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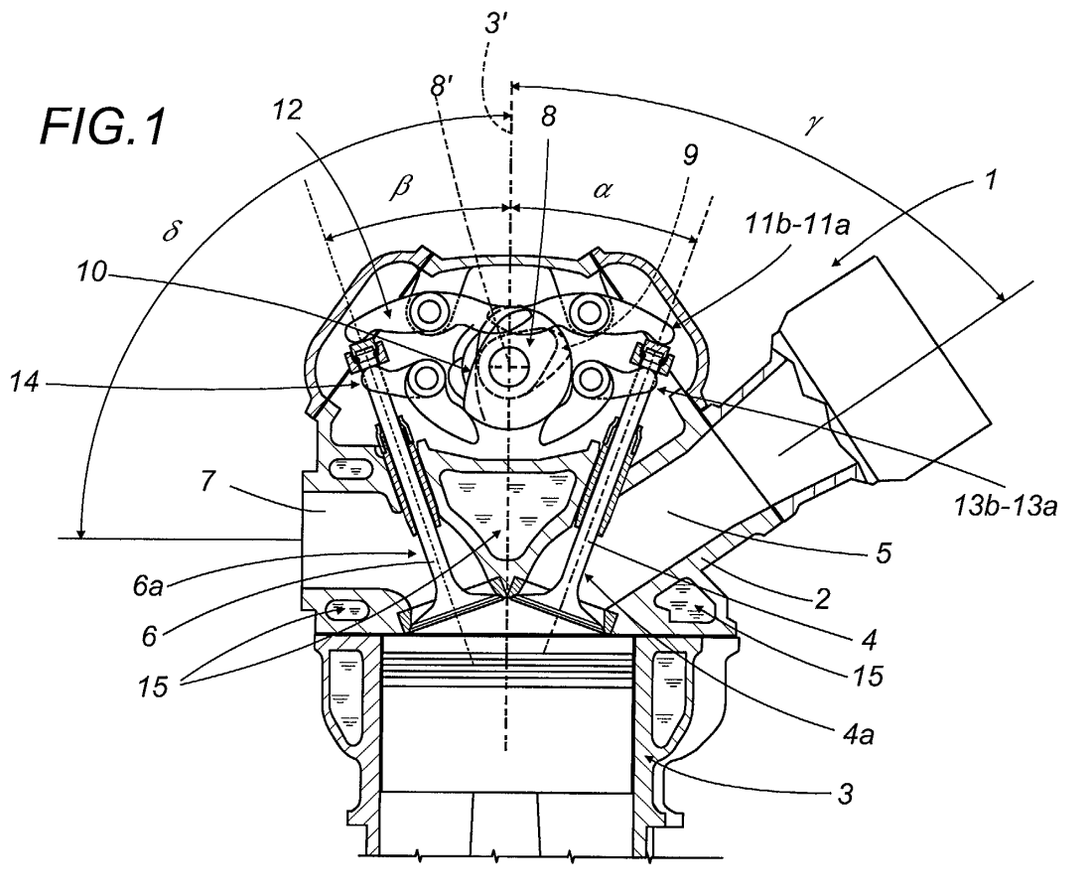
(54) A set of cylinder heads with desmodromic valve operation, for internal combustion engines

(57) In a set of heads (1) for the cylinders (3) of internal combustion engines with desmodromic valve operation, each head (1) comprises an assembly (4a) of one or two inlet valves (4), and an assembly (6a) of one or two exhaust valves (6), so as to form heads with two, three and four valves. The assembly (4a) of inlet valves is positioned at an angle to the assembly (6a) of exhaust valves. The two assemblies (4a, 6a) are actuated through respective rockers (11a, 11b, 12a, 12b) by a single camshaft (8) located substantially along the line running centrally between the two assemblies (4a, 6a). The inlet duct (5) and the exhaust duct (7) are located in the same position within the head (1) and have the same connections to the induction and exhaust systems in all the two-, three- and four-valve versions.

FIG.1



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Description

[0001] The present invention relates to a set of cylinder heads for internal combustion engines, operated by desmodromic valves, that is to say, valves with positive actuation for both opening and closing. The cylinder heads for internal combustion engines according to the present invention are applicable in particular to motorcycle engines with either air or liquid cooling, with a single camshaft and with two, three or four valves.

[0002] The present invention also relates to motorcycle engines equipped with the set of heads described herein. It relates in particular also to motorcycle engines with cylinders arranged in a V configuration at 90 degrees and equipped with the heads according to the present invention.

[0003] United States patent 4 754 728 discloses a four-valve cylinder head for a motorcycle engine with desmodromic valve operation, double camshaft and liquid cooling system.

[0004] Engines of this kind have excellent power characteristics but are expensive to construct, not only because of the double camshaft but also because of the desmodromic valve gear.

[0005] Moreover, since an engine is not always required to deliver the maximum power possible for its cylinder capacity, it is often preferable to use two- or three-valve heads, that is to say, cylinder heads with a single inlet valve and a single exhaust valve or with two inlet valves and a single exhaust valve.

[0006] The use of four desmodromically operated valves in air cooled cylinder heads does not permit adequate cooling because of the small size of the passages for the cooling air, and also in relation to the power that can be delivered by this type of valve timing system and hence, in relation to the heat developed by the head. In other words, the large area of the inlet and exhaust ports means that a four-valve desmodromic engine can be considerably charged and, if the engine is air-cooled the cylinder head will reach extremely high temperatures that can lead to permanent structural deformation and irreversible damage to the head.

[0007] For this reason, the use of four valves with desmodromic operation in air-cooled engines may not only be useless but also dangerous. The power levels that can be reached by an engine with this type of valve configuration lead to temperatures that the usual constructions used for air-cooled engines cannot support, thus giving rise to non-uniform deformation and, eventually, to breakage.

[0008] With desmodromic valve operation and air cooling, cylinder heads cannot have more than three valves (two inlet valves and one exhaust valve), whereas a liquid cooling system, because of its greater cooling capacity, gives more manoeuvring room for developing the power characteristics also of engines with four valves (two inlet valves and two exhaust valves).

[0009] The liquid-cooled version of a cylinder head can also be made with three valves because this configuration still constitutes a good compromise between economy of construction and the possibility of developing engine power, which may be further increased compared to air-cooled versions of three-valve cylinder heads, closely approaching the power level that can be obtained with a four-valve head.

[0010] The set of cylinder heads for internal combustion engines according to the present invention, being available with two, three or four valves, makes it possible to flexibly adapt engine power and, hence, the thermal level of the cylinder head, to the type of cooling, that is to say, air or liquid.

[0011] In particular, the three-valve version according to the present invention, with either air or liquid cooling, constitutes an optimal compromise between cooling capacity, deliverable power and economy of construction.

[0012] One of the problems of making a cylinder head in different versions, with two three or four valves, with either air or liquid cooling, is the positioning of the respective induction and exhaust systems and of the parts adjacent to the cylinder head itself. This is a particularly critical problem for motorcycle engines where the cylinders have a "V" configuration, especially those where the "V" is at 90 degrees, because these types of engine are relatively large and it is therefore difficult to fit the engine and engine accessories to the motorcycle frame.

[0013] Usually, the different internal configurations of different head versions require different positioning of the inlet and exhaust ducts and different connections for the respective induction and exhaust systems. The layout of these systems and the space they occupy must therefore be modified and adapted when a different cylinder head version is made. This is not always simple or even possible to do, and involves modifying the parts adjacent to the cylinder head and the connections of the induction and exhaust systems and, in some cases, even completely re-designing these parts.

[0014] The present invention therefore has for an object to provide a set of improved cylinder heads for internal combustion engines, where the positions of the inlet and exhaust ducts and the connections of the induction and exhaust systems are always the same for two-, three- and four-valve versions, whether air-cooled or liquid-cooled.

[0015] This facilitates mounting of the engine on the frame and means that the connections with the induction and exhaust systems do not have to be changed when the type of engine is changed, thus improving the flexibility of motorcycle production. Further, the versions with two, three or four valves and with liquid or air cooling allow the power level to be adapted to the type of engine required: engine more economical or more powerful.

[0016] According to one aspect of it, the present invention provides a set of cylinder heads for internal combustion engines with desmodromic valve operation, as described in the independent claim below. The dependent claims describe preferred, advantageous embodi-

ments of the invention.

[0017] Preferred embodiments of the invention will now be described, without restricting the scope of the inventive concept, with reference to the accompanying drawings in which:

- Figure 1 is a lateral cross section of a three-valve, liquid-cooled cylinder head forming part of the set of heads according to the present invention;
- Figure 2 is a partial cross section, with some parts cut away, of the engine cylinder head illustrated in Figure 1, showing the rocker arms for closing the valves;
- Figure 3 is a partial cross section, with some parts cut away, of the engine cylinder head illustrated in the previous figures, showing the rocker arms for opening the valves;
- Figure 4 is a lateral cross section of a three-valve, air-cooled cylinder head forming part of the set of heads according to the present invention;
- Figure 5 is a partial view of the combustion chamber of the cylinder head illustrated in Figure 4, showing the configuration of the valves;
- Figure 6 is a lateral cross section of a four-valve, liquid-cooled cylinder head forming part of the set of heads according to the present invention;
- Figure 7 is a partial view of the combustion chamber of the cylinder head illustrated in Figure 6, showing the configuration of the valves;
- Figure 8 is a partial cross section, with some parts cut away, of the engine cylinder head illustrated in Figures 6 and 7, showing the rocker arms for closing the valves;
- Figure 9 is a partial cross section, with some parts cut away, of the engine cylinder head illustrated in Figures 6 to 8, showing a first embodiment of the rocker arms for opening the valves;
- Figure 10 is a partial cross section, with some parts cut away, of the engine cylinder head illustrated in the previous figures, showing a second embodiment of the rocker arms for opening the valves;
- Figure 11 is a lateral cross section of a two-valve, air-cooled cylinder head forming part of the set of heads according to the present invention;
- Figure 12 is a partial view of the combustion chamber of the cylinder head illustrated in Figure 11, showing the configuration of the valves;
- Figure 13 is a partial cross section, with some parts cut away, of the engine cylinder head illustrated in Figures 11 and 12, showing the rocker arms for closing the valves; and
- Figure 14 is a partial cross section, with some parts cut away, of the engine cylinder head illustrated in Figures 11 to 13, showing the rocker arms for opening the valves.

[0018] With reference to the accompanying drawings as listed above, the numeral 1 denotes in its entirety a cylinder head forming part of the set of heads according the present invention. The head 1 comprises a block 2 which forms the combustion chamber of a cylinder 3. The block 2 an inlet valve assembly 4a comprising one or two inlet valves 4, with a respective inlet duct 5, and an exhaust valve assembly 6a comprising one or two exhaust valves 6, with a respective exhaust duct 7. When an assembly 4a or 6a has two valves, the valves are parallel to each other.

[0019] The inlet valve assembly 4a is positioned at an angle α of between 10 and 20 degrees to the axis 3' of the cylinder. Similarly, the exhaust valve assembly 6a is positioned at an angle β of between 10 and 20 degrees to the axis 3' of the cylinder. As a whole, the inlet and exhaust valve assemblies 4a, 6a make with each other an angle that may vary from 20 to 40 degrees. Preferably, the inlet and exhaust valve assemblies 4a and 6a are each positioned at an angle of 12 degrees to the axis 3' of the cylinder 3, thus making an angle of 24 degrees with each other.

[0020] These angles make it possible to strike an optimal compromise between a compact form of the combustion chamber, the curvature angle of the inlet and exhaust ducts close to the valves and the dimensions of the systems connected to the cylinder head.

[0021] The camshaft 8 is positioned substantially along the centreline half way between the valve assemblies 4a, 6a and comprises at least two cams 9a, 9b for opening the inlet and exhaust valve assemblies, and at least two cams 10a, 10b for closing the inlet and exhaust valve assemblies 4a, 6a.

[0022] Preferably, each inlet valve 4 and exhaust valve 6 is opened and closed by single actuating cams 9a, 9b, 10a, 10b through single rocker arms 11, 12 for opening, and single rockers arms 13, 14 for closing.

[0023] In other words, each valve opening and closing cam 9a, 9b, 10a, 10b actuates just one valve 4, 6 through a single rocker arm 11, 12, 13 , 14. This reduces the weight of the reciprocating parts of the valve timing system, thus allowing the engine to reach higher revolutions per minute.

[0024] With single rocker arms 11, 12 for valve opening, the centreline positioning of the camshaft 8 also enables the use of identical rocker arms 11, 12. Single rocker arms 13, 14 for closing the valves may also be identical.

[0025] Other advantageous characteristics of the valve timing system to obtain high revolutions per minute and low inertia are connected with the positioning of the camshaft 8 and of the rocking axes of the rocker arms.

[0026] The camshaft 8 is positioned in the head 3 with its axis 8' at a height corresponding to the ends of the stems of the valves 4, 6. The rocker arms 11, 12, 13, 14 can therefore be as short as possible, thus reducing their weight and moment of inertia to a minimum.

[0027] The rocking axis of the rocker arms 11, 12, 13, 14 is closer to the camshaft 8 than it is to the ends of

the stems of the valves 4, 6. Therefore, the lever arm of the rocker arms 11, 12, 13 , 14 on the cam side is shorter than the lever arm on the valve side. The ratio of the lever arm on the cam side to the lever arm on the valve side is between 0.5 and 0.8 and is preferably 0.8 for the opening rocker arms and 0.7 for the closing rocker arms.

[0028] Thanks to the favourable lever arm ratio of the rocker arms, the lift of the valves 4, 6 can be higher than the lift of the corresponding actuating cams and this reduces valve inertia as well as the overall dimensions of the cylinder heads.

[0029] The characteristics of each of the cylinder heads made according to the present will now be described.

[0030] Figures 1 to 3 illustrate the three-valve, liquid-cooled version and show the passages 15 for the cooling liquid. The inlet duct 5 is positioned at an angle γ to the cylinder axis 3', the angle γ being between 35 and 55 degrees, preferably 45 degrees.

[0031] Notice that the difference between the angle β of the inlet valve 6 and the angle γ of the inlet duct 5 is between 15 and 45 degrees, that is to say, a small difference. This permits a wide-angle connection between the inlet duct and the valve face and prevents the valve from obstructing the passage.

[0032] The angle of the exhaust duct 7 is greater than that of the inlet duct because the problem of obstruction is less likely since the exhaust gases are under relatively high pressure. Thus, the exhaust duct is positioned at an angle δ ranging from 80 to 100 degrees to the cylinder axis 3' the angle δ being preferably 90 degrees.

[0033] The angles α, β, γ, δ are the same for all the cylinder heads in the set according to the present invention, even in the two- and four-valve versions. Further, as mentioned above, the connections to the respective induction and exhaust systems are also the same for all the heads, both in terms of position and shape.

[0034] That means, for the three- and four valve versions of the cylinder heads, that the inlet duct 5 starts from two valve faces and merges into a single duct like the two-valve cylinder heads which has a single valve face. The exhaust duct, too, in the four-valve version, starts from two valve faces and merges into a single duct as in the two- and three-valve versions where it starts from a single valve face.

[0035] The above mentioned angles γ and δ of the inlet and exhaust ducts are especially advantageous for a V-shaped cylinder configuration with induction on the inside of the cylinders.

[0036] In particular, it is advantageous to have the inlet ducts positioned at an angle γ that is equal to half the angle between the cylinders. For example, with a preferred angle of 90 degrees between the cylinders, the angle γ of the inlet duct will be 45 degrees. This value for the angle γ constitutes an optimum compromise between the need to limit the dimensions of cylinder heads and the need to make inlet ducts as straight as possible.

[0037] Figure 2 is a partial cross section showing the two rocker arms 13a, 13b for closing the two inlet valves and the rocker arm 14 for closing the exhaust valve. The three valve closing rocker arms 13a, 13b, 14 are identical, thus reducing the costs of production and of spare parts.

[0038] Figure 3 is a partial cross section showing the two rocker arms 11a, 11b for opening the two inlet valves, and the rocker arm 12 for opening the exhaust valve. The valve opening rocker arms 11a, 11b, 12 are also identical to each other.

[0039] As shown in Figures 2 and 3, the camshaft 8 comprises three cams 10a, 10b, 10c for closing the valves 4, 6 and three cams 9a, 9b, 9c for opening the valves 4, 6. That is to say, each valve is actuated by a single cam.

[0040] Figure 4 illustrates the three-valve, air-cooled version. The illustration shows the air passages even between the inlet and exhaust valves helping to dissipate heat.

[0041] Figure 5 is a front view, with some parts cut away, of the combustion chamber, showing the positions of the valves and of the two spark plugs 16.

[0042] Owing to the centreline position of the camshaft 8, it is not possible to fit a single spark plug and, therefore, there are two spark plugs 16 also positioned along the centreline, inclined towards the exhaust valve and in such a way as not to interfere with the camshaft 8. The spark plugs 16 are oriented towards the exhaust valve 6 so that combustion starts in the hotter part of the combustion chamber first, thus eliminating the possibility of knocking, which, as is known, is more likely to occur in the hotter parts of the combustion chamber.

[0043] To reduce the typical combustion roughness of the double firing system, and to improve the smoothness of combustion, the two spark plugs 16 fire at different moments, with a small phase angle relative to the crank angle. To avoid creating hot areas in the cylinder head 2 and in the piston crown, each of the spark plugs 16 is cyclically alternated with the other in firing first.

[0044] The double firing system with different firing times for the two spark plugs also makes combustion more silent and experiments have shown that the noise produced by engines made in this way is 3 dB less than engines with simultaneous firing.

[0045] It should be noticed that a single exhaust valve with a single exhaust duct provides two major advantages.

[0046] The first advantage is effective cooling even in air-cooled versions because the single duct reduces the air screening effect in the parts around and behind the exhaust duct.

[0047] The second advantage is that the single exhaust duct, being substantially cylindrical in shape, keeps the exhaust gases hotter as they flow towards the exhaust system because its ratio of lateral surface area to area of passage cross section is smaller than that of two-valve configurations with two exhaust ducts.

[0048] The fact that the exhaust gases remain hot dur-

ing their passage to the exhaust system helps warm up the catalytic converter more quickly so that it can start treating the burnt gases sooner, thus reducing pollution. In other terms, with a configuration of this kind, having a single exhaust valve and single exhaust duct, the catalytic converter reaches its operating temperature more quickly.

[0049] Figures 6 to 10 show the four-valve, liquid-cooled version.

[0050] In this case, and as mentioned above, a configuration cooled only by liquid has been selected because it permits effective dissipation of heat.

[0051] The part of the combustion chamber on the induction side, with the inlet valves and ducts, is substantially the same as that in the three-valve version of the cylinder head.

[0052] On the exhaust side, there are two exhaust valves 6 and their respective exhaust ducts merge to form a single duct. Thus, besides having the same positions and the same exhaust system connections as the other cylinder heads in the set according to the invention (that is, those with two and three valves), it allows the exhaust gases to be kept at a higher temperature than versions with two separate exhaust ducts and this, as stated above, has the advantage of rapidly bringing the catalytic converter up to operating temperature.

[0053] Figure 8 illustrates a configuration of the single closing rocker arms 13a, 13b, 14a, 14b, each of which closes a single valve 4, 6 by means of a respective cam 10a, 10b, 10c, 10d.

[0054] Figures 9 and 10 illustrate two different embodiments of the configurations of the opening rocker arms.

[0055] Figure 9 shows a configuration with single opening rocker arms 11a, 11b, 12a, 12b, each of which opens a single valve 4, 6 by means of a cam 9a, 9b, 9c, 9d.

[0056] Figure 10 shows a configuration with two rocker arms 11 and 12, each of which simultaneously opens two valves 4, 6 through respective cams 9a, 9b.

[0057] The second embodiment, although it slightly increases the inertia of the valve timing gear, makes it possible to reduce the space occupied by the opening cams, since there are two less, which means that the camshaft 8 is shorter.

[0058] In another embodiment which is not illustrated, the valve closing rocker arms 13, 14 also simultaneously close two valves 4, 6 each through respective cams 10a, 10b. In this embodiment, the camshaft 8 is very similar to that of the two-valve version of the cylinder head as illustrated in Figures 13 and 14 and described below.

[0059] This four-valve version also has a double firing system to avoid interference between the camshaft 8 and the spark plugs 16.

[0060] Figures 11 to 14 illustrate the two-valve, air-cooled version of the cylinder head.

[0061] In this two-valve version, which is derived from the three-valve, air-cooled version described above, the part of the combustion chamber on the exhaust side, with the valve 6 and the exhaust duct 7, is substantially the same as the corresponding side of the cylinder head with three valves. On the induction side, there is just one inlet valve 4 and one inlet duct 5. In this version, too, the positions and connections for the induction and exhaust systems are the same as in the other cylinder heads of the present set (with three and four valves).

[0062] As shown in Figures 13 and 14, the valves 4, 6 are opened and closed by respective rocker arms 11, 12, 13, 14 actuated by single cams 9a, 9b, 10a 10b.

[0063] In this case, the camshaft 8 has only four cams (two for opening and two for closing), and is therefore relatively short. For this reason, only one spark plug 16, located in a substantially central position, is used.

[0064] The invention has important advantages.

[0065] Thanks to their modular structure, the cylinder heads in the set according to the present invention are economical to make. Indeed, the part of the three-valve head on the exhaust side, is substantially the same as the corresponding part of the two valve head in the set, while the part of it on the induction side is substantially the same as the corresponding part of the four-valve head. The rocker arms that actuate the valves are the same in the respective opening rocker arm assembly and in the closing rocker arm assembly. Moreover, the opening and closing rocker arms may be the same for the different cylinder head versions with two, three and four valves.

[0066] The lever ratio of the rocker arms is such as to reduce the inertia of the valve timing gear and the overall dimensions of the cylinder heads. The single camshaft design makes for compact heads and low production costs.

[0067] The structure of the heads according to the present invention, with inlet and exhaust ducts in the same position, and with the same connections to the respective exhaust and induction systems, greatly simplifies the design of these systems and of the parts adjacent to the engine, and is very convenient for V engines, especially engines in which the V configuration is at 90 degrees, because it facilitates the mounting of the engine on the frame.

[0068] The fact that there is a single exhaust duct and, in the two- and three-valve versions, a single exhaust valve, is advantageous to reduce exhaust emissions because the exhaust gases are kept at a higher temperature, thus allowing the catalytic converter to reach operating temperature more quickly.

[0069] The double firing system igniting the spark plugs at different moments relative to the crank angle makes the engine run more silently than engines with simultaneous firing system.

Key

[0070]

1 engine cylinder head

2 cylinder head block
3 cylinder
3' cylinder axis
4 inlet valve
4a inlet valve assembly
5 inlet duct
6 exhaust valve
6a exhaust valve assembly
7 exhaust duct
8 camshaft
8' camshaft axis
9a, 9b, 9c, 9d opening cams (induction, exhaust)
10a, 10b, 10c, 10d closing cams (induction, exhaust)
11, 11a, 11b rockers for opening inlet valve
12, 12a, 12b rockers for opening exhaust valve
13, 13a, 13b rockers for closing inlet valve
14, 14a, 14b rockers for closing exhaust valve
15 passages for cooling liquid
16 spark plugs

Claims

1. A set of cylinder heads with desmodromic valve operation, for internal combustion engines, each head (1) being applicable to a cylinder (3) with an axis (3'), and comprising an assembly (4a) of one or two inlet valves (4) and an assembly (6a) of one or two exhaust valves (6) so as to form a set of heads with two, three and four valves, the assembly (4a) of inlet valves being positioned at an angle to the assembly (6a) of exhaust valves, a single camshaft (8) located substantially along the line running centrally between the two inlet and exhaust valve assemblies (4a, 6a), each inlet valve (4) and each exhaust valve (6) being opened by a respective rocker arm (11a, 11b, 12a, 12b) actuated by an opening cam (9), and closed by a respective rocker arm (13a, 13b, 14a, 14b) actuated by a closing cam (10), an inlet duct (5) connected to the inlet valves (4) and an exhaust duct (7) connected to the exhaust valve (6), the inlet duct (5) and the exhaust duct (7) being located on opposite sides of the centreline and having connections to the respective induction and exhaust systems,
the set of cylinder heads being **characterised in that** the inlet duct (5) and the exhaust duct (7) of each head (1) are located in the same position within the head (1) itself and have the same connections to the induction and exhaust systems in all the versions with two, three and four valves.

2. The set of cylinder heads (1) for internal combustion engines according to claim 1, **characterised in that** the inlet duct (5) is positioned at an angle (γ) of between 35 and 55 degrees to the cylinder axis (3').

3. The set of cylinder heads (1) for internal combustion engines according to claim 1 or 2, **characterised in that** the exhaust duct (7) is positioned at an angle (δ) of between 80 and 100 degrees to the cylinder axis (3').

4. The set of cylinder heads (1) for internal combustion engines according to any of the foregoing claims, **characterised in that** the inlet valve assembly (4a) is positioned at an angle (α) of between 10 and 20 degrees to the cylinder axis (3').

5. The set of cylinder heads (1) for internal combustion engines according to any of the foregoing claims, **characterised in that** the exhaust valve assembly (6a) is positioned at an angle (β) of between 10 and 20 degrees to the cylinder axis (3').

6. A cylinder head (1) for internal combustion engines according to any of the foregoing claims, **characterised in that** it comprises two inlet valves (4) and one exhaust valve (6).

7. The cylinder head (1) for internal combustion engines according to any of the foregoing claims from 1 to 5, **characterised in that** it comprises two inlet valves (4) and two exhaust valves (6).

8. The cylinder head (1) for internal combustion engines according to any of the foregoing claims from 1 to 5, **characterised in that** it comprises one inlet valve (4) and one exhaust valve (6).

9. The set of cylinder heads (1) for internal combustion engines according to any of the foregoing claims, **characterised in that** it comprises two spark plugs (16).

10. The set of cylinder heads (1) for internal combustion engines according to claim 9, **characterised in that** the two spark plugs (16) fire at different moments, with a small phase angle relative to the crank angle, and **in that** each of the spark plugs (16) is cyclically alternated with the other in firing first.

11. A motorcycle engine equipped with a cylinder head (1) forming part of the set of cylinder heads according to any of the foregoing claims.

12. The motorcycle engine according to claim 11, **characterised in that** it comprises two cylinders arranged in a V configuration of 90 degrees.

FIG.1

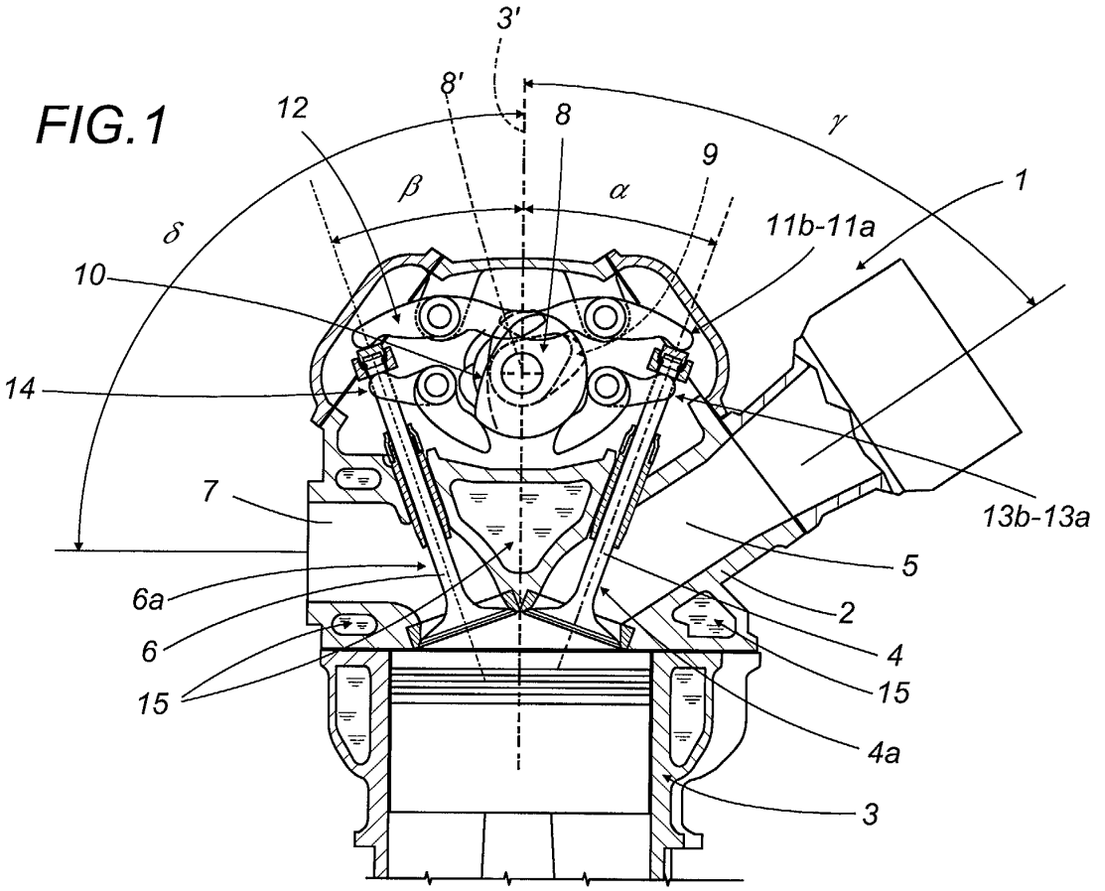


FIG.2

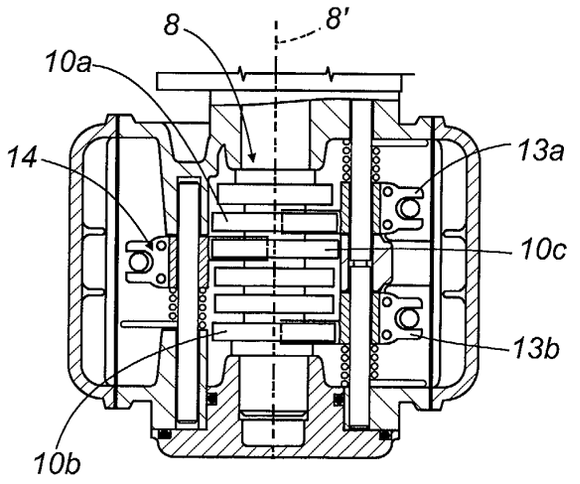


FIG.3

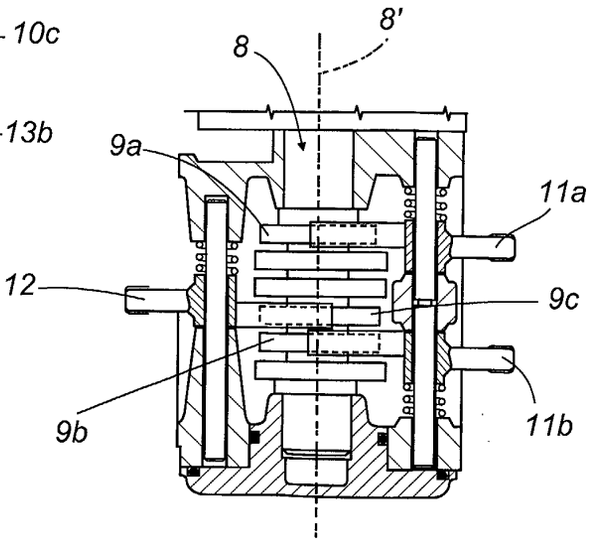


FIG.4

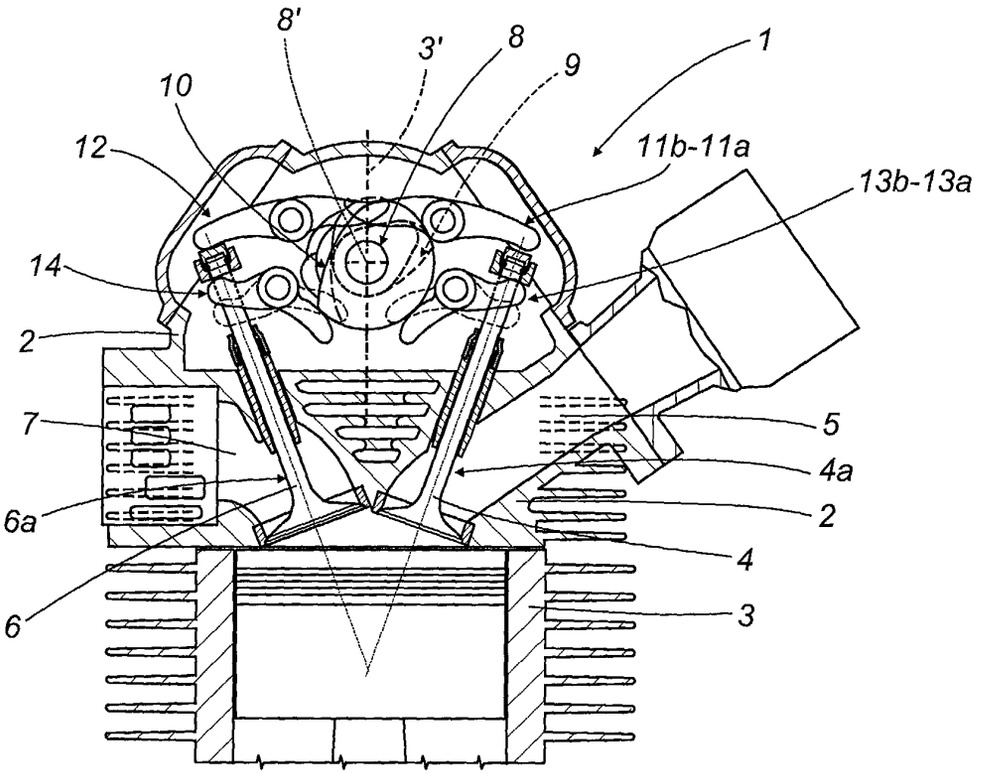


FIG.5

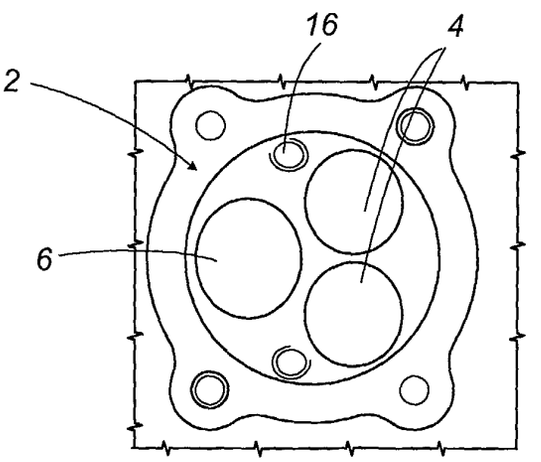
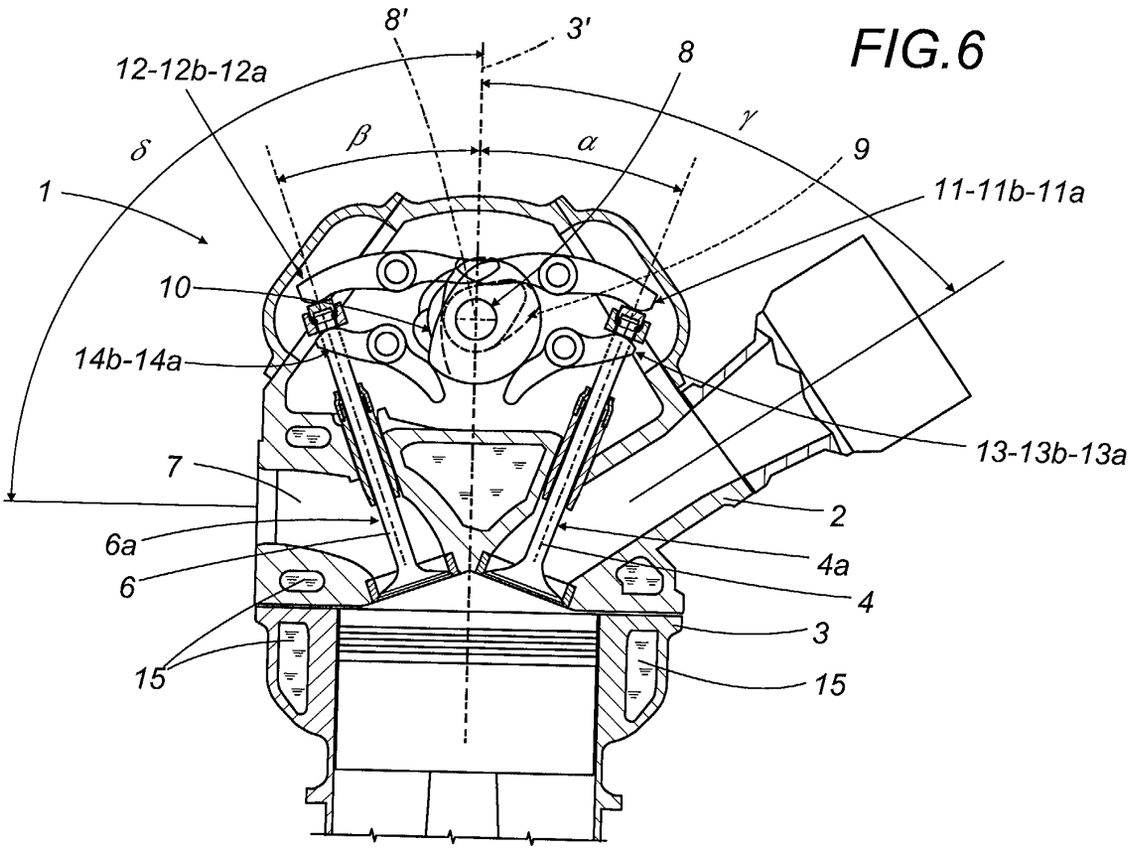


FIG.6


8'
3'
8
12-12b-12a
δ
β
α
γ
9
1
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7
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6a
4a
6
4
3
15
15

FIG.7

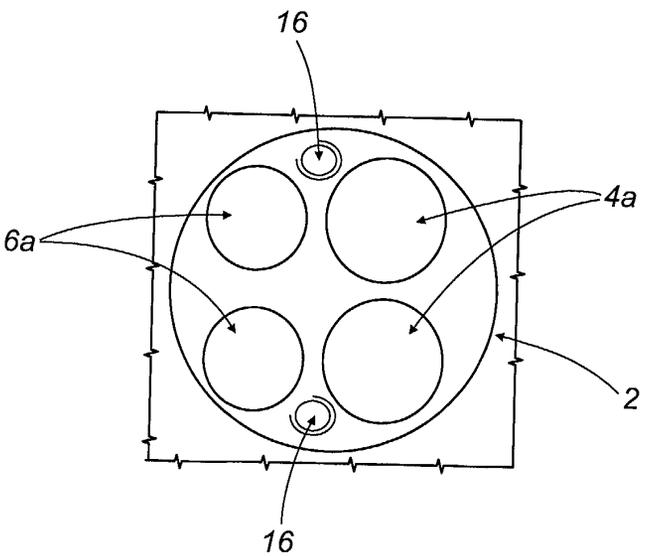

16
4a
6a
2
16

FIG.8

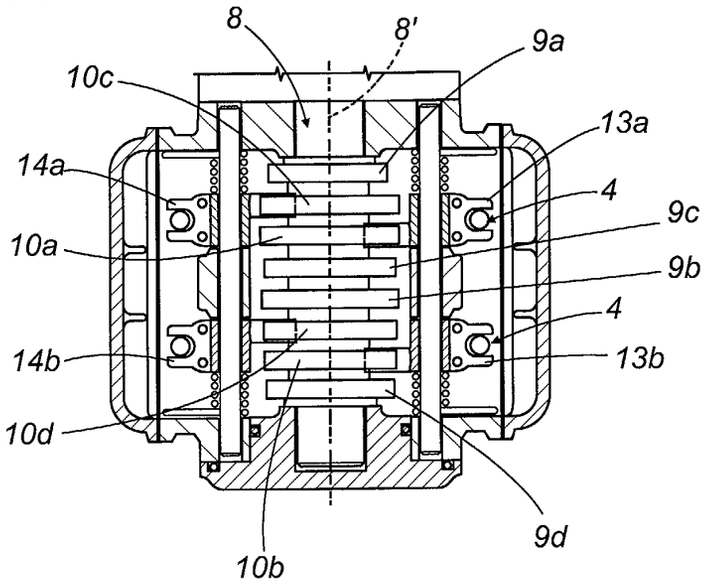


FIG.9

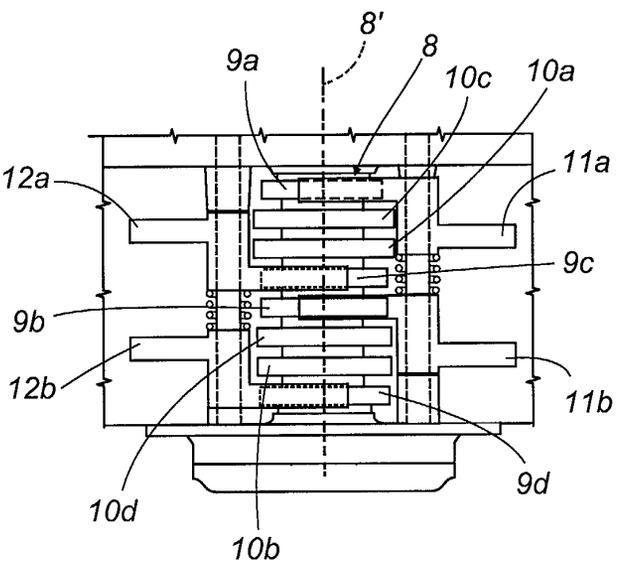


FIG.10

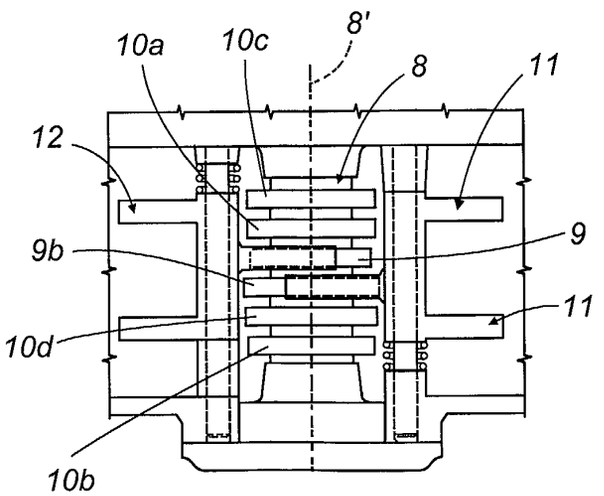


FIG.11

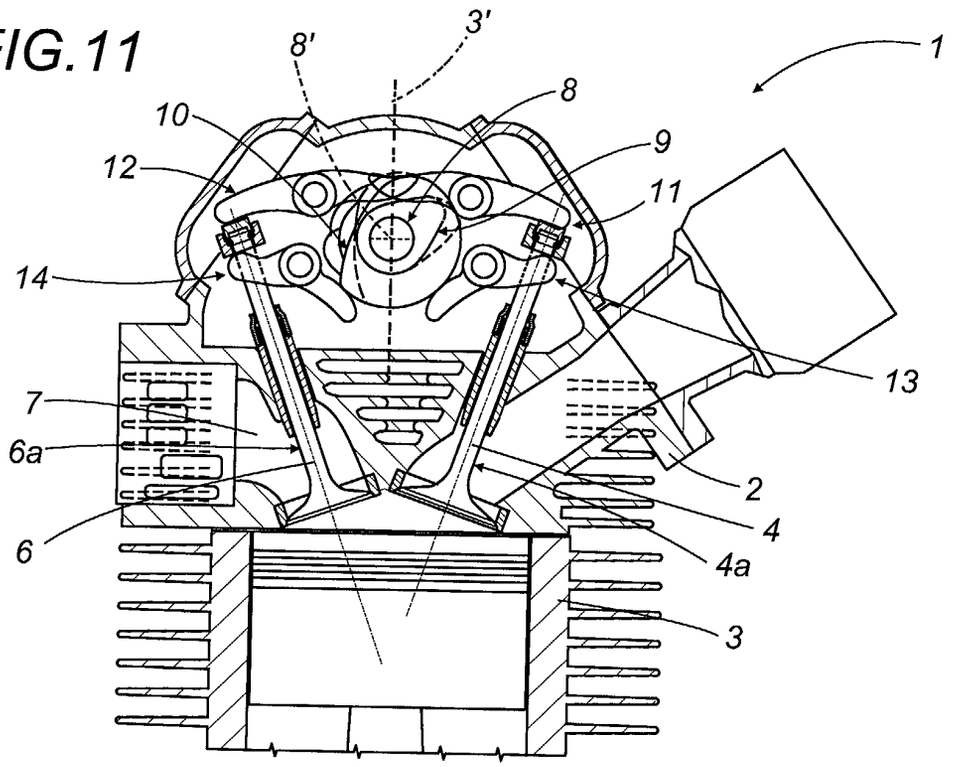


FIG.12

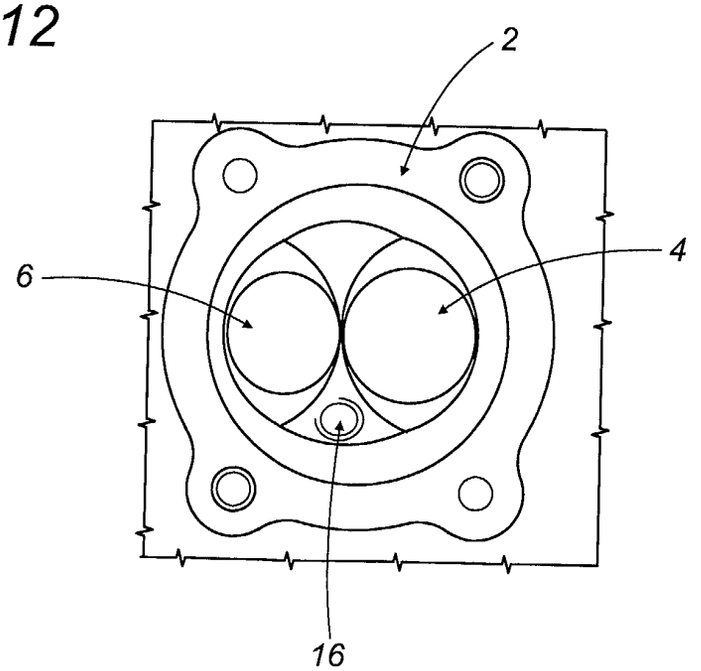


FIG.13

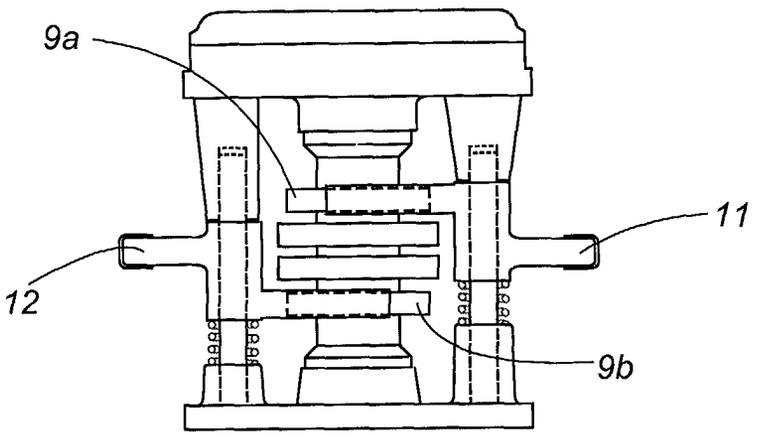
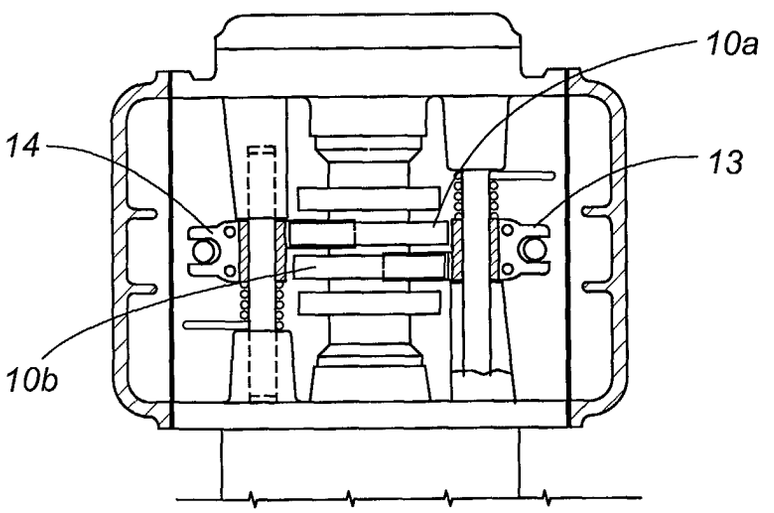


FIG.14



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Application Number
EP 01 83 0479

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A	US 4 754 728 A (BORDI MASSIMO ET AL) 5 July 1988 (1988-07-05) * figure 1 *	1-12	F01L1/30
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A	DE 42 15 053 A (AUDI NSU AUTO UNION AG) 11 November 1993 (1993-11-11) * figure 1 *	1-12	

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F01L
F02F
F01B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	3 December 2001	Paulson, B

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