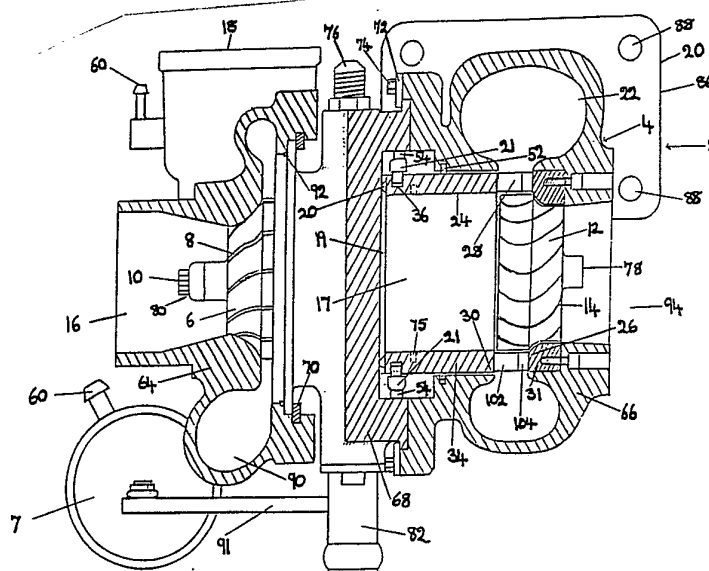




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁴ : F01D 17/14, F04D 29/46 F02C 6/12	A1	(11) International Publication Number: WO 89/11583 (43) International Publication Date: 30 November 1989 (30.11.89)															
(21) International Application Number: PCT/GB89/00584 (22) International Filing Date: 26 May 1989 (26.05.89) (30) Priority data: <table border="0" style="width: 100%;"> <tr> <td style="width: 30%;">8812664.4</td> <td style="width: 40%;">27 May 1988 (27.05.88)</td> <td style="width: 30%;">GB</td> </tr> <tr> <td>8817230.9</td> <td>20 July 1988 (20.07.88)</td> <td>GB</td> </tr> <tr> <td>8827153.1</td> <td>21 November 1988 (21.11.88)</td> <td>GB</td> </tr> <tr> <td>8827761.1</td> <td>28 November 1988 (28.11.88)</td> <td>GB</td> </tr> <tr> <td>8901803.0</td> <td>27 January 1989 (27.01.89)</td> <td>GB</td> </tr> </table> (71)(72) Applicant and Inventor: LEAVESLEY, Malcolm, George [GB/GB]; 54 Heylyn Square, Malmesbury Road, Bow, London E3 2DW (GB). (74) Agent: JONES, Graham, Henry; Graham Jones & Com- pany, 77 Beaconsfield Road, Blackheath, London SE3 7LG (GB).		8812664.4	27 May 1988 (27.05.88)	GB	8817230.9	20 July 1988 (20.07.88)	GB	8827153.1	21 November 1988 (21.11.88)	GB	8827761.1	28 November 1988 (28.11.88)	GB	8901803.0	27 January 1989 (27.01.89)	GB	(81) Designated States: AT (European patent), AU, BE (Euro- pean patent), CH (European patent), DE (European pa- tent), FR (European patent), GB, GB (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent), US. Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the</i> <i>claims and to be republished in the event of the receipt of</i> <i>amendments.</i>
8812664.4	27 May 1988 (27.05.88)	GB															
8817230.9	20 July 1988 (20.07.88)	GB															
8827153.1	21 November 1988 (21.11.88)	GB															
8827761.1	28 November 1988 (28.11.88)	GB															
8901803.0	27 January 1989 (27.01.89)	GB															

(54) Title: TURBOCHARGER APPARATUS**(57) Abstract**

Variable turbocharger apparatus (2) comprising a housing (4), a compressor (6) mounted for rotation in the housing (4), a turbine (12) mounted for rotation in the housing (4), a first inlet (16) for enabling air to be conducted to the compressor (6), an outlet (18) for air from the compressor (6), a second inlet (20) for enabling exhaust gases from an engine to be conducted to the turbine (12), a chamber (22) which surrounds the turbine (12) and which receives the exhaust gases from the second inlet (20) before the exhaust gases are conducted to the turbine (12), and a piston (24) which is positioned between the turbine (12) and the housing (4) and which is slidable backwards and forwards to form a movable wall separating the turbine (12) from the chamber (22) which surrounds the turbine (12), the piston (24) having a plurality of vanes (102), the piston (24) being such that in its closed position it terminates short of an adjacent part of the housing (4) so that there is always a gap between the end (30) of the piston (24) and the adjacent part (26) of the housing (4), the piston (24) being biased to its closed position against pressure from exhaust gases in the chamber (22), and the piston (24) being movable by fork means (21) which locates in a groove (36) in the piston (24).

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT Austria
AU Australia
BB Barbados
BE Belgium
BF Burkina Fasso
BG Bulgaria
BJ Benin
BR Brazil
CF Central African Republic
CG Congo
CH Switzerland
CM Cameroon
DE Germany, Federal Republic of
DK Denmark
ES Spain

FI Finland
FR France
GA Gabon
GB United Kingdom
HU Hungary
IT Italy
JP Japan
KP Democratic People's Republic
of Korea
KR Republic of Korea
LJ Liechtenstein
LK Sri Lanka
LU Luxembourg
MC Monaco
MG Madagascar

ML Mali
MR Mauritania
MW Malawi
NL Netherlands
NO Norway
RO Romania
SD Sudan
SE Sweden
SN Senegal
SU Soviet Union
TD Chad
TG Togo
US United States of America

- 1 -

TURBOCHARGER APPARATUS

This invention relates to turbocharger apparatus and it relates more especially to variable turbocharger apparatus.

5 Different types of turbocharger apparatus are known. One known type of turbocharger apparatus comprises a housing, a compressor mounted for rotation in the housing, a turbine mounted for rotation in the housing, a first inlet for enabling air to be conducted to the compressor, an outlet for air from the compressor, 10 a second inlet for enabling exhaust gases from an engine to be conducted to the turbine, and a chamber which surrounds the turbine and which receives the exhaust gases from the second inlet before the exhaust gases are conducted to the turbine. This known type of 15 turbocharger apparatus is such that there is a fixed gap through which the exhaust gases in the chamber can pass to the turbine. The size of this gap is chosen to be a compromise between the various different sizes of gap that are ideally required for different engine 20 operating conditions. This means that, for most engine operating conditions, the gap is not exactly correct and the turbocharger apparatus thus operates at less than

its optimum performance. For example, with a relatively small gap, the turbocharger apparatus gives a quick response but excessive pressure tends to build up in the chamber. With a large gap, the
5 build up of excessive pressure in the chamber is avoided but then the response time of the turbine apparatus is slow.

It is an aim of the present invention to obviate or reduce the above mentioned problem.

10 Accordingly, this invention provides variable turbocharger apparatus comprising a housing, a compressor mounted for rotation in the housing, a turbine mounted for rotation in the housing, a first inlet for enabling air to be conducted to the
15 compressor, an outlet for air from the compressor, a second inlet for enabling exhaust gases from an engine to be conducted to the turbine, a chamber which surrounds the turbine and which receives the exhaust gases from the second inlet before the exhaust
20 gases are conducted to the turbine, and a piston which is positioned between the turbine and the housing and which is slidable backwards and forwards to form a movable wall separating the turbine from the chamber which surrounds the turbine, the piston having a
25 plurality of vanes, the piston being such

in its closed position it terminates short of an adjacent part of the housing so that there is always a gap between the end of a piston and the adjacent part of the housing whereby exhaust gases from the chamber can always pass through the gap to act on the turbine, the piston being such that in its open position the gap is increased, and the piston being biased to its closed position against pressure from exhaust gases in the chamber during use of the variable turbocharger apparatus whereby the piston slides backwards and forwards to vary the gap in dependence upon engine operating conditions, and the variable turbocharger apparatus being such that the piston is moved by fork means which locates in a groove in the piston.

The fork means enables the piston to be moved backwards and forwards in an axial direction without forcing the piston to one side and thus causing it to bind in the variable turbocharger apparatus.

Preferably, the piston comprises a cylindrical body portion having the groove provided at that end of the body portion remote from the gap. Preferably, at the grooved end of the piston, there is a lug for receiving a pin for preventing rotation of the piston.

- 4 -

The piston will usually be arranged to slide in a cylindrical part of the housing.

Preferably, the fork means is located on a shaft that is mounted in the housing. The shaft may
5 be connected to an actuator valve which enables movement to be applied to the fork means.

The fork means is preferably a bifurcated fork but other types of fork means may be employed.

The variable turbocharger apparatus may include
10 an air bleed passage which leads from the outlet for air from the compressor to the actuator valve, the air bleed passage enabling air to be directed against a diaphragm in the actuator valve in order to cause movement of the actuator valve, whereby movement of the actuator valve
15 can be transmitted to the fork means and the piston in dependence upon air bleed pressure. The air bleed pressure will usually be dependent upon the speed of rotation of the compressor.

As an alternative to using air which is bled
20 from the compressor, a separate air supply may be used. Thus, for example, the separate air supply may be provided by a small separate electronic compressor. Also, micro-processors can be used to monitor a selected parameter or parameters and to compute the position of

the piston to give the required piston position.

The variable turbocharger apparatus may be one in which the piston is provided with a lug which co-operates with a pin for preventing rotation of the piston.

5

In a first embodiment of the invention, the variable turbocharger apparatus is one in which the vanes on the piston co-operate with vanes provided on or engaging the turbine housing. The vanes on or engaging the turbine housing are preferably on an insert secured to the turbine housing. If desired however the vanes may be cast as part of the turbine housing. In the first embodiment of the invention, the vane arrangement may allow a close down of over 50% between the vanes in the closed position, whilst maintaining the vanes in an overlapping position when in the open position, so that the vanes are able to direct all the available gases at an appropriate angle onto the turbine.

10

15

In a second embodiment of the invention, the vanes on the piston co-operate with slots in a heat shield. The heat shield may have a chamber into which the vanes project, the chamber being sealed tight so as to prevent gas leakage to a low pressure side of the turbine. In the second embodiment of the invention, the vane arrangement

20

- 6 -

may be one in which the heat shield has through slots which accommodate inlet vanes mounted on the piston, the inlet vanes entering into the chamber which is a part of the back of the heat shield. The advantage of this design is that the vanes are always in the gas flow to direct the gases at an appropriate angle onto the turbine.

Usually, the piston will be spring biased to its closed position. Preferably, the piston is spring biased to its closed position by a single coil spring. Advantageously, the single coil spring is axially positioned inside the actuator valve. In alternative embodiments of the variable turbocharger apparatus, more than one spring may be employed. Also, if desired, biasing means other than springs may be employed.

The variable turbocharger apparatus may include sealing means for forming a sliding seal between the piston and the housing. The sealing means may comprise at least one sealing piston ring.

Preferably, only one sealing piston ring is employed but more than one sealing piston ring may be employed if desired. The or each sealing piston ring

- 7 -

may be located in a cylindrical body portion of the piston. Alternatively, the or each sealing piston ring may be mounted in the housing.

5 The end of the piston adjacent the gap may be chamfered. This chamfered end of the piston may help to prevent the build up of products of combustion at this point with some types of engine, for example 2- and 4- stroke petrol driven engines.

10 If desired, the variable turbocharger apparatus may include at least one bearing against which the sealing means slides backwards and forwards. When a bearing is employed, it is preferred that the bearing be located in the housing adjacent the cylindrical body portion of the piston.

15 The variable turbocharger apparatus may include a heat shield. Preferably, the variable turbocharger apparatus includes a heat shield which is positioned inside the piston such that the piston is slidable backwards and forwards over the heat shield. The heat
20 shield may be mounted over the bearing housing so as to leave an air space between the bearing housing and the heat shield.

 The heat shield may have a flange at one end so that it can be held in position on the bearing housing

by screws or by any other desired and appropriate means.

Advantageously, the housing is separable into at least two parts. This may facilitate assembly of the variable turbocharger apparatus and it may also facilitate fixing of the variable turbocharger apparatus in various engine compartments of various vehicles. The housing may be separable into three parts comprising two end parts and a central part.

The variable turbocharger apparatus may advantageously include a chamber in which the fork means locates, the piston being such as to cover the chamber to prevent a heat build-up on the fork means and to prevent a turbulent gas flow at an exit part of the turbine.

The variable turbocharger apparatus may be one in which the piston has an end in which is mounted a conical diffuser, the conical diffuser being for facilitating gas extraction from the turbine.

The variable turbocharger may advantageously be one in which the piston includes at least one solid piston ring.

The variable turbocharger apparatus may be one in which the piston is mounted inside the turbine housing such that the piston slides directly over the turbine to allow a large gas exit area. This in effect means that the turbine is so constructed that it does not have a trim part.

The present invention also extends to an engine when provided with the variable turbocharger apparatus. The engine may be any general type of engine including diesel and petrol driven engines.

Embodiments of the invention will now be described solely by way of example and with reference to the accompanying drawings in which:

Figure 1 is a cross section through first variable turbocharger apparatus;

Figure 2 is a side view of the piston shown in Figure 1;

Figure 3 is an end view of the piston shown in Figure 2;

Figure 4 is an end view of part of the first variable turbocharger apparatus;

Figure 5 is a side view of a heat shield showing an air gap over a bearing housing;

- 10 -

Figure 6 is a cross section through an air actuator valve;

Figure 7 is a cross section through second variable turbocharger apparatus;

5 Figure 8 is a cross section through third variable turbocharger apparatus;

Figure 9 is a cross section through fourth variable turbocharger apparatus;

10 Figure 10 is an end view of the second, third and fourth variable turbocharger apparatus shown in Figures 7, 8 and 9;

Figure 11 is an end view of a heat shield provided with vanes;

15 Figure 12 is a side view of the heat shield shown in Figure 11;

Figure 13 illustrates how the vanes enter slots;

Figure 14 is a side view showing a first vane arrangement in an open position;

20 Figure 15 is a side view showing the first vane arrangement of Figure 14 in a closed position;

Figure 16 is a cross sectional view showing a second vane arrangement in an open position;

- 11 -

Figure 17 is a cross sectional view showing the second vane arrangement in a closed position;

Figure 18 is an end view of the second vane arrangement;

5 Figure 19 is a side view showing the vanes of the second vane arrangement in an open position; and

Figure 20 is a side view showing the vanes of the second vane arrangement in a closed position.

Referring to Figures 1 to 6, there is shown
10 first variable turbocharger apparatus 2. The variable turbocharger apparatus 2 comprises a housing 4 and a compressor 6. The compressor 6 has blades 8. The compressor 6 is mounted for rotation in the housing 4 by being mounted on a central shaft 10. A turbine 12
15 is also mounted for rotation in the housing 4 by being mounted on the shaft 10. The turbine 12 has blades 14.

The housing 4 has a first inlet 16 for enabling air to be conducted to the compressor 6. The housing 4 also has an outlet 18 for air from the compressor. The
20 outlet 18 enables air from the compressor 6 to be conducted to an engine (not shown).

The housing 4 has a second inlet 20 for enabling exhaust gases from the engine to be conducted to the turbine 12. A chamber 22 surrounds the turbine 12 and this chamber 22 receives the exhaust gases from the second inlet 20 before the exhaust gases are conducted

- 12 -

to the turbine 12. The chamber 22 may be regarded as a volute-shaped toroidal chamber.

A piston 24 is positioned between the turbine 12 and the housing 4. The piston 24 is slidable
5 backwards and forwards to form a movable wall separating the turbine 12 from the chamber 22 which surrounds the turbine 12.

The piston 24 is such that in its closed position it terminates short an adjacent part 26 of the
10 housing 4 so that there is always a gap 28 between the end 30 of the piston 24 and the adjacent part 26 of the housing 4. This means that exhaust gases from the chamber 22 can always pass through the gap 28 to act on the blades 14 of the turbine 12. The piston 24 is such that
15 in its open position, the gap 28 is increased.

The piston 24 is biased to its closed position against pressure from exhaust gases in the chamber 22 during use of the variable turbocharger apparatus 2 so that the piston 24 slides backwards and forwards to vary
20 the gap 28 in dependence upon engine operating conditions. The piston 24 is biased by means of an actuator valve 7.

As can be seen from Figures 1 and 2, the piston 24 comprises a cylindrical body portion 34 having a groove 36 at that end of the body portion 34 remote from the
25 gap 28.

- 13 -

As can best be seen from Figures 1 and 4, fork means in the form of a bifurcated fork 21 is located in the groove 36. The fork 21 is also fitted to a shaft 54 which can rotate in a bearing housing 68. On top of the shaft 54 is a metal bar 91 which is connected to the actuator valve 7. The actuator valve 7 thus acts as control means.

When the pressure starts to exceed a given level selected by the strength of a spring 95, see Figure 6, the air pressure inside a housing 9 of the actuator valve 7 pushes a flexible diaphragm 98, thereby displacing the piston 24 to a more open position. The piston 24 acts as an area control element piston 24. The displacing of the piston 24 to a more open position in turn increases the flow area 28 and reduces the velocity of the gases entering the turbine 12.

As shown in Figures 1 to 6, the first variable turbocharger apparatus 2 includes sealing means in the form of a sealing piston ring 52. The sealing piston ring 52 is for forming a sliding seal between the piston 24 and the housing 4. The sealing piston ring 52 is located in the turbine housing 66. The sealing piston ring 52 can alternatively be located in the piston 24

- 14 -

as shown by dotted lines 58 in Figure 2.

5 The end 30 of the piston 24 is chamfered as shown so that any products of combustion from the exhaust gases in the chamber 22, which may tend to build up on the part of the piston 24 forming the movable wall, may tend to break away and thus not hinder the sliding movement of the piston 24.

10 The variable turbocharger apparatus 2 includes a heat shield 17. The heat shield 17 has a flange 19. The heat shield 17 is mounted with screws 20 over the bearing housing 68. Figure 5 shows an air gap between the bearing housing 68 and the heat shield 17. In an alternative construction, a sealing ring may be located in the heat shield 17 as shown in Figure 5 by dotted lines 5. In a further alternative construction, the sealing ring may be located inside the bore of the piston 24, as shown in Figure 1 by dotted lines 75, to operate on the outside of the heat shield 17.

20 An advantageous feature of the first variable turbocharger apparatus shown in Figures 1 to 6 is that the housing 4 is separable into two end parts 64,66 and a central part 68. This may facilitate positioning of the variable turbocharger apparatus 2 in various

required positions in various engine compartments in vehicles or in other apparatus. The end part 64 is secured to the central part 68 by means of a cir-clip 70. The end part 66 is secured to the
5 central part 68 by locking washers 72 which are held in position by bolts 74. The end part 64 forms a compressor housing, the end part 66 forms a turbine housing, and the central part 68 forms a bearing housing.

10 The variable turbocharger apparatus 2 is also provided with an oil intake pipe 76 for providing oil for bearings (not shown) on the shaft 10. The shaft 10 is formed with a friction welded head 78 at one end. The other end of the shaft 10 is screw threaded as shown
15 to receive a nut 80, which is effective to hold the compressor 6 in position. An oil return pipe 82 is also provided for enabling the oil provided for the bearings via the oil intake pipe 76 to drain away.

20 The second inlet 20 is provided with a flange 86. The flange 86 has bolt holes 88 so that the flange 86 can be bolted to an exhaust outlet (not shown) of the engine.

The compressor 6 is surrounded by a chamber 90 which is somewhat similar to the chamber 22. In order

- 16 -

to prevent the loss of air from the chamber 90 as the air passes to the outlet 18, a seal in the form of an O-ring seal 92 is provided as shown.

5 By being able to vary the size of the gap 28, the exhaust gases from the engine are able to drive the turbine 12 at substantially always the required rate to enable the compressor 6 to provide the amount of air required by the engine from the variable turbocharger apparatus 2, via the outlet 18.

10 The bleeding of air along the air bleed passage 60 is effective to act on the actuator valve 7 to cause the piston 24 to slide towards its open position in which the size of the gap 28 is increased. After the exhaust gases have driven the turbine 12,
15 they are exhausted via an exhaust outlet 94 formed in the housing 4.

As shown in Figure 2, the piston 24 is provided with an annular groove, shown by the dotted lines 58, for receiving the sealing piston ring 52. Alternatively,
20 the sealing piston ring 52 may be located in the housing 4 as shown in Figure 1. Also shown in Figure 2, is the groove 36 for receiving the fork 21.

Figures 2, 3 and 4 show that on the piston 24 there is a lug 146 which may have a slot 144 as shown,

or a hole (not shown), for location on to a pin 142. The pin 142 may be mounted in the bearing housing 68 as shown, or alternatively in the turbine housing 66. The pin 142 and the lug 146 are provided to prevent rotation of the piston 24.

As shown in Figure 3, the piston 24 is such that the face 100 of the end 30 is provided with vanes 102. The vanes 102 are oriented so that they direct the incoming gas flow in a tangential direction to provide the appropriate gas flow. The vanes 102 are cut or otherwise provided in the end 30 of the piston 24. Vanes 104 are also provided in the turbine housing 66, the vanes 104 being provided in the form of an insert 31 as shown in Figure 1. Alternatively, the vanes 104 may be cast into the turbine housing 66. The angular positions of the vanes 102, 104 in the turbine housing 66 and the piston 24 are such that the vanes 102 on the piston 24 are interposed with the vanes 104 in the turbine housing 66. Relative displacement of the piston 24 varies the extent of overlap of the vanes 102, 104.

Referring to Figure 7, there is shown second variable turbocharger apparatus in which similar parts as in Figure 1 have been given the same reference numerals

and will not again be described. In Figure 7, the relative positions of the fork 21 and the piston 24 have been changed so that the piston 24 operates in the opposite direction to that shown in Figure 1.

5 Figure 7 also shows how the heat shield 17 is used as an insert to hold the vanes 104. The insert is also shown in Figure 11 and Figure 12. Figures 11 and 12 show respectively an end view and a side view of the heat shield 17, provided with the
10 vanes 104.

Referring to Figure 8, there is shown third variable turbocharger apparatus in which similar parts as in Figure 7 have been given the same reference numerals and will not again be described. In Figure 8,
15 a trim 136 as shown in Figure 7 on the turbine 12 has been removed. This is to allow a larger exit area from the turbine 12. The piston 24 is slightly different in that the piston 24 terminates in a conical diffuser 132.

20 Figure 9 shows fourth variable turbocharger apparatus 2 which is similar to the variable turbocharger apparatus 2 shown in Figure 8 but which employs a longer piston 24 to prevent gases building up in an area 134. Also, turbulent gas flow in the area 134 and turbulent

- 19 -

gas flow leading to the outlet of the variable turbocharger apparatus 2 is avoided or reduced. The longer piston 24 of Figure 9 also has the conical diffuser 132.

5 Referring now to Figure 10, there is shown an end view of turbocharger apparatus 2 which may be the variable turbocharger apparatus 2 shown in either of Figures 7, 8 or 9. Again similar parts as in the previous Figures have been given the same reference numerals and
10 their precise construction and operation will not again be given. In Figure 10, there is shown a control arm 91 which terminates in a connection member 140 for connecting to the actuator valve 7. As indicated above, the actuator valve 7 takes pressure from the compressor
15 side of the turbine 12. Alternatively, the pressure may be taken from an engine management system (not shown). Figure 10 also shows a pin 142 which locates in an aperture 144 in a lug 146 formed on the piston 24. The pin 142 acts to stop rotation of the piston 24 during
20 the backwards and forwards sliding movement of the piston 24. The piston 24, the pin 142, the aperture 144 and the lug 146 are shown in more detail in Figures 2 and 3.

Figure 10 further shows how the fork 21 has two arms 148, 150. The arm 148 has a pin 152 and the arm 150 has a pin 154. The pins 152, 154 locate in the groove 36 and thus enable the piston 24 to be moved backwards and forwards without putting undue sideways pressure on the piston 24 which could move it out of axial sliding alignment and could thus cause the piston 24 to bind. The fork 21 is attached to a rod 54 which is mounted in the turbine housing 66.

10 The rod 54 connects to the control arm 91 as shown.

In Figures 1, 7, 8 and 9 described above, co-operating vanes 102, 104 are shown. In Figures 13, 14 and 15, there is shown a vane arrangement in which the piston 24 is modified so that slots 10 are provided between the vanes 102 on the piston 24. These slots 10 have the advantage that they allow the gap 28 between the piston 24 and the housing 4 to be closed down more than 50%, whilst maintaining the vanes 102 on the piston 24 and the housing 4 in an overlapping manner in the open position of the piston 24. If the piston 24 is in an open position and the vanes 102, 104 are not in an overlapping manner, then the vanes 102, 104 are not able to direct all the available gases at the appropriate angle on to the turbine 12, and a turbulent gas flow may result. By utilising the slots 10 shown in Figures 13,14

and 15, this turbulence may be prevented, thus avoiding a decrease in efficiency due to the turbulent gas flow.

5 In Figures 13, 14 and 15, the slots 10 are provided in the piston 24. The slots 10 receive the vanes 104 and the vanes 104 may extend from an insert. The reverse arrangement may be employed in which the slots are in the insert, and in which the vanes 104 for the slots then project from the piston 24. The
10 slots may be cast in the turbocharger apparatus housing.

In further modifications of the variable turbocharger apparatus 2, the slots 10 may be omitted. The slots that may be omitted may thus be in the piston 24 or in the insert 31.

15 The above described variable turbocharger apparatus employs sealing means in the form of a sealing piston ring 52. The sealing means may be a sealing ring other than a split piston ring. Where a split piston ring is employed, this may be inwardly sprung to bear
20 against the outer surface of the piston 24 in order to effect the required seal against gases. Such a split piston ring 52 will rub on the surface of the piston 24 and thus some friction will be created. Whilst this is satisfactory in many circumstances, if it is desired

to reduce or obviate this friction, then a solid piston ring may be employed. Because this solid piston ring does not have a split in it, it is not inwardly sprung and thus friction is reduced.

5 In addition, as the variable turbocharger apparatus operates, exhaust gases will be contacting the piston ring. With a split piston ring, these exhaust gases may cause the split piston ring to operate with a hammering effect on the surface of the
10 piston 24, and this can be disadvantageous and can cause undesirable wear on the surface of the piston 24. The use of the solid piston ring may help to avoid this hammering effect and may thus again reduce undesirable wear on the surface of the piston 24.

15 Irrespective of whether a split piston ring or a solid piston ring is employed, it may be advantageous to produce the piston ring from a material which has substantially the same rate of expansion as the material from which the piston 24 is produced. Thus, as the
20 piston 24 and the piston ring become hot during operation of the variable turbocharger apparatus, the piston 24 and the piston ring can expand at substantially the same rate to avoid creating unnecessary friction as might be the case if the piston 24 expanded more than the piston

ring. The piston 24 and the piston ring can be made of the same or different materials.

In Figures 16 and 17 a second vane arrangement is shown in which the heat shield 17 is replaced by a heat shield 201. The heat shield 201 has a chamber 203 at the back of the heat shield 201. On a face 312, there are slots 260 provided in the heat shield 201, so as to allow the vanes 102 on the piston 24 to enter the chamber 203. In order to prevent gases leaking past the chamber 203, the chamber 203 is preferably a sealed unit along a face 320.

Figures 18, 19 and 20 illustrate the heat shield 201. Figure 18 is an end view which shows the heat shield 201 with the vanes 102 entering slots 260 in the heat shield 201. Figure 19 shows the vanes 102 in the open position, whilst Figure 20 shows the vanes 102 in the closed position. The movement of the piston 24 on this second vane arrangement is the same as described above with reference to Figures 7, 8 and 9.

It is to be appreciated that the embodiments of the invention described above with reference to the accompanying drawings have been given by way of example only and that modifications may be effected. Thus, for example, the vanes 102, 104 may take a different shape to those shown, and more or less vanes than those shown

- 24 -

may be employed. If desired, the vanes 104 may be cast into the turbine housing 4 or they may be located in the turbine housing 4 as a separate part. If desired, the vanes may be reversed to allow a reverse rotation of the turbine 12.

The variable turbocharger apparatus 2 may be produced in various sizes commensurate with the size of engine to which the variable turbocharger apparatus 2 is to be fitted. The shape of the housing 4 can be varied as may be desired. Water cooled bearings may be incorporated. The housing 4 and the various components within the housing 4 can be made of any desired and suitable materials. Also, sealing rings may be added or dispensed with as desired.

CLAIMS

1. Variable turbocharger apparatus comprising a housing, a compressor mounted for rotation in the housing, a turbine mounted for rotation in the housing, a first inlet for enabling the air to be conducted to the compressor, an outlet for air from the compressor, a second inlet for enabling exhaust gases from an engine to be conducted to the turbine, a chamber which surrounds the turbine and which receives the exhaust gases from the second inlet before the exhaust gases are conducted to the turbine, and a piston which is positioned between the turbine and the housing and which is slidable backwards and forwards to form a movable wall separating the turbine from the chamber which surrounds the turbine, the piston having a plurality of vanes, the piston being such that in its closed position it terminates short of an adjacent part of the housing so that there is always a gap between the end of the piston and the adjacent part of the housing whereby exhaust gases from the chamber can always pass through the gap to act on the turbine, the piston being such that in its open position the gap is increased, and the piston being biased to its closed position against pressure from exhaust gases in the chamber during use of the variable turbocharger apparatus whereby the piston slides backwards

and forwards to vary the gap in dependence upon engine operating conditions, and the variable turbocharger apparatus being such that the piston is moved by fork means which locate in a groove in the piston.

5

2. Variable turbocharger apparatus according to claim 1 in which the fork means is located on a shaft which is mounted in the housing.

3. Variable turbocharger apparatus according to claim 2 in which the shaft is connected to an actuator valve.

10

4. Variable turbocharger apparatus according to claim 3 and including an air bleed passage which leads from the outlet for air from the compressor to the actuator valve, the air bleed passage enabling air to be directed against a diaphragm in the actuator valve in order to cause movement of the actuator valve, whereby movement of the actuator valve can be transmitted to the fork means and the piston in dependence upon the air bleed pressure.

15

20

5. Variable turbocharger apparatus according to any one of the preceding claims in which the piston is provided with a lug which co-operates with a pin for preventing rotation of the piston.

5 6. Variable turbocharger apparatus according to any one of the preceding claims in which the vanes on the piston co-operate with vanes provided on or engaging the turbine housing.

10 7. Variable turbocharger apparatus according to claim 6 in which the vanes provided on or engaging the turbine housing are on an insert secured to the turbine housing.

15 8. Variable turbocharger apparatus according to any one of claims 1 to 5 in which the vanes on the piston co-operate with slots in a heat shield.

9. Variable turbocharger apparatus according to claim 8 in which the heat shield has a chamber into which the vanes project, the chamber being sealed so as to prevent gas leakage to a low pressure side of the turbine.

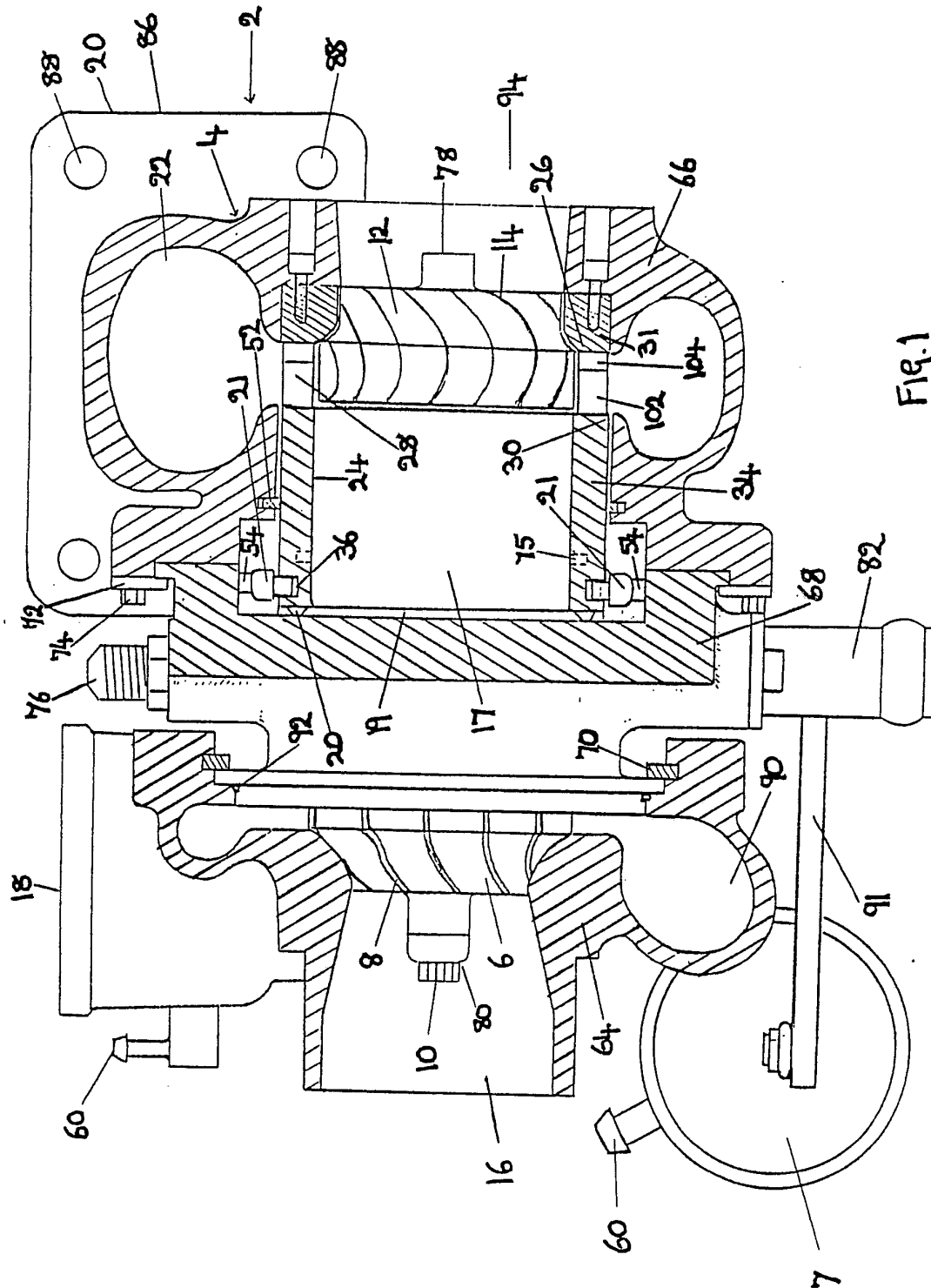
10. Variable turbocharger apparatus according to any one of the preceding claims in which the piston is spring biased to its closed position.
- 5 11. Variable turbocharger apparatus according to any one of the preceding claims and including sealing means for forming a sliding seal between the piston and the housing.
- 10 12. Variable turbocharger apparatus according to claim 6 or claim 7 and including a heat shield which is positioned inside the piston such that the piston is slidable backwards and forwards over the heat shield.
- 15 13. Variable turbocharger apparatus according to any one of the preceding claims and including a chamber in which the fork means locates, the piston being such as to cover the chamber to prevent a heat build-up on the fork means and to prevent a turbulent gas flow at an exit part of the turbine.
14. Variable turbocharger apparatus according to any one of the preceding claims in which the piston has

an end in which is mounted a conical diffuser, the conical diffuser being for facilitating gas extraction from the turbine.

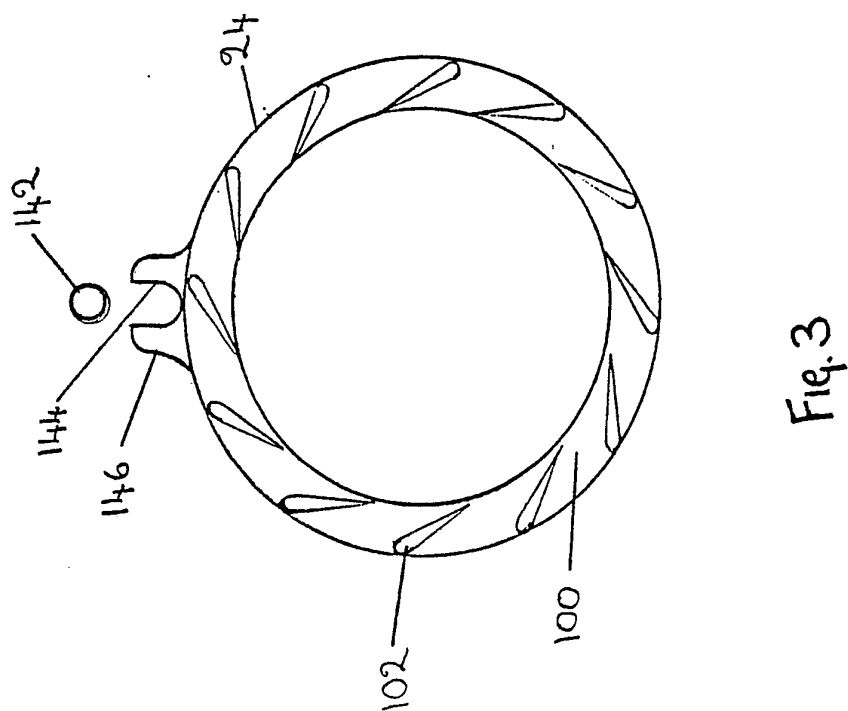
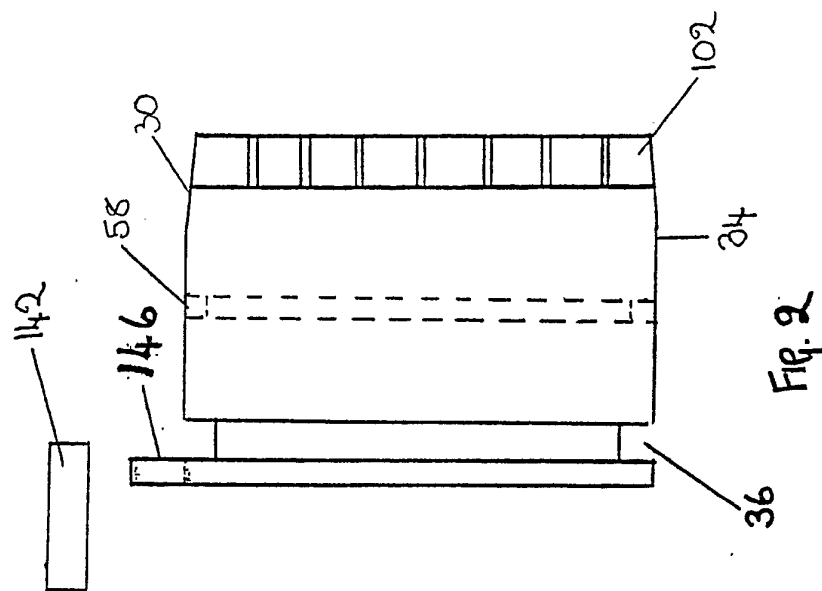
5 15. Variable turbocharger apparatus according to any one of the preceding claims in which the piston includes at least one solid piston ring.

10 16. Variable turbocharger apparatus according to any one of the preceding claims in which the piston is mounted inside the turbine housing such that the piston slides directly over the turbine to allow a large gas exit area.

1/13



2/13



3/13

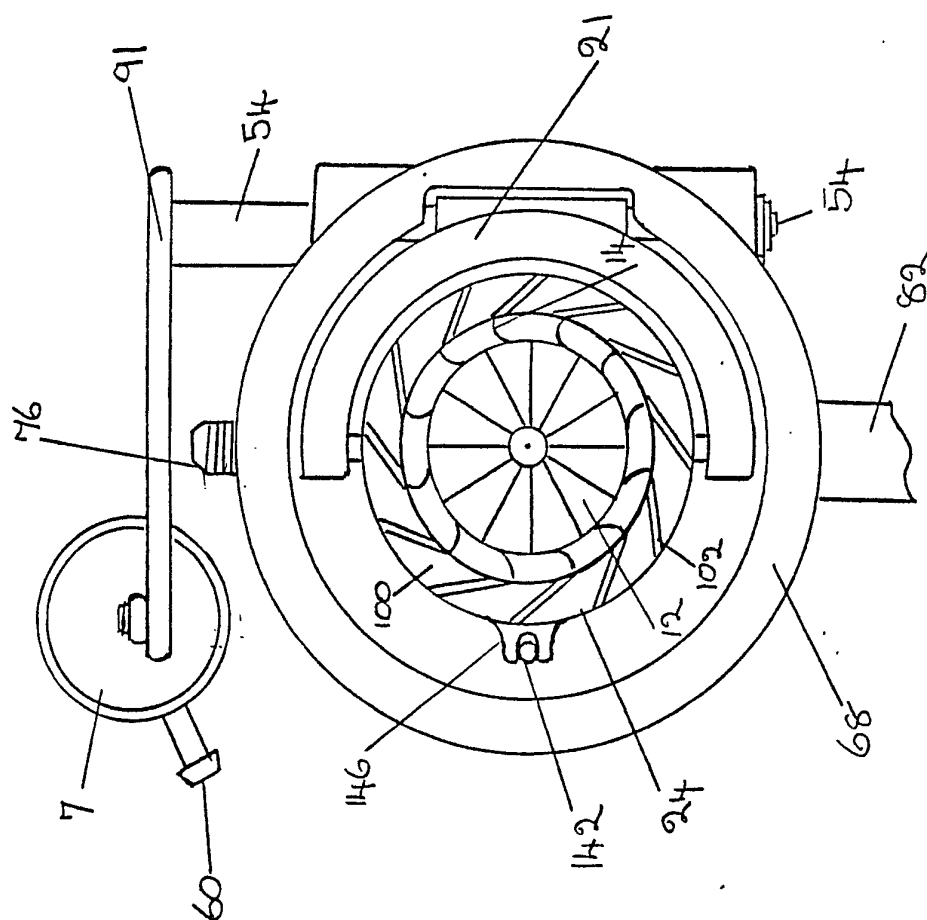


Fig. 4

4/13

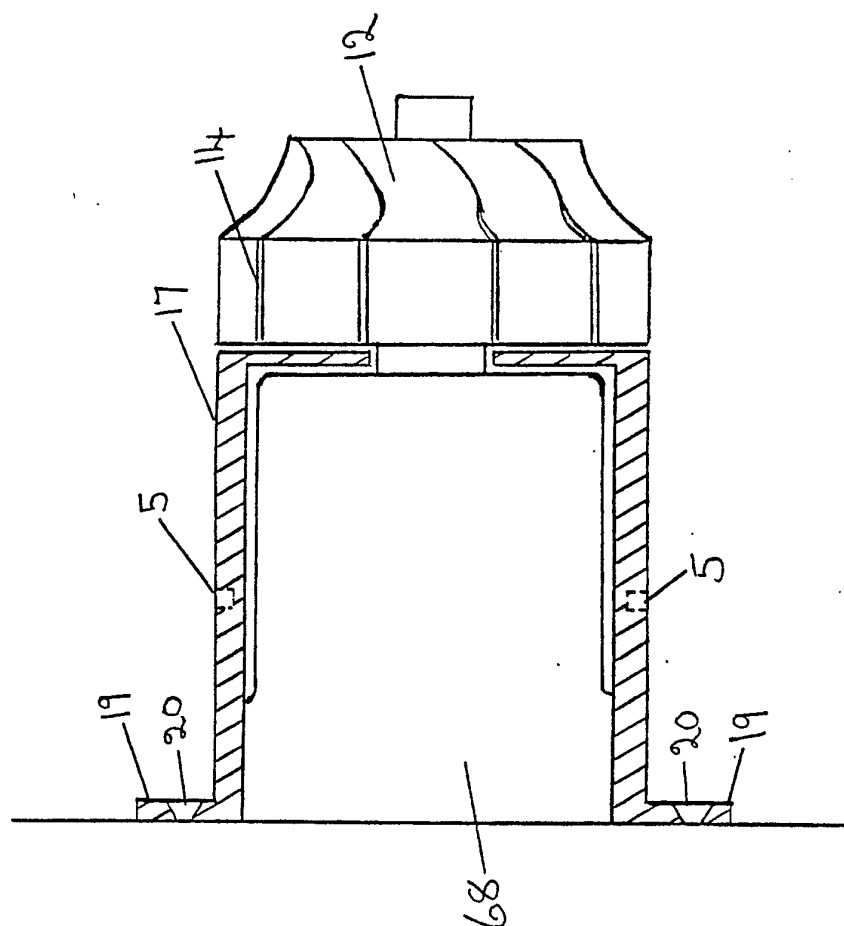


FIG. 5

5/13

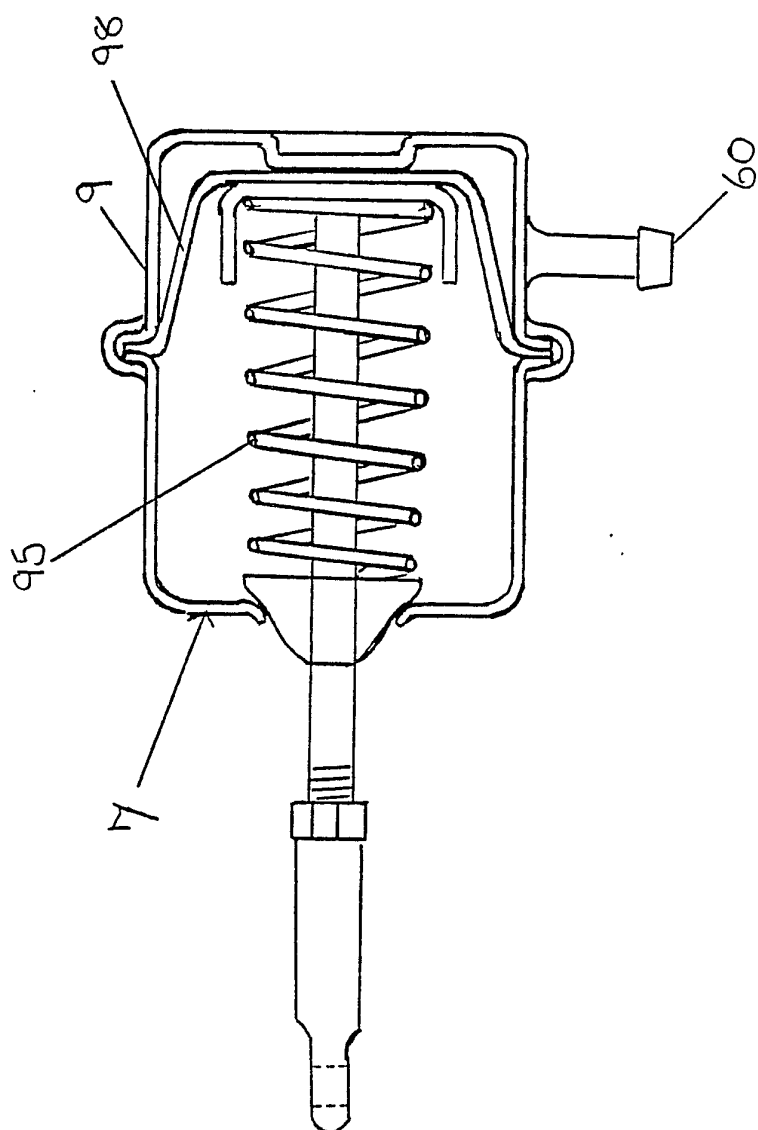


Fig. 6

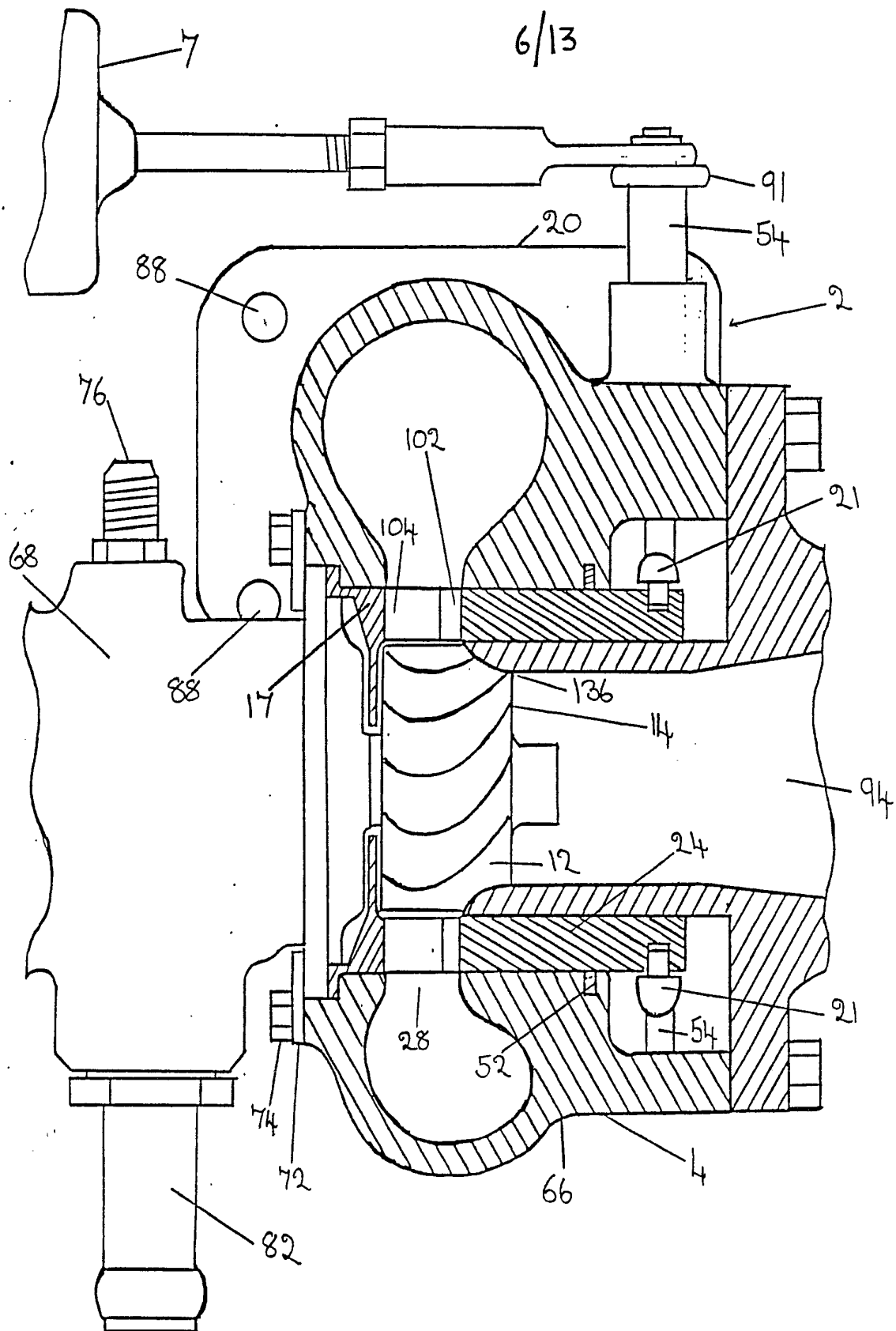


Fig. 7

SUBSTITUTE SHEET

7/13

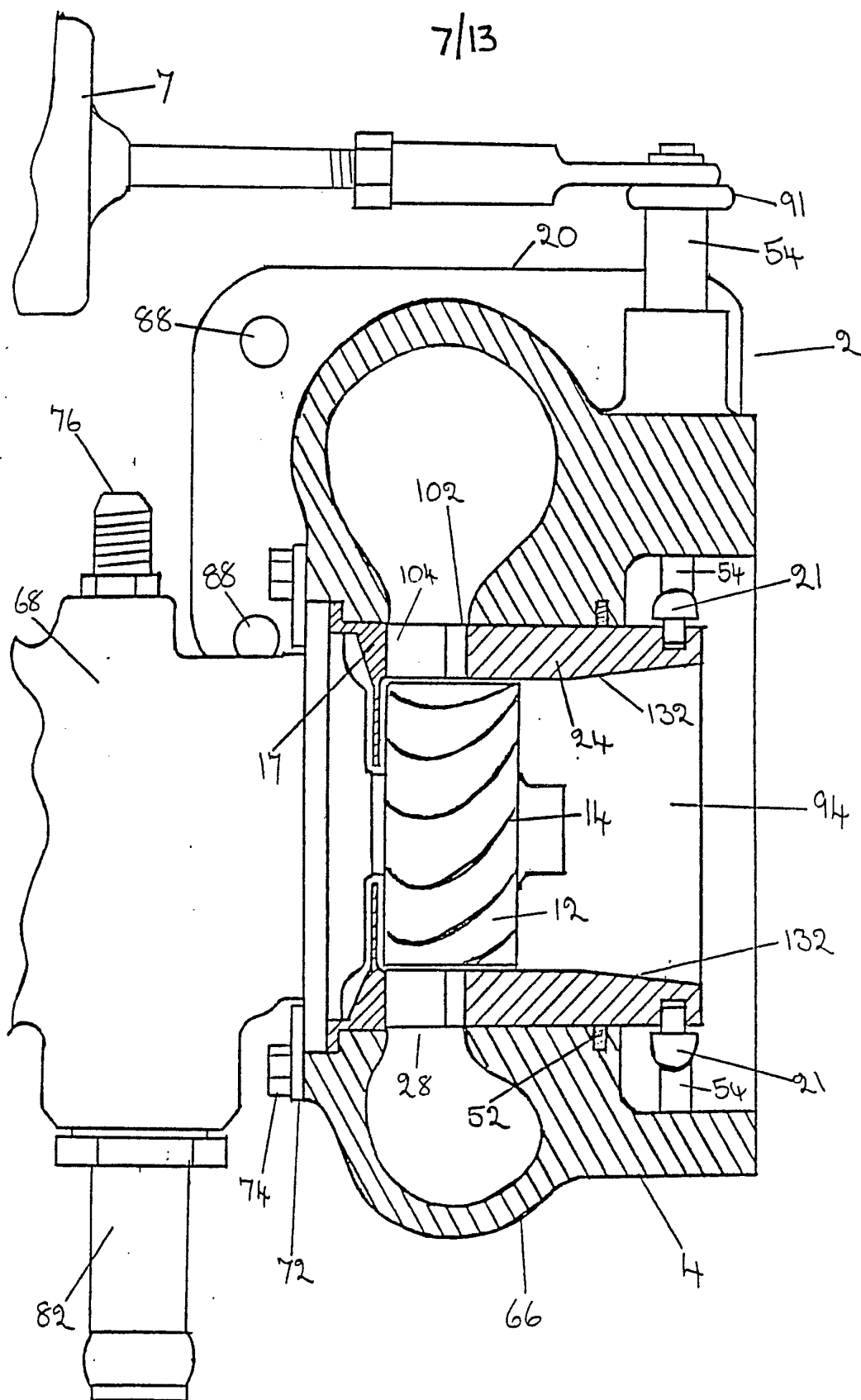


Fig. 8

SUPSTITUTE SHEET

9/13

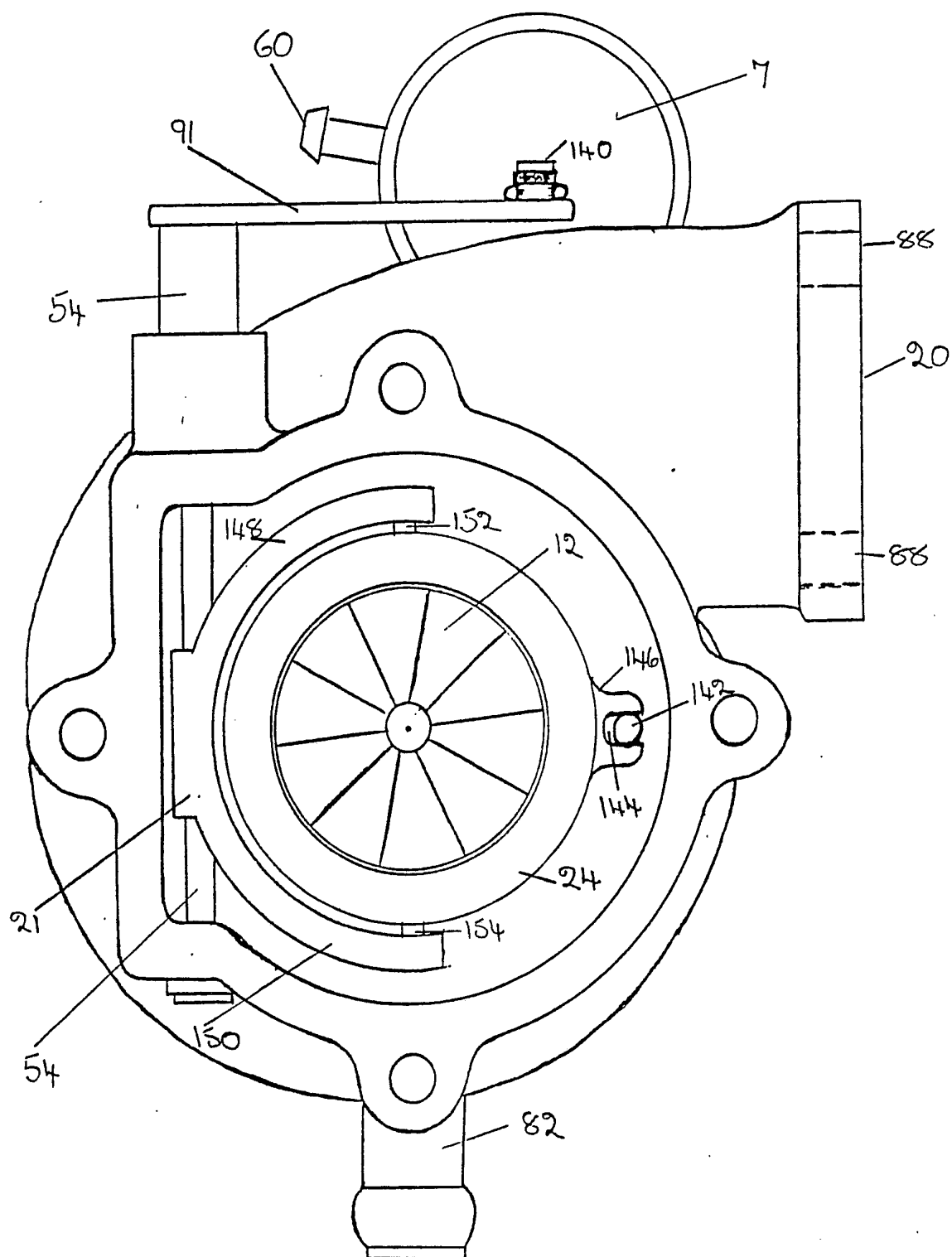


Fig. 10

10/13

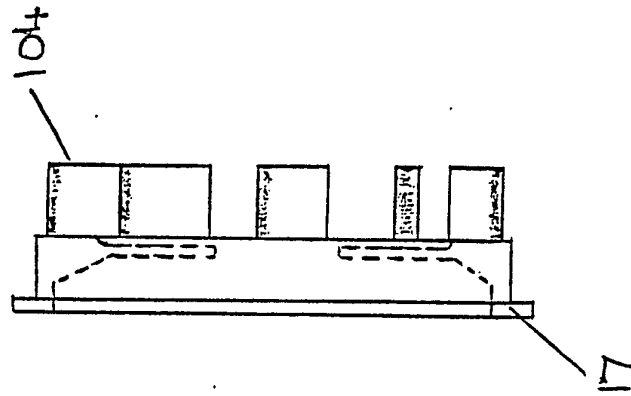


Fig. 12

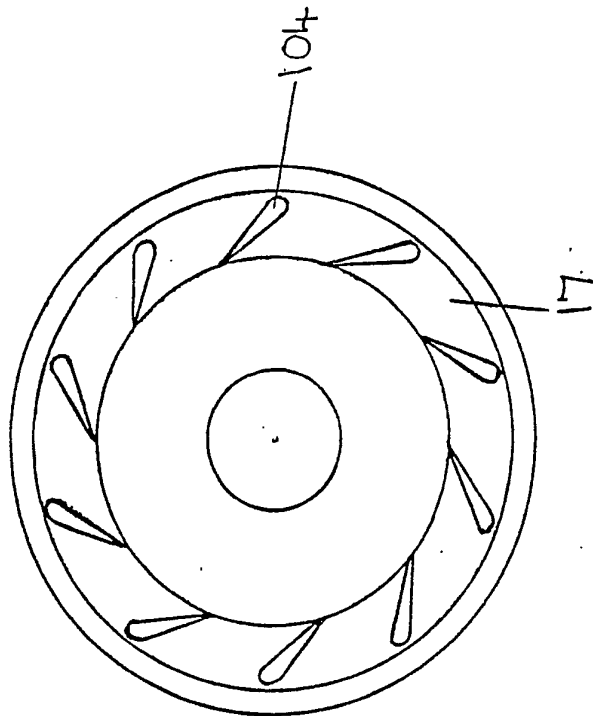


Fig. 11

11/13

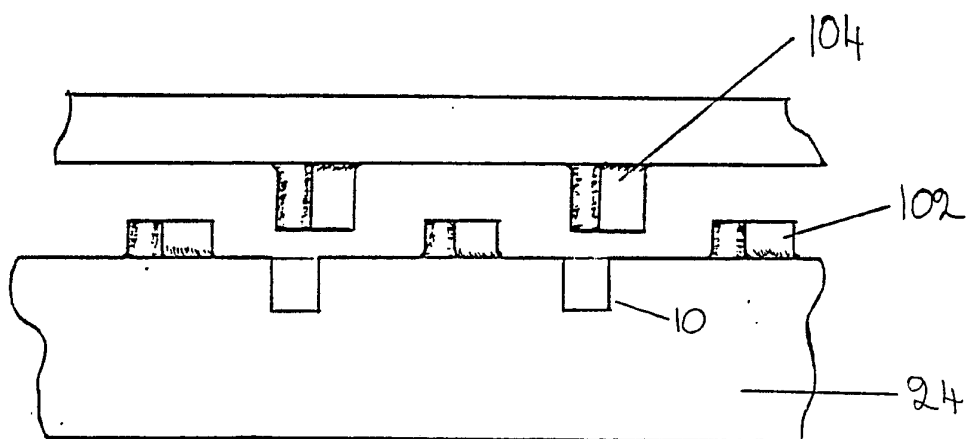
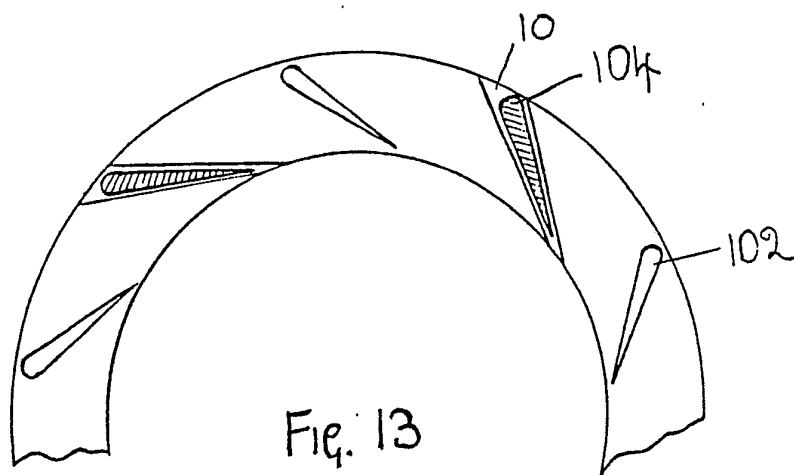


Fig. 14

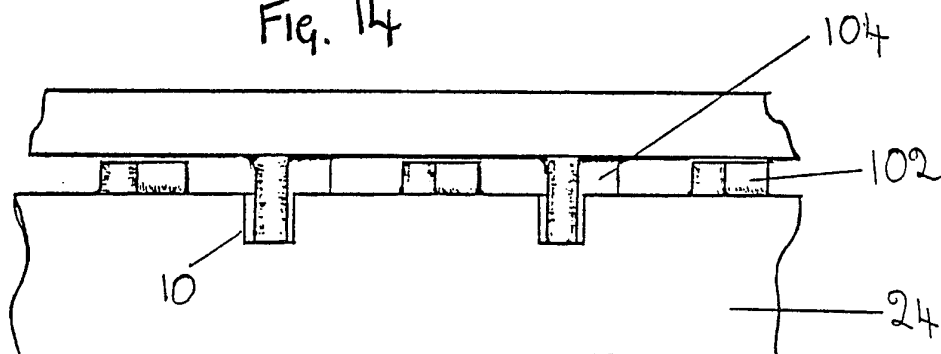


Fig. 15

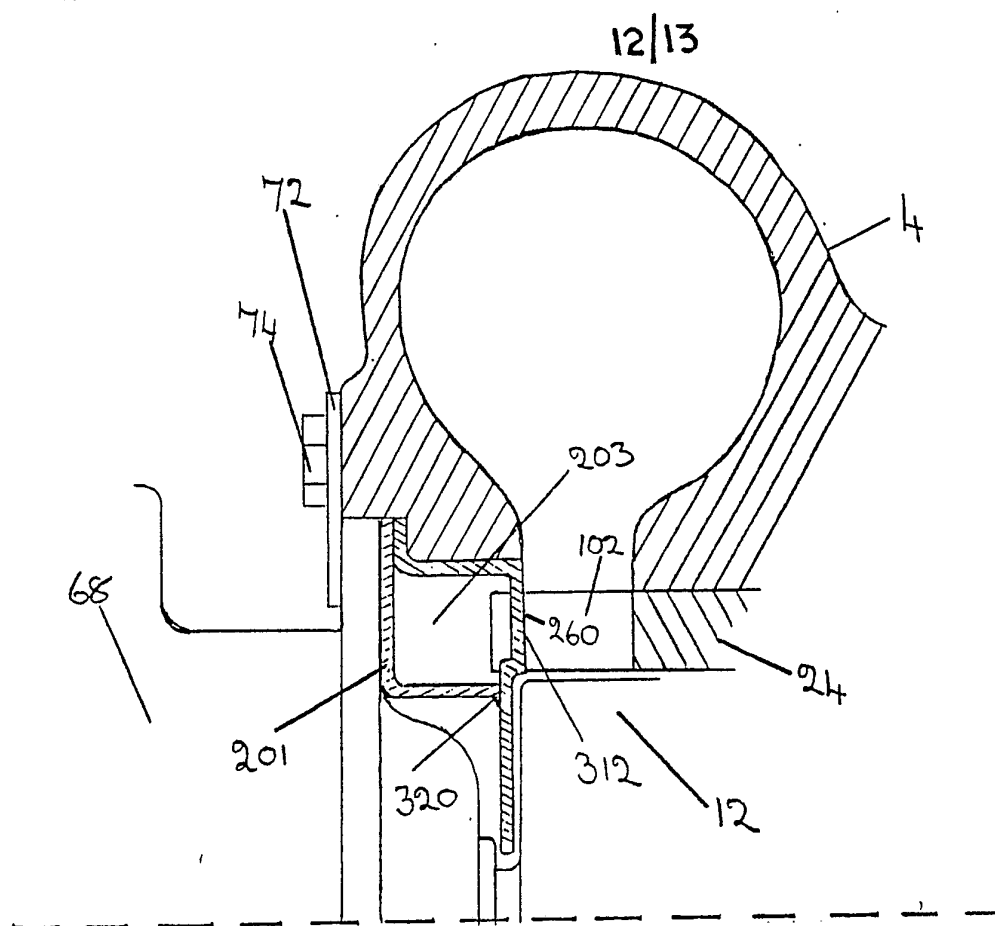


Fig. 16

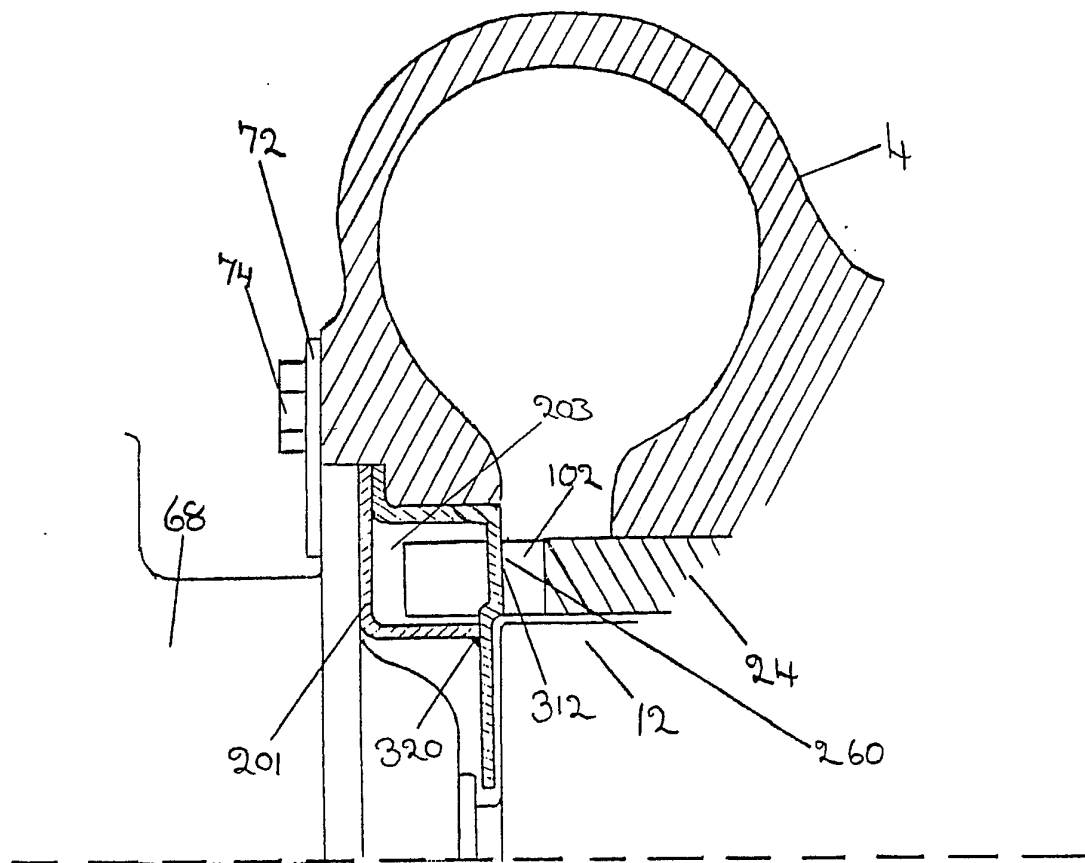


Fig. 17

13/13

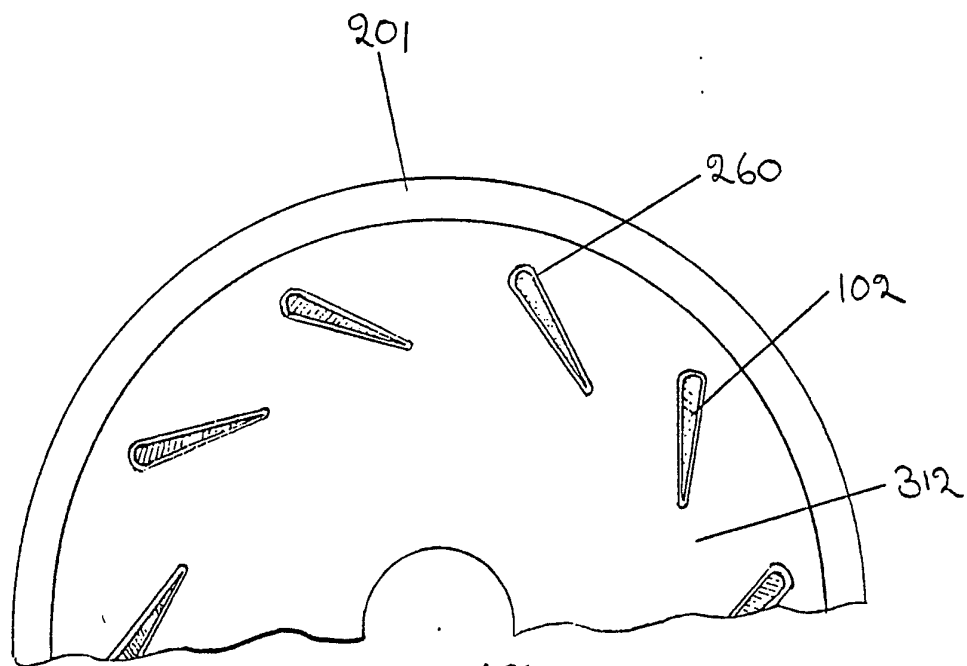


Fig. 18

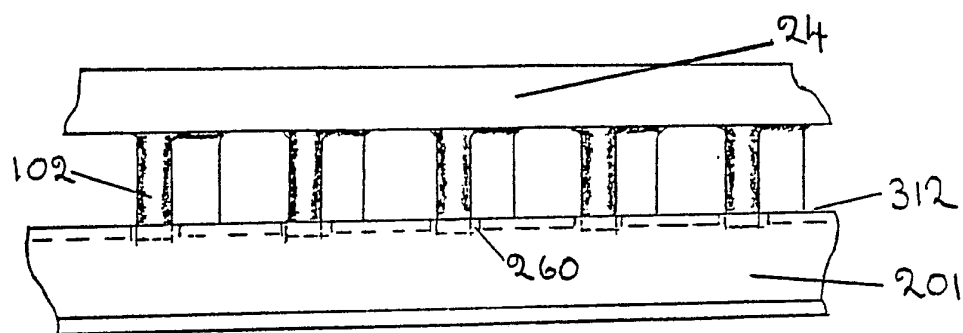


Fig. 19

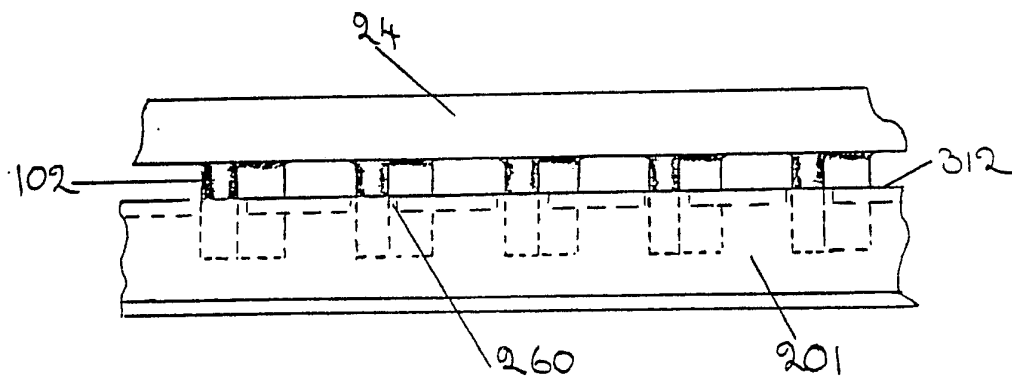


Fig. 20

INTERNATIONAL SEARCH REPORT

International Application No. PCT/GB 89/00584

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶ According to International Patent Classification (IPC) or to both National Classification and IPC IPC ⁴ : F 01 D 17/14, F 04 D 29/46, F 02 C 6/12		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
IPC ⁴	F 01 D, F 04 D	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹		
Category ⁹	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
X	EP, A, 0034915 (PEARSON) 2 September 1981, see page 3, line 6 until the end of the document	1,6,7,10,11
Y	--	1,2,5,8
Y	DE, A, 3244190 (MESSERSCHMIDT) 20 October 1983, see the whole document	1,2,5,8
A	US, A, 4403914 (ROGO) 13 September 1983, see column 3, line 17 - column 6, line 54; figures 1,3,4	1,8,11
A	EP, A, 0093462 (HÖRLER) 9 November 1983, see page 3, line 17 - page 6, line 2; figure 1	1,10,14,16

<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>¹⁰ Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p> </div> </div>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
18th August 1989	19. 09 89	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE	T.K. WILLIS	

ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.

GB 8900584

SA 28961

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 07/09/89. The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A- 0034915	02-09-81	JP-A- 56129705	12-10-81
DE-A- 3244190	20-10-83	DE-A- 3151414	11-05-83
US-A- 4403914	13-09-83	None	
EP-A- 0093462	09-11-83	DE-A- 3375419	25-02-88
		JP-A- 58192925	10-11-83
		US-A- 4586336	06-05-86