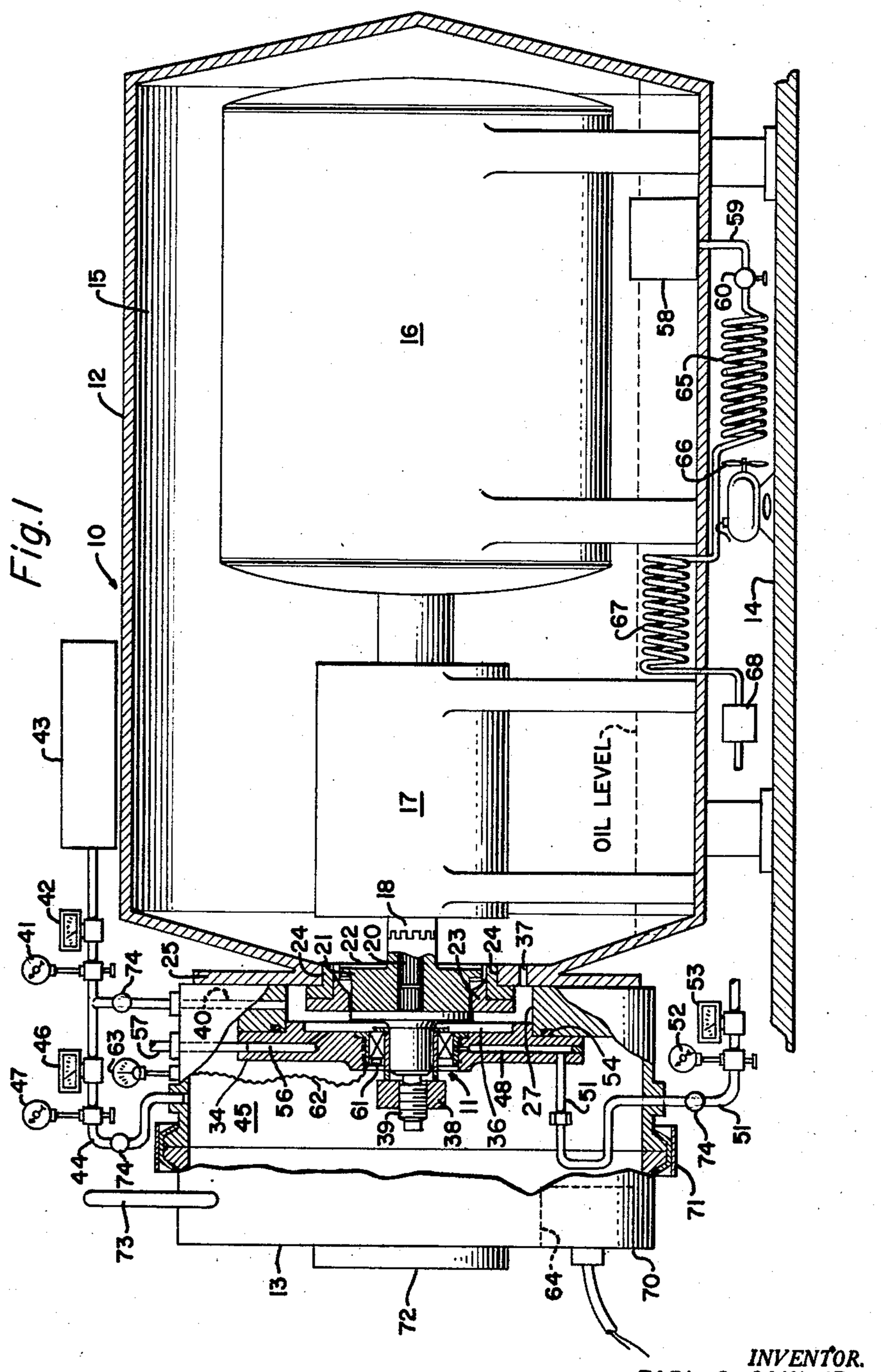
April 27, 1965 E. S. CAIN, JR., ETAL 3,180,135

SEAL EVALUATION MACHINE

Filed July 13, 1961 2 Sheets-Sheet 1

Fig. 1



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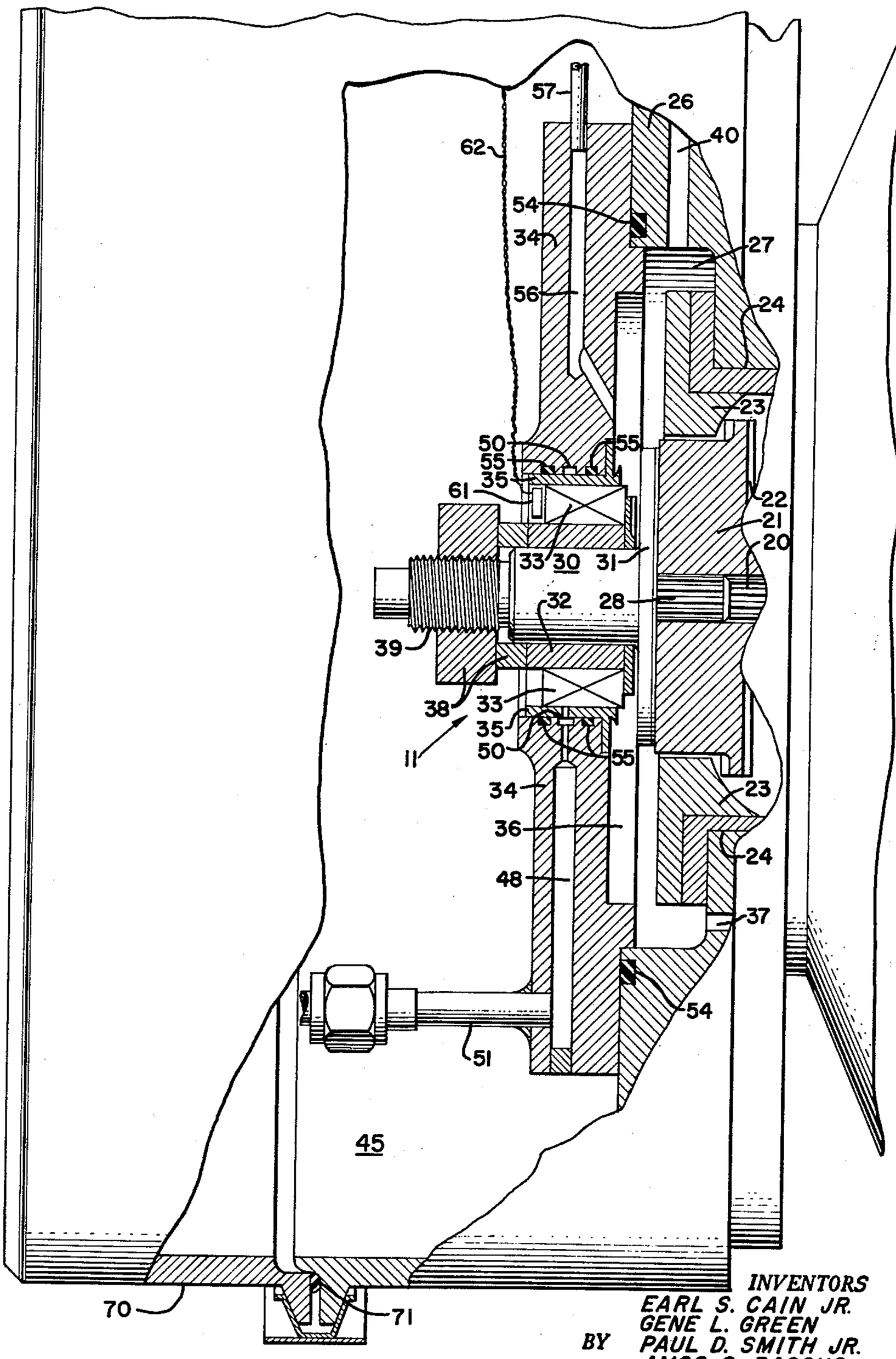

Fig. 2

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SEAL EVALUATION MACHINE

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This invention relates to an apparatus for testing seals for rotatable shafts and aims to provide a novel machine for making various qualitative and quantitative determinations of the operating characteristics of seals which are designed for use with high-speed rotatable shafts.

Many types of high-speed rotary machines, such as turbomachinery, require fluid-tight seals which will withstand the high pressures and temperatures encountered in such machines. In the past there have been no satisfactory testing machines which would make it possible to check shaft seals under conditions which might be encountered in actual use. The result of this deficiency has been that pretesting of shaft seals has been superficial, and in many cases unreliable, so that actual operating failures have been more numerous than is desirable.

It is an object of this invention to provide a seal-testing apparatus which is efficient in use and gives data showing the performance of shaft seals under simulated operating conditions.

Another object of the invention is to provide a seal-testing apparatus including a plurality of pressure chambers so that various portions of a seal may be subjected to different simulated operating pressures.

Another object is to provide a seal-testing apparatus as specified in the last paragraph and including means for indicating and measuring any fluid leakage between chambers.

Still another object of the invention is to provide a seal-testing apparatus which permits shaft speeds up to 120,000 r.p.m., and operating pressures on all exposed areas of the seal up to 200 p.s.i.

A further object of the invention is to provide a seal-testing machine which includes instruments for controlling and monitoring gas pressures in a plurality of pressure chambers, test spindle speeds, test seal temperatures, gas flow rates between pressure chambers, and oil pressure.

Still another object of the invention is to provide a seal evaluation apparatus which includes a spindle adapted to operate over a wide range of speeds and a removable adapter in which the seal to be tested may be mounted.

Another object of the invention is to provide a seal evaluation apparatus as specified in the last preceding paragraph and in which the adapter includes a first passage for supplying oil to oil-test the seal and a second passage and an associated chamber for applying pressure to the peripheral edge of the seal being tested.

The above and other features and advantages of the invention will be apparent from the following more detailed description and the accompanying drawing, in which:

FIG. 1 is a side elevational view, partly in section and partly schematic, showing a seal evaluation apparatus embodying the principles of this invention; and

FIG. 2 is a somewhat enlarged fragmentary elevational view with portions broken away and in section, showing the details of the removable adapter and associated parts for supporting the seal to be tested.

Referring now to FIG. 1, it will be noted that an improved seal-testing and evaluating machine 10, constructed in accordance with this invention, comprises a seal supporting device 11 having a large tank-like housing 12 on one side thereof and a smaller removable housing or enclosure means 13 on the other side thereof. The tank or housing 12 is rigidly supported on a suitable base 14 and provides a first pressure chamber 15 in which a motor 16 and transmission 17 are mounted. Speeds from zero to above 120,000 r.p.m. may be transmitted to a spindle or stub shaft 18 by the motor and transmission which are mounted to keep shaft vibrations at a minimum. A coupling spindle 20 having an enlarged hub 21 and oil deflecting grooves 22 is mounted on the end of stub shaft 18 and positioned and centered in a flanged supporting member 23 which is fitted into an axially aligned opening 24 in the tank 12. The coupling spindle 20 is separately supported on resiliently mounted antifriction bearings (not shown) to reduce resonant vibrations of the associated parts; and the enlarged hub 21 is designed to act as a clearance-type oil seal to prevent uncontrolled oil leakage from chamber 15. Opening 24 is formed with outwardly extending supporting flanges 25, to which the housing 13 is firmly attached in any convenient manner.

As best shown in FIG. 2, the housing 13 has a supporting member 26 formed or mounted on the inner wall thereof and provided with a cylindrical opening 27 for purposes which will hereinafter appear. Coupling spindle 20 has an axial bore for the reception of the inner reduced end 28 of a test spindle 30 which is provided with an enlarged flange 31 so that it may be securely fastened to the face of the hub 21. A cylindrical bushing 32 is fitted on spindle 30 for the reception of a cylindrical seal 33 which is suitably centered in an opening provided in a special adapter plate 34, and separated therefrom by a flanged retainer 35 forming part of the seal. Seal 33 is the seal to be tested, and, along with the adapter plate 34, acts to close the cylindrical opening 27 so as to provide an oil and pressure chamber 36. This chamber 36 is in fluid communication with the large housing chamber 15, both through the clearance or space around the hub 21 and through a special passage 37. The spindle 30 and associated bushing 32 are held for rotation with the coupling member by a washer and lock nut 38 threaded on a reduced outer end 39 of said spindle 30. By having the motor and transmission enclosed in the chamber 15, which is in fluid communication with the chamber 36 and one side of the seal 33, it is unnecessary to have another seal for the transmission shaft.

Pressure is applied to chamber 36 through a passage 40 which is connected to a conduit having a pressure regulator and gauge 41 and flowmeter 42 therein and, in turn, is connected to a suitable source of fluid pressure 43. It will be understood that the fluid pressure in chamber 36 will be applied to the exposed inner face of the seal 33. Similarly, fluid pressure of predetermined amount may be applied to the other or outer exposed face of the seal 33 by a conduit 44 which is connected at one end to the source 43 and at the other end to a closed chamber 45 formed by the housing 13. A flowmeter 46 and pressure regulator and gauge 47 may be provided in conduit 44 if desired. Finally, fluid pressure may also be applied to the peripheral edge of the seal 33 through a passage 48 which is connected at one end to an annular groove 50 surrounding the seal and at the other end to a conduit 51. This conduit runs through the wall of housing 13, has a pressure regulator and gauge 52, and flowmeter 53 therein, and is connected to the fluid pressure supply 43. A gasket or O-ring 54 between the inner face of the adapter 34 and the support 26 provides a pressure seal for chamber 36; and gasket 55 on both sides of the groove or chamber 50 effectively seal the adapter 34 against the flanged retainer 35 of the seal 33.

It will be understood that by subjecting the three pressure chambers 15, 45 and 50 to different pressure conditions, so that there may be a predetermined pressure differential between chambers, and then by observing the various flowmeters and gauges described above, it is possible to indicate and measure fluid leakage between chambers; and said gauges and flowmeters constitute means for indicating and/or measuring such fluid leakage.

To make it possible to test the seal 33 under different oil conditions, chamber 36 is connected by a passage 56 with an oil supply line 57. It will be apparent that oil entering the chamber 36 through passage 56 will flow through passage 37 into the chamber 15 and will settle in the bottom thereof. A predetermined quantity of oil is placed in the chamber 15 and circulated by a pump 58 and conduit 59 to all parts of the machine for lubrication. With this pressure supply and a control valve 60, oil flow may be controlled to conduit 57, passage 56 and chamber 36. This arrangement of parts thus constitutes a means for supplying and circulating oil in the seal-testing system.

Temperature conditions of the seal 33 under test and other parts of the apparatus, such as the main bearings (not shown) for the coupling spindle 20, are also important. To observe and measure temperatures, suitable pyrometers may be provided at strategic locations in the apparatus. One such pyrometer 61 is shown mounted adjacent the outer face of the seal 33 and connected by a wire or lead 62 to a temperature gauge 63. This gauge will give a ready indication of the temperature of the seal and may also be connected to controls to de-energize motor 16 if seal or bearing temperatures get too high. Should it be desired to increase the seal temperature or change the temperature of the pressurized fluid, a heater 64 may be located in the chamber 45 inside housing 13 and/or at other suitable places in the apparatus.

Provision may also be made for cooling the oil to a predetermined temperature level so as to cool the chamber 15 and other parts over which the oil circulates. Such cooling means may include a cooling coil 65 connected to conduit 59 outside the housing 12, a fan 66 for forcing air over the coil 65, a second coil 67 in the chamber 15 and suitable thermostats or temperature controls 68.

Operation of the entire seal-testing apparatus will be apparent from the foregoing description. Special adapter plates 34 are provided for seals of widely different types and sizes; and these may be installed in the apparatus through the housing 13. For this purpose, said housing has a removable outside cover 70 which may be attached to the housing with a suitable sealing mechanism 71; and said cover may be provided with an observation window 72 and handle 73 if desired. With the adapter plate 34 and seal shown in FIG. 2, it is necessary to remove the plate in order to install a different seal, since the flange of the retainer 35 is on the inside of said plate. Obviously, seals and adapter plates may be provided to allow for changing seals without removing the entire adapter plate; and in such case, it is merely necessary to remove the nut and washer 38.

Certain operational safety features may be incorporated in the apparatus if desired. For example, a control may be included which will prevent activation of the motor 16 until the electrical system and bearings are properly heated, and further until there is a predetermined acceptable oil flow to effect necessary lubrication. Also, safety valves 74 may be provided in any of the pressure lines to prevent over-pressurization of any of the three pressure chambers.

It will be understood that all of the meters, indicators and controls may be arranged in a single accessible control panel, and that environmental conditions, such as speed, pressure magnitude and ratio, temperature, oil flow rate, and the like, may be varied as desired during operation. Direct reading fluid leakage between chambers may then be correlated with dynamic conditions of operation. The arrangement and mounting of the spindles render them substantially free of vibration, but shimming adjustments may be made to simulate environmental conditions of both misalignment and radial runout. Furthermore, the spindle design and changeable adapter plates permit testing seals of various sizes, for example, from a 3/16-inch bore up to a 3-inch bore. Also, the design and arrangement of the apparatus permit easy changes of seals and allow the parts to be observed during operation.

Various changes may be made in the apparatus herein described and certain features may be employed without others without departing from the invention or sacrificing any of its advantages.

We claim:

1. Apparatus for testing annular seals for the shafts of rotating machinery, such annular seals having inner and outer faces and an outer peripheral edge, said apparatus comprising: a support; a rotatable spindle extending through said support and adapted to receive the seal to be tested; an adapter plate removably connected to said support for holding said seal; passage means in said adapter plate in fluid communication with said outer peripheral edge; and means for independently applying fluid under pressure to both inner and outer faces of said seal and to said passage means.

2. Apparatus for testing annular seals for the shafts of rotating machinery, such annular seals having inner and outer faces and an outer peripheral edge, said apparatus comprising: a support; a rotatable spindle extending through said support and adapted to receive the seal to be tested; an adapter plate removably connected to said support for holding said seal; passage means in said adapter plate in fluid communication with said outer peripheral edge; means for independently applying fluid under pressure to both inner and outer faces of said seal and to said passage means; and means for measuring any fluid flow between said peripheral edge and said inner and outer faces so as to provide a measure of fluid leakage through said seal.

3. Apparatus for testing annular seals for rotating shafts comprising: means providing a pair of chambers separated by a wall; means on said wall for holding a seal to be tested with opposite ends of said seal exposed to the respective chambers; shaft means extending through the seal to be tested; means in one of said chambers and connected with said shaft means to impart rotary motion thereto; and means for introducing fluid under different controlled pressures to said chambers.

4. Apparatus for testing annular seals for rotating shafts comprising: means providing a pair of chambers separated by a wall; means on said wall for holding a seal to be tested with opposite ends of said seal exposed to the respective chambers; shaft means extending through the seal to be tested, said seal forming the only potential path for communication between said chambers; means in one of said chambers and connected with said shaft means for imparting rotary motion thereto; means communicating with at least one of said chambers for creating a controlled pressure differential between said chambers; and means for detecting any changes in said pressure differential.

5. Apparatus for testing annular seals for rotating shafts comprising: means providing a pair of chambers separated by a wall; means on said wall for holding a seal to be tested with opposite ends of said seal exposed to the respective chambers; shaft means extending through the seal to be tested, said seal forming the only potential path for communication between said chambers; means in one of said chambers and connected with said shaft means for imparting rotary motion thereto; means communicating with said chambers for supplying fluid at different controlling pressures thereto; and means for detecting change and rate of change in pressures in said chambers.

6. Apparatus for testing annular seals for rotating shafts comprising: means providing a pair of chambers separated by a wall; means on said wall for holding a seal to be tested with opposite ends of said seal exposed to the respective chambers, said wall providing a third chamber around the periphery of said seal intermediate the ends thereof; gasket means between said seal and said wall at points between said third chamber and the chambers of said pair of chambers; shaft means extending through the seal to be tested, said seal forming the only potential path for communication between said chambers; means in one of said chambers and connected with said shaft means for imparting rotary motion thereto; means communicating with said chambers for selectively supplying controlled pressures thereto; and means for detecting pressure changes in any one of said chambers.

7. Apparatus for testing annular seals for rotating shafts comprising: means providing a pair of chambers separated by a wall; means on said wall for holding a seal to be tested with opposite ends of said seal exposed to the respective chambers; shaft means extending through the seal to be tested, said seal forming the only potential path for communication between said chambers; means in one of said chambers and connected with said shaft means for imparting rotary motion thereto; means communicating with said chambers for supplying fluid at different controlled pressures thereto; means for varying the temperature of the fluid supplied to said chambers; and means for detecting changes in pressure in said chambers due to leakage through the seal being tested.

8. Apparatus for testing annular seals for rotating shafts comprising: means providing a pair of chambers separated by a wall; means on said wall for holding a seal to be tested with opposite ends of said seal exposed to the respective chambers; shaft means extending through the seal to be tested, said seal forming the only potential path for communication between said chambers; means in one of said chambers and connected with said shaft means for imparting rotary motion thereto; means communicating with said chambers for supplying fluid at different controlled pressures thereto; means for varying the temperature of the fluid supplied to said chambers; means for indicating the temperature of the seal being tested; and means for detecting changes in pressure in said chambers due to leakage through said seal.

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ISAAC LISANN, *Primary Examiner.*