July 10, 1928. 1,677,026

B. O. BUCKLAND ET AL

GEARED TURBINE INSTALLATION

Filed Nov. 6, 1925 3 Sheets-Sheet 1

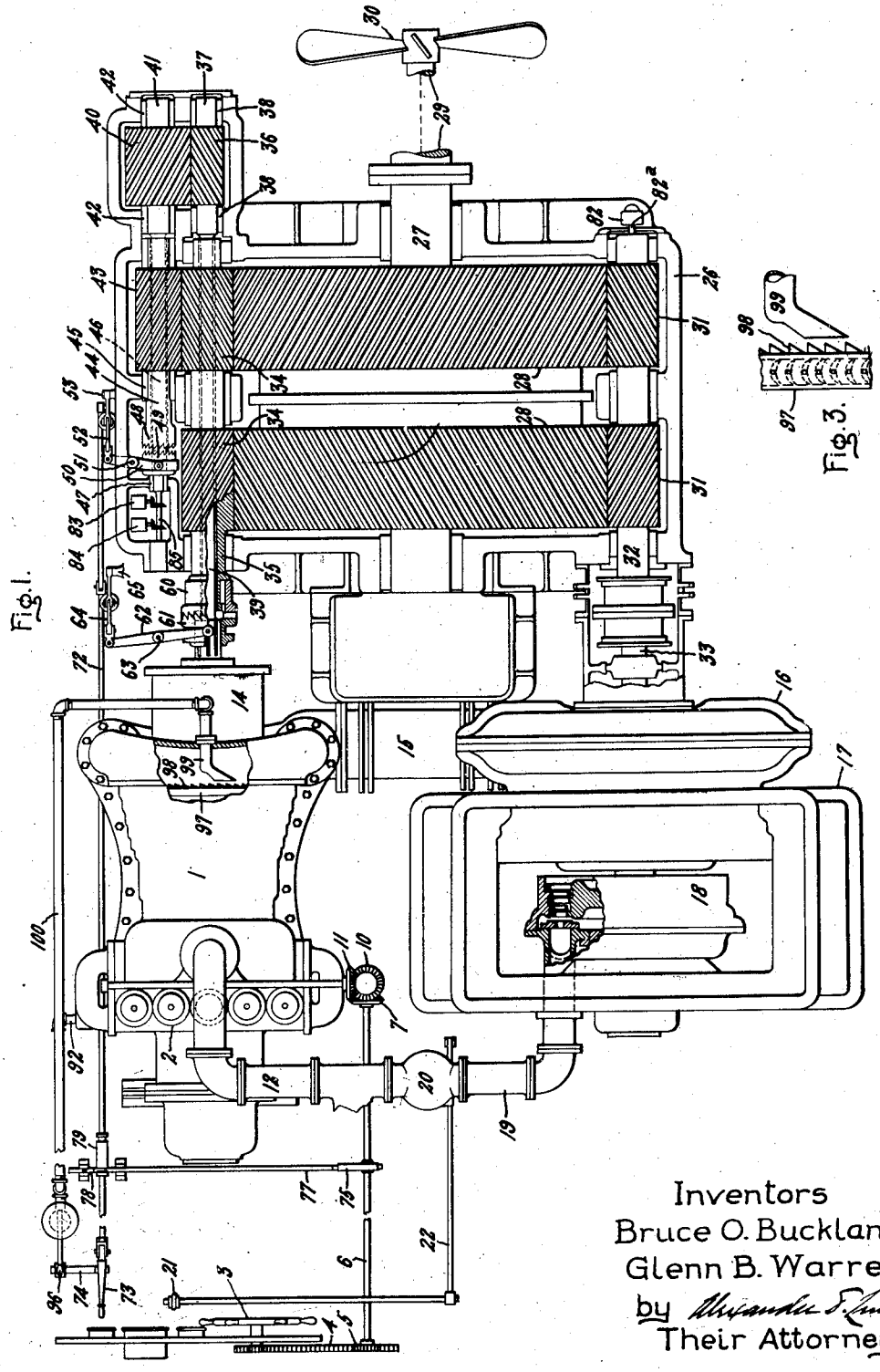


Fig. 1.

Fig. 3.

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Filed Nov. 6, 1925 3 Sheets-Sheet 2

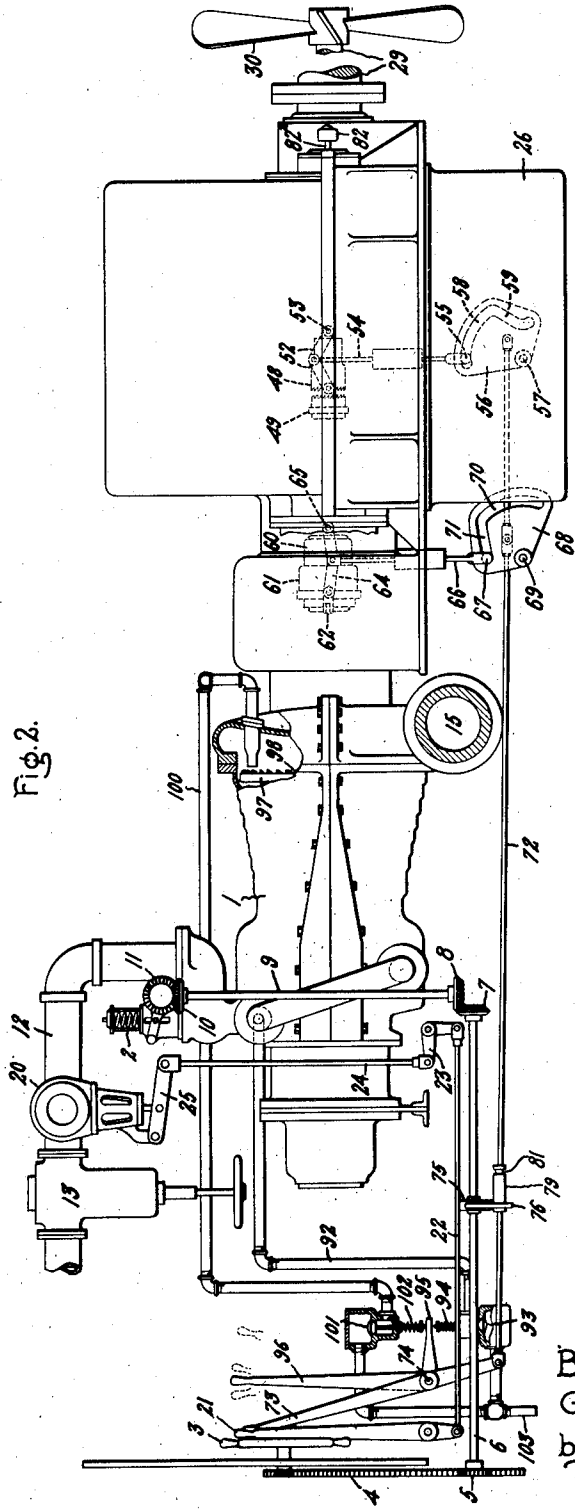


Fig. 2.

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Filed Nov. 6, 1925 3 Sheets-Sheet 3

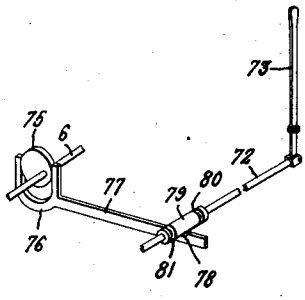


Fig.4.

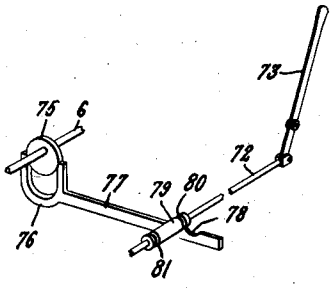


Fig.5.

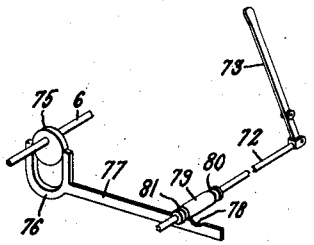
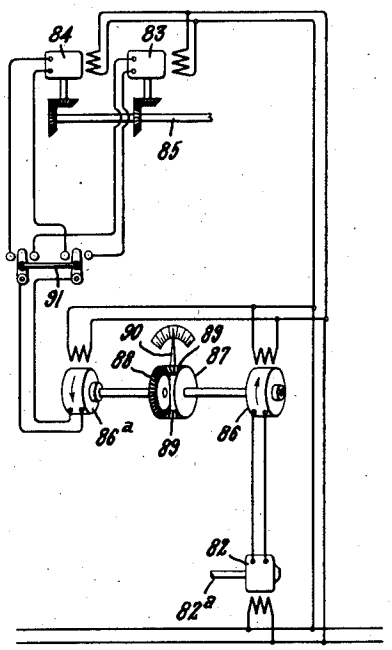


Fig.6.

Fig.7.



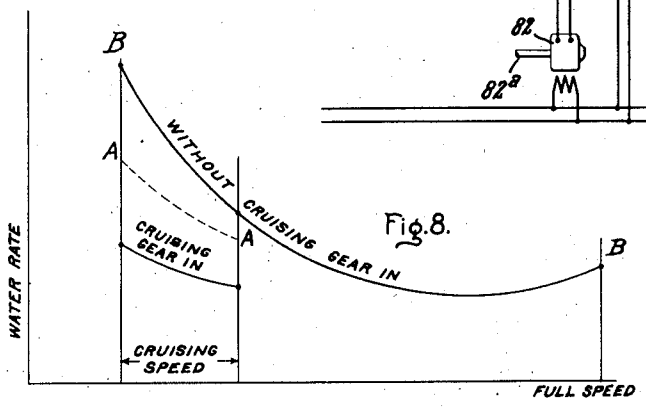


Fig.8.

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UNITED STATES PATENT OFFICE.

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GEARED TURBINE INSTALLATION.

Application filed November 6, 1925. Serial No. 67,424.

In certain turbine installations, such as, for example, those on naval vessels, the conditions are met wherein it is required that the turbine installations be operated under widely different load and speed conditions. For example, in the case of a naval vessel, a turbine installation may be required to operate at full load and also at loads of the order of 1/20 to 1/8 full load, these latter loads corresponding to cruising speeds. A naval vessel may operate for long periods of time at cruising speeds and for this reason it is required that the turbine installations be efficient at both full load and partial load.

Also, in connection with naval vessels, it is desired that the turbine installation be as light in weight as possible.

The object of our invention is to provide a turbine installation capable of operating efficiently at both full load and light load and which, at the same time, is light in weight, and for a consideration of what we believe to be novel and our invention, attention is directed to the accompanying description and the claims appended thereto.

In the drawing, Fig. 1 is a plan view of a turbine installation embodying our invention; Fig. 2 is a side elevation, on a larger scale, the low pressure turbine being omitted; Fig. 3 is an enlarged detail; Figs. 4, 5 and 6 are detail diagrammatic views of an interlocking arrangement; Fig. 7 is a wiring diagram of a synchronizing arrangement, and Fig. 8 is a diagram.

Referring to the drawing, 1 indicates a high pressure turbine provided with valve means 2 which controls the admission of elastic fluid to it. Any suitable type of valve means may be used. In the drawing, a known arrangement is indicated diagrammatically and by way of example. The valve means is opened and closed by means of a hand wheel 3 connected to the valve means by gear wheels 4 and 5, a horizontal shaft 6, bevel gear wheels 7 and 8, a vertical shaft 9 and bevel gear wheels 10 and 11. The arrangement is such in the present instance that turning shaft 6 through an angle of 180 degrees serves to move the valve means from full open position to closed position, or from closed position to full open position. Elastic fluid is supplied to turbine 1 by a supply conduit 12. In supply conduit 12 is a manually-operated valve 13.

High pressure turbine 1 exhausts into an exhaust header 14 which is connected by a conduit 15 to the high pressure end of a low pressure turbine 16. 17 indicates the exhaust housing of turbine 16 which may be connected to the usual condenser, not shown. In exhaust housing 17 is a reversing turbine section 18 to which elastic fluid is supplied by a conduit 19. In conduit 19 is a suitable valve 20 arranged to be opened and closed by a hand lever 21 connected to it by a rod 22, bell crank lever 23, rod 24 and lever 25. Valve 20 is normally closed but may be opened when it is desired to use the reversing turbine section.

Adjacent to the turbine casing is a gear casing 26 having suitable bearings in which is journaled the shaft 27 of a driven gear 28. Shaft 27 is connected to propeller shaft 29 which carries propeller 30. Meshing with driven gear 28 is a pinion 31, the shaft 32 of which is carried in bearings in gear casing 26 and is coupled directly to shaft 33 of low pressure turbine 16. Also, journaled in bearings in gear casing 26 and meshing with gear wheel 28 is a pinion 34 having a quill shaft 35. Arranged in axial alignment with pinion 34 is a pinion 36 carried by a shaft 37 journaled in bearings 38. Pinion shaft 37 is connected to the shaft of high pressure turbine 1 by a shaft 39 which extends through quill shaft 35 and forms in substance an extension of the high pressure turbine shaft. Meshing with pinion 36 is a gear wheel 40 having a shaft 41 journaled in bearings 42 in the gear casing. In axial alignment with gear wheel 40 is a pinion 43 which meshes with pinion 34 and is carried by a quill shaft 44 journaled in bearings 45. Extending through quill shaft 44 is a shaft 46 which forms an extension of shaft 41 and is journaled at its outer end in a bearing 47. Shaft 46 is adapted to be connected to shaft 44 by a clutch comprising a fixed clutch member 48 on one end of shaft 44 and a sliding clutch member 49 splined on shaft 46. Sliding clutch member 49 is moved by an arm 50 pivoted to the gear casing at 51. The inner end of arm 50 is suitably connected to clutch member 49 and the outer end is connected to one end of a toggle 52. The other end of toggle 52 is pivoted to the gear casing as is indicated at 53, while its central portion is connected by a rod 54 to a pin 55 which slides in a slot in an actuating cam segment 56 pivoted at 57 to a suitable support. The

slot has a holding section 58 which is concentric with pivot point 57 and an actuating section 59. When cam segment 56 stands in the position shown in Fig. 2 of the drawing, the clutch is disengaged. When turned in an anticlockwise direction as viewed in Fig. 2, no movement of the clutch takes place while pin 55 moves through the holding section 58 of the slot. When moved through actuating section 59, rod 54 is pulled downward turning lever 50, thereby moving clutch member 49 into engagement with clutch member 48.

Fastened on the left hand end of quill shaft 35 is a fixed clutch member 60. Splined on the adjacent portion of shaft 39 is a sliding clutch member 61 adapted to be moved into and out of engagement with clutch member 60 to connect shaft 39 to and disconnect it from shaft 35. Sliding clutch member 61 is moved by an arm 62 pivoted on a suitable support (not shown) at 63. The inner end of arm 62 is suitably connected to clutch member 61 and the outer end is connected to one end of a toggle 64. The other end of toggle 64 is pivoted to a suitable support 65 while its central portion is connected by a rod 66 to a pin 67 which slides in a slot in a cam segment 68 pivoted at 69 on a suitable support. The slot has a holding section 70 and an actuating section 71. When cam segment 68 stands in the position shown in Fig. 2, the clutch is engaged. When turned in an anticlockwise direction as viewed in Fig. 2, actuating section 71 of the slot forces lever 66 upward, moving the toggle 64 and turning lever 62 in a direction to move clutch member 61 out of engagement with clutch member 60. After the clutch is disengaged, pin 67 enters holding section 70 of the slot, which permits further turning of segment 68 while the clutch is held in out position. Segments 56 and 68 are both pivotally connected to an actuating rod 72 which is pivotally connected to a hand operated clutch lever 73 fulcrumed on a shaft 74 carried in a suitable support, (not shown). Hand lever 73 thus turns segments 56 and 68 simultaneously, and it will be seen that the slots in the segments are arranged so that upon moving rod 72 toward the left in Fig. 2, clutch member 61 is first disengaged after which upon further movement clutch member 49 is engaged, and that upon movement back again, clutch member 48 is first disengaged after which clutch member 61 may be engaged. This forms an interlocking arrangement for the two clutches so that one must be disengaged before the other can be engaged.

In the position of the parts shown in Figs. 1 and 2, clutch member 61 is in engagement with clutch member 60 thereby connecting quill shaft 35 to shaft 39 while clutch member 49 is disengaged from clutch member 48. The high pressure turbine 1 now drives propeller shaft 29 directly through pinion 34 and driven gear wheel 28. At the same time, low pressure turbine 16 drives the propeller shaft through pinion 31 and driven gear wheel 28. Pinion 36 rotates along with shaft 39 and turns gear wheel 40. Also pinion 34 turns pinion 43. However, since clutch member 49 is disengaged from clutch member 48, gear wheel 40 and pinion 43 run idly. This is the position of the parts for full load, the propeller being operated at the highest speed.

Now, if it is desired to operate the propeller at cruising speed, hand lever 73 is moved to disengage clutch member 61 from clutch member 60, thus opening the direct connection between shaft of turbine 1 and pinion 34. The hand lever 73 is then moved further to bring clutch member 49 into engagement with clutch member 48 thereby connecting gear wheel 40 to pinion 43. The high speed turbine 1 now drives driven gear wheel 28 through pinion 36, gear wheel 40, pinion 43 and pinion 34. This provides a double reduction gearing between high pressure turbine 1 and the propeller shaft so that the high pressure turbine in driving the propeller shaft at cruising speed may thus operate at substantially its normal speed. In this connection it is well understood that an elastic fluid turbine is essentially a high speed machine and gives its best efficiency at high speed, the efficiency falling off rapidly as the speed decreases.

The arrangement of the high pressure and low pressure turbine is such that when the propeller is operated at full speed with the full speed gearing in use, the load is about equally divided between the two machines. When operating at cruising speed, however, and with the cruising gearing in use, the major portion of the load is transferred from the low pressure turbine to the high pressure turbine. For example, at one-half speed the high pressure turbine may carry eighty-two per cent of the load and the low pressure turbine eighteen per cent of the load. By this arrangement efficient operation of the turbine installation is obtained for cruising conditions.

As an illustration of the gain in efficiency obtained by the foregoing arrangement, attention is directed to Fig. 8 which shows curves wherein speed is plotted against water rate. The curve A shows the water rate from full load down to partial load with the gearing connected for full load operation. The curve B shows the water rate which is obtained at cruising speed when the turbine 1 is connected through the gearing for cruising operation. As will be clear a substantial gain in water rate results.

In connection with the installation, it is desirable that the operative be prevented from throwing the clutches while valve

means 2 is in open position. To prevent this, we provide an interlocking means between shaft 6 and rod 72. This interlocking means is illustrated in Figs. 4, 5 and 6. On shaft 6 is arranged a cam 75 which engages with a forked end 76, on a sliding bar 77. In bar 77 is a slot 78 in which a sleeve 79 slides. In sleeve 79 are two grooves 80 and 81 in which bar 77 is adapted to slide. When valve means 2 is closed, slot 78 stands in line with sleeve 79 as is shown in Fig. 4, and when in this position, hand lever 73 can be operated to move rod 72 to operate the clutches. When one of the clutches is in, groove 80 stands in line with bar 77 and when the other clutch is in, groove 81 stands in line with bar 77. In any other position of lever 73 and rod 72 grooves 80 and 81 are both out of line with bar 77. This prevents valve means 2 from being operated except when one clutch or the other is in. Whenever the valve means is moved toward open position bar 77 stands in one of the grooves 80 or 81 locking lever 73 and thus preventing the clutches from being moved.

In view of the loads on the gearing and the speeds involved, it is desirable to bring the two clutch members of either clutch to the same speed before engaging them. For this purpose there is provided a synchronizing means for indicating the relative speeds of the clutch members and also means for either increasing or decreasing the speed of rotation of the rotor of turbine 1 to bring the clutch members to the desired relative speeds. For indicating the relative speeds of the clutch members there is provided a small synchronizing generator 82 having its shaft 82^a connected to shaft 32. This indicates the speed of driven gear wheel 28 and hence the speeds of clutch members 48 and 60 which always turn with driven gear wheel 28. For indicating the speeds of clutch members 49 and 61 there are provided two small synchronizing generators 83 and 84 geared to a shaft 85 which forms an extension of shaft 46. These generators are operated always in accordance with the speed of turbine 1 since, because of their location, they are connected to the shaft of turbine 1 through shaft 39, pinion 36, and gear wheel 40. The gear ratios between generator 83 and shaft 85 and generator 84 and shaft 85 are such that one indicates the speed of shaft 46 and the other indicates the speed of shaft 39.

Adjacent to the operative is an indicator comprising two synchronous motors 86 and 86^a having their shafts connected to bevel gear wheels 87 and 88, of a differential gearing. Gear wheels 87 and 88 mesh with the gears 89 of the differential and to which is connected an indicating pointer 90. Gear wheels 87 and 88 rotate in opposite directions and when running at the same speed gears 89 and pointer 90 remain stationary; when running at different speeds, however, the pointer will travel in one direction or the other. A differential speed indicator of this type is known and its operation well understood. It is shown, accordingly, only diagrammatically in the drawing. Motor 86 is electrically connected to generator 82 so that it indicates the speed of clutch members 48 and 60. Motor 86^a is arranged to be connected by a switch 91 either to generator 83 or to generator 84 so that it may be made to indicate the speed of either clutch member 49 or 61, as desired.

In synchronizing the clutch members, it may be necesary to either increase or decrease the speed of the turbine rotor. For increasing the speed of the turbine rotor, we provide a pipe 92 through which elastic fluid may be supplied to the high pressure nozzles of the turbine. In pipe 92 is a valve 93 which is held closed normally by a spring 94. The end of the stem of valve 93 terminates adjacent to the end of an arm 95 mounted on shaft 74 and adapted to be moved by a hand lever 96 to open valve 93. For retarding the speed of the turbine rotor, we provide on the surface of the last stage wheel 97 adjacent to its periphery, a ring of notches 98 which face in a reverse direction, and a nozzle 99 for discharging elastic fluid against the notches. Elastic fluid is supplied to nozzle 99 by a pipe 100 in which is located a controlling valve 101 normally held on its seat by a spring 102. The stem of valve 101 projects out to a point adjacent to arm 95 so that the valve may be opened by hand lever 96. Pipes 92 and 100 both connect to a supply pipe 103 which may lead from any suitable source of elastic fluid pressure.

The arrangement of arm 95 and the stems of valves 93 and 101 is such that when hand lever 96 is moved toward the left as shown in Fig. 2, valve 101 is opened to admit elastic fluid through nozzle 99 to retard the rate of rotation of the rotor turbine 1 and when it is moved toward the right, valve 93 is opened to admit elastic fluid to the high pressure nozzles of turbine 1 to increase the speed of rotation.

With the parts in the positions shown in Figs. 1 and 2, high pressure turbine 1 is connected to driven shaft 27 through pinion 34, clutch member 61 being engaged and clutch member 49 being disengaged. This is for full speed operation. If now it is desired to connect turbine 1 for cruising speed operation, the procedure is as follows: the operative first turns hand wheel 3 to close valve means 2, thereby shutting off admission of elastic fluid to turbine 1. This serves to bring slot 78 in line with sleeve 79 thereby releasing clutch lever 73. Lever 73 is now moved to disengage clutch

member 61 from clutch member 60. The operative if he has not already done so, then moves switch 91 to a position connecting generator 84 to synchronous motor 86a. Now by observing pointer 90 the operative can ascertain the relative speeds of clutch members 48 and 49 and by manipulating hand lever 96 he can increase or retard the rate of rotation of turbine rotor 1 as is required to bring the clutch members 48 and 49 to the same speed of operation. The operative then moves hand lever 73 further to bring clutch member 49 into engagement with clutch member 48. This movement of hand lever 73 serves to unlock the operating mechanism for valve means 2 so that valve means 2 may be again opened to admit elastic fluid to the turbines.

Preferably, the gearing is of the double helical type this being a type of gearing well adapted for applications of the character disclosed and for reasons well understood.

At cruising speed, the load to be transmitted is comparatively small so that one-half of the pinion member 34 is employed to transmit the load. This being the case, the pinion 43 forms a single helical pinion engaging only one of the pinion members of the pinion 34. However, if desired a double helical installation pinion may be used.

In connection with the operation of the installation, no special valve means is required for regulating the admission of elastic fluid to low pressure turbine 16 the load being automatically shifted from it to the high pressure turbine 1 under the varying operating conditions.

As will be noted, the turbine installation, while it is capable of giving good efficiency at both full load and partial load, is at the same time comparatively simple in structure and light in weight. The arrangement avoids entirely the use of special cruising turbines which are undesirable not only because of the additional cost but also because of the additional weight which they add to the equipment and the floor space occupied by them.

In accordance with the provisions of the patent statutes, we have described the principles of operation of our invention, together with the apparatus which we now consider to represent the best embodiment thereof, but we desire to have it understood that the apparatus shown is only illustrative and that the invention may be carried out by other means.

What we claim as new and desire to secure by Letters Patent of the United States, is,—

1. In a turbine installation, a high pressure turbine, a low pressure turbine, a driven shaft, and gears through which said turbines drive said shaft, said gears comprising a driven gear wheel, a pinion meshing therewith driven by the low pressure turbine, gear means comprising a pinion meshing directly with said driven gear wheel and a pinion connected thereto through a reduction gearing, and means whereby said high pressure turbine may be connected to drive through either of said pinions.

2. In combination, an elastic fluid turbine having a shaft and rotating members thereon, a driven shaft, a gear wheel connected to the driven shaft, a pinion meshing with said gear wheel, a clutch for connecting it to the turbine shaft, a second pinion connected with the turbine shaft, means including a reduction gearing and a clutch for connecting the first-named pinion to the turbine shaft through said second-named pinion, and means for increasing or retarding the speed of rotation of the turbine shaft for enabling the clutches to be engaged readily, said means including a pair of elastic fluid admission conduits for the turbine through which said elastic fluid is supplied to impinge upon certain of said rotating members, a valve in each of said conduits, and means for operating said valves.

3. In combination, an elastic fluid turbine having a shaft, a driven shaft, a gear wheel connected to the driven shaft, a pinion meshing with said gear wheel, a clutch for connecting it to the turbine shaft, a second pinion connected with the turbine shaft, means including a reduction gearing and a clutch for connecting the first-named pinion to the turbine shaft through said second-named pinion, means for increasing or retarding the speed of rotation of the turbine shaft for enabling the clutches to be engaged readily, and means for indicating the relative speeds of the shafts to be connected.

4. In combination, an elastic fluid turbine having a shaft, a driven shaft, a gear wheel connected to the driven shaft, a pinion meshing with the gear wheel, a clutch for connecting it to the turbine shaft, a pinion connected directly to the turbine shaft, gear wheels forming a reduction gearing, a clutch for connecting the last-named pinion to the first-named gear wheel through said reduction gearing, means for operating said clutches so that only one can be engaged at a time, an elastic fluid admission valve for the turbine, and an interlock means connected with said valve and with said clutch operating means which permits the latter to operate only when the valve is closed.

5. In combination, an elastic fluid turbine having a shaft, a driven shaft, a gear wheel connected to the driven shaft, a pinion meshing with said gear wheel, a clutch for connecting the pinion to the turbine shaft, a second pinion connected with the turbine shaft, means including a reduction gearing and a clutch for connecting the first-named

pinion to the turbine shaft through said second-named pinion, means for increasing or retarding the speed of rotation of the turbine shaft for enabling the clutches to be engaged readily, means for indicating the relative speeds of the rotating members to be connected by said clutches, said means including a speed indicating generator connected with the driven shaft and gear wheel, a speed-indicating motor connected with said generator, a pair of speed-indicating generators connected with the turbine shaft, a second speed-indicating motor, switch means for connecting said last-named motor to either one of said last-named generators, and means connected with the motors for indicating their differential speed.

6. In combination, an elastic fluid turbine having a shaft, a pinion carried by said shaft, a quill shaft surrounding said first-named shaft, a clutch for connecting said shafts, a pinion carried by said quill shaft, a driven gear wheel with which said last-named pinion meshes, a second shaft, a gear carried by said shaft, which gear meshes with the first-named pinion, a second quill shaft surrounding said second shaft, a clutch for connecting said second shaft and quill shaft, a pinion carried by the second quill shaft, which pinion meshes with the pinion carried by the first-named quill shaft, means connected with the clutches for opening and closing them, said means including an interlock which prevents closing one clutch before opening the other, and means including a remotely-controlled electrically-operated indicator and a selector switch for alternately indicating the relative speeds of the members of each clutch when disengaged.

7. In a turbine installation, a high pressure turbine, a low pressure turbine, a driven shaft, and gears through which said turbines drive said shaft, said gears comprising a driven gear wheel mounted on said shaft, a pinion meshing therewith driven by the low pressure turbine, a second pinion meshing with the driven gear wheel, a third pinion driven by the high pressure turbine, a speed reducing gearing through which the third pinion is connected with the second pinion, a clutch in said last-named gearing for opening and closing the connection provided thereby, and a second clutch which provides a separable connection between the high pressure turbine and the second pinion.

8. In a turbine installation, a high pressure turbine, a low pressure turbine, a driven shaft, and gears through which said turbines drive said shaft, said gears comprising a driven gear wheel mounted on said shaft, a pinion meshing therewith driven by the low pressure turbine, a second pinion meshing with the driven gear wheel, a third pinion driven by the high pressure turbine, a speed reducing gearing through which the third pinion is connected with the second pinion, a clutch in said last-named gearing for opening and closing the connection provided thereby, a second clutch which provides a separable connection between the high pressure turbine and the second pinion, and means connected with said clutches for opening and closing them, said means including an interlock which prevents closing both clutches at the same time.

In witness whereof, we have hereunto set our hands this 5th day of November, 1925.

BRUCE O. BUCKLAND.
GLENN B. WARREN.