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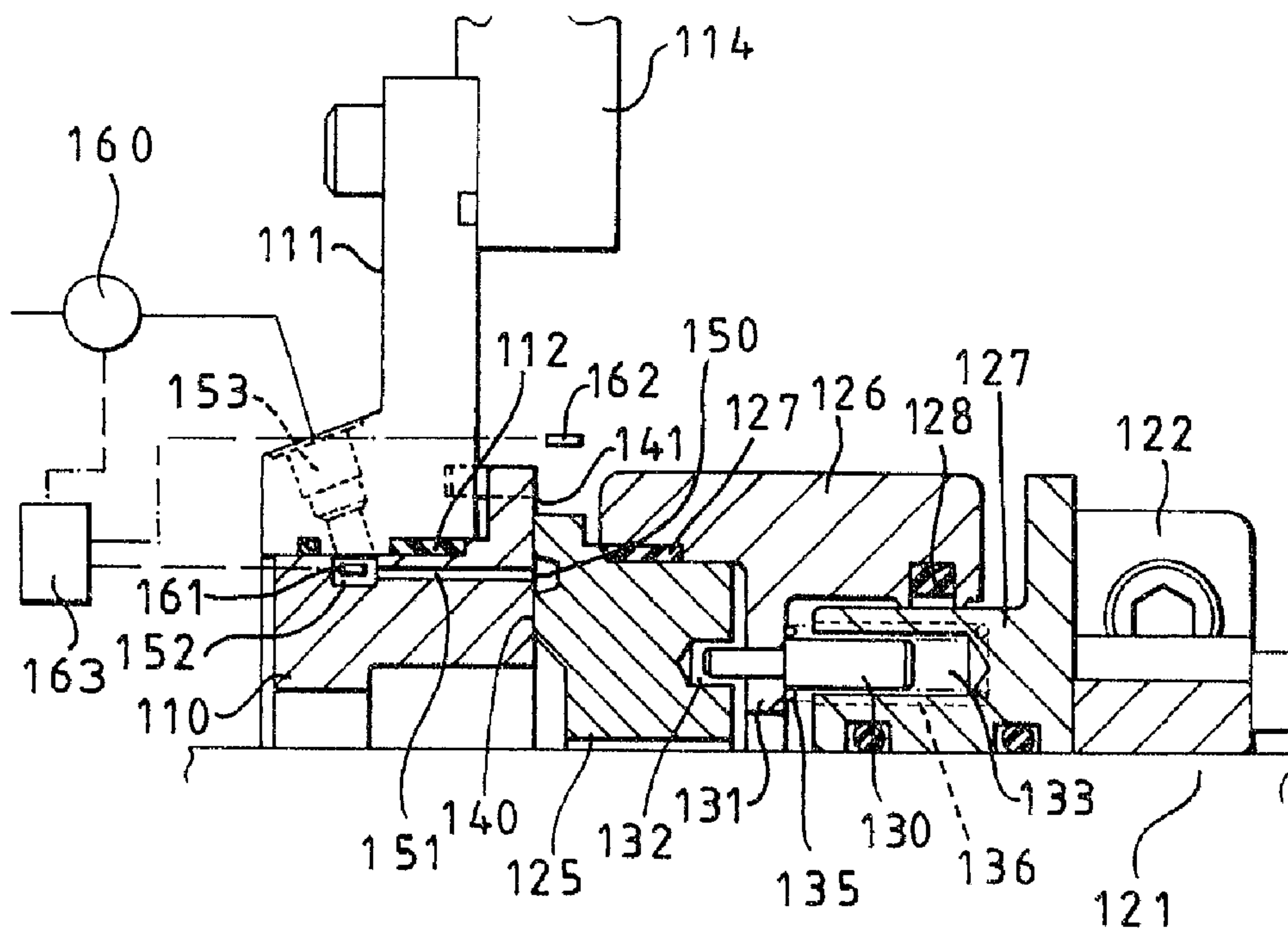
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(57) Abrégé/Abstract:

A mechanical face seal includes a first seal face member mounted in fixed axial and rotational relationship and sealed with respect to a housing and a second seal face member mounted in fixed rotational relationship and sealed with respect to a shaft, the second seal face member is movable axially of the shaft towards the first seal face member so that opposed sealing faces of the first and second seal face members are urged into sealing engagement, a passage is provided through one of the seal face members, the passage opening to the sealing face of the seal face member at a point intermediate of the radial extremities of the face engaged by the sealing face of the other seal face member, the passage being connected to an external source of fluid under pressure, sensors being provided for monitoring operating conditions at the interface between the first and second seal face members and control means for adjusting the pressure of fluid delivered via the passage to the sealing faces, to optimise performance of the seal.



ABSTRACT

A mechanical face seal includes a first seal face member mounted in fixed axial and rotational relationship and sealed with respect to a housing and a second seal face member mounted in fixed rotational relationship and sealed with respect to a shaft, the second seal face member is movable axially of the shaft towards the first seal face member so that opposed sealing faces of the first and second seal face members are urged into sealing engagement, a passage is provided through one of the seal face members, the passage opening to the sealing face of the seal face member at a point intermediate of the radial extremities of the face engaged by the sealing face of the other seal face member, the passage being connected to an external source of fluid under pressure, sensors being provided for monitoring operating conditions at the interface between the first and second seal face members and control means for adjusting the pressure of fluid delivered via the passage to the sealing faces, to optimise performance of the seal.

MECHANICAL FACE SEALS

The present invention relates to mechanical face seals.

5 In a mechanical face seal, a pair of seal face members, one associated with a rotary component and the other associated with a stationary component, are urged axially together into sealing engagement.

10 The "closing force" urging the seal face members into engagement is usually generated by a combination of a permanent biasing means, for example a spring element, and hydraulic loading from the fluid being sealed, the latter varying with fluid pressure.

15 In order to improve wear of the sealing faces and reduce heat generation, seals are designed to operate with a film of fluid between the sealing faces. This film of fluid normally resulting from a combination of static and dynamic pressure gradients across the seal interface. Methods have been used for enhancing the generation of a fluid film at the seal interface, for example the sealing faces may be cut away radially to promote penetration by the fluid being sealed. However, the approaches
20 generally adopted are dependent upon seal motion to generate interface lubrication via the fluid film.

This approach becomes unsatisfactory where the pressure

in the fluid being sealed falls to or below atmospheric pressure and fluid penetration between the faces reduces or is destroyed by air being drawn across the seal interface. It is also unsatisfactory where abrasive debris are present in the fluid causing destruction of the interface surfaces resulting in premature wear. Particular problems also arise at start-up where, for example, in a pump seal low seal motion and low fluid pressure will provide poor lubrication.

It has been proposed to provide lubrication by feeding fluid into the interface from an external source, for example a static header tank. This overcomes many of the problems, for example lubrication at start-up and the presence of abrasive debris in the fluid film. However, no account has been taken hitherto of variations in the pressure of the fluid being sealed and consequently while this method would ensure that some lubrication is provided at all times, the effectiveness of the fluid film will vary with the local environment of the seal.

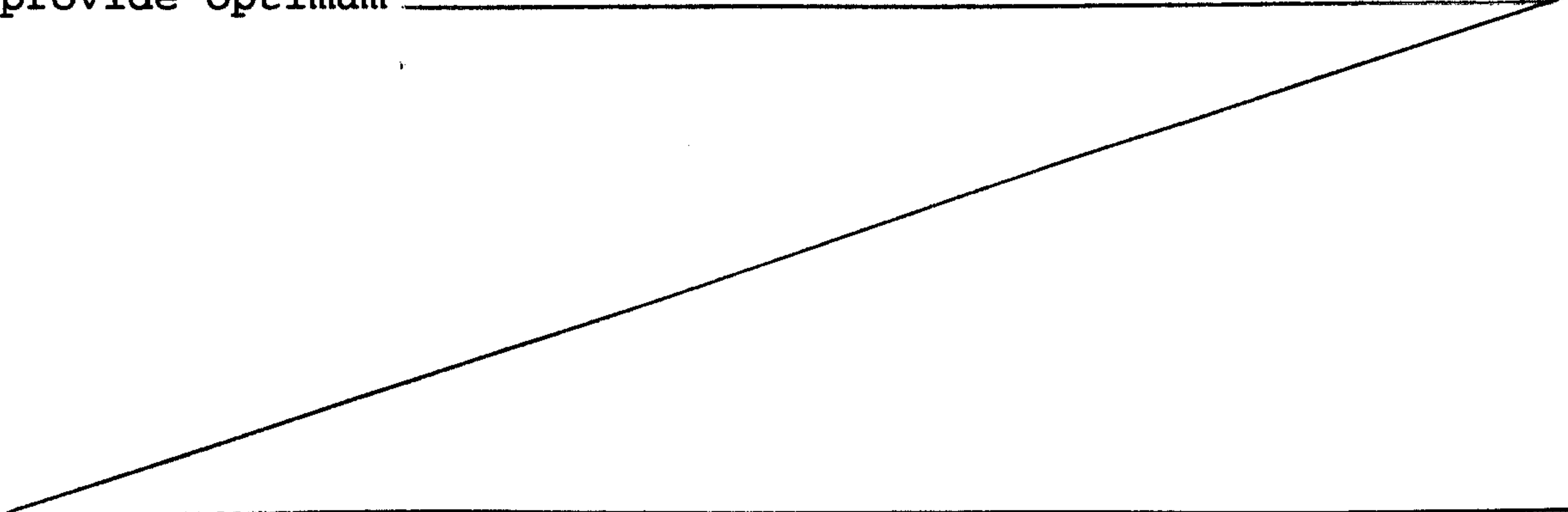
The present invention provides means of ensuring that the fluid film characteristics of the seal are optimised for the working conditions of the seal.

According to one aspect of the present invention a mechanical face seal for providing a fluid tight seal between a pair of relatively rotatable components

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comprises a first seal face member mounted in fixed axial and rotational relationship and sealed with respect to one of the components and a second seal face member mounted in fixed rotational relationship and sealed with respect to the other component, the second seal face member being movable axially of the components and being resiliently biased axially towards the first seal face member so that opposed sealing faces of the first and second seal face members are urged into sealing engagement, a passage being provided through one of the seal face members, said passage opening to the sealing face of that seal face member at a point intermediate of the radial extremities of the face engaged by the sealing face of the other seal face member, the passage being connected to an external source of fluid under pressure, means being provided for monitoring operating conditions at the interface between the first and second seal face members and providing a signal to a control unit, the control unit adjusting the pressure of fluid delivered via the passage to the sealing faces, as a function of the operating conditions, in order to optimise the performance of the seal.

According to one embodiment of the invention the pressures of the fluid delivered to the interface of the sealing faces and the pressure of the sealed fluid are monitored, and the pressure of fluid delivered to the interface controlled in response to variations in the pressure of the sealed fluid, so that the fluid film at the interface may be maintained to provide optimum



lubrication of the sealing faces. Alternatively or in addition, the temperature of the sealing faces may be monitored to provide a measure of the effectiveness of the lubrication provided by the fluid film, the pressure of fluid delivered to the interface being adjusted to increase or decrease the effectiveness of the fluid film, as required. Other parameters that may be monitored to control the pressure of fluid delivered to the interface may include speed of rotation, seal leakage and/or wear of the sealing faces.

The invention is now described, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1 shows a part sectional elevation of a seal formed in accordance with the present invention;

Figure 2 shows a sectional elevation along the line I-I of Figure 1;

Figure 3 shows a part sectional side elevation of an alternative form of seal formed in accordance with the present invention; and

Figure 4 illustrates an alternative form of control system for use with seals of the type illustrated in Figures 1 and 3.

As illustrated in Figures 1 and 2, a seal includes a first seal face member or seat 10 which is located on the internal diameter of the seat housing 11 and is sealed with respect thereto by means of an elastomeric sealing strip 12. The seat housing 11 is formed in two parts which are secured together to clamp about the seat 10, by means of bolts 13. The seat housing 11 is bolted to a pump housing 14 by means of a series of angularly spaced bolts 15, with the seat 10 outermost. A pair of pins 16 (only one shown) engage in bores in the seat housing 11 and engage complementary formations on the seat 10 to prevent relative rotation therebetween.

Externally of the housing 14, an elastomeric bush 20 is mounted on a shaft 21 for rotation therewith, by clamping ring 22. The bush 20 extends from the clamping ring 22 towards seat 10 and the end of the bush 20 adjacent seat 10 is provided with a metal retaining ring 23, with which it makes sealing engagement. The second seal face member 25 is located in the retaining ring 23 and sealed with respect thereto by means of a sealing strip 26.

The bush 20 is located on the shaft 21 such that under normal operation, it will be under compression when face 30 of the seal face member 25 engages the opposed face 31 of seat 10, the bush 20 thereby imposing a resilient load biasing faces 30 and 31 into sealing engagement. A series of angularly spaced dowels 33 are provided on the

internal diameter of seal face member 25 and extend into close proximity with the shaft 10, in order to centralise the seal face member 25 on the shaft 10 without inhibiting the relative axial movement therebetween, so
5 that the seal face member 25 may move axially to accommodate wear of the faces 30 and 31 and to allow the formation of a lubricating fluid film therebetween.

An annular groove 40 is provided in the face 30 intermediate of the extremities thereof engaged by the
10 face 31. A pair of diametrically opposed passages 41 are provided through the seat 10, the passages 41 extending from the outer diameter of the seat 10 and opening to the face 31 in radial alignment with the annular groove 40. An inlet 42 is provided to one of the passages 41 and an
15 outlet 43 from the other. A further passage 44 is provided extending radially through the seat 10 from its outer diameter to its inner diameter.

The inlet 42 is connected to a source of fluid under pressure 50, which may, for example, be a tapping from
20 the pump outlet, a boost pump or mains water supply. The outlet 43 is connected via a pressure control valve 51 to passage 44. Fluid may thus be injected through inlet 42 to the faces 30 and 31, sufficient back pressure being provided by the fluid control valve 51 to produce a fluid
25 film between the faces 30 and 31. Fluid passing from outlet 43 through the fluid control valve 51 and passage

44, will flush the internal surface of the seal and assist in cooling of the seat 10 and seal face member 25.

5 Pressure sensing means 53 and 54 are provided to monitor the pressure of injected fluid at the interface between seal 10 and seal face member 25 and the pressure of the sealed fluid within the housing 14, respectively. Also, a temperature sensor 55 may optionally be provided on the seat 10 to measure the temperature generated at faces 30 and 31.

10 Signals from the pressure sensors 53 and 54 are fed to an electronic control unit 56, which controls the valve 51 so that the pressure at the interface between seat 10 and seal face member 25 may be adjusted with variations in the pressure within the housing 14, so that the fluid
15 film produced between faces 30 and 31 may be optimised for the working conditions of the seal. The temperature sensor 55, if fitted, will also give an indication of the effectiveness of lubrication afforded by the fluid film, which may also be taken into account in controlling the
20 fluid film.

The seal described above will thus permit accurate control of the fluid film between the faces of the seat 10 and seal face member 25 under all operating conditions of the seal. The consequent improvement in lubrication
25 and cooling of the sealing faces will reduce wear thereof

and prolong the life of the seal. Using this system, the formation of the fluid film is not dependent on seal movement or the pressure of fluid sealed and, for example, a fluid film may be generated under start-up conditions. As a result of the improved lubrication, the seal face members may be made of materials which were hitherto considered unsuitable for such applications. Furthermore, with this seal arrangement clean fluid may be injected between the seal faces thereby avoiding the problem of abrasive contaminants. Even where fluid is tapped off from the pump outlet, this may be filtered before injecting between the seal faces.

Figure 3 illustrates an externally pressurised seal. In this seal, a seat 110 is located on the internal diameter of a seal housing 111 and is sealed with respect thereto by means of a sealing strip 112, in similar manner to that described with reference to Figures 1 and 2. The seal housing 111 is however secured to housing 114 with seat 110 innermost.

A seal face member 125 is mounted within a retaining ring 126 and sealed with respect thereto by means of an elastomeric sealing strip 127. The retaining ring 126 is slidably mounted upon a collar 127 which is secured on shaft 121 by means of clamping ring 122. The retaining ring 126 is sealed with respect to collar 127 by means of sealing ring 128. A plurality of angularly spaced

axially extending pins 130 are located on an internal flange formation 131 on carrier ring 126, the pins 130 engaging at one end in bores 132 in the seal face member 125 and at the other end in bores 133 in the carrier ring 127, so as to prevent relative rotation between the seal face member 125, carrier ring 126 and shaft 121. A series of compression springs 135 are located in axial extending bores 136 in collar 127 at angularly spaced locations intermediate of the pins 130. The springs 135 act between the ends of bores 136 and the flange formation 131, to urge the carrier ring 126 and seal face member 125 towards the seat 110 and face 140 of seal face member 125 into engagement with face 141 of seat 110.

An annular groove 150 is provided in face 140 of seal face member 125. An axial passage 151 extends through seat 110 from face 141 to an annular groove 152. The annular groove 152 is closed by the internal diameter of the seat housing 111 and an inlet 153 is provided through the seat housing 111 to groove 152. The inlet 153 is connected to a controllable pressure source 160 from which fluid may be supplied to the interface between seat 110 and seal face member 125 to provide a fluid film between faces 140 and 141. Pressure sensors 161 and 162 are provided to monitor the pressure of fluid at the interface between the seat 110 and seal face member 125 and the pressure of fluid within housing 114, respectively. Signals from the pressure sensors 161 and

162 are fed to electronic control unit 163 which controls the pressure source 160. The pressure of fluid supplied from pressure source 160 may thereby be controlled in response to variation in pressure within the housing 114, in order to optimise the fluid film generated between face 140 and 141.

In the system illustrated in Figure 4 a temperature sensor 220 is mounted in the seat 210 adjacent the sealing face thereof. The sensor 220 is connected to an electronic control module 221 and produces an analogue signal proportional to the temperature of the seal interface.

A passage 212 is provided through a seat 210 and leads to the interface between the seal face members in similar manner to that described above with reference to Figures 1 and 3. The passage 212 is connected to a liquid reservoir 230 located at a level above the seal, via a non-return valve 231 so that liquid is thereby delivered from the reservoir 230 to the seal interface at a minimum pressure equal to the head of liquid.

An air operated double acting diaphragm pump 240 is connected between passage 212 and reservoir 230, in parallel with the non-return valve 231. A compressed air supply 241 is connected to pump 240 via an electro-pneumatic control valve 242 which controls the pressure

of air delivered to the pump 240 in response to an electronic signal from the electronic control module 221. The pump 240 delivers liquid from reservoir 230 to passage 212 and hence to the seal interface, at a pressure equal to the pressure of air delivered to the pump 240.

The electronic control module 221 is microprocessor based and is programmed to compare the analogue signal from sensor 210 with prescribed limits. The control module 221 will then produce an output signal to control the electro-pneumatic control valve 242 so that the pressure of air delivered to pump 240 and hence pressure of liquid delivered to the seal interface will adjust the liquid film to maintain the temperature of the interface within the prescribed limits.

Instead of using the temperature of the seal interface to control the pressure of fluid delivered to passage 212, the system described above may utilise a sensor which measures the pressure of fluid retained by the seal, the control module 221 being programmed to adjust the pressure of liquid delivered to the seal interface relative to the pressure of fluid retained by the seal in prescribed manner. A sensor may also be provided to measure the pressure of liquid at the seal interface in order to provide positive feed back to the control module 221.

Instead of using an air operated double acting diaphragm pump 240 as described above, an air operated piston pump which will multiply the air pressure, may be used.

Alternatively an air pressurised liquid reservoir may be used.

Various modifications may be made without departing from the invention. For example, while in the above embodiments annular grooves are provided in one of the seal face members in order to enhance fluid film formation, this is not essential, and the faces may be plane or have local rather than circumferential recesses. Furthermore, the circumferential or local recesses may be provided in the seal face member having a passage through which fluid is delivered to the sealing faces.

Although in the above embodiments single passages are provided for injection of fluid to the sealing faces, a plurality of angularly spaced passages may be provided for this purpose. While it is convenient to deliver fluid to the sealing faces through passages in the seal face member connected to the stationary component when said seal face member is axially fixed, the fluid may be delivered through passages in a rotating and/or axially movable seal face member, provided that suitable rotary and/or axially movable fluid connections are used.

In addition to controlling the pressure of fluid

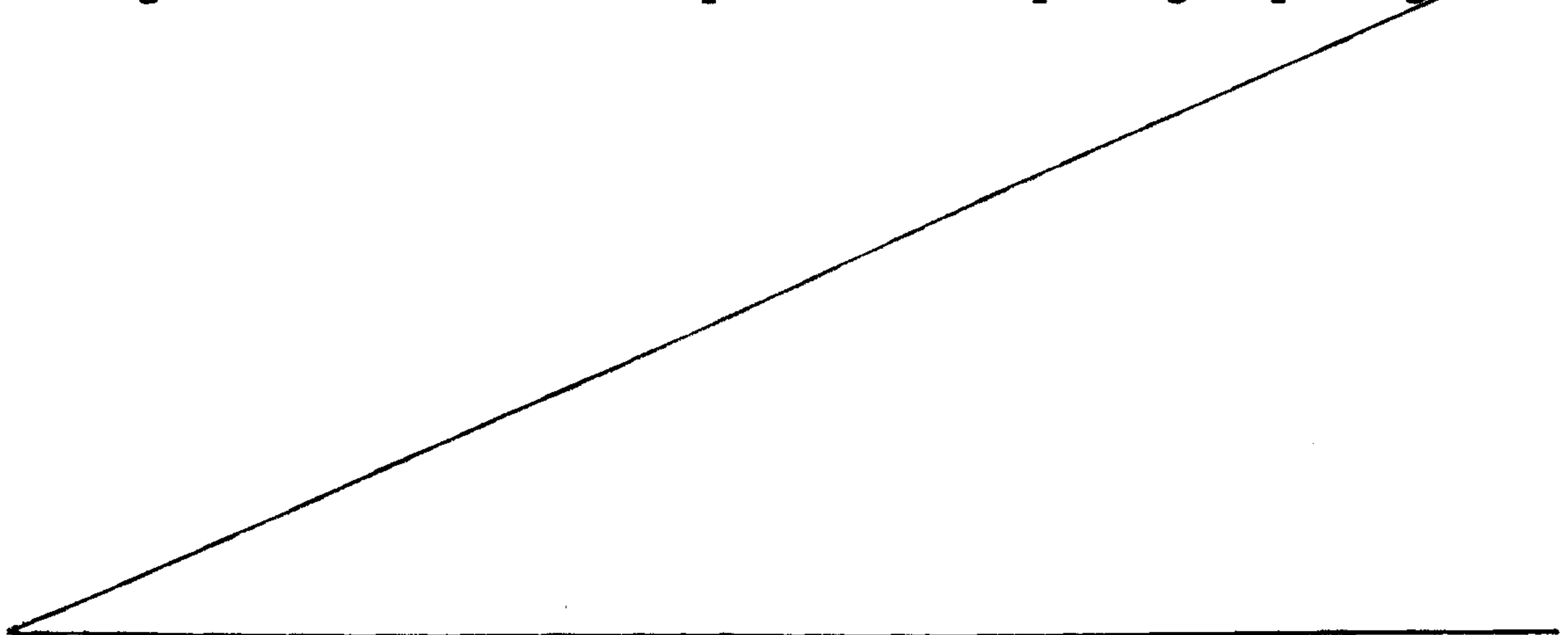
delivered to the sealing faces the sensing and control equipment may also be arranged to provide an indication of imminent seal failure or that the seal requires attention.

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CLAIMS

1. A mechanical face seal for providing a fluid tight seal between a pair of relatively rotatable components comprising a first seal face member mounted in fixed axial and rotational relationship and sealed with respect to one of the components and a second seal face member mounted in fixed rotational relationship and sealed with respect to the other component, the second seal face member being movable axially towards the first seal face member so that opposed sealing faces of the first and second seal face members are urged into sealing engagement, a passage being provided through one of the seal face members, said passage opening to the sealing face of that seal face member at a point intermediate of the radial extremities of the face engaged by the sealing face of the other seal face member, the passage being connected to an external source of fluid under pressure, means being provided for monitoring operating conditions at the interface between the first and second seal face members and providing a signal to a control unit, the control unit adjusting the pressure of fluid delivered via the passage to the sealing faces, as a function of the operating conditions, in order to optimise the performance of the seal.

2. A mechanical face seal according to Claim 1 in which a circumferentially extending recess is provided in one of the sealing faces at a radius equal to said passage opening,



3. A mechanical face seal according to Claim 1 in which a plurality of passages are provided to deliver fluid to the interface between the first and second seal face members.

5 4. A mechanical face seal according to Claim 1 in which a first passage is provided to deliver fluid to the interface between the first and second seal face members, a second passage is provided to permit removal of excess fluid from the interface between the first and second
10 seal face members, an external source of fluid under pressure being connected to the first passage and a fluid control valve being connected to the second passage, the fluid control valve being controlled in response to operating conditions at the interface between the first
15 and second seal face members to provide a back pressure sufficient to produce the appropriate fluid film.

5. A mechanical face seal according to Claim 4 in which fluid from the fluid control valve is passed through a third passageway which extends between the outer and
20 inner diameters of the seal face member, to flush the internal diameters of the first and second seal face members.

6. A mechanical face seal according to Claim 1 in which the pressure of the external source of fluid is
25 controllable.

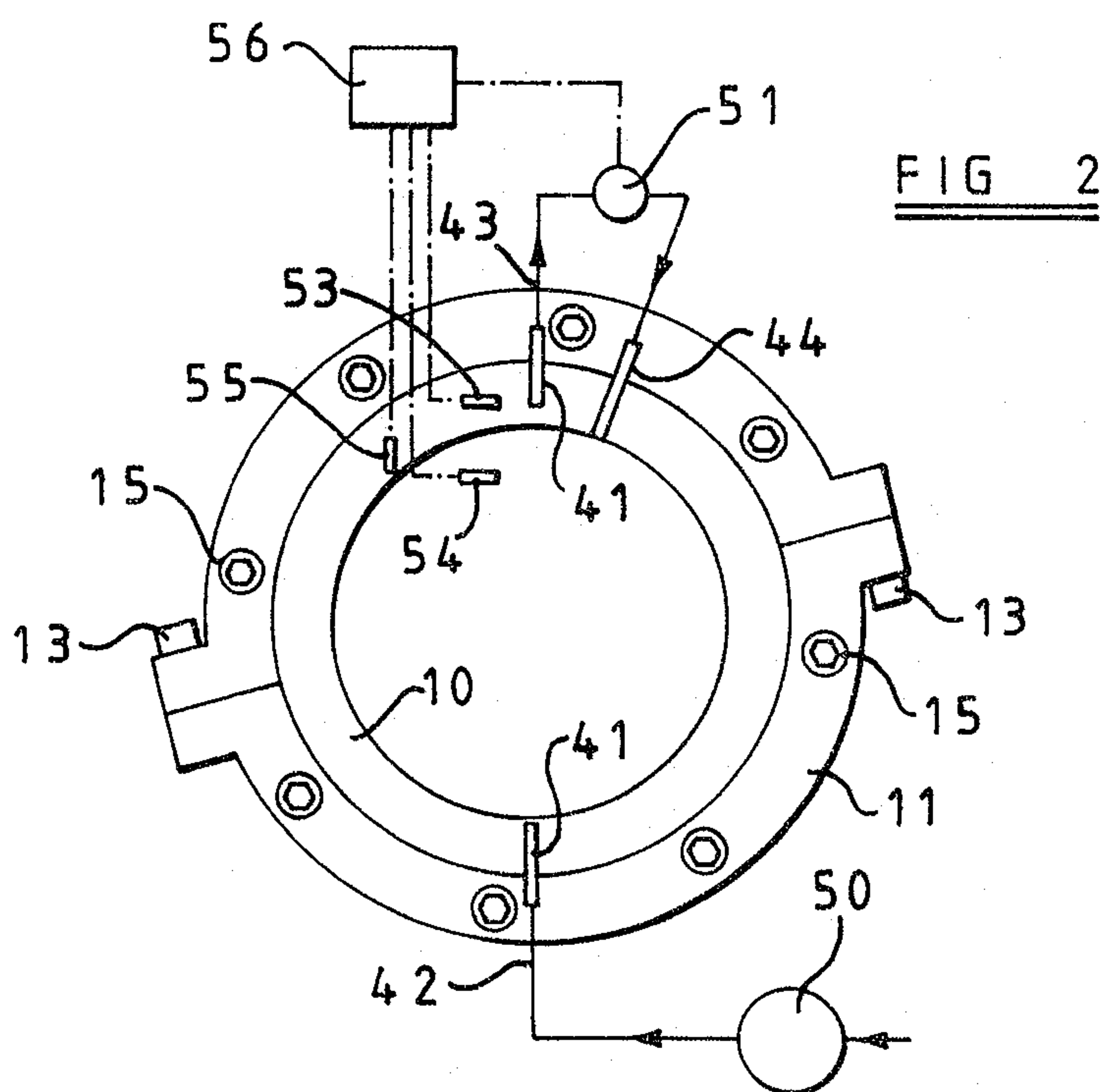
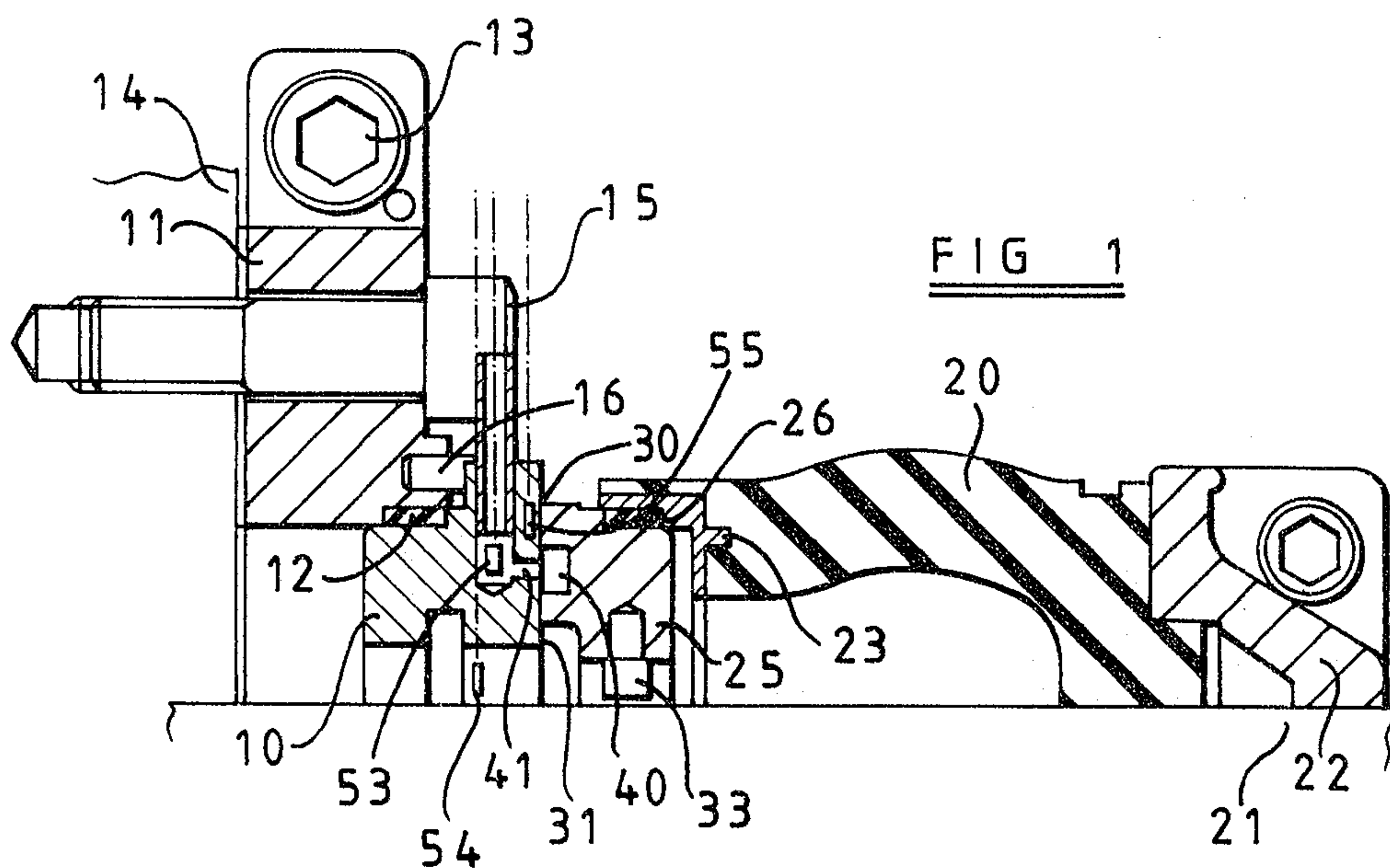
7. A mechanical face seal according to Claim 1 in which a sensor is provided for measuring the pressure of fluid at the interface between the first and second seal face members.

5 8. A mechanical face seal according to Claim 1 in which a sensor is provided for measuring the pressure of fluid retained by the seal, control means serving to adjust the pressure of fluid delivered to the sealing faces in response to variations in the pressure of the sealed
10 fluid.

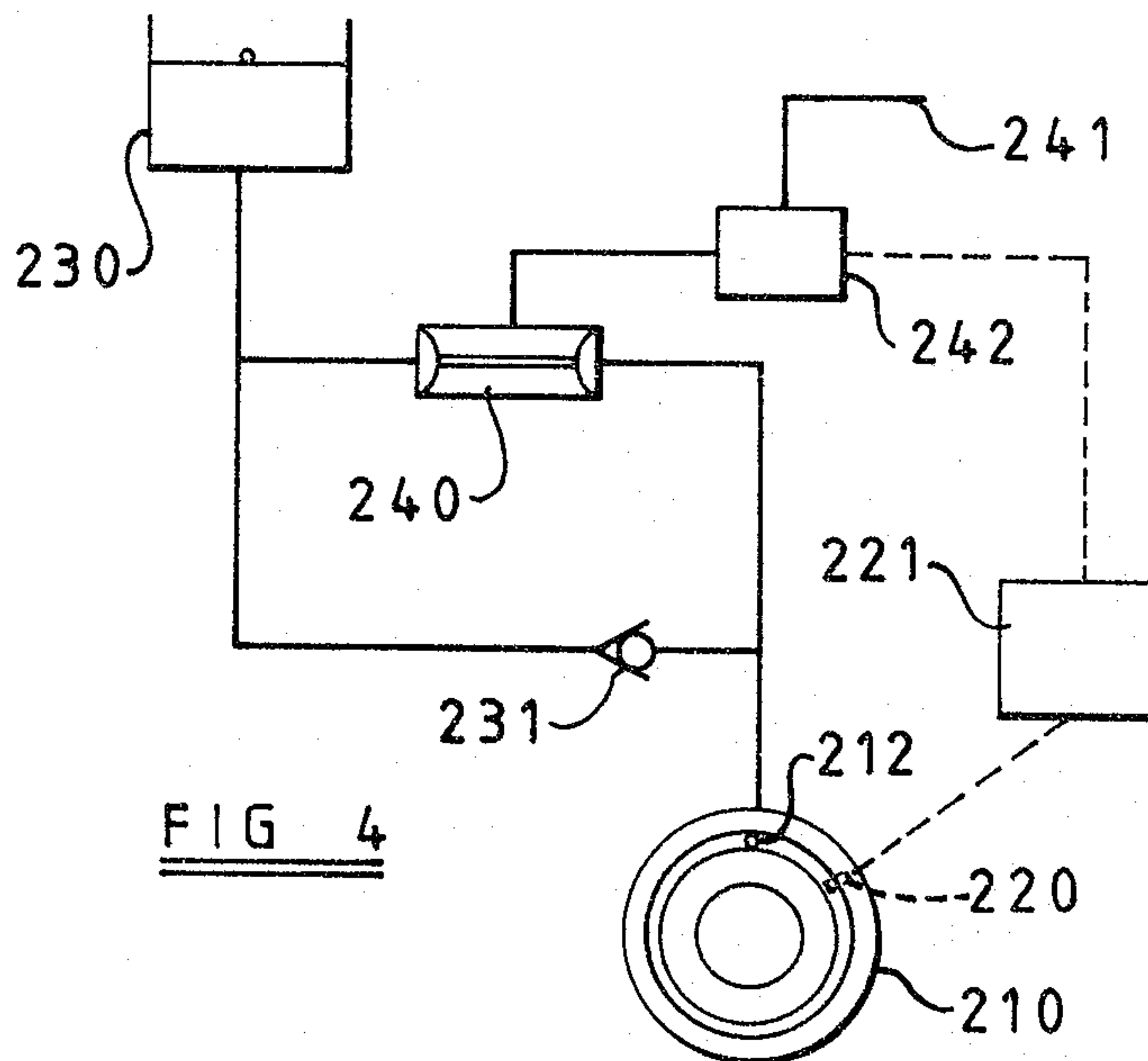
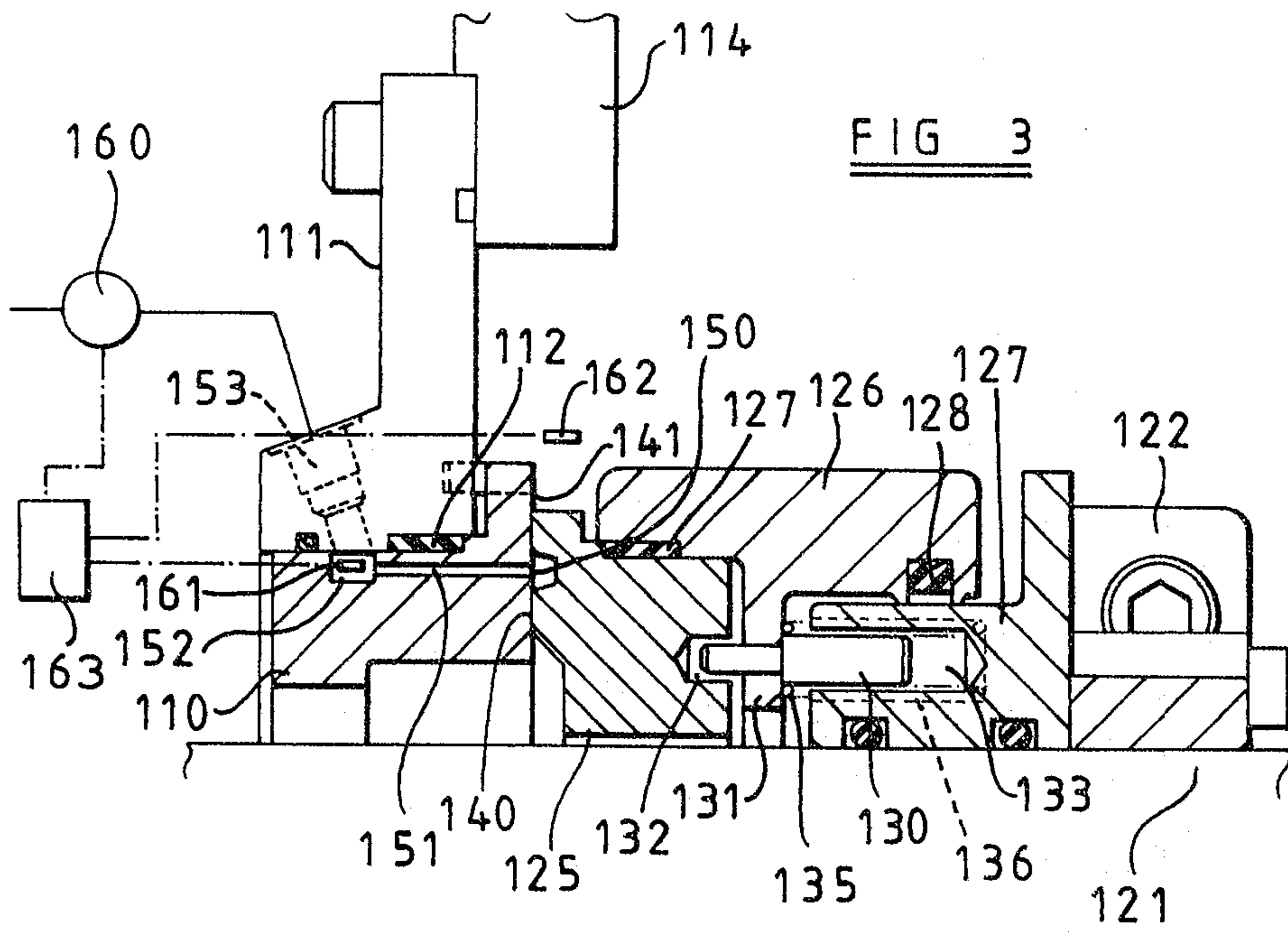
9. A mechanical face seal according to Claim 1 in which a sensor is provided for measuring the temperature of the sealing faces, control means serving to adjust the pressure of fluid delivered to the sealing faces in
15 response to variations in the temperature of the sealing faces.

10. A mechanical face seal according to Claim 9 in which the control means serves to adjust the pressure of fluid delivered to the sealing faces to maintain the
20 temperature of the sealing faces within predetermined limits.

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