Dec. 5, 1933. H. SINCLAIR 1,938,357

HYDRAULIC COUPLING OR GEAR

Filed Nov. 29, 1932

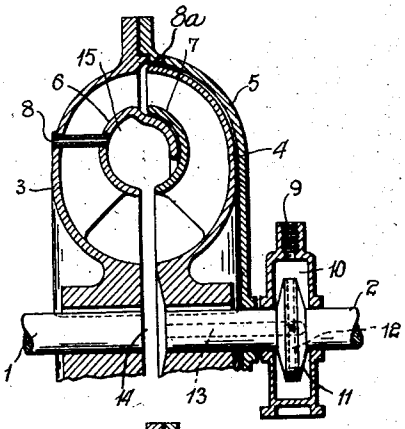


Fig. 1.

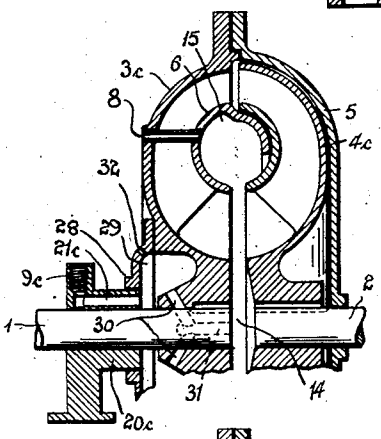


Fig. 3.

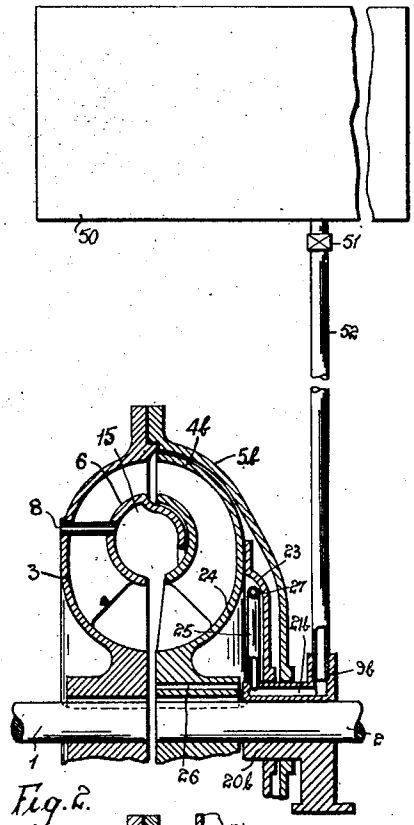


Fig. 2.

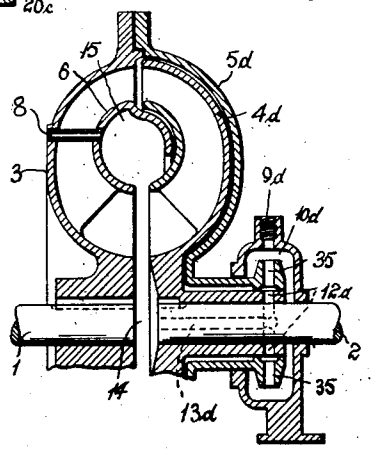


Fig. 4.

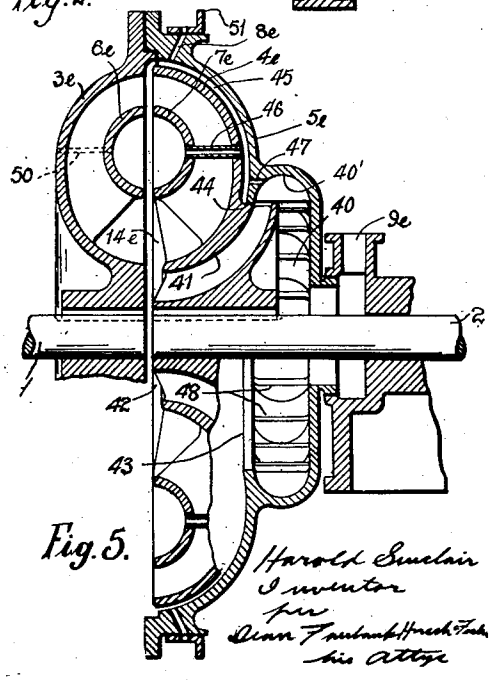


Fig. 5.

Harold Sinclair
Inventor
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UNITED STATES PATENT OFFICE

1,938,357

HYDRAULIC COUPLING OR GEAR

Harold Sinclair, Surbiton Hill, England

Application November 29, 1932, Serial No. 644,808, and in Great Britain November 25, 1931

17 Claims. (Cl. 60—54)

The present invention relates to hydraulic couplings, or gears, of the kinetic type, and provided with means for varying the quantity of liquid in the working circuit thereof while the coupling is operating whereby the slip characteristic is correspondingly varied.

When a hydraulic coupling is employed to connect a driving engine to a driven machine, by suitably varying the slip in the coupling, the speed of the driven machine may be caused to increase with rise in speed of the driving engine but at a lower rate of increase, or alternatively the speed of the driven machine may be maintained constant during a wide variation in the speed of the driving engine, or, if desired, the speed of the driven machine may be caused to decrease as the speed of the driving engine rises, and, within certain limits, to increase as the speed of the driving engine falls.

Further, when the driving engine runs at a constant speed, by suitably varying the slip characteristic of the coupling, the speed of the driven machine may be regulated independently of the load imposed by it on the drive; for example, the speed of the driven machine may be maintained substantially constant with a varying load.

It is common to vary the slip characteristic of such hydraulic couplings by varying the quantity of working liquid in the working circuit of the coupling, liquid being admitted to or discharged from the working circuit while the coupling is operating. In one known arrangement the degree of filling of the circuit, and hence the slip in the coupling, depends on the quantity of liquid admitted to the circuit. In another known arrangement liquid is discharged continuously from the working circuit, the degree of filling being varied by increasing or reducing the rate of admission of liquid to the circuit.

It has been previously proposed to employ compressed air for applying pressure to liquid in a reservoir communicating with the working circuit of a hydraulic coupling, with the object of controlling the slip in the coupling by controlling the pressure in the coupling, the air pressure in the reservoir being regulated automatically by a centrifugal governor in accordance with the speed of the driving member of the coupling. This proposal however, does not contemplate varying the liquid content of the working circuit, except for the slight variation due to change of volume of the air entrained with the working liquid.

An object of the present invention is the provision, in hydraulic couplings, or gears, of the type set forth, of improved means for varying the liquid content of the working circuit within considerable limits, whereby correspondingly wide variations in the slip are obtainable.

A further object is to provide, in hydraulic couplings, or gears, of the type set forth and which are capable of being substantially emptied of working liquid during operation improved means for regulating the rate of filling of the circuit.

According to the present invention a hydraulic coupling, or gear, of the type set forth is provided with means for admitting working liquid to the working circuit while the coupling is operating, which means include a counterpressure pump, drivably connected with the driving or the driven coupling member, the pump being so arranged that it opposes the inflow of liquid to the working circuit. Thus an increase in the speed of the pump automatically effects a reduction in the rate of admission of liquid to the working circuit.

The pump is preferably of the kinetic type. Thus it may be of the usual centrifugal or propeller type, it may be formed by ports in a rotatable part of the coupling through which liquid passes in a radially inward direction on its way into the working chamber, or it may comprise a tube or the like the outlet orifice of which is adapted to be submerged in a ring of liquid contained in a rotatable annular chamber.

The invention will be described, by way of example, with reference to the accompanying diagrammatic drawing, in which:

Figs. 1 to 4 are sectional side elevations of five forms of coupling respectively, of the type wherein liquid is discharged continuously during operation.

Fig. 5 is a sectional side elevation of a coupling of the type provided with valve-controlled outlet ports.

Corresponding parts are referred to by like numerals in the several constructional examples shown in the drawing.

Referring to Fig. 1, a hydraulic coupling of the Vulcan (or so-called Föttinger) type comprises a driving shaft 1 to which is keyed an impeller member 3 to the periphery of which is fixed a dished casing 5 enclosing the back of the runner member 4 which is keyed to a driven shaft 2, the impeller and the casing together enclosing a working chamber. Working liquid is supplied from a source of constant pressure, for example a gravity tank, not shown, through a port 9 to a stationary annular chamber 10 made in halves and enclosing a part 11 of the driven shaft 2 which is of larger diameter than the main portion of this shaft. Radial ports 12 lead from the periphery

of the enlarged part 11 to an axial channel 13 in the driven shaft, which communicates with the working circuit formed in coupling members 3 and 4 through the clearance space 14 provided between the bosses of these members, this space being made wide enough to prevent it from assisting the flow of liquid from the axial channel to the working circuit by centrifugal pumping action. A core guide ring is provided in the working circuit, being formed of two parts 6 and 7 secured respectively to the impeller and runner. The core guide member 6 is shaped to form an annular channel 15 communicating with the outside of the circuit by one or more exhaust ducts 8 whose axes are parallel or nearly parallel to the coupling axis, the arrangement of these ducts being as described in the specification of my copending patent application Serial No. 507,355 allowed May 3, 1933.

The operation of this coupling is as follows: Assuming in the first case that the impeller 3 is driven at substantially constant speed, liquid is being admitted to the working circuit, which is partly full, through the port 9, the chamber 10, the radial ports 12 and the axial channel 13, that liquid is being discharged from the exhaust ducts 8 at the same rate as it is being admitted, and that the runner 4 is revolving at a lower speed than the impeller 3. If now the load on the driven shaft 2 is increased, the speed of rotation of this shaft falls, and the centrifugal force acting on the liquid passing through the radial inlet ports 12 thereby decreases, with the result that the rate of admission of liquid to the working circuit rises. The quantity of liquid in the circuit thereupon begins to increase, causing the fall in speed of the driven shaft to be checked. Similarly, if the load on the driven shaft is reduced, the quantity of liquid in the circuit decreases correspondingly. Thus this arrangement automatically ensures that a relatively large change in the load on the coupling effects only a relatively small change in speed of the driven shaft thereof.

If the speed of the driving member is varied, for example increased, the resulting increase in speed of the driven member causes the liquid content of the coupling to decrease automatically, and therefore the increase in speed of the driven shaft is less than would be the case if the liquid content of the coupling remained unchanged.

With the arrangement of outlet ducts described above, the rate of discharge of liquid from the coupling does not vary greatly with variation in the quantity of liquid in the working circuit. In place of these ducts there may be employed, if desired, small outlet ports 8*a* formed in the periphery of the shell of the driving member, and in this case the rate of discharge of liquid will vary considerably with the quantity of liquid in the working circuit.

The constructional example described above may be so employed that the functions of the driving and driven members are transposed, that is to say, the driving engine is connected to the shaft 2 in which the radial filling ports are formed, while the driven machine is connected to the coupling member 3 provided with outlet ports. With this arrangement the rate of admission of liquid to the working circuit is varied automatically and inversely with the speed of the driving member.

In the alternative arrangement shown in Fig. 2, the impeller is arranged as described with reference to Fig. 1. On the back of the runner 4*b* is fixed a cover 23 which encloses an annular chamber 24 which communicates with the working chamber by a port 26 leading through the boss of the runner. A stationary sleeve 20*b* surrounding the driven shaft 2 and projecting into the chamber 24 is provided with an axial inlet passage 21*b* to which liquid is admitted at constant pressure through an inlet port 9*b*. Any suitable means may be employed for delivering the liquid under pressure. As illustrated there is employed an overhead tank 50 connected by a coupling 51 to a pipe 52 leading to the inlet port 9*b*. A tube 25 carried by the sleeve 20*b* and communicating with the passage 21*b* projects radially within the chamber 24 and terminates in a mouth 27 opening tangentially to a circle whose centre lies on the axis of rotation of the chamber 24, the direction of opening of said mouth being opposite to the normal direction of motion of the adjacent peripheral part of the annular chamber 24. When the runner 4*b* is rotating, since the port 26 is nearer the coupling axis than is the mouth 27 of the scoop tube, this mouth is submerged in a ring of liquid in the chamber 24, and the back-pressure on the inlet passage due to the rotational velocity of the liquid in this chamber serves to regulate the rate of admission of liquid to the working circuit.

If desired, the coupling member to which the annular chamber enclosing the scoop tube is fixed may be employed as the impeller instead of as the runner.

In the constructional example shown in Fig. 3, to the periphery of the impeller 3*c* is attached a dished casing 5 enclosing the runner 4*c*. Fixed on the side of the impeller is a casing 28 enclosing an annular chamber 29. A stationary sleeve 20*c* surrounding the driving shaft 1 projects into the chamber 29 and is provided with a longitudinal passage 21*c* for admitting liquid thereto from an inlet port 9*c*. One or more ports 30 are formed through the boss of the impeller, leading obliquely from the chamber 29 to an axial bore 31 in the shaft 1 leading to the clearance space 14 between the impeller and runner bosses, which may be made wider than is usual for the reasons hereinbefore set forth. The ports 30 are so arranged that the distance from their inlet ends in the chamber 29 to the axis of the driving shaft is less than the greatest radius of this chamber. Thus when oil is used as the working liquid, any foreign matter present in the oil admitted to the chamber 29 while the driving shaft is rotating is deposited against its inner peripheral surface by centrifugal action, and clean oil is transferred by the oblique ports to the working circuit. The annular chamber may be provided with ports 32 in its periphery, or other suitable means, for discharging the foreign matter. The increase in the speed of the driving shaft 1 causes a reduction in the rate of admission of liquid through the ports 31 owing to the increase of centrifugal head generated in these ports.

In a modification of the last described arrangement, the coupling member on which the annular chamber and the oblique inlet ports are formed is employed as the runner.

In the arrangement shown in Fig. 4, the liquid admitted to the working circuit is passed through two counter-pressure pumps, one of which is driven by the driving member of the coupling and the other by the driven member. Radial inlet ports 12*d* formed in the boss of the runner 4*d* and the driven shaft communicate with an axial bore 13*d* in this shaft leading to

the working circuit. The boss of the casing 5*d* is provided with an extension through which are formed radial ports 35, the inner ends of which communicate with the ports 12*d* and the outer ends of which open into a stationary chamber 10*d* provided with an inlet port 9*d*.

In the constructional examples described above, liquid may be supplied to the coupling from a reservoir to which the liquid exhausted from the coupling is constantly returned, and the effective liquid-containing capacity of the reservoir may be variable, for example where a gravity reservoir is employed, by means of a movable outlet weir, such as is described in my U. S. Patent No. 1,938,607; in this arrangement the maximum degree of filling of the working circuit is determined by the position of the movable weir, while the degree of filling may still vary automatically in accordance with the conditions under which the coupling is operating.

The kinds of coupling described above are particularly suitable for transmitting the drive from the shaft of an internal-combustion engine to the impeller of a turbo-blower employed to supercharge the engine. By suitable arrangement and proportioning of the inlet and outlet passages, the relationship between the delivery pressure of the blower and the speed of the engine may be varied over a wide range. For example, the delivery pressure may be automatically maintained constant with varying engine speed, or it may fall automatically with increase of engine speed, or again, it may rise automatically with increase of engine speed but at a lower rate than would be the case if a coupling operating with a constant liquid content were employed.

The invention may also be applied to the type of coupling in which the slip characteristic depends on the quantity of liquid admitted to the working circuit and wherein there need not be a continuous flow of liquid from a filling duct, through the working circuit, and to an outlet port. Where such a coupling is employed to connect a driving machine running at a substantially constant speed to a load imposing a high starting torque, it is desirable, in order to minimize the acceleration period when the driving machine is started, to secure a rapid initial rate of filling of the working circuit so that the full starting torque may be developed quickly, followed by a reduced rate of filling as the driven machine accelerates, so as to avoid overloading the driving machine.

Fig. 5 shows a Vulcan coupling designed, according to the present invention, to effect automatically such a variation of the filling rate. To the periphery of the impeler 3*e* is fixed a dished casing 5*e* serving to enclose the runner 4*e*, an exhaust valve 51 of known type controlling exhaust ports 8*e* near the periphery of the casing 5*e*. Liquid is admitted, for example under constant pressure, through a port 9*e* into a chamber 40 formed between the runner 4*e* and the casing 5*e*, the radially outer part of this chamber being constituted by a channel 40′ of semi-circular cross section. The runner 4*e* is provided with a main inlet passage 41 extending inwards in a generally radial direction from the annular channel 40′ towards the axis of rotation. The passage 41 is provided with vanes 42 preferably curved similarly to the vanes in a centrifugal pump. A flange 43 formed on the casing 5*e* runs in close proximity to a seating 44 formed on the runner 4*e* and thus prevents the free passage of liquid between the chamber 40 and the space 45 between the outer part of the runner 4*e* and the casing 5*e*. Ports 46 connect the interior of the core guide ring 6*e*, 7*e* with the space 45. Auxiliary ports 47 connect the chamber 40 directly with the space 45.

The peripheral portion 40′ of the chamber 40 is provided with vanes 48, which in the example shown are radial. The number and shape of the vanes 42 and 48 may be varied according to the extent of the assisting or retarding effect required during successive periods in the filling of the coupling.

The operation of this coupling is as follows: When the coupling is empty and the driving shaft 1 is rotating, opening of the valve which controls the supply of liquid to the port 9*e* causes a rush of liquid into the coupling, this initial filling being assisted by the relative motion between the vanes 48 and 42. As a result of the high circulation velocity set up in the working circuit between the impeller and the runner however, under starting conditions, a back pressure is created in the clearance space 14*e* between the bosses of the elements 3*e* and 4*e* which reduces the rate of filling through the passage 41 while the runner accelerates. By varying the dimensions of the several passages by which liquid passes into the working circuit and by which air is released, the rate of filling at this stage can be adjusted to requirements.

As the runner 4*e* accelerates, a counter-pressure is created in the radial passages 41; owing to centrifugal force, and at the same time the relative velocity between the vanes 48 and 42 is reduced, with the result that the rate of feeding through this passage progressively diminishes and will cease if the counter-pressure equals or exceeds the pressure of the incoming liquid. In the meantime, the filling is continued, through the ports 47 and 46, at a rate depending on the area of these ports. Hence, when the speed of the runner approaches its maximum and the back-pressure created by the internal circulation decreases, the final filling of the coupling is completed slowly, as desired.

In the couplings herein described there may be provided vent passages, leading from a point of low pressure within the working circuit, for example the interior of the core guide ring, to the outside of the circuit for the purpose of permitting air to flow into or out of the circuit when the liquid content thereof is decreased or increased. Such a passage is denoted by 50 in Fig. 5.

Although the examples shown in the drawing are all hydraulic couplings of the type in which the ratio of the driving torque to driven torque is 1 to 1, it is clear that the invention is also applicable to hydraulic gears, that is to say couplings of the type having a stationary reaction member included in the working circuit and serving to effect a change of torque between driving shaft and driven shaft; and the word "coupling" in the following claims is to be understood as including both these types.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A hydraulic coupling of the kinetic type comprising a rotatable impeller member, a rotatable runner member, said members defining a hydraulic working circuit chamber, a duct for supplying working liquid to said working chamber while the coupling is operating, and a counter-pressure pump for automatically regulating the flow of liquid through said duct, said pump being

drivably connected with one of said rotatable members.

2. A hydraulic coupling of the kinetic type comprising a rotatable impeller member, a rotatable runner member, having therein a hydraulic working circuit, means for supplying working liquid to said working circuit while the coupling is operating, said means including a hydraulic turbine pump serving to oppose the flow of liquid to said working circuit, and a driving connection between said pump and one of said coupling members, whereby an increase in speed of the coupling member driving said pump automatically reduces the rate of admission of liquid to said circuit.

3. A hydraulic coupling of the kinetic type comprising a rotatable impeller member, a rotatable runner member, having therein a hydraulic working circuit, means for admitting fresh working liquid to said working circuit while the coupling is operating, said means including a liquid transfer member which is mounted for rotation with one of said members and is so disposed that centrifugal force acting on the liquid within said transfer member acts to oppose the transfer of liquid thereby to said working circuit, whereby an increase in speed of the coupling member driving said liquid transfer member automatically reduces the rate of admission of liquid to said circuit.

4. A hydraulic coupling of the kinetic type comprising a rotatable impeller member, a rotatable runner member, said members being co-axially disposed, and having a hydraulic working circuit, an annular chamber co-axial with said members, means for supplying fresh working liquid to said annular chamber, a circuit filling duct formed in one of said coupling members, debouching from said annular chamber, and opening into said working circuit at a radius about the coupling axis that is substantially shorter than the maximum radius of said annular chamber about said axis, said filling duct and annular chamber co-operating to regulate automatically the flow of fresh liquid into said working circuit in accordance with variation in the speed of rotation of the member in which said filling duct is formed.

5. A hydraulic coupling of the kinetic type comprising a rotatable impeller member, a rotatable runner member, a hydraulic working circuit including said members, a duct mounted for rotation with one of said members and serving to conduct working liquid to said working circuit, the distance of the inlet end of said duct from the axis of rotation thereof being greater than the distance of the outlet end of said duct from said axis, whereby said duct serves as a counter-pressure pump which automatically reduces the rate of admission of liquid to said circuit upon increase in speed of rotation of said duct.

6. A hydraulic coupling of the kinetic type comprising co-axial and rotatable impeller and runner members, a hydraulic working circuit including said members, an annular channel co-axial with said members, means for supplying working liquid to said annular channel, and a duct formed in one of said members, said duct being rotatable relative to said annular channel and serving to conduct liquid to said working circuit, the inlet end of said duct debouching from said annular channel, and said duct opening into said working circuit at a distance from the axis of rotation of said members that is shorter than the distance from said inlet end to said axis.

7. A hydraulic coupling of the kinetic type comprising a rotatable impeller member, a rotatable runner member, a hydraulic working circuit including said members, and means for supplying working liquid to said working circuit including an annular liquid transfer chamber mounted for rotation with one of said members, a stationary liquid inlet member provided with a mouth opening within said annular chamber, and a duct communicating said annular chamber with said working circuit, said rotatable annular chamber and said stationary inlet member co-operating to act as a counter-pressure pump.

8. A hydraulic coupling of the kinetic type comprising a rotatable impeller member, a rotatable runner member, a hydraulic working circuit including said members, and means for supplying working liquid to said working circuit including an annular liquid transfer chamber mounted for rotation with one of said members, a stationary liquid inlet member provided with a mouth opening within said annular chamber in a direction facing the direction of motion of adjacent parts thereof, and a duct communicating said annular chamber with said working circuit, said rotatable annular chamber and said stationary inlet member co-operating to act as a counter pressure pump.

9. A hydraulic coupling of the kinetic type comprising a rotatable impeller member, a rotatable runner member, a hydraulic working circuit including said members, an annular chamber mounted for rotation and co-axial with one of said members, a stationary liquid inlet member provided with a mouth opening within said annular chamber, and a duct rotatable with said annular chamber and communicating said chamber with said working circuit, said duct debouching from said chamber at a distance from the chamber axis that is shorter than the distance from the mouth of said stationary liquid inlet member to said axis.

10. A hydraulic coupling of the kinetic type comprising a hydraulic working circuit including a rotatable runner member, and means for supplying working liquid to said working circuit including an annular liquid transfer chamber connected for rotation with said runner member, a stationary liquid inlet member provided with a mouth opening within said annular chamber, and a duct communicating said annular chamber with said working circuit, said rotatable annular chamber and said stationary inlet member co-operating, upon increase of speed of said runner member, to retard automatically the rate of admission of liquid to said working circuit.

11. A hydraulic coupling of the kinetic type comprising co-axial and rotatable impeller and runner members, a hydraulic working circuit including said members, an annular channel co-axial with said members, means for supplying working liquid to said annular channel, a duct formed in said runner member, said duct being rotatable relative to said annular channel and serving to conduct working liquid to said working circuit, the inlet end of said duct debouching from said annular channel, and said duct opening into said working circuit at a distance from the axis of rotation of said members that is shorter than the distance from said inlet end to said axis.

12. A hydraulic coupling of the kinetic type comprising co-axial and rotatable impeller and runner members, a hydraulic working circuit including said members, an annular channel co-

axial and rotatable with said impeller member, means for supplying working liquid to said annular channel and a duct rotatable with said runner member and serving to conduct liquid to said working circuit, the inlet end of said duct debouching from said annular channel and said duct opening into said working circuit at a distance from the axis of rotation of said members that is shorter than the distance from said inlet end to said axis.

13. A hydraulic coupling of the kinetic type comprising co-axial and rotatable impeller and runner members, a hydraulic working circuit including said members, an annular channel co-axial and rotatable with said impeller member and provided with vanes, means for supplying working liquid to said annular channel, a duct rotatable with said runner member, and serving to conduct working liquid to said working circuit, the inlet end of said duct debouching from said annular channel and being provided with vanes which co-operate with said first-mentioned vanes to regulate the rate of admission of liquid to said working circuit.

14. A hydraulic coupling of the kinetic type comprising a working circuit including a rotatable runner member, and means for supplying working liquid to said working circuit while the coupling is operating, said means including a counter-pressure pump drivably connected with said runner member whereby the flow therethrough decreases upon increase of speed of said runner member, and a duct in parallel with said counter-pressure pump which is adapted to maintain the supply of liquid to said working circuit when the flow through said counter-pressure pump ceases.

15. A hydraulic coupling of the kinetic type comprising a rotatable vaned impeller member, a rotatable vaned runner member, said members defining a hydraulic working circuit, means capable of effecting a substantially complete removal of working liquid from said working circuit while the coupling is operating so as to permit said runner member to come to rest while said impeller member is rotating, and means for admitting working liquid to said circuit while the coupling is operating, said last mentioned means including a hydraulic pump of the kinetic type drivably connected with one of said coupling members and so arranged that increase in the speed of said pump automatically effects a reduction in the rate of admission of liquid to said circuit.

16. A hydraulic coupling of the kinetic type comprising a rotatable impeller member, a rotatable runner member, said members defining a hydraulic working chamber, means for supplying working liquid to said chamber while said coupling is operating, said means including two counterpressure pumps for automatically regulating the rate of admission of liquid to said circuit, said pumps being drivably connected with said impeller and runner members respectively.

17. A hydraulic coupling of the kinetic type, comprising a rotatable impeller member, a rotatable runner member, having therein a hydraulic working circuit, and means for admitting fresh working liquid to said working circuit while the coupling is operating, said means including a part forming an annular liquid chamber encircling the axis of rotation of said members and a part within said chamber having a duct extending in a direction having a radial component and having an open end terminating within said annular chamber, the duct and the chamber being in series in the path of flow of the liquid into said working circuit, one of said parts being stationary and the other rotatable with one of said members about the axis of rotation of said members, whereby increase in the speed of rotation of the rotatable part automatically increases the resistance to flow through said duct and reduces the rate of admission of liquid to said circuit.

HAROLD SINCLAIR.