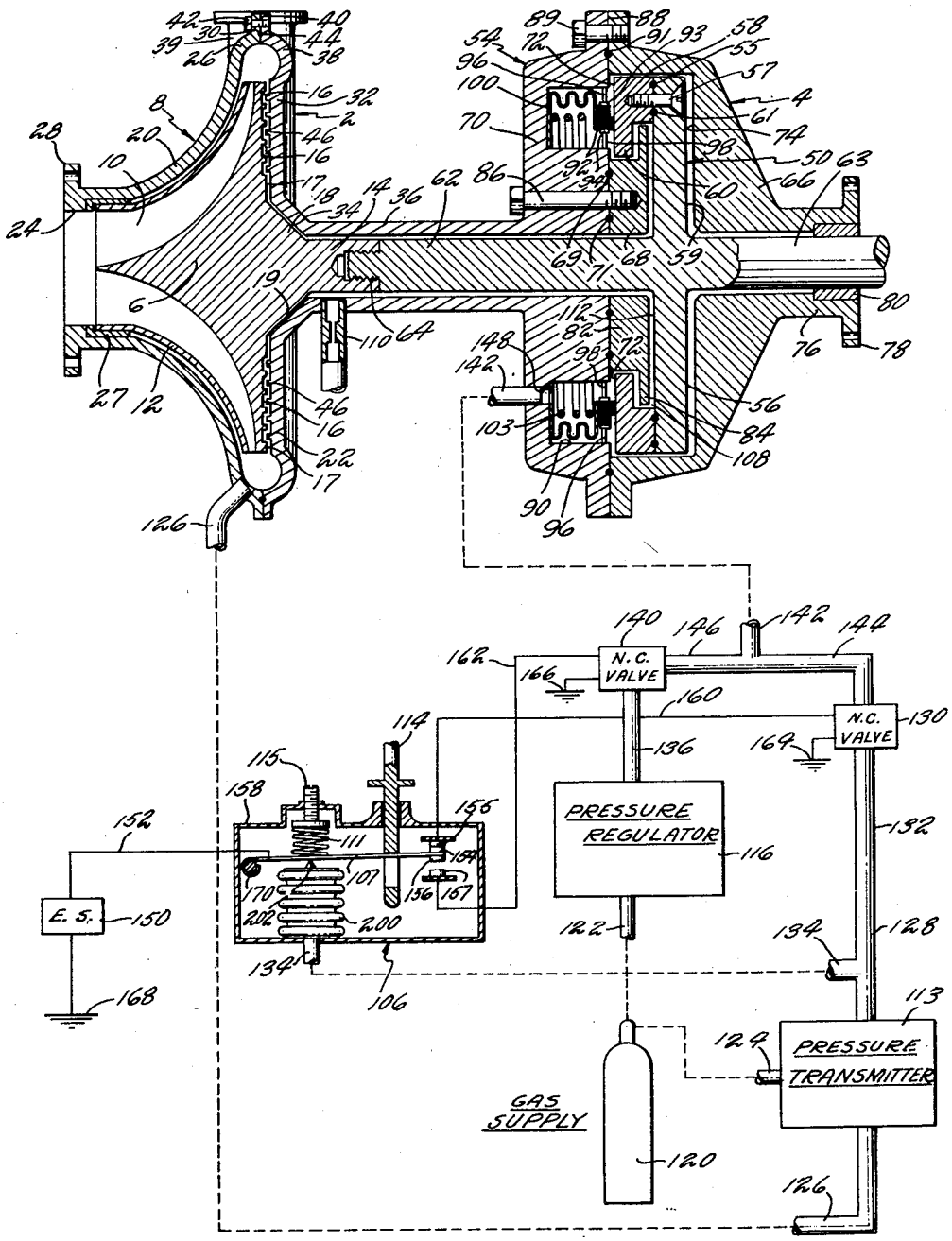
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COMBINATION SEAL FOR A PUMP

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INVENTORS
GEORGE P. FULTON
DAVID M. ELOVITZ
BY Jack N. McCarthy
AGENT

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COMBINATION SEAL FOR A PUMP

David M. Elovitz, Elmwood, and George P. Fulton, Coventry, Conn., assignors to United Aircraft Corporation, East Hartford, Conn., a corporation of Delaware

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This invention relates to a pump with means for sealing the drive shaft of said pump and a control system for said sealing means.

An object of this invention is to provide a seal which will maintain efficient operation under high temperatures.

Another object of this invention is to provide a pump shaft seal having a combination dynamic seal and a positive face seal.

A further object of this invention is to provide a shaft seal which has means for removing from said seal and from around said shaft, the pumped material which has leaked into said seal and around said shaft during pump operation. This is especially advantageous where liquid metals, corrosive fluids and fluids which solidify under lower than operating temperatures are used.

Another object of this invention is the use of an inert gas to provide a buffer pocket between the main pump fluid and the positive seal face.

Another object of this invention is to provide a control system for the seal. The pressure of the inert gas supplied to the seal is controlled in accordance with pump operation.

Further objects and advantages will be apparent from the specification and drawing.

The figure shows a longitudinal sectional view of the pump and seal with the control system connected thereto. Said control system is shown in diagrammatic form.

With reference to this figure, the embodiment of the invention consists of three main parts: (*a*) the first part comprising a pump **2**, (*b*) the second part comprising a seal **4**, and (*c*) a third part comprising a control system.

The pump **2** is made up of an impeller **6** rotatably mounted in a housing **8**. The impeller **6** has blades **10** which are fully covered by a shroud **12**. The back of the impeller has a shaft section **14** extending therefrom and has annular grooves **16** formed around a flat back face **17**. The impeller **6** has a short conical valve section **18** which extends from its back face **17** to the shaft section **14**. This conical section **18** is for a purpose to be hereinafter described.

The pump housing **8** is made up of two sections **20** and **22**. Section **20** provides an inlet **24** to the impeller blades **10**, covers the shroud **12** of the impeller and forms part **26** of the outlet collector ring. This section **20** is provided at its forward end with a flange **28** for its connection with a conduit containing a material to be pumped. Pump housing section **20** is also provided with another flange **30** which extends outwardly adjacent part **26**. A bearing member **27** is fixed within section **20** in which impeller **6** rotates.

Section **22** of the pump housing **8** provides a cover section **32** for the flat back face **17** of the impeller **6**, a cover section **34** for the short conical valve section **18** and a cover section **36** for the shaft section **14**. Cover section **34** is formed on its inner side as a valve seat **19** adapted to receive valve section **18**. Section **22** also forms part **38** of the outlet collector ring adjacent the outer edge

of cover **32**. A flange **40** extends outwardly adjacent part **38** of section **22** and is adapted to be connected to flange **30** of part **20**. Bolts **42** hold these flanges together and a metallic O-ring **44** is provided between the abutting faces of the flanges **30**, **40** to prevent any leakage from the outlet collector ring formed by parts **26** and **38** of the housing **8**. The impeller **6** has an outlet from the outlet collector ring at **39**. The inner side of cover section **32** is provided with annular flanges **46** extending therefrom which are adapted to fit into the annular grooves **16** formed around the flat back face **17** of the impeller. This forms a labyrinth seal to deter leakage from the outlet collector ring of the pump into the shaft cover section **36**, and provides a high pressure drop.

The seal **4** is made up of a seal rotor **50** and a face seal means mounted in a housing **54**. The seal rotor **50** comprises an annular rotor member **56** having a smaller annular member **58** fixed to its outer edge with an inwardly extending flange portion **60**. This member **58** is attached by a plurality of bolts **57**. Metallic O-rings **55**, **61** are provided on each side of bolts **57** to prevent leakage between member **56** and member **58**. A shaft section **62** extends from the seal rotor **50** in a direction so as to be attached to the short shaft section **14** of pump **2**. These two sections are shown attached by a simple threaded means at **64**. Another shaft section **63** extends from the other side of seal rotor **50** to a driving means. While no driving means is shown, any motivating means desired may be used.

The seal housing **54** is made up of three sections **66**, **68** and **70**. Sections **66** and **68** enclose all of the seal rotor **50** except the seal plate surface **72**. Section **66** extends around the outer periphery of the seal rotor and has a surface **74** positioned adjacent to surface **59** of the seal rotor. Section **66** also has a cover section **76** for a portion of the shaft **63**. This section **66** is provided at its free end over shaft section **63** with a flange **78** for its connection with other housing or supporting means if necessary. A bearing member **80** is fixed within this shaft cover **76** in which shaft **63** rotates.

Section **68** consists of an annular member **82** which has an annular flange **84** extending outwardly from its outer periphery. Annular member **82** is positioned around shaft section **62** and extends outwardly to a point where its outer periphery is adjacent the inner periphery of flange portion **60** of the seal rotor **50**. The outwardly extending flange **84** of annular member **82** extends into the annular groove or chamber **108** formed between the flange portion **60**, inner edge of annular member **58** and annular rotor member **56**. The outer edge of the flange is positioned adjacent the bottom of the groove. Section **68** is held in position by being affixed to section **70** of the seal housing by bolts **86**. Metallic O-rings **69**, **71** are provided on each side of bolts **86** to prevent leakage between sections **68** and **70**.

Section **70** of the seal housing **54** consists of an annular member positioned around shaft **62** and being affixed to section **66** by the use of flange means shown at **88**. A plurality of bolts **89** holds the flange means together and a metallic O-ring **91** is positioned between the flange means to prevent leakage therethrough. This section **70** is shown integrally attached to cover section **36** of section **22** of the pump housing **8**.

An annular groove, or chamber, **90** is formed in section **70** facing the seal plate surface **72** of the seal rotor **50**. An annular seal block member **92** is mounted in said annular groove for axial movement between two annular members **93** and **94**. Members **93** and **94** are supported by a plurality of arms **96** and **98**, respectively, attached to the section **70**. A bellows **100** is fixed at one end to the bottom of the annular groove **90** and at its other

end to the rear of the annular seal block member 92. This bellows may serve to both seal the area between the bottom of the groove 90 and the back of seal block member 92 and act as a spring force to bias the face 102 of of the seal block member 92 against the seal plate surface 72 of seal rotor 50. A spring 103 may be employed additionally between the bottom of the annular groove and the back of the annular seal block 92 if more biasing force is needed, for example, if a bellows were used not having a biasing force.

The control system which controls the inert gas, such as helium, to be supplied to the inner side of the bellows 100 is arranged so that two different gas pressures may be selected to be admitted. A rod 114 is provided to manually select these pressures and for starting. An automatic arrangement operates so that when the pump is operating, a gas pressure is admitted to the interior of bellows 100 which is a function of the pressure of the fluid at the outlet of the pump. This is accomplished by a pressure transmitter 113. When the pump is at rest or producing a pressure lower than a value as determined by spring 111 of pressure switch 106, a high inert gas pressure is admitted to the interior of the bellows 100 so that any pumped material which has leaked along shaft sections 14 and 62 and into the dynamic seal at 108 is forced back to and out of the drain 110. Screw means 115 is provided to vary the force exerted by spring 111. This pressure is also of a value so that it will act against face 112 of the seal rotor 50 thereby moving it to the right closing the valve section 18 upon its valve seat 19. This high pressure is selected by a pressure regulator 116 which has its output pressure manually set. This closing of valve section 18 prevents unnecessary exposure of the seal parts and pump shaft to the pumped fluid during periods of inoperation.

This control system comprises two main parts, the first part is the mechanical portion which includes a pressure transmitter 113, a pressure regulator 116, a pressure actuated arm 107, an inert gas containing means 120, two valves, and the piping necessary to provide the proper connections therebetween and the second part is the electrical portion which includes an electrical source 150, two pairs of contacts for use with said arm 107, two solenoids for use with the aforementioned valves, and the wiring necessary to properly connect these various electrical elements.

A container 120 for supplying an inert gas at a high pressure is connected to the pressure regulator 116 by conduit 122 and is connected to the pressure transmitter 113 by conduit 124. The pressure transmitter 113 receives a signal from the pressure in the outlet collector ring 38 by means of conduit 126. The pressure transmitter permits a gas pressure to leave by means of conduit 128 which is directed to normally closed valve 130 by conduit 132 and to the pressure switch 106 by way of conduit 134. The pressure of the inert gas leaving the pressure transmitter 113 is at some value which is a function of the pressure of the fluid at the outlet of the pump as carried by conduit 126. This predetermined function is set in the pressure transmitter by means well known in the art. Pressure transmitters of this type are well known. One such transmitter is manufactured by Moore Products Co. of Philadelphia, Pennsylvania and is listed in their catalogue as Nullmatic Pressure Transmitter Model 15. The pressure regulator permits a gas pressure to leave by means of conduit 136 which is directed to a normally closed valve 140. The pressure of the inert gas leaving the pressure regulator 116 is at some predetermined value which is set in the pressure regulator by means well known in the art as mentioned hereinbefore.

The outlet of the normally closed valve 130 is connected to conduit 142 by a conduit 144 and the outlet of the normally closed valve 140 is connected to said conduit 142 by conduit 146. The other end of conduit 142 is connected to section 70 of the seal housing 54. A passageway 158 connects this end of the conduit 142 to the inner side of the bellows 100.

The two normally closed valves 130, 140 are solenoid operated and receive their electrical energy for operation from an electrical source 150. An electrical conductor 152 is connected to contacts 154 and 156 on the end of the pressure actuated arm 107 which is located in the housing 158 of the pressure switch 106. Contacts 155 and 157 are positioned so as to be contacted by contacts 154 and 156, respectively. Electrical conductors 160 and 162 connect contacts 155 and 157 to the solenoids of valves 130 and 140, respectively. The solenoid of valve 130 is grounded at 164, the solenoid of valve 140 is grounded at 166, and the power source 150 is grounded at 168.

Pressure actuated arm 107 is connected at one end in housing 158 to a pin 170. This arm is of the snap action type by which it is maintained in either an "up" or "down" position. That is, either contacts 154 and 155 or contacts 156 and 157 are in engagement at all times. As mentioned hereinbefore, spring 111 provides a force upon the arm 107 which may be varied to predetermine the force needed to move contacts 154, 155 into contact. A bellows 200 is fixed to the inside of housing 158 with the interior thereof connected to the end of 134. The opposite end of the bellows 200 contacts arm 107 at 202 and provides a force acting thereon in opposition to the force exerted by spring 111.

When the pump 2 is being driven at normal operating speeds, pressure in the outlet pressure ring of the pump is transmitted through the fluid in conduit 126 to the pressure transmitter 113. The inert gas entering 113 through conduit 124 leaves the pressure transmitter through conduit 128 at some pressure which is a function of the pressure of the fluid in conduit 126, as determined by a manual setting in the transmitter. This same fluid pressure in conduit 128 is transmitted through conduit 134 to bellows 200 of pressure switch 106 which controls valves 130 and 140. Spring 111 is adjusted so that during normal operation of the pump the pressure of inert gas acting on bellows 200 will compress the spring and close contacts 154, 155. Current flowing from a grounded source 150 through conductor 152, switch arm 107, contacts 154, 155, conductor 160, and the solenoid of normally closed valve 130 to ground 164 will open valve 130 and allow the inert gas to flow from source 120 through conduit 124, transmitter 113, valve 130, conduit 142, and passageway 148 to the interior of bellows 100.

The inert gas admitted to bellows 100 forms a buffer pocket of gas which prevents molten metal or corrosive liquid which has leaked past pump 2 into chamber 108 from coming into contact with the annular seal block member 92 of the face seal.

If, however, the speed at which pump 2 is driven falls below a predetermined value, transmitter 113 will supply a lower pressure of inert gas to conduits 128 and 134. When this pressure becomes too low to successfully oppose spring 111, the latter will open contacts 154, 155 and close contacts 156, 157. Opening of contacts 154, 155 will result in closing of normally closed valve 130, while closing of contacts 156, 157 will result in opening of normally closed solenoid valve 140. Valve 140 will then admit inert gas from source 120 at a higher pressure than before to conduit 142, the pressure being determined by the setting of the regulator 116. This pressure regulator is simply an adjustable pressure reducing device.

Opening of valve 140 and admission of inert gas to conduit 142 under high pressure causes gas to flow through passageway 148 into bellows 100 as before, except that the inert gas is now at a higher pressure than before.

The pressure of the inert gas, as determined by the pressure setting of regulator 116 is now sufficiently high to force any molten metal which may be in chamber 108

of the dynamic seal back through the communicating passages between member **56** and housing section **68** and between shaft section **62** and cover section **36**, forcing the leakage metal out through drain **110**.

At the same time the higher pressure inert gas acts against face **112** of seal rotor **50**, thereby moving the latter to the right to seat the valve section **18** upon its valve seat **19**. The amount of axial movement of shaft **62** required to seat valve **18** on valve seat **19** is so small that the fluid passage between bellows **100** and drain **110** always remains open. As a result of this application of high gas pressure by opening valve **140** the molten metal is isolated from the seal parts and pump shaft during periods when the pump is inoperative or rotating slowly.

Having now described the invention so that others skilled in the art may clearly understand the same, what it is desired to obtain by Letters Patent is as follows:

1. In combination, a pump, said pump comprising a housing and impeller, said housing having an inlet and outlet for said impeller, said impeller having a shaft extending therefrom, said housing covering said shaft, said impeller having a valve member, said housing having a valve seat adapted to receive said valve member, means including a gas under pressure for moving said shaft and said impeller axially to seat said valve member in said valve seat, said last named means also including a face on said shaft against which said gas pressure may be applied.

2. In combination, a pump, said pump comprising a housing and impeller, said housing having an inlet and outlet for said impeller, said impeller having a shaft extending therefrom, said housing covering said shaft, said impeller having a valve member, said housing having a valve seat adapted to receive said valve member, means including a gas under pressure for moving said shaft and said impeller axially to seat said valve member in said valve seat, said last named means including a face on said shaft against which said gas pressure may be applied, means responsive to pump operation for controlling the pressure of the gas applied.

3. In combination, a pump, said pump comprising a housing and impeller, said housing having an inlet and outlet for said impeller, said impeller having a shaft extending therefrom, said housing covering said shaft, said shaft having a seal rotor located thereon, said seal rotor having a housing, said seal rotor having a seal plate surface, a chamber in said seal housing, an annular seal block member mounted in said chamber, said seal block member having a face biased against the seal plate surface of the seal rotor, a bellows connected to the chamber at one end and to the annular seal block member at its other end, a source of inert gas connected to said bellows, means responsive to decrease in pump operation for controlling the pressure of said inert gas in said bellows.

4. In combination, a pump, said pump comprising a housing and impeller, said housing having an inlet and outlet for said impeller, said impeller having a shaft extending therefrom, said housing covering said shaft, said shaft having a seal rotor located thereon, said seal rotor having a housing, said seal rotor having a seal plate surface, a chamber in said seal housing, an annular seal block member mounted in said chamber, said seal block member having a face biased against the seal plate surface of the seal rotor, a bellows connected to the chamber at one end and to the annular seal block member at its other end, a source of inert gas connected to said bellows, means responsive to decrease in pump discharge pressure for controlling the pressure of said inert gas in said bellows, said means having a pressure regulator.

5. In combination, a pump, said pump comprising a housing and impeller, said housing having an inlet and outlet for said impeller, said impeller having a shaft extending therefrom, said housing covering said shaft, said

impeller having a valve member attached thereto, said housing having a valve seat adapted to receive said valve, said shaft having a seal rotor located thereon, said seal rotor having a housing, said seal rotor having a seal plate surface, a chamber in said seal housing, an annular seal block member mounted in said chamber, said seal block member having a face biased against the seal plate surface of the seal rotor, a bellows connected to the chamber at one end and to the annular seal block member at its other end, a source of high pressure fluid connected to actuate said bellows, means responsive to decrease in pump discharge pressure controlling the admission of fluid from said source to actuate said bellows and move said shaft axially to seat said valve member in said valve seat.

6. In combination, a pump, said pump comprising a housing and impeller, said housing having an inlet and outlet for said impeller, said impeller having a valve member attached thereto, a shaft extending from said valve member, said housing covering said shaft, said housing having a valve seat adapted to receive said valve, means for mounting said shaft and impeller for axial movement relative to said housing, said shaft having a seal rotor located thereon, said seal rotor having a housing, said seal rotor having a face, means for applying a pressure against said face to move said shaft and impeller axially to seat said valve member in said valve seat.

7. In combination, a pump, said pump comprising a housing and impeller, said housing having an inlet and outlet for said impeller, a shaft extending from said impeller, said housing covering said shaft, said shaft having a seal rotor located thereon, said seal rotor having a housing, said seal rotor forming a dynamic seal with said seal housing, means for applying a fluid pressure to said dynamic seal to provide a seal when said shaft is rotating at normal operating speeds and for applying a higher fluid pressure to said dynamic seal to force any pumped liquid from said seal and from around said shaft when said shaft is rotating at a reduced speed or has ceased to rotate.

8. In combination, a pump, said pump comprising a housing and impeller, said housing having an inlet and outlet for said impeller, a shaft extending from said impeller, said housing covering said shaft, said shaft having a seal rotor located thereon, said seal rotor having a housing, said seal rotor forming a dynamic seal with said seal housing, a source of high pressure fluid, means responsive to pump discharge pressure for applying a fluid pressure from said source to said dynamic seal to provide a seal when said shaft is rotating at normal operating speeds and means responsive to a decrease in pump discharge pressure for applying a higher fluid pressure from said source to said dynamic seal to force any pumped liquid from said seal and from around said shaft when said shaft is rotating at a reduced speed or has ceased to rotate.

9. In combination, a pump, said pump comprising a housing and impeller, said housing having an inlet and outlet for said impeller, said impeller having a valve member attached thereto, a shaft extending from said valve member, said housing covering said shaft, said housing having a valve seat adapted to receive said valve, said shaft having a seal rotor located thereon, said seal rotor having a housing, said seal rotor forming a dynamic seal with said seal rotor housing, means for applying a fluid pressure to said dynamic seal to provide a seal when said shaft is rotating at normal operating speeds and for applying a higher fluid pressure to said dynamic seal to force any pumped liquid from said seal and from around said shaft when said shaft is rotating at a reduced speed or has cease to rotate, said seal rotor being acted upon by said fluid pressure in a direction to seat said valve in said valve seat when said last mentioned means is applying said higher fluid pressure.

10. In combination, a shaft, a housing covering said shaft, said shaft having a seal rotor located thereon, said seal rotor having a housing, said seal rotor forming a dynamic seal with said seal housing, means responsive to

pump discharge pressure for applying a fluid pressure to said dynamic seal to provide a seal when said shaft is rotating at normal operating speeds and for applying a higher fluid pressure to said dynamic seal to force any liquid from said seal and from around said shaft when said shaft is rotating at a reduced speed or has ceased to rotate.

11. In combination, a shaft, a housing covering said shaft, a valve member attached to said shaft, said housing having a valve seat adapted to receive said valve, said shaft having a seal rotor located thereon, said seal rotor having a housing, said seal rotor forming a dynamic seal with said seal housing, means for applying a fluid pressure to said dynamic seal to provide a seal when said shaft is rotating at normal operating speeds and for applying a higher fluid pressure to said dynamic seal to force any liquid from said seal and from around said shaft when said shaft is rotating at a reduced speed or has ceased to rotate.

12. In combination, a pump, said pump comprising a housing and impeller, said housing having an inlet and outlet for said impeller, said impeller having a valve member attached thereto, a shaft extending from said valve member, said housing covering said shaft, said housing having a valve seat adapted to receive said valve member, said shaft having a seal rotor located thereon, said seal rotor having an annular chamber opening radially inwardly, said seal rotor having a housing, said housing having a circular flange extending into said annular chamber, said pump housing and seal housing being connected, said seal rotor having a face, said face extending from said shaft to said annular chamber, means for applying a pressure against said face to set said valve member in said valve seat.

13. In combination, a pump, said pump comprising a housing and impeller, said housing having an inlet and outlet for said impeller, said impeller having a valve member attached thereto, a shaft extending from said valve member, said housing covering said shaft, said housing having a valve seat adapted to receive said valve member, said shaft having a seal rotor located thereon, said seal rotor having an annular chamber opening radially inwardly, said seal rotor having a housing, said seal rotor housing having a circular flange extending into said annular chamber, said seal rotor having an annular seal plate surface, said seal rotor housing having an annular chamber adjacent said seal plate surface, a seal means mounted in said second chamber, said seal means having a face biased against the seal plate surface of the seal rotor, a bellows connected to the chamber at one end and to the seal means at its other, said pump housing and seal housing being connected, said seal rotor having a face, said face extending from said shaft to said annular chamber, means for applying a pressure from said bellows against said face to seat said valve member in said valve seat and to force any pumped fluid from said seal and from around said shaft which has leaked thereto.

14. In combination, a pump, said pump comprising a housing and impeller, said housing having an inlet and outlet for said impeller, said impeller having a shaft extending therefrom, said housing covering said shaft, said shaft having a seal rotor located thereon, said seal rotor having a housing, said seal rotor having a seal plate surface, a chamber in said seal rotor housing, a seal block member mounted in said chamber, said seal block member having a face biased against the seal plate surface of the seal rotor, a bellows connected to the chamber at one end and to the annular seal block member at its other end, a source of high pressure fluid, means for connecting said source to said bellows, means responsive to the pressure at the outlet of said pump for controlling the pressure of fluid from said source in said bellows.

15. In combination, a pump, said pump comprising a housing and impeller, said housing having an inlet and outlet for said impeller, said impeller having a shaft extending therefrom, said housing covering said shaft, said shaft having a seal rotor located thereon, said seal rotor having a housing, said seal rotor having a seal plate surface, a chamber in said seal rotor housing, a seal block member mounted in said chamber, said seal block member having a face biased against the seal plate surface of the seal rotor, a bellows connected to the chamber at one end and to the annular seal block member at its other end, a source of high pressure fluid, means for connecting said source to said bellows, means responsive to the pressure at the outlet of said pump for controlling the pressure of said fluid in said bellows, said fluid being maintained at a pressure to provide a seal when said pump is at regular operating speeds and being maintained at a higher pressure to force any pumped fluid from said seal rotor and from around said shaft which has leaked thereto when the outlet pressure of said pump falls below a predetermined value.

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