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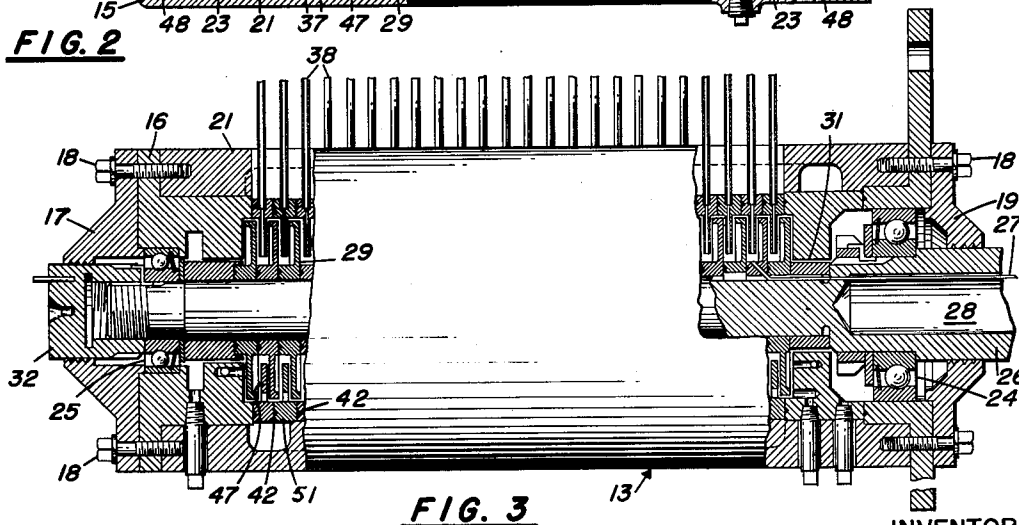
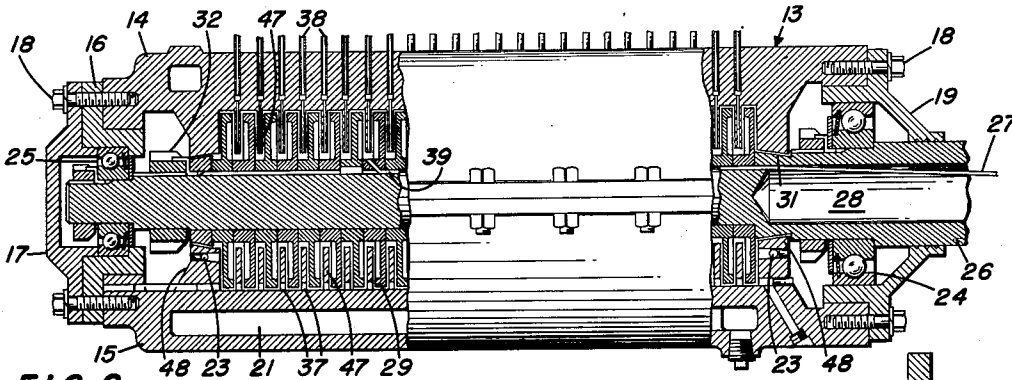
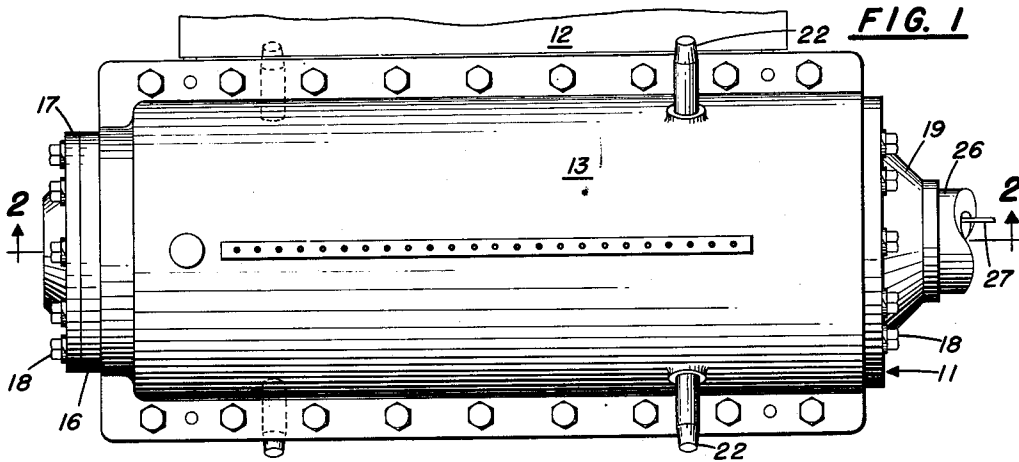
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2,633,744

MERCURY TYPE PRESSURE TRANSFER DEVICE

Filed April 18, 1949

2 SHEETS—SHEET 1



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MERCURY TYPE PRESSURE TRANSFER DEVICE

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2 SHEETS—SHEET 2

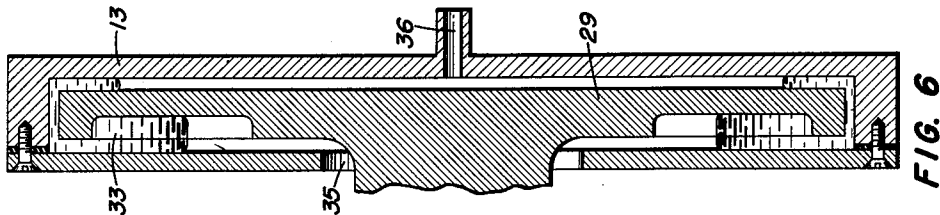


FIG. 6

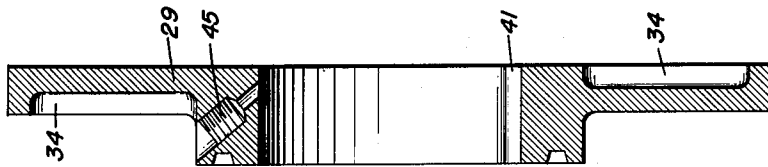


FIG. 5

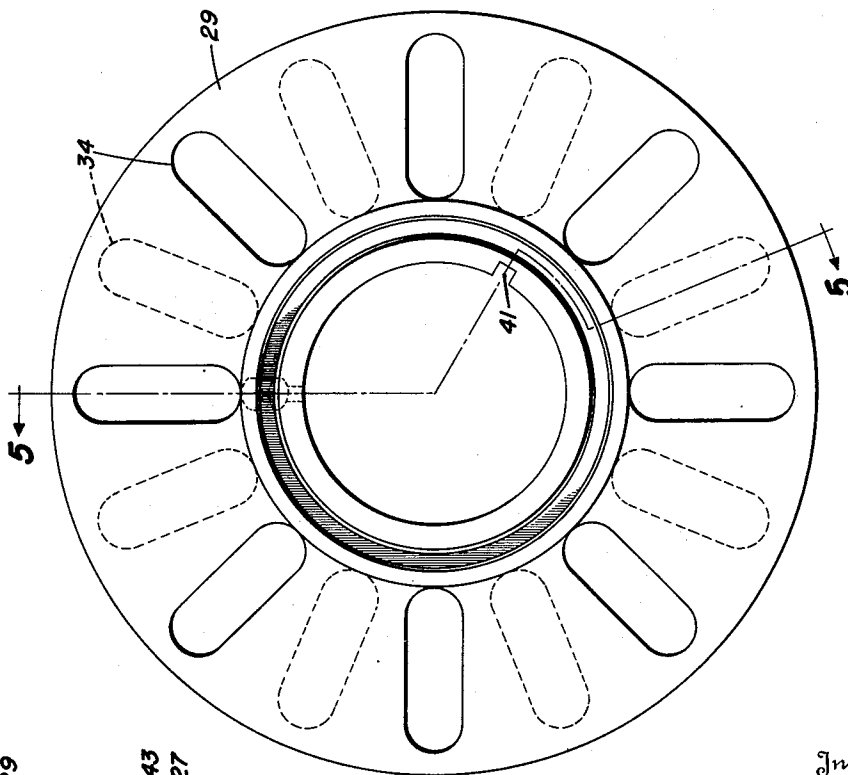


FIG. 4

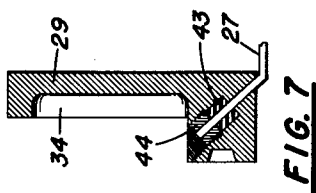


FIG. 7

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MERCURY TYPE PRESSURE TRANSFER
DEVICE

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5 Claims. (Cl. 73—147)

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sec. 266)

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The present invention relates to a pressure transfer device and more particularly to a device for transferring simultaneously multiple pressures from a rotating object to a stationary object, or vice versa.

An object of the invention is the provision of a device for transferring simultaneously and without leakage numerous channels of fluids from rotating objects to stationary objects.

Another object is to provide a device for transferring simultaneously at least twenty-four pressures from a rotating object to a stationary object without appreciably increasing the size of the device.

A further object is to provide a pressure transfer device which will transfer efficiently high pressure differences.

Still another object is to provide a pressure transfer device capable of transmitting pressure differences higher than those ordinarily encountered in recording pressures on rotating airfoils.

A still further object of this invention is the provision of a pressure transfer device capable of operating at speeds up to 6000 revolutions per minute.

Other objects and many attendant advantages of the present invention will be apparent from the following detailed description when taken together with the accompanying drawings in which:

Fig. 1 is a plan view of one form of pressure transfer device according to the present invention.

Fig. 2 is a sectional view taken along the line 2—2 of Fig. 1 looking in the direction of the arrows.

Fig. 3 is a sectional view similar to Fig. 2 illustrating another embodiment of the invention.

Fig. 4 shows a front elevational view of a typical impeller of the device of Figs. 1 to 3.

Fig. 5 is a sectional view taken along the line 5—5 of Fig. 4.

Fig. 6 illustrates a single mercury seal between the impeller and stator according to the invention; and

Fig. 7 is a detail of a preferred connection between the impeller and the rotor tube according to the invention.

Referring now to the drawings, wherein like reference characters designate like or corresponding parts throughout the several views, there is shown in Fig. 1 a pressure transfer device, generally designated 11, connected by any suitable means to a flat tank 12 containing mercury, or any other suitable fluid. Transfer device 11 com-

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prises a stator 13 consisting of two halves 14, 15 suitably joined together at one end by means of bearing support 16, cover plate 17 and bolts 18 extending through plate 17, support 16 and halves 14, 15 of stator 13. The halves 14, 15 are connected together at the other end by means of bearing member 19 suitably secured to stator 13 such as by additional bolts 18.

Stator 13 has a self-contained water jacket 21 for cooling the stator during the operation of the device, there being suitable passages 22, 22 in stator 13 for permitting the water to flow therethrough from an external source, not shown. Rotatably supported in stator 13 by means of sealed bearings 24, 25 is a rotor shaft 26 which is adapted to be connected by any suitable means, to the rotating object, not shown, whose pressure is to be measured, there being suitable tubes, one of which is shown at 27, extending through a central passage 28 in rotor shaft 26, each tube being adapted to be connected to a point on the rotating object whose pressure is to be measured.

On an airfoil, for example, under test for pressure conditions at distributed points along the surface thereof, the motor shaft 26 is rigidly coupled by any known means, as by bolting, to the hollow shaft of the airfoil, and the tubes 27 are extended into the airfoil shaft and connected to manometer tubes embedded in the airfoil surface and extending to a series of distributed test points thereon. Preferably, radially adjacent manometer points are connected to axially adjacent impeller spacings so as not to overload each impeller unit; and in this manner large pressure differences may be summed by the apparatus.

Each tube 27 is preferably made of a metal which will not react chemically with the mercury, such as stainless steel, and extends to an impeller 29, mounted on shaft 26, through a longitudinal groove 39 in shaft 26, as clearly shown in Fig. 2. The connection between tube 27 and impeller 29 is made airtight by any suitable means, such as silver soldering a tapered fitting to the end of tube 27, coating the fitting with rubber cement and driving the fitting tightly into the aperture 45 in impeller 29. The impellers 29 are each keyed as at 41 to shaft 26 and are pressed tightly against each other by means of shoulder 31 at one end of shaft 26 and a nut 32 at the other end of the shaft, the bearing surfaces being preferably ground and lapped in order to provide airtight junctions.

Referring now to Figs. 4 to 6, wherein are shown the details of a single mercury seal ac-

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cording to this invention, it can be seen that impeller 29 causes mercury 33 to rotate in a circular chamber and mercury 33 forms a seal around the periphery of impeller 29. The faces of the impeller 29 are provided with radial cut outs 34 in order to provide sufficient traction to rotate the mercury, it being seen in Fig. 4 that alternate cut outs 34 are provided on opposite faces of impeller 29. It has been found that impellers comprising smooth disks or disks with small radial grooves on each face proved to be unsatisfactory to permit pressure transfer at the rotational speeds contemplated.

Impeller 29, according to the invention, will cause mercury 33 to rotate at the periphery thereof when its rotational speed is approximately 350 revolutions per minute, or higher if the spacing between impeller 29 and stator 13, as shown in Fig. 6, is approximately 0.045 inch. It is essential that the sides of impeller 29 near the periphery thereof be smooth in order to prevent turbulence, and that cut outs 34 in the faces of impeller 29 not extend to the outer surface, as shown in Figs. 4 to 6, in order to form a perfect seal.

In operation, when a difference in pressure exists across impeller 29, between points 35 and 36 in Fig. 6, rotating mercury 33 assumes the shape shown in Fig. 6, the centrifugal force of the mercury balancing the force caused by the difference in pressure and thereby forming a seal. When the force on mercury 33 caused by the difference in pressure exceeds the centrifugal force, the gas or liquid in tube 27 will leak from one side of the impeller to the other thereby disrupting the operation of the device. However, because the specific gravity of mercury is high, it has been found that the diameter of impeller 29 need not exceed three inches to provide for sufficient centrifugal force for the transfer of airfoil pressures, if cut outs 34 are of approximately 0.625 inch in order to provide sufficient traction for mercury 33.

Tank 12 for mercury 33 is of relatively large volume so as to serve as a reservoir for the excess mercury during operation, and to assure equal distribution throughout the various cells. The passage from tank 12 to stator 13 is through openings 23 while the level of the tank is between openings 23 and the lower surfaces of the central opening in wall members 48 in order to prevent the mercury from passing over the openings in the wall members 48 and into the spacing between members 48 and bearings 24 or 25.

Under initial static conditions, mercury 33 from tank 12 enters stator 13 through openings 23 and is distributed equally throughout the various cells by means of vents or openings 37 in the radial partitions or fins 47 of stator 13. When the impeller rotates, the mercury is carried around the impeller chamber, additional mercury flowing into the chamber from the tank to supply the added amount required to balance the tank and impeller pressures. When impeller rotation ceases, the excess mercury flows back to the tank. In this manner, adequate mercury supply for the casing is assured without flooding of the shaft bearings.

It will be apparent that the device 11 will not only measure simultaneously a plurality of pressures, but that a large pressure differential, such as between the extremes of a rotating airfoil, can be readily reproduced, since device 11 will measure this large differential in a step by step manner. In other words, although the pressure

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differential between extreme cells may be exceedingly great, the pressure differential across each cell will be sufficiently small so that it can be equalized by the centrifugal force. In this manner the pressure distribution along the rotating object is readily obtainable, and, by a summation of the individual pressure differences across each cell, the total pressure differential can be measured.

The pressure transfer from each cell to external indicators, not shown, is made through openings in the inner ends of the upper portions of fins 47; as shown in Fig. 2 and through tubes 38 extending into fins 47, it being understood that any suitable pressure measuring device may be used as an indicator.

It is essential that there be a smooth juncture between halves 14, 15 of stator 13, if leaks around impellers 29 are to be prevented during operation of the device. Experimentation has demonstrated that the transfer device of Figs. 1 and 2 will perform transfers satisfactorily for rotational speeds up to approximately 4000 revolutions per minute, there being a leakage of mercury out of stator 13, where halves 14, 15 join, at speeds greater than 4000 revolutions per minute.

Referring now to Fig. 3, there is shown an improved embodiment of the present invention which is capable of satisfactorily operating at least as high as 6600 revolutions per minute, and which does not require the difficult machining and finishing of the two halves 14, 15 of the stator 13 of Figs. 1 and 2. As shown in Fig. 3, stator 13 comprises a plurality of circular rings 51, each having a groove on one side into which is inserted a sealing ring 42 of suitable material, such as neoprene. When rings 51 are pressed tightly against one another in assembly, a highly effective seal is formed which permits operation, without leakage, at very high speeds. A similar arrangement of sealing rings 42 was used for impellers 29 of Fig. 3 in order to avoid the necessity of lapped surfaces, as in the embodiment of Figs. 1 and 2.

To avoid the use of solder and to form a more perfect seal between tubes 27 and impellers 29, a form of neoprene seal, as clearly shown in Fig. 7, was utilized. After tubes 27 were inserted in their associated impellers 29 a section of neoprene tubing 43 was placed thereover and a screw 44 was forced against tubing 43 to form an excellent seal. A similar connection, not shown, was utilized between disks 41 of stator 13 and tubes 38. The remaining parts of the device of Fig. 3 correspond to those of the device of Figs. 1 and 2, and reference is made to the earlier description thereof for the operation of this improved embodiment.

Although the devices illustrated have been primarily designed for transferring only twenty-four pressures simultaneously, it is clear that the number of pressure channels may be increased considerably with only a relatively small increase in length of the device, particularly when the embodiment of Fig. 3 is utilized. Almost all of the metal parts of the device should be made of a material which resists chemical reaction with or corrosion by mercury, such as stainless steel.

It has been experimentally determined that the power required to operate the transfer device increases approximately with the cube of the rotational speed and, since the power is largely expended in the form of heat, consider-

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able attention must be given to the cooling system where operation at speed higher than 6000 revolutions per minute are contemplated.

Various modifications are contemplated and may obviously be resorted to by those skilled in the art without departing from the spirit and scope of the invention, as hereinafter defined by the appended claims, as only preferred embodiments thereof have been disclosed.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed is:

1. In a device for determining the pressure distribution on the surface of a rotating object, a rotatable shaft, a plurality of impellers mounted on said shaft and extending radially outwardly thereof; each of said impellers having a plurality of radial cut outs on at least one of the surfaces thereof terminating short of the impeller periphery to form a smooth annulus, a plurality of tubes each extending longitudinally along said shaft and terminating at one end in the spacing between adjacent impellers, the other end of each of said tubes being adapted to be connected to a point on said object, a casing enclosing said shaft and impellers and having a plurality of radial fins each extending into one of said spacings, said casing being adapted to receive fluid means responsive to the rotation of said shaft for forming a seal between each impeller and its associated fin, and duct means extending from the inner end of each of said fins outwardly of said casing.

2. In a device for determining the pressure distribution on the surface of a rotating object, a rotatable shaft having a plurality of disc impellers mounted transversely thereon, each of said impellers having a plurality of radial cut outs on the surface thereof, a plurality of tubes extending along said shaft each terminating at one end in separate spacings between adjacent impellers, the other end of each of said tubes being adapted to be connected to a point on the surface of said object, a casing enclosing said shaft and impellers and having a plurality of radial fins each projecting into said spacing, said casing being adapted to receive liquid sealing means between said fins and impeller, duct means extending from the inner ends of each of said fins to without said casing, and a liquid containing tank mounted below the level of said shaft and connected for liquid flow to and from said casing for holding the liquid level of said sealing means below said shaft when the shaft is stationary.

3. In a device for determining the pressure distribution on the surface of a rotating object, the combination comprising a rotatable shaft, a plurality of disc impellers mounted transversely

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on said shaft each including a radially outwardly extending flange having cut outs in the surface thereof terminating short of the impeller periphery, sealing elements between each pair of impellers, a plurality of tubes extending longitudinally along said shaft and each terminating at one end in the spacing between adjacent impeller flanges, a stationary casing surrounding said shaft and said impellers, a plurality of annular members coaxial with said shaft and positioned between said shaft and said casing, sealing elements between said members, each of said members having a fin extending inwardly into said spacing, fluid sealing means in said casing for forming a seal between each of said fins and its associated flange, and duct means extending from the inner end of each of said fins to without said casing, the other end of said tubes being adapted for connections to pressure devices on said rotating object.

4. The combination according to claim 1, and openings in the outer end of each of said fins for equalizing the distribution of said fluid sealing means.

5. In a device for determining the pressure distribution on the surface of a rotating object, a rotatable shaft, a plurality of impellers mounted on said shaft and extending radially outwardly thereof; each of said impellers having a plurality of radial cut-outs on the surface thereof, a plurality of tubes each extending longitudinally along said shaft and terminating at one end in separate spacings between adjacent impellers, the other end of each of said tubes being adapted to be connected to a point on said object, a casing enclosing said shaft and having a plurality of radial fins each extending into said spacing, fluid means responsive to the rotation of said shaft for forming a seal between each impeller and its associated fin, duct means extending from the inner end of each of said fins outwardly of said casing, and a fluid reservoir for supplying fluid to said fluid means, said reservoir between positioned at a level such that in normal operation fluid is supplied to said reservoir under static conditions and fluid is supplied to said casing when said shaft is in rotation.

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