

Jan. 29, 1946.

I. J. KARASSIK

2,393,691

PUMPING UNIT

Filed Nov. 3, 1943

4 Sheets-Sheet 1

FIG. 1.

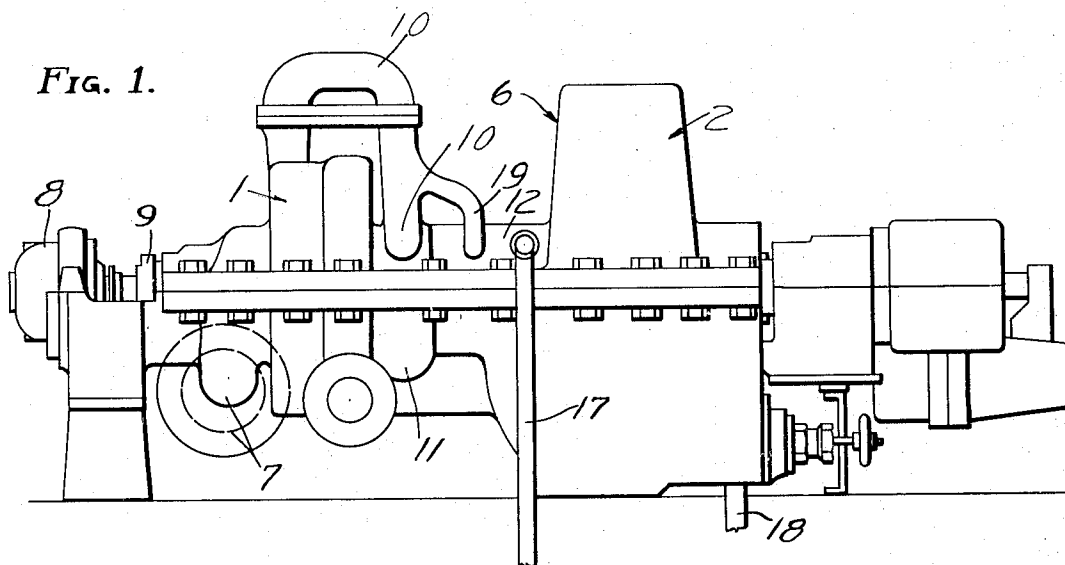


FIG. 5.

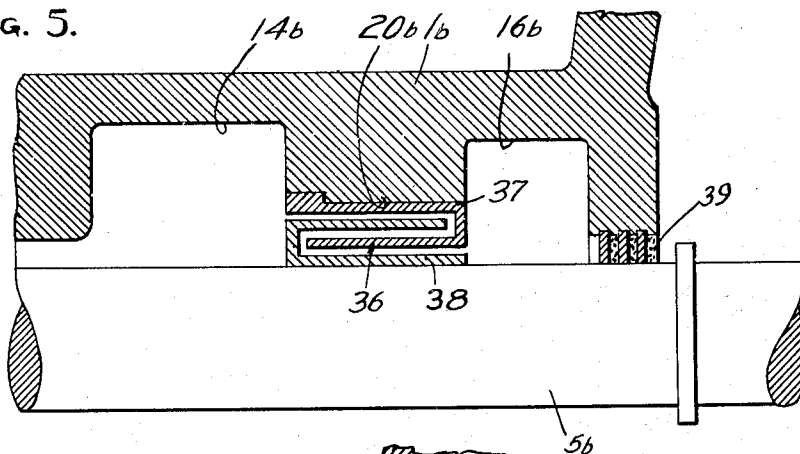
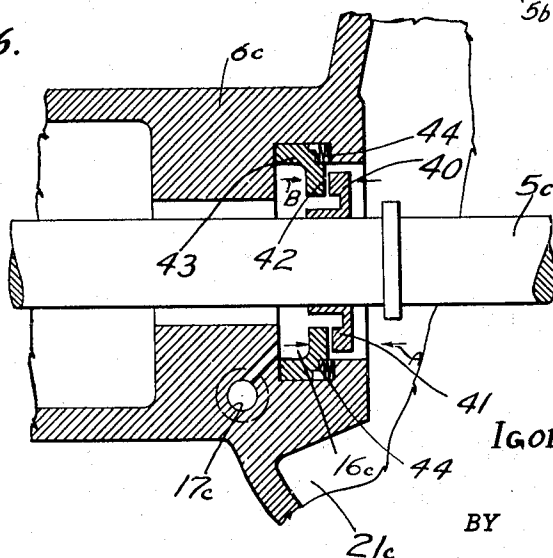


FIG. 6.



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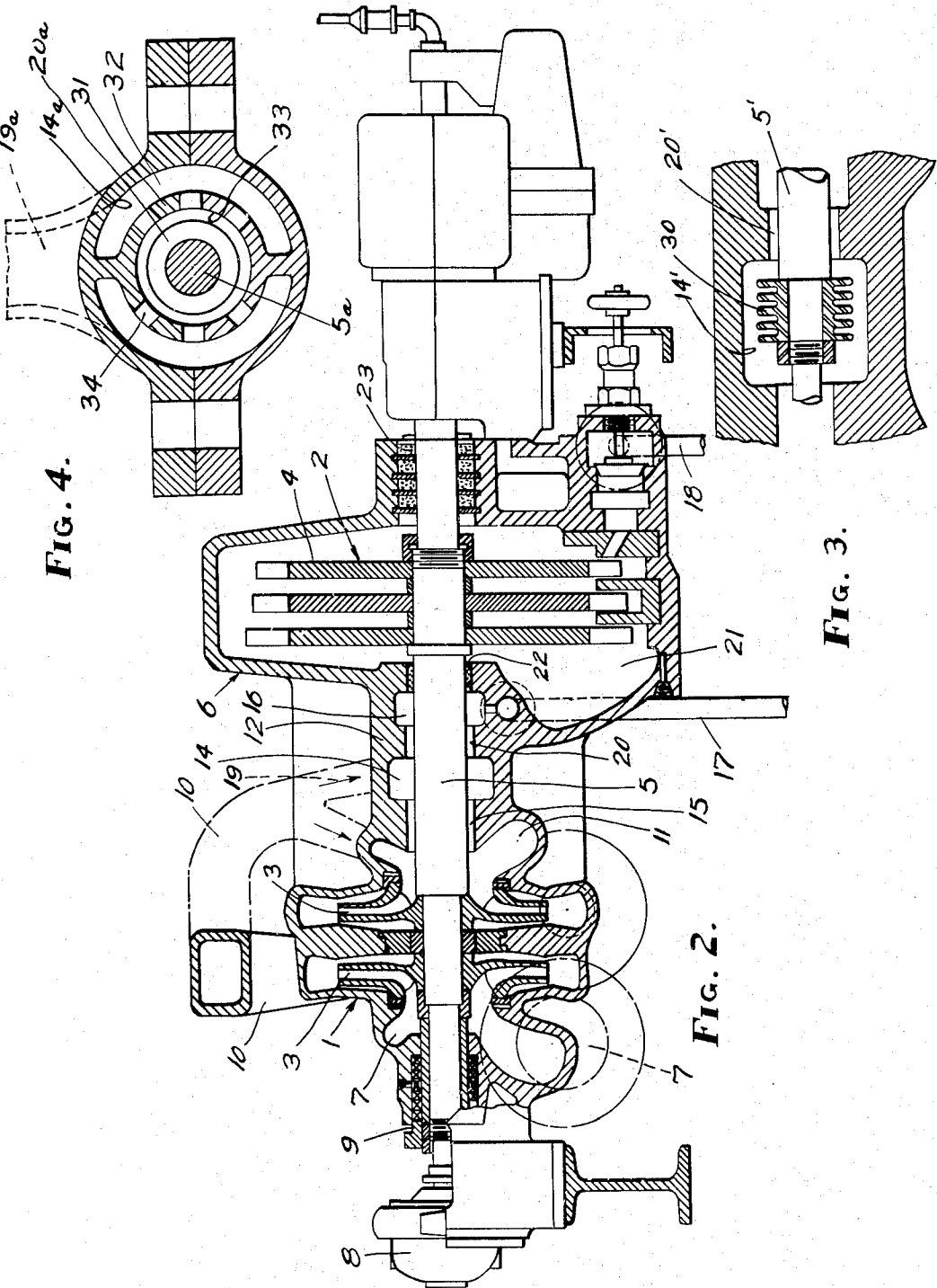
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4 Sheets-Sheet 2



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4 Sheets-Sheet 3

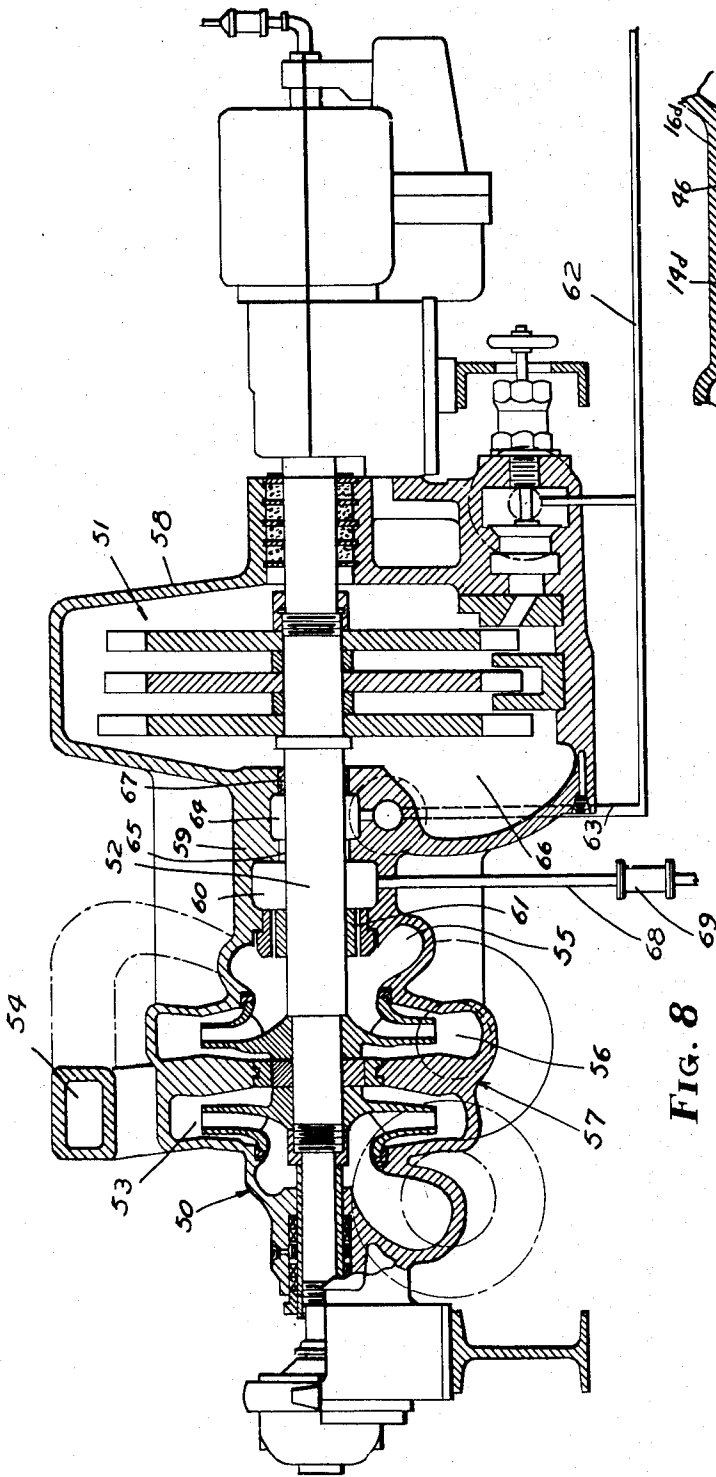


FIG. 8

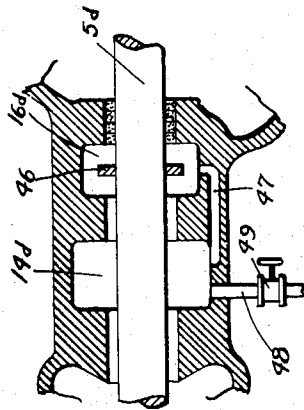


FIG. 7.

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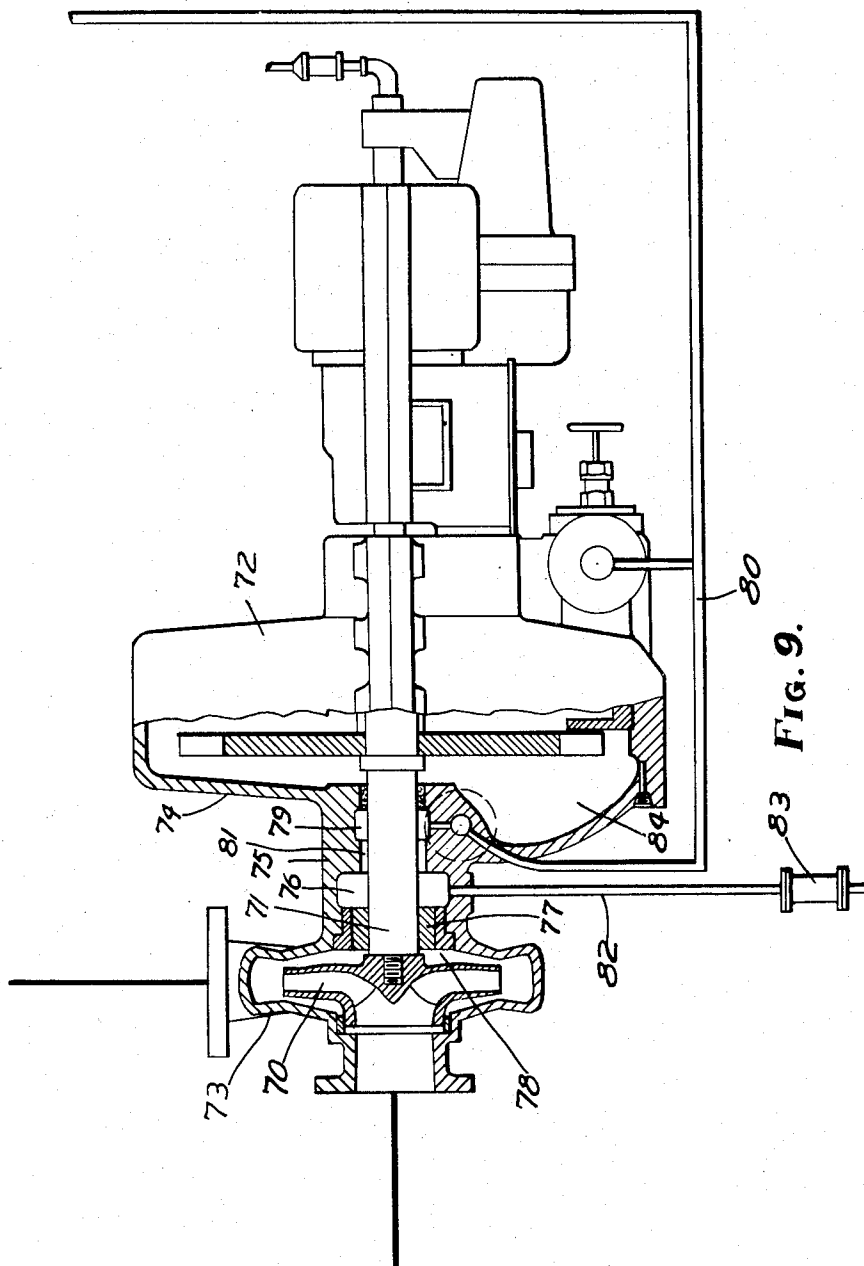
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PUMPING UNIT

Filed Nov. 3, 1943

4 Sheets-Sheet 4



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2,393,691

PUMPING UNIT

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Application November 3, 1943, Serial No. 508,807

23 Claims. (Cl. 103—87)

This invention relates to pumping units, and more particularly to turbine driven centrifugal pumps designed for handling high pressures such as five hundred to one thousand pounds per square inch and particularly adaptable for use as boiler feed pumps.

The general novelty and advantages of the present invention are particularly applicable for use in steam turbine driven boiler feed pumps, refinery centrifugal pumps driven by natural gas, and analogous pumping units.

An object of the present invention is to provide a turbine driven centrifugal pump for handling high pressures at high operating speeds which is of greatly simplified construction over present day approved pumping units of similar nature, especially with respect to stuffing boxes and sealing structures, and a pumping unit which will eliminate many of the problems and difficulties contingent with effectively sealing the pump.

In modern power plant construction, the trend in design in boiler feed pumps is toward high operating speeds such as five thousand to seven thousand revolutions per minute and pressures per stage of the pump as high as five hundred pounds per square inch. This tendency results in a lesser number of stages, smaller casing areas, greater reliability of the axially split casing joint, and greater efficiency on the part of the driving turbine and the pump, but increases difficulty of effectively sealing the pump structure against leakage, and introduces difficult problems with reference to the stuffing boxes employed in the pump structure.

In the event a standard approved type of pump and turbine construction are employed, for instance, a two stage pump designed to develop one thousand pounds per square inch at a speed of seven thousand revolutions per minute, one of the stuffing boxes would be subject to suction pressure of the pump, while the second stuffing box would be under the discharge pressure of the first stage or five hundred pounds per square inch.

It is a well-known fact that the difficulty of packing a stuffing box under high pressures or temperatures or both can be linked with the product of pressure, temperature, and linear speed, or with the product of some exponential function of all three. Thus it can be said that doubling the rotating speed has about the same effect on the stuffing box as doubling the pressure to which the stuffing box is subjected. No experience today exists of successfully packing a centrifugal pump against one thousand pounds per square

inch at thirty six hundred revolutions per minute, and, therefore, it is safe to presume that it would be difficult and highly expensive to pack a similar pump against a pressure of five hundred pounds per square inch and seven thousand revolutions per minute. While pressure reducing structures such as pressure reducing labyrinths might be employed to reduce the pressure in advance of the stuffing box such labyrinths are expensive, materially increase the bulk of the pump and are unsatisfactory both from the point of view of efficiency and satisfaction of the operation.

To obviate the disadvantages presented by the above outlined factors, the present invention contemplates the elimination of the second stuffing box in such a pump; i. e., the stuffing box which would be subject to the discharge pressure of the first stage of the pump; by providing in such a pumping unit a combined turbine and pump structure embodying an internal leakage joint incorporating therein a mixing chamber into which liquid leaks from the pump under approximately the discharge pressure of the first stage of the pump, and into which steam under a pressure greater than the liquid pressure is led, resulting in a condensation of a part of the steam in the mixing chamber, return of leakage water and condensate to the pump, and a stoppage or damping of leakage of liquid into the turbine, thus effectively sealing the pump at the high pressure leakage point without embodying the many disadvantages and problems of a stuffing box at such point in the pump.

With these and other objects in view, as may appear from the accompanying specification, the invention consists of various features of construction and combination of parts, which will be first described in connection with the accompanying drawings, showing a pumping unit of a preferred form embodying the invention, and the features forming the invention will be specifically pointed out in the claims.

In the drawings:

Figure 1 is a side elevation of the improved pumping unit.

Figure 2 is a longitudinal section through the pumping unit.

Figure 3 is a detailed section of a part of the pumping unit showing a form of mixer in the mixing chamber.

Figure 4 is a detail cross-section illustrating a further modified construction for providing thorough mixing of the steam and water in the mixing chamber.

Figure 5 is a detail longitudinal section illustrating the embodiment of pressure reducing apparatus for preventing back flow of liquid into the turbine.

Figure 6 is a detail section illustrating a form of pressure reducing apparatus for reducing the leakage and the pressure of high pressure steam from the sealing arrangement into the back pressure portion of the turbine.

Figure 7 is a detail section of a slight modification of the sealing arrangement.

Figure 8 is a longitudinal section of a pumping unit constructed in accordance with the present invention which unit is driven by a gas operated turbine.

Figure 9 is a longitudinal section through a modified form of gas turbine driven pumping unit.

Referring more particularly to the drawings, the improved pumping unit comprises a multistage centrifugal pump 1, and a steam turbine 2 for driving the pump. The impellers 3 of the pump and the blade wheels 4 of the turbine are mounted upon a single shaft 5 providing a direct uncoupled driving connection between the turbine 2 and the pump 1. The casing of the centrifugal pump 1 and the casing of the turbine 2 are formed, cast together, or connected to form a continuous or sectionalized casing free from spaces which freely communicate with the atmosphere, thus providing in effect a unitary casing for the turbine 2 and the centrifugal pump 1. Such a structure eliminates couplings or analogous structures between the turbine and the pump and with the novel sealing arrangement as will be hereinafter described eliminates a stuffing box for the pump and a stuffing box for the turbine.

The impellers 3 of the multistage pump are disposed in back-to-back relation with the inlet or suction 7 of the pump facing the end of the casing outwardly from the pump and away from the turbine so that the joint where the shaft 5 passes out of the casing to the bearing structure 8 is subjected only to suction pressure of the pump which is the lowest pressure in the pumping unit. The joint between the casing and the shaft or rather the opening in the casing 6 through which the shaft 5 projects is packed or sealed with a stuffing box 9 of any approved construction. The first stage of the pump discharges through a cross over passage 10 into the suction passage 11 of the second stage of the pump so that the opening in the casing 6 at the inner end of the pump through which the shaft 5 extends is subject only to the discharge pressure of the first stage of the pump. While in the drawings a two-stage centrifugal pump is shown, it is to be understood that any number of stages in a centrifugal pump may be employed without departing from the spirit of the present invention so long as the stage impellers are arranged in such manner that the outer end of the pump casing is subject to suction pressure and the inner end is subject to the pressure of the second stage or one of the lower stages of the pump.

The casing 6 embodies a connecting portion 12 which connects the pump enclosing portion of the casing 6 and the turbine enclosing portion of the casing 6. The connection portion 5 has an annular chamber 14 formed therein intermediate its ends which will be designated as a mixing chamber, and this chamber 14 is open through a leakage passage indicated at 15 to the suction chamber 11 so that water or other

liquid being pumped may leak from the suction chamber 11 into the mixing chamber 14.

A second chamber 16 is formed in the connecting portion 12 and it has a steam supply line 17 connected thereto for delivering steam into the chamber 16. The steam delivered to the chamber 16 may be taken from the steam supply line 18 to the turbine 2 or from any other suitable supply source for steam under pressure greater than the pressure of water or other liquid in the suction chamber 11.

The discharge from the first stage impeller of the pump through the cross-over passage 10 is divided into two streams, one of which flows into the suction chamber 11 and the other through the passage 19 into the chamber 14. The steam-receiving chamber 16 has connection with the mixing chamber 14 through a leakage passage 20 and with the back pressure area 21 of the turbine through a leakage passage 22.

The suction chamber 11 of the pump is under a pressure corresponding to the discharge pressure of the first stage of the pump and the same pressure exists in the mixing chamber 14. The live steam which is admitted to the chamber 16 is under a pressure in excess of the pressure in the mixing chamber 14. The pressure difference results from the fact that the discharge pressure of the centrifugal pump 1 is generally from fifteen to twenty five percent in excess of the boiler pressure of the system in which the boiler feed pump is employed, and thus the first stage discharge pressure will be of an order of fifty-seven percent to sixty-two percent of the steam pressure at the turbine inlet and of the steam pressure in the chamber 16 if they are fed by steam from the same boiler into which the boiler feed pump discharges.

The space 21 is under a pressure corresponding to the back pressure of the turbine and, therefore, a differential exists between the chamber 16 and the space 21. This chamber 16 and the space 21 which have communication through the leakage passage 22 are separated by suitable packing in this leakage passage 22. The packing in the passage 22 may be of any approved or suitable type similar to that used on back pressure steam turbines and similar to that indicated at 23 in the opening about the shaft 5 at the end of the casing outwardly of the turbine.

In operation, when steam is admitted to the chamber 16 through the steam supply pipe 17, a certain portion of this steam leaks into the back pressure space or chamber 21 of the turbine and another portion of the steam leaks into the mixing chamber 14. In the mixing chamber, the steam is condensed by the action of the incoming water into the mixing chamber 14 and leaks from the mixing chamber through the passage 15 into the suction chamber 11 of the pump from which it is picked up by the second stage impeller of the pump. The steam entering the steam space 16 need not necessarily correspond to the steam pressure in the turbine inlet since the pressure difference between the chamber 16 and the mixing chamber 14 is more than sufficient to cause flow, and since such excess pressure would increase the steam leakage into the back pressure space or area 21 beyond that absolutely necessary. Consequently, the pressure of the steam delivered through the steam inlet 17 to the chamber 16 may be such as to provide an adequate excess pressure in the chamber 16 over that in the chamber 14.

This excess pressure of the steam will cause a

stoppage or damming of the water or liquid flow towards the turbine 21 and serve to seal the inner end of the pump casing against leakage without the employment of stuffing box or the like.

It may be desirable to facilitate the mixing of the steam and the water flowing into the mixing chamber 14, and Figures 3 and 4 of the drawings show different structures for facilitating this mixing.

In Figure 3 of the drawings, a mixing labyrinth member 30 is mounted in any suitable manner upon the shaft 5' and is located in the mixing chamber 14' and it comprises a plurality of alternate circular vanes and passages arranged to bring the steam flowing through the leakage passage 20' into full contact with the water entering the chamber 14 through the by-pass 19.

The modified construction of the mixing apparatus illustrated in Figure 4 comprises a circular partition 31 which is placed within the mixing chamber 14a, dividing the mixing chamber into an outer space 32 and an inner space 33. The water flows through the by-pass 19a into the outer annular space 32, and from there through a plurality of openings 34 formed in the circular partition 31 into the inner space 33, while the steam flows into the inner space 33 through the communicating passage 20a; thus the water enters the inner chamber 33 in radial flow substantially perpendicular to the direction of the steam flowing into the mixing chamber causing a thorough and complete mixing of the steam and water in the mixing chamber.

It may be desirable to provide against the possibility of back flow of water from the mixing chamber into the steam chamber and Figure 5 of the drawings shows an arrangement for this purpose. In Figure 5, the mixing chamber 14b is connected to the steam chamber 16b by an annular passage 20b surrounding the shaft 5b the same as in Figure 2 of the drawings. However, a labyrinth 36 comprising a stationary element 37 carried by the casing 1b and a rotating element 38 carried by the shaft 5b is inserted in the passageway. As is usual in the construction of pressure reducing, flow retarding labyrinths, the elements 37 and 38 comprise inner engaging sections spaced sufficiently to provide a restricted, sinuous passage which would result in a reduction of the pressure of water or liquid sufficiently to prevent its back flow into the chamber 16b in the event of lowering of the steam pressure therein.

This Figure 5 also shows packing at 39 which will retard the flow of steam from the chamber 16b into the back pressure chamber or space of the turbine. This packing may be any standard form of packing used in high pressure steam turbines, or if it is so desired, a sealing arrangement such as that shown in Figure 6 of the drawings may be substituted for the packing 39 or the packing in the leakage passage 22.

The sealing arrangement illustrated in Figure 6 of the drawings comprises a sealing disc 40 carried by the shaft 5c which has a highly polished surface 41 co-acting with a highly polished surface 42 formed on the co-operating disc 43. The disc 43 is carried by the casing 6c and is mounted for limited movement towards or away from the disc 40, it being urged away from the disc 40 by a plurality of springs 44, while it is urged towards the disc 40 by the pressure of the steam in the steam chamber 16c. Steam is delivered to the chamber 16c through a suitable steam inlet 17c. The pressure against the disc 40 is the back pressure of the steam in the back pressure space or

chamber 21c of the turbine. The polished surfaces or the discs 40 and 43 are of dissimilar materials so as to prevent their seizing, and the two polished surfaces are held in contact by the springs 44 so as to form a yieldable sealing arrangement between the steam chamber 16c and the back pressure space or chamber 21c in the turbine.

It is to be understood, of course, that steam for the steam chamber 16 may be taken directly from the steam line 18 to the turbine 2 in which event the steam pressure in the chamber 16 will be equal to the inlet pressure of the steam to the turbine, and it would be desirable to provide suitable means to prevent excessive flow of steam from the chamber 16 into the back pressure space or chamber 21, or the steam to the steam chamber 16 may be taken directly from the boiler at a point where the pressure is lower than the pressure of the steam delivered to the turbine or from any other suitable source of steam having a pressure sufficiently in excess of the pressure of the water in the suction chamber 15 to insure the proper sealing operation of the apparatus.

It may be desirable to provide means for preventing leakage of water along the shaft of the pumping unit into the turbine housing or casing when the pump is idle or at such other times as the pressure of the steam is lower than the pressure of the leakage water, and for the purpose of preventing the leakage of water into the turbine casing a slightly modified construction is illustrated in Figure 7 of the drawings. In the structure shown in Figure 7 of the drawings, a deflector disc 46 is shown as mounted upon the shaft 5d and positioned within the second chamber 16d so that any water leaking along the shaft will, upon contact with the deflecting disc 46 be deflected from the shaft outwardly into the chamber 16d from which it will pass through a passageway 47 back to the mixing chamber 14d. Means are provided, to vent the mixing chamber 14d, if necessary, at such times or when the pumping unit is shut down. Such means are shown in Figure 7 of the drawings as a venting or drainage pipe 48 having a manually operated valve 49 therein. The pipe 48 may drain to atmosphere or to any suitable low pressure point so as to prevent flooding of the mixing chamber 14d when the pump is shut down.

Figures 1 to 4 inclusive of the drawings show structures which are particularly applicable for use in steam turbine driven boiler feed pumping units, however, the invention is equally applicable for employment in pumping units driven by gas turbines such as, for instance, refinery centrifugal pumps driven by gas turbines operated by natural gas under pressure, and Figures 8 and 9 of the drawings show structures of the pumping units of the gas turbine driven type, it being understood that the various features of Figures 3, 4, 5, 6, and 7 are applicable to these gas turbine driven structures if desired or needed.

In Figure 7 of the drawings, a multistage centrifugal pump 50 is shown which is driven from a natural gas turbine 51 of any approved construction through the drive shaft 52. The pump structure 50 is similar to or substantially the same as the pump structure shown in Figure 2 of the drawings having the discharge from the first stage 53 of the pump carried by a cross over passage 54 and discharged into the inlet space or chamber 55 of the second stage 56 of the pump and thus the two outside ends of the pump casing are subjected to the lowest pressures in the

pump. The end of the casing outwardly of the inlet of the first stage 53 of the pump being subjected only to the suction pressure of the first stage, while the end of the casing which faces the turbine 51 is subjected only to the suction pressure of the second stage.

The casing 57 of the centrifugal pump is connected to the casing 58 of the natural gas turbine 51 by a connecting portion 59. The connecting portion 59 has a mixing chamber 60 formed therein which is open through a pressure reducing bushing 61 of any approved construction to the suction chamber 55 of the second stage 56 of the pump thus permitting leakage from the pump about the shaft 7 to pass into the mixing chamber 60. The pressure fluid or such as natural gas or the like employed in operating the turbine 51 is delivered to the turbine through a suitable delivery system or pipe 62, and a branch pipe 63 is connected to the pipe 62 and opens into a second chamber 64 formed in the connecting portion 59. The second chamber 64 has communication with the mixing chamber 60 through a reduced communicating passage 65 so that the gas under pressure will enter the mixing chamber 60, and set up a counteracting pressure against the leakage fluid from the pump into the chamber 60 thus preventing leakage of the fluid pumped along the shaft out of the casing 57 or connection 59 or into the back pressure chamber 66 of the turbine 51. Packing of any other suitable leakage retarding pressure reducing means is provided between the second chamber 64 and the back pressure chamber 66 to retard leakage of gas from the chamber 64 into the turbine housing.

A leak-off line 68 is connected to the mixing chamber 60 and may have its outlet at any point in the pumping cycle where a lower pressure exists than the pressure in the mixing chamber 60. A pressure reducing orifice 69 is interposed in the leak-off line 68. This pressure reducing orifice 69 may be of any approved type which may be purchased upon the open market, such for example, the type of pressure reducing orifice shown in application for U. S. Letters Patent, Serial No. 499,780, filed August 24, 1943. The dimensions of the pressure reducing orifice 69 are calculated in such manner as to impose a back pressure of a known quantity at the mixing chamber 60 and to provide for a relatively small quantity of leak-off of the mixture of fluid pumped and gas from the mixing chamber 60 through the leak-off line 68. The back pressure in the mixing chamber 60 is preferably selected in such manner as to be lower by fifty to one hundred pounds per square inch than the pressure at the entrance chamber 55 of the second stage of the pump, and thus it will be seen that the pressure drop through the pressure reducing bushing 61 is relatively low and the life of this pressure reducing bushing will therefore be considerably longer than if it were selected to act as a pressure reducing labyrinth ahead of a conventional stuffing box.

The form of the invention shown in Figure 9 of the drawings likewise is a centrifugal pump adapted for being driven by a gas operated turbine. This structure differs somewhat however from the structure disclosed in Figure 8 of the drawings in that a single stage centrifugal pump is illustrated in which the impeller 70 is an overhung impeller mounted upon the end of the drive shaft 71 and having its suction eye facing outwardly away from the turbine 72 which drives

the shaft 71. As in all of the constructions shown in the drawings of the present invention, the turbine 72 is directly connected to the impeller of the pump which it drives without the use of couplings, gearing or any analogous structure.

The casing 73 of the centrifugal pump is connected to the casing 74 of the turbine by a connecting portion 75. The connecting portion 75 has a mixing chamber 76 therein which has communication through a pressure reducing bushing structure 77 with the space 78 in the pump casing 73 behind the impeller 70, thus any leakage from the pump casing along the shaft 71 will be through the pressure reducing bushing 77 into the mixing chamber 76. The connecting portion 75 also has a second chamber 79 formed therein which receives gas under pressure either from the supply line 80 of pressure motive fluid to the turbine 72 or from any other suitable source where the gas will have a pressure in excess of the pressure of the fluid leaking into the mixing chamber 76. The gas entering the chamber 79 will pass through the restricted passageway 81 into the mixing chamber 76 where its pressure will counteract the outward flow pressure of the leakage fluid and where the gas and fluid pumped will be thoroughly mixed. A leak-off line 82 is connected to the mixing chamber 76 and to any suitable point in the pumping circuit or elsewhere where the pressure is lower than the pressure in the mixing chamber. A pressure reducing orifice 83 is mounted in the leak-off line 82 and serves the same function and may be of the same construction as the pressure reducing orifice 69 shown in Figure 8 of the drawings. Packing is provided in the space between the second chamber 79 and the back pressure area 84 of the housing or casing 74 of the turbine 72 so as to reduce the pressure of any gas leaking into the back pressure chamber 84 and also so as to retard the leakage of such gas into the back pressure chamber.

In all of the forms shown, the manner of preventing leakage of liquid pumped out of the pump casing along the shaft thereof prevents the loss of any water or liquid pumped by the pump out of the pumping system or cycle, and in the case of steam driven turbines and boiler feed systems it not only prevents the loss of feedwater from the system but the steam employed, going back into the system, serves as a make up thus requiring the addition of a smaller quantity of non-deaerated or treated make-up water which it is necessary to feed into the boiler feed system during operation.

It will be understood that the invention is not to be limited to the specific construction or arrangement of parts shown, but that they may be widely modified within the invention defined by the claims.

What is claimed is:

1. In a turbine driven pumping unit adapted to pump liquids at a pressure from 500 lbs. per sq. in. or upwardly, a casing for the pump, a casing for the turbine and a connecting portion between the pump and turbine, said connecting portion having a chamber therein for receiving liquid under pressure from the pump, a connecting liquid leakage passage leading from said pump casing into said chamber, said passage being of smaller cross sectional area than the chamber and having a second chamber therein for receiving pressure fluid at a pressure in excess of leakage pressure from the turbine, said chambers having connection whereby the liquid and pres-

sure fluid pressures will counteract each other to prevent leakage of liquid into the turbine or leakage of pressure fluid into the pump.

2. In a turbine driven pumping unit adapted to pump liquids at a pressure from 500 lbs. per sq. in. or upwardly, a casing for the pump, a casing for the turbine, and a connecting portion between the pump and turbine, said connecting portion having a chamber therein for receiving liquid under pressure from the pump and having a second chamber therein for receiving pressure fluid from a source exteriorly of the turbine, said chambers having connection whereby the liquid and pressure fluid pressures will counteract each other to prevent leakage of liquid into the turbine or leakage of pressure fluid into the pump, and pressure reducing means in the connection between said chambers.

3. In a turbine driven pumping unit adapted to pump liquids at a pressure from 500 lbs. per sq. in. or upwardly, a casing for the pump, a casing for the turbine, and a connecting portion between the pump and turbine, said connecting portion having a chamber therein for receiving liquid under pressure from the pump and having a second chamber therein for receiving pressure fluid from the turbine operating supply at a pressure in excess of the leakage pressure from the turbine, said chambers having connection whereby the liquid and pressure fluid pressures will counteract each other to prevent leakage of liquid into the turbine or leakage of pressure fluid into the pump, said liquid chamber opening into the pump to permit leakage of liquid from the chamber back into the pump at a point where the pressure is lower than the pressure liquid received into the chamber from the pump.

4. In a turbine driven pumping unit adapted to pump liquids at a pressure from 500 lbs. per sq. in. or upwardly, a casing for the pump, a casing for the turbine, and a connecting portion between the pump and turbine, said connecting portion having a chamber therein for receiving liquid under pressure from the pump and having a second chamber therein for receiving pressure fluid from the turbine operating supply at a pressure in excess of the leakage pressure from the turbine, said chambers having connection whereby the liquid and pressure fluid pressures will counteract each other to prevent leakage of liquid into the turbine or leakage of pressure fluid into the pump, said second chamber connected to the back pressure chamber of the turbine to permit limited leakage of pressure fluid from the second chamber into the turbine, and pressure reducing means in the connection between the second chamber and turbine.

5. In a steam turbine driven pumping unit adapted to pump liquids at a pressure from 500 lbs. per sq. in. or upwardly, a casing for the pump, a casing for the turbine, and a connecting portion between the pump and turbine, said connecting portion having a chamber therein for receiving liquid under pressure from the pump and having a second chamber therein for receiving steam from a source external of the turbine and at a pressure in excess of leakage pressure from the turbine, said chambers having connection whereby the liquid and steam pressures will counteract each other to prevent leakage of liquid into the turbine or leakage of steam into the pump, and mixing means for causing thorough mixing of the steam and liquid in the liquid chamber to cause condensation of the steam, said liquid chamber opening into the pump to permit

leakage of liquid and condensation from the chamber back into the pump at a point where the pressure is lower than the pressure of liquid received by the chamber from the pump.

6. In a turbine driven pumping unit adapted to pump liquids at a pressure from 500 lbs. per sq. in. or upwardly, a casing for the pump, a casing for the turbine, and a connecting portion between the pump and turbine, a shaft extending through said housing and forming the turbine driven shaft and the pump driving shaft, a packing carried by said housing at the outer end of the pump, said pump being arranged whereby said packing will be subject only to the lowest liquid pressure in the pump.

7. In a steam turbine driven pumping unit adapted to pump liquids at a pressure from 500 lbs. per sq. in. or upwardly, a casing for the pump, a casing for the turbine and a connecting portion between the pump and turbine, said housing being constructed and arranged so as not to have any spaces between the pump and turbine which freely communicate with atmosphere, said connecting portion having a chamber therein for receiving liquid under pressure from the pump and having a second chamber therein for receiving steam, said chambers having connection whereby the liquid and steam pressures will counteract each other to prevent leakage of liquid into the turbine or leakage of steam into the pump, a shaft extending through said housing and forming the turbine driven shaft and the pump driving shaft, a stuffing box carried by said housing at the outer end of the pump, said pump being arranged whereby said stuffing box will be subject only to the lowest liquid pressure in the pump.

8. In a steam turbine driven pumping unit adapted to pump liquids at a pressure from 500 lbs. per sq. in. or upwardly, a casing for the pump, a casing for the turbine, and a connecting portion between the pump and turbine, said connecting portion having a chamber therein for receiving liquid under pressure from the pump and having a second chamber therein for receiving steam, said chambers having connection whereby the liquid and steam pressures will counteract each other to prevent leakage of liquid into the turbine or leakage of steam into the pump, a shaft extending through said housing and forming the turbine driven shaft and the pump driving shaft, a stuffing box carried by said housing at the outer end of the pump, said pump being arranged whereby said stuffing box will be subject only to the lowest liquid pressure in the pump, and pressure reducing means in the connection between said chambers.

9. In a steam turbine driven pumping unit adapted to pump liquids at a pressure from 500 lbs. per sq. in. or upwardly, a casing for the pump, a casing for the turbine, and a connecting portion between the pump and turbine, said connecting portion having a chamber therein for receiving liquid under pressure from the pump and having a second chamber therein for receiving steam, said chambers having connection whereby the liquid and steam pressures will counteract each other to prevent leakage of liquid into the turbine or leakage of steam into the pump, a shaft extending through said housing and forming the turbine driven shaft and the pump driving shaft, a stuffing box carried by said housing at the outer end of the pump, said pump being arranged whereby said stuffing box will be subject only to the lowest liquid pressure in the

pump, said steam chamber connected to the back pressure chamber of the turbine to permit leakage of steam from the chamber into the turbine, and leakage retarding means in the connection between steam chamber and turbine.

10. In a steam turbine driven pumping unit adapted to pump liquids at a pressure from 500 lbs. per sq. in. or upwardly, a casing for the pump, a casing for the turbine, and a connecting portion between the pump and turbine, said connecting portion having a chamber therein for receiving liquid under pressure from the pump and having a second chamber therein for receiving steam, said chambers having connection whereby the liquid and steam pressures will counteract each other to prevent leakage of liquid into the turbine or leakage of steam into the pump, a shaft extending through said housing and forming the turbine driven shaft and the pump driving shaft, a stuffing box carried by said housing at the outer end of the pump, said pump being arranged whereby said stuffing box will be subject only to the lowest liquid pressure in the pump, said steam chamber connected to the back pressure chamber of the turbine to permit leakage of steam from the chamber into the turbine, and leakage retarding means in the connection between the steam chamber and turbine, said liquid chamber opening into the pump to permit leakage of liquid from the chamber into the pump.

11. In a steam turbine driven pumping unit adapted to pump liquids at pressures from 500 lbs. per sq. in. a housing including a casing for the pump and a casing for the turbine, said pump being arranged in the casing so that the lowest liquid pressure area in the pump will be at the outer end of the housing, a shaft extending through said housing and forming the turbine driven shaft and the pump driving shaft, a stuffing box in said housing and about said shaft at the outer end of the housing which stuffing box is subject to the lowest liquid pressure in the pump, a connecting portion formed in said housing between the pump and turbine, said connecting portion having a chamber therein for receiving liquid under pressure from the pump and a second chamber for receiving steam, said connecting portion being provided with a passage connecting said steam and liquid chambers to permit flow of steam into the liquid chamber.

12. The method of preventing leakage of fluid pumped out of a turbine driven centrifugal pump about the shaft of the pump, which consists in counteracting the flow of leakage by subjecting it to counteraction of and mixing with a part of the pressure motive fluid employed to drive the turbine, and returning the mixed pressure fluid and leakage to the circuit of the fluid pumped.

13. The method of preventing leakage of fluid pumped out of a turbine driven centrifugal pump about the shaft of the pump, which consists in counteracting the flow of leakage by subjecting it to counteraction of and mixing with a part of the pressure motive fluid employed to drive the turbine, and returning the mixed pressure fluid and leakage to the circuit of the fluid pumped, and providing a back pressure of a predetermined known quantity on the point of mixing of the leakage and motive fluid.

14. The method of preventing leakage of fluid pumped out of a turbine driven centrifugal pump about the shaft of the pump, which consists in counteracting the flow of leakage by subjecting it to counteraction of and mixing with a part of

the pressure motive fluid employed to drive the turbine, allowing the mixed leakage and motive fluid to leak off to a point of lower pressure, and providing a back pressure of a predetermined known quantity to the point of mixing of the leakage and motive fluid.

15. In a steam turbine driven pumping unit adapted to pump liquids at high pressures, a casing for the pump, a casing for the turbine, said pump being arranged in the casing so that the lowest liquid area in the pump will be at the outer end of the casing, a shaft extending through said casing and forming the turbine driven shaft and the pump driving shaft, a connecting portion in said casing between the pump and turbine, said connecting portion having a chamber therein for receiving liquid under pressure from the pump and a second chamber for receiving steam, said connecting portion being provided with a passage connecting said steam and liquid chambers to permit flow of steam into the liquid chamber.

16. In a turbine driven pumping unit, a casing for the pump, a casing for the turbine, and a connecting portion between said pump and turbine casing, said connecting portion having a chamber therein for receiving liquid under pressure from the pump, a connecting liquid leakage passage leading from the pump casing into said chamber, said leakage passage being of smaller cross sectional area than the chamber, said connecting portion having a second chamber therein for receiving pressure fluid at a pressure in excess of leakage pressure from the turbine, said chambers having connection whereby the liquid and pressure fluid pressures will counteract each other to prevent leakage of liquid into the turbine or leakage of pressure fluid into the pump, and pressure reducing means associated with said chambers to prevent back flow of pressure fluid into the turbine.

17. In a steam turbine driven pumping unit adapted to pump liquids at high pressures, a casing for the pump, a casing for the turbine, said pump being arranged in the casing so that the lowest liquid area in the pump will be at the outer end of the casing, a shaft extending through said casing and forming the turbine driven shaft and the pump driving shaft, a connecting portion in said casing between the pump and turbine, said connecting portion having a chamber therein for receiving liquid under pressure from the pump and a second chamber for receiving steam, said connecting portion being provided with a passage connecting said steam and liquid chambers to permit flow of steam into the liquid chamber, and pressure reducing means associated with said chambers to prevent back flow of pressure fluid into the turbine.

18. In a steam turbine driven pumping unit adapted to pump liquids at high pressures, a casing for the pump, a casing for the turbine, said pump being arranged in the casing so that the lowest liquid area in the pump will be at the outer end of the casing, a shaft extending through said casing and forming the turbine driven shaft and the pump driving shaft, a connecting portion in said casing between the pump and turbine, said connecting portion having a chamber therein for receiving liquid under pressure from the pump and a second chamber for receiving steam, said connecting portion being provided with a passage connecting said steam and liquid chambers to permit flow of steam into the liquid chamber, pressure reducing means associated

with said chambers to prevent back flow of pressure fluid into the turbine, said pressure reducing means comprising a stationary element, and a co-acting rotary element carried by and rotatable with said shaft.

19. In a turbine driven pumping unit, a casing for the pump, a casing for the turbine, a connecting portion between the pump and turbine, said connecting portion having a chamber therein for receiving liquid under pressure from the pump and having a second chamber therein for receiving pressure fluid from the operating fluid supply to the turbine, said chambers having connection whereby the liquid and pressure fluid pressures will counteract each other to prevent leakage of liquid into the turbine or leakage of pressure fluid into the pump, and pressure reducing means in the connection between said chambers.

20. In a turbine driven pumping unit, a casing for the pump, a casing for the turbine, a connecting portion between the pump and turbine, said connecting portion having a chamber therein for receiving liquid under pressure from the pump and having a second chamber therein for receiving pressure fluid from the operating fluid supply to the turbine, said chambers having connection whereby the liquid and pressure fluid pressures will counteract each other to prevent leakage of liquid into the turbine or leakage of pressure fluid into the pump, and pressure reducing means associated with said chambers to prevent back flow of pressure fluid into the back pressure area of the turbine.

21. In a turbine driven pumping unit, a casing for the pump, a casing for the turbine, a connecting portion between the pump and turbine, said connecting portion having a chamber therein for receiving liquid under pressure from the pump and having a second chamber therein for receiving pressure fluid from the

operating fluid supply to the turbine, said chambers having connection whereby the liquid and pressure fluid pressures will counteract each other to prevent leakage of liquid into the turbine or leakage of pressure fluid into the pump, and pressure reducing means in the connection between said chambers, said pressure reducing means comprising a stationary element, and a coacting rotary element.

22. In a turbine driven pumping unit, a casing for the pump, a casing for the turbine, a connecting portion between said pump and turbine casings, said connecting portion having a chamber therein for receiving liquid under pressure from the pump and having a second chamber therein for receiving pressure fluid at a pressure in excess of the leakage pressure from the turbine, said chambers having connection whereby the liquid and pressure fluid pressures will counteract each other to prevent leakage of liquid into the turbine or leakage of pressure fluid into the pump, an outlet connection for said first-named chamber, and pressure reducing means in said outlet connection.

23. In a turbine driven pumping unit, a casing for the pump, a casing for the turbine, a connecting portion between the pump and turbine, said connecting portion having a chamber therein for receiving liquid under pressure from the pump and having a second chamber therein for receiving pressure fluid from the operating fluid supply to the turbine, said chambers having connection whereby the liquid and pressure fluid pressures will counteract each other to prevent leakage of liquid into the turbine or leakage of pressure fluid into the pump, pressure reducing means in the connection between said chambers, an outlet connection for said first-named chamber, and pressure reducing means in said outlet.

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