

[54] **FLUID COUPLINGS**

[75] Inventor: **John Elderton**, Hampton Hill,
England

[73] Assignee: **Fluidrive Engineering Company
Limited**, Isleworth, England

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Primary Examiner—Edgar W. Geoghegan
Attorney, Agent, or Firm—Woodhams, Blanchard and
Flynn

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60/365

[51] **Int. Cl.²** **F16D 33/00**

[58] **Field of Search** 60/327, 330, 334, 347,
60/351, 352, 357, 365

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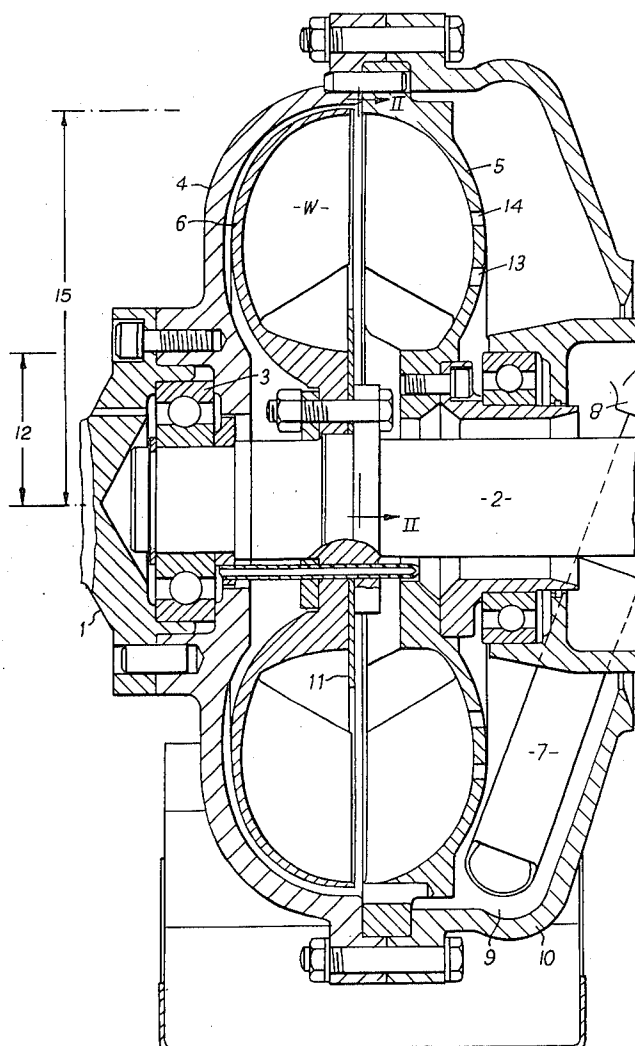
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ABSTRACT

A scoop-trimmed fluid coupling is modified by increasing the size of its baffle, drilling two sets of holes in the impeller wall and altering the numbers of vanes on the impeller and the runner. A substantially constant output torque is maintained when accelerating a load simply by increasing the filling when the input torque drops but otherwise holding the filling constant.

12 Claims, 9 Drawing Figures



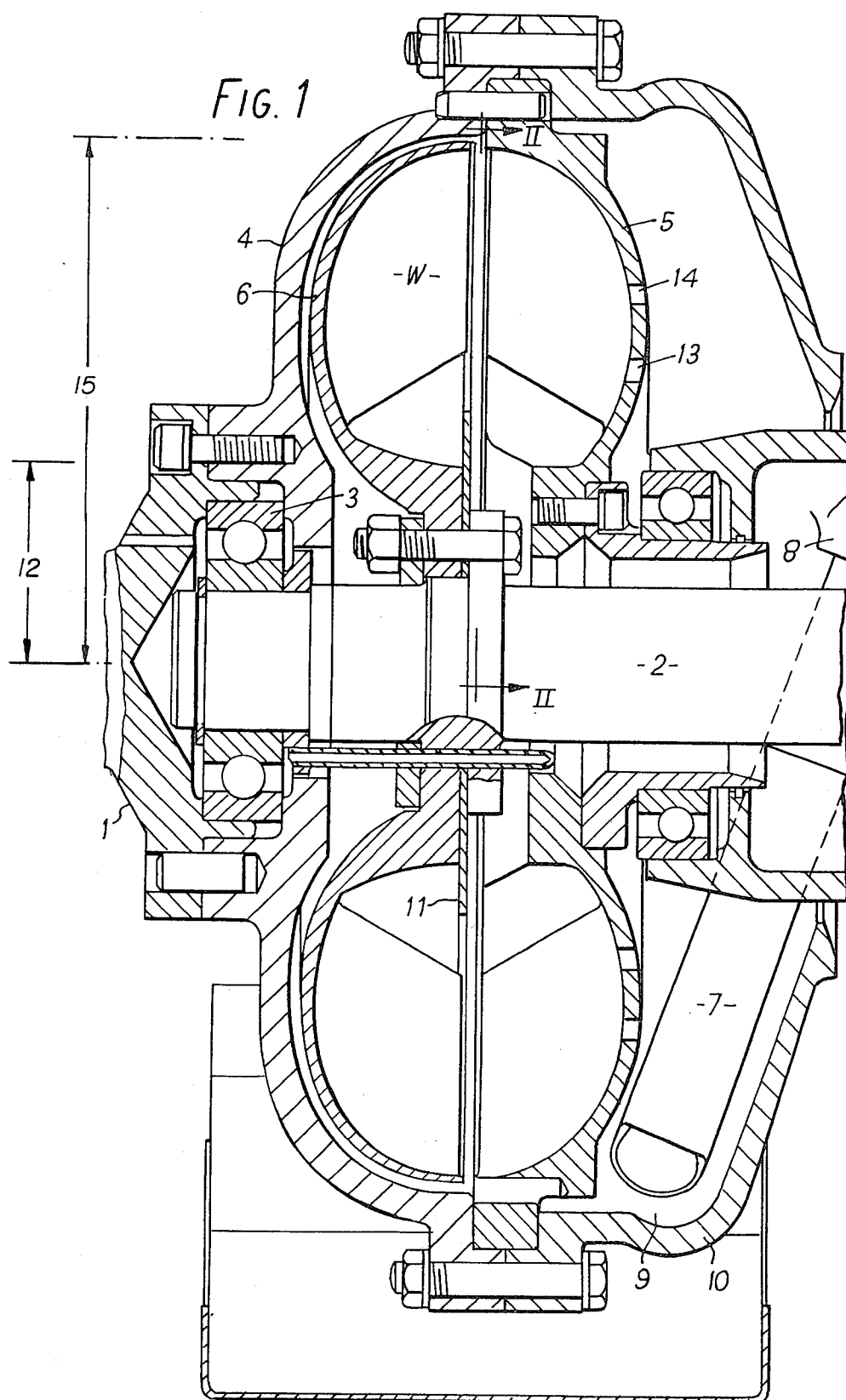
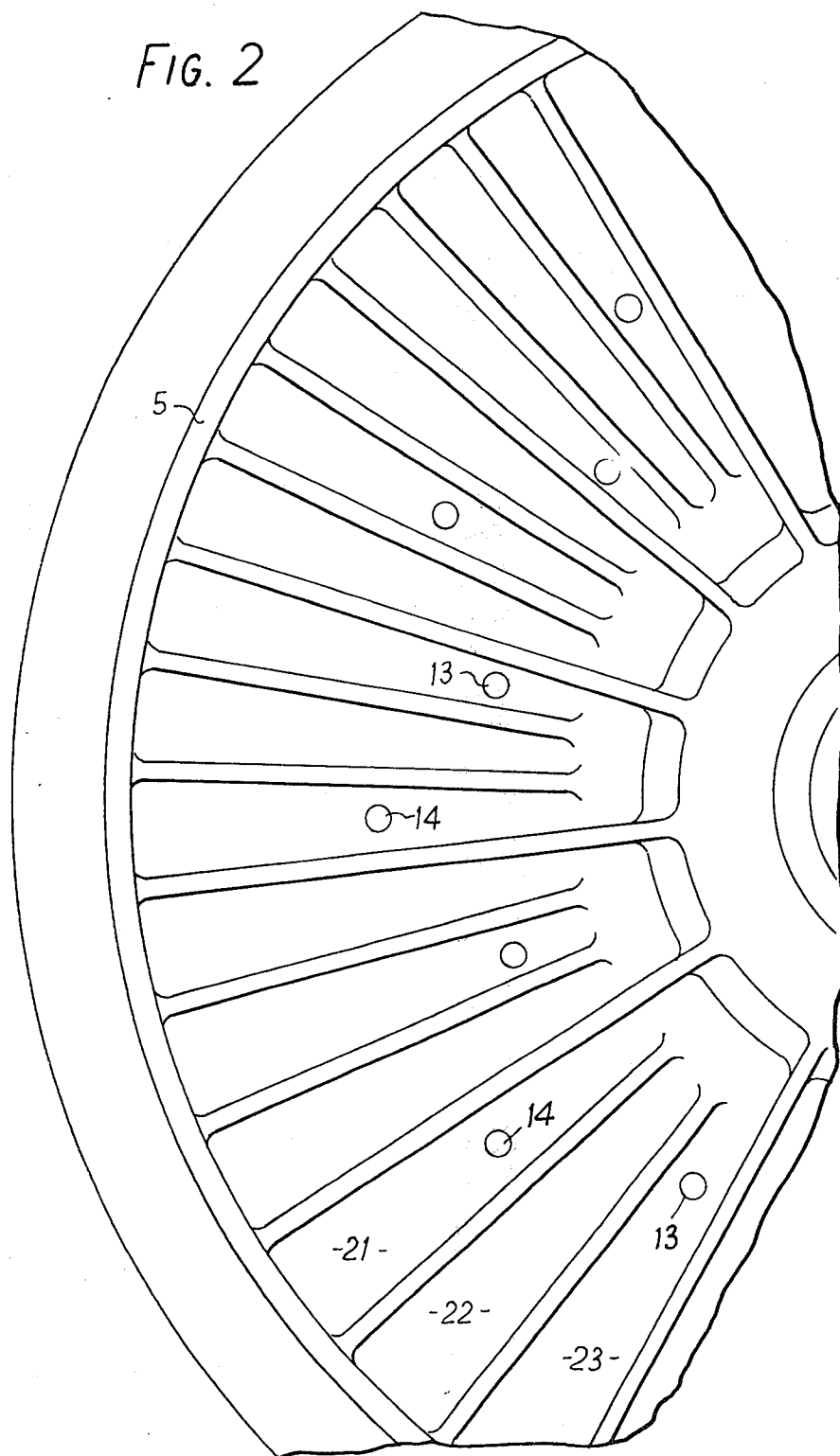


FIG. 2



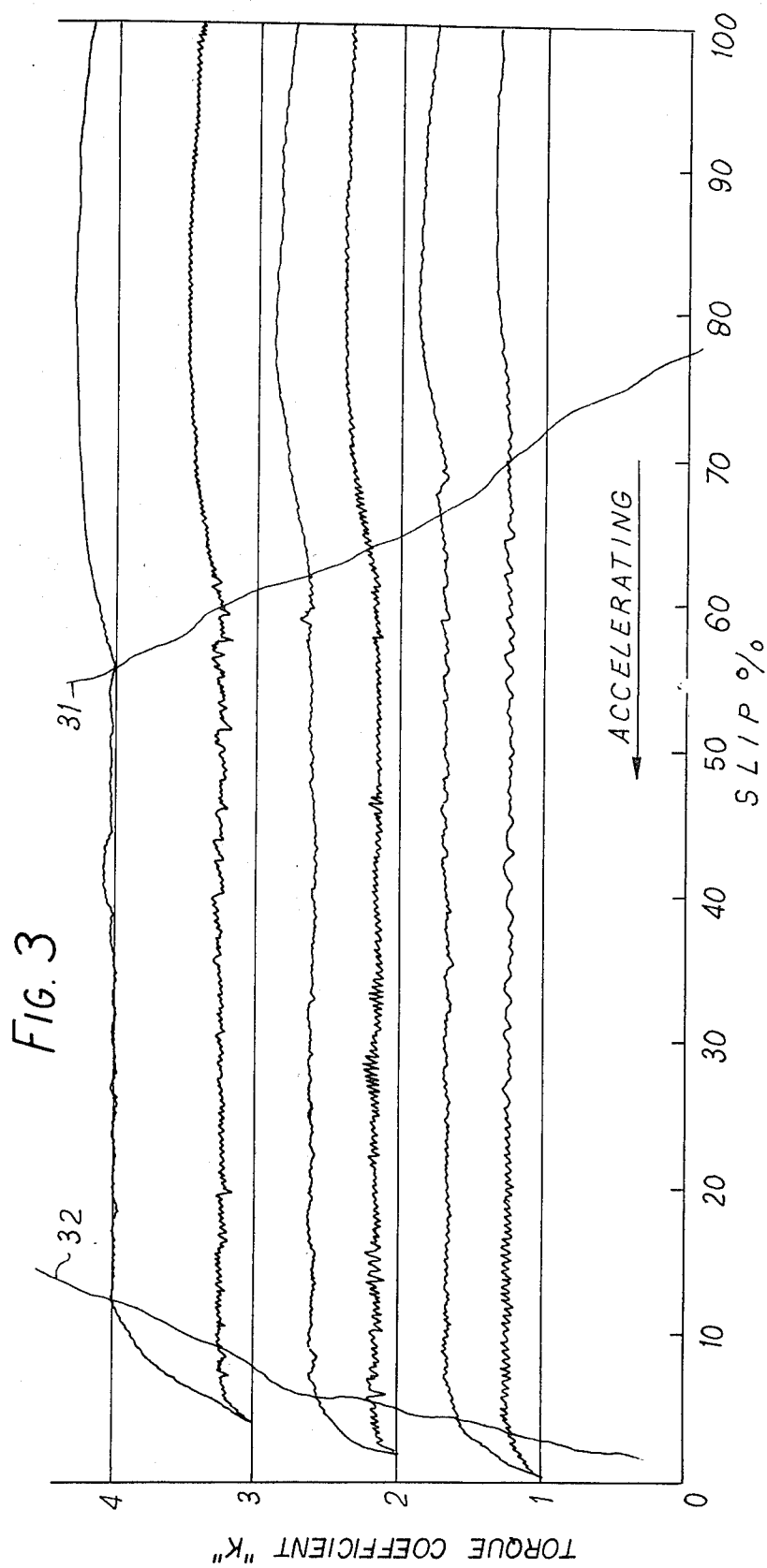


FIG. 4

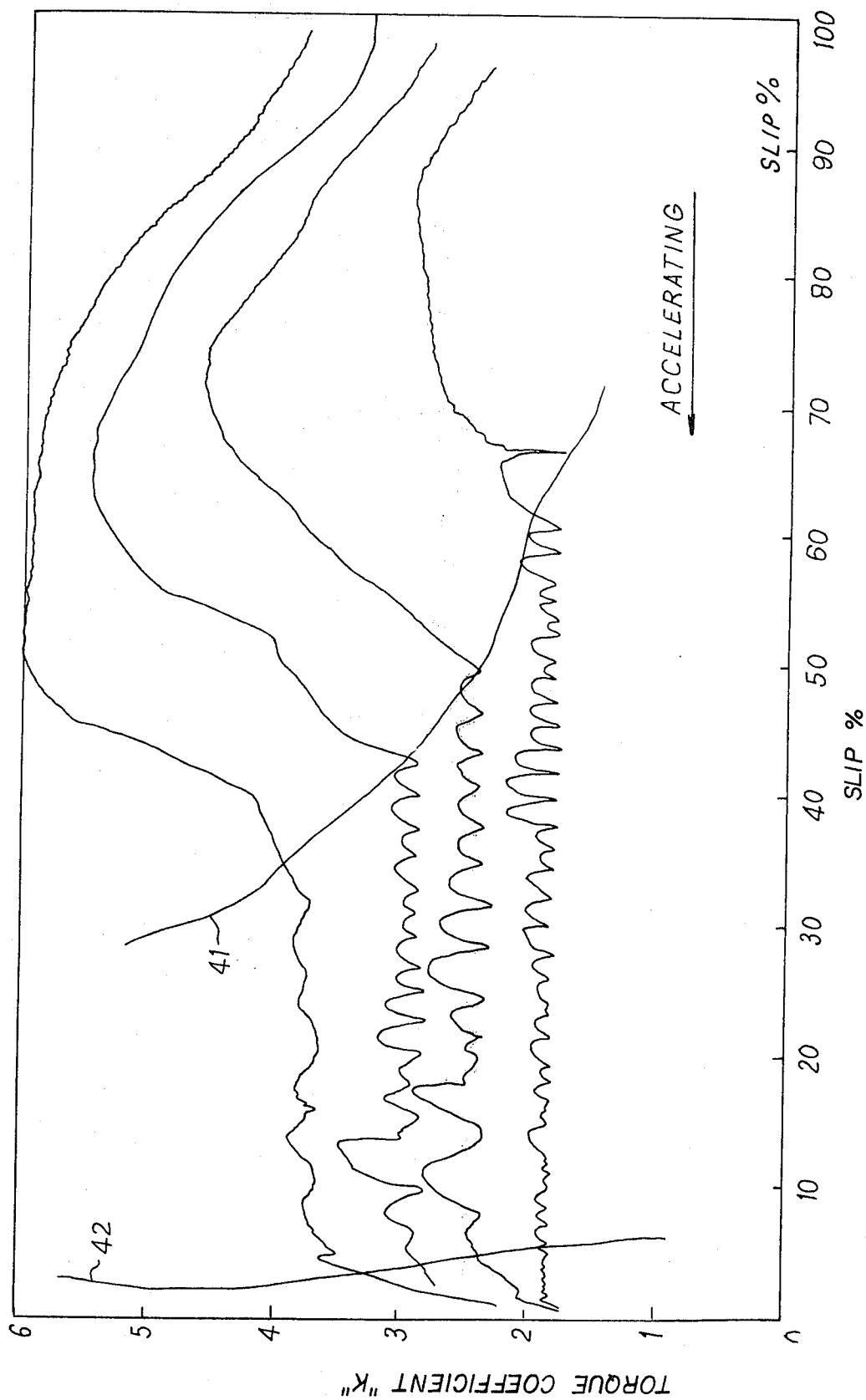


FIG. 5

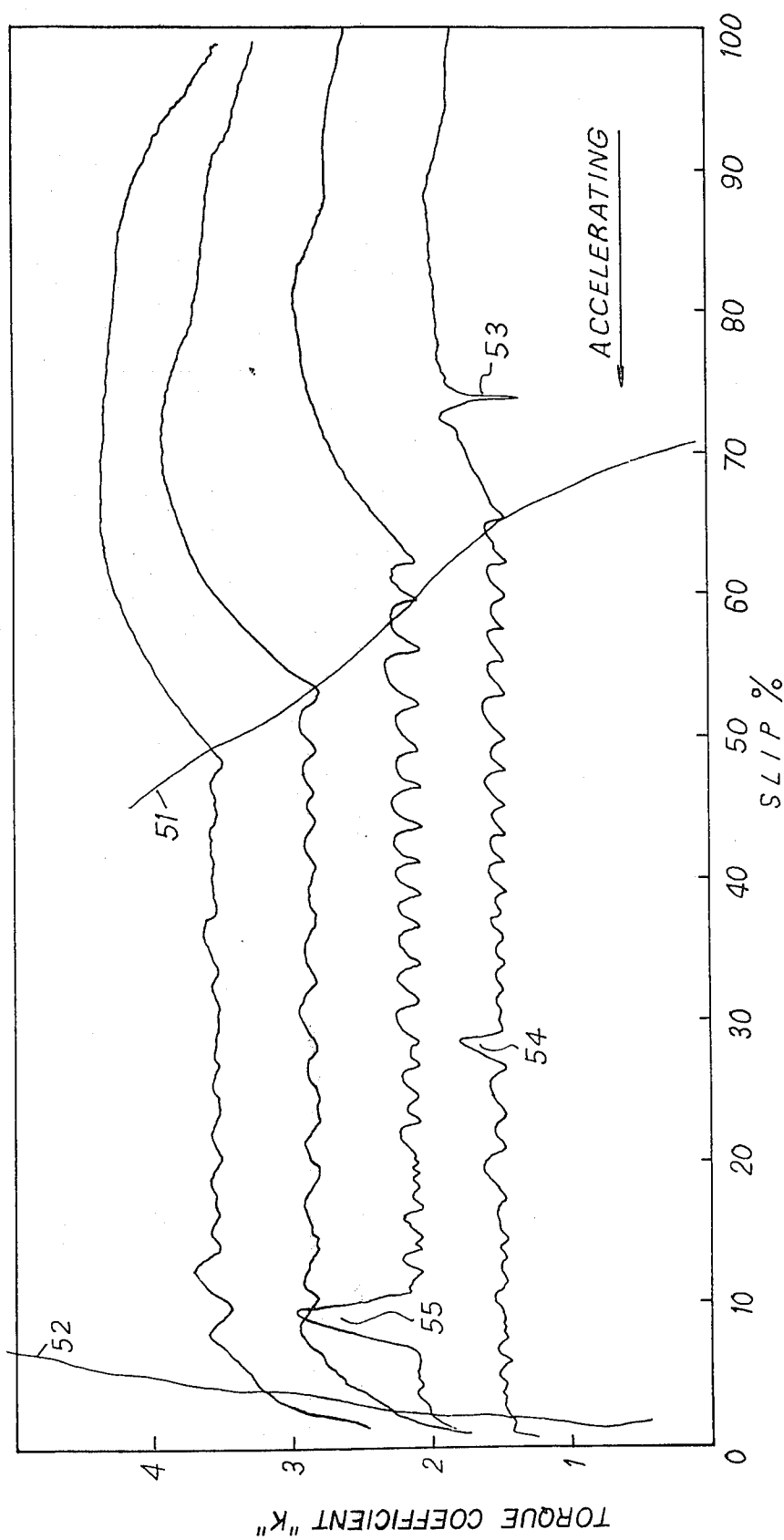
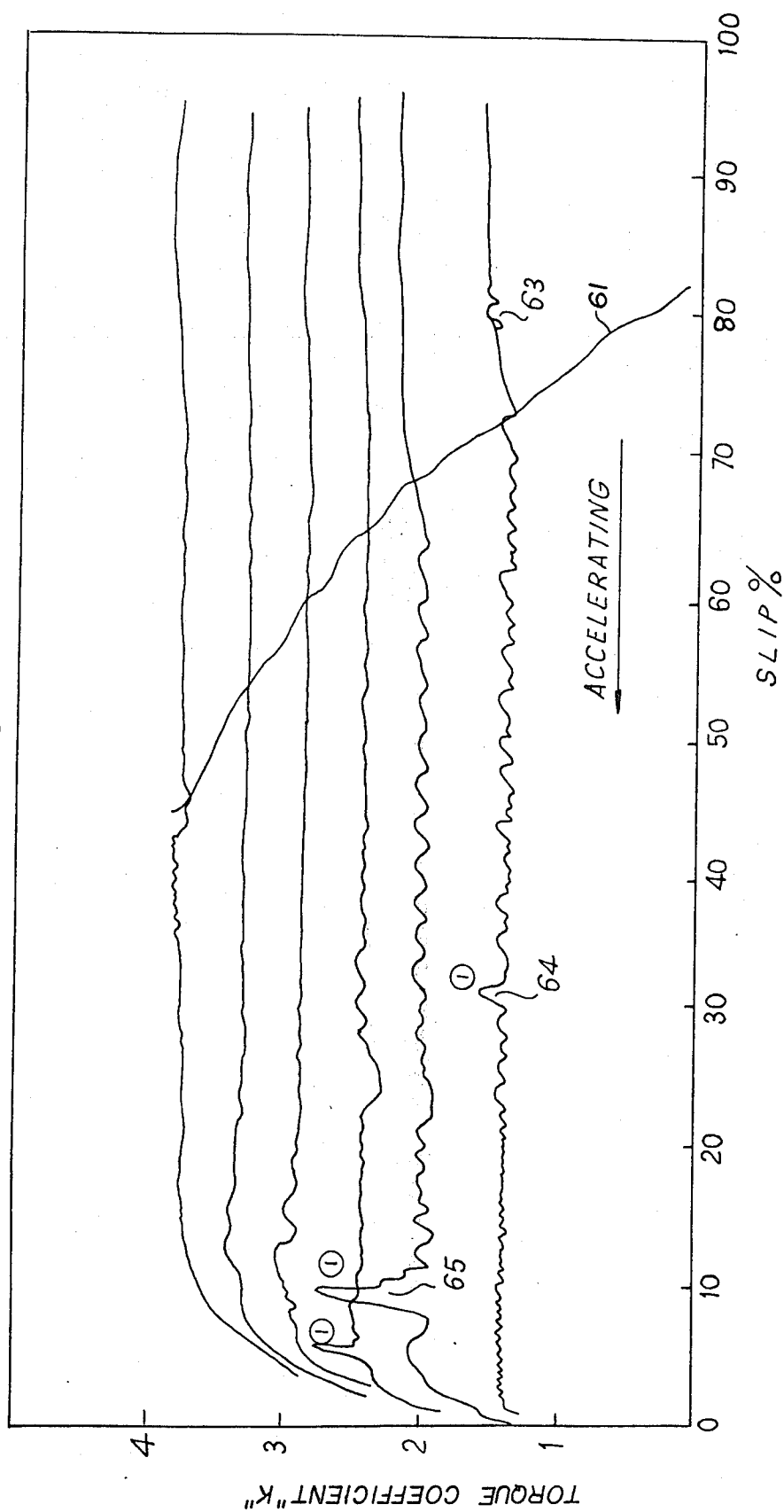
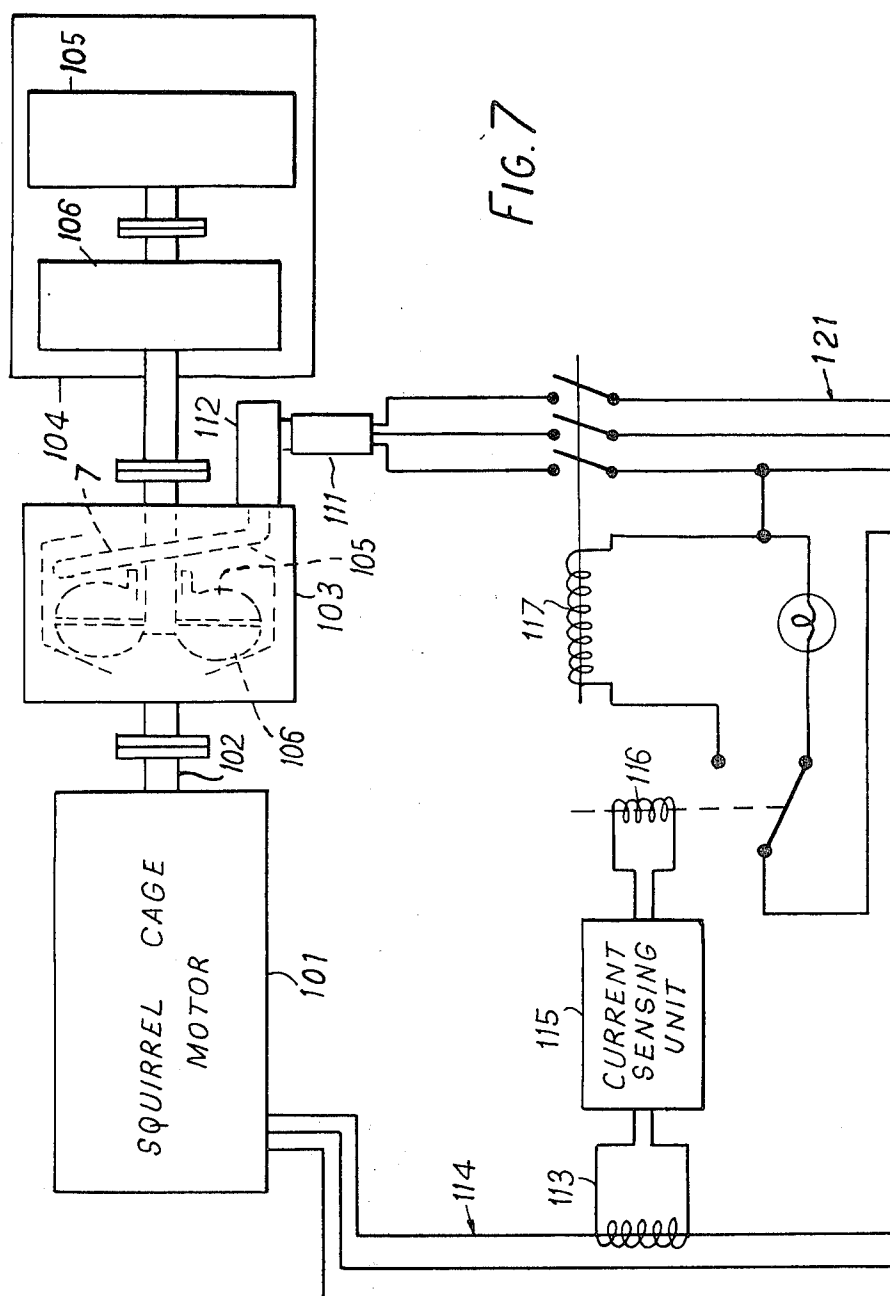


FIG. 6





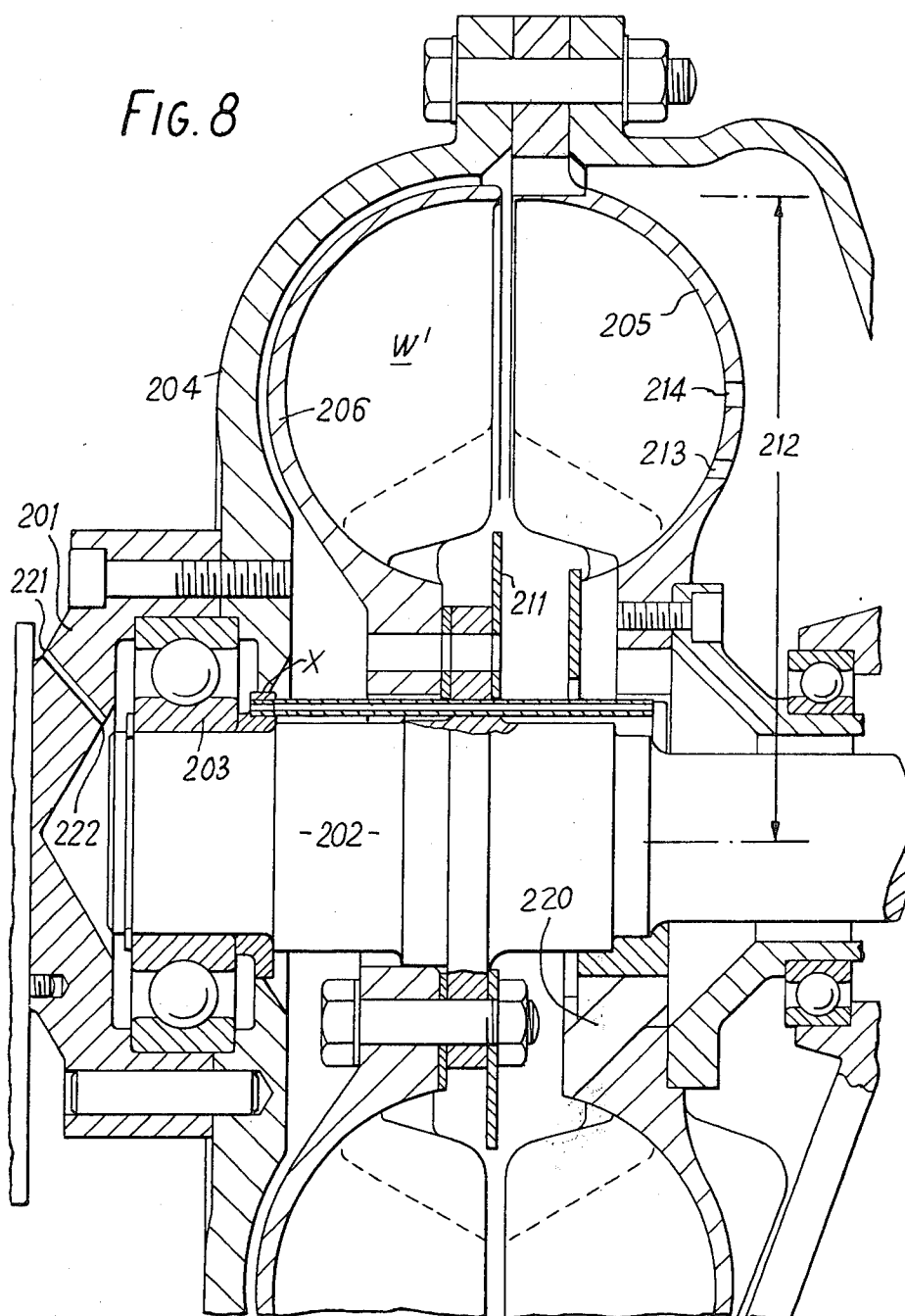
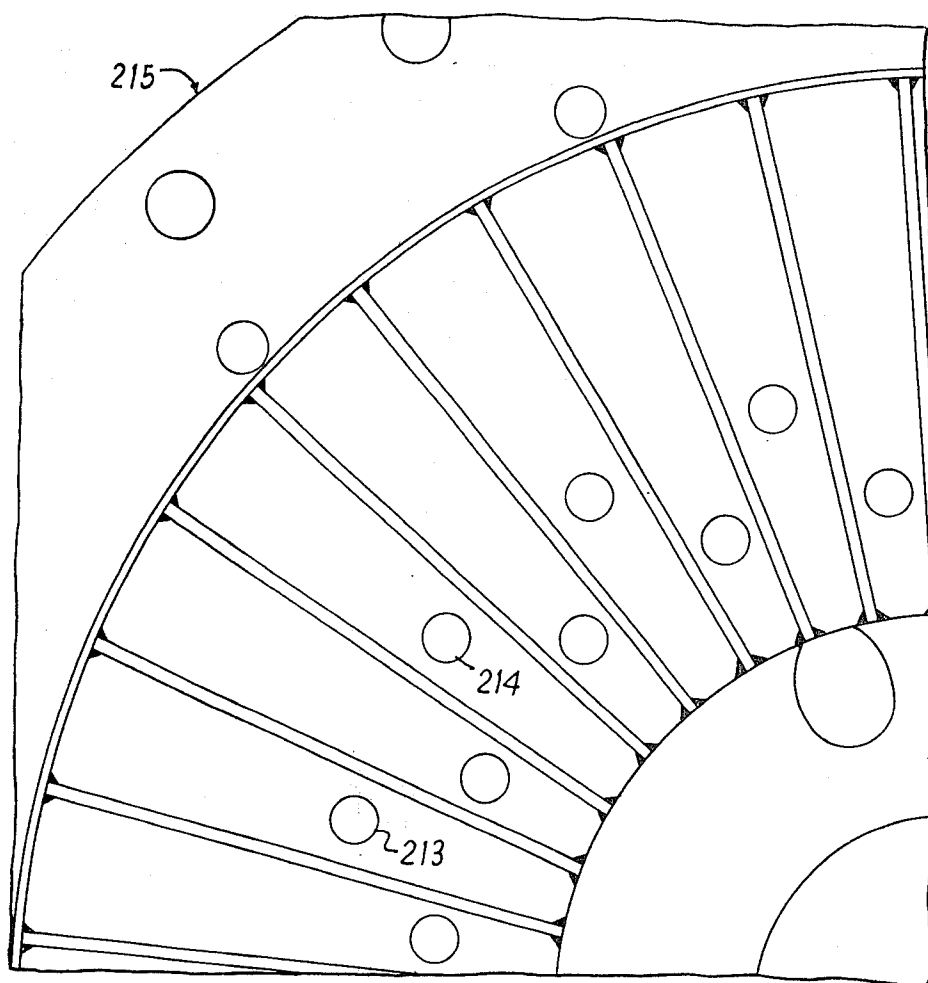


FIG. 9



FLUID COUPLINGS

This invention relates to fluid couplings of the kind comprising vaned impeller and runner elements which together define a toroidal working circuit for a liquid and in which the degree of filling of the working circuit can be varied in use. An object of the invention is to provide a variable-filling fluid coupling which will transmit a substantially uniform torque whilst accelerating a load, when under the control of a control arrangement for the coupling such that the filling of the working circuit is increased whenever the transmitted torque falls below a predetermined value and the filling is held constant whenever the transmitted torque is not below the predetermined value. One field in which such a requirement arises is to be found in drives for long conveyor belts. Such conveyor belts, which may be several miles in length, are used for example for conveying minerals from a mine to a railhead or harbour. Considerable economies can be made in the capital cost of the conveyor belt by reducing the number of belt plies so that the belt will for example withstand forces up to but not greater than say 50% greater than the normal operating values. To prevent damage to the belt, the belt drive must be prevented from exerting forces greater than 150% of the normal full load value. Another application where the same requirements apply would be a large fan where the application of excessive driving torques could cause damage to the fan. Furthermore, in the case of electric motor drives, limitation of the maximum torque applied to the load and thus of the maximum torque applied to the motor can prevent undue disturbance of the electrical network and can also prevent excessive voltage drop where the electric motor is situated in a remote location requiring long power lines.

According to the present invention, there is provided a variable-filling fluid coupling typically of the scoop trimming type having a baffle of diameter at least 1.25 times the inner profile diameter of the working circuit, the runner of the coupling having between 10 and 35% more vanes than the impeller of the coupling, and the impeller having two sets of holes drilled therethrough, the centres of one set of holes being spaced from the coupling axis by from 53 to 63% of the outer profile radius of the working circuit and the centres of the second set of holes are spaced from the coupling axis by from 65 to 75% of the outer profile radius of the coupling. Preferably, the spacing between the two sets of holes is about 10%, measured in the radial direction of the coupling, of the radius of the outer profile of the working circuit.

Preferably the runner has between 15 and 25% more blades than the impeller. In one advantageous embodiment, the baffle has the diameter of 1.3 times the inner profile diameter of the working circuit, the two sets of holes have pitch circle diameters respectively 58 and 70% of the outer profile diameter and the runner has approximately 20% more blades than the impeller.

Embodiments of the invention will now be described by way of example with reference to the accompanying drawings in which:

FIG. 1 is an axial sectional view of a scoop trimmed fluid coupling in accordance with the invention,

FIG. 2 shows a view of the impeller as seen in the direction of the arrows II—II in FIG. 1,

FIG. 3 is a graph showing the torque coefficient K plotted against percentage slip as the coupling accelerates a load from rest to operational speed, the filling of the coupling being increased whenever the transmitted torque falls below a predetermined value K ,

FIG. 4 is a graph corresponding to FIG. 3 for a conventional coupling, similar to that shown in FIGS. 1 and 2 but without any of the characterising features of the invention,

FIG. 5 shows a similar graph to FIG. 4 for a coupling of conventional construction with the exception of having an enlarged baffle,

FIG. 6 shows a corresponding graph for a coupling having a baffle and pattern of holes in the impeller wall in accordance with the invention but having a substantially equal number of vanes on the impeller and runner,

FIG. 7 shows diagrammatically an installation incorporating the coupling and its control arrangement and

FIGS. 8 and 9 are views corresponding to FIGS. 1 and 2 of another coupling in accordance with the invention.

The scoop-trimmed fluid coupling shown in FIGS. 1 and 2 is of conventional construction in so far as it comprises coaxially mounted input and output shafts 1 and 2 interconnected by a ball bearing 3, a rotating casing 4 secured to the input shaft 1, a vaned impeller 5 secured to the casing 4, a vaned runner 6 secured to the output shaft 2 and defining with the impeller 5 a toroidal working circuit W , and a trimming scoop 7 slidably mounted in a stationary structure 8 and projecting into a scoop chamber 9 defined between the back of the impeller 5 and a scoop chamber casing 10 secured to the outer periphery of the rotating casing 4 and to the impeller 5.

The coupling shown in FIGS. 1 and 2 departs however from conventional practice in that its baffle 11 has a radius 1.3 times the inner profile radius 12, as opposed to a more conventional value of 1.1 times the inner profile radius, the impeller 5 has two series of holes 13 and 14 drilled through it and the runner 6 has about 20% more vanes than the impeller. In the particular coupling shown in FIGS. 1 and 2, the working circuit W has an outer profile radius 15 of $5\frac{1}{4}$ inches. A conventional coupling of this size would have for example 42 vanes on the impeller and 40 vanes on the runner. In the coupling shown in FIGS. 1 and 2, the impeller has 45 vanes but the runner has 54 vanes and may be of similar construction to the impeller shown in FIG. 2 (the pattern in each of the three sectors of the coupling being identical) with the exception that the three widest pockets 21, 22, 23 formed between the vanes are each divided into two pockets by the addition of a vane in each of these pockets. Alternatively, the vanes in both impeller and runner may be equi-spaced.

The two sets of holes, 13, 14 are drilled through the wall of the impeller. The holes 13, 14 are typically $\frac{1}{4}$ inch in diameter. With the exception of one pocket, alternate pockets each have one hole, either 13 or 14. The centres of the holes 13 lie on a circle centred on the coupling axis and of diameter 6% inches. The centres of the holes 14 also lie on a circle centred on the coupling axis of diameter $8\frac{1}{2}$ inches. Thus, the holes 13 lie on a circle whose radius is about 58% of the outer profile radius 15 while the holes 14 lie on a circle whose radius is about 70% of the outer profile radius 15.

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FIG. 3 shows the "K" value (proportional to the transmitted torque for a constant motor speed) plotted against the percentage slip for a variety of different loads when accelerating a load from rest (100% slip) to full speed. The graphs were obtained with a control system (similar to that shown in FIG. 7) which served merely to move the scoop tube in the direction to increase the working circuit filling in response to a reduction in the transmitted torque as measured for example by measuring the current taken by a squirrel-cage electric motor driving the coupling. Such a control system has no provision for reducing the torque transmitted by the coupling in the event that the transmitted torque exceeds the predetermined value. Despite this, it will be noticed that the transmitted torque does not rise more than about 10% above the predetermined value. Furthermore, between the lines 31 and 32 the transmitted torque is particularly constant. The portions of graphs to the right of the line 31 correspond to the fixed initial position of the scoop which is reached by the scoop on starting up of the system, this position corresponding to the degree of filling of the working circuit required to transmit the predetermined torque at 100% slip.

In contrast, FIG. 4 shows the corresponding curves obtained with an unmodified coupling. In the region to the right of the line 41, the transmitted torque rises to a maximum about 50% greater than the predetermined value. While this may not be detrimental for some purposes, there are some applications such as the driving of long conveyor belts having a minimum number of belt plies where the increase in torque during acceleration could cause damage.

Even in the range between the lines 41 and 42, there are appreciable variations in the transmitted torque, in some cases amounting to more than 10% of the predetermined value.

The curves in FIG. 5 show the effect of increasing the diameter of the baffle in an otherwise conventional coupling. While the magnitude of the maximum transmitted torque is somewhat reduced, it still represents a value some 30% above the predetermined value. Furthermore, although the torque between the lines 51 and 52 is in general more constant, it will be seen that there are a number of disturbances such as are shown at 53, 54 and 55 which may be unacceptable for some purposes.

FIG. 6 shows the effect of the combination of the larger baffle and the two sets of holes in the impeller wall in an otherwise standard coupling in which the impeller has 42 vanes and the runner has 40 vanes. By comparison with FIG. 5, it will be seen that the two sets of holes render the transmitted torque much more uniform over virtually the whole slip range up to the operating value but there are still a number of irregularities as shown at 63, 64 and 65. Nevertheless, it will be seen that the pattern of holes avoids any significant increase in the torque in the high slip range to the right of the line 61.

Comparison of FIG. 6 with FIG. 3 shows that the increase in the number of vanes in the runner eliminates the irregularities such as those shown at 63, 64 and 65.

FIG. 7 shows diagrammatically an application of the coupling shown in FIGS. 1 and 2, the coupling being indicated at 103.

In the arrangement shown in FIG. 7, a three phase high voltage high power squirrel cage motor 101 has its output shaft 102 connected to the input of the scoop-

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trimmed fluid coupling 103, such as that shown in FIGS. 1 and 2, the output of which is connected to the load 104 to be driven. In general, the load 104, for example a long conveyor belt, may be represented by a flywheel 105 representing the inertia of the load and a friction brake 106 representing the power dissipated by the load as the result of friction, air resistance and like losses.

In known manner, the position of the scoop tube 7 determines the degree of filling of the working circuit W of the coupling 103. The scoop 7 is movable over its whole range of positions by a small reversible motor 111 driving through a reduction gearbox 112.

The torque in the shaft 102 of the motor 101 is approximately proportional to the current drawn by the motor 101. This current is measured by a pickup coil 113 surrounding one of the leads of the three-phase electrical supply 114 to the motor 101 and forming with this lead a transformer. The ends of the coil 113 which thus forms the secondary winding of this transformer, are connected to a current sensing unit 115 which, when the current in the leads exceeds a predetermined value energizes a relay 116 which in turn de-energizes a motor controller 117 for the motor 111. The current sensing unit 115 is arranged to de-energize the relay 116 when the current in the leads 114 falls below the predetermined value, thereby re-energizing the controller 117 to start up the motor 111 again.

In operation, with the system at rest, the scoop tube 7 of the coupling 103 is in its "circuit empty" position. The motor 101 is switched on and runs rapidly up to its normal speed since the working circuit W of the coupling 103 is empty. The relatively low voltage supply 121 for the motor 111 is then switched on and the motor 111 is energized by the motor controller 117 to begin to draw the scoop tube 7 out in the direction of the "circuit full" position.

As a result, the working circuit W begins to fill and the torque load imposed on the motor 101 rises. Correspondingly, the current drawn from the high voltage supply through the leads 114 rises until its value, as sensed by the coil 113 and the current sensing unit 115 reaches a predetermined value, for example 140% or 150% of the normal operational full speed load value, whereupon the current sensing unit 115 actuates the relay 116 to cause the motor controller 117 to stop the motor 111. This in turn stops the scoop tube 7.

The motor 101 then continues to drive the load 104 through the partially filled working circuit W. The torque transmitted by the working circuit W is sufficient to overcome the frictional forces represented by the brake 106 and to continue to accelerate the load 104 against its inertia (represented by the flywheel 105).

If the characteristics of the coupling 103 are such that as the speed rises, the torque transmitted by the coupling with this particular degree of filling also rises, then the motor 111 will remain de-energized and although the torque exerted by the motor will increase somewhat, the filling of the working circuit W will remain constant. When, as a result of increasing speed, the characteristics of the coupling cause the transmitted torque to fall below the predetermined value, the fall in the current in the leads 114 will be sensed by the current sensing unit which will cause the relay 116 to operate the motor control 117 to drive the scoop tube 7 further towards the "circuit full" position until the predetermined torque value is re-established. This "on-

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off switching" of the motor 111 continues until the scoop tube 7 reaches its "circuit full" or normal operating position.

The motor 101 then continues to drive the load at normal speed. When the motor 101 is switched off to close down the system, a reversing switch (not shown) for the motor 111 causes the motor 111 to drive the scoop tube 7 into its "circuit empty" position ready for the next time the motor 101 is started up.

The fluid coupling shown in FIGS. 8 and 9 differs from that shown in FIGS. 1 and 2 principally in that it is designed to transmit higher power at higher speeds than that shown in FIGS. 1 and 2. In this embodiment, the outer profile radius 212 is 8¾ inches. The axial width of the working circuit W is slightly greater than its maximum radial dimension.

As in the case of the couplings shown in FIGS. 1 and 2, the couplings shown in FIGS. 8 and 9 is modified from conventional practice in a number of respects. Thus, the external diameter of the baffle 211 is increased from its normal value of 1.1 times the inner profile diameter of the working circuit to 1.25 or 1.3 times the inner profile diameter. For some applications, the value of 1.25 is preferable as it gives a slightly higher maximum starting torque.

Furthermore, the impeller 205 has 45 vanes instead of the conventional 51 vanes and the runner 206 has 54 vanes instead of the conventional 48 vanes. Two sets of holes 213 and 214 are drilled in the impeller 205 with their centres respectively at radial distances of 58% and 70% of the outer profile radius 212 from the axis of the coupling.

In addition, the impeller hub has inlet ports 220 which are inclined at 45° to the coupling axis instead of the more usual radial disposition. Under some conditions, the inclined disposition of the inlet ports is found to cause less delay in establishing a stable vortex within the working circuit when starting.

Care should be taken that there is no excessive loss of working liquid through the bearing 203 interconnecting the inlet shaft 201 and the outlet shaft 202 under the varying operating conditions to be encountered by the coupling. With this in mind, in the arrangement shown in FIG. 8, a single inclined vent passage 221 permits some circulation of liquid through the bearing 203 but has its inner end 222 positioned radially inwards of the balls of the bearing 203. Further, the running clearance X between the hub of the casing 204 and the shaft 202 is relatively small, being in this case about 0.0025 inch.

The impeller has twenty-two holes 213 and twenty-three holes 214, both sets of holes being ⅝ inch in diameter.

I claim:

1. In a variable filling fluid coupling having vaned impeller and runner elements together defining a toroidal working circuit for a liquid, comprising the improvement wherein the coupling has a baffle of diameter at least 1.25 times the inner profile diameter of the working circuit, the runner of the coupling has between 10 and 35% more vanes than the impeller of the coupling, and the impeller has two sets of holes through the wall thereof, the centres of one set of holes being spaced

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from the coupling axis by from 53 to 63% of the outer profile radius of the working circuit and the centres of the second set of holes being spaced from the coupling axis by from 65 to 75% of the outer profile radius of the working circuit.

2. A coupling according to claim 1, wherein the spacing between the two sets of holes is about 10%, measured in the radial direction of the coupling, of the radius of the outer profile of the working circuit.

3. A coupling according to claim 1 wherein the runner has between 15 and 25% more vanes than the impeller.

4. A coupling according to claim 1, wherein the two sets of holes have pitch circle diameters respectively substantially 58% and 70% of the outer profile diameter of the working circuit, and the runner has approximately 20% more vanes than the impeller.

5. A coupling according to claim 1, wherein the baffle has a diameter of substantially 1.3 times the inner profile diameter of the working circuit.

6. A coupling according to claim 1, wherein the two sets of holes have pitch circle diameters respectively substantially 58% and 70% of the outer profile diameter, and the runner has between 15% and 25% more vanes than the impeller.

7. A coupling according to claim 6, wherein the baffle has a diameter of substantially 1.3 times the inner profile diameter of the working circuit.

8. A coupling according to claim 1, wherein the spacing between the two sets of holes is about 10%, measured in the radial direction of the coupling, of the radius of the outer profile of the working circuit, and wherein the runner has between 15% and 25% more vanes than the impeller.

9. In a variable filling fluid coupling having vaned impeller and running elements together defining a toroidal working circuit for a liquid, comprising the improvement wherein the coupling has a baffle of diameter greater than the inner profile diameter of the working circuit to minimize the maximum torque generated by the coupling when driving a load, the runner of the coupling has between 10 and 35% more vanes than the impeller of the coupling, and the impeller has two sets of holes through the wall thereof, the centres of one set of holes being spaced from the coupling axis by from 53 to 63% of the outer profile radius of the working circuit, and the centres of the second set of holes being spaced from the coupling axis by from 65 to 75% of the outer profile radius of the working circuit.

10. A coupling according to claim 9, wherein the runner has between 15% and 25% more vanes than the impeller.

11. A coupling according to claim 9, wherein the centres of said one set of holes are spaced from the coupling axis by about 58% of the outer profile radius of the working circuit, and wherein the centres of said second set of holes are spaced from the coupling axis by about 70% of the outer profile radius of the working circuit.

12. A coupling according to claim 11, wherein the runner has about 20% more vanes than the impeller.

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