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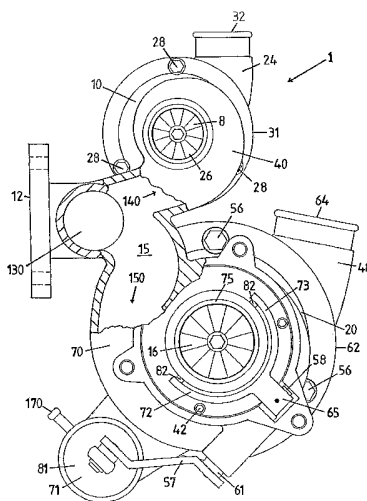
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(54) Title: TWIN TURBOCHARGER APPARATUS



(57) Abstract: Twin turbocharger apparatus (1) comprising a first stage turbocharger (10) and a second stage turbocharger (20); comprising also a slidable piston (75) for closing or restricting an area over the second stage turbine (16), and control means (81) which is connected to the slidable piston (75) and which is for controlling the sliding movement of the slidable piston (75); and the twin turbocharger apparatus (1) being such that when the slidable piston (75) is in a closed or restricted position for closing or restricting the area over the second stage turbine (16), the exhaust gases are directed to the first stage turbine (8) such that when a given boost pressure is reached on the first stage turbocharger (10), then the slidable piston (75) operates to control the turbine speed of the first stage turbocharger (10) and to allow exhaust gases to be directed to the second stage turbine (16).

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TWIN TURBOCHARGER APPARATUS

This invention relates to a turbocharger apparatus and, more especially, this invention relates to twin turbocharger apparatus.

State of the art turbocharger apparatus for supercharging internal combustion engines usually comprises a single-stage compressor driven by a single-stage turbine, of a radial type. Two-stage turbocharger apparatus is also known, sometimes also including intermediate cooling. The apparatus is usually based on standard assemblies, which is costly to manufacture.

Internal combustion engines of the future will require higher efficiency turbocharger apparatus which will require higher charging pressures in order to lower and control exhaust emissions more accurately. Turbocharger apparatus with a higher efficiency offers a greater prospect of meeting future demands for environmentally friendly and fuel efficient engines.

A first known problem with twin turbocharger apparatus is such that there is a problem in controlling gas flow accurately between the first stage turbocharger and the second stage turbocharger in order to prevent a pressure drop occurring between the first stage turbocharger and the second stage turbocharger. A second known problem is the guiding and controlling of the gas flow accurately onto the second stage turbocharger without utilising a waste gate system, in order to improve efficiency of the twin turbocharger apparatus.

It is an aim of the present invention to reduce the above mentioned problems by producing an economically viable twin turbocharger apparatus which makes better use of the energy in the engine exhaust gas flow, thereby allowing increased operating efficiency.

Accordingly, in one non-limiting embodiment of the present invention there is provided twin turbocharger apparatus comprising a first stage turbocharger and a second stage turbocharger:

the first stage turbocharger comprising a first stage compressor, a first stage turbine, a first stage compressor housing having an inlet for enabling air to be conducted to the first stage compressor, a compressor housing outlet for enabling air to exit from the first stage compressor housing, a first stage turbine housing which surrounds the first stage turbine and which receives exhaust gases from the engine before the exhaust gases are conducted to the first stage turbine, first stage turbine housing inlet for enabling the exhaust gases to be conducted to the first stage turbine in order to rotate the first stage turbine, and a bearing assembly for permitting rotation of the first stage turbine and the first stage compressor;

the second stage turbocharger comprising a second stage compressor, a second stage turbine, a second stage compressor housing having an inlet for enabling air to be conducted to the second stage compressor, a compressor housing outlet for enabling air to exit from the second stage compressor housing, a second stage turbine housing which surrounds the second stage turbine and which

receives the exhaust gases before the exhaust gases are conducted to the second stage turbine, a second stage turbine housing inlet for enabling the exhaust gases to be conducted to the second stage turbine in order to rotate the second stage turbine, and a bearing assembly for permitting rotation of the second stage turbine and the second stage compressor;

the twin turbocharger apparatus also comprising a slidable piston for closing or restricting an area over the second stage turbine, and control means which is connected to the slidable piston and which is for controlling the sliding movement of the slidable piston; and

the twin turbocharger apparatus being such that when the slidable piston is in a closed or restricted position for closing or restricting the area over the second stage turbine, the exhaust gases are directed to the first stage turbine such that when a given boost pressure is reached on the first stage turbocharger, then the slidable piston operates to control the turbine speed of the first stage turbocharger and to allow exhaust gases to be directed to the second stage turbine.

The twin turbocharger apparatus of the present invention controls the exhaust gas flow directly over the turbine of the second stage turbocharger. This allows for an accurate gas flow onto the second stage turbine. It also prevents a pressure drop between the first stage turbocharger and second stage turbocharger, when controlling the first and second stage turbochargers.

The twin turbocharger apparatus of the present invention is advantageous in that the slidable piston controls the turbine speed of the first stage turbocharger and the second stage turbocharger, and is able to operate without a waste gate bypass system.

The twin turbocharger apparatus of the present invention may be used with a single control system.

The twin turbocharger apparatus of the present invention may include guide vanes for guiding the exhaust gases accurately onto the first and/or the second stage turbine. When the guide vanes are employed, then they preferably guide the exhaust gases onto the second stage turbine.

The slidable piston may be one in which a flange with slots is provided on the end of the piston that controls the area over the turbine, the flange being allowed to slide over the vanes such as to allow an accurate gas flow between the flange and the gap over the turbine, throughout the operating range of the twin turbocharger apparatus, the flange also allowing exhaust gas pressure to work both sides of the flange in order to prevent a high pressure side load on one side of the flange. The flange may be integrally formed as a part of the slidable piston. Alternatively, the flange may be separately formed and then mounted on the slidable piston.

The flange may have a chamfer on one side of the flange for allowing exhaust gases to work on both sides of the flange when the slidable piston is in a closed position.

The turbocharger apparatus may be one in which exhaust gases work both sides of the flange in the second stage turbocharger, such that

there is no exhaust gas pressure drop between the vanes and the slots in the flange when controlling the gas flow onto the turbine.

The use of the guide vanes allows the exhaust gases to be guided accurately onto the first and/or second turbine. The flange on the end of the piston allows for an accurate gas flow to be maintained when controlling the gas flow throughout the flow range of the twin turbocharger apparatus. Thus the performance of the twin turbocharger apparatus is able to be enhanced. When exhaust gases are allowed to work on both sides of the flange, then side pressure on the control system is low. This reduces wear on components of the control system. It also allows for a smaller control system to be used than would otherwise be the case. The use of the smaller control system enables a reduction in manufacturing costs for the twin turbocharger apparatus.

The twin turbocharger apparatus may include a twin volute turbine housing on the second stage turbocharger.

The twin turbocharger apparatus may include adjuster means for setting the piston to allow a very small amount of exhaust gases past the slidable piston in order to allow rotation of the second stage turbine wheel and thereby prevent oil leakage. The oil leakage is prevented from leaking from the second stage turbocharger bearing assembly when the slidable piston is in a closed position, and the exhaust gases are working on the first stage turbine. The adjuster means is preferably employed when the turbocharger apparatus only includes a single volute turbine housing on the second stage turbocharger. The adjuster means may however also be

employed when the twin turbocharger apparatus includes the twin volute on the second stage turbocharger.

Preferably, the adjuster means comprises a stop ring which is on the slidable piston and which abuts against an insert. The adjuster means, for example the stop ring, sets the gap accurately in order to prevent a large gas bypass. When the stop ring is allowed to butt against the insert, this also prevents exhaust gas leakage past the outside diameter of the piston and the bore of the insert. When allowing a very small gap for the purpose of allowing some gases to work on the second stage turbine, a sudden pressure drop when moving the piston to control the boost pressure of the first stage turbocharger is also avoided.

A sealing ring may also be used between the piston and insert in order to prevent exhaust gas leakage, when the piston is moved within the bore of the insert.

The twin turbocharger apparatus may include an insert which allows the piston to slide in a bore in the insert, preferably, the insert is a removable insert. The use of the removable insert facilitates assembly of the twin turbocharger apparatus. When guide vanes are employed, the guide vanes may be cast as part of an insert. Alternatively, the guide vanes may be cast as part of a heat shield.

The twin turbocharger apparatus may be one in which, when the exhaust gases exit from the first stage turbine housing, the exhaust gases enter into the twin volute turbine housing on the second stage turbocharger, such that the exhaust gases are kept apart so as to allow different pressures

in each volute, in order to allow the gases from the first stage turbocharger to work on the second stage turbine. This design allows the exhaust gases from the first stage turbine to rotate the second stage turbine. This is particularly advantageous when the second stage piston is in a closed position, and the exhaust gases are being directed onto the first stage turbine. This design also allows for gases from the first stage turbine to work on the second stage turbine throughout the flow range of the twin turbocharger apparatus, without increasing back pressure on the exit area of the first stage turbine.

If desired, the twin volute turbine housing may be such that the volute that takes the exhaust gases from the first stage turbine housing may be of a size so as to limit the gas flow through the volute. This may then limit the gas flow through the first stage turbine, in order to allow a larger gas flow through the second stage turbine at a given part of the flow range.

When using the twin volute turbine housing, the overall efficiency of the twin turbocharger apparatus may be enhanced as compared with not using the twin volute turbine housing.

The twin turbocharger apparatus of the present invention may be one in which the first stage turbocharger includes a control flap mounted in the exhaust gas inlet of the turbine housing in order to allow for a control system of the twin turbocharger apparatus, whereby the exhaust gases are able to be prevented from working on the first stage turbine, in order to send all of the exhaust gases to the second stage turbine at higher flow rates, or in order to allow both turbine areas to be closed for an exhaust gas braking

system. The control flap may also be used for controlling pressure in the twin turbocharger apparatus at idle and low engine speeds, in order to keep a given pressure within the turbine housing, and thereby to reduce pressure build up time within the turbine housings.

The twin turbocharger apparatus may be one in which the turbine housings are cast as a single unit with the exhaust manifold. This may reduce manufacturing costs of the twin turbocharger apparatus. Alternatively, the turbine housings may be cast as a single unit and may be mounted on an engine exhaust manifold, or two single turbochargers may be used.

When the twin turbocharger apparatus includes the guide vanes, then the guide vanes may be held against the turbine housing, a heat shield or bearing assembly in order to prevent exhaust gases working around the end face of the guide vanes. This gives an accurate gas flow around the guide vane area.

The removable insert may be one which is held in place by clamping means, by being bolted directed to the turbine housing, or by spring means.

If desired, the insert may be a non-removable insert which is not removable from the turbine housing.

The twin turbocharger apparatus may include at least one heat shield for shielding the bearing assemblies from heat from the exhaust gases. Usually two heat shields will be employed, one for each bearing assembly. The or each heat shield may be a ring-shaped heat shield. Alternatively, the or each heat-shield may be a disc-shaped heat shield having an outer ring

portion, an inner wall portion, and an aperture through the inner wall portion. The heat shield may alternatively be of a design which allows the heat shield to float and be held in position by spring means in order to prevent gas leakage. If desired, the guide vanes may be mounted on the heat shield.

The twin turbocharger apparatus may be one in which the control means includes a fork member which is connected to the piston on two opposed sides. The turbocharger apparatus may prevent hot gases from working on the fork member and its associated parts, by having the piston such that it slides within a bore of an end cover. The control means may alternatively include a U-shaped member which is connected to the piston on a face of the piston.

The control means may be an electronic control means which operates as part of an engine management system. The control means may use an air or oil-operated control actuator in conjunction with the engine management system.

The twin turbocharger apparatus of the present invention is advantageous in that it is able to use the second stage variable turbine area using a slidable piston, that allows the turbine area to be closed or restricted such that the exhaust gases are allowed to be directed to the first stage turbine. This allows a faster response of the first stage turbine, such that when a given boost pressure is reached on the first stage turbocharger, the slidable piston is allowed to open so as to control the boost pressure of the first stage turbocharger and allow exhaust gases to work on the second stage turbocharger.

Also the use of the slidable piston of a second stage turbocharger apparatus allows control of the first and second stage turbochargers of the twin turbocharger apparatus, without the need to employ a waste gate bypass system.

The twin turbocharger apparatus of the present invention may prevent the exhaust gases from working on the second stage twin turbocharger directly over the turbine of the second stage turbocharger in order to allow gases to enter into the second stage turbine housing and thereby prevent a pressure drop between the first and second turbocharger stages. This allows for a quicker response of the second stage turbine. It also allows the exhaust gases to be guided accurately onto the second stage turbine, for example through the guide vanes and the flange on the piston, allowing for an accurate gas flow throughout the flow range of the twin turbocharger apparatus. A single control unit may be used without the need for a waste gate bypass system.

The exhaust gases from the first stage turbine may be used to increase the efficiency of the twin turbocharger apparatus such that the exhaust gases are able to be sent through the above mentioned preferred twin volute second stage turbine housing in which the exhaust gases are kept apart. This allows the exhaust gases from the first stage turbine to work on the second stage turbine throughout the flow range of the twin turbocharger apparatus. The control flap may be used to control the exhaust gas flow to the first stage turbine such as to allow an exhaust gas braking

system to be used, and also to allow the exhaust gases to be directed to the second stage turbine.

The twin turbocharger apparatus of the present invention is able to be manufactured economically and to make better use of the energy in the engine exhaust gas flow. This provided increased efficiency, thereby helping to meet future demands for environmentally friendly and fuel efficient 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 sectional side view of first twin turbocharger apparatus;

Figure 2 is a part section of the control of the twin turbocharger apparatus shown in Figure 1;

Figure 3 is a part sectional view of a control of second twin turbocharger apparatus, showing a twin volute turbine housing;

Figure 4 is a sectional side view of third twin turbocharger apparatus, showing a flap on a first stage turbine housing;

Figure 5 is a part sectional view of the control of the twin turbocharger apparatus shown in Figure 4, with a control piston being in a closed position;

Figure 6 is a part sectional view of the control of the twin turbocharger apparatus shown in Figure 4, with the control piston being in an open position;

Figure 7 is a sectional side view of fourth twin turbocharger apparatus showing a control flap on a first stage turbine housing, and the bypass of

gases from the first stage turbine housing to a twin volute turbine housing on a second stage turbine;

Figure 8 is a part sectional view of the control of the twin turbocharger apparatus shown in Figure 7, and shows the twin volute second stage turbine housing and a flap on the first stage turbine housing;

Figure 9 is a sectional side view of fifth twin turbocharger apparatus;

Figure 10 is a part sectional view of the fifth twin turbocharger apparatus shown in Figure 9; and

Figure 11 is a sectional side view of a turbine housing assembly for twin turbocharger apparatus, and shows a compact design.

Referring to Figures 1 and 2, there is shown first turbocharger apparatus 1. The turbocharger apparatus 1 comprises a housing 15. The housing 15 forms an exhaust manifold section 130, a first stage turbine housing section 40, and a second stage turbine housing 70.

The twin turbocharger apparatus 1 comprises a first stage turbocharger 10 mounted onto the first stage turbine housing 40. The first stage turbocharger 10 comprises a turbine 8, a compressor (not shown) which is mounted for rotation on a common shaft and which may be part of the turbine 8. The first stage turbocharger 10 also comprises a bearing assembly and heat shield (not shown) for allowing rotation of the compressor and turbine wheel. The first stage turbocharger also comprises a compressor housing 24, which is mounted on the first stage turbocharger 10 in order to allow rotation of a compressor within the compressor housing 24. The compressor housing 24 is held in position by bolts 28. The

compressor housing 24 has a first compressor inlet 31, and a first compressor outlet 32.

The housing 15 has an exhaust gas inlet 12 for allowing exhaust gases from an engine (not shown) to enter an exhaust manifold section 130 of the housing 15. The housing 15 has an inlet 140 for allowing exhaust gases to enter into the first stage turbine housing 40. This allows exhaust gases to work on the first stage turbine 8. The turbine housing 40 has an outlet 26 from the first stage turbine housing 40.

The turbocharger apparatus 1 has a second inlet 150 in the housing 15 for allowing exhaust gases to enter into the second stage turbine housing 70. This allows exhaust gases to work on the second stage turbine 16.

The twin turbocharger apparatus 1 comprises a second stage turbocharger 20. The second stage turbocharger 20 is mounted onto the second stage turbine housing 70 such as to allow exhaust gases to work on the second stage turbine 16. The second stage turbocharger 20 comprises the turbine wheel 16, and a compressor (not shown) which is mounted for rotation on a common shaft 37 which is part of the turbine 16 as shown in Figure 2. The second stage turbocharger 20 also comprises a bearing assembly 51 and a heat shield 52 for shielding the bearing assembly 51 from hot gases. The bearing assembly 51 allows rotation of the compressor and turbine 16. Also forming part of the second stage turbocharger 20 is a compressor housing 48 which is mounted on the turbocharger assembly 20 so as to allow rotation of a compressor within the compressor housing 48. The compressor housing 48 is held in position by bolts 56. The compressor

housing 48 has an inlet 62 and an outlet 64. Also shown in Figure 2 is the bearing assembly 51 being held in place by clamping plates 76 and bolts 74.

The twin turbocharger apparatus 1 comprises a variable turbocharger second stage. This includes the second turbine housing 70 and a piston 75. The piston 75 is a slidable piston 75. The piston 75 is slidable between a chamber 80 and the turbine 16. This allows the piston 75 to slide and close the area between the chamber 80 and the turbine 16. This allows the exhaust gases to be directed onto the first stage turbine 8 in the first stage turbine housing 40. When a given boost level is achieved on the first stage turbocharger, the piston 75 is able to control the gap over the second stage turbine 16 so as to control the turbine speed of the first stage turbine wheel 8, and also to allow exhaust gases to pass to the second stage turbine 16. The second stage slidable piston 75 is such that the piston 75 is able to control the speed of the turbine in the first stage turbocharger and also the speed of the turbine in the second stage turbocharger, without a waste gate system being employed. This saves on the manufacturing costs of the waste gate system, and it also avoids the possibility of the waste gate system wearing and breaking down.

The slidable piston 75 has an end 27 formed to have a flange 47. The flange 47 may have slots (not shown) formed in the flange 47 in order to allow vanes to slide through the slots. The flange 47 has a chamfer 87 for allowing exhaust gases to work both sides of the flange 47 when the piston 75 is in a closed position over the turbine wheel 16 of the second stage turbocharger. The flange is such as to allow exhaust gases to work both

sides of the flange, and this prevents a high side load on the piston 75. This in turn helps to allow for the control unit 81 to be formed of a compact design as shown.

The piston 75 is allowed to slide within the bore of an insert 53. The insert 53 has vanes 21. A flange 47 of the piston 75 is allowed to slide over the vanes 21 and the piston 75 is able to slide between the vanes and the turbine wheel. Adjuster means in the form of a stop ring 50 forms part of the piston 75. The stop ring 50 has a groove 90 for receiving part of a control system. The stop ring 50 allows the piston 75 to be set so as to allow a very small gas flow past the second stage turbocharger when the piston 75 is in a closed position and if desired. This allows rotation of the second stage turbine 16, in order to prevent oil leakage past the bearing assembly 51 when the exhaust gases are being directed to the first stage turbine 8.

The stop ring 50 is allowed to abut against the end 19 of the insert 53. This enables an accurate setting to be achieved. When the stop ring 50 is allowed to butt against the end 19 of the insert 53, this prevents gas leakage past the bore of the insert 53 and the outer diameter of the piston 75.

In order to prevent gas leakage when controlling the first and second stages of the twin turbocharger apparatus 1, a sealing ring 35 may be located in the piston 75 (see Figure 2). If desired, the sealing ring 35 may be located within the bore of the insert 53.

The twin turbocharger apparatus 1 has control means 81 for controlling the sliding movement of the piston 75. The control means 81 has an air intake 170 for controlling an actuator 71. A diaphragm (not shown) in the actuator member 71 is acted upon by air or a vacuum. The air intake is controlled by an electronic control device (not shown). Movement of the diaphragm causes movement of a lever 57. This in turn causes rotation of a rod 58 which is connected to the lever 57. The rod 58 is allowed to rotate within a bush 61. The bush 61 is mounted within the turbine housing 70. The rod 58 is connected to a fork device 65. The fork device 65 has a pair of arms 72, 73. Each arm 72, 73 has a locator member 82. Each locator member 82 locates in a groove 90 of the stop ring 50 shown in Figure 2. The stop ring 50 forms part of the piston 75. The control is such that movement of the lever 57 allows movement of the fork device 65. This in turn causes a sliding movement of the piston 75 in order to control the area over the second stage turbine wheel 16.

An alternative form of control of the slidable piston on the second stage turbocharger is shown in Figures 9 and 10.

Referring now to Figures 9 and 10, there is shown the control means 41 having an air intake 270 for controlling an actuator member 45. A diaphragm (not shown) in the actuator member 45 is acted upon by air or a vacuum. The air intake or vacuum is controlled by an electronic control device (not shown). Movement of the diaphragm causes movement of a rod 18 and movement of the piston 55 that is connected to the rod 18 by arms 25 of the piston 55.

An alternative control means to the actuator control 71 shown in Figure 1 may be an electronic control device (not shown).

Figure 2 shows an end cover 84 on the second stage turbocharger turbine housing 70. The end cover 84 is held in position by bolts 85. The end cover 84 allows assembly of the second stage turbocharger, when a fork device 65 is used, and it allows the piston 75 to slide within the bore of the end cover 84 in order to prevent side ways movement of the piston 75. The end cover 84 prevents hot gases working on the fork device 65.

It can be seen from Figure 2, the vanes 21 are mounted on the insert 53. In an alternative embodiment of the invention, the vanes may be mounted on a heat shield or insert, as shown in the turbocharger apparatus of Figure 10.

Figure 2 shows the insert 53 being mounted within the turbine housing 70 in order to allow the vanes 21 to be held against the turbine housing 70. In an alternative embodiment of the invention, the vanes may be held against a heat shield or the bearing assembly. When the end of the vanes are held this way, the gases are not allowed to work around the end face of the vanes. This enables a more accurate gas flow to be achieved around the end of the vane area.

Figure 2 shows the insert 53 being mounted within the turbine housing 70 in order to prevent the exhaust gas loss between the insert 53 and the turbine housing 70. Figure 2 shows the use of a clamping plate 17 which may be of a spring-type material. The clamping plate 17 may be held in place with bolts 42. Alternatively, the clamping plate may be formed as

part of the insert. Alternatively, the insert may be held in position by spring means as shown in Figure 10, whereby the spring 67 holds the insert 68 and prevents gas leakage past the spring 67. The spring means may be advantageous for manufacture and assembly of the twin turbocharger apparatus.

Referring now in detail to Figures 3 – 11, similar parts as in Figures 1 and 2 have been given the same reference numerals for ease of comparison and understanding.

Referring now to Figure 3, there is shown a part section of second twin turbocharger apparatus 2. The twin turbocharger apparatus 2 has a twin volute turbine housing 23. When exhaust gases exit from the first stage turbocharger turbine housing 40, the exhaust gases may be sent to the second stage twin volute turbine housing 23 such that the exhaust gases enter into the volute chamber 77 of the twin volute turbine housing 23. This allows the exhaust gases from the first stage turbocharger to work on the turbine 16 of the second stage turbocharger. It also allows the turbocharger apparatus 2 to be such that the volute chambers 77 and 78 of the twin volute turbine housing 23 are separate so as to allow different pressures in each volute chamber 77 and 78. Thus the volute chamber 78 of the turbine housing 23 may be used to control the twin turbocharger apparatus, and allow the chamber 78 to be closed so as to prevent exhaust gases from the engine working on the turbine 16 in order to send the exhaust gases to the first stage turbocharger.

Referring now to Figures 4 – 6, Figure 4 is a sectional side view of a third twin turbocharger apparatus 3. The twin turbocharger apparatus 3 is such that the second stage turbocharger works and is controlled in the same way as shown in Figures 1 and 2. The twin turbocharger apparatus 3 has a first stage turbocharger, having a control flap 34. The control flap 34 is mounted within the exhaust gas inlet 38 of the turbine housing 94. This forms a control system for the twin turbocharger apparatus 3 which is such that the exhaust gases are able to be prevented from working on the turbine 8 at higher flow rates, in order to direct the exhaust gases to the second stage turbine 16.

The control flap 34 also allows both turbine areas to be closed so as to allow an exhaust braking system to be used in the twin turbocharger apparatus 3. The control flap 34 may also be used to control pressure in the twin turbocharger apparatus 3 at engine idle speeds, in order to keep a given pressure within the turbine housing(s) 94, and 95. This reduces pressure build up time within the turbine housings 94, 95. As also shown in Figure 4, the twin turbocharger apparatus 3 is such as to allow fitting of the control flap 34, the turbine housings 94, 95 being a single cast housing 97 that is mounted onto the exhaust manifold 198. The control flap 34 has an actuator control unit 92 for controlling movement of the control flap 34. Air or vacuum may be used to control movement of the control actuator 92. Alternatively, if desired, an electronic control unit may be employed.

Referring to Figure 5, there is shown a part section of the control system of the second stage turbocharger shown in Figure 4. The control

system works in the same way as shown in Figures 1 and 2. The piston 75 is shown in a closed position. Also shown in Figure 5 is a side view of the control lever 98. As can be seen, a connector pin 96 is employed to connect the actuator control unit 92 to the control flap 34.

Referring now to Figure 6, there is shown a part section of the control system of the second stage turbocharger as shown in Figures 4 and 5. Figure 6 shows the piston 75 in an open position.

Referring now to Figure 7, there is shown a sectional side view of fourth twin turbocharger apparatus 4. The twin turbocharger apparatus 4 combines design features of the twin turbocharger apparatus shown in Figures 1 – 6. The twin turbocharger apparatus 4 may be especially efficient in operation. The twin turbocharger apparatus 4 has a second stage variable turbine area as shown in Figures 1 and 2. The twin turbocharger apparatus 4 has the twin volute turbine housing shown in Figure 3 for allowing exhaust gases from the first stage turbine housing to work on the second stage turbine. The twin turbocharger apparatus 4 has the control flap shown in Figures 4 – 6.

Referring now to Figure 8, there is shown a part section of control means for the twin turbocharger apparatus 4 shown in Figure 7. As shown in Figure 8, the twin turbocharger apparatus 4 employs the design features of the twin turbocharger apparatus shown in Figures 1 – 7. Thus the twin turbocharger apparatus 4, has a second stage variable turbine area as shown in Figures 1 – 2, showing the piston 75 in a closed position. The twin turbocharger apparatus 4 has the twin volute turbine housing shown in

Figure 3 for allowing exhaust gases from the first stage turbine to work on the second stage turbine. The twin turbocharger apparatus 4 has the control flap shown in Figure 4 – 7, in order to allow exhaust gases to be directed to the second stage turbine at high flow rates if desired, and to allow the use of an exhaust gas braking system with the twin turbocharger apparatus 4.

Referring now to Figures 9 and 10, there is shown an alternative form of control means for controlling the sliding piston on the second stage turbocharger of fifth twin turbocharger apparatus 5. The control means is shown as control means 41 having an air intake 270 for controlling an actuator member 45. When a diaphragm (not shown) in the actuator member 45 is acted upon by air or a vacuum, the movement of the diaphragm causes movement of a rod 18 and movement of a piston 55 that is connected to the rod 18 by arms 25 of the piston 55. The vanes 60 may be mounted on the insert 68 or on the heat shield 59. When the vanes 60 are mounted on the insert 68, a spring 67 may push the end 107 of the vanes 60 against the heat shield 59 in order to allow an accurate gas flow around the end of the vanes 60. Figure 9 also shows how the gases that exit from the first stage turbocharger 102 are able to be sent through the exit chamber 105 of the second stage turbocharger.

Referring now to Figure 11, there is shown a part sectional side view of an exhaust manifold and twin turbocharger housing 307. The housing 307 is cast as a single housing. The housing 307 is of a compact design. Specifically, the turbine area 305 of the second stage turbocharger is cast

very close to the exhaust manifold 302. This allows the volute chamber 310 to be as close as possible to the exhaust manifold 302. This allows for a reduction in pressure build-up time within the volute chambers of the twin turbocharger apparatus. To prevent the compressor housing from touching the exhaust manifold 302, the design is such that the compressor housing is allowed to overlap the end section of the exhaust manifold 302.

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, guide vanes may be used on the first stage turbocharger. Two single turbochargers may be mounted on the exhaust manifold. The first stage turbocharger may also use a slidable piston.

CLAIMS

1. Twin turbocharger apparatus comprising a first stage turbocharger and a second stage turbocharger:

the first stage turbocharger comprising a first stage compressor, a first stage turbine, a first stage compressor housing having an inlet for enabling air to be conducted to the first stage compressor, a compressor housing outlet for enabling air to exit from the first stage compressor housing, a first stage turbine housing which surrounds the first stage turbine and which receives exhaust gases from the engine before the exhaust gases are conducted to the first stage turbine, first stage turbine housing inlet for enabling the exhaust gases to be conducted to the first stage turbine in order to rotate the first stage turbine, and a bearing assembly for permitting rotation of the first stage turbine and the first stage compressor;

the second stage turbocharger comprising a second stage compressor, a second stage turbine, a second stage compressor housing having an inlet for enabling air to be conducted to the second stage compressor, a compressor housing outlet for enabling air to exit from the second stage compressor housing, a second stage turbine housing which surrounds the second stage turbine and which receives the exhaust gases before the exhaust gases are conducted to the second stage turbine, a second stage turbine housing inlet for enabling the exhaust gases to be conducted to the second stage

turbine in order to rotate the second stage turbine, and a bearing assembly for permitting rotation of the second stage turbine and the second stage compressor;

the twin turbocharger apparatus also comprising a slidable piston for closing or restricting an area over the second stage turbine, and control means which is connected to the slidable piston and which is for controlling the sliding movement of the slidable piston; and

the twin turbocharger apparatus being such that when the slidable piston is in a closed or restricted position for closing or restricting the area over the second stage turbine, the exhaust gases are directed to the first stage turbine such that when a given boost pressure is reached on the first stage turbocharger, then the slidable piston operates to control the turbine speed of the first stage turbocharger and to allow exhaust gases to be directed to the second stage turbine.

2. Twin turbocharger apparatus according to claim 1 in which the slidable piston controls the turbine speed of the first stage turbocharger and the second stage turbocharger.

3. Twin turbocharger apparatus according to claim 1 or claim 2 in which the slidable piston is used in the second stage turbocharger, and in which the piston controls the gas flow directly over the turbine of the second stage turbocharger and allows exhaust gases to enter into the second stage

turbine housing when the piston is in a closed position, in order to prevent a pressure drop occurring between the first stage turbocharger and the second stage turbocharger when controlling the twin turbocharger apparatus between turbocharger stages, thereby to allow an accurate gas flow between stages and a faster second stage turbine response.

4. Twin turbocharger apparatus according to any one of the preceding claims including guide vanes for guiding the exhaust gases accurately onto the first and/or second stage turbine.

5. Twin turbocharger apparatus according to claim 4 in which the guide vanes are cast as part of an insert, or are cast as part of a heat shield.

6. Twin turbocharger apparatus according to claim 4 or claim 5 and including a flange with slots provided on the end of the piston that controls the area over the turbine the flange being allowed to slide over the guide vanes such as to allow an accurate gas flow between the flange and the gap over the turbine throughout the operating range of the twin turbocharger apparatus, the flange also allowing exhaust gas pressure to work both sides of the flange so as to prevent a high pressure side load on one side of the flange.

7. Twin turbocharger apparatus according to claim 6 and including a chamfer on one side of the flange for allowing exhaust gases to work on both sides of the flange when the slidable piston is in a closed position.
8. Twin turbocharger apparatus according to claim 6 or claim 7 in which exhaust gases work both sides of the flange in the second stage turbocharger, such that there is no exhaust gas pressure drop between the vanes and the slots in the flange when controlling the gas flow onto the turbine.
9. Twin turbocharger apparatus according to any one of the preceding claims and including adjuster means for setting the piston in order to allow a very small amount of exhaust gas past the second stage slidable piston, in order to allow rotation of the second stage turbine wheel and thereby prevent oil leakage.
10. Twin turbocharger apparatus according to claim 9 in which the adjuster means is a stop ring on the piston for butting against an insert.
11. Twin turbocharger apparatus according to claim 9 in which the insert is a removable insert.

12. Twin turbocharger apparatus according to claim 9 or claim 10 and including a sealing ring for forming an auxiliary seal for preventing loss of exhaust gases that may pass between the piston and the insert.

13. Twin turbocharger apparatus according to any one of the preceding claims and including a twin volute turbine housing on the second stage turbocharger.

14. Twin turbocharger apparatus according to claim 13 in which the exhaust gases exit from the first stage turbine housing such that the exhaust gases enter into the twin volute turbine housing, the twin volute turbine housing being positioned on the second stage turbocharger, and the exhaust gases being kept apart in order to allow different pressures in each volute, in order to allow the gases from the first stage turbocharger to work on the second stage turbine wheel.

15. Twin turbocharger apparatus according to claim 13 or claim 14 in which the twin volute turbine housing is such that exhaust gases are kept apart in order to allow different pressures in each volute in order to allow the gases from the first stage turbocharger to work on the second stage turbine wheel, the twin volute turbine housing being such that the slidable piston is allowed to work within a second volute of the twin volute turbine housing in order to control gas flow and thereby allow the exhaust gases to be directed

to the first stage turbocharger and allow control of the turbine speeds of the first stage turbocharger and second stage turbocharger.

16. Twin turbocharger apparatus according to any one of claims 13 – 15 in which the twin volute turbine housing on the second stage turbocharger allows exhaust gases from the first stage turbocharger to work on the turbine of the second stage turbocharger, and in which exhaust gases from the first stage turbocharger are allowed to flow through the twin volute turbine housing throughout the flow range of the twin turbocharger apparatus without causing a high back pressure on the first stage turbine wheel.

17. Twin turbocharger apparatus according to any one of claims 13 - 16 in which the twin volute turbine housing is such that the volute that takes the exhaust gases from the first stage turbine is of a size to limit the gas flow through the volute.

18. Twin turbocharger apparatus according to any one of the preceding claims and including a control flap mounted in the exhaust gas inlet of the first stage turbine housing.

19. Twin turbocharger apparatus according to claim 18 in which the control flap operates to allow control of the twin turbocharger apparatus whereby the exhaust gases are prevented from working on the first stage

turbine, so as to send the exhaust gases to the second stage turbine at higher flow rates.

20. Twin turbocharger apparatus according to claim 18 or claim 19 in which the control flap operates to allow for twin turbocharger apparatus in which both turbine areas are able to be closed to allow for an exhaust gas braking system.

21. Twin turbocharger apparatus according to claim 18, claim 19 or claim 20 in which the control flap operates to allow control of exhaust gas pressure within the turbine housings of the twin turbocharger apparatus at engine idle speeds, and thereby to reduce exhaust gas pressure build up time within the turbine housings of the twin turbocharger apparatus.

22. Twin turbocharger apparatus according to any one of the preceding claims in which the turbine housings are cast as a single unit with the exhaust manifold.

23. Twin turbocharger apparatus according to any one of claims 1 – 21 in which the twin turbocharger housings are cast as a single casting.

24. Twin turbocharger apparatus according to claim 11 or any claim when dependent upon claim 11 in which the guide vanes are mounted on the removable insert, and in which the vanes are held against the turbine

housing, a heat shield or the bearing housing in order to prevent exhaust gases working around the end face of the guide vanes, thereby to give an accurate gas flow around the guide vane area.

25. Twin turbocharger apparatus according to claim 11 or any claim when dependent upon claim 11 in which the removable insert is held in place by clamping means, direct bolting to the turbine housing, or by spring means.

26. Twin turbocharger apparatus according to any one of the preceding claims and including at least one heat shield for shielding the bearing assemblies from heat from the exhaust gases.

27. Twin turbocharger apparatus according to claim 26 in which the heat shield is a ring-shaped heat shield.

28. Twin turbocharger apparatus according to claim 26 in which the heat shield is a disc-shaped heat shield having an outer ring portion, an inner wall portion, and an aperture through the inner wall portion.

29. Twin turbocharger apparatus according to claim 26 in which the heat shield is such that it floats and is held in position by spring means in order to prevent gas leakage.

30. Twin turbocharger apparatus according to claim 4 and 26 in which the guide vanes are mounted on the heat shield.
31. Twin turbocharger apparatus according to any one of the preceding claims in which the control means includes a fork member which is connected to the piston on two opposed sides.
32. Twin turbocharger apparatus according to claim 31 in which the fork member is connected to the slidable piston such that the fork member is protected from hot gases by allowing the piston to slide within a bore of an end cover.
33. Twin turbocharger apparatus according to any one of claims 1 – 29 in which the control means includes a U-shaped member which is connected to the piston on a face of the piston.
34. Twin turbocharger apparatus according to any one of the preceding claims in which the control means includes an electronic means which operates as part of an engine management system.
35. Twin turbocharger apparatus according to any one of the preceding claims in which the control means includes an air or oil operated control actuator.

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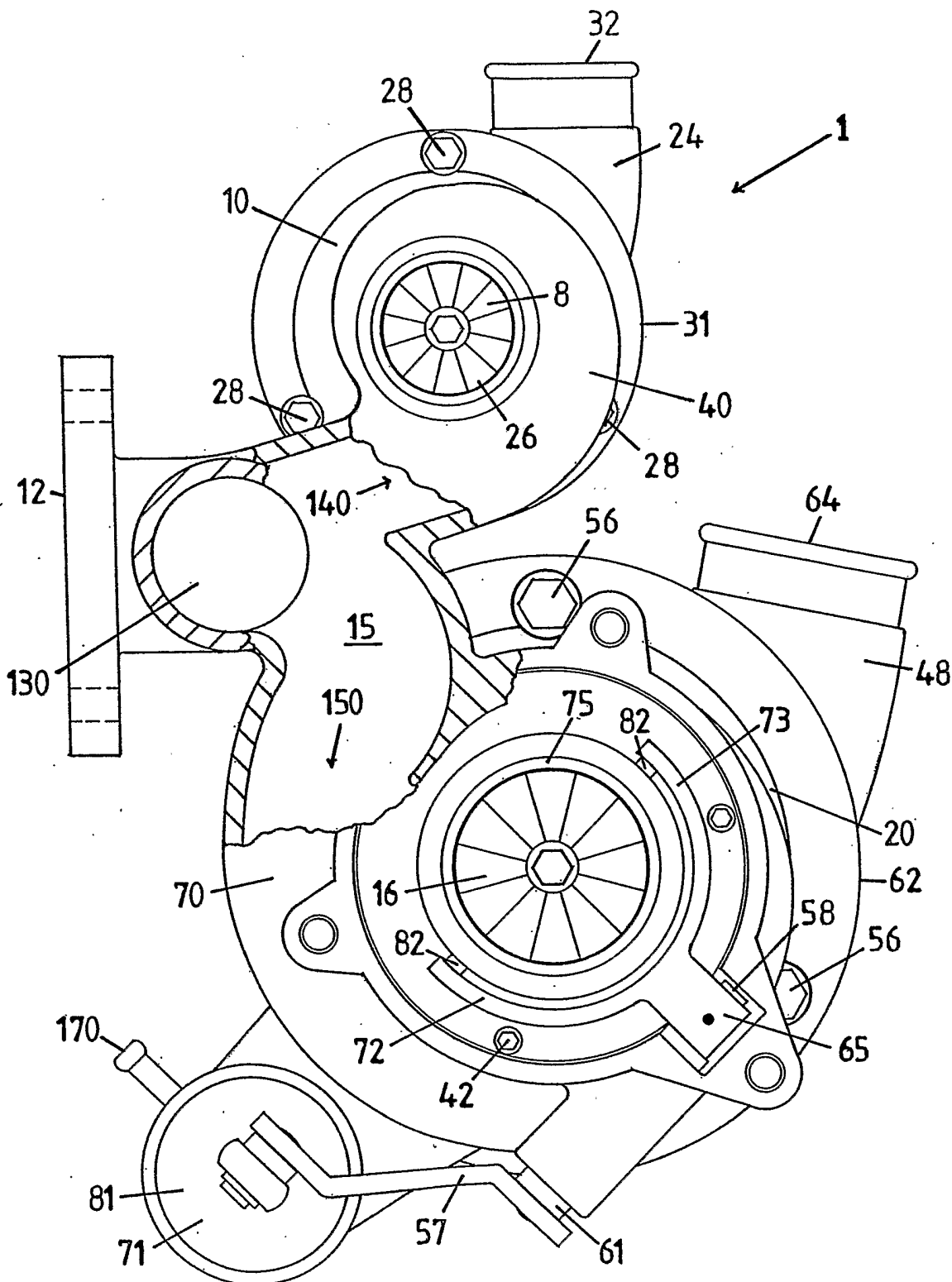


FIG1

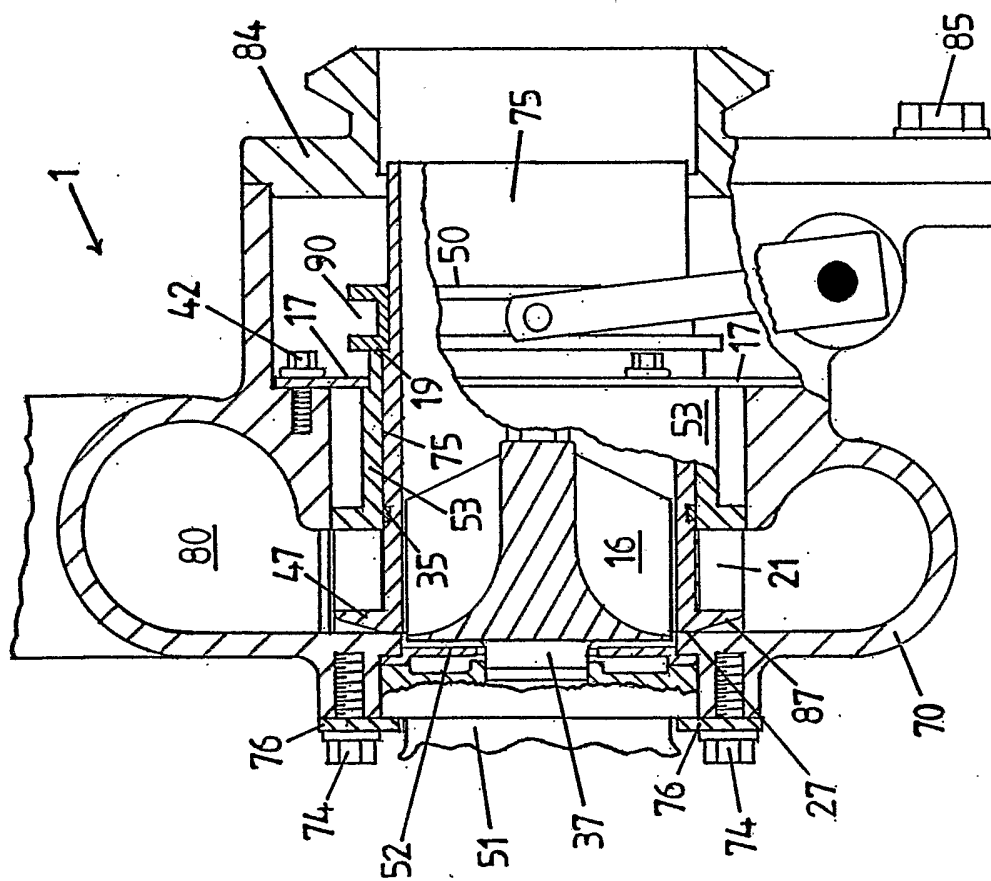


FIG 2

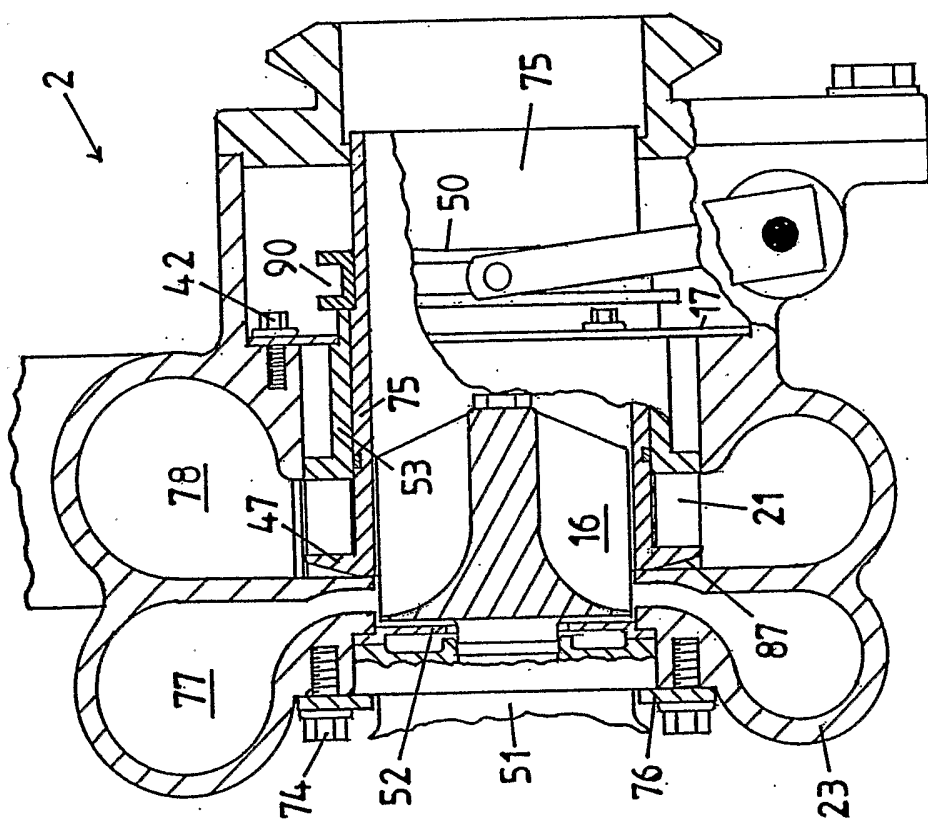


FIG 3

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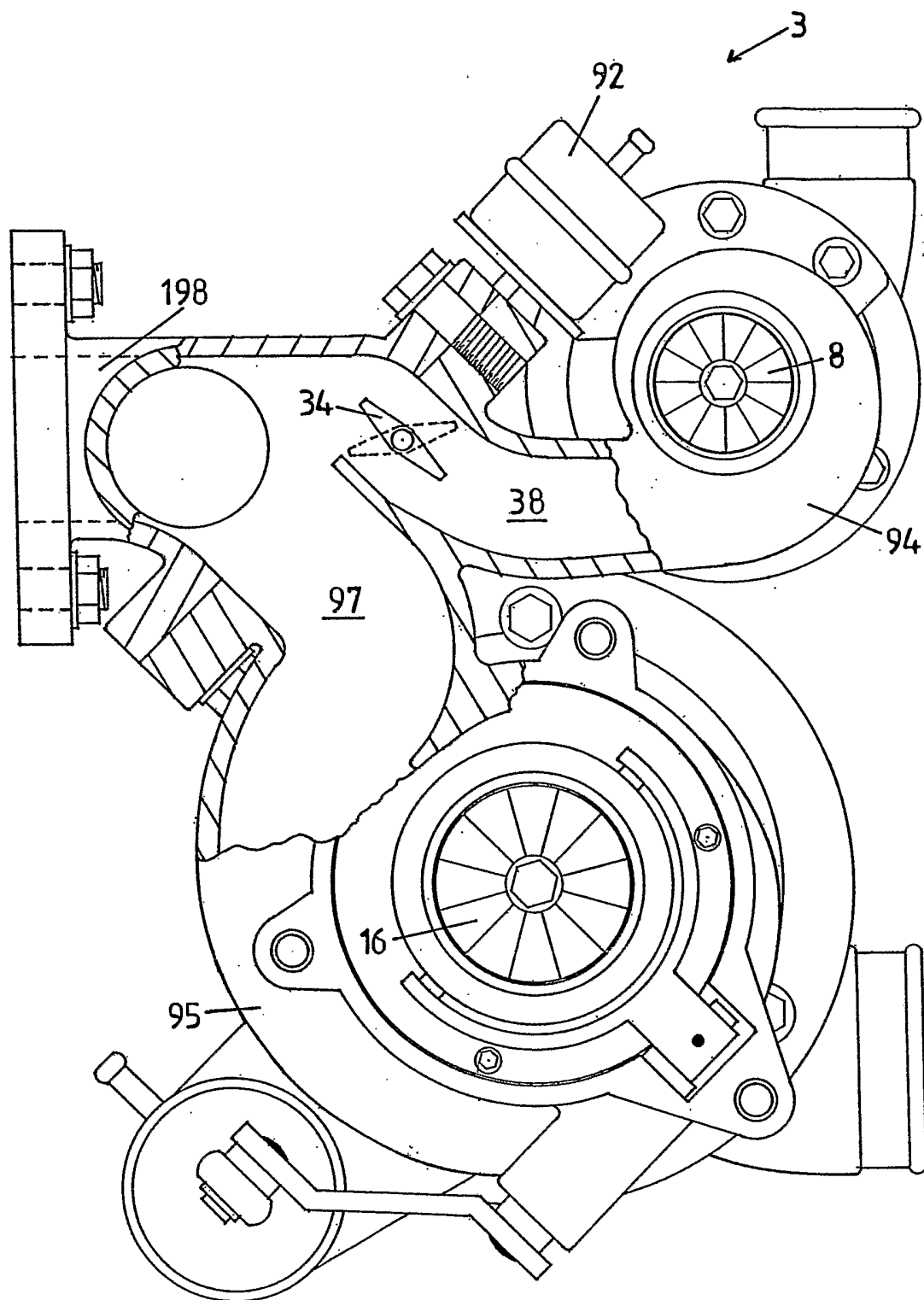


FIG 4

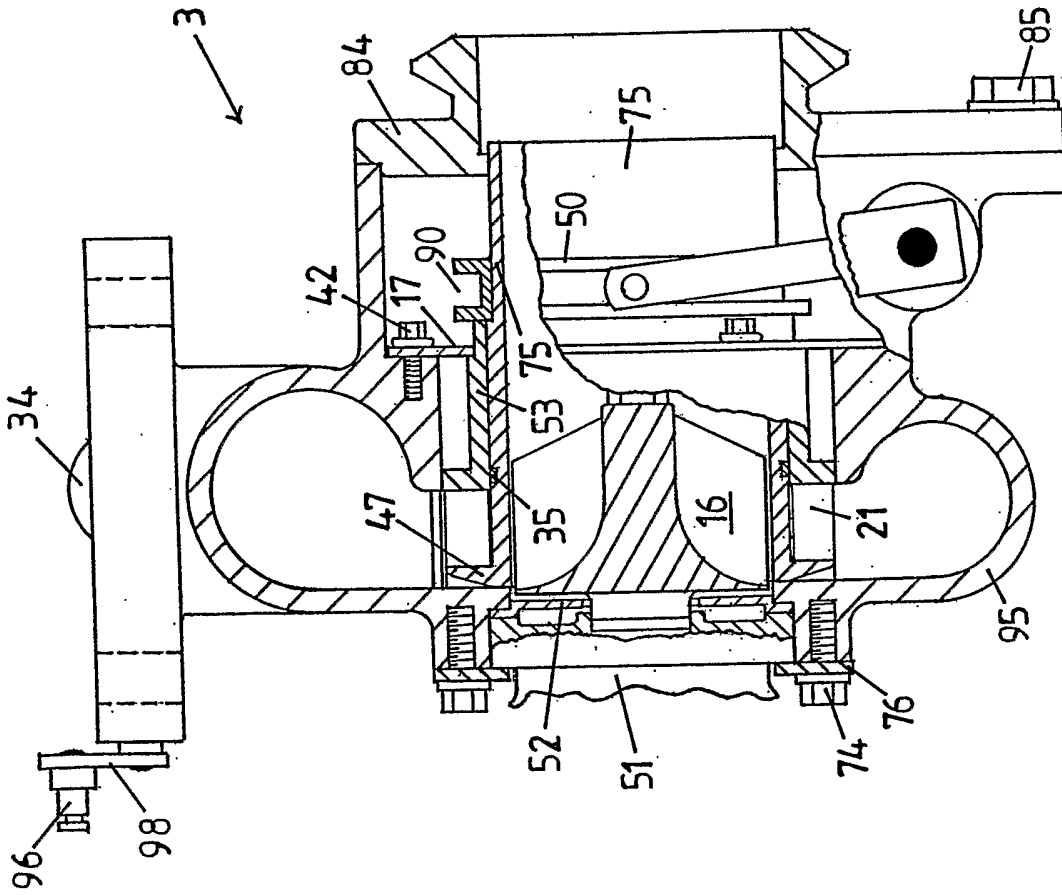


FIG 5

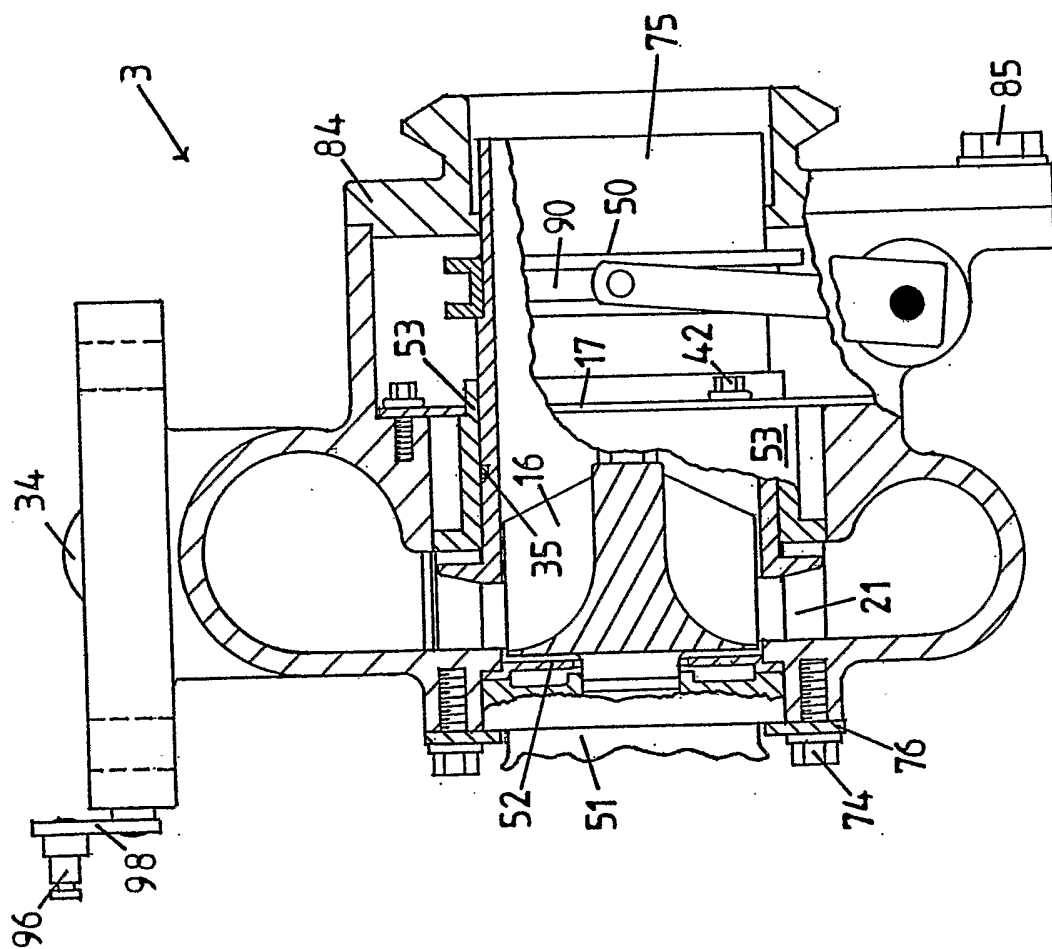


FIG 6

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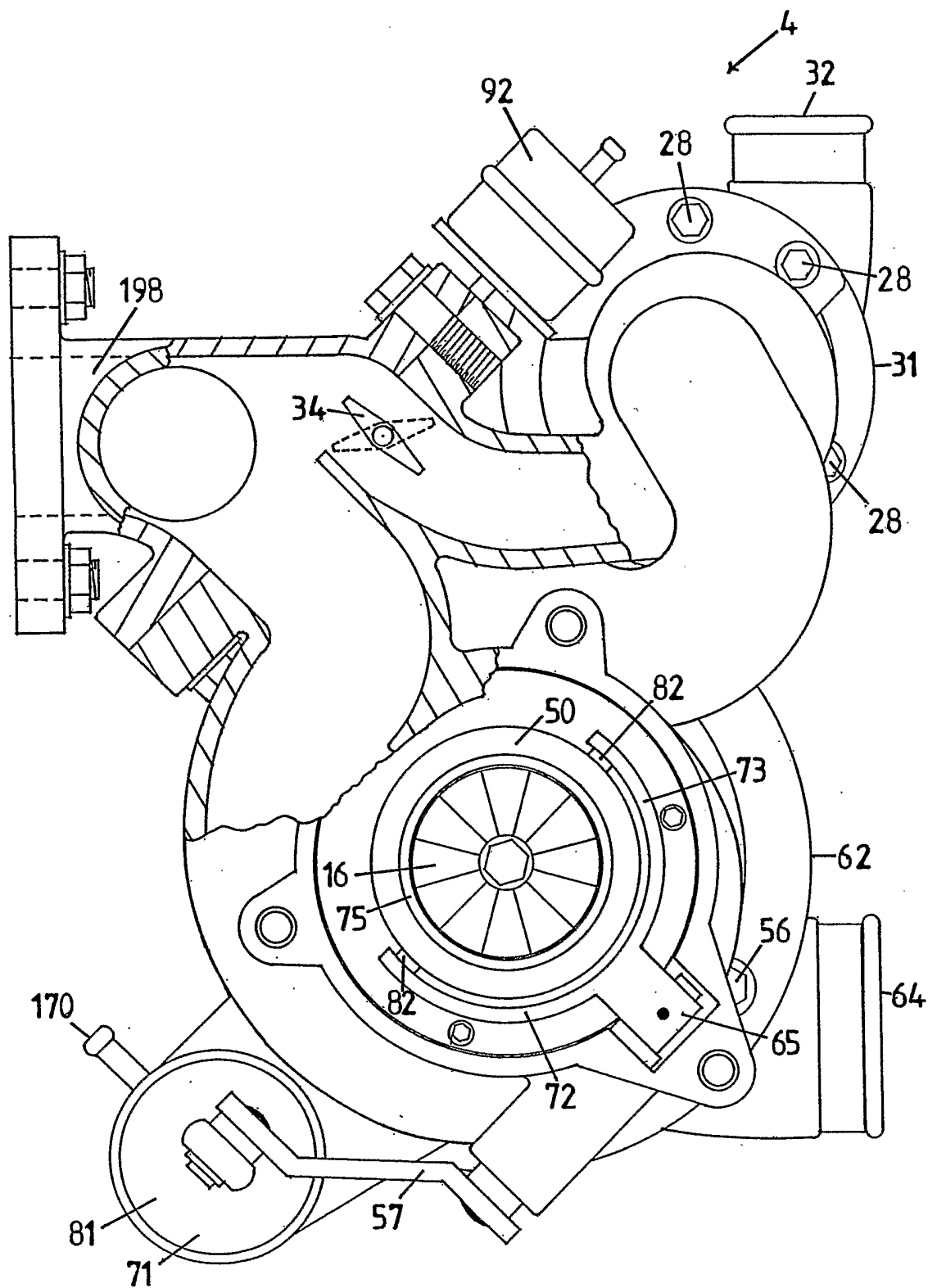


FIG 7

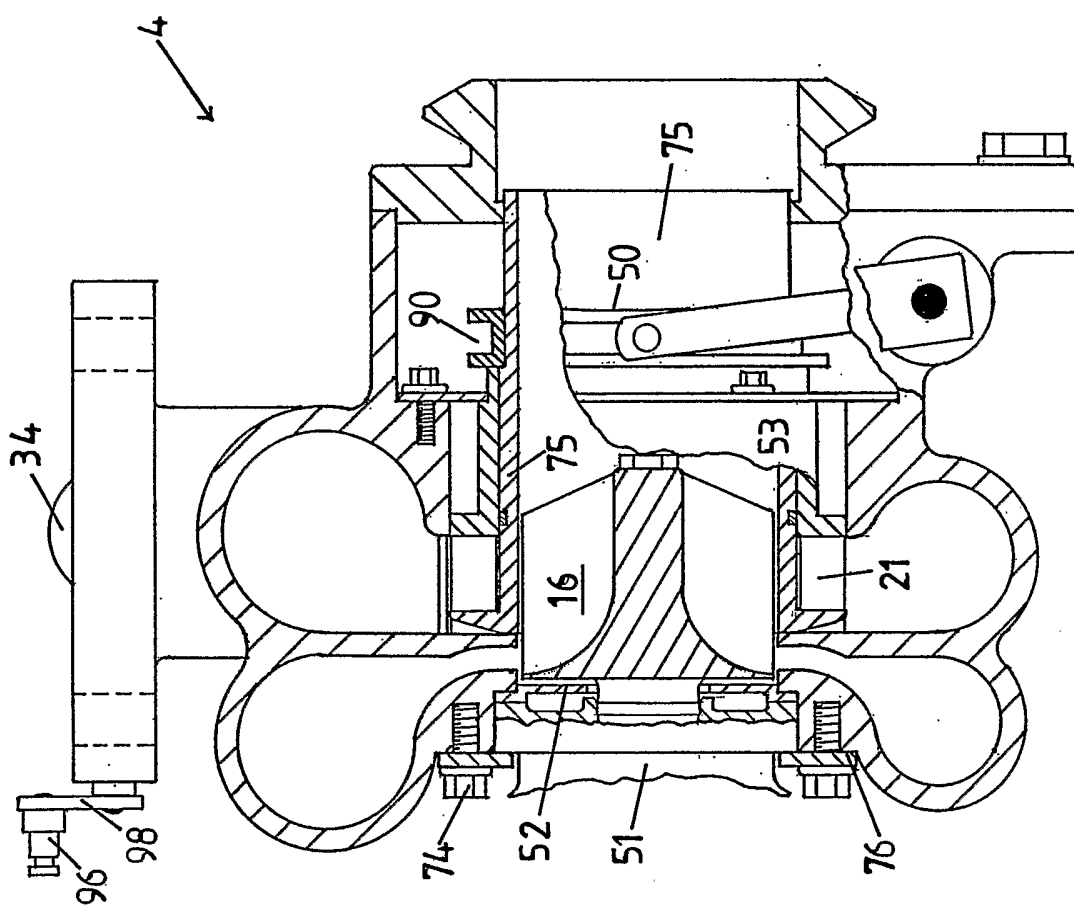


FIG 8

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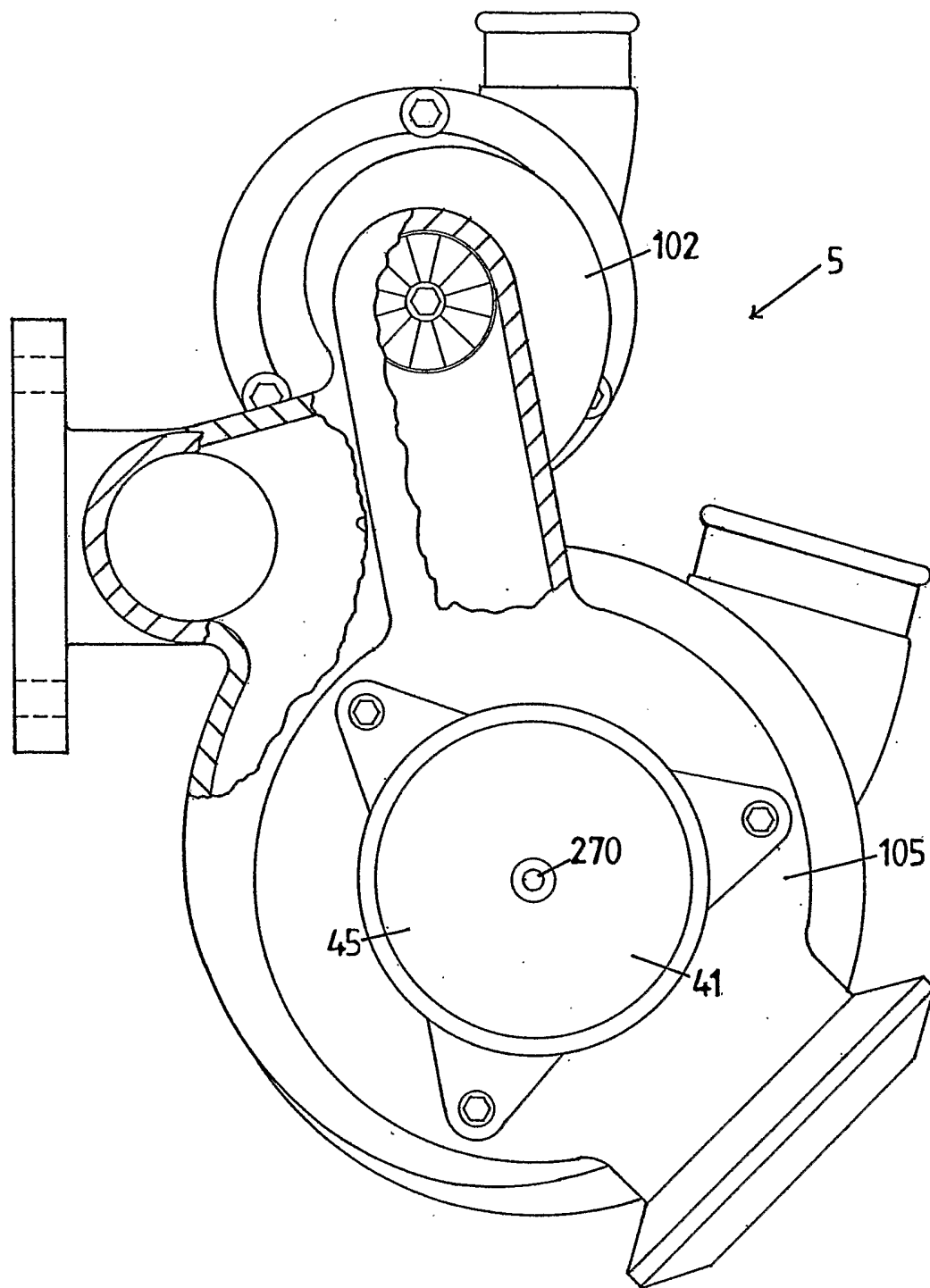


FIG 9

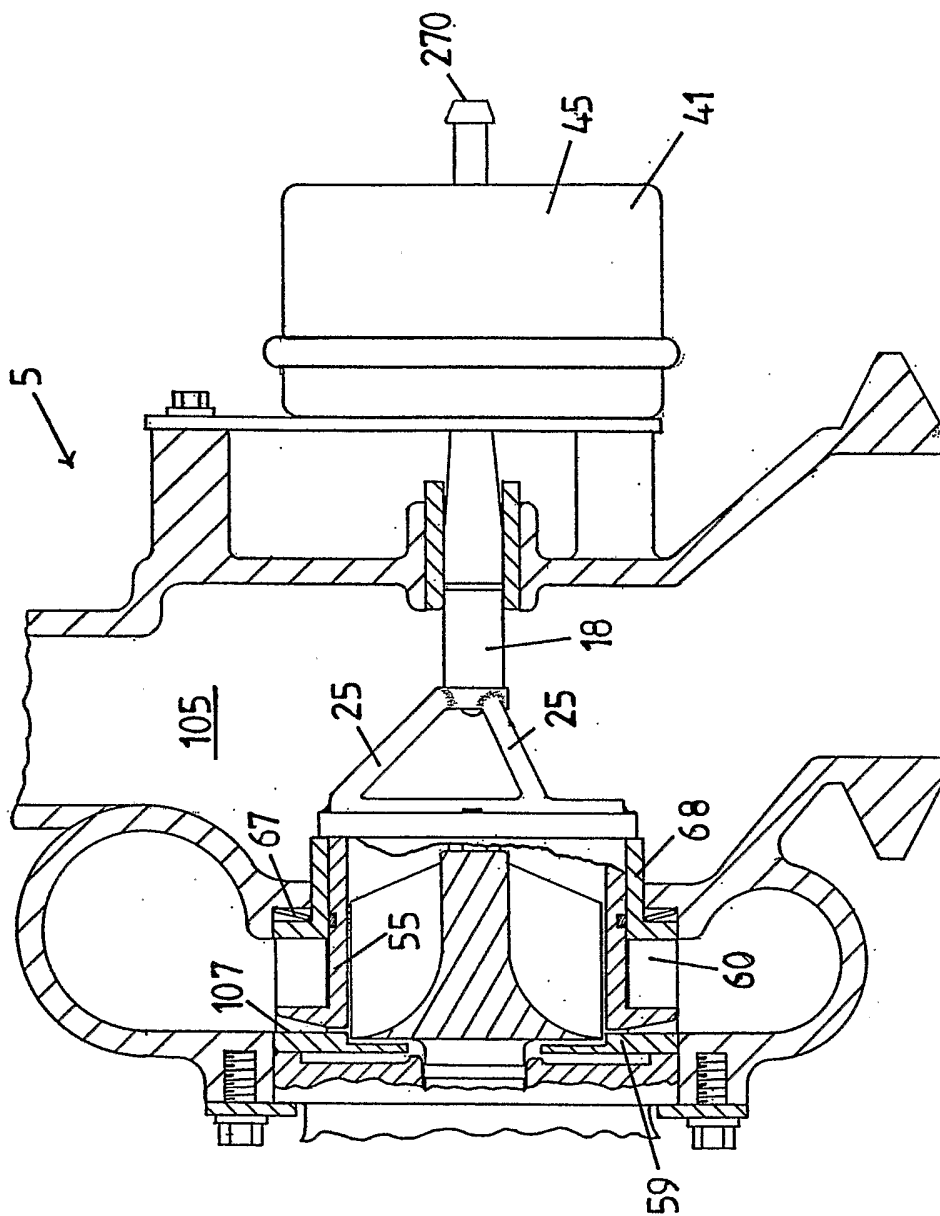


FIG 10

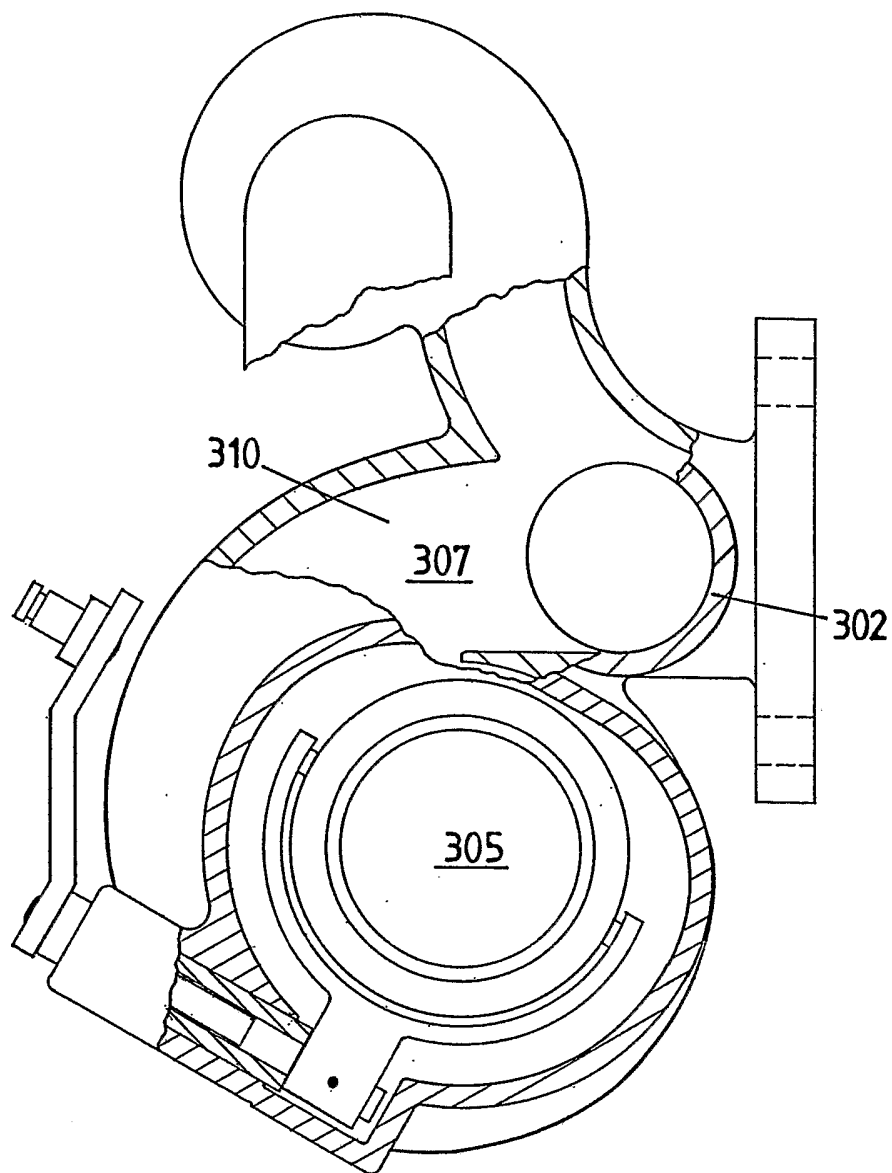


FIG 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2006/001610

A. CLASSIFICATION OF SUBJECT MATTER
INV. F02C6/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F02C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 032 262 A (ZEHNDER ET AL) 28 June 1977 (1977-06-28) figures column 3, line 5 - column 4, line 19 -----	1-35
A	PATENT ABSTRACTS OF JAPAN vol. 014, no. 327 (M-0998), 13 July 1990 (1990-07-13) -& JP 02 112618 A (TOYOTA MOTOR CORP), 25 April 1990 (1990-04-25) abstract; figures -----	1-35
A	PATENT ABSTRACTS OF JAPAN vol. 018, no. 279 (M-1612), 27 May 1994 (1994-05-27) -& JP 06 050158 A (FUJI HEAVY IND LTD), 22 February 1994 (1994-02-22) abstract; figures -----	1-35
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See patent family annex.

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Date of the actual completion of the international search

20 July 2006

Date of mailing of the international search report

01/08/2006

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INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2006/001610

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Information on patent family members

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