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(54) **Valve assembly.**

(57) A valve assembly (10) for regulating air flow to an internal combustion engine comprises a valve body (12) having a valve bore (14) forming an induction passage, and a shaft (16) extending across the valve bore. A valve member (18) having a chamfered peripheral edge (24) is secured to the shaft for rotation in excess of 90 degrees between a non-actuating position and a maximum actuating position. A return mechanism (26) urges the valve member toward the non-actuating position when the valve member is rotated away from the non-actuating position.

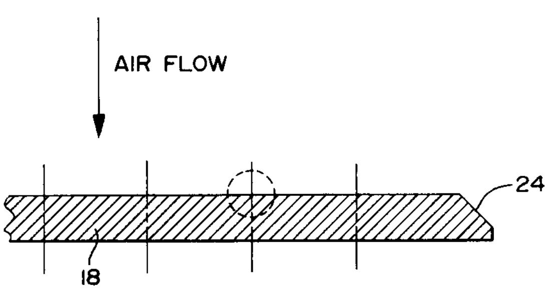

FIG 4

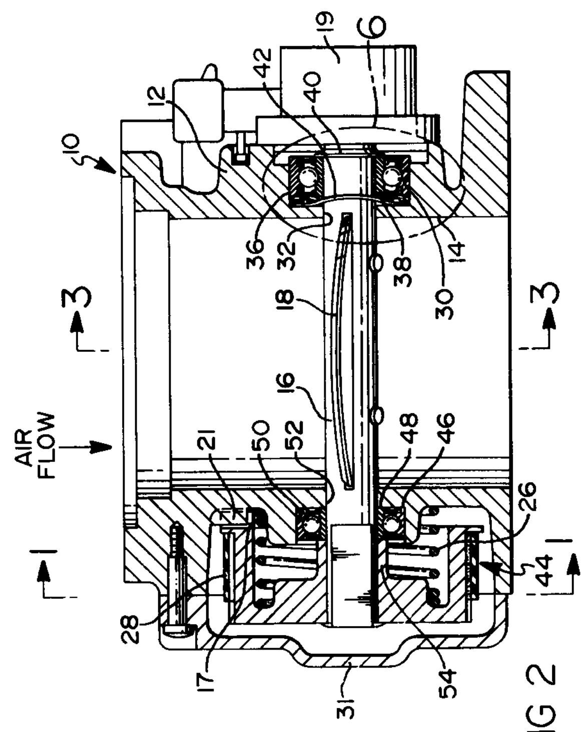

FIG 2

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This invention relates to a valve assembly for regulating the air flow to an internal combustion engine. More particularly, the invention relates to a valve assembly for an electronic throttle control system for an internal combustion engine.

Electronic throttle control systems for internal combustion engines frequently utilize a rotatable valve member disposed in an engine air induction passage to regulate the air flow through the passage. The valve member can be a throttle valve which is positioned by an operator by way of a motor and shaft to control air flow to the internal combustion engine. Air flow to the internal combustion engine varies as a function of the air flow area around the valve member.

The air flow valve area around the valve member is geometrically related to the angular position of the valve member. In many valve assemblies, the change in air flow area around the valve member is substantial when the valve member is near its minimum air flow position. This can decrease control of the air flow to the internal combustion engine during low load conditions. Also, the air flow around the valve member when the motor is not actuated can be sufficiently restricted to prevent the internal combustion engine from producing enough power to idle or drive the vehicle.

Moreover, in some valve assemblies, an axial load on the shaft can cause the throttle valve to scrape on its bore. The wear which can result tends to admit more air flow though the valve body than was originally calibrated. This can allow increased air flow around the valve member, which can be relatively substantial when the valve member is near its minimum air flow position. This can further decrease control of the air flow to the internal combustion engine during low load conditions. Mechanisms to control endplay of the shafts are known, but many are difficult to assemble to the valve body. Examples of the prior art can be found in US Patent Nos. 4462358, 4474150 and 4860706.

A valve assembly in accordance with the present invention is characterised over US Patent No. 4474150 by the features specified in the characterising portion of claim 1.

The present invention provides a valve assembly for regulating air flow to an internal combustion engine comprising a valve body having a valve bore forming an induction passage, and a shaft extending across the valve bore. A valve member having a peripheral edge which is chamfered secured to the shaft for rotation in excess of 90 degrees between a non-actuating position and a maximum actuating position. A return mechanism urges the valve member toward the non-actuating position when the valve member is rotated away from the non-actuating position.

The shaft may extend through a ball bearing disposed in a shaft socket. In this case, a spring washer is disposed between the ball bearing and the shaft socket to resist displacement of the outer race of the ball bearing toward the valve bore; and a thrust collar is secured to the end of the shaft to resist displacement of the inner race of the ball bearing away from the valve bore.

The rotation of the valve member in excess of 90 degrees enables a relatively low change in air flow around the valve member when the valve member is rotated between the positions at which the minimum air flow is produced, thereby facilitating control of the air flow at low engine loads. The chamfered peripheral edge reduces sharp changes in the air flow as the valve member approaches and moves away from the wall of the valve bore during decreases and increases in the air flow, respectively. The engagement of the ball bearing with the shaft and the valve body limits axial float or displacement of the shaft with respect to the bore.

The present invention will now be described by way of example, with reference to the following description of a specific embodiment of the invention taken together with the accompanying drawings, in which:-

Figure 1 is an elevational view of the valve assembly of the present invention;

Figure 2 is a sectional elevational view of the valve assembly on the line 2-2 of Figure 1;

Figure 3 is a schematic view through the valve assembly generally in the plane indicated by line 3-3 of Figure 2;

Figure 4 is an enlarged view of the portion of Figure 3 circled by line 4 showing the chamfer at the peripheral edge of the valve member;

Figure 5 is a graph showing the flow area allowed by the valve assembly of Figure 1 for various angles of the valve member and for various thicknesses of the peripheral edge of the valve member; and

Figure 6 is an enlarged view of the portion of Figure 2 circled by line 6 showing one of the ball bearings which limits end play.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

Referring now to the drawings in detail, numeral 10 generally indicates a valve assembly of the present invention for regulating air flow to an internal combustion engine. The valve assembly 10 comprises a valve body 12 having a valve bore 14 forming an induction passage for air flow to an internal combustion engine (not shown) with the valve bore having a generally circular cross section of substantially uniform diameter. A shaft 16 has opposite ends which are journalled for rotation in the valve body 12. The shaft 16 extends across the valve bore 14.

A (flat butterfly) valve member 18 is secured to the shaft 16 for rotation between a non-actuating position, indicated in phantom by numeral 20, and a maximum actuating position, indicated in phantom by numeral 22. The valve member 18 allows the maximum air flow when in the maximum actuating position 22. The valve member 18 is typically parallel to the axis of the valve bore 14 when in the maximum actuating position 22. The valve member 18 is rotated approximately 95 degrees between the maximum actuating position 22 and the non-actuating position 20. The rotation of the valve member 18 between the maximum actuating position 22 and the non-actuating position 20 enables control of the air flow through the valve bore 14. The non-actuating position 20 can be defined by engagement of a shaft boss 17 with a non-actuating stop 21 fixed to the valve body 12. The shaft boss 17 is fixed to a pulley which is fixed to the shaft 16. Similarly, the maximum actuating position 22 can be defined by engagement of the shaft boss 17 with an actuating stop 23 fixed to the valve body 12.

An actuator includes a toothed timing belt 28 which wraps around a correspondingly toothed pulley which is connected to the shaft 16 to produce rotation of the valve member 18. The actuator includes a motor 29 having a toothed pulley which the timing belt 28 also wraps around. The motor 29 rotates its pulley to cause displacement of the timing belt 28 to rotate the valve member 18. An adjustable tensioner can enable adjustment in the distance between the shaft 16 and motor shaft to adjust the tension in the timing belt 28.

The valve member 18, shown in Figure 3, has a peripheral edge 24 which is chamfered, wherein, when the valve member is rotated away from the maximum actuating position 22, the upstream side of the valve member is inclined toward the peripheral edge. The thickness of the valve member 18 thereby decreases in the radial direction toward the peripheral edge 24.

A return means 26, such as a single coil torsional spring, acts on the valve member 18 when the valve member is rotated away from the non-actuating position 20 to urge the valve member toward the non-actuating position.

Figure 5 is a graph showing the flow area of the valve assembly 10 for various angles of the valve member 18 and for various thicknesses of the peripheral edge 24. The graph is based on theoretical calculations. The flow area is the area of the space between the valve member 18 and the valve bore 14 perpendicular to the axis of the valve bore. Flow area is generally proportional to air flow. The variations in thickness of the peripheral edge 24 are produced by varying degrees of thickness reduction produced by the chamfer in the peripheral edge 24. The 0 degree position corresponds to the valve member 18 being in a plane perpendicular to the axis of the valve bore 14.

Figure 5 illustrates the value of the (chamfered) peripheral edge 24 since it results in a gradual change in flow area produced by oscillation of the valve member 18 in the region wherein the flow area is minimum. This improves control of the internal combustion engine at low loads since small oscillations of the valve member 18, when it is in the positions wherein the flow area is minimum, do not substantially affect engine output. The (chamfered) peripheral edge 24 enables these control improvements while also allowing the valve member 18 to be sufficiently thick for strength requirements. The valve member 18 is preferably 2 mm thick, with the chamfer producing a peripheral edge having a thickness of 0.5 mm.

Figure 5 also illustrates the capability of the valve assembly 10 to allow engine operation if the motor 29 does not actuate the valve member 18 since under such conditions, the valve member will be urged by the return means 26 to rotate the valve member to the non-actuating position 20. When the valve member 18 is in the non-actuating position 20 (that is, rotated approximately 5 degrees beyond the 0 degree position away from the maximum actuating position 22), the flow area is sufficient to allow sufficient air to flow to the internal combustion engine to allow it to produce sufficient output to idle or drive the vehicle.

Another advantage of the valve assembly 10 is that the shaft boss 17 is away from the non-actuating stop 21 when the valve member 18 is in the position wherein the flow area is minimum which is typically the position of the valve member when the internal combustion engine is idling. This reduces the likelihood of the shaft boss 17 contacting the non-actuating stop 21 when the internal combustion engine is idling.

The valve assembly 10 also includes a shaft socket 30 connected to the valve body 12 externally thereof. The shaft socket 30 has an axis which intersects the centre of the valve bore 14 and which is perpendicular to the valve bore. The shaft socket 30 has a socket opening 32 enabling one end of the shaft 16 to extend into the shaft socket.

A ball bearing having outer race 36 and an inner race 38 is disposed in the shaft socket 30 so that the one end of the shaft 16 extends through the inner race 38. The inner race 38 has an inner diameter which is sized to establish a clearance between the inner race 38 and shaft 16. The outer race 36 has an outer diameter which is sized to establish a clearance between the outer race and shaft socket 30.

A thrust collar 40 is secured to the shaft 16, by a press fit, to prevent displacement of the inner race 38 along the axis of the shaft away from the valve bore 14. A resilient washer 42 is disposed between the outer race 36 and shaft socket 30 to resist displacement of the outer race toward the valve bore 14 along the axis of the shaft 16.

A bearing means 44 is provided between the valve body 12 and the other end of the shaft 16. The bearing means 44 is adapted to urge the other end of the shaft 16 away from the valve bore 14 along the axis of the shaft to limit axial end float of the shaft.

The bearing means 44 comprises a ball bearing having an outer race 46 and an inner race 48 with the other end of the shaft 16 extending through the inner race 48. The inner race 48 has an inner diameter which is sized to establish a clearance between the inner race 48 and shaft 16. The bearing means 44 further comprises a bearing seat 50 connected to the valve body 12 externally thereof. The bearing seat 50 has a seat opening 52 through which the other end of the shaft 16 extends. The outer race 46 is disposed on the bearing seat 50 so that axial displacement of the outer race 46 along the shaft toward the valve bore 14 is obstructed. The bearing means 44 also includes a thrust retainer 54 engaging the inner race 48 to urge the inner race 48 toward the valve bore 14 along the axis of the shaft 16.

Axial float of the shaft 16 with respect to the valve bore 14 is limited by the thrust collar 40 and bearing means 44 which limit displacement of the shaft 16 inward toward the valve bore 14 along the axis of the shaft, with the resilient washer 42 maintaining a selected clearance between the valve member 18 and valve bore 14. The urging of the shaft 16 by the resilient washer 42 and bearing means 44 also reduces axial play between the outer and inner races 36, 38, and between the outer and inner races 46, 48. The resilient washer 42 can also deflect to maintain the selected clearance if temperature changes produce different thermal expansions of the shaft 16 and valve body 12.

Claims

1. A valve assembly (10) for regulating air flow to an internal combustion engine, the valve assembly comprising a valve body (12) having a valve bore (14) forming an induction passage for air flow to the internal combustion engine; a shaft (16) having opposite ends which are journalled for rotation in the valve body, the shaft extending across the valve bore; a valve member (18) of the flat butterfly type, the valve member being secured to the shaft for rotation between a non-actuating position (20) and a maximum actuating position (22) to control air flow through the valve bore, the valve member allowing the maximum air flow when in the maximum actuating position, the valve member being rotated through an angle in excess of 90 degrees from the maximum actuating position when in the non-actuating position; characterised in that the valve bore has a generally circular cross section; in that the valve member has a peripheral edge (24) which is chamfered; and by a return means (26) adapted to urge the valve member toward the non-actuating position when the valve member is rotated away from the non-actuating position.

2. A valve assembly as claimed in claim 1, comprising a shaft socket (30) connected to the valve body (12) externally thereof, the shaft socket having an axis intersecting the centre of the valve bore (14) and being perpendicular to the valve bore, the shaft socket having a shaft socket opening (32) enabling one end of the shaft (16) to extend into the shaft socket; a ball bearing having an outer race (36) and an inner race (38) disposed in the shaft socket so that the one end of the shaft extends through the inner race, the inner race having an inner diameter being sized to establish a clearance between the inner race and the shaft, the outer race having an outer diameter being sized to establish a clearance between the outer race and the shaft socket; a thrust collar (40) secured to the one end of the shaft to prevent displacement of the inner race along the axis of the shaft away from the valve bore; a resilient washer (42) disposed between the outer race and the shaft socket to resist displacement of the outer race toward the valve bore along the axis of the shaft; and a bearing means (44) provided between the valve body and the other end of the shaft, the bearing means being adapted to urge the other end of the shaft away from the valve bore along the axis of the shaft.

3. A valve assembly as claimed in claim 2, wherein the bearing means (44) comprises a ball bearing having an outer race (46) and an inner race (48), the other end of the shaft (16) extending through the inner race, the inner race of the bearing means having an inner diameter being sized to establish a clearance between the inner race and the shaft; a bearing seat (50) connected to the valve body (12) externally thereof, the bearing seat having a bearing seat opening (52) through which the other end of the shaft extends, the outer race of the bearing means being disposed on the

bearing seat so that axial displacement of the outer race along the shaft toward the valve bore (14) is obstructed; and a thrust retainer (54) engaging the inner race of the bearing means to urge the inner race toward the valve bore along the axis of the shaft.

4. A valve assembly (10) comprising a valve body (12) having a valve bore (14) forming an induction passage for air flow to an internal combustion engine; a shaft (16) having opposite ends which are journalled for rotation in the valve body, the shaft extending across the valve bore; a valve member (18) of the flat butterfly type secured to the shaft for rotation to control air flow through the valve bore; a shaft socket (30) connected to the valve body externally thereof, the shaft socket having an axis intersecting the centre of the valve bore and being perpendicular to the valve bore, the shaft socket having a shaft socket opening (32) enabling one end of said shaft to extend into the shaft socket; a ball bearing having an outer race (36) and an inner race (38) disposed in the shaft socket so that the one end of the shaft extends through the inner race, the inner race having an inner diameter being sized to establish a clearance between the inner race and the shaft, the outer race having an outer diameter being sized to establish a clearance between the outer race and the shaft socket; a thrust collar (40) secured to the one end of the shaft to prevent displacement of the inner race along the axis of the shaft away from the valve bore; a resilient washer (42) disposed between the outer race and shaft socket to resist displacement of the outer race toward the valve bore along the axis of the shaft; and a bearing means (44) provided between the valve body and the other end of the shaft, the bearing means being adapted to urge the other end of the shaft away from the valve bore along the axis of said shaft.

5. A valve assembly as claimed in claim 4, wherein the bearing means (44) comprises a ball bearing having an outer race (46) and an inner race (48), the other end of the shaft (16) extending through the inner race, the inner race of the bearing means having an inner diameter being sized to establish a clearance between the inner race and the shaft; a bearing seat (50) connected to the valve body (12) externally thereof, the bearing seat having a bearing seat opening (52) through which the other end of the shaft extends, the outer race of the bearing means being disposed on the bearing seat so that axial displacement of the outer race along the shaft toward the valve bore (14) is obstructed; and a thrust retainer (54) engaging the inner race of the bearing means to urge the inner race toward the valve bore along the axis of the shaft.

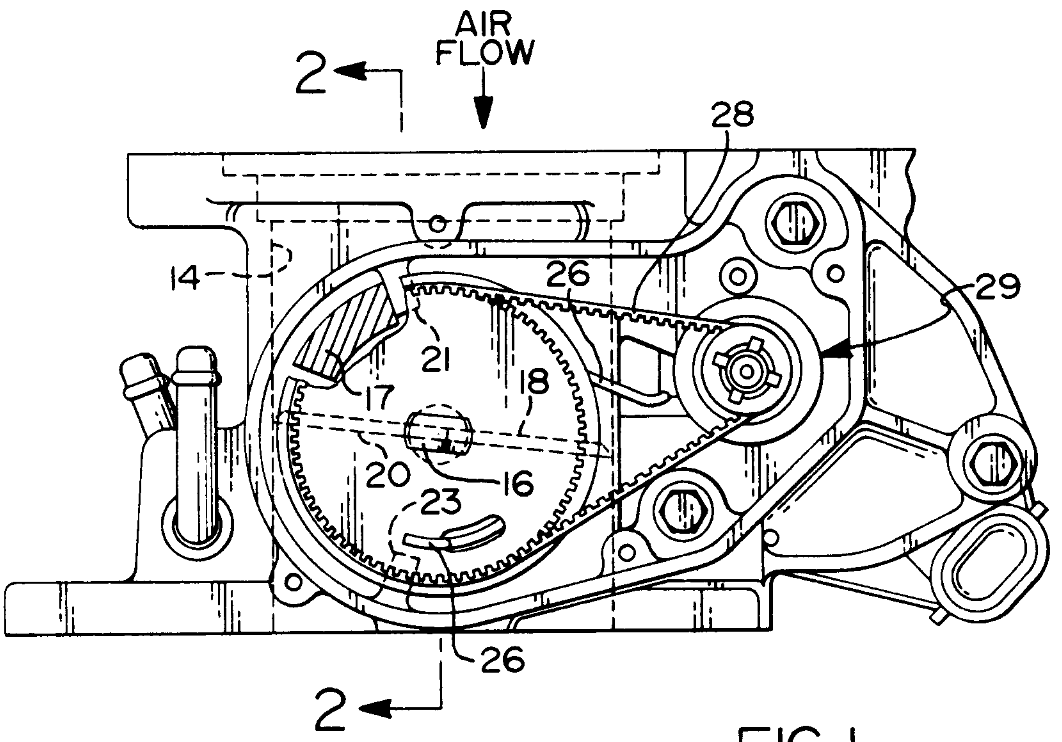
AIR
FLOW
2
2
14
26
21
17
18
20
16
23
26
28
29

FIG 1

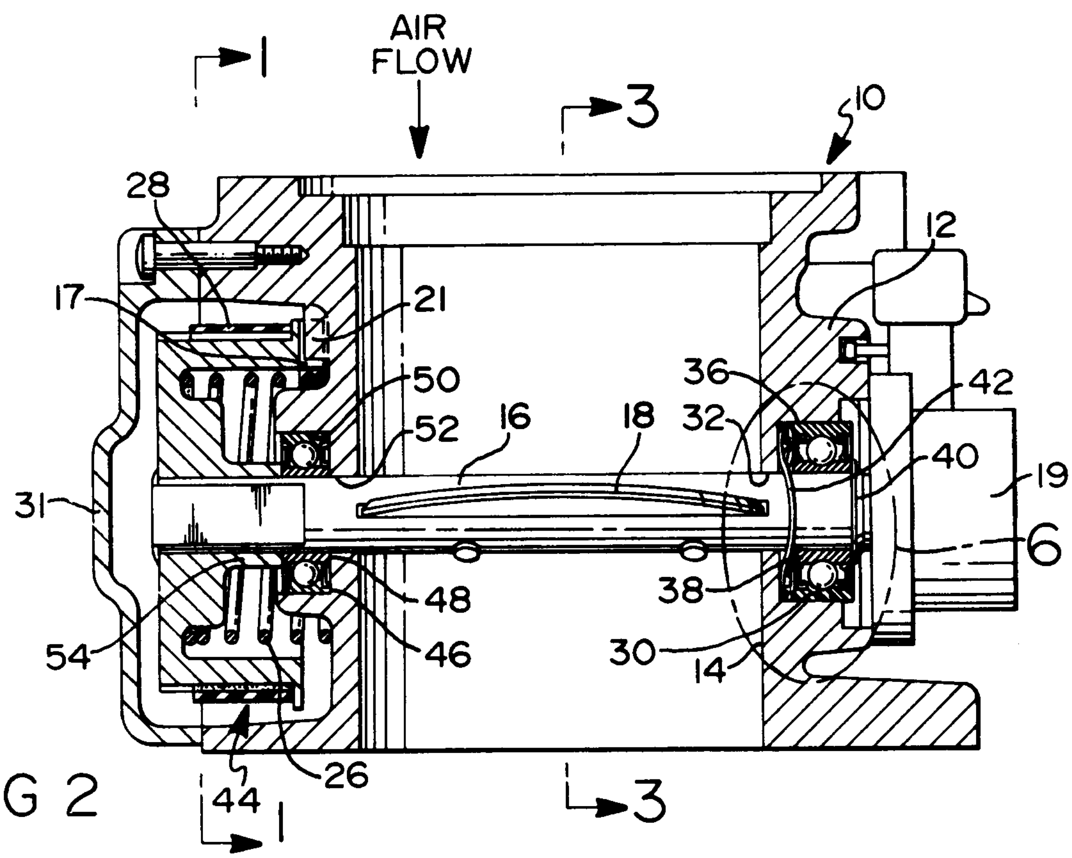
AIR
FLOW
1
1
3
3
10
28
17
21
50
52
16
18
36
32
42
40
19
12
31
6
54
48
46
38
30
14
44
26

FIG 2

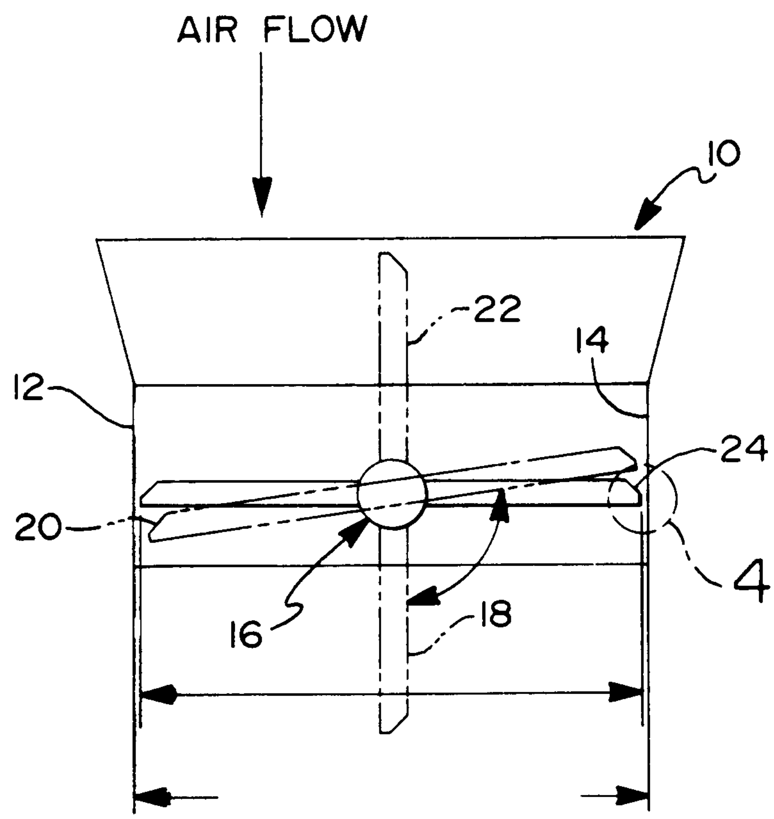

FIG 3

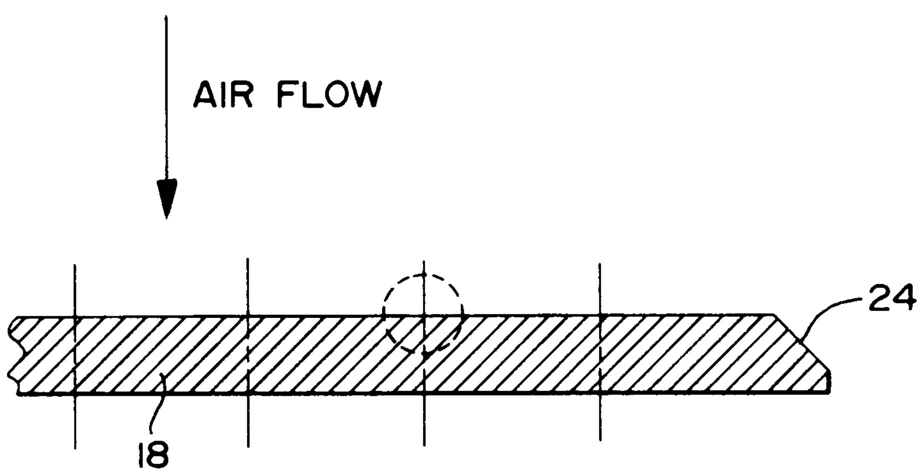

FIG 4

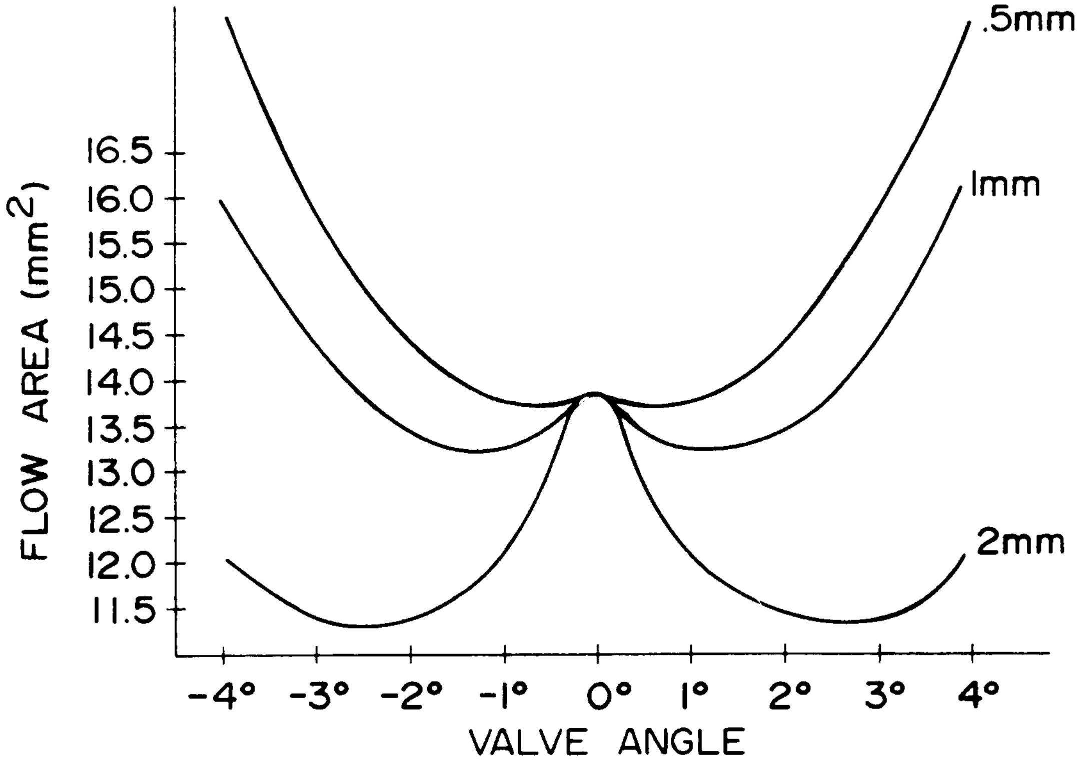
.5mm
1mm
2mm
FLOW AREA (mm2)
16.5
16.0
15.5
15.0
14.5
14.0
13.5
13.0
12.5
12.0
11.5
-4°
-3°
-2°
-1°
0°
1°
2°
3°
4°
VALVE ANGLE

FIG 5

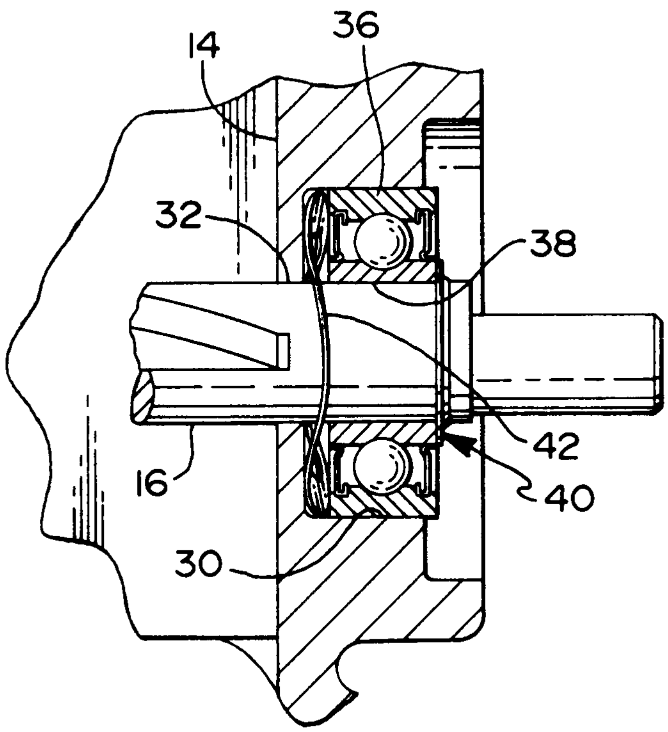
14
36
32
38
42
16
40
30

FIG 6

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91 20 1535

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	DE-A-3 205 160 (AUDI NSU AUTO UNION AG) – – –	1	F 02 D 9/10 F 16 K 1/22
Y	US-A-4 318 386 (SHOWALTER ET AL.) * column 9, line 37 - line 41; figure 1 * * – – –	1	
Y	PATENT ABSTRACTS OF JAPAN vol. 11, no. 348 (M-642)14 November 1987 & JP-A-62 129 538 (TOYOTA MOTOR CORP.) 11 June 1987 * the whole document * * – – –	4,5	
Y	PATENT ABSTRACTS OF JAPAN vol. 13, no. 299 (M-847)11 July 1989 & JP-A-01 087 838 (HITACHI LTD) 31 March 1989 * the whole document * * – – –	4,5	
D,A	US-A-4 474 150 (FOLEY ET AL.) * column 1, line 46 - line 66; figure 1 * * – – –	1	
A	US-A-4 938 452 (IMAMURA ET AL.) * claims * * * column 1, line 38 - line 60 * * * figures 1,2,5-7 * * – – –	4,5	**TECHNICAL FIELDS SEARCHED (Int. Cl.5)**
D,A	US-A-4 860 706 (SUZUKI ET AL.) * claims 1,2,6; figures 1-3,22-25 * * – – –	1-5	F 02 D F 02 M F 16 K
A	GB-A-2 067 719 (NISSAN MOTOR CO.) * page 1, line 110 - line 118; figures 7-14 * * – – –	4,5	
A	DE-C-837 785 (BAYERISCHE MOTOREN WERKE AG) * page 2, line 10 - line 68; figures 1,2 * * – – –	4	
A	EP-A-0 076 612 (SHOWALTER) * page 7, line 1 - page 8, line 7; figures 1,2 * * – – – – –	1	

The present search report has been drawn up for all claims

Place of search	Date of completion of search	Examiner
The Hague	10 October 91	ALCONCHEL Y UNGRIA J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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