

June 13, 1939.

G. H. WALKER
HYDRAULIC APPARATUS
Filed Jan. 22, 1937.

2,162,541

3 Sheets-Sheet 1

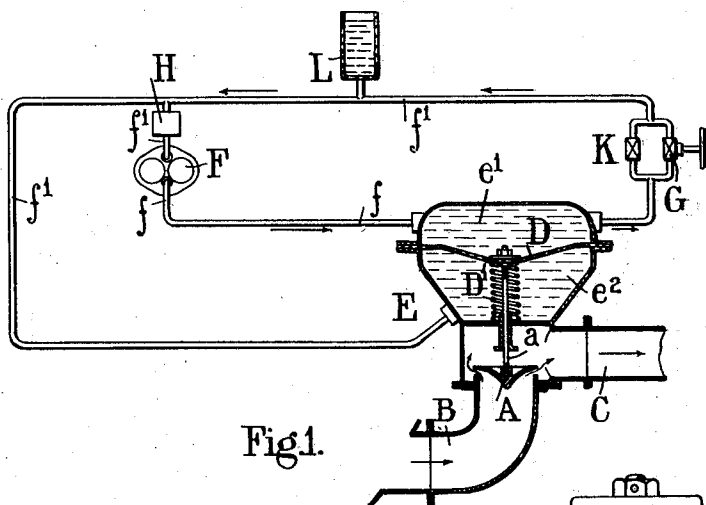


Fig. 1.

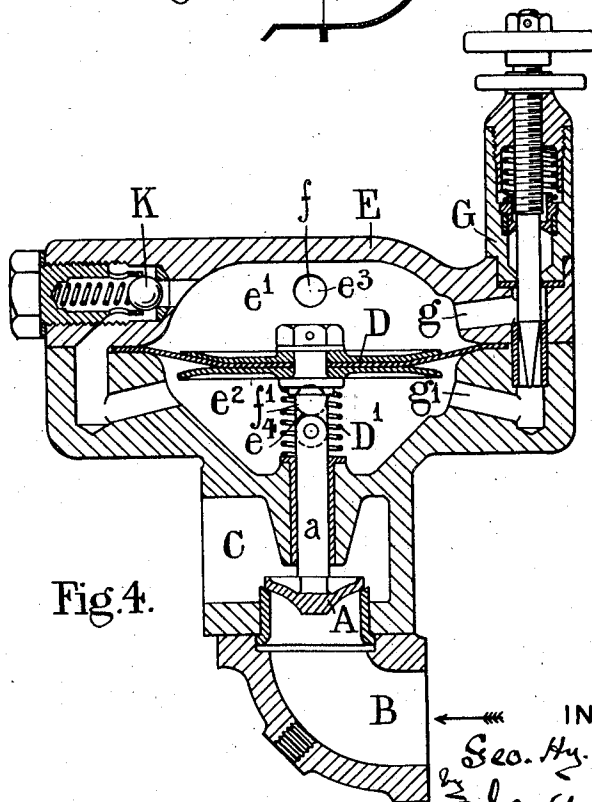


Fig. 4.

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3 Sheets-Sheet 2

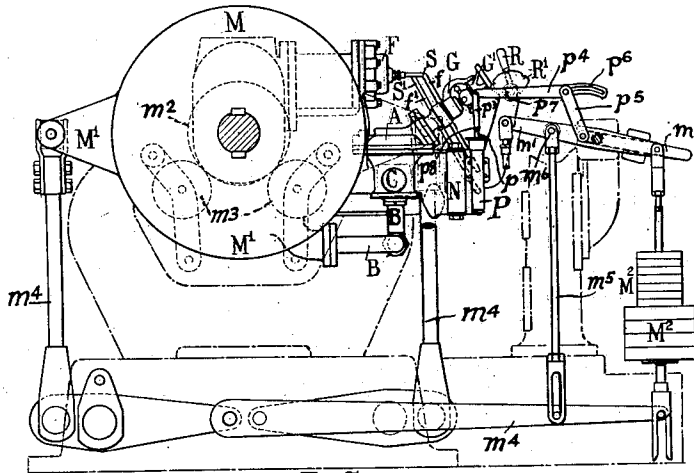


Fig. 7

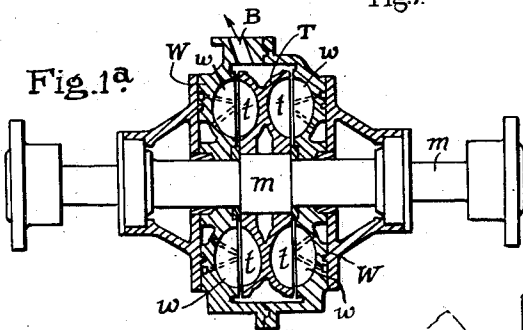


Fig. 1a

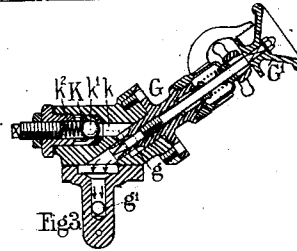


Fig. 3

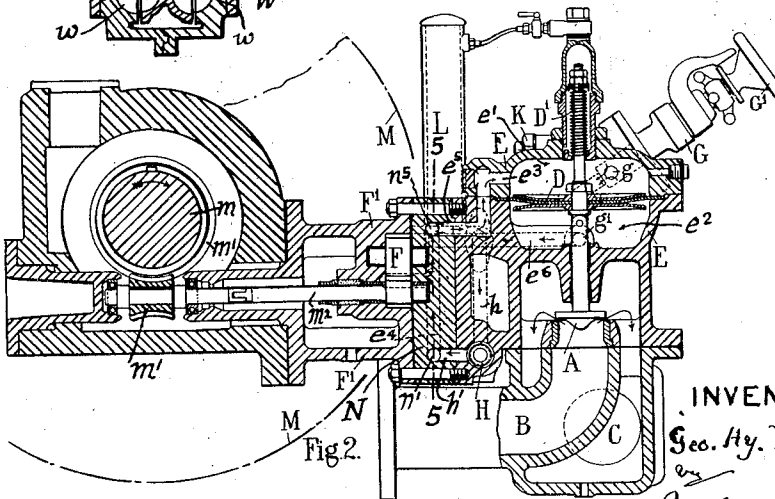


Fig. 2

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3 Sheets-Sheet 3

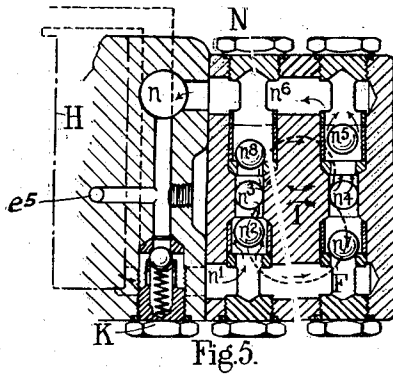


Fig. 5.

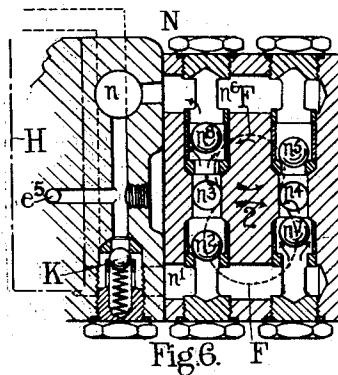


Fig. 6.

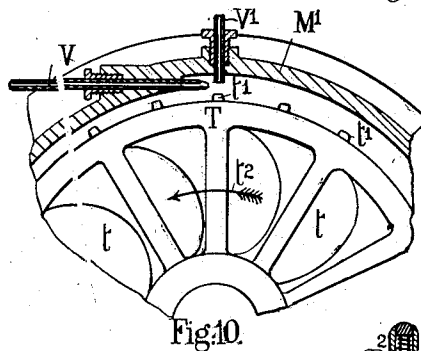


Fig. 10.

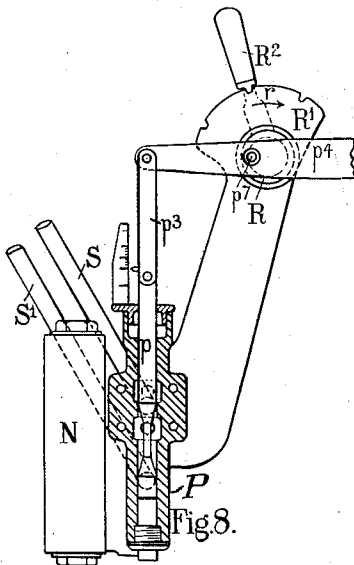


Fig. 8.

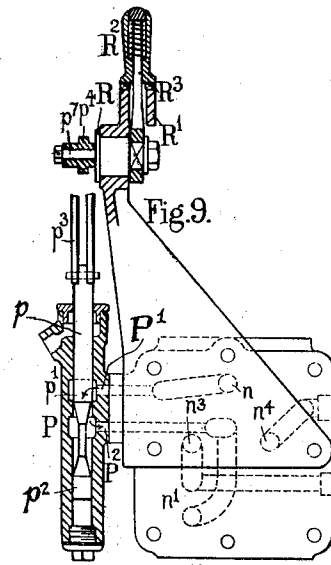


Fig. 9.

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2,162,541

HYDRAULIC APPARATUS

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Application January 22, 1937, Serial No. 121,799
In Great Britain February 6, 1936

8 Claims. (Cl. 188—90)

This invention relates to improvements in hydraulic apparatus of the type comprising primary and secondary vaned members such as is well known can be employed for the absorption and indication of power as in the case of absorption brakes and absorption dynamometers and for the transmission of power as in the case of hydraulic couplings.

When such apparatus is constructed for use as a brake the secondary vaned element is anchored against rotation while the primary element is driven by the source of power to be braked; when constructed for use as a clutch both elements are free to rotate while transmitting power at different rotational velocities and when constructed for use as a dynamometer the casing or secondary vaned element is attached to a measuring device which restrains its movement and indicates the torque transmitted thereto.

It is usual to provide the apparatus with means for varying the transmission or absorption capability thereof by varying the degree of filling of the apparatus which may be effected by controlling the rate of influx or efflux of the hydraulic liquid to or from the elements, such means being described for example in the specification of prior U. S. Patent No. 1,035,700.

Under running conditions of the apparatus the liquid tends to emerge from the interior to the exterior of the elements under the influence of a pressure self-generated within the working compartment and this pressure increases as the relative speed of the elements or the absolute speed of the primary element increases.

This increase in pressure will for a given outlet opening, cause the outlet rate to increase, so that if the inlet rate remains constant, the working compartment will tend to empty itself of liquid. Thus the transmission or absorption capability of the apparatus will decrease as the speed of the prime mover increases, which is undesirable, as it will cause the prime mover to race.

It is known that if it were possible to keep the volume of water in the working compartment constant despite changes of speed, then the load exerted by the dynamometer would follow well known hydraulic laws. The pressure of water in the working compartment would vary as the square of the speed and the torque developed by the dynamometer would also vary as the square of the speed of the dynamometer shaft.

The object of the present invention is to control the outlet of the liquid from the apparatus so as to maintain a constant amount of liquid in the working compartment thereof despite changes in

speed of the primary element and it has been found that provided the pressure of water in the working compartment varies as the square of the speed, then the quantity of liquid contained in the working compartment will remain constant, despite alterations in speed; and, further, the torque developed by the dynamometer will also vary as the square of the speed.

According to the invention a valve is arranged in the outflow from the working compartment of the apparatus and is controlled automatically in accordance with variation in speed of the primary member the arrangement being such that for any increase in speed of the primary member above the normal speed the valve is moved from its normal position towards its closed position so as to maintain a constant volume of liquid in the working compartments.

The invention will be described with reference to the accompanying drawings in which:

Fig. 1 is a diagrammatic view illustrating the principle of the invention, the valve in the outlet being controlled by liquid circulated by a pump or the like driven at a speed proportional to that of the primary element of the dynamometer, brake or clutch.

Fig. 1a is a section of the type of hydraulic apparatus to which the invention relates showing the primary and secondary vaned members.

Fig. 2 is a transverse section of a hydraulic brake with the invention applied thereto and showing a hand operated valve for the setting of the normal power absorbing or transmitting capability of the apparatus.

Fig. 3 is a detail sectional view of one form of the hand operated valve shown in Fig. 2.

Fig. 4 is a detail, sectional view of another form of outlet control valve in combination with a hand operated valve for the setting of the normal power absorbing or transmitting capability of the apparatus.

Figs. 5 and 6 are detail views of a reversing valve box arranged between the pump driven from the shaft of the primary rotor of the brake, clutch or dynamometer and the speed controlled valve whereby the liquid controlling the latter will always flow in the same direction whether the rotor is rotating in one direction or the other, the section being taken on line 5—5 Fig. 2.

Fig. 7 is a transverse section showing the invention applied to a hydraulic dynamometer similar to that described in specification of U. S. Patent No. 1,627, 586 and having an automatically controlled valve operated on any variation in torque of the dynamometer.

Figs. 8 and 9 are detail sectional views of the automatically controlled valve.

Fig. 10 is a diagrammatic view showing a modification of the invention in which the pump circulating the liquid controlling the valve in the outlet is replaced by the primary element of the apparatus.

The invention relates to hydraulic apparatus of the type shown in Fig. 1a having a primary vaned member T formed with cups *t* and a secondary vaned member W formed with co-acting cups *w* comprising the working compartments.

The essential feature of the invention and its manner of operation will be best understood from the diagrammatic view shown in Fig. 1. A valve A of disc or mushroom type is arranged in the egress B from the working compartment of the hydraulic apparatus and when this valve is closed the flow of liquid from the apparatus is prevented while when the valve is partially open liquid will flow past the valve to the outlet C connected either to a drain or to a storage reservoir from which the water is recirculated through the apparatus. The valve A thus controls the quantity of liquid in the apparatus.

The valve A is connected by a rod *a* to a flexible diaphragm D or a piston arranged in a vessel E separating it into two chambers *e*¹, *e*². The chamber *e*¹ is in communication with a pump F driven at a speed proportional to that of the primary element of the apparatus either by being geared to or having its impeller mounted on the shaft thereof. The discharge side *f* of the pump F is directly connected with the chamber *e*¹ and the suction side *f*¹ of the pump is connected with the chamber *e*² through a valve G and strainer H. Thus one side of the diaphragm D is exposed to a pressure varying with the speed of the pump F and consequently with the speed of the primary element of the apparatus.

The valve G is preferably of the needle type capable of giving close adjustment of the resistance to flow of the liquid. A by-pass having a spring-loaded relief valve K inserted in it also connects the pressure chamber *e*¹ with the pump suction, so as to prevent the diaphragm D being accidentally subjected to too great a pressure. An expansion chamber L is preferably in communication with the connection between the valve G and the pump F, the chamber L containing a suitable supply of the circulating liquid.

The chamber *e*² at the other side of the diaphragm D forms a low pressure chamber communicating as shown in Fig. 1 with the suction side *f*¹ of the pump F through the strainer H.

When working the pump F discharges liquid into the pressure chamber *e*¹ at a rate proportional to the speed of revolution of the primary element of the apparatus the differential pressure between the chambers *e*¹ and *e*² being determined by the throttling effect of the valve G. By fully opening the valve G, the pressure maintained in the chamber *e*¹ relative to that in the chamber *e*² is caused to fall to a minimum, thereby causing the diaphragm D to rise to its highest position and the valve A to be widest open thereby opposing minimum back pressure against the outflow of liquid from the egress B and causing the apparatus to absorb or transmit minimum power. When the valve G is partially closed the pressure in the chamber *e*¹ relative to that in the chamber *e*² will be increased and the diaphragm D will fall to an intermediate position and the valve A to be partially closed. When the valve G is nearly closed the pressure in the chamber

*e*¹ relative to the chamber *e*² will be at a maximum and the diaphragm D will fall to its lowest position and the valve A be closed or almost closed thereby causing the back pressure against the outflow of liquid from the egress B to be at a maximum and consequently the power absorbed or transmitted by the apparatus to be a maximum. Intermediate settings of the valve G between the two extremes will have intermediate effect on the absorption or transmission capability of the apparatus. The valve G thus serves to set the normal absorption or transmission capability at which it is desired the apparatus should work.

Since however any variation of the speed of rotation of the pump F, after the valve G has been set to give the desired normal differential pressure between the chambers *e*¹ and *e*² will create an alteration of pressure in the chamber *e*¹, and as the speed of the pump is proportional to that of the primary element of the apparatus it follows that any increase in speed of the latter will cause the valve A to close to some extent thus reducing the outlet opening.

It will thus be seen that for any given setting of the valve G any increase in speed of the primary element of the apparatus above normal will cause the valve A to move from its normal position towards the closed position, thus opposing the tendency for the increased internal pressure to increase the outlet rate.

The liquid content of the apparatus thus remains unaltered despite the increase in speed and this is true whether the rate of inflow into the working circuit remains constant or increases; for assuming the rate of inflow to increase above a given normal, momentarily increasing the liquid content of the apparatus, the pressure in the apparatus will increase and cause the valve A to open sufficiently to restore the pressure in the working circuit to normal.

By connecting the low pressure chamber *e*² to the suction side *f*¹ of the pump F the difference of pressure between the two sides of the diaphragm D is that created by the pump and is independent of the height of liquid in the expansion chamber L and consequently variations in pressure closely proportional to variation in speed are obtained.

The combined weights of the diaphragm D or piston, the rod *a* and the valve A are balanced by a spring D¹. Thus the valve A will be moved from its normal position as soon as the speed of the primary element increases above the normal.

The form of the invention shown in Figs. 2 to 6 is slightly different from the diagrammatic form shown in Fig. 1 in that the outlet from the valve G communicated with the strainer H and suction side *f*¹ of the pump not directly but indirectly through the low pressure chamber *e*². The pump F (which is illustrated as a gear pump although a centrifugal pump could be employed) is arranged in a casing F¹ and is driven from the primary shaft *m* of the apparatus M through the gearing *m*¹ and shaft *m*² at right angles to the shaft *m*.

The vessel E divided into a high pressure chamber *e*¹ and low pressure chamber *e*² by the diaphragm D is bolted or otherwise affixed to the pump casing F¹, the diaphragm D being connected by the rod *a* to the valve A controlling the flow of liquid from the outlet B to the pipe C. The high pressure chamber *e*¹ is connected to the discharge side of the pump F through the

port e^3 and to the suction side through the valve G the outlet port g^1 of which opens into the low pressure chamber e^2 . A port e^4 in the chamber e^2 is connected by the duct h , strainer H and ducts h^1 and e^4 to the suction side of the pump. A reversing valve N is preferably arranged between the pump F and the pressure chambers e^1 and e^2 , the port e^3 of the chamber e^1 being connected by the duct e^3 to the discharge chamber n of this valve N whilst the outlet from the strainer H is connected to the suction chamber n^1 of the reversing valve N. The duct h is also connected to the expansion chamber L.

The port g of the needle valve G is opened and closed by the rotation of the hand wheel G^1 .

The reversing valve N is necessary with apparatus the primary element of which is adapted to rotate in either direction to maintain the port e^3 in the high pressure chamber e^1 always in communication with the discharge side of the pump F and the port e^4 in the low pressure chamber e^2 always in communication with the suction side of the pump F irrespective of the direction of rotation of the latter.

The reversing valve N is shown in Figs. 5 and 6, the former showing the direction of flow of the liquid therethrough when the wheels of the pump F are rotating in one direction and the latter showing the direction of flow when the wheels are rotating in the opposite direction.

When the wheels of the pump F are rotating in the direction shown by the arrows 1, Fig. 5 the liquid enters from the strainer H through the suction chamber n^1 lifts the ball valve n^2 and passes to the space n^3 . It is then carried round by the teeth of the gear pump F to the space n^4 opening the ball valve n^5 and passes by the duct n^6 to the pressure chamber n connected to the port e^3 of the high pressure chamber e^1 of the vessel E and from thence through the needle valve G and chamber e^2 back to the strainer H.

When the direction of rotation of the wheels of the pump F is reversed as shown by the arrows 2 in Fig. 6 the pressure on the top of the ball valve n^2 keeps the latter closed but opens the ball valve n^7 which was previously held closed and the liquid entering from the strainer H at n^1 passes through the valve n^7 to the wheels of the pump F, is carried by the teeth of the latter from the space n^4 to the space n^3 lifts the ball valve n^5 and so passes to the discharge chamber n .

As shown in Fig. 3 the casing for the relief valve K is attached to the valve G the inlet port g of the latter being connected to the port k of the former. The valve K comprises a ball k^1 controlled by a spring k^2 whereby should the pressure of the liquid rise above the pressure of the spring k^2 the ball will be lifted from its seating and the liquid can then pass through a passage (not shown) to the chamber e^2 .

In the construction of the valve A shown in Fig. 4 the combined weights of the diaphragm D, valve rod a and the valve A are as previously stated balanced by a spring D^1 so that the valve will be operated immediately there is any increase in pressure on the top of the diaphragm but in the construction of valve shown in Fig. 2 the valve A is normally held open by a spring D^1 which is of such strength that the valve A is not moved by an increase in pressure in the chamber e^1 relative to the chamber e^2 caused by an increase in the speed of the primary element until such increase of pressure above the normal has reached a predetermined value of sufficient amount to force the diaphragm downwards

against the upward pull of the spring D^1 . After the predetermined difference of pressure above the normal has been reached any further increase in pressure between the chambers e^1 and e^2 to rise rapidly tending to close the valve A against the outflowing liquid and creating a correspondingly rapid increase of pressure in the working compartment of the apparatus this increasing the resistance to rotation of the primary element and enabling the apparatus to govern within reasonably close limits the speed of rotation of the shaft to which the primary element is connected.

The apparatus above described with reference to Figs. 2 to 6 is applicable as an hydraulic brake, hydraulic dynamometer or hydraulic clutch but the apparatus shown in Figs. 7 to 9 is applicable only to a hydraulic dynamometer. It is designed to provide a dynamometer which can be used either for testing engines having their own speed governors by which the speed of the engine and consequently of the dynamometer is maintained constant or for testing ungoverned engines.

In this construction in addition to the hand operated valve G for setting the normal power absorption capability of the dynamometer for use with an ungoverned engine the chambers e^1 and e^2 are connected through an automatically controlled valve P preferably of the balanced piston type arranged in parallel with the valve G. When used for testing an engine having its own speed governor and the speed of which therefore remains constant, the valve G is closed so that all the liquid discharged by the circulating pump passes through the valve P which is automatically controlled to vary the opening of the valve A on any variation in torque of the dynamometer thereby automatically maintaining the torque constant.

Fig. 7 shows this arrangement applied to a reversible dynamometer M capable of absorbing power in either direction of the type described in the specification of U. S. Patent No. 1,627,586 being controlled through a system of levers from the weight arm m^1 pivotally mounted at m^6 on a vertical rod m^5 , whereby the opening and closing of the valve is controlled by the oscillation of the casing M^1 of the dynamometer, the torque reaction upon which is balanced by the weights M^2 suspended from the arm m^1 . In such construction of dynamometer the casing M^1 is formed with trunnions m^2 carried upon rollers m^3 to permit the casing to oscillate freely and the casing is connected to the pivoted weight arm m^1 by a system of levers and links m^4 and connecting rod m^5 to the top m^6 of which the arm m^1 is pivoted whereby the arm m^1 will move to raise the weights M^2 on an increase in absorption of power by the casing irrespective of the direction of rotation of the rotor of the dynamometer.

As before stated the valve P is of the balanced piston type and the rod p carrying the pistons p^1 and p^2 is connected by the links and levers p^3 , p^4 and p^5 to the weight arm m^1 of the dynamometer. The link p^5 is pivotally mounted at its lower end on the arm m^1 and its other end is adjustably mounted in a slotted quadrant p^6 on the lever p^4 . The lever p^4 is pivoted at p^7 and its other end is pivotally connected to the link p^3 attached by the pin p^8 to the piston rod p . The valve P is formed with two ports P^1 and P^2 the port P^2 being connected to the suction chamber or port n^1 of a reversing valve N such as hereinbefore described and the port P^1 through the chamber e^1 to the discharge chamber or port

n thereof. The pistons p^1 and p^2 are of conical shape and the rise and fall of the pistons on the rod p will control the effective area of the ports P^1 and P^2 thereby controlling the amount of liquid circulated through the back pressure valve A by the pump F . A spring controlled relief valve K is arranged in the casing to open the liquid circulation system in the event of too high a pressure being attained.

In operation the absorption of power in the casing M^1 of the dynamometer tends to rotate it about its trunnion supports m^2 and to lift the weights M^2 thereby moving the arm m^1 about its fulcrum. This movement of the arm m^1 is communicated through the links and levers p^5 , p^4 and p^3 to the valve rod p which causes the latter to rise and the port P^1 to open thereby reducing the difference in pressure at the ports n^1 and n . This reduces the pressure on the diaphragm D and allows the valve A to open, whereby the consumption of power in the dynamometer is diminished until the torque is reduced and the arm m^1 returns to its normal position of equilibrium whereupon the port P is closed, the pressure on the diaphragm is decreased and normal working resumed. Thus torque resisting rotation of the shaft of the dynamometer M is maintained constant irrespective of changes in speed of the dynamometer shaft.

To facilitate the use of the dynamometer in rapidly applying or removing load to or from the engine i. e. for varying the normal torque of the dynamometer, the pivot p^7 of the lever p^4 is mounted upon an eccentric R secured to a quadrant R^1 by a hand lever R^2 and spring loaded detents R^3 . By pushing the lever R^2 in the direction indicated by the arrow r in Fig. 8 the eccentric R is caused to rotate through part of a circle, thereby lifting the lever p^4 and raising the point of attachment to the link p^3 simultaneously opening the ports P^1 and relieving the back pressure and consequently the torque exerted by the dynamometer. Motion of the hand lever in the opposite direction tends to close the port P^1 and consequently increase the torque.

In Fig. 7 the pump is shown mounted on the casing of the dynamometer and is connected to the valve P by connections S and S^1 the flow of liquid being from the pump F through the reversing valve N to the valve P and simultaneously to the high pressure chamber c^1 of the valve A .

Although the pump F has been hereinbefore described as a gear pump a centrifugal pump may be employed or the primary rotor of the apparatus may itself control the pressure on the two sides of the diaphragm D such a construction being shown in Fig. 10.

In the construction shown in Fig. 10 the primary element T of the apparatus is formed in the usual way with cups t and in addition with vanes t^1 on the rim for the purpose of maintaining rotational circulation of liquid in the annular space between the rim of the rotor T and the casing M^1 direction of rotation being counterclockwise as shown by the arrow t^2 . An open ended tube V is inserted into this annular space, its open mouth pointing tangentially against the direction of rotation and a second open-ended tube V^1 is arranged radially so that its mouth projects into the casing at about the same radial distance from the axis of rotation as the mouth of the tube V .

The outer end of the tube V is connected by ports, passages or piping to the high pressure

compartment of the valve A and the tube V^1 is connected to the low pressure compartment. When the rotor T of the apparatus rotates in the direction of the arrow t^2 the working liquid impinges on the open end of the tube V which conveys to one side of the diaphragm D a pressure equal to the sum of the static and dynamic heads whilst the tube V communicates to the low pressure chamber the static pressure only, so that the diaphragm D which separates the two chambers is subject to the difference between these liquid pressures i. e. to dynamic head only.

As previously explained the normal magnitude of this liquid pressure is controllable by the valve G which communicates from the high pressure to the low pressure chamber, but for any given setting of the valve G the differential pressure upon the diaphragm and consequently the resistance to the outlet of liquid from the working compartment of the apparatus increases with any increase in the speed of rotation of the primary element, above the normal speed.

I claim:

1. Hydraulic apparatus of the type referred to comprising primary and secondary vaned members forming working compartments having in combination with the liquid outlet of the apparatus, a valve arranged in the said outlet, a fluid operated diaphragm controlling said valve, and means driven by the primary vaned member for automatically varying the pressure of the fluid on one surface of the diaphragm relative to the other in accordance with variation in speed of the primary vaned member to vary the opening of the valve to maintain a constant volume of liquid in the working compartments.

2. Hydraulic apparatus of the type referred to comprising primary and secondary vaned members forming working compartments having in combination with the liquid outlet of the apparatus a valve arranged in the said outlet, a fluid operated diaphragm controlling said valve, a vessel in which the diaphragm is located and is separated thereby into two chambers—a low pressure chamber and a high pressure chamber and a pump geared to the primary vaned element, the high pressure chamber being connected to the delivery side of said pump and the low pressure chamber to the suction side thereof so that the pressure of the fluid on the high pressure side of the diaphragm relative to the pressure of the fluid on the low pressure side is varied in accordance with variation in speed of the pump and consequently of the primary vaned member to vary the opening of the valve to maintain a constant volume of liquid in the working compartments.

3. Hydraulic apparatus of the type referred to comprising primary and secondary vaned members forming working compartments having in combination with the liquid outlet of the apparatus a valve arranged in the said outlet, a fluid operated diaphragm controlling said valve, a vessel in which the diaphragm is located and is separated thereby into two chambers, a low pressure chamber and a high pressure chamber, a pump geared to the primary vaned element, the high pressure chamber being connected to the delivery side of said pump and the low pressure chamber to the suction side thereof so that the pressure of the fluid on the high pressure side of the diaphragm relative to the pressure of the fluid on the low pressure side is varied in accordance with variation in speed of the pump and consequently of the primary vaned member

to vary the opening of the valve to maintain a constant volume of liquid in the working compartments, and a hand operated valve between the high pressure chamber and the low pressure chamber for the purpose of varying the normal pressure difference between the two chambers for setting the normal power characteristic of the apparatus.

4. Hydraulic apparatus of the type referred to comprising primary and secondary vaned members forming working compartments, having in combination with the liquid outlet of the apparatus, a valve arranged in the said outlet, a fluid operated diaphragm controlling said valve, a vessel in which the diaphragm is located and is separated thereby into two chambers—a low pressure chamber and a high pressure chamber, a pump geared to the primary vaned element, the high pressure chamber being connected to the delivery side of said pump and the low pressure chamber to the suction side thereof so that the pressure of the fluid on the high pressure side of the diaphragm relative to the pressure of the fluid on the low pressure side is varied in accordance with variation in speed of the pump and consequently of the primary vaned member to vary the opening of the valve to maintain a constant volume of liquid in the working compartments, a hand operated valve between the high pressure chamber and the low pressure chamber for the purpose of varying the normal pressure difference between the two chambers for setting the normal power characteristic of the apparatus, and an automatically controlled valve in parallel with the hand controlled valve said automatic valve being controlled by movement of the secondary vaned member whereby on any variation in torque of the latter when the hand controlled valve is closed, the differential pressure on the diaphragm will be varied to move the valve to vary the internal pressure of the apparatus and maintain the torque constant.

5. Hydraulic apparatus of the type referred to comprising primary and secondary vaned members forming working compartments having in combination with the liquid outlet of the apparatus a valve arranged in the said outlet, a fluid operated diaphragm controlling said valve, a vessel in which the diaphragm is located and is separated thereby into two chambers—a low pressure chamber and a high pressure chamber, a pump geared to the primary vaned element, the high pressure chamber being connected to the delivery side of said pump and the low pressure chamber to the suction side thereof so that the pressure of the fluid on the high pressure side of the diaphragm relative to the pressure of the fluid on the low pressure side is varied in accordance with variation in speed of the pump and consequently of the primary vaned member to vary the opening of the valve to maintain a constant volume of liquid in the working compartments, a hand operated valve between the high pressure chamber and the low pressure chamber for the purpose of varying the normal pressure

difference between the two chambers for setting the normal power characteristic of the apparatus and a relief valve in parallel with the control valve to prevent the diaphragm being accidentally subjected to too great a pressure.

6. Hydraulic apparatus of the type referred to comprising primary and secondary vaned members forming working compartments having in combination with the liquid outlet of the apparatus a valve arranged in the said outlet, a fluid operated diaphragm controlling said valve, a vessel in which the diaphragm is located and is separated thereby into two chambers—a low pressure chamber and a high pressure chamber, a pump geared to the primary vaned element, the high pressure chamber being connected to the delivery side of said pump and the low pressure chamber to the suction side thereof so that the pressure of the fluid on the high pressure side of the diaphragm relative to the pressure of the fluid on the low pressure side is varied in accordance with variation in speed of the pump and consequently of the primary vaned member to vary the opening of the valve to maintain a constant volume of liquid in the working compartments, a hand operated valve between the high pressure chamber and the low pressure chamber for the purpose of varying the normal pressure difference between the two chambers for setting the normal power characteristic of the apparatus, and an automatic reversing valve in the liquid circuit between the pump and the diaphragms whereby the flow of liquid to the pressure chamber is always in the same direction irrespective of the direction of rotation of the primary vaned member and therefor of the pump.

7. Hydraulic apparatus of the type referred to comprising primary and secondary vaned members having in combination with the liquid outlet of the apparatus a valve arranged in the said outlet, a diaphragm controlling said valve, a vessel in which the diaphragm is located and is separated thereby into two chambers—a low pressure chamber and a high pressure chamber, a tube arranged tangentially in the space between the primary element and the secondary element with its orifice opening against the direction of rotation of the former, said tube being connected to the high pressure chamber and a second tube arranged radially in the space between the primary element and the secondary element said second tube being connected to the low pressure chamber.

8. Hydraulic apparatus of the type referred to as claimed in claim 1 having in combination with the valve and diaphragm a spring which holds the valve open until the difference in pressure between the two sides of the diaphragm has reached a predetermined amount sufficient to overcome the pressure of the spring, thus preventing the valve from operating until a predetermined speed of the primary member above the normal is attained.

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