

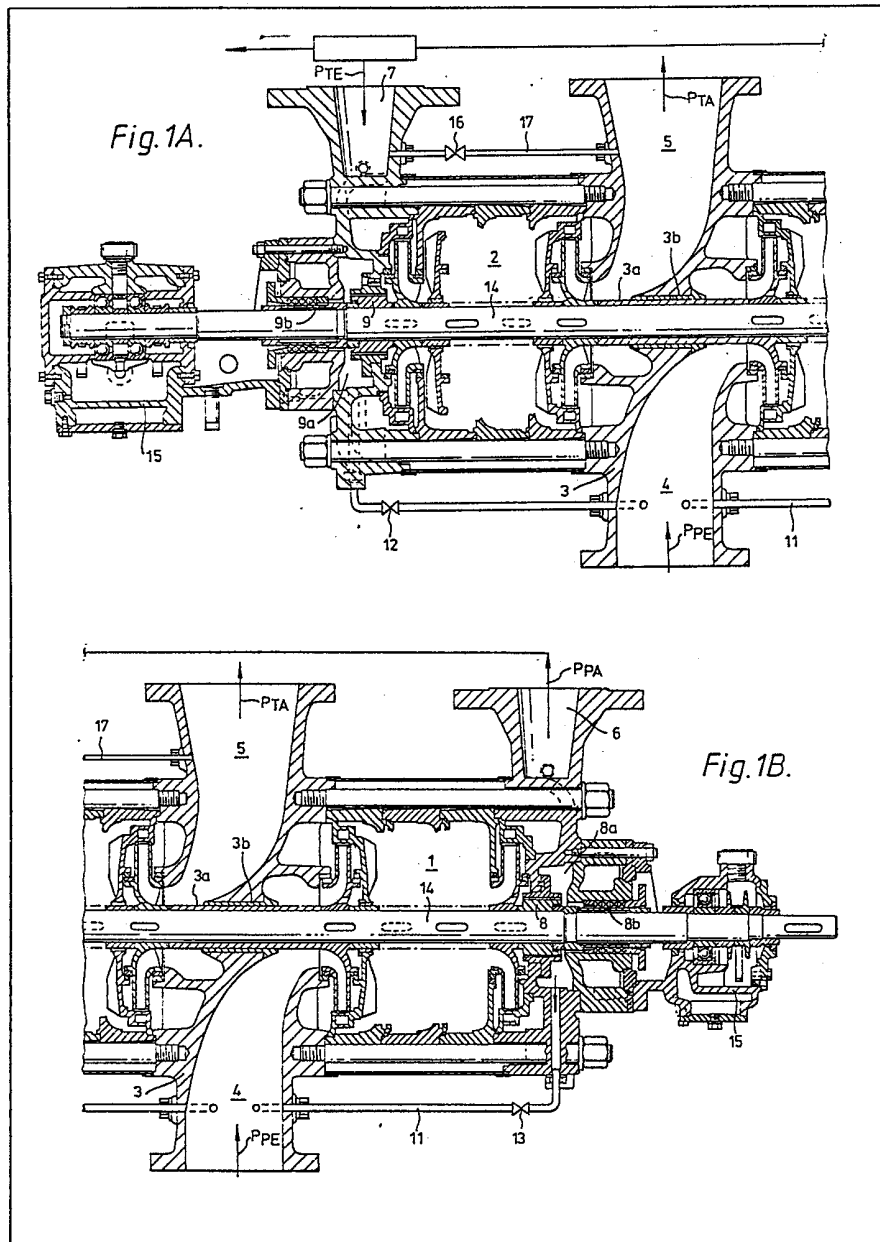
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(54) Turbopump

(57) In a turbopump comprising a centrifugal pump section 1 and a turbine section 2, the rotors of which are disposed on a common shaft, the low-pressure intake end of the centrifugal pump section and the low pressure delivery end of the turbine section are disposed closest to one another, and are physically connected and separated from one another by a

physically interposed low-pressure section 3 which provides an entry spigot 4 for the centrifugal pump section and a delivery spigot 5 for turbine section. Pistons 8 and 9 disposed at opposite ends of the common shaft are acted on by the fluid pressures in respective chambers to provide axial forces on the shaft counteracting those due to the centrifugal pump unit and the turbine unit.



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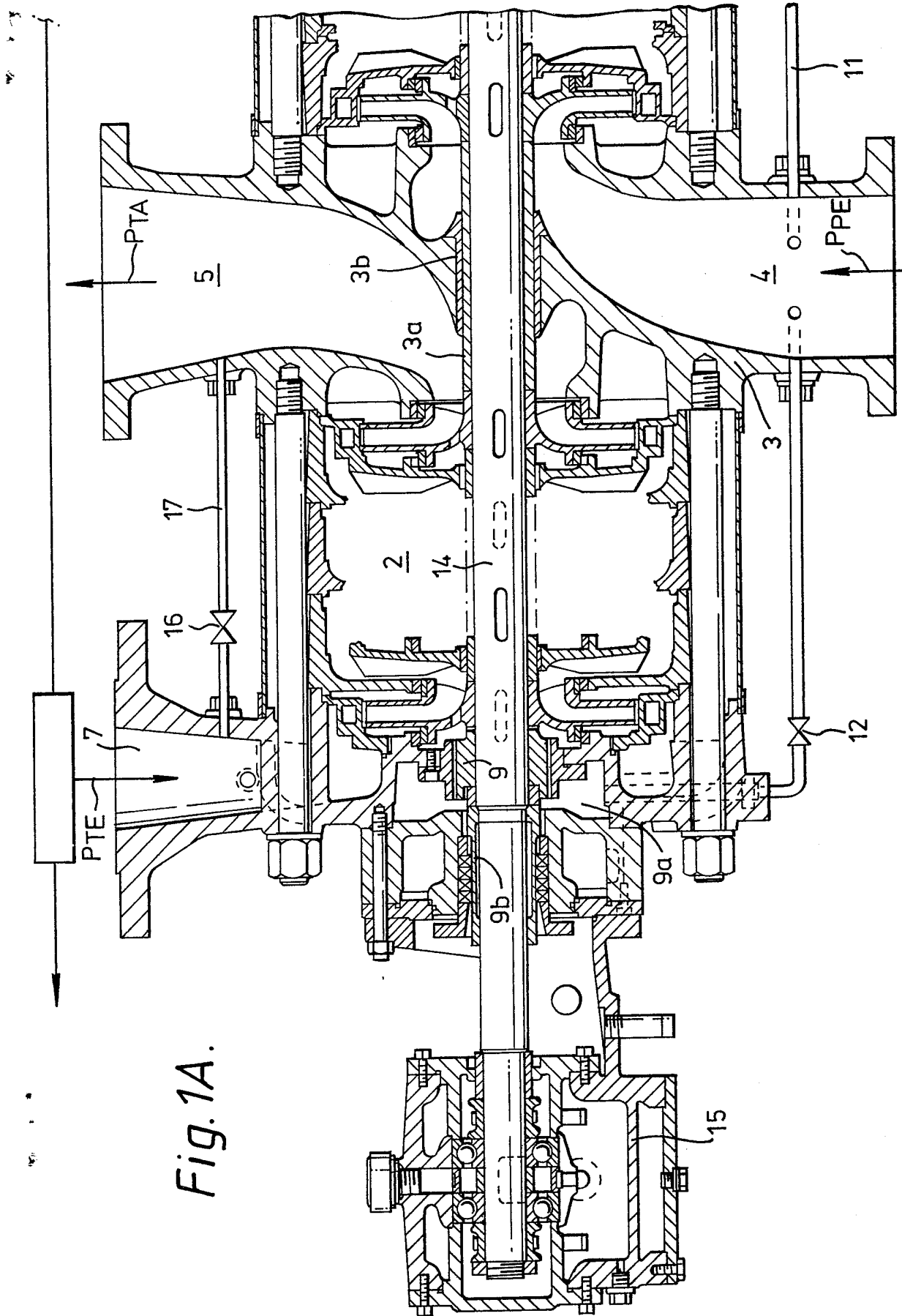
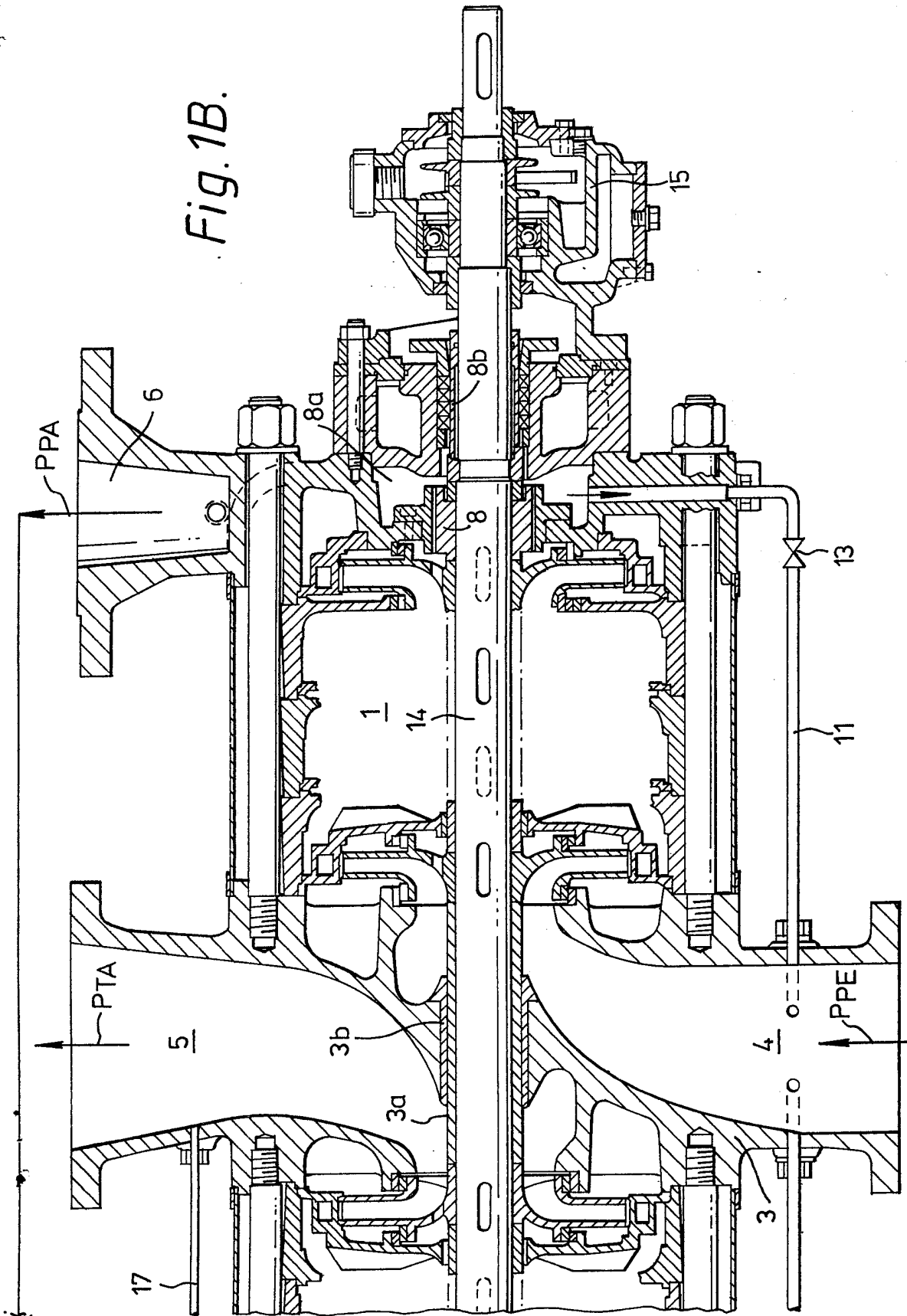


Fig. 1A.

Fig. 1B.



SPECIFICATION

Turbopump

This invention relates to a turbopump comprising a centrifugal pump section having an inlet and an outlet and, disposed on the same shaft, a turbine section having its own inlet and outlet.

Turbopumps for large pump units in storage operation which have a pump rotor and a turbine rotor disposed on the same line of shafting are known.

Also known are turbopumps in which multistage centrifugal pumps are coupled with radial stages adapted to operate as turbines. In these turbopumps, the pump section and the turbine section are disposed on a common shaft. Units of this kind are used more particularly in washing and cleaning processes where high-pressure liquid is needed and the liquid discharged from the circuit must have its pressure reduced. Product flows of the pump circuit can be branched off so that smaller quantities at lower pressure than the pump delivery pressure are available for the turbine section. To keep the whole circuit in operation, the pump section must provide the necessary pressure. The additional energy which must be provided because of the branched flow of product and of unavoidable losses is normally provided by an electric motor or some other drive. The same is connected to the unit by way of a coupling. However, the main feature of such units is that the energy input to operate the circuit process but not required for the flow of product is recovered directly as driving energy.

European Patent Application 0008260 discloses a turbopump in which the pump section and the turbine section are coupled together at their high-pressure ends. This arrangement helps to balance the axial forces of the pump section and turbine section but has the disadvantage of needing an expensive central member whose strength characteristics must be suitable for a high pressure.

It is an object of the invention to provide a turbopump which requires only a low-cost central member.

According to the invention there is provided a turbopump comprising a centrifugal pump section having an inlet and outlet and, disposed on the same shaft, a turbine section having its own inlet and outlet, and in which a low-pressure section is interposed physically between, and mechanically connects, the centrifugal pump section and the turbine section.

The pump/turbine separation needed in the low-pressure section in a turbopump embodying the invention is simply because the pressure difference between the pump intake orifice and the turbine exit is low. Also, such a separation has low losses. Since this low-pressure section is required to withstand only a low pressure, it is simple to produce and construct.

As a means of fully compensating for axial forces in a turbopump embodying the invention,

65 relief pistons may be provided on the high-pressure side of each of the centrifugal pump section and turbine section, the piston diameters being adapted to the different axial forces involved. The unit can therefore operate with low-loss rolling bearings.

70 Pressure-reducing flows guided by way of the relief pistons can also be used for control purposes, viz. to adapt the turbine characteristic to the pump characteristic. Since the consumption of multistage pumps operated as turbines is not variable, there must be optimal adaptation of the operating points of the pump section and turbine section to one another and this may be achieved quite simply in this case by a control line.

80 In a preferred embodiment of the invention, the spigots of the low-pressure section of the turbopump, viz. the entry spigot of the centrifugal pump section and the delivery spigot of the turbine section, are disposed on the same axis as one another.

85 An embodiment of the invention is described below with reference to the accompanying drawing which shows a view in axial section of a turbopump embodying the invention.

90 The turbopump comprises a centrifugal pump section 1 and a turbine section 2. A common low-pressure section 3 mechanically interconnects the sections 1 and 2. The section 3 comprises inlet spigot 4 of the pump section 1 and outlet spigot 5 of turbine section 2. The free end parts of the spigots 4 and 5 extend along a common axis perpendicular to that of the pump shaft 14. Also, the pump section 1 has a pump outlet 6 and the turbine section 2 has a turbine inlet 7.

100 Means for compensating for axial forces are disposed at the high-pressure side of the sections 1 and 2, and comprise a relief piston 8 in the pump section 1 and a relief piston 9 in the turbine section 2. Relief lines 10, 11 having restrictors 12, 13 are also provided. Shaft 14 is sealed by conventional shaft seals (not shown). Shaft 14 runs in rolling bearings 15.

105 A connection 17 for fluid flow, having a control element 16, extends between the high-pressure section 7 and the low-pressure section 5 of the turbine 2.

110 The process liquid enters entry spigot 4 of pump section 1 at entry pressure p_{PE} . After having its pressure increased in pump section 1 the liquid leaves the same by way of outlet 6 at an outlet pressure p_{PA} . A proportion of the liquid no longer required for the process and at a pressure p_{TE} reduced by system losses as compared with p_{PA} enters the high-pressure section of the turbine section 2 and goes therefrom to turbine exit 5 where the liquid is still at the pressure p_{TA} . The energy yielded by the liquid in its flow through the turbine 2 is supplied directly by way of the shaft 14 to the pump section 1. The energy yielded to the process flow and lost in friction is replaced by a drive (not shown) such as an electric motor.

115 Because of the pressure difference $p_{PE} - p_{TA}$ between the pump inlet 4 and the turbine exit 5 a fixed restrictor, acting as separation between the

sections 1 and 2, is supplied with liquid. Consequently, and as at all the other sealing zones within the complete unit, an additional bearing is provided. A plain bearing through which fluid flows due to the pressure differences between its ends, is defined between shaft 14 and the portion of section 3 through which shaft 14 extends. Similar plain bearings through which fluid flows due to analogous pressure differences are defined at other places where the shaft 14 passes through fixed members of the turbopump. Since the pressures in the pump section 1 and turbine section 2 differ from one another, the shaft 14 experiences axial forces which are compensated for by relief piston 8 of the pump and relief piston 9 of the turbine. A chamber on the right hand side of the piston 8 is connected with the inlet 4 by the line 11 while a chamber on the left hand side of the piston 9 is connected with the inlet 4 by the line 12. Since the pistons 8, 9 are disposed at respective readily accessible ends of the turbopump, they can be replaced readily when worn just by disassembly of the rolling bearings 15. Since the relief pistons can have different diameters at choice, the turbopump can be adapted to different pressure relationships, thus opening the way to use with different liquids and processes at relatively high pressure differences between the pump section and the turbine section.

The restrictors 12, 13 in the relief lines 10, 11 can be so chosen that a pressure sufficient to prevent the outgassing of a fluid, or the coming out of solution, in a fluid, of gas dissolved therein, and consequent sealing difficulties, can be set up upstream of the shaft seal. Optimum efficiency of the turbine section 2 can be obtained by

adjustment of the bypass flow by means of the control element 16 in dependence upon the relationship between the desired flow and the total flow.

CLAIMS

1. A turbopump comprising a centrifugal pump section having an inlet and outlet and, disposed on the same shaft, a turbine section having its own inlet and outlet, and in which a low-pressure section is interposed physically between, and mechanically connects, the centrifugal pump section and the turbine section.
2. A turbopump according to claim 1, in which a respective relief piston is provided on the high-pressure side of each of the centrifugal pump section and turbine section to provide axial forces to counteract the axial forces placed on the shaft by the centrifugal pump section and the turbine section.
4. A turbopump according to claim 1 or claim 2 wherein an adjustable connection is provided for fluid flow between the high-pressure side and the low-pressure side of the turbine section.
4. A turbopump according to any preceding claim wherein said low-pressure section has an entry spigot which provides a passage for fluid flow to the centrifugal pump section, and a delivery spigot which provides a passage for fluid flow from the turbine section, and wherein the entry spigot and the delivery spigot are disposed on the same axis as one another.
5. A turbopump substantially as hereinbefore described with reference to, and as shown in, the accompanying drawing.
6. Any novel feature or combination of features described herein.