This invention relates to fluid drives, and particularly to a fluid drive or coupling having improved features of fluid circulation such as to provide improved performance, both as regards operation in the stalling range and minimum slip range. In the type of fluid couplings or fluid drives with which the present invention is concerned there is provided an impeller connected with a driveshaft and a runner connected with a driven shaft, the impeller and runner being located in close juxtaposition with one another, and means being provided for circulating fluid into the space between the two juxtaposed elements.

In operation as torque is applied onto the impeller the fluid is acted upon by the impeller vanes to set up a vortical or whirling flow between the impeller and the runner vanes. The vortical flow provides a fluid connection between the impeller and runner such that motion is transmitted to the runner and to the output shaft to perform useful work.

It will be appreciated that during the operation of the fluid drive the action of the impeller and runner vanes on the fluid tends to cause relatively high fluid temperatures. In the conventional arrangements the fluid is therefore circulated through a cooler structure connected in circuit with the space between the impeller and runner vanes. The need for circulation through the cooler is dependent in large measure on the degree of slip between the impeller and runner, since it will be appreciated that during certain conditions of impeller-runner slip the kinetic energy transfer is increased so as to raise the fluid temperature over that which is encountered during other operational conditions. It therefore desirable that the circulation of fluid into and out of the coupling be correlated with the fluid temperature, the desirable arrangement being one where the oil is maintained at a fairly constant temperature during all of the various different operating conditions.

The fluid could be maintained at a relatively low operating temperature by continuously circulating all of the fluid through a cooler and discharging all of the fluid back into the runner-impeller circuit. However, if such procedure were followed, considerable pumping losses would be experienced. Thus, when the fluid is taken into the impeller-runner circuit it is moving at a relatively slow velocity such that its energy state is relatively low. As the fluid is received onto the impeller vanes it is given a rapid acceleration to provide the vortical, whirling motion within the impeller-runner space. Such increase in fluid speed consumes part of the input horsepower and prevents same from operating on the output shaft.

In view of these circumstances it is desirable that the circulation arrangement be such that small an amount of fluid as possible be circulated into and out of the impeller. As previously explained, the cooling requirements are increased under certain slip conditions. Therefore under such conditions it is desirable that considerable circulation of fluid take place through the coupling in order to prevent the cooling from overheating. At other slip conditions the cooling requirements are considerably less, and it is not necessary under such conditions to circulate as much liquid through the coupling.

Conventionally the degree of slip between the impeller and the runner is controlled by controlling the amount of fluid in the space between the impeller vanes and runner vanes, the arrangement being such that when it is desired to operate at maximum slip the amount of fluid within the runner-impeller circuit is reduced and when it is desired to operate at minimum slip the amount of fluid in the circuit is increased. The control of fluid level in the circuit is effected in the usual arrangements through the provision of a scoop chamber defined by a casing element rotating with the impeller and receiving fluid from the impeller-runner periphery. This scoop chamber is provided with a scoop tube which dips into the liquid in the scoop chamber to extract fluid and thereby maintain a desired level in the scoop chamber. The level of the liquid in the scoop chamber and thence of the work chamber may be adjusted by adjusting the position of the scoop tube so that its operative intake end is further from or closer to the periphery of the scoop chamber.

Under the present invention it is proposed to provide a fluid control structure operating in conjunction with the fluid-withdrawing means from the work circuit such that circulation through the work chamber is controlled in accordance with the conditions of slip and cooling load; in general more fluid is being circulated through the work chamber during conditions of increased slip operation and less fluid is being circulated through the work chamber during conditions of minimum slip. By the arrangement of the invention substantial advantages are obtained, principally in minimization of such energy losses as would otherwise be encountered by the indiscriminate pumping of liquid through the work chamber and by improving the general operation of the coupling, particularly in lowering the input torque at which the coupling stalls out.

Under the present invention there is proposed a relatively simple control mechanism which functions to accurately control the fluid circulation through the work chamber in response to slippage and cooling requirements and which at the same time is of relatively low cost construction and which is of rugged construction not easily tending to malfunction during prolonged service.

It is a principal object of the present invention to provide a fluid coupling having the above-mentioned features of control, wherein the work fluid is circulated so as to be maintained at a safe temperature level and so as to subtract minimum energy from the available power supply to the input shaft of the coupling.

It is a further object of the invention to provide such a control which is of relatively low cost and which will supplant much more expensive control structures heretofore employed.

It is another object of the invention to provide a fluid control structure for a fluid coupling wherein the control structure is operative to circulate varying quantities of fluid through the work chamber accordingly as the fluid coupling is operating under increased slip or minimum slip conditions.

It is a supplementary object to provide a fluid control structure of the above type which operates effectively over all output shaft speed ranges, i.e., in all conditions between maximum slip and minimum slip conditions.

The device is thus more than merely an on-off control or an intermittently operating control, but is on the contrary continuously operative to maintain satisfactory conditions throughout the entire fluid coupling range of operation.

Other objects of this invention will appear in the following description and appended claims, reference being had to the accompanying drawings forming a part of this specification wherein like reference characters designate corresponding parts in the several views.

In the drawings:

FIG. 1 is a sectional view through a fluid coupling show-
ing a fluid circuit and control structure of the present invention therewith;

FIG. 2 is a sectional view taken substantially on line 2—2 in FIG. 1; and

FIG. 3 is a sectional view taken substantially on line 3—3 in FIG. 2; and

FIG. 4 is an elevational view illustrating features of another embodiment of the invention.

Before explaining the present invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and arrangement, as shown in the accompany drawings, since the invention is capable of other embodiments and of being practiced or carried out in various ways. Also, it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

Referring to the drawings and particularly FIG. 1, there is disclosed a fluid coupling 10 located within an upright casing defined by a bottom wall portion 11, upper wall portion 13, and end wall portions 15 and 17. The coupling is provided with an input shaft 12 and an output shaft 14 suitably journaled in the bearings at 16, 18, 20 and 21. Input shaft 12 is provided with a face plate 22 which carries the conventional vane impeller 24 and casing element 26. Output shaft 14 is provided with the face plate 28 which mounts the vane runner 30, the arrangement being such that the impeller and runner are disposed in close juxtaposition with respect to one another so as to define a work chamber in the space occupied by impeller vanes 32 and runner vanes 34.

In the illustrated embodiment the work chamber is supplied with fluid from a line 36, said line discharging into an annular chamber 38 formed by the fixed end plate 40 of the fixed housing construction. Chamber 38 feeds the fluid through a duct 42 formed through the input shaft 12. Duct 42 in turn communicates with a passage 44 formed in the impeller to thereby deliver the working fluid into the work chamber. During operation of the fluid coupling the fluid in the work chamber is acted upon by the impeller vanes to whirl about with a vortical motion within the work chamber as denoted by the arrows in FIG. 1. It will be noted that there is a peripheral space 46 between the outer periphery of the runner 30 and the inner periphery of the shaft 26. This space 46 exhausts fluid from the work chamber through suitable ports 49 in plate 50 into a scoop chamber generally identified by numeral 48.

During various periods in the operation of the fluid coupling fluid may be withdrawn from the scoop chamber 48 to maintain a desired operating level in the work chamber. In the illustrated arrangement the fluid-withdrawing means takes the form of a scoop tube 52 which dips into the fluid in the scoop chamber and permits the fluid to be drawn into the tube so as to travel in the arrow 54 direction. The scoop tube is mounted on a relatively small housing structure 56 which is provided with a duct 58, said duct receiving the fluid from tube 52 and directing it out of the fluid coupling into the surrounding space generally designated by numeral 60. The fluid from duct 58 then merely drains down into the receiver or sump at 62.

It will be noted that the scoop tube housing 56 is affixed to the rotary shaft 64 which carries the gear 66. By reference to FIG. 2 it will be seen that gear 66 meshes with a rack 68 carried on a slidable rod 70. The rod is mounted for back-and-forth slidable motion in the bearing structures generally designated by numerals 72 and 74, so that movement of the rod is effective to vary the position of rack 68 for rotating the gear 66 and thereby adjusting the extent of penetration of the scoop tube 52 into the scoop chamber 48. In this connection it will be appreciated that the scoop tube is configured to extend around the shaft 14 and that during rotation of gear 66 the intake end 76 of the scoop tube occupies different positions along the radius of the scoop chamber, i.e., in the space between shaft 14 and the scoop chamber casing peripheral wall 78. It will be understood that the position of tube 52 as dictated by gear 66 is effective to control the amount of liquid in the scoop chamber and thus also in the work chamber, and the scoop tube control unit is therefore effective to determine the degree of slip existing between the runner and impeller. Thus with a relatively great amount of fluid in the work chamber there is little slip between the runner and impeller, while with a lesser quantity of fluid in the work chamber there is more slip between the impeller and runner.

Particularly during higher slip operations the fluid in the work chamber tends to overheat, and the fluid must be circulated relatively rapidly through the circuit and cooler system. The FIG. 1 embodiment utilizes a circulation system including the pump 80 for circulating fluid into and out of the work chamber. The pump as shown in the drawings is located in the sump 62 so as to be in a submerged condition below the oil surface level 84.

In the device as shown in the drawings the pump is driven from the fluid coupling input shaft 12 by means of the sprocket 66, chain 88 and sprocket 90, the arrangement being such that oil is drawn into the pump casing adjacent its lower end and discharged out of the pump casing to a conduit 92, from whence it flows through a conventional cooler 94. The cooled fluid emerges from cooler 94 and is directed into a line 96 which feeds it to a control valve structure indicated generally by numeral 98. The control valve structure is shown substantially schematic in FIG. 1, while FIGS. 2 and 3 illustrate the control structure in a practical form. In this connection the control structure 98 is shown out of its actual position in FIG. 1 since the figure is intended to illustrate diagrammatically the entire flow circuit which would otherwise be difficult to illustrate in a single figure. The dotted line 69 in FIG. 1 serves to correlate the functional position of the control structure with the physical disposition thereof relative to the fluid coupling.

It will be seen from FIG. 1 that the control structure is provided with an inlet 100 and two outlets 102 and 104, and that the flow from the inlet is apportioned to the two outlets by means of the slidable valve plate 106 having the flow control orifice 108 therethrough. The general arrangement is such that when the valve plate is slid to the right relatively more of the inlet fluid is directed to the outlet 102 and when the valve plate is slid to the left a relatively great amount of the inlet fluid is directed into the outlet 104. Outlet 102 connects with the aforementioned fluid line 36 leading back to the work chamber by means of the previously described passages at 38, 42 and 44. Valve outlet 104 connects with a fluid line 110 which discharges into a chamber 112 formed in the fluid coupling end bell 116, said chamber 112 being in open communication with the sump 62 so that the fluid from line 110 by-passes the work chamber circuit and discharges to the sump.

The general arrangement as shown in FIG. 1 is operated so that when the rod 70 is moved to the right (FIG. 1) the scoop tube 52 is positioned with its intake end 76 relatively close to the peripheral wall 78 of the scoop chamber so as to maintain a relatively small quantity of fluid in the work chamber. At such conditions there is a high slip between the impeller and the runner, and there is a need for relatively rapid circulation of fluid in and out of the work chamber. In this connection it will be appreciated that higher slip conditions tend to elevate the fluid temperature. With rod 70 adjusted to a slip position creating the maximum heat load the flow orifice 108 is automatically positioned to pass a relatively large proportion of the inlet fluid into the line 36 so that the work chamber is rapidly replenished with cooled fluid. In the declutched or maximum slip load condition only
enough fluid is circulated through the circuit to cool the windage and bearing losses.

When the coupling is set to operate under conditions of minimum slip the rod 70 is adjusted to the left (FIG. 1) so that orifice 108 passes relatively small quantities of fluid through the line 36 and relatively great quantities of fluid into line 110. As previously mentioned, line 110 is connected into the fluid coupling. This means the fluid charge of the work chamber is not required to circulate substantial fluid quantities during its condition of minimum slip operation. It will of course be realized that the circulation of fluid into and out of the work chamber subtracts from the useful energy which is delivered to the runner and output shaft, since the fluid when it is received onto the impeller vanes has a relatively low energy condition and therefore the impeller and input shaft must act on the incoming fluid to give it a vortical operative motion in the work chamber. With the arrangement as illustrated in FIG. 1, the circulation of fluid into and out of the work chamber is automatically maintained as low as possible under all operating conditions, and a number of important advantages are thereby obtained. Thus, since the impeller is not required to set considerable quantities of fluid from a substantially zero energy condition to a high energy condition in the work chamber, a substantially greater quantity of the input energy through shaft 12 is available to provide useful work. Thus, under maximum heat load conditions a relatively large flow of cool fluid is obtained to assure safe operating temperatures, and under minimum heat load conditions the flow of fluid through the work chamber will be relatively small so that the impeller will be enabled to transfer substantially all of its energy to the output shaft via the fluid connection with the runner. Also, at the maximum slip or declutched position there is a minimum circulation to minimize the windage or drag losses.

It will be seen that structure 98 as schematically shown in FIG. 1 is relatively simple and can be built as a relatively low cost item. One manner in which the device can be constructed is better shown in FIGS. 2 and 3. As there shown the control structure 98 has the valve plate 106 thereof built with an opening 120 and with an enlarged boss portion 122. The valve plate is connected with the operator rod 70 by having the rod extend through boss 122 and locking it in an adjusted position by means of the nuts 124. The valve plate extends through the valve body 126 defining a bore 128 and 130, said housing members being suitably secured together by means of the studs 132 as shown in FIG. 2. A stud 134 may be secured onto the valve plate 106 to adjustably mount a stop nut 136. The entire control structure (including the gear 66 and valve plate 106) may be operated from any desired point in the chain of linkage, including the left end 140 of rod 70, stud 134, or the shaft 64.

The condition controlling the operation of the control structure can of course be any suitable condition or mechanism, including manual control, speed responsive control, etc. If desired structure 98 can be disposed within the interior of the fluid coupling housing, in which event there would be lessened need for a tight seal at valve element 106 (because leakage would drain into the coupling housing interior).

FIGS. 1 through 3 illustrate a particular circuit and a particular arrangement of pump 80 with respect to the sump 62 and with respect to the coupling 64. However it will be appreciated that the pump can be located in various locations within the circuit. The control valve structure 98 as shown in FIG. 1 is positioned downstream of the cooler 94. However it will be appreciated that the control valve structure could be positioned upstream of the cooler, in which case the cooler would be located in line 56 so that a portion of the fluid subsequently admitted to the work chamber.

FIG. 1 shows a particular scoop chamber-scoop tube relationship employing an accurate, pivotally mounted type of scoop tube. However, it will be appreciated that other fluid-withdrawing means such as a straight scoop tube can be employed to control the work chamber level.

FIG. 4 illustrates features of a construction having a straight scoop tube 52a employed therein. The constructional details of the FIG. 4 arrangement are more particularly shown in co-pending application Serial No. 612,994 filed October 1, 1956.

In the FIG. 4 arrangement the straight scoop tube 52a extends into the fluid coupling housing 10a at an oblique angle to the fluid coupling components so as to clear the runner shaft 14 and dip into the scoop chamber 48a. The upwardly travelling fluid in tube 52a is discharged through openings 58a in the tube so as to be directed into the sump 62a.

In the FIG. 4 device the scoop tube may be adjusted to give different liquid levels in the scoop chamber and work chamber by movement of the tube in the direction of its length. Any suitable means such as a rack-pinion mechanism (not shown) may be employed for this purpose. As shown in FIG. 4 the scoop tube may be directly connected to the valve element 106 which apportions the fluid from cooler 94 into lines 36a and 110a. Line 110a is directed to a conduit 111 which discharges into sump 62a. Line 36a is directed to a conduit 42a which feeds cooled fluid into the scoop chamber 48a. In the FIG. 4 arrangement the oil level in the work chamber is maintained by reason of the peripheral communication 113 between the work chamber and scoop chamber. FIG. 4 illustrates only the major components of the coupling, and for a more detailed description reference may be made to the aforementioned application, Serial No. 612,994.

It will be appreciated that various modifications and redesigns may be resorted to without departing from the spirit of the invention as set forth in the accompanying claims.

I claim:

1. In a fluid coupling comprising a housing including opposed end walls defining a liquid reservoir therebetween, an input shaft extending through one end wall, an output shaft extending through the other end wall, an impeller carried on the input shaft and a runner carried on the output shaft in opposed, spaced axial alignment to define a toroidal work chamber, a casing extending from the impeller beyond the runner to define a scoop chamber coaxial to the work chamber and in free liquid communication with the work chamber whereby the level of liquid in the scoop chamber determines the level of liquid in the work chamber and the slip in the coupling, a scoop tube having an intake adjustable within the scoop chamber to withdraw liquid and discharge to the reservoir, an operator connected to the scoop tube to adjust the position of the scoop tube intake and vary liquid level in the scoop chamber and thereby the amount of liquid in the work chamber, a liquid cooler, and a pump connected to the cooler to move liquid from the reservoir through the cooler to the work chamber, and the improvement of a valve including an inlet connected to receive liquid from the cooler, said valve also including a first outlet connected to the work chamber, a second outlet connected to by-pass to the reservoir, and an adjustable slide plate proportioner to divert variable quantities of liquid from the inlet into the two outlets, and a common operating means simultaneously moving said scoop tube operator and said proportioner, whereby adjustment of the scoop tube to vary the
amount of liquid in the work chamber is effective to adjust said valve to deliver cooled liquid to the work chamber in accordance with the amount of liquid and degree of slip, and need for cooling, and by-pass the remainder of cooled liquid from the valve inlet into the reservoir.

2. In a fluid coupling, a vaned impeller and runner shells positioned in opposed, spaced, axial alignment to define a toroidal work chamber, supply means including a conduit for supplying cooled liquid to said work chamber, a scoop chamber in axial alignment adjacent said work chamber and in free fluid communication therewith whereby the level of liquid in said scoop chamber determines the amount of liquid in said work chamber and the slip in the coupling, a scoop tube having an intake adjustable in said scoop chamber to withdraw liquid and discharge to said supply means, an adjustable valve in said supply conduit and having a cooled liquid inlet connected to receive liquid from said supply means, a work chamber outlet connected to supply liquid to the work chamber, a by-pass outlet connected to return liquid to said supply means, and a movable orifice plate to proportion flow from said inlet between said outlets, and common operator means simultaneously adjusting said scoop tube and said orifice plate to deliver cool liquid into said work chamber in accordance with the amount of liquid therein, the need of slip, and the need for cooling, and by-pass the remainder of cooled liquid from the valve inlet to the reservoir.

3. In a fluid coupling, a toroidal work chamber defined by opposed impeller and runner shells, a scoop chamber coaxial to said work chamber and in free liquid communication therewith, a scoop tube in said scoop chamber adjustable to vary liquid level in said scoop chamber and thereby the amount of liquid in said work chamber, a liquid reservoir to receive liquid from said scoop tube, a pump connected to pump liquid from said reservoir, a cooler connected to said pump, an adjustable proportioning valve connected to receive liquid from said cooler and deliver same in proportioned amounts to said work chamber and by-pass the remainder to said reservoir, and means connecting said scoop tube and valve for simultaneous adjustment, whereby said valve is effective to deliver cooled liquid to said work chamber in accordance with liquid level, degree of slip and need for cooling.

4. In a fluid coupling including vaned impeller and runner shells defining a toroidal work chamber, a control chamber in axial alignment and free liquid communication with the work chamber whereby the level of liquid in the control chamber determines the amount of liquid in the work chamber and the slip in the coupling, and adjustable liquid withdrawing means in the control chamber to vary the amount of liquid therein, the improvement of a liquid circuit for supplying cooled liquid to the work chamber in response to conditions of slip therein, comprising a reservoir to receive liquid from the liquid withdrawing means, a liquid cooler, a pump connected to move liquid from the reservoir to said cooler.

5. In a fluid coupling, a toroidal work chamber defined by opposing impeller and runner shells, supply means including a conduit connected to supply cooled liquid to said work chamber, a control chamber in axial alignment and free liquid communication with said work chamber to control level of liquid in said work chamber, adjustable means to regulate the quantity of liquid in said work chamber, means to regulate the quantity of liquid in said control chamber and thus in said work chamber, a proportioning valve in said supply conduit adjustable to by-pass variable amounts of cooled liquid back to the supply means and deliver the remainder to the work chamber in accordance with liquid level in the work chamber, and a common operator for said regulating means and said proportioning valve to increase flow of cooled liquid to the work chamber as the amount of liquid in the work chamber is reduced and the slip and need for cooling increase.

6. In a fluid coupling, a toroidal work chamber defined by opposing impeller and runner shells, a scoop chamber coaxial to said work chamber and in free liquid communication therewith, a scoop tube adjustable in said scoop chamber to vary liquid level therein and thus in said work chamber, a liquid reservoir connected to receive liquid from said scoop tube, a pump connected to move liquid from said reservoir, a cooler connected in fluid flow relation to said pump, an adjustable proportioning valve connected to receive liquid from said cooler and deliver same in proportioned amounts to said work chamber and in by-pass relation to said reservoir, said proportioning valve comprising a housing having an inlet connected to both a work chamber outlet and a by-pass outlet, a slide plate transversely movable in said housing between said inlet and said outlets, said slide plate having an aperture simultaneously movable across said outlets to proportion flow therebetween, and common operator means connecting said scoop tube at coupling full condition and said valve slide plate at minimum by-pass position for simultaneous adjustment, whereby said valve is effective to deliver cooled liquid to said work chamber in accordance with liquid level, degree of slip and need for cooling.

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