODS**

(75) Inventors: **V. Durga Nageswar Rao**, Bloomfield Township; **Daniel Joseph German**; **Gary Allan Vrsek**, both of Brighton; **Jeffrey Eliot Chottiner**, Farmington Hills; **Mark Michael Madin**, Canton, all of MI (US)

(73) Assignee: **Ford Global Technologies, Inc.**, Dearborn, MI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/691,668**

(22) Filed: **Oct. 18, 2000**

(51) **Int. Cl.**[7] **F02B 75/04**
(52) **U.S. Cl.** .... **123/48 B**; 123/78 E
(58) **Field of Search** .... 123/48 B, 78 E

(56) **References Cited**

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3,633,429 A		1/1972	Olson	74/44
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4,979,427 A		12/1990	Pfeffer et al.	92/60.5
5,562,068 A		10/1996	Sugimoto et al.	123/48 B
5,755,192 A		5/1998	Brevick	123/78 B

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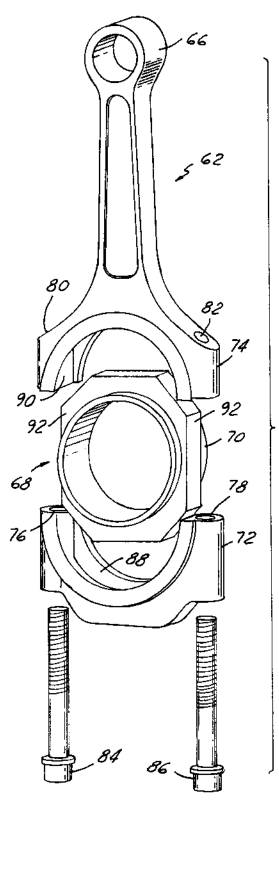
* cited by examiner

Primary Examiner—Noah P. Kamen
(74) *Attorney, Agent, or Firm*—Jerome R. Drouillard

(57) **ABSTRACT**

A variable length connecting rod assembly for imparting a variable compression ratio to an internal combustion engine. The assembly contains a first part (**22**; **72**), a second part (**20**; **74**), and a third part (**34**; **70**) assembled together to form the large end of the connecting rod assembly and provide a variable length for the connecting rod assembly. The first part is a semi-circular cap. One (**20**; **74**) of the second and third parts is fastened tight to the first part (**22**; **72**). Guides (**36**, **38**, **48**; **88**, **90**, **92**) disposed at opposite sides of the large end operatively relate the other (**34**; **70**) of the second and third parts and the fastened parts to provide for relative sliding motion between the other of the second and third parts and the fastened parts over a limited adjustment range to change the length of the connecting rod assembly.

6 Claims, 2 Drawing Sheets



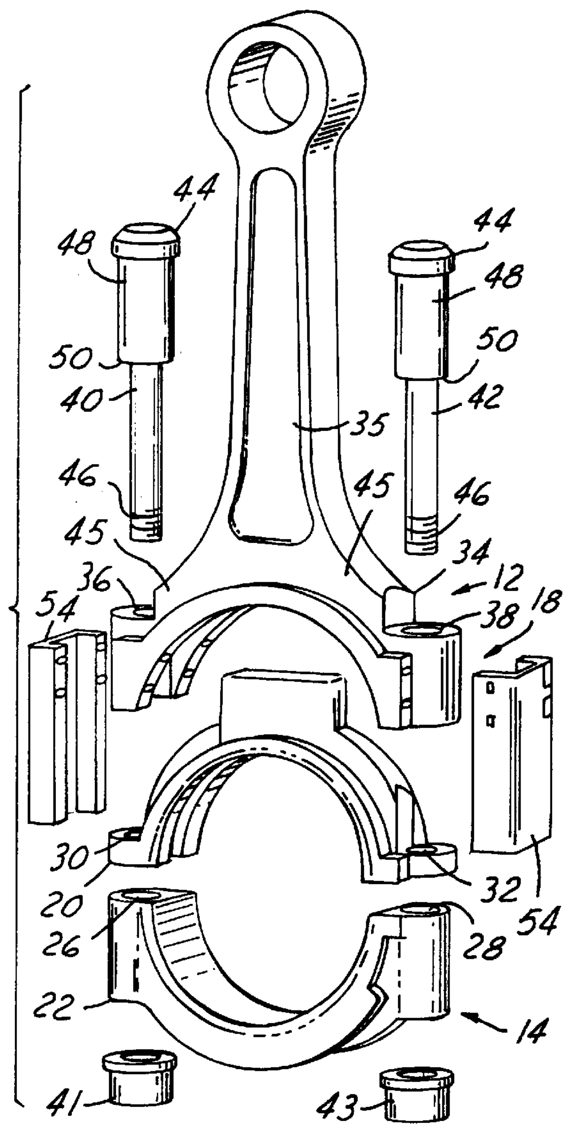

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FIG. 1

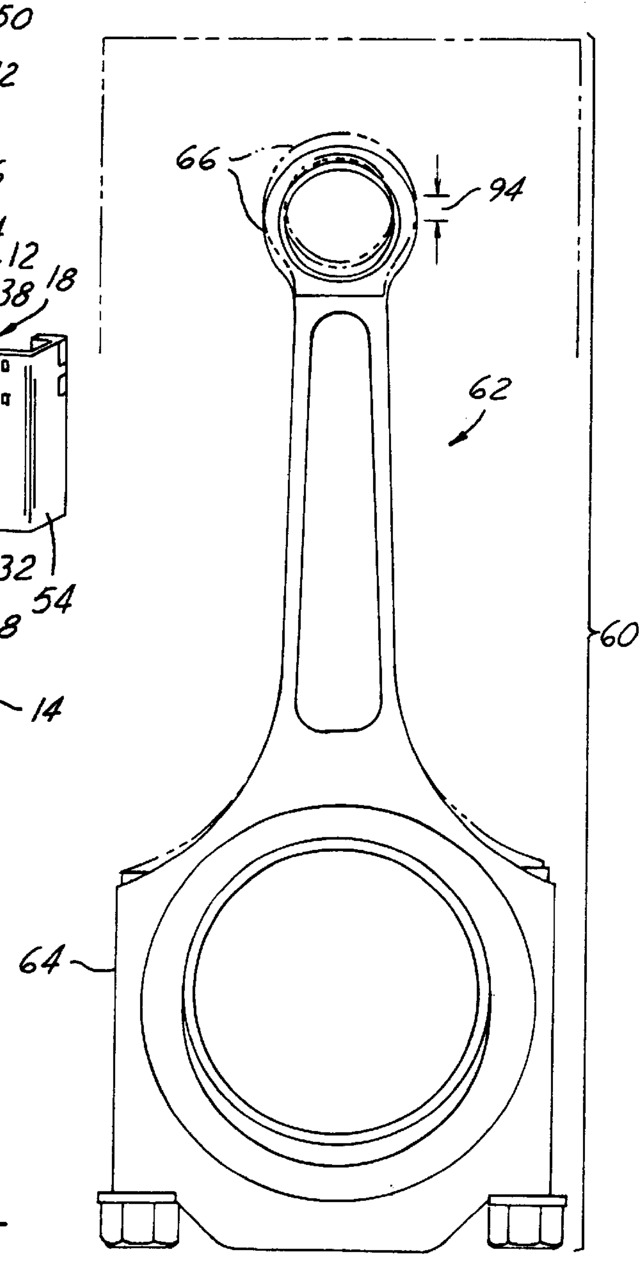
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FIG. 4

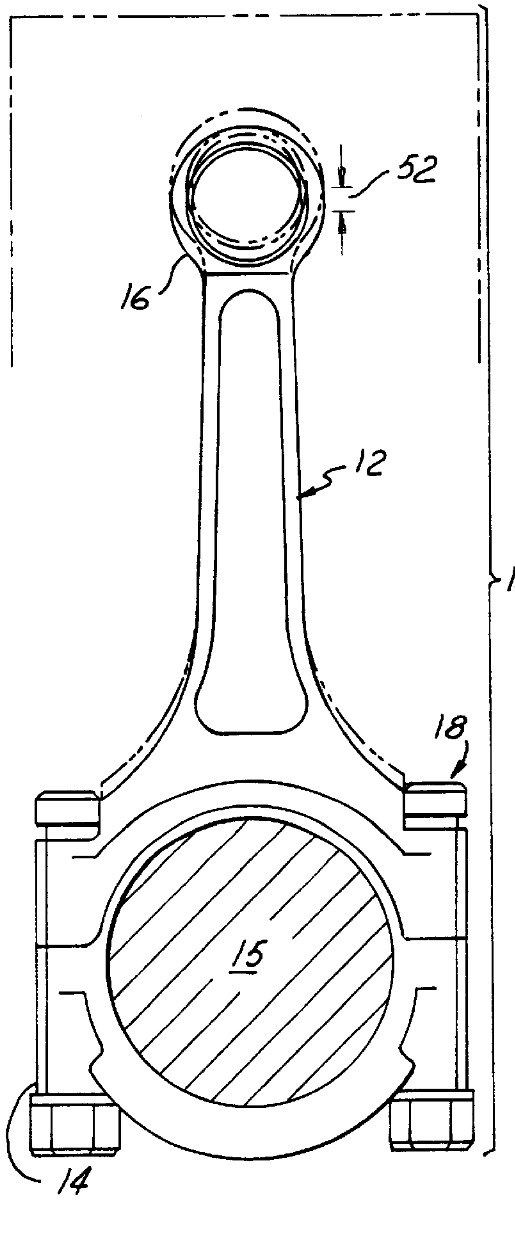

FIG.2

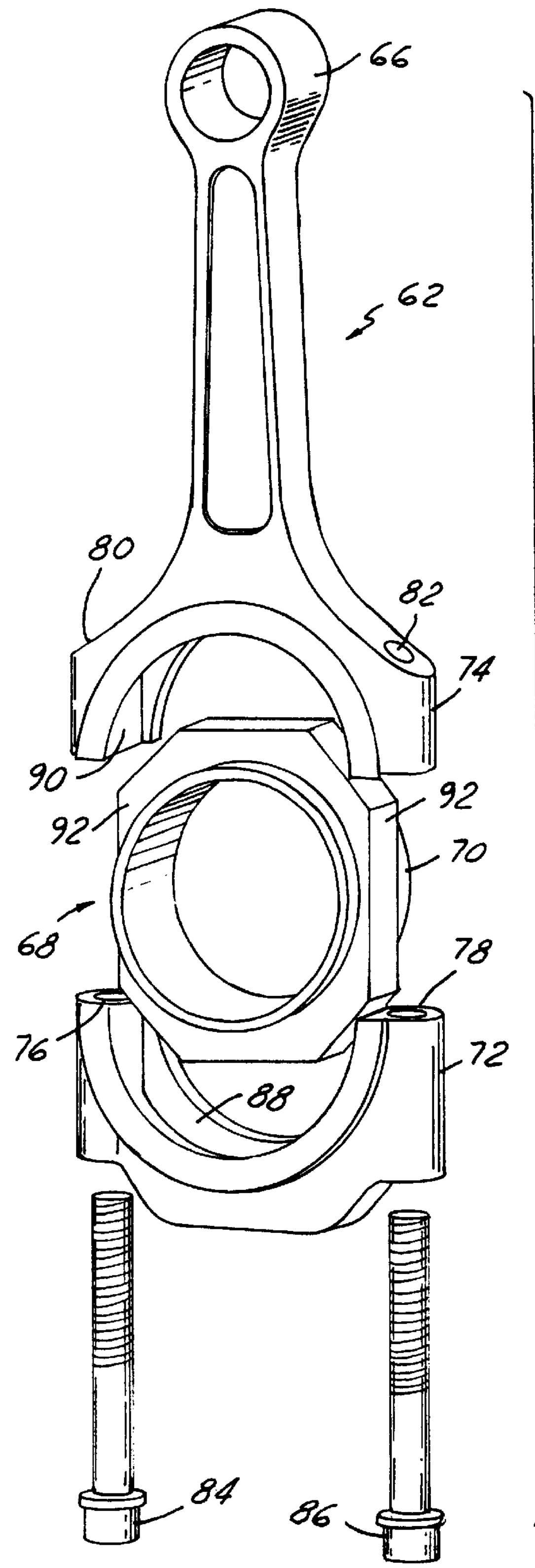

FIG.3

VARIABLE COMPRESSION RATIO CONNECTING RODS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to reciprocating piston type internal combustion (I.C.) engines for motor vehicles. More specifically it relates to I.C. engines having variable compression ratio connecting rods.

2. Background Information

A gasoline engine whose compression ratio remains invariant as operating conditions change is said to be knock-limited. This means that the compression ratio built into the engine design must be selected to avoid objectionable engine knock that would otherwise occur during certain conditions of engine operation if the compression ratio were larger. However, those conditions that give rise to engine knocking in a motor vehicle typically prevail for only limited times as the vehicle is being driven. At other times, the engine could operate with better efficiency, and still without knocking, if the compression ratio could be made higher, but unfortunately the engine is incapable of achieving more efficient operation during those times because its compression ratio cannot change.

Certain technologies relating to reciprocating piston I.C. engines having variable compression ratio pistons and connecting rods are disclosed in various patents, including U.S. Pat. Nos. 1,875,180; 2,376,214; 4,510,895; 4,687,348; 4,979,427; 5,562,068; and 5,755,192. Various reasons for employing such technologies in I.C. engines have been advanced in those documents. One reason is to improve efficiency by enabling an engine that is relatively more lightly loaded to run at a compression ratio that is higher than a compression ratio at which the engine operates when running relatively more heavily loaded.

The compression ratio of an engine can be varied by varying the overall effective length of a connecting rod and piston. Change in overall effective length may be accomplished in either the connecting rod, or the piston, or in both. The foregoing patents describe various mechanisms for varying overall effective length.

U.S. Pat. No. 5,562,068 discloses a variable compression ratio connecting rod where adjustment of effective length takes place at the large end. Adjustment is performed via an eccentric ring that is generally coincident with a crank pin, but can be selectively locked to the crank pin and to the large end of the rod. When locked to the crank pin, the eccentric ring assumes a position that causes the rod to have a longer effective length and hence a higher compression ratio. When locked to the rod, the eccentric ring assumes a position that causes the rod to have a shorter effective length and hence a lower compression ratio.

SUMMARY OF THE INVENTION

The present invention relates to further improvements in variable length connecting rods of reciprocating piston I.C. engines for varying engine compression ratios as engine operating conditions change. In particular the invention contemplates constructions for effecting length change at the large end of a connecting rod so that the incorporation of variable compression ratio by length change does not adversely contribute to the reciprocating mass of an engine in a way that might otherwise create unacceptable imbalance.

A general aspect of the invention relates to a variable length connecting rod assembly for imparting a variable

compression ratio to an internal combustion engine. The assembly contains a first part, a second part, and a third part assembled together to form the large end of the connecting rod assembly and provide a variable length for the connecting rod assembly. The first part is a semi-circular cap. One of the second and third parts is fastened tight to the first part. Guides disposed at opposite sides of the large end operatively relate the other of the second and third parts and the fastened parts to provide for relative sliding motion between the other of the second and third parts and the fastened parts over a limited adjustment range to change the length of the connecting rod assembly.

Further aspects will be seen in various features of two presently preferred embodiments of the invention that will be described in detail.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings that will now be briefly described are incorporated herein to illustrate a preferred embodiment of the invention and a best mode presently contemplated for carrying out the invention.

FIG. **1** is an exploded perspective view of a connecting rod constituting a first embodiment.

FIG. **2** is a non-exploded view of FIG. **1**, looking along a main axis of an engine.

FIG. **3** is an exploded perspective view of a connecting rod constituting a second embodiment.

FIG. **4** is a non-exploded view of FIG. **3** looking along a main axis of an engine.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

FIGS. **1** and **2** show a connecting rod **12** of a first piston/connecting rod embodiment **10** for endowing an engine with a variable compression ratio. Connecting rod **12** comprises a large end **14** for journaling on a crank pin **15** of a crankshaft and a small end **16** for journaling on a central portion of a wrist pin for coupling the connecting rod to the piston (as schematically shown). A variable length mechanism **18** is embodied in the connecting rod at its large end to provide for variation in overall length as measured between the large and small ends.

Large end **14** comprises an upper cap **20** and a lower cap **22** that are fastened together around the crank pin. Lower cap **22** comprises parallel through-holes **26**, **28** at opposite ends of its semi-circumference. At opposite ends of its semi-circumference, upper cap **20** comprises through-holes **30**, **32** that align with holes **26**, **28** respectively when the two caps are girdling the crank pin.

Connecting rod **12** further comprises a part **34** containing a connecting rod portion **35**. One end of part **34** contains small end **16**, and the opposite end is coupled through variable length mechanism **18** with large end **14**. That coupling comprises through-holes **36**, **38** that align with through-holes **30**, **32** respectively, fasteners **40**, **42**, and nuts **41**, **43**. Through-holes **36**, **38** are disposed mutually parallel, and are contained in free ends of curved arms **45** that extend from connecting rod portion **35**.

Each fastener **40**, **42** comprises a head **44** at a proximal end and a screw thread **46** at a distal end. Intermediate proximal and distal ends, each fastener comprises a circular cylindrical guide surface **48**. The parts are assembled in the manner suggested by the Figures with the respective fastener shanks passing though respective aligned through-holes **36**, **30**; **38**, **32**; and **26**, **28**; and threading into respective nuts **41**,

43. The diameters of through-holes **36**, **38** are larger than those of through-holes **30**, **32** to allow shoulders **50** at the ends of guides **48** to bear against the margins of through-holes **30**, **32**. As the fasteners and nuts are tightened, such as by turning with a suitable tightening tool, the two caps **20**, **22** are thereby forced together at their ends, crushing the crank pin bearing in the process.

The axial length of each guide surface **48**, as measured between head **44** and shoulder **50**, is slightly greater than the axial length of each through-hole **36**, **38**, and the diameters of the latter are slightly larger than those of the former to provide sliding clearance. In this way it becomes possible for rod part **34** to slide axially over a short range of motion relative to large end **12**. That range of motion is indicated by the reference **52** in FIG. **2** and constitutes a limited adjustment range for changing the length of the connecting rod assembly. When arms **45** abut part **20** around the margins of through-holes **30**, **32**, the connecting rod assembly has minimum length. When arms **45** abut heads **44**, the connecting rod assembly has maximum length.

Channels **54** may be assembled at the sides to provide additional bearing support for the axial sliding motion. Mechanism **18** may comprise passive and/or active elements for accomplishing overall length change, and resulting compression ratio change.

FIGS. **3** and **4** illustrate the connecting rod **62** of a second piston/connecting rod embodiment **60** for endowing an engine with a variable compression ratio. Connecting rod **62** comprises a large end **64** for journaling on a crank pin of a crankshaft (not shown) and a small end **66** for journaling on a central portion of a wrist pin (also not shown) for coupling the connecting rod to the piston (also not shown). A variable length mechanism **68** is embodied in the connecting rod at its large end to provide for variation in overall length between the large and small ends.

Mechanism **68** is provided by a bearing retainer **70** which is captured between a cap **72** and one end of a rod part **74**. Opposite ends of the semi-circumference of cap **72** contain holes **76**, **78** that align with threaded holes **80**, **82** in rod part **74**. Fasteners **84**, **86** fasten the cap to the rod part. The cap and rod part have channels **88**, **90** that fit to respective portions of a flange **92** of bearing retainer **70**. The channel and flange depths are chosen to allow the assembled cap and rod part to move axially a short distance on the bearing retainer, thereby changing the overall length, as marked by the reference **94** in FIG. **4**. Mechanism **68** may comprise passive and/or active elements for accomplishing overall length change and corresponding compression ratio change. The channels form the groove, and the flange the tongue, of a tongue-and groove type joint providing for sliding motion that adjusts the length of the connecting rod assembly.

While a presently preferred embodiment has been illustrated and described, it is to be appreciated that the invention may be practiced in various forms within the scope of the following claims.

What is claimed is:

1. A variable length connecting rod assembly for imparting a variable compression ratio to an internal combustion engine, the assembly comprising:

a first part, a second part, and a third part assembled together to form the large end of the connecting rod assembly and provide a variable length for the connecting rod assembly;

the first part comprising a semi-circular cap;

one of the second and third parts being fastened tight to the first part; and

guides disposed at opposite sides of the large end operatively relating the other of the second and third parts and the fastened parts to provide for relative sliding motion between the other of the second and third parts and the fastened parts over a limited adjustment range to change the length of the connecting rod assembly;

fasteners disposed on opposite sides of the large end for fastening the one of the second and third parts tight to the first part;

wherein the one of the second and third parts fastened tight to the first part by the fasteners comprises a semi-circular cap fastened to the semi-circular cap of the first part providing for the two fastened semi-circular caps to girdle a crank pin; and

the guides comprise surfaces of the fasteners disposed in through-holes in the other of the second and third parts.

2. A variable length connecting rod assembly as set forth in claim **1** in which the other of the second and third parts comprises a connecting rod portion, and the through-holes are disposed at ends of arms of the other of the second and third parts that extend to opposite side of the connecting rod portion at the large end of the connecting rod assembly.

3. A variable length connecting rod assembly as set forth in claim **2** further comprising additional parts assembled to opposite sides of the large end of the connecting rod assembly to aid in providing guidance for relative sliding motion between the other of the second and third parts and the fastened parts.

4. A variable length connecting rod assembly as set forth in claim **3** in which the additional parts comprises channels.

5. A variable length connecting rod assembly as set forth in claim **1** in which the fasteners comprise shoulders spaced from heads, the shoulders abut the one of the second and third parts to fasten the one part tight to the first part, and the heads are disposed to be abutted by the other of the second and third parts to define a limit of maximum length for the connecting rod assembly.

6. A variable length connecting rod assembly for imparting a variable compression ratio to an internal combustion engine, the assembly comprising:

a first part, a second part, and a third part assembled together to form the large end of the connecting rod assembly and provide a variable length for the connecting rod assembly along a longitudinal centerline extending from the large end to a point of attachment to a piston;

the first part comprising a semi-circular cap;

one of the second and third parts being fastened tight to the first part; and

guides disposed at opposite sides of the large end lateral to and parallel with the longitudinal centerline for operatively relating the other of the second and third parts and the fastened parts to provide for relative sliding motion between the other of the second and third parts and the fastened parts over a limited adjustment range to change the length of the connecting rod assembly;

fasteners disposed on opposite sides of the large end for fastening the one of the second and third parts tight to the first part;

wherein the one of the second and third parts fastened tight to the first part by the fasteners comprises a connecting rod portion having, at one end, a semi-circular cap fastened to the semi-circular cap of the first part, the two fastened caps capture the other of the second and third parts, and the guides comprise tongue-and-groove type guides;

the tongues are disposed on the other of the second and third parts, and the grooves are disposed on the two fastened semi-circular caps.

* * * * *

US006394047B1

(12) **United States Patent**
Rao et al.

(10) **Patent No.: US 6,394,047 B1**
(45) **Date of Patent: May 28, 2002**

(54) **CONNECTING ROD FOR A VARIABLE COMPRESSION ENGINE**

(75) Inventors: **V. Durga Nageswar Rao**, Bloomfield Hills; **Yash Andrew Imai**, Troy, both of MI (US); **Michael Zaitz**, High Point, NC (US); **Pravin Sashidharan**, Inkster; **Daniel James Baraszu**, Plymouth, both of MI (US)

(73) Assignee: **Ford Global Technologies, Inc.**, Dearborn, MI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/682,263**

(22) Filed: **Aug. 10, 2001**

(51) **Int. Cl.**[7] **G05G 1/00**
(52) **U.S. Cl.** .... **123/48 B**
(58) **Field of Search** .... 123/48 B, 197.3

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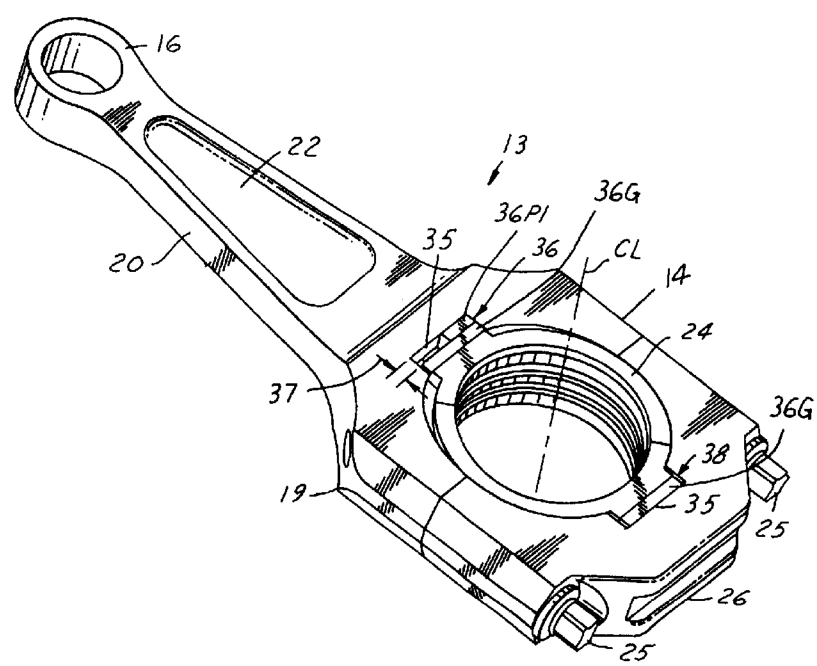
Assistant Examiner—Jason Benton
(74) *Attorney, Agent, or Firm*—John F. Buckert; Allan J. Lippa

(57) **ABSTRACT**

A variable length connecting rod **13** for changing a compression ratio of an engine is provided. The connecting rod **13** includes a first locking assembly **36** for locking the connecting rod **13** in a first effective length setting corresponding to a high compression ratio. The connecting rod **13** further includes a second locking assembly **38** for releasably locking the connecting rod **13** in a second effective length setting corresponding to a low compression ratio. When a length change is initiated, hydraulic fluid unlocks one of the locking assemblies **36**, **38**, allowing inertial force to effect the length change during an engine cycle. At completion of a length change, the other locking assembly **36**, **38** automatically locks. The locking assemblies **36**, **38** are self-contained units that are assembled to a bearing retainer **24**.

21 Claims, 5 Drawing Sheets



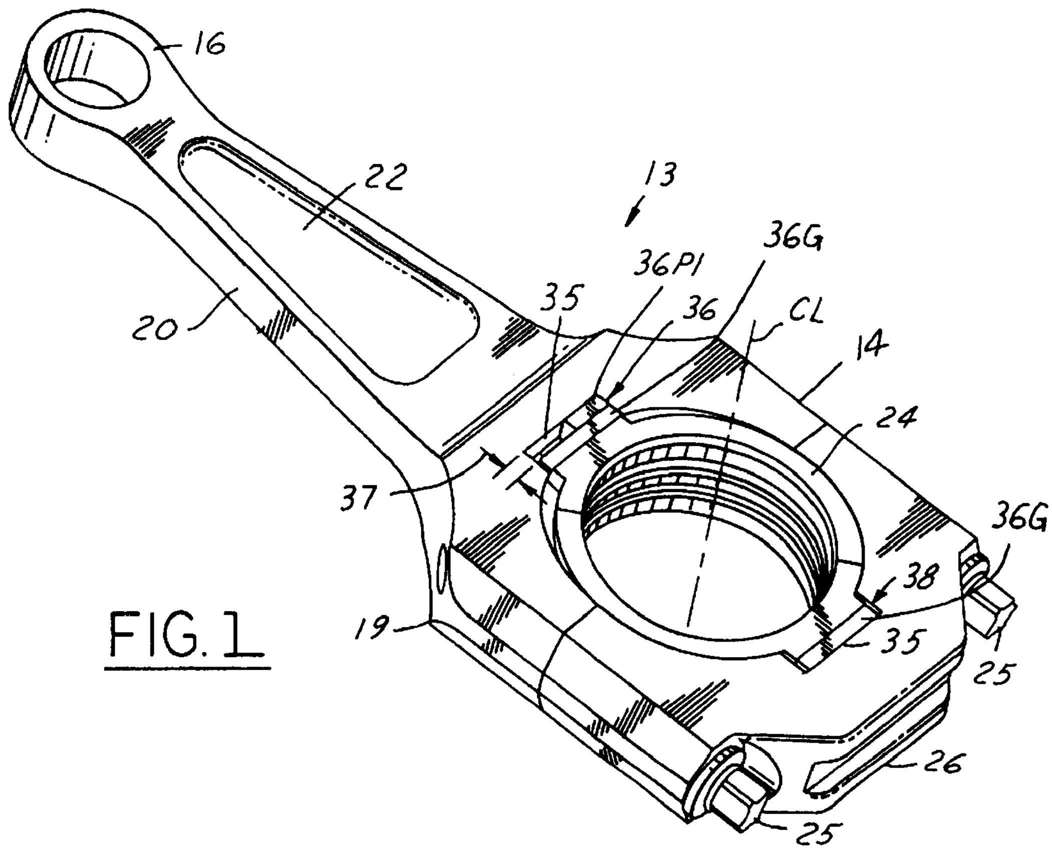
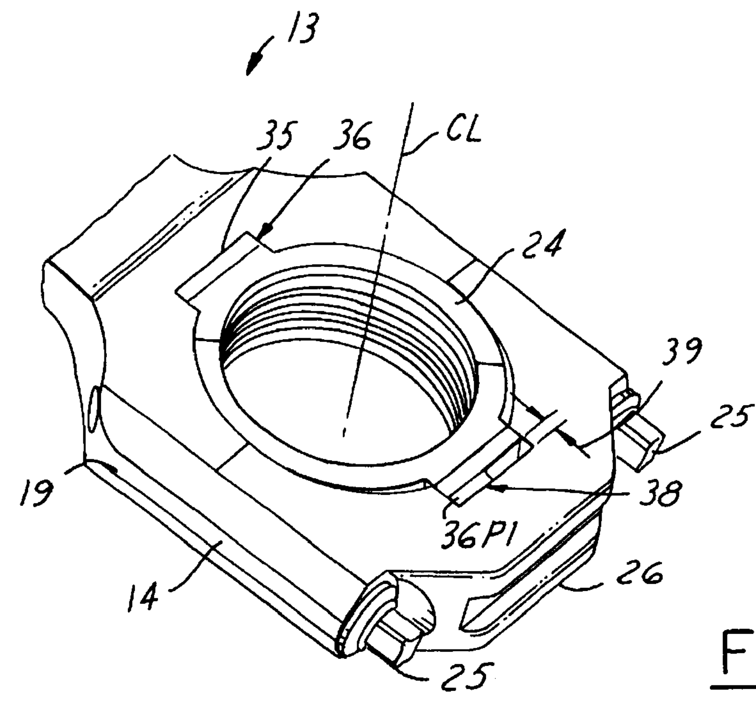

16
22
13
36G
36P1
35
36
CL
14
20
24
37
36G
38
35
19
25
26
25

FIG. 1


13
35
36
CL
24
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25
38
19
36P1
26
14
25

FIG. 1A

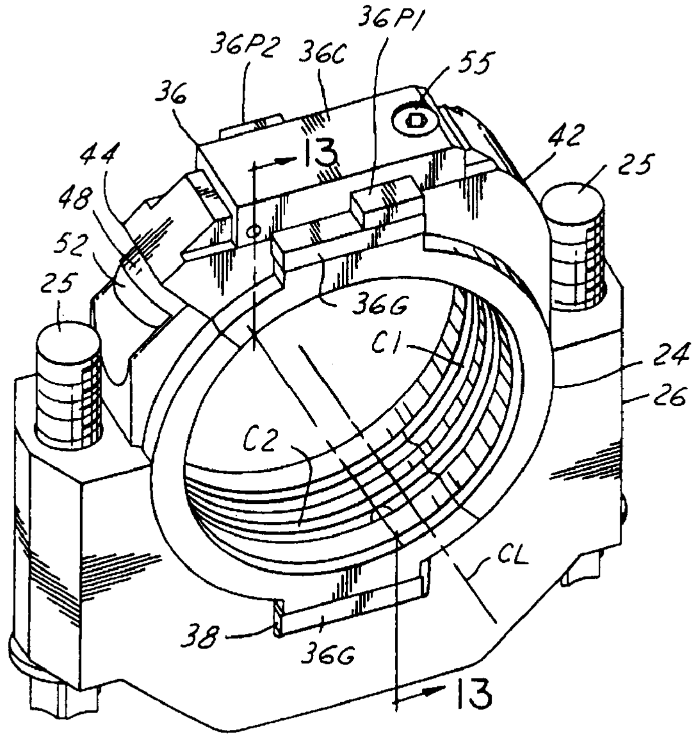
36P1
36P2
36C
55
36
42
25
44
13
48
52
25
36G
C1
24
26
C2
CL
38
36G
13

FIG. 2

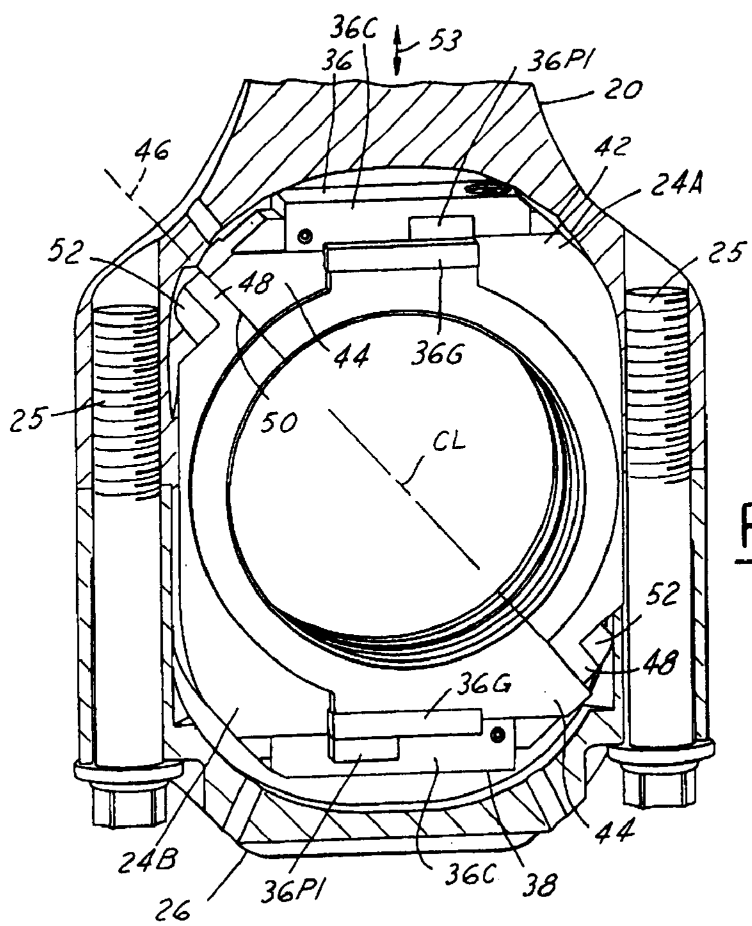
36C
53
36
36P1
20
46
42
24A
52
48
25
44
36G
25
50
CL
52
48
36G
44
24B
26
36P1
36C
38

FIG. 3

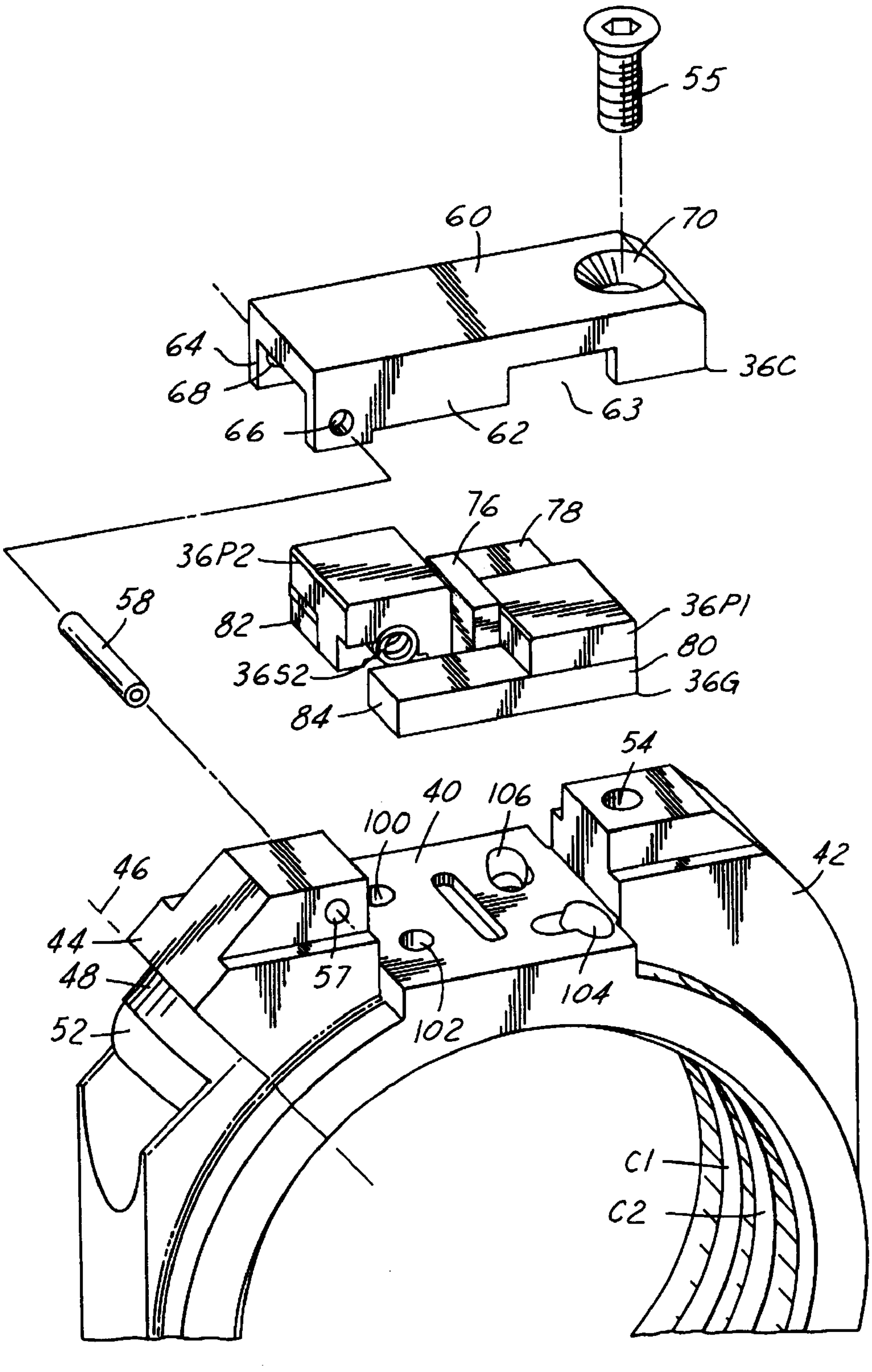
55
60
70
64
68
36C
66
62
63
76
78
36P2
36P1
58
82
80
36S2
36G
84
54
40
106
100
42
46
44
48
57
104
102
52
C1
C2

FIG. 4

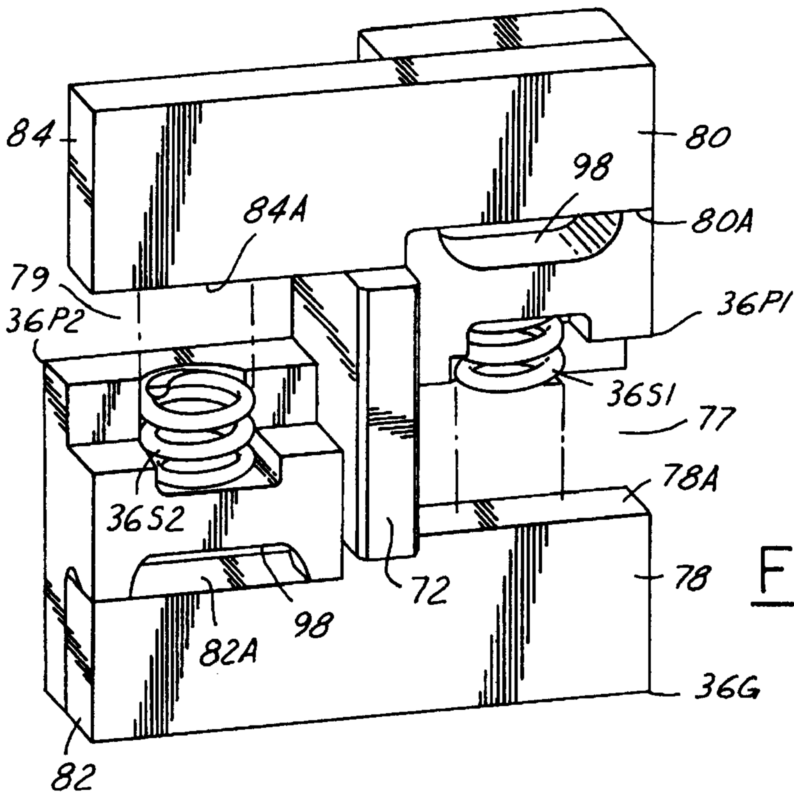
84
80
98
84A
80A
79
36P2
36P1
36S1
77
78A
36S2
72
78
98
82A
36G
82

FIG. 5

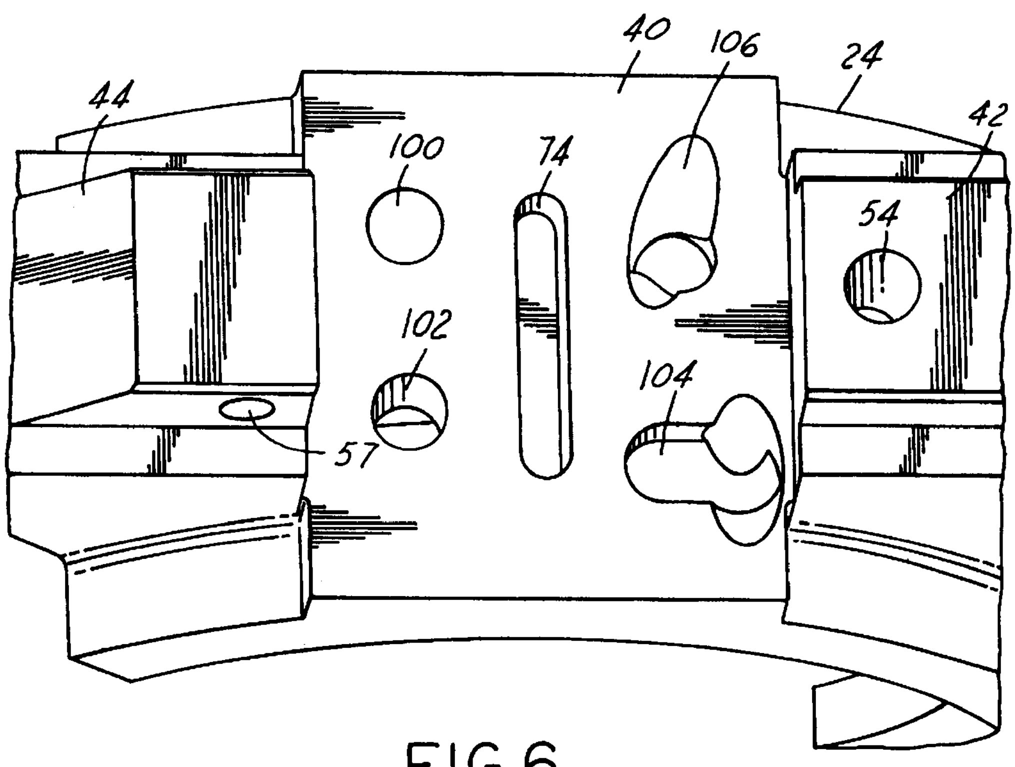
40
106
24
44
42
100
74
54
102
104
57

FIG. 6

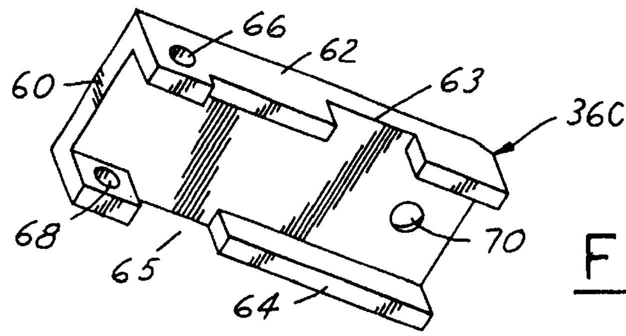

FIG. 7

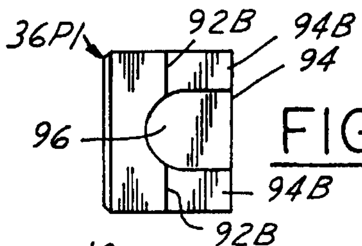

FIG. 10

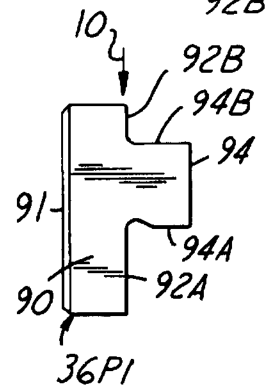

FIG. 9

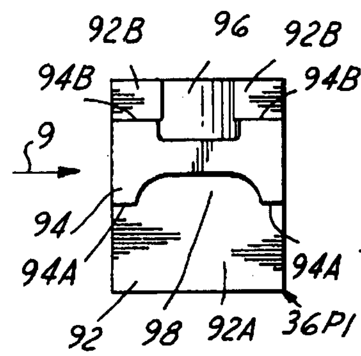

FIG. 8

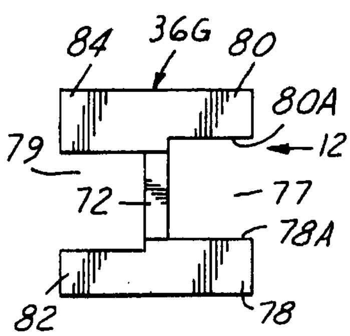

FIG. 11

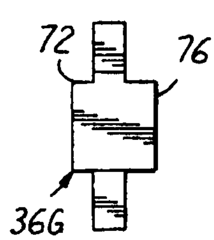

FIG. 12

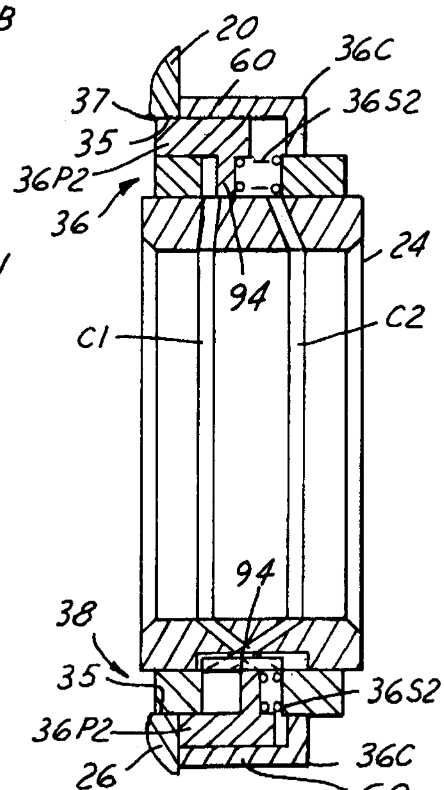

FIG. 13

CONNECTING ROD FOR A VARIABLE COMPRESSION ENGINE

BACKGROUND OF INVENTION

This invention relates generally to a connecting rod for an internal combustion engine, and particularly, to a variable length connecting rod that can vary a compression ratio of the engine.

The "compression ratio" of an internal combustion engine is defined as the ratio of the volume in a cylinder above a piston when the piston is at bottom-dead-center (BDC) to the volume in the cylinder above the piston when the piston is at top-dead-center (TDC). The higher the compression ratio, the more the air and fuel molecules are mixed and compressed resulting in increased efficiency of the engine. This in turn results in improved fuel economy and a higher ratio of output energy versus input energy of the engine.

In conventional internal combustion engines, however, the compression ratio is fixed and thus the compression ratio cannot be changed to yield optimal performance. Accordingly, variable compression ratio (VCR) internal combustion engines have been developed to vary the clearance volume of a cylinder in order to achieve improved fuel economy and increased engine power performance.

One known system for changing the compression ratio of an engine utilizes a connecting rod whose effective length can be varied. Those skilled in the art will recognize that varying the effective length of a connecting rod allows the compression ratio of an associated engine cylinder to be varied. In particular, the apparatus includes a bearing retainer disposed between a connecting rod and a corresponding crankpin, the bearing retainer has an inner surface in communication with the crankpin and an outer surface in communication with the connecting rod. The connecting rod is axially movable relative to the bearing retainer along a longitudinal axis of the connecting rod to effect a selective displacement of the connecting rod relative to the bearing retainer. The displacement causes a change in the effective length of the connecting rod and the compression ratio of the internal combustion engine. A locking mechanism is provided in cooperation with the bearing retainer and the connecting rod for maintaining the connecting rod at a selected position relative to the bearing retainer. The selected position corresponds to a selected compression ratio of the internal combustion engine. The locking mechanism is housed in an "extruded portion" on the side of a connecting rod. The extruded portion includes a hydraulically actuated lock pin that can engage a corresponding aperture in the bearing retainer to lock the connecting rod relative to the bearing retainer.

A problem associated with the known connecting rod is that the overall width of the connecting rod having the extruded portion for the locking mechanism is wider than a conventional "constant length" connecting rod. Thus, to accommodate the extruded portion, clearance grooves are machined in the counterweights of the crankshaft to allow the extruded portion of the connecting rod to move therethrough. Thus, utilizing the known connecting rod requires additional machining of "stock" crankshafts which increases manufacturing costs and the assembly time.

SUMMARY OF INVENTION

The aforementioned limitations and inadequacies of conventional connecting rods are substantially overcome by the inventive connecting rod for selectively varying a compression ratio of an internal combustion engine. The connecting rod has a variable effective length and integrates a locking mechanism within the body of the connecting rod without utilizing an extruded portion for the locking mechanisms.

The inventive connecting rod includes a body portion extending along a first axis having an aperture extending therethrough generally perpendicular to the first axis and parallel to a crankpin axis. The connecting rod further includes a bearing retainer disposed in the aperture between the body portion and a crankpin of the engine. The aperture is configured to allow selective displacement of the body portion along the first axis relative to the bearing retainer. The displacement causes a change in the effective length of the body portion and the compression ratio of the engine. The connecting rod further includes a first locking mechanism contained within the aperture of the body portion and operably disposed between the bearing retainer and the body portion. The first locking mechanism has a first locking element that extends into a first gap formed between first and second opposing surfaces of the body portion and the bearing retainer, respectively, to create a first compression fit. The compression fit locks the body portion at a first position relative to the bearing retainer. The first position corresponds to a first selected compression ratio of the engine.

The inventive connecting rod in accordance with the present invention provides a substantial advantage over conventional systems and methods. In particular, the connecting rod integrates a locking mechanism within the body of the connecting rod without utilizing extruded portions to hold the locking mechanisms. Thus, the connecting rod can be utilized with conventional crankshafts with minimal additional machining being required on the crankshafts. Thus, the inventive connecting rod provides for reduced manufacturing costs and a reduction in assembly time as compared with known variable length connecting rods.

Another advantage associated with the inventive connecting rod is that the connecting rod is lighter than known variable effective length connecting rods because no extruded housings are utilized for the locking mechanisms.

Still another advantage associated with the inventive connecting rod is that the locking mechanism is compressively loaded between the body portion and the bearing retainer (i.e., creates a compression fit) to lock the bearing retainer relative to the body of the connecting rod. The compression fit results in decreased bending of the locking member as compared with known locking members having shear loading between two members of the connecting rod.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is perspective view of a connecting rod constituting an exemplary embodiment of the invention, with the connecting rod positioned relative to a bearing retainer to have an effective length that provides a high compression ratio.

FIG. **1A** is a partial perspective view of the connecting rod shown in FIG. **1** with the connecting rod positioned relative to a bearing retainer to have an effective length that provides a low compression ratio.

FIG. **2** is a fragmentary perspective view of the large end of the connecting rod, broken away to show more detail of one of its two locking assemblies.

FIG. **3** is another fragmentary perspective view of the large end of the connecting rod, with the rod being shown in cross section substantially at its medial plane.

FIG. **4** is a view looking in same general direction as FIG. **2**, with the locking assembly shown in exploded view on a larger scale to illustrate detail.

FIG. **5** is an enlarged perspective view of certain elements of the locking assembly, namely a guide and two spring-biased locking members.

FIG. **6** is an enlarged fragmentary perspective view of a portion of the bearing retainer on which a locking assembly is disposed.

FIG. **7** is a perspective view of another element of the locking assembly by itself, namely a cover.

FIG. **8** is a bottom plan view of a locking member of the locking assembly by itself.

FIG. **9** is a view in the direction of arrow **9** in FIG. **8**.

FIG. **10** is a view in the direction of arrow **10** in FIG. **9**.

FIG. **11** is a bottom plan view of a guide of the locking assembly by itself.

FIG. **12** is a view in the direction of arrow **12** in FIG. **11**.

FIG. **13** is a cross section view generally in the direction of line **13**—**13** in FIG. **2**.

DETAILED DESCRIPTION

FIGS. **1** and **1A** show an embodiment of a variable length connecting rod **13** for varying a compression ratio of an internal combustion engine. Connecting rod **13** comprises a large end **14** for journaling on a crankpin of a crankshaft (not shown). Connecting rod **13** further includes a small end **16** for journaling on a central portion of a wrist pin (not shown) for coupling the connecting rod **13** to a piston (not shown). The connecting rod **13** may be utilized with the engine described in commonly owned U.S. patent application Ser. No. 09/690,961 entitled "System And Method For Varying The Compression Ratio Of An Internal Combustion Engine" filed Oct. 18, 2000, which is incorporated herein in its entirety.

Connecting rod **13** comprises a fixed length body portion **19** formed by rod portions **20** and **26** that are fastened together by fasteners **25**. Rod portion **20** comprises a small end **16** and a middle portion **22** that extends from the small end **16** to large end **14**. The connecting rod **13** further includes a bearing retainer **24** which is assembled onto a crankpin (not shown) of a crankshaft (not shown) with its centerline CL concentric with that of the crankpin. Bearing retainer **24** is captured between a generally semi-circular portion of rod portion **20** at large end **14** and a generally semi-circular cap that forms rod portion **26**. Body portion **19** and bearing retainer **24** are constructed to allow body portion **19** to move a short distance on bearing retainer **24**, thereby changing the effective length of connecting rod **13** by re-positioning the centerline of large end **14** relative to the centerline of bearing retainer **24**. FIG. **1** shows connecting rod **13** locked in a longer length setting that provides a higher compression ratio in an engine cylinder. FIG. **1A** shows a shorter length setting that provides a smaller compression ratio in an engine cylinder.

Referring to FIG. **1**, a bearing (not shown) resides within bearing retainer **24** to function as a bearing surface between the inside diameter (I.D.) of the bearing retainer **24** and the outside diameter (O.D.) of the crankpin (not shown). The bearing may be constructed as disclosed in commonly owned U.S. patent application Ser. No. 09/690,951, filed on Oct. 18, 2000 which is incorporated herein in its entirety. In particular, the bearing may be constructed as shown in FIGS. **9**A, **9**B of U.S. patent application Ser. No. 09/690,951 where the bearing resides within the bearing retainer. Referring again to FIG. **1**, the crankpin is girdled by the bearing retainer **24** as the retainer **24** turns on the crankpin in response to crankshaft rotation. Referring to FIG. **2**, the bearing retainer **24** includes two circumferentially continuous channels C**1**, C**2**. The bearing also includes two series of circumferentially spaced apart through-holes through which hydraulic fluid can enter the channels C**1**, C**2** from the crankpin.

Connecting rod **13** includes two locking assemblies **36**, **38**. Locking assembly **36** is disposed at large end **14** between small end **16** and a centerline CL. Locking assembly **38** is disposed at large end **14** diametrically opposite locking assembly **36** relative to centerline CL. As illustrated, assemblies **36, 38** may have identical configurations.

Referring to FIGS. **4**–**6**, locking assembly **36** comprises several parts including two locking members, or lock pins **36P1**, **36P2**, two bias springs **3651**, **36S2**, a guide, or base, **36**G, and a cover **36**C, the latter two parts forming an enclosure of the assembly.

Locking assembly **38** comprises the same parts as locking assembly **36**, namely two locking members or lock pins, two bias springs, a guide, or base, and a cover. Only some of the elements of assembly **38** are illustrated for purposes of clarity.

Locking assembly **36** locks connecting rod **13** in a longer effective length setting, while locking assembly **38** locks the connecting rod **13** in a shorter effective length setting. Referring to FIG. **1**, when connecting rod **13** has a longer length setting, a gap **37** exists between an edge of guide **36**G and the confronting edge of a notch **35**. The confronting edge is formed in rod portion **20** in one face of body portion **19** at the middle of the semi-circular portion of large end **14**. A distal end of locking member **36P1** protrudes from locking assembly **36** to fit very closely in gap **37** to create a compression fit that prevents body portion **19** from moving on bearing retainer **24** and thus prevents shortening the effective length of the connecting rod **13**. If connecting rod **13** were rotated 180° about a long axis in FIG. **1** to reveal an opposite face, the opposite face would appear identical to the one shown. Thus, gap **37** is also present on the opposite face where an end of locking member **36P2** protrudes into gap **37**. As shown in FIG. **1**, the two locking members **36P1**, **36P2** thereby lock the connecting rod **36** in the longer length setting. Force acting in a sense tending to shorten the length of the connecting rod **13** results in the application of a compression force to the extended portions of locking members **36P1** and **36P2** and the portions of guide **36**G that underlie the extended portions of the locking members. In this way, the locking assembly locks the connecting rod without shearing force being exerted on the members **36P1**, **36P2** and guide **36**G.

Referring to FIG. **1A**, when connecting rod **13** has a shorter length setting, a gap **39** exists between an edge of guide **36**G of locking assembly **38** and the confronting edge of a notch **35**. The confronting edge is formed in rod portion **26** in one face of body portion **19** at the middle of the semi-circular portion of large end **14** formed by the rod portion **26**. As illustrated in FIG. **1**, when connecting rod **13** is locked in the longer length setting, gap **39** is closed. Further, the locking members **36P1**, **36P2** of locking assembly **38** are retracted into the locking assembly enclosure.

As illustrated, bearing retainer **24** may be generally circular, and includes features for accommodating locking assemblies **36**, **38**. At the location of each locking assembly **36**, **38**, the bearing retainer **24** has a flat mounting surface **40** for the respective guide **36**G. Referring to FIG. **2**, guide **36**G of locking assembly **36** is disposed flat against surface **40**. Locking members **36P1**, **36P2** are disposed on guide **36**G, and cover **36**C fits over members **36P1**, **36P2** to hold the members between cover **36**C and guide **36**G. Formations **42** and **44** of bearing retainer **24** are disposed adjacent respective sides of mounting surface **40**.

Formations **42, 44** serve multiple purposes as described below. One purpose is to provide for the precise locating and the secure attachment of cover **36**C to the bearing retainer **24**. A second purpose is to guide the fixed length connecting rod **19** on bearing retainer **24** when the connecting rod effective length is changed. A third purpose is to allow two semi-circular elements **24**A, **24**B that form bearing retainer **24** to be fastened together at a diagonal parting plane **46**.

Referring to FIG. **3**, parting plane **46** illustrates the position where the two elements **24**A, **24**B are joined. Each element **24**A, **24**B includes an apertured ear **48** that abuts a mating surface **50** in formation **44** of the opposite element at parting plane **46**. The threaded shank of a headed screw **52** passes through the aperture of each ear **48** and threads into a tapped blind hole that extends into formation **44** from surface **50**. The screw **52** is tightened so that its head forces ear **48** against surface **50**, thereby securing the two elements **24**A, **24**B together at parting plane **46**.

Referring to FIGS. **1, 2, 3**, cap **26** and the semi-circular portion of rod portion **20** at large end **14** have grooves that fit closely onto formations **42, 44** to provide the small relative movement of the body portion **19** on bearing retainer **24**. The small relative movement allows the effective connecting rod length to change along the direction of a straight line **53**. As shown in FIG. **3**, line **53** perpendicularly intersects centerline CL of bearing retainer **24**.

Referring to FIG. **4**, formation **42** has a tapped hole **54** that is proximate mounting surface **40** and parallel to line **53**. Hole **54** provides for fastening of one end of cover **36**C to the bearing retainer **24** by means of a headed screw **55**. Formation **44** also has a circular through-hole **57** that is proximate mounting surface **40** and parallel to centerline CL. Hole **57** provides for fastening of the other end of cover **36**C to the bearing retainer **24** by means of a pressed-in cylinder such as a roll pin **58**.

Referring to FIG. **7**, cover **36**C comprises a rectangular-shaped top **60** and sides **62, 64** that depend from opposite lengthwise side margins of top **60**. Sides **62, 64** have equal nominal height. At the lengthwise end portion of cover **36**C that is proximate formation **44**, sides **62, 64** have respective aligned circular through-holes **66, 68** of equal diameters with that of through-hole **57**. At the lengthwise end portion of cover **36**C that is proximate formation **42**, top **60** comprises a through-hole **70**. When cover **36**C and bearing retainer **24** are assembled together, the threaded shank of screw **55** passes through hole **70** and threads into hole **54**. The screw is tightened to seat its head flush with top **60** securing the cover to the bearing retainer. At the end of cover **36**C proximate formation **44**, through-holes **66, 68** register with opposite ends of through-hole **57**, and roll pin **58** is pressed in the three aligned holes to secure that end of the cover to the bearing retainer. Side **62** has a rectangular through-notch **63** that interrupts its bottom edge to provide clearance for locking member **36P1** when the cover is assembled over it. Likewise side **64** has a rectangular through-notch **65** that interrupts its bottom edge to provide clearance for locking member **36P2** when the cover is assembled over member **36P2**.

Referring to FIGS. **5, 11, 12**, guide **36**G has opposite parallel faces, and a generally straight rectangular ridge **72** that runs parallel to centerline CL. Ridge **72** protrudes centrally from one face of guide **36**G that is disposed against mounting surface **40**. Mounting surface **40** comprises a central straight through-slot **74** into which ridge **72** closely fits to accurately locate guide **36**G on the mounting surface. The faces of formations **42, 44** at the sides of mounting surface **40** also aid in locating the guide.

The other face of guide **36**G that is disposed toward top **60** of cover **36**C comprises a straight, generally rectangular ridge **76** that runs parallel to bearing retainer centerline CL. Ridge **76** protrudes centrally from the face opposite ridge **72**. The portion of guide **36**G to one side of ridges **72, 76** comprises a rectangular notch **77** that extends between top and bottom faces of the guide **36**G to endow the guide with spaced-apart, parallel arms **78, 80** that run perpendicular to the bearing retainer centerline. In similar fashion, the portion of guide **36**G to the opposite side of ridges **72, 76** comprises a rectangular notch **79** that extends between top and bottom faces of the guide to endow the guide **36**G with spaced-apart, parallel arms **82, 84** that run perpendicular to the bearing retainer centerline opposite arms **78, 80** thereby giving the guide **36**G a general H-shape as shown in FIG. **11**.

Referring to FIGS. **8, 9, 10**, locking member **36P1** comprises a generally rectangular body **90** having an essentially flat top surface **91** and an essentially flat bottom surface **92**. Surface **92** is divided into two surface portions **92**A, **92**B by a somewhat rectangular bar **94** that is transverse to the length of the locking member **36P1**. Bar **94** depends from bottom surface **92** of body **90** and is disposed in notch **77** between arms **78** and **80**. Bar **94** comprises opposite side surfaces **94**A, **94**B. A central area of surface **94**B and an adjoining central area of surface portion **92**B are formed to provide a recess **96** that serves to seat and locate one end of spring **36S1**. For locking member **36P1**, the opposite end of spring **36S1** bears against a surface **78**A of arm **78** that faces surface **94**B. Top **60** of cover **36**C overlies top surface **91** of body **90**. One side surface of body **90** confronts the side surface of ridge **76** while the opposite side surface of body **90** confronts the surface of formation **42** that adjoins mounting surface **40**. A recess **98** is formed centrally in side surface **94**A of bar **94**.

Referring to FIG. **5**, locking member **36P2** is identical to locking member **36P1**, arm **82** is identical to arm **80**, and arm **84** is identical to arm **78**. Spring **3GS2** is disposed between arm **84** and locking member **36P2** with one end of spring **36S2** bearing against a surface **84**A of arm **84** that faces surface **94**B. Locking member **36P2** is arranged in relation to guide **36**G, cover **36**C, and formation **44** in the same manner as locking member **36P1** is arranged relative to the guide, the cover and formation **42**. The difference is that the two locking members **36P1, 36P2** operate in opposite directions, as will be explained in greater detail below.

Referring to FIGS. **1, 2, 4, 5**, a locked condition of locking assembly **36** is illustrated. As shown locking members **36P1, 36P2** are extended during the locked condition. To extend locking members **36P1, 36P2**, springs **36S1** and **36S2** force the bars **94** of the respective locking members **36P1, 36P2** against the respective arms **80, 82** with surfaces **94**A constituting stop surfaces that abut stop surfaces **80**A, **82**A of the arms **80, 82**. As a result, the lengthwise end of body **90** of locking member **36P1** opposite spring **36S1** protrudes from notch **63** to end essentially flush with the outer end surface of guide **36**G which is common to both arms **80, 84**. Further, the lengthwise end of body **90** of locking member **36P2** opposite spring **36S2** protrudes from notch **65** to end essentially flush with the outer end surface of guide **36**G which is common to both arms **78, 82**.

When locking assembly **36** is operated to an unlocked condition, the two locking members **36P1, 36P2** are retracted along respective straight lines (i.e. they translate) toward the interior of the locking assembly enclosure, resiliently compressing the respective bias springs **36S1, 36S2** in the process. As locking member **36P1** retracts, its surface portion **92**A slides across the top surface of arm **80**. As locking member **36P2** retracts, its surface portion **92**A slides across the top surface of arm **82**. The top surfaces of bodies **90** slide across the bottom surface of cover top **60**. Inboard side surfaces of the locking members **36P1, 36P2** slide across ridges **72** and **76**, and outboard side surfaces slide across the respective surfaces of formations **42** and **44** that adjoin mounting surface **40**. The protruding ends of the locking members **36P1, 36P2** retract into notches **63, 65**.

Referring to FIGS. **5, 6,** bearing retainer **24** includes a first passage **100** that extends from channel C1 to notch **79** between arms **82** and **84**. It also comprises a second passage **102** that extends from channel C2 to notch **79**. Each passage **100, 102** opens to notch **79** at a different location. In particular, passage **100** opens proximate arm **82** while passage **102** opens proximate arm **84**.

Bearing retainer **24** further comprises a third passage **104** that extends from channel C1 to notch **77** between arms **78** and **80**. It also comprises a fourth passage **106** that extends from channel C2 to the same notch, and importantly, each passage **104, 106** opens to notch **77** at a different location. In particular, passage **104** opens proximate arm **80** while passage **106** opens proximate arm **78**. Each of passages **100, 102** extends straight from the respective channel C1, C2. However, creating a straight passage for passages **104, 106** may not be possible in the available space. Therefore, passages **104, 106** may have to be slant drilled to establish the required communication with the proper channel.

Operation of the two locking members **36P1, 36P2** of locking assembly **36** to the unlocked condition is accomplished by the delivery of hydraulic fluid under pressure through channel C1 and passages **100, 104**. With the two locking members **36P1, 36P2** in locked condition, hydraulic fluid is delivered through the respective notches **79, 77** in guide **36G** to respective confined spaces that are provided by the respective recess **98** in each locking member. The hydraulic pressure acts on the surface of each recess **98** to create a force opposite that of the respective bias spring **36S1, 36S2**. The hydraulic force is great enough to retract each locking member **36P1, 36P2** against the spring force.

As the locking members **36P1, 36P2** retract, their ends move out of the respective gaps **37** thereby unlocking the assembly to allow an effective length change of body portion **19**. Because the opposite locking assembly **38** is already unlocked, the length change occurs as soon as the inertial force acting along the length of the connecting rod **13** becomes sufficiently great. When the length change concludes, connecting rod **13** has a slightly shorter overall effective length there by resulting in a lower compression ratio.

Referring to FIGS. **1A** and **5**, when the length change is completed, locking assembly **38** automatically locks. The fact that locking assembly **38** will automatically lock can be appreciated from consideration of its identical construction with locking assembly **36**. One difference however between the two assemblies **36, 38** is that at locking assembly **38**, channel C1 supplies hydraulic fluid to recess **96** for extending the two locking members **36P1, 36P2** of mechanism **38**, and channel C2 supplies hydraulic fluid to recess **98** for retracting the locking members **36P1, 36P2**. This can be seen in FIG. **13** which shows locking assembly **36** locked and locking assembly **38** unlocked. Hence, channel C1 is communicated to the two spaces of locking assembly **38** where the two bias springs are disposed. This allows hydraulic pressure in channel C1 to act on surfaces **94B** of the two locking members **36P1, 36P2** of locking assembly **38** at the same time that the pressure is also acting to retract the two locking members **36P1, 36P2** of locking assembly **36**.

As the length change is ending, gaps **39** open sufficiently wide to cease interfering with the extension of locking members **36P1, 36P2** of assembly **38**. The locking members **36P1, 36P2** are immediately forced to translate to their extended positions by both spring force and hydraulic force, to fit closely in the open gaps. When the increased hydraulic pressure in channel C1 ceases, the springs **36S1, 36S2** of locking assembly **38** keep the locking members in locked condition. Although the locking members **36P1, 36P2** of locking assembly **36** are no longer being forced into retraction by hydraulic pressure, the closure of gap **37** that occurred during the length change now presents an interference to their extension by the bias springs, and hence they remain retracted in the unlocked condition. Force acting in a sense tending to lengthen the connecting rod **13** results in the application of force of compression to the extended portions of locking members **36P1, 36P2** of locking assembly **38** and the portions of guide **36G** that underlie the extended portions of the locking members **36P1, 36P2**. Thus, locking assembly **38** locks the connecting rod **13** without shearing force being exerted on its two locking members **36P1, 36P2** and guides **36G**.

The connecting rod **13** is lengthened by increasing hydraulic pressure in channel C2. Assembly **38** is unlocked in the same manner as assembly **36** was unlocked when the length was decreased. The length change is accomplished by inertial force, and assembly **36** automatically re-locks upon completion of the length change. The hydraulic pressure increase in channel C2 can be discontinued. Because the length change occurs within one engine cycle and increased hydraulic pressure is discontinued after the connecting rod has been re-locked in the new length, the increased pressure for performing a length change is in the nature of a pulse.

From the foregoing description, several aspects of operation may be recognized. A first aspect is that the locking of one assembly is sufficient to lock the connecting rod in one of two possible lengths. A second aspect is that it is not possible for both locking assemblies to be locked at the same time. A third aspect is that a length change is initiated by unlocking a locked assembly so that both locking assemblies are unlocked. A fourth aspect is that one of the assemblies will automatically lock the connecting rod upon completion of a length change.

The hydraulic control systems disclosed in commonly owned U.S. patent application Ser. No. 09/799,305, filed on Mar. 5, 2001, which is incorporated herein in its entirety, may be utilized for operating the connecting rod **13**. In one embodiment, passages **30, 32** illustrated in FIG. **1** of U.S. patent application Ser. No. 09/799,305 may selectively supply hydraulic fluid to grooves C1 and C2, respectively, in FIG. **2** of the present application to adjust an effective length of connecting rod **13**.

A method for assembling a connecting rod **13** to a crankshaft (not shown) of an engine in accordance with the present invention is also provided. Referring to FIGS. **1, 2,** the method includes attaching first locking mechanism **36** to first portion **24A** of bearing retainer **24**. The method further includes attaching second locking mechanism **38** to second portion **24B** of bearing retainer **24**. The method further includes securing first and second portions **24A, 24B** around a crankshaft (not shown) of the engine. The method further includes inserting first rod portion **20** over first locking mechanism **36** for mechanism **36** to be received in a portion of an aperture defined by first rod portion **20**, until a top surface of mechanism **36** abuts an inner surface of first rod portion **20**. The method further includes inserting second body portion **26** over second locking mechanism **38** for mechanism **38** to be received in a portion of the aperture defined by second rod portion **26**, until a top surface of second locking mechanism **38** abuts an inner surface of second rod portion **26**. Further, while inserting second rod portion **26** over second locking mechanism **38**, moving first and second locking members **36P1, 36P2** inwardly toward one another to an unlocked position. Finally, the method includes securing first rod portion **20** to second rod portion **26**. The first and second rod portions **20, 26** may be secured using conventional bolts, screws, or other attachment means known to those skilled in the art.

The inventive method for assembling a connecting rod **13** to an engine crankshaft represents a significant advantage over known assembly methods for variable compression connecting rods. In particular, the method allows the locking mechanisms **36, 38** to be attached to a respective portion of the bearing retainer **24** prior to the bearing retainer **24** being attached to an engine crankshaft. The inventive assembly method is much simpler and faster than known assembly methods that first attach the bearing retainer to the crankshaft and thereafter assemble at least a portion of the locking mechanisms to the bearing retainer or connecting rod within the limited space of the engine.

The inventive connecting rod **13** also provides a substantial advantage over conventional connecting rods for variable compression engines. In particular, the inventive connecting rod **13** integrates locking mechanisms **36, 38** completely within the body of the connecting rod **13** without utilizing extruded housing portions to contain the lock mechanisms. Thus, the inventive connecting rod **13** can be utilized with conventional crankshafts with minimal additional machining being required on the crankshafts, resulting in reduced manufacturing costs. Further, the inventive connecting rod **13** is lighter than known variable length connecting rods because no extruded housing is needed for the locking mechanisms. Still further, the connecting rod **13** utilizes a locking member that is compressively loaded between the body portion **19** and the bearing retainer **24**. The compressive loading reduces the possibility of bending the locking member while maintaining a locked position as compared to known connecting rods that have locking members that are shear loaded between a body portion and a bearing retainer.

What is claimed is:

1. A connecting rod for selectively varying a compression ratio of an internal combustion engine, said connecting rod being operably connected between a crankshaft and a piston of said engine, said connecting rod comprising:

a body portion extending along a first axis having a aperture extending therethrough generally perpendicular to said first axis and parallel to a crankpin axis;

a bearing retainer disposed in said aperture between said body portion and a crankpin of said engine, said receiving aperture being configured to allow selective displacement of said body portion along said first axis relative to said bearing retainer, said displacement causing a change in the effective length of said body portion and the compression ratio of said engine; and,

a first locking mechanism contained within said aperture of said body portion and operably disposed between said bearing retainer and said body portion, said first locking mechanism being configured to create a first compression fit between said body portion and said bearing retainer to lock said body portion at a first position relative to said bearing retainer, said first position corresponding to a first selected compression ratio of said engine.

2. The connecting rod of claim **1** wherein said first locking mechanism includes a first locking element that extends generally parallel to said crankpin axis to fill a first gap between said body portion and said bearing retainer to create said first compression fit between said body portion and said bearing retainer.

3. The connecting rod of claim **1** wherein said first locking member is biased toward said first gap.

4. The connecting rod of claim **1** wherein said first locking member is integral with said bearing retainer.

5. The connecting rod of claim **1** wherein said first locking mechanism is disposed at a first end of said bearing retainer,

said connecting rod further including a second locking mechanism contained within said aperture of said body portion and operably disposed between said body portion and said bearing retainer, said second locking mechanism being disposed at a second end of said bearing retainer opposite said first end, said second locking mechanism being configured to create a second compression fit between said body portion and said bearing retainer for locking said body portion at a second position relative to said bearing retainer, said second position corresponding to a second selected compression ratio of said engine.

6. The connecting rod of claim **5** wherein said second locking mechanism includes a second locking element that extends outwardly to fill a second gap between said body portion and said bearing retainer to create said second compression fit between said body portion and said bearing retainer.

7. The connecting rod of claim **1** wherein said first locking mechanism includes a first locking member that moves generally parallel to said crankpin axis, first and second guide members disposed on an outer peripheral surface of said bearing retainer guiding movement of said first locking member, and a first spring disposed between said first guide member and said locking member biasing said locking member in a first direction parallel to said crankpin axis toward a locked position.

8. The connecting rod of claim **7** wherein said outer surface of said bearing retainer includes an aperture communicating with a fluid chamber formed between said first locking member and said second guide member, wherein fluid delivered into said fluid chamber moves said first locking member in a second direction opposite said first direction against a bias force of said first spring toward an unlocked position.

9. The connecting rod of claim **7** wherein said first locking mechanism further includes a second locking member that moves generally parallel to said crankpin axis, said first and second guide members guiding movement of said second locking member, and a second spring disposed between said first guide member and said second locking member biasing said second locking member in a second direction opposite said first direction toward a locked position.

10. A connecting rod for selectively varying a compression ratio of an internal combustion engine, said connecting rod being operably connected between a crankshaft and a piston of said engine, said connecting rod comprising:

a body portion extending along a first axis having a aperture extending therethrough generally perpendicular to said first axis and parallel to a crankpin axis;

a bearing retainer disposed in said aperture between said body portion and a crankpin of said engine, said receiving aperture being configured to allow selective displacement of said body portion along said first axis relative to said bearing retainer, said displacement causing a change in the effective length of said body portion and the compression ratio of said engine; and,

a first locking mechanism contained within said aperture of said body portion and operably disposed between said bearing retainer and said body portion, said first locking mechanism having a first locking element that extends into a first gap formed between first and second opposing surfaces of said body portion and said bearing retainer, respectively, to create a first compression fit, said compression fit locking said body portion at a first position relative to said bearing retainer, said first position corresponding to a first selected compression ratio of said engine.

11. The connecting rod of claim **10** wherein said first locking mechanism is disposed at a first end of said bearing retainer, said connecting rod further including a second locking mechanism contained within said aperture of said body portion and operably disposed between said body portion and said bearing retainer, said second locking mechanism being disposed at a second end of said bearing retainer opposite said first end, said second locking mechanism being configured to create a second compression fit between said body portion and said bearing retainer for locking said body portion at a second position relative to said bearing retainer, said second position corresponding to a second selected compression ratio of said engine.

12. A variable compression ratio engine, comprising:

a crankshaft that rotates about a crankshaft axis;

a piston driven by a connecting rod coupled between said piston and said crankshaft;

said connecting rod having:

a body portion extending along a first axis having a aperture extending therethrough generally perpendicular to said first axis and parallel to a crankpin axis;

a bearing retainer disposed in said aperture between said body portion and a crankpin of said engine, said receiving aperture being configured to allow selective displacement of said body portion along said first axis relative to said bearing retainer, said displacement causing a change in the effective length of said body portion and the compression ratio of said engine; and,

a first locking mechanism contained within said aperture of said body portion and operably disposed between said bearing retainer and said body portion, said first locking mechanism being configured to create a first compression fit between said body portion and said bearing retainer to lock said body portion at a first position relative to said bearing retainer, said first position corresponding to a first selected compression ratio of said engine.

13. The variable compression engine of claim **12** wherein said first locking mechanism includes a first locking element that extends generally parallel to said crankpin axis to fill a first gap between said body portion and said bearing retainer to create said first compression fit between said body portion and said bearing retainer.

14. The variable compression engine of claim **12** wherein said first locking mechanism is disposed at a first end of said bearing retainer, said connecting rod further including a second locking mechanism contained within said aperture of said body portion and operably disposed between said body portion and said bearing retainer, said second locking mechanism being disposed at a second end of said bearing retainer opposite said first end, said second locking mechanism being configured to create a second compression fit between said body portion and said bearing retainer for locking said body portion at a second position relative to said bearing retainer, said second position corresponding to a second selected compression ratio of said engine.

15. The variable compression engine of claim **12** wherein said second locking mechanism includes a second locking element that extends generally parallel to said crankpin axis to fill a second gap between said body portion and said bearing retainer to create said second compression fit between said body portion and said bearing retainer.

16. The variable compression engine of claim **12** wherein said first locking mechanism includes a first locking member that moves generally parallel to said crankpin axis, first and second guide members disposed on an outer peripheral surface of said bearing retainer guiding movement of said first locking member, and a first spring disposed between said first guide member and said locking member biasing said locking member in a first direction parallel to said crankpin axis toward a locked position.

17. The variable compression engine of claim **12** wherein said outer surface of said bearing retainer includes an aperture communicating with a fluid chamber formed between said first locking member and said second guide member, wherein fluid delivered into said fluid chamber moves said first locking member in a second direction opposite said first direction against a bias force of said first spring toward an unlocked position.

18. The variable compression engine of claim **12** wherein said first locking mechanism further includes a second locking member that moves generally parallel to said crankpin axis, first and second guide members guiding movement of said second locking member, and a second spring disposed between said first guide member and said second locking member biasing said second locking member in a second direction opposite said first direction toward a locked position.

19. A method for assembling a connecting rod for a variable compression engine, said connecting rod having a body portion comprising first and second rod portions defining an aperture, a bearing retainer having first and second portions adapted to fit around an engine crankshaft when joined together, first and second locking mechanisms configured to be mounted on opposite ends of said bearing retainer, said first and second locking mechanisms having first and second locking members, respectively, that selectively extend outwardly along a crankshaft axis in opposite directions, said method comprising:

attaching said first locking mechanism to said first portion of said bearing retainer;

attaching said second locking mechanism to said second portion of said bearing retainer; securing said first and second portions of said bearing retainer around a crankshaft of said engine;

inserting said first rod portion over said first locking mechanism for said first locking mechanism to be received in a first portion of said aperture defined by said first rod portion until a top surface of said first locking mechanism abuts an inner surface of said first rod portion; and,

inserting said second rod portion over said second locking mechanism for said second locking mechanism to be received in a second portion of said aperture defined by said second rod portion until a top surface of said second locking mechanism abuts an inner surface of said second rod portion.

20. The method of claim **19** wherein said step of inserting said second rod portion over said second locking mechanism includes moving said first and second locking members inwardly toward one another to an unlocked position.

21. The method of claim **19** further including securing said first rod portion to said second rod portion.

* * * * *

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(12) **United States Patent**
Tibbles

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(45) **Date of Patent:** **May 18, 2004**

(54) **VARIABLE COMPRESSION RATIO CONTROL SYSTEM FOR INTERNAL COMBUSTION ENGINE**

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(51) **Int. Cl.**[7] **F02B 75/04**
(52) **U.S. Cl.** **123/78**
(58) **Field of Search** .... 123/78 E

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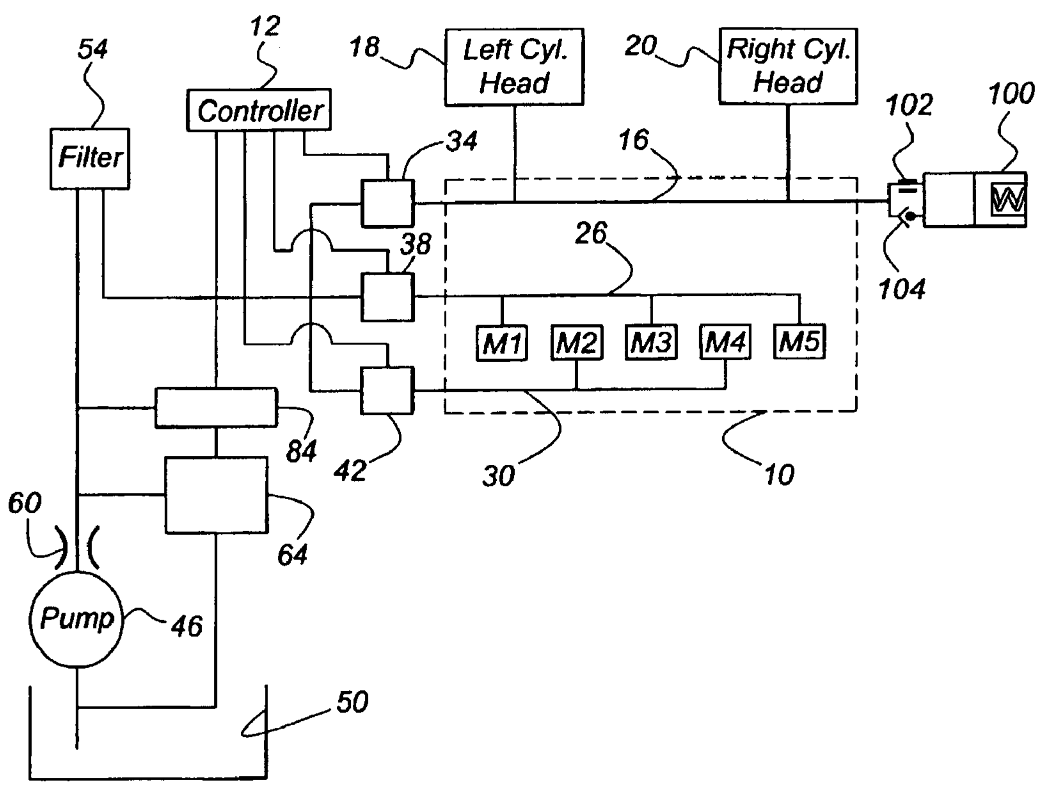
Assistant Examiner—Douglas A Salser

(57) **ABSTRACT**

A variable compression ratio control system for an internal combustion engine includes a lubrication system for selectively providing lubricating oil to connecting rods within the engine at either a lubrication pressure or at a control pressure. The oil is provided to compression ratio adjusters so as to cause the adjusters to move from one compression ratio to another, to achieve a desired change in compression ratio. A lubricating pump provides lubricating oil to the connecting rods through the lubrication system. The lubricating pump is selectively operable at one of a lubricating pressure and a control pressure by means of a control valve which is integral with the lubricating pump.

17 Claims, 5 Drawing Sheets



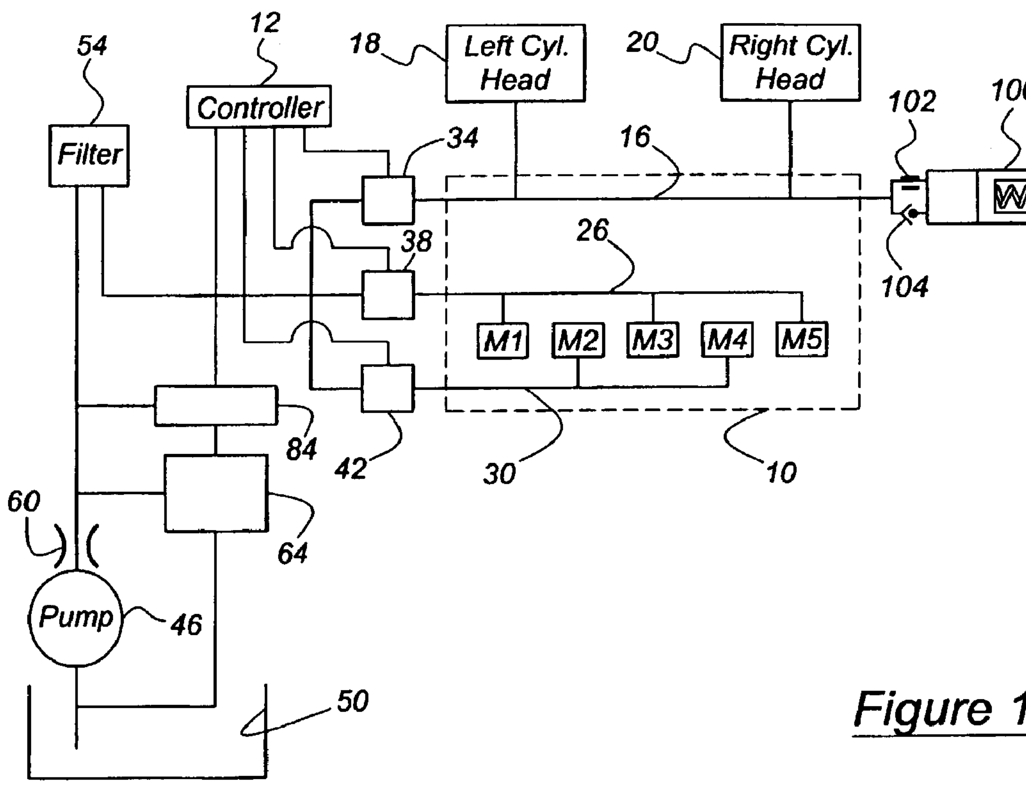

54
12
18
Left Cyl. Head
20
Right Cyl. Head
Filter
Controller
34
16
102
100
38
26
104
M1
M2
M3
M4
M5
84
42
30
10
60
64
Pump
46
50

Figure 1

	Solenoids				Gallery Press (psi)		
State	Relief	Head	Hi CR	Lo CR	Head	Hi CR	Lo CR
Lube	Off	Off	Off	Off	70	70	70
High	On	On	Off	On	0	140	0
Low	On	On	On	Off	0	0	140

Figure 2

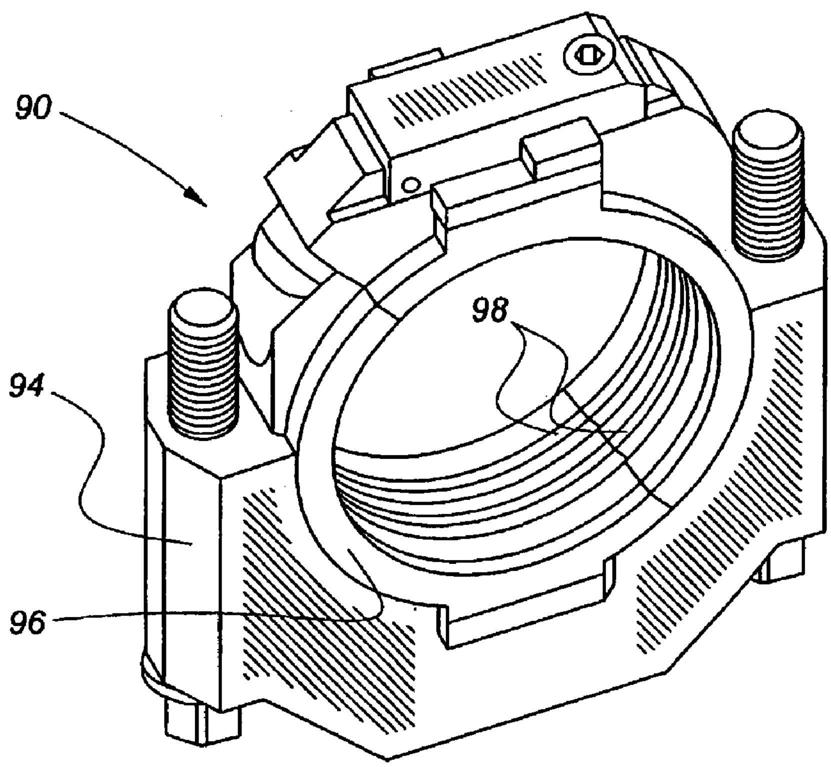


Figure 3

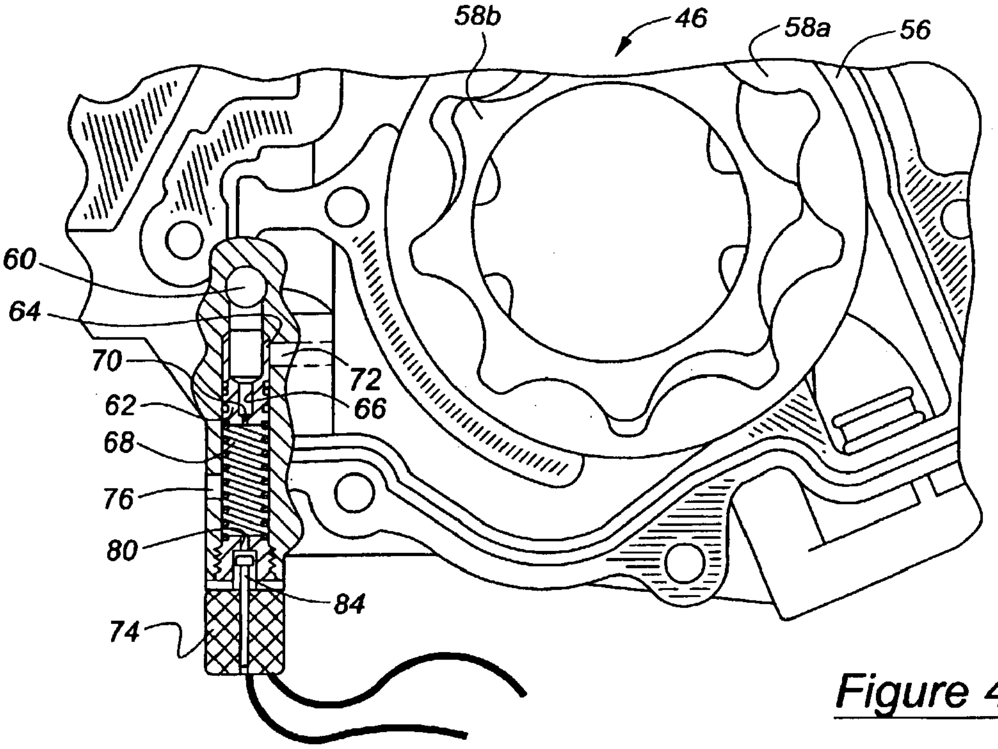


Figure 4

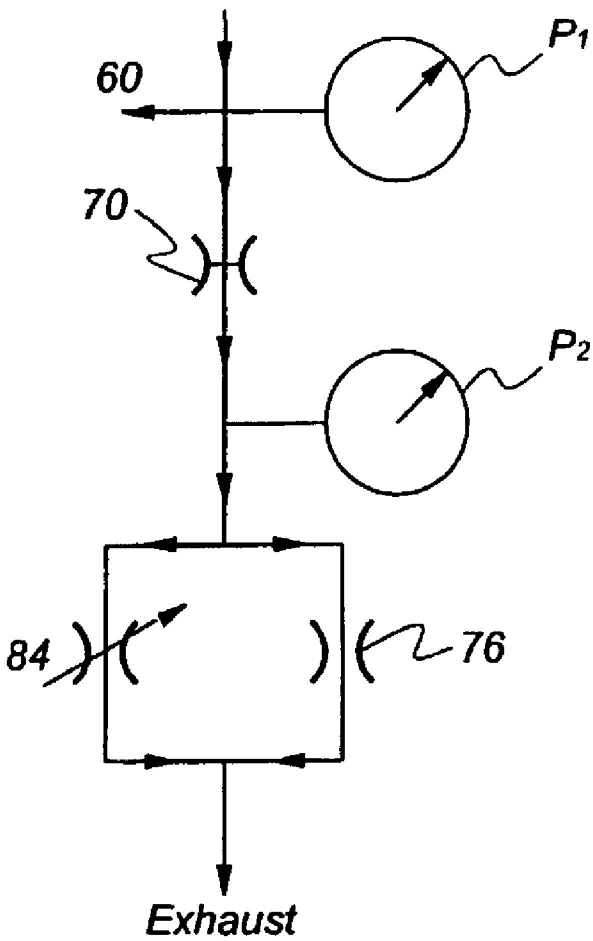


Figure 5

VARIABLE COMPRESSION RATIO CONTROL SYSTEM FOR INTERNAL COMBUSTION ENGINE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an internal combustion engine having a system for controlling the engine's compression ratio by means of a dual purpose lubricating oil pump having variable pressure output.

2. Disclosure Information

For many years, engine designers have desired to implement variable compression ratio control systems for use with reciprocating internal combustion engines. The ability to control an engine's compression ratio is desirable because it is well known that higher compression ratios promote superior fuel economy, but at the expense of knocking operation in the event of either excessive engine loading or inferior quality fuel. With a variable compression ratio system, it is possible to run at an higher compression ratio during low engine load and to alter the compression ratio to operate at a lower compression ratio during operation at higher engine loads. Moreover, if variable compression ratio control capability is coupled with the ability to boost the engine such as through the use of a supercharger, very high specific output maybe achieved at high loads, while preserving the capability to obtain superior fuel economy with higher compression at lower loads.

Many types of variable compression ratio designs have been proffered. Some systems such as those proposed by the BICERI organization change the compression height of the piston through use of hydraulic elements. Other systems change compression height of the piston through the use of a elastic element such as a Belleville spring interposed between the crown of the piston and its main body.

U.S. Pat. No. 6,394,047B1, which is assigned to the assignee of the present invention, and which is hereby incorporated by reference in this specification, discloses and claims a variable compression ratio connecting rod which employs a grooved bearing to pick up an oil pressure switching signal from the crankshaft of the engine. The present invention deals with a system for providing that signal to the crankshaft.

Although there are known systems for providing a high pressure oil signal to a variable compression ratio system in an engine, such systems typically use an external pump or an added hydraulic pump having significantly greater complexity than pumps currently found on engines. These additional pump systems typically include numerous check valves, solenoid valves, hydraulic accumulators, additional pumping elements and other devices which greatly increase the cost of a variable compression ratio system. In contrast, the present system utilizes the engine driven lube oil pump as a dual purpose, multi-pressure device. In other words, only the single pump is needed. Moreover, the present system does not use any uniquely dedicated control passages. In another words, all of the oil passages are used for normal lubrication, with two of the passages having dual roles for use as both lubrication and control signal passages.

SUMMARY OF INVENTION

A variable compression ratio control system for an internal combustion engine includes a lubrication system for selectively providing oil to connecting rods within the

engine at both a lubrication pressure and at a control pressure. A plurality of compression ratio adjusters is responsive to the pressure of lubricating oil being provided to the connecting roads through the lubrication system. One of the compression ratio adjusters is associated with each of the connecting rods. A lubricating pump provides lubricating oil to the connecting rods through the lubrication system. The lubricating pump is selectively operable at either the lubricating pressure or the control pressure.

The present system further includes a controller for sensing a plurality of engine operating parameters and for operating the lubricating pump at a pressure level which is dependent at least in part upon the sensed values of the engine operating parameters. The controller operates the lubricating pump and the valves of the variable compression ratio control system to cause the compression ratio adjusters to adjust to a lower compression ratio at higher engine loads and to a higher compression ratio at lower engine loads.

According to another aspect of the present invention, a lubricating pump comprises a supply element and a pressure relief element, with the pressure relief element being controllable so as to determine the pressure of lubricating oil discharged by the lubricating pump to the lubrication system. The supply element and pressure relief element are preferably located within a common housing, with the pump itself being driven by the engine.

According to another aspect of the present invention, the lubricating pump has an integral pressure regulator which comprises an elastic element for maintaining oil discharge pressure during normal operating condition and an electronically controlled valve for increasing discharge pressure when the compression ratio is being changed.

According to another aspect of the present invention, a compression ratio control system includes a lubrication system for providing lubricating oil to a plurality of components within an engine, with the lubrication system having a main bearing oil supply passage which is bifurcated into two passages such that the first group of main bearings is provided with oil by one of said passages, and a second group of main bearings is provided with oil by the other said passages. A plurality of compression ratio adjusters is responsive to the relative pressures of the lubricating oil being provided to the first and second groups of main bearings through the bifurcated oil passages. The compression ratio adjusters are switchable between a higher compression ratio and a lower compression ratio. The lubricating pump provides oil at a lower pressure during normal operation of the engine and at a higher pressure when the compression ratio adjusters are being switched from one compression ratio to the other compression ratio.

It is an advantage of the present invention that an engine may be equipped with a variable compression ratio controller without the necessity of adding another hydraulic pump with its attendant cost and complexity.

It is a further advantage of the present invention that implementation of a variable compression ratio control system according to this invention will necessitate only minor changes to many existing engine designs.

It is a further advantage of the present invention that the present system provides variable compression ratio with very little power consumption.

Other advantages, as well as objects and features of the present invention will become apparent to the reader of this specification.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a schematic representation of an engine having a variable compression ratio control system according to the present invention.

FIG. 2 is a table showing various control pressures and control valve settings for a control system according to the present invention.

FIG. 3 illustrates a portion of an adjustable compression ratio connecting rod which is useful for practicing the present invention.

FIG. 4 illustrates a lubricating oil pump having a control valve system according to one aspect of the present invention.

FIG. 5 is a hydraulic systematic illustrating operation of the pressure control valve incorporated in an engine oil pump according to the present invention.

DETAILED DESCRIPTION

As shown in FIG. **1**, an engine having engine block **10** has three oil galleries. Head gallery **16** provides lubricating oil to left cylinder head **18** and right cylinder head **20**. High compression ratio gallery **26** provides oil at both lubricating pressure and, as required, at a higher control pressure, to main bearings **1**, **3** and **5** of the engine, which are labeled **M1**, **M3**, and **M5**. On the other hand, low compression ratio gallery **30** provides oil at normal lubricating pressure and, at a higher control pressure as needed, to main bearings **2** and **4** which are labeled **M2** and **M4**. Thus, it is seen that the crankshaft of the engine illustrated in FIG. **1** has five main bearings. Those skilled in the art will recognize however, that a system according to this invention could be employed in an engine having a greater or lesser number of main bearings. What is important is that the crankpins of the crankshaft may be fed with oil at different pressures as required so that the compression ratio adjusters shown in FIG. **3** and described in the '047 patent, may be used.

Those skilled in the art will appreciate in view of this disclosure that controller **12**, which controls the selective provision of high pressure oil to the present compression ratio adjusters, will sample a plurality of engine operating parameters such as engine speed, engine load, throttle position, transmission gear selection, spark timing, and other parameters. Although a number of algorithms known to those skilled in the art may be employed to indicate the need to switch the compression ratio, it is expected that engine load would enter into this decision, with lower engine loads indicating higher compression ratio and higher engine loads indicating lower compression ratio. Engine load may be inferred from such operating parameters as engine speed, throttle position, intake manifold pressure, fuel injection rate, spark timing, vehicle speed, transmission gear, and other operating parameters.

As shown in FIG. **3** connecting rod **90** having cap **94** has a plurality of grooves **98** formed in bearing **96**. These grooves receive both lubricating oil and higher pressure control oil from an engine oil pump thereby, causing switching of the compression ratio of the engine by changing the effective length of the connecting rod, as set forth in the '047 patent. Those skilled in the art will appreciate in view of this disclosure that FIG. **3** does not include the smaller end of connecting rod **90** which would receive a wrist pin in conventional fashion.

The present invention deals with the manner in which lubricating oil may be supplied to the various main bearing galleries of the engine, at both a lower lubricating pressure, and, selectively, at a higher pressure sufficient to switch the compression ratio adjusters located within connecting rods **90**. Oil provided to galleries **16**, **26** and **30** arises from oil pump **46**, which draws engine oil from pump **50**. The oil passes first into filter **54** and then through three solenoid valves. Each of the valves **34**, **38** and **42** is normally open. In other words, each of valves **34**, **38**, and **42** is open unless a voltage has been applied to the valve in its closed position. Valve **34** controls the flow from oil pump **46** to head gallery **16**. Valve **38** controls the flow from pump **46** to high compression ratio gallery **26** and finally, normally open solenoid valve **42** controls the flow from pump **46** to low compression ratio gallery **30**. During normal operation of the engine, pump **46** circulates oil at about 70 psi to the three galleries. This is shown in FIG. **2**. As noted in FIG. **2**, during the lubricating state, solenoid valves **34**, **38** and **42** are in their normally open position. When each of solenoid valves **34**, **38**, **42** and **84** is in the open position, the pressure produced by pump **46** is determined solely by relief valve **64**. In the case shown in line one of FIG. **2**, cylinder head gallery **16** and high and low compression ratio galleries **26** and **30** are all at about 70 psi. Those skilled in the art will appreciate in view of this disclosure that the pressures shown in FIG. **2** are merely meant to be exemplary and may be shifted either up or down depending on the design requirements of any particular engine lubricating system and variable compression ratio control system provided by one wishing to practice the present invention.

In the event that it desirable to switch the compression ratio of an engine according to the present invention, head gallery solenoid valve **34** will be switched to the valve closed position. In another words, cylinder head solenoid valve **34** will be energized to the valve closed position. Moreover, one of the valves **38** and **42** will also be closed. If it is desired to obtain high compression ratio, valve **38** will be maintained in the open position. In other words valve **38** will kept open, whereas valve **42** will be energized to the closed position. Valve **84** will also be energized to the closed position. As a result, oil at approximately 140 psi, or at some other desired pressure selected by one employing present invention, will be directed to high compression ratio gallery **26**, and the compression ratio adjusters of the FIG. **3** and '047 patent, for example, will be directed to switch to the high compression ratio setting. If on the other hand it is desired to move from the high compression ratio to the low compression ratio, solenoid valve **42** will be left in the "off" or "open" position whereas valves **34** and **38** will be closed, as will solenoid valve **84** attached to pump **46**. In this manner, high pressure oil will be directed to low compression ratio gallery **30** and the adjusters associated with each connecting rod will be toggled to the low compression ratio setting.

Although other compression ratio control systems have used oil as a working fluid, the present system is advantageous because a single set of galleries is employed for furnishing both lubricant under normal pressure and higher control pressure to the main bearings and then to the crankshaft and to the connecting rods. FIG. **4** illustrates a gerotor pump having housing **56** and inner gerotor element **58*b*** and an outer gerotor element **58*a***. Although a particular pump is shown as having a large inside diameter on gerotor element **58*b*** sufficient to allow passage of the crankshaft of an engine, those skilled in the art will appreciate in view of this disclosure that other types gerotor pumps or gear pumps, or other types of positive displacement oil pumps could be utilized with a system according to the present invention. FIG. **4** also shows pump discharge port **60** as is also seen in FIG. **1**. Pump relief valve **64** is one control element used in the delivery of both the high and low pressures needed for normal lubrication and also for higher pressure for switching the compression ratio controllers.

Pump relief valve **64** allows oil to be discharged to pump relief port **72**, thereby limiting the pressure output of oil pump **46**. Pump relief valve **64** is biased into a closed position by means of relief valve spring **68** but more importantly, by means of fluid pressure which also biases pump relief valve **64** into the closed position. This fluid pressure is controlled by valve orifice **70** which is drilled axially through pump relief valve **64**. The normal relief pressure is further controlled by primary exhaust orifice **76** which is drilled through the side of valve bore **62**. Finally, solenoid valve **84** further serves to control the pressure available at pump discharge port **60**.

Solenoid valve **84**, which has previously been described as being normally open, allows oil to flow through secondary exhaust orifice **80** when valve **84** is in its normally open position. Accordingly, the pressure at pump discharge port **60** depends upon the sizes of orifices **70**, **76** and **80** during normal operation at lower lubricating pressure. This is the 70 psi setting noted in FIG. **2**. If however, solenoid valve **84** is energized into its closed position by the application of current to coil **74**, then the pressure available at pump discharge port **60** will be determined solely by the sizes of orifices **70** and **76**. Because secondary exhaust orifice **80** will be closed by solenoid valve **84**, pressure will be allowed to build up in valve bore **62** and the force resulting from this hydraulic pressure or fluid pressure acting on the backside of pump relief valve **64** will combine with the force produced by relief valve spring **68** to greatly increase the pressure available at pump discharge port **60**. As further described above, this increased pressure will be selectively available at high compression ratio gallery **26**, or low compression ratio gallery **30**, so as to achieve the desired switching of compression ratio.

FIG. **5** is a hydraulic schematic in which P1 represents the discharge pressure from pump **46**. Valve orifice is shown as contributing to the determination of P1, as do valve **84** and primary exhaust orifice **76**, which act together with relief valve spring **68** to produce P2, the unit pressure acting on the back side of relief valve **64**.

According to another aspect of the present invention, a control system according to the present invention may further comprise, as shown in FIG. **1**, hydraulic accumulator **100** which is hydraulically plumbed to head gallery **16** through orifice **102** and check valve **104**. During normal operation of the engine, accumulator **100** will fill with oil. Then, when compression ratio is being switched and cylinder head solenoid valve **34** is turned off, oil will flow from accumulator **100** into cylinder head gallery **16**. As a result, a variable valve timing control system (not shown) fed through cylinder head gallery **16** will be allowed to maintain proper operation for the brief interlude in which solenoid valve **34** is placed in the "off" or "closed" position.

Although the present invention has been described in connection with particular embodiments thereof, it is to be understood that various modifications, alterations, and adaptations may be made by those skilled in the art without departing from the spirit and scope of the invention. It is intended that the invention be limited only by the appended claims.

What is claimed is:

1. A variable compression ratio control system for an internal combustion engine, comprising:

a lubrication system for selectively providing oil to connecting rods within the engine at either a lubrication pressure or at a control pressure;

a plurality of compression ratio adjusters responsive to the pressure of lubricating oil being provided to the connecting rods through said lubrication system, with one of said compression ratio adjusters being associated with each of said connecting rods; and

a lubricating pump for providing lubricating oil to said connecting rods through said lubrication system, with said lubricating pump being selectively operable at one of said lubricating pressure and said control pressure.

2. A variable compression ratio control system according to claim **1**, further comprising a controller for sensing a plurality of engine operating parameters and for operating said lubricating pump at a pressure level which is dependent at least in part upon the sensed values of said engine operating parameters.

3. A variable compression ratio control system according to claim **2**, wherein said controller operates said lubricating pump at a pressure level which causes said compression ratio adjusters to be adjusted to a higher compression ratio at lower engine loads.

4. A variable compression ratio control system according to claim **2**, wherein said controller operates said lubricating pump at a pressure level which causes said compression ratio adjusters to be adjusted to a lower compression ratio at higher engine loads.

5. A variable compression ratio control system according to claim **1**, wherein said lubricating pump comprises a supply element and a pressure relief element, with said pressure relief element being controllable so as to determine the pressure of lubricating oil discharged by the lubricating pump to said lubrication system.

6. A variable compression ratio control system according to claim **5**, wherein said supply element and said pressure relief element are located within a common housing.

7. A variable compression ratio control system according to claim **1**, wherein said lubricating pump is driven by said engine.

8. A variable compression ratio control system according to claim **1**, wherein said lubricating pump comprises a gerotor pump driven by a crankshaft of said engine.

9. A variable compression ratio control system according to claim **1**, further comprising a controller for sensing a plurality of engine operating parameters and for operating said lubricating pump at a pressure level which is dependent at least in part upon the sensed values of said engine operating parameters, wherein said controller selectively operates said lubricating pump at one of said lubricating pressure level corresponding to a higher compression ratio at lower load, and a higher control pressure level corresponding to a lower compression ratio at higher engine load.

10. A variable compression ratio control system according to claim **1**, further comprising a controller for sensing a plurality of engine operating parameters and for operating said lubricating pump at a pressure level which is dependent at least in part upon the sensed values of said engine operating parameters, wherein said controller selectively operates said lubricating pump at the lubricating pressure level during normal engine operation, and a higher control pressure level when the compression ratio is being adjusted.

11. A variable compression ratio control system for an internal combustion engine having a crankshaft with a plurality of main bearings, and with a plurality of connecting rods being attached to said crankshaft, with said variable compression ratio control system comprising:

a lubrication system for providing lubricating oil to a plurality of components within the engine, with said lubrication system having a main bearing oil supply passage which is bifurcated into two passages such that a first group of main bearings is provided with oil by one of said passages, and a second group of main bearings is provided with oil by the other of said passages;

a plurality of compression ratio adjusters responsive to the relative pressures of the lubricating oil being provided to the first and second groups of main bearings through said bifurcated oil passages, with one of said compression ratio adjusters being associated with each of said connecting rods, and with said compression ratio adjusters being switchable between a higher compression ratio and a lower compression ratio; and

a dual purpose lubricating pump for providing lubricating oil to said connecting rods through said bifurcated oil passages, with said lubricating pump having an integral pressure regulator which discharges oil from the pump at a lower pressure during normal operation of the engine, and at a higher pressure when the compression ratio adjusters are being switched from one compression ratio to the other compression ratio.

12. A variable compression ratio control system according to claim **11**, further comprising a controller for operating the integral pressure regulator of said lubricating pump.

13. A variable compression ratio control system according to claim **11**, wherein said pressure regulator comprises an elastic element for maintaining oil discharge pressure during normal operating conditions and an electronically controlled valve for increasing the discharge pressure when the compression ratio is being changed.

14. A variable compression ratio control system according to claim **13**, wherein said electronically controlled valve is operated by a controller which senses a plurality of engine operating parameters and which controls the valve at a setting which is based at least in part upon the sensed values of said engine operating parameters.

15. A variable compression ratio control system according to claim **13**, wherein said elastic element comprises a spring-biased relief valve, with said electronically controlled valve applying a fluid pressure bias to the relief valve, so as to increase the discharge pressure from the lubricating pump.

16. A variable compression ratio control system according to claim **13**, further comprising a hydraulic accumulator for supplying lubricating oil to a variable valve timing actuator, with lubricating pump furnishing said accumulator with oil.

17. A method for operating a variable compression ratio control system for a reciprocating internal combustion engine, comprising the steps of:

determining a compression ratio at which the engine is to be operated;

increasing the discharge pressure of an engine lubricating pump from a lower pressure used during normal operation to a high pressure sufficient to operate a plurality of compression ratio adjusters; and

applying lubricating oil at said higher pressure to said compression ratio adjusters to cause the compression ratio to be adjusted.

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