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

(11) Publication number: **0 210 601 A2**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 86110188.9

(22) Date of filing: 24.07.86

(51) Int. Cl.[4]: **F02F 1/24**

(30) Priority: 31.07.85 IT 2177885

(43) Date of publication of application: 04.02.87 Bulletin 87/06

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

(71) Applicant: Dott. Vittorio Gilardoni S.p.A.
1, Via Marconi
I-22054 Mandello del Lario Como(IT)

(72) Inventor: Panzeri, Umberto
Frazione Castello Bella Vista, 1
I-22043 Galbiate Como(IT)

(74) Representative: Marietti, Giuseppe
CENTRO DI CONSULENZA IN PROPRIETA' INDUSTRIALE Viale Caldara, 43
I-20122 Milano(IT)

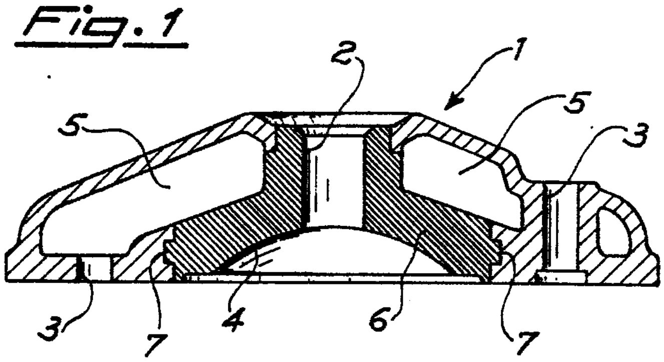
(54) Cylinder head for internal combustion engines.

(57) The present invention concerns a cylinder head for reciprocating internal combustion engines, in particular for high speed engines with spontaneous or controlled ignition.

The cylinder head according to the invention is characterized by the fact that the wall separating the combustion chamber from the cooling fluid is made, at least in part, of copper or of an alloy of copper having a high thermal conductivity coefficient.

This cylinder head, for the same area of heat exchange, allows a reduction of the temperature of the internal wall of the combustion chamber, allowing higher compression ratios to be used without the phenomenon of knocking, or the use of fuels with lower knock ratings.

Fig. 1



EP 0 210 601 A2

"CYLINDER HEAD FOR INTERNAL COMBUSTION ENGINES"

The present invention patent refers to reciprocating internal combustion engines, in particular to high speed engines with spontaneous or regulated ignition, and concerns the cylinder heads of such engines.

As is known, it is essential to maintain the temperature of the cylinder heads of reciprocating internal combustion engines, especially those with high compression ratios, below a certain maximum to avoid the phenomenom of knocking. In fact, the presence of hot-spots inside the combustion chamber, especially those far from the spark plug, can act as a source of ignition for the fresh gases. Such spontaneous combustion, which happens more on edges in the combustion chamber, prevents normal propagation of the combustion and therefore of the pressure wave from the spark-plug to the parts further away and therefore causes too rapid combustion and a shock-wave with different and contrasting direction of propagation. It could happen that combustion begins normally with the spark from the plug (from where the wave usually starts) and that there is a hot-spot on some distant point of the walls which becomes, in the presence of fresh gases, the origin of a second pressure wave - (of combustion) before the arrival of the one from the spark-plug, causing interference with the first. In modern reciprocating internal combustion engines the cylinder head is usually made of aluminium and cooled by a coolant circulating in passageways cast directly into the head.

The problem of cooling the head is particularly pressing in the case of high-performance two-stroke motorcycle engines which have high compression ratios and where there is a power stroke with each turn of the crankshaft. In such engines the head is usually cooled by extensive finning or by a cooling liquid which is circulated through the head by a pump or by a thermo-syphon effect caused by the temperature difference between the cylinder head and the radiator.

The main object of the present invention is to provide a cylinder head for reciprocating internal combustion engines, especially two-stroke or supercharged four-stroke ones, which permits greater dispersal of the heat produced by combustion for the same area of heat exchange.

This object is realized through the use of a cylinder head characterized by the fact that the wall separating the combustion chamber from the coolant is partly realized in copper or a copper alloy with a high thermal conductivity coefficient. It is noted that, given the high thermal conductivity of copper compared to aluminium, making the wall alone, which separates the coolant circulating in the head from the combustion chamber, from copper would reduce the temperature of the head itself considerably for the same area of heat exchange. This lowering of the temperature of the head has a beneficial effect on the regular functioning of the engine, as was said above, especially the low r.p.m., and allows high compression ratios to be used without the phenomenom of knocking. Or, for the same compression ratio, fuel with lower knock ratings can be used. More favourable operating temperatures are provided for the spark-plugs, which are always under considerable thermal stress. It is further possible, by adopting cooling liquids with higher boiling points than normal (oils with a boiling point of 180 °C), to have cooling cycles with higher thermal exchange temperatures, with consequent advantages in the amount of coolant needed to be circulated due to the greater difference in temperature between the coolant and the air flowing over the radiator. This is possible because the copper walls of the cylinder head allow higher temperatures in contact with the coolant for the same temperature of the combustion chamber.

Suppose, for the sake of simplicity, that the walls separating the coolant from the combustion chamber are flat, the rate of heat transfer would be linear:

$$Q = \frac{\lambda}{s} \cdot S(T1 - T2) \qquad (1)$$

Q = rate of heat transfer

λ = conductivity of the wall material

s = wall thickness

S = heat exchange area

T1 -T2 = temperature difference

T1 = internal wall temperature

T2 = external wall temperature

from (1)

$$(T1 - T2) = \frac{Q \cdot s}{S \cdot \lambda} \qquad (2)$$

$$T1 = \frac{Q \cdot s}{S \cdot /} + T2 \qquad (3)$$

$$T2 = T1 - \frac{Q \cdot s}{S \cdot \lambda} \qquad (4)$$

from (2) it can be seen that from the same walls of thickness "s" and heat exchange area of "S", with thermal conductivity of copper of "λ " almost twice that of aluminium, it is possible to remove heat at the same rate "Q" (heat that must be dispersed) from a temperature difference that is much less than before, almost half, in fact. From (3) it can be seen, for example, that for the same coolant and regulating the cooling to give the same wall temperature "T2 " in contact with the coolant, the internal temperature "T1" of the combustion chamber is lower.

Assuming the cooling system is regulated - (type of coolant, quantity, flow-rate, etc.) in such a way as to have "T1" (combustion chamber internal wall temperature) within the same acceptable limits, either with the traditional head or with a copper walled head, from (4) it can be seen that for the same values of "s" and "Q", the temperature "T2" of the wall in contact with the coolant is much higher (λ copper > λ aluminium). This allows all the heat exchange temperatures to be raised, which is advantageous because it allows the cooling system to be made lighter and more economical. Further, given that copper and aluminium have similar coefficients of expansion, an aluminium head can be made easily with a copper insert that forms at least part of the wall separating the combustion chamber from the coolant, be that water or air.

To check the validity of the invention, the cylinder head of a high performance two-stroke motorcycle engine cooled by water thermo-syphon, was modified by inserting a copper separating wall between the combustion chamber and the coolant.

Sensors were attached to the production head and to the modified head to record the temperature of the separating wall, the spark plug, and the coolant at the head outlet pipe.

The engine was tested with both heads in trials where the temperatures shown by the sensors were accurately recorded. The following table shows the maximum values recorded for the areas of the production and modified heads, for the same external conditions, and with the radiator respectively open and partly covered.

.Temperatures were revealed for the combustion chamber, the spark plug, and the coolant:

EXTERNAL TEMPERATURE 6°C, RADIATOR OPEN:

	combustion chamber 1mm from inner wall °C	sparking plug °C	coolant °C
Production Head	180	140	80
Modified Head	147	115	82

EXTERNAL TEMPERATURE 3-6°C, RADIATOR PARTLY COVERED:

	combustion chamber 1mm from inner wall °C	sparking plug °C	coolant °C
Production Head	183	142	106
Modified Head	157	128	101

As an analysis of the figures in the table will show, the utilization of a copper wall separating the combustion chamber from the coolant, without any other modification to the engine or the cooling system, reduces the temperature of the combustion chamber significantly .

The principal characteristics of the head according to the invention will be described in greater detail with reference to the accompanying drawings, in which:

Figure 1 is a sectional view of the cylinder head of a single-cylinder, pressurized water-cooled, two-stroke motorcycle engine;

Figure 2 is a sectional view of the cylinder head of a single-cylinder, thermo-syphon water-cooled, two-stroke motrocycle engine;

Figure 3 is a sectional view of the cylinder head of a single-cylinder , air-cooled, two-stroke motorcycle engine;

Figures 4 and 5 are sectional views of a four-stroke engine, and sections being through the two valves and spark plug respectively;

Figure 6 is a sectional view of a small single cylinder agricultural engine;

Figures 7 and 8 are partial cross-section view of another embodiment of the invention.

With reference to Fig. 1 first of all, 1 is the cylinder head of a single-cylinder, two-stroke motorcycle engine cooled by pressurized water. The head 1 is made of aluminium and presents a threaded central hole 2 for the spark plug and a number of holes 3 for the retaining bolts rising from the cylinder and fixed at their opposite ends into the crankcase of the engine. The parts of the head 1 turned towards the cylinder presents a circular concavity 4 comprising the upper part of the combustion chamber. Inside the head there are linked passageways 5 for the circulation of the cooling liquid which is circulated in the interior of the head, and then in the walls of the cylinder, and finally to a radiator by the action of a pump (not illustrated).

The walls of the head delimiting the upper part of the combustion chamber and separating the same chamber from the cooling fluid are made of copper or an alloy of copper with a high coefficient of heat conductivity. In greater detail, there is a copper insert 6 in the head which constitutes the upper part of the combustion chamber. Such insert 6 could be placed in the mould during the casting of the production head in aluminium and has raised rings 7 to ensure the cohesion of the insert and the aluminium casting.

In this way, a head is obtained identical to the production head except for the material constituting the wall separating the cooling liquid and the combustion chamber. The use of such a head on production engines would produce a significant reduction in the temperature of the combustion chamber, with the temperature of the cooling liquid almost unchanged.

With reference to Fig. 2, the cylinder head illustrated is that of a water-cooled, two-stroke motorcycle engine where the liquid circulates by thermo-syphon.

As in the head illustrated in the preceding figure, the head presents a central hole 20 for the spark plug, a number of holes 21 for the retaining bolts rising from the cylinder and passageways 22 for the circulation of the cooling liquid.

The passageways 22 are linked with a pipe 23 through which the hot cooling liquid, by a thermo-syphon effect, passes to the cooling radiator.

As in the head in the preceding figure, the wall separating the combustion chamber and the cooling liquid is made by placing a circular copper insert 24 in the mould during casing of the production head, the insert having raised rings 25 to ensure cohesion between the two materials.

In this way, a head is obtained identical to the production head except for the material constituting the wall separating the cooling liquid and the combustion chamber. The use of such a head with thermo-syphon cooling on production engines would produce a significant reduction in the temperature of the combustion chamber and a slight rise in the temperature of the coolant which would be converted into more rapid circulation of the same in the cooling circuit. As can be seen from the foregoing, using the described high heat conductivity head, it is possible to cool an engine which would require a pressurized cooling circuit with the conventional head, with the thermo-syphon system. It is obvious that the first solution has important weight and cost advantages.

With reference to Fig. 3, the cylinder head 30 is of a single-cylinder, air-cooled, two-stroke motorcycle engine.

As in the preceding figures, the wall separating the combustion chamber and the cooling fluid, in this case air, is made of copper by inserting an insert 31 in such material into the head mould.

Notwithstanding the advantages of the invention in the field of high performance two stroke motorcycle engines, it can also have advantageous applications in four stroke engines both in automobiles and motorcycles and, in general, for all internal combustion engines, (with regulated or spontaneous ignition), where there is a necessity to reduce the temperature of the internal walls of the combustion chamber or obtain advantages in the circuit and elements of the cooling system of the engine.

There are particular advantages in using heads with high heat conductivity inserts for the reduction of the temperature of the internal walls of the combustion chamber in supercharged engines where, apart from the knock problem, there is a general problem of overheating of all the parts moving or in contact with the combustion chamber, such as, for example, the crown of the piston, the inlet and exhaust valves, as well as the spark plugs.

Further, with respect to the conventional head in aluminium, those with a high heat conductivity insert can be manufactured in such a way as to allow the valves, in four stroke-engines, to be seated directly into the internal walls of the combustion chamber, without introducing special ring-seats in hard material as happens with the conventional head in aluminium.

In fact, it is possible to produce inserts in special alloys of copper which, apart from having high heat conductivity, are sufficiently hard when hot to withstand the wear imposed by the rapidly opening and closing valves.

From what has been said above, the seat itself would be at a lower temperature with consequent advantages in simplifying construction, machining, etc., and better functioning of the valve itself which would be working at a lower temperature.

Especially for supercharged engines there are particular avantages, if not only cylinder head inserts, but also cylinder liners in copper or high heat conductivity alloy are used. These liners could have a layer of some hard material electroplated onto the internal swept walls , as is already done on conventional aluminium liners.

In Figs. 4 and 5 a four-stroke head is shown. Also here, the insert in copper or copper alloy 40 is connected to the aluminium casting 41 by teeth and interpenetrating faces 42. It should be noted that the hole for the spark plug 43 in the insert and the valve seats 44 are machined directly in the insert itself without recourse to the customery seats in hard materials of the conventional head, indicated by the dotted line 45 in Fig. 4.

Moreover, the invention can be applied to engines for agriculture, for example, motor-saws, hedge-trimmers, in general small in size and widely used. Such motors must provide a high power/weight ratio while, for reasons of weight and size, the cooling systems are undersized (small ventilators, air passages, etc.). In these cases the engine is usually air-cooled and the cylinder and head are usually a single casting, as illustrated in Fig. 6. Here, too, it is possible to have the aluminium casting 50 with a copper insert 51 in the head area, to locally reduce the temperature under spark plug, for the same cooling conditions. One of the biggest problems with these engines is, in fact, the high temperatures reached near the spark plug.

Finally, said copper or copper allow insert 60 can be mechanically positioned after the casting of aluminium head 62, as shown in figures 7 and 8. Said head 62 is machined at the surfaces 64 and 66 and a pre-formed copper insert 60 is mounted by heat shrinkage or with the use of O-rings (68 and 70; fig. 8) in a high temperature rubber material. In this case, the insert 60 is kept in its operating position by a butting parts lying against the upper surface of cylinder 72 which is connected to the head by bolts 74, as usual.

Claims

1) A cylinder head (1, 30) for high-speed reciprocating internal combustion engines, with controlled or spontaneous ignition, characterized in that the head wall separating the combustion chamber and the cooling fluid is made, at least in part, of copper or an alloy of copper (6, 24, 31, 40, 51, 60) with high heat conducitivity coefficient.

2) A cylinder head according to Claim 1, characterized in that said wall in copper or in a high thermal conductivity allow is constituted by an insert (6, 24, 31, 40, 51, 60) partially sunk into the aluminium casting (1, 30, 41, 50) of the head.

3) A cylinder head according to Claim 2 characterized in that said insert in copper presents an essentially circular form with a diameter substantially equal to the cylinder liner and in that its outer surface presents one or more raised rings to achieve cohesion between the same insert and the rest of the head.

4) A cylinder head according to Claim 1, characterized in that said insert (60) in mechanically forced in the head aluminium casting (62) (fig. 7).

5) A cylinder head according to Claim 1, characterized in that said insert (60) is housed in a seat of the head aluminium casting (62) with the use of sealing O-rings (68, 70), and is kept in position by bolts (74) connnecting said head to its cylinder - (72) (fig.8).

6) A cylinder head according to any preceding claims, for four-stroke engines, characterized in that said high thermal conductivity wall is of an alloy of copper which is very hard when hot and in that the valves are seated directly in the same wall.

Fig. 1

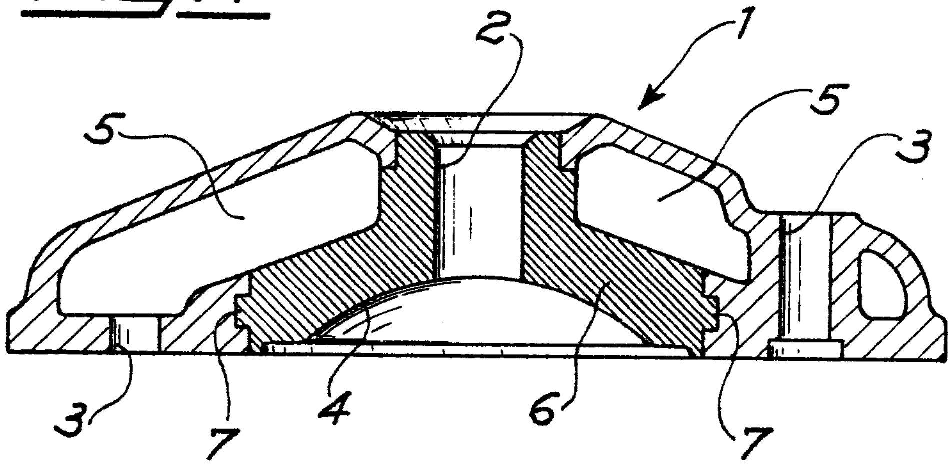


Fig. 2

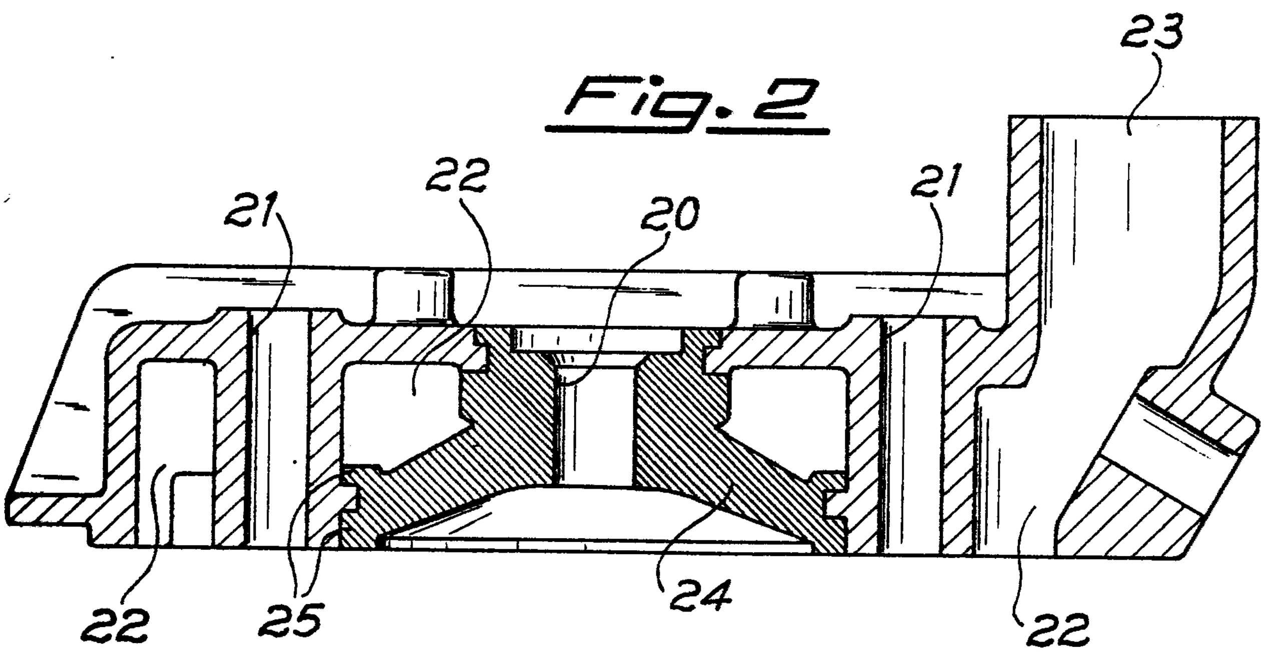


Fig. 3

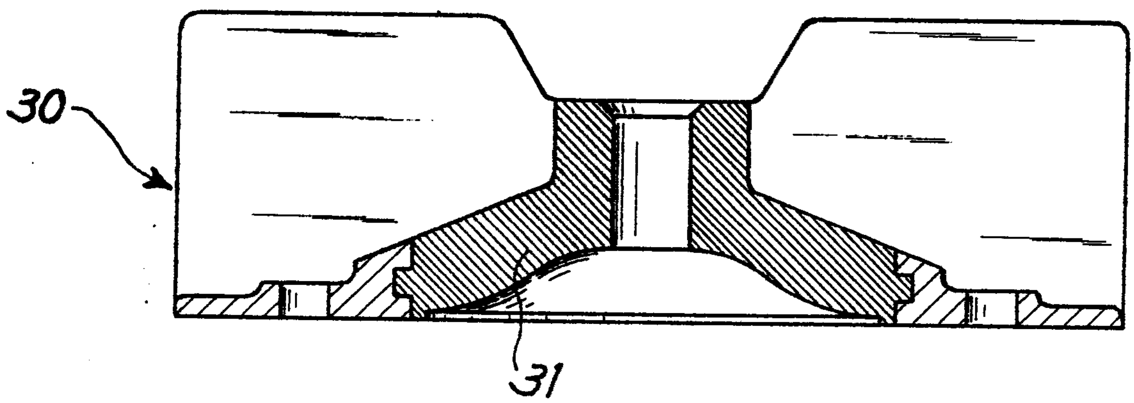


Fig. 4

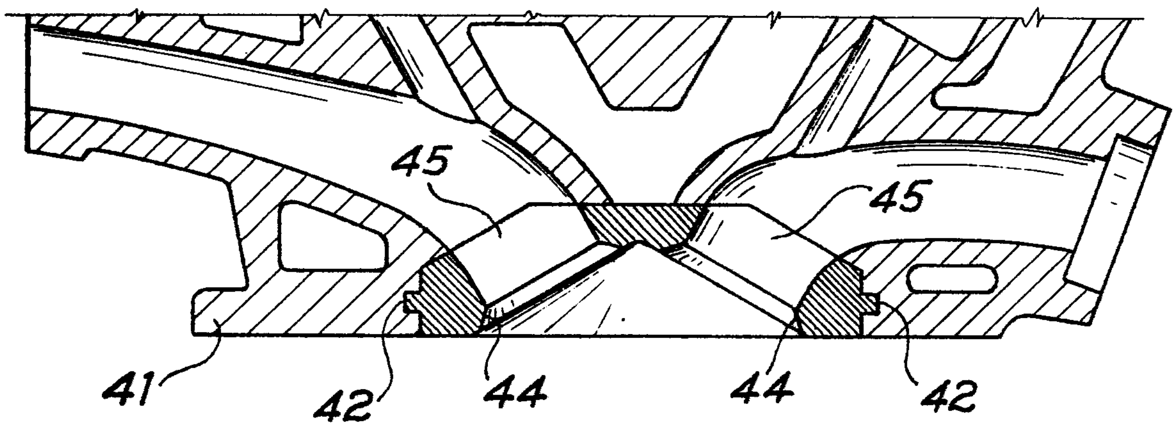
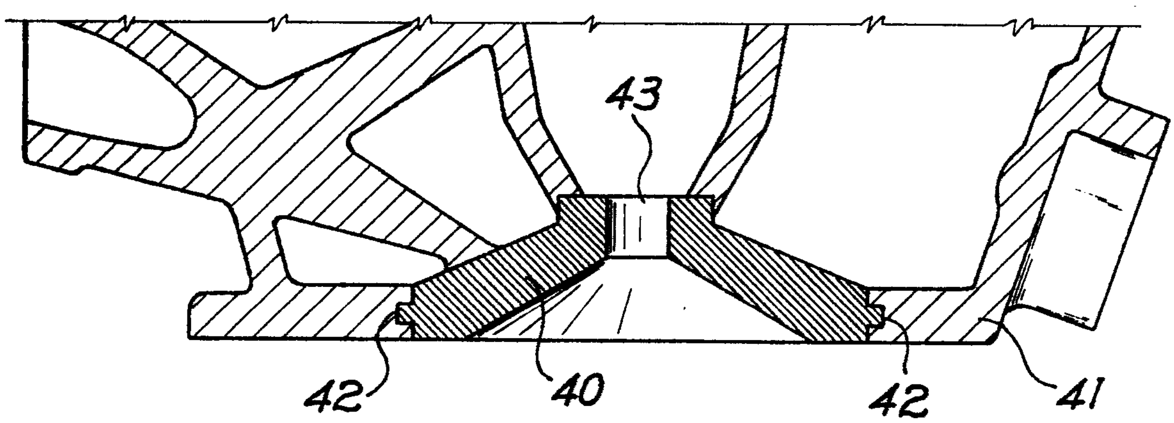


Fig. 5



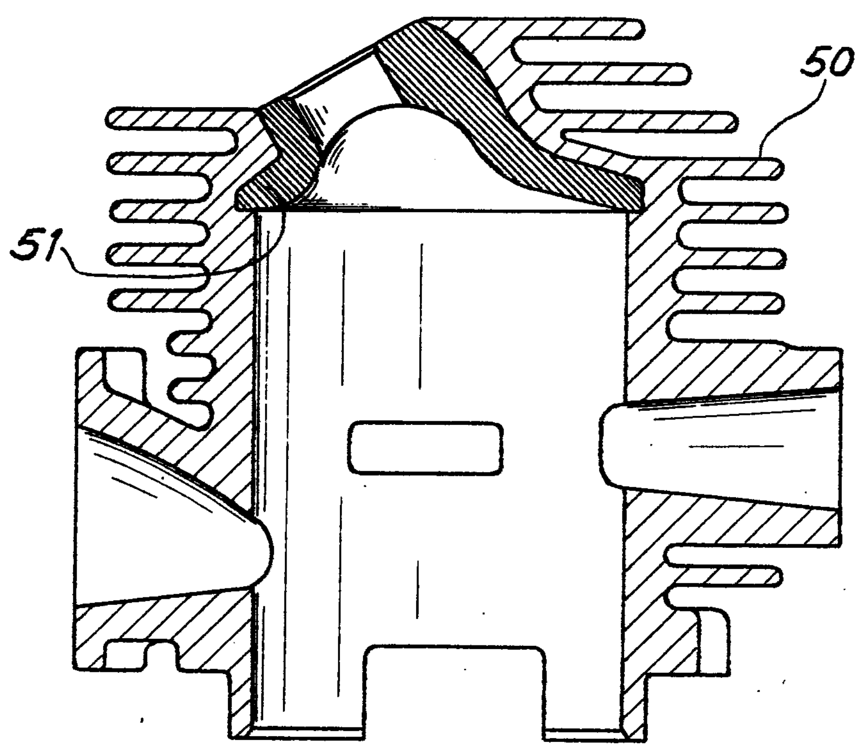


Fig. 6

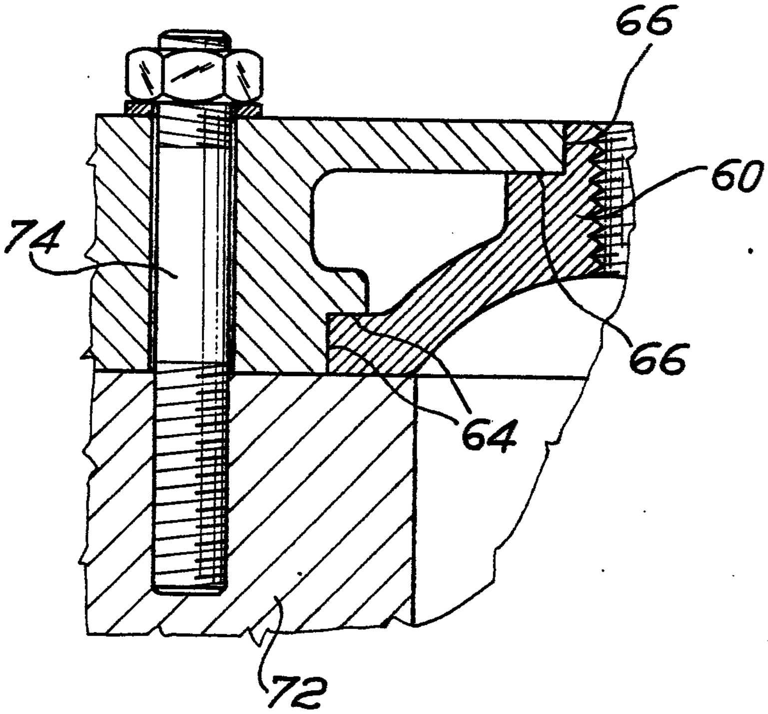


Fig. 7

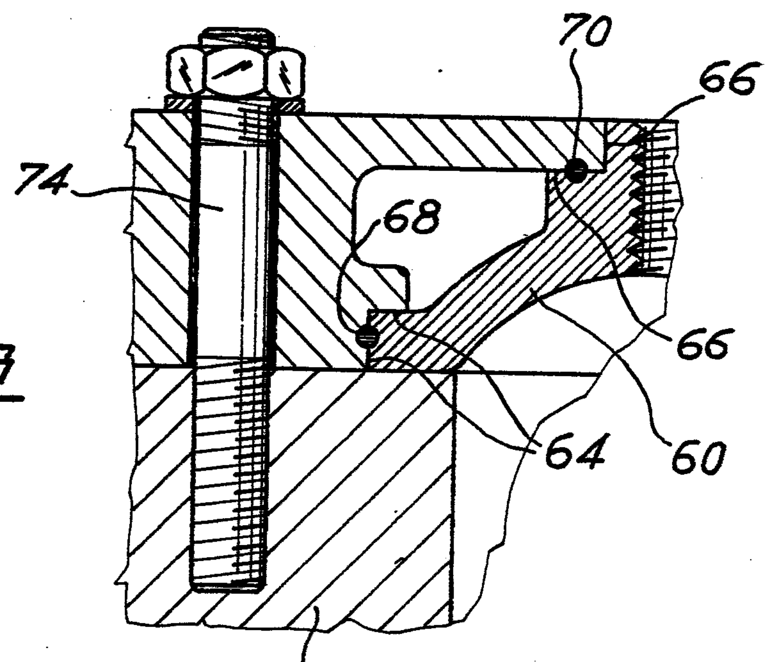


Fig. 8