Jan. 1, 1935. R. G. DE LA MATER ET AL 1,985,889

METHOD AND APPARATUS FOR CONTROLLING RESISTANCE OF HYDRODYNAMIC BRAKES

Filed March 22, 1932 2 Sheets-Sheet 1

Fig. 1.

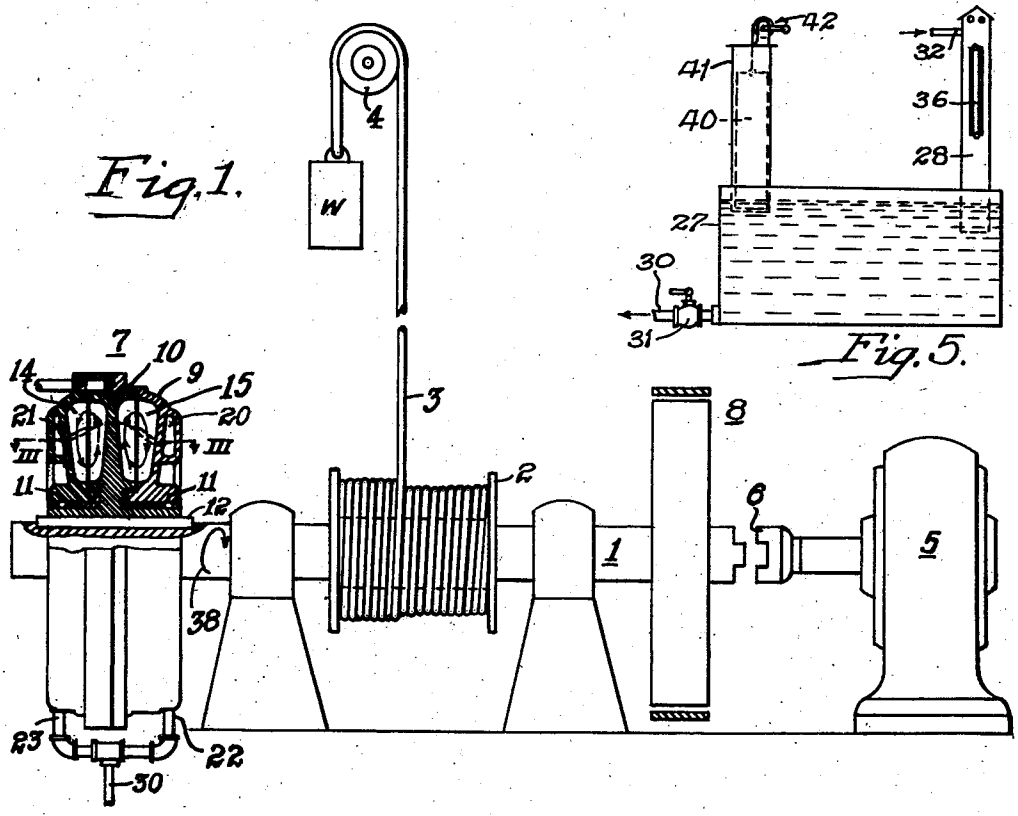


Fig. 5.

Fig. 3.

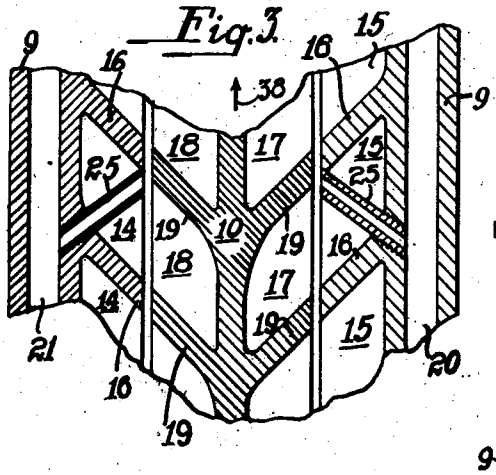
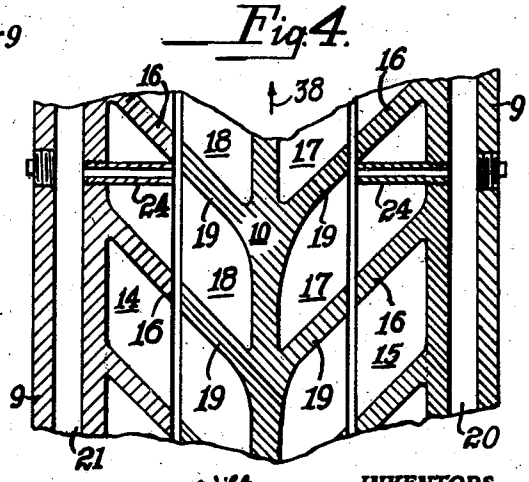


Fig. 4.



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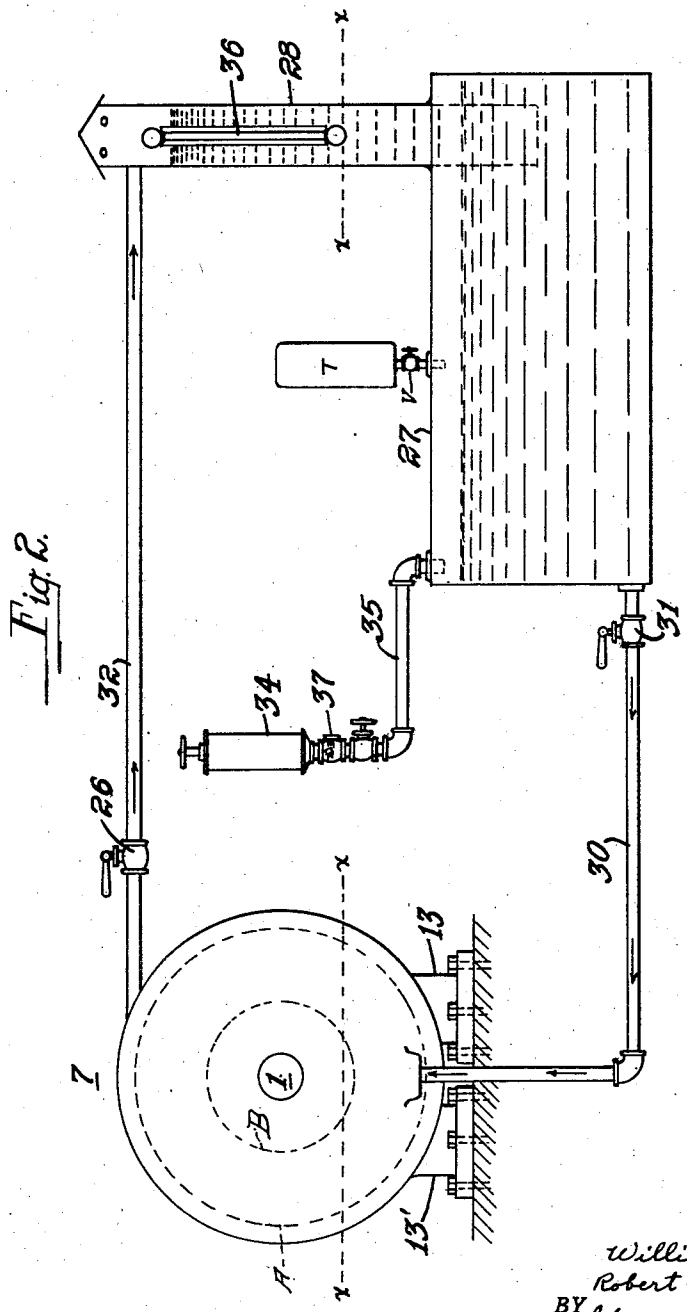
BY Green & McCallister
Their ATTORNEYS

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METHOD AND APPARATUS FOR CONTROLLING RESISTANCE OF HYDRODYNAMIC BRAKES

Filed March 22, 1932 2 Sheets-Sheet 2

Fig. 2.



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Patented Jan. 1, 1935 1,985,889

UNITED STATES PATENT OFFICE

1,985,889

METHOD AND APPARATUS FOR CONTROLLING RESISTANCE OF HYDRODYNAMIC BRAKES

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Application March 22, 1932, Serial No. 600,476

23 Claims. (Cl. 188—90)

This invention relates to a method of and means for regualting and controlling the braking effort developed by the so-called hydro-dynamic brakes of the type in which energy is absorbed by fluid friction.

Heretofore hydro-dynamic brakes have been designed to operate full of liquid or water which is introduced to the brake under pressure. Such brakes unless provided with sufficient liquid to maintain them full at all times, or unless a supply pump, or a source of liquid under pressure was provided to introduce liquid to the brakes at the same rate as it was discharged therefrom, would not function properly. In accordance with this invention it is proposed to provide an hydro-dynamic brake which may be operated either full of liquid or water, or only partially full.

A brake constructed in accordance with this invention may be operated full of liquid or water, or partially full, with or without discharge of liquid therefrom. The brake will develop maximum braking effort when operated full of liquid with no discharge therefrom. However, if no discharge takes place, and no liquid is circulated through the brake, the temperature of the liquid may be raised to the point where steam pockets may form therein, thereby either impairing or destroying the braking action thereof. It is therefore proposed to discharge liquid from the brake, whether operated full or partially full of liquid and to circulate cool liquid through the brake so that the temperature of the liquid therein will be below the point where steam may develop.

If no discharge of liquid from the brake is permitted, there is no leakage between the stator and rotor, hence the back pressure and brake resistance are a maximum. If liquid is discharged from the brake, leakage between rotor and stator takes place, causing the back pressure and brake resistance to be reduced. Therefore, by regulating the rate of discharge, the back pressure and the braking effort or resistance may be regulated within predetermined limits.

Where hydro-dynamic brakes are utilized to regulate or control the speed of descent of a loaded hoist, the speed at which the load descends will be substantially constant for a given rate of discharge of liquid from the brake. In hoist applications, it is therefore apparent that the primary function of means for obtaining regulation is that of governing the descent of the load and providing for variations in speed over a predetermined range.

If such regulation is dependent entirely on the rate of discharge of liquid from a brake operating full of liquid, it will be apparent that the range of speed regulation will be rather limited.

An object of this invention is the provision of means for controlling the braking effort developed by hydro-dynamic brakes whereby such braking effort may be regulated from practically zero value to the maximum value that may be obtained with a brake full of liquid with no discharge therefrom.

Another object of the invention is the provision of a method and means of obtaining primary regulation of the braking effort independent of the rate of discharge of liquid and secondary regulation by controlling the rate of liquid discharge from the brake.

A still further object of the invention is the provision of a brake which will function in its intended manner although only partially filled with liquid.

It is also an object of the invention to provide means whereby the volume of liquid in the brake may be predetermined and maintained constant at such volume.

It is also an object of the invention to provide a fluid friction brake system wherein the heat absorbed in the liquid in the brake may be utilized to automatically increase the braking action.

Other objects of the invention will, in part, be apparent and will, in part, be obvious from the following description taken in conjunction with the accompanying drawings in which:

Figure 1 is a view of a hoist to which an hydro-dynamic brake is applied, the brake being shown partially in section;

Fig. 2 is a more or less diagrammatic illustration of apparatus for obtaining primary and secondary regulation of the braking effort developed by the hydro-dynamic brake shown in Fig. 1;

Fig. 3 is a fragmentary sectional view of the hydro-dynamic brake taken on line III—III of Fig. 1 showing one form of nozzle or inlet tube for introducing liquid to the brake, and

Fig. 4 is a similar fragmentary sectional view showing another form of nozzle or inlet tube for introducing liquid to the brake;

Fig. 5 is a view of a tank, such as shown in Fig. 2, provided with a modified form of apparatus for regulating the level of the liquid therein and the braking action of the brake.

Throughout the drawings and the specification similar and like parts are designated by the same reference characters.

In the drawings, with particular reference to Fig. 1, a hoist rig is shown that comprises a shaft 1 on which a drum or reel 2 is mounted. A cable 3 wound on the drum, operates over a pulley 4 and carries a load W. A motor 5 coupled to the shaft by means of a clutch 6, for example a jaw clutch, is utilized to turn the shaft, whereby the cable is wound on the drum when it is desired to raise the load. When the load is to be lowered, the clutch is shifted to disengage the motor from the shaft, permitting the load to fall under the action of gravity, thereby turning the drum and unwinding the cable.

In order that the speed at which the load falls or descends may be regulated and limited to some desired safe speed, an hydro-dynamic brake 7 is provided, the load being stopped and/or held in the desired position by means of a mechanical or solid friction brake 8 of standard or known construction mounted on the reel shaft. When the load is being raised by the motor, brake 7 offers negligible resistance to rotation of the reel shaft.

As shown, brake 7 is mounted on a portion of shaft 1 that overhangs its bearing so that the brake may be easily removed. The brake may preferably be mounted on an overhanging shaft requiring the braking qualities or functions thereof. The mounting on an overhanging shaft expedites assembly or disassembly. However, the brake may be mounted in any position on the shaft, or mounted on an auxiliary shaft driven from the shaft, the braking of which is required.

The hydro-dynamic brake 7 comprises a stator 9 having a rotor 10 therein which is journalled in bushings 11 mounted in the stator. The journal of the rotor is hollow to accommodate the reel shaft 1, and is provided with a keyway to accommodate a key 12 so that the rotor may be held fast on the shaft. The stator may be bolted to a foundation as indicated at 13 and 13' (see Fig. 2) to prevent its turning when the brake is in operation, or it may be mounted on the shaft and the stator prevented from rotating by tying it to the foundation or any stationary support.

The stator is provided with a series of radially disposed pockets or recesses 14 on one side thereof and a similar series of radially disposed pockets or recesses 15 on the opposite side. Each series of pockets, or recesses are formed concentrically to the axis of rotation of the rotor as indicated by the broken line circles A and B of Fig. 2, representing, respectively, the outer and inner ends of the recesses. The pockets of each series or group are separated by vanes or partitions 16 which slope in a direction rearward to that in which the rotor rotates while functioning as a brake.

Each side of the rotor is provided with a series of pockets or recesses 17 and 18 of substantially the same shape and size as the pockets in the stator and occupy substantially the same position relative thereto. The pockets in the rotor are separated by sloping vanes or partitions 19. As shown the rotor partitions or vanes slope in a forward direction with respect to the direction in which the rotor rotates when functioning as a brake.

In order that liquid may be introduced to the brake to replace the water which is permitted to discharge therefrom at the top of the stator, the stator is provided with circular chambers 20 and 21 having inlets 22 and 23, respectively, at the bottom of the stator. These inlets are connected by a pipe to a source of supply of liquid. The liquid is introduced into the pockets of the rotor through nozzles or tubes 24 which are threaded into tapped holes formed in the stator walls separating the stator pockets from the chambers. In one form, the nozzles may extend at right angles to the rotor as shown in Fig. 4. In another form, nozzles 25 inclined at an angle as shown in Fig. 3, may be provided. When mounted as shown in Fig. 3, liquid is discharged from the nozzles in the general direction of rotation of the rotor when functioning as a brake.

The particular form of brake shown and described above is shown and described in the copending application of Robert G. De La Mater, Serial No. 601,337, filed March 26, 1932. In such a brake, the braking action is not dependent upon the amount of liquid in the brake, except as it affects the degree of braking effort or resisting torque developed thereby, nor is it necessary to introduce liquid into the brake under pressure. However, the braking action may be varied from a minimum, or practically zero value, to a maximum value by controlling the amount of liquid confined in the brake. Thus the braking action is a minimum when the brake is empty, and a maximum when full with the discharge port closed.

In accordance with this invention it is proposed to vary the quantity of liquid in the brake by regulating the liquid level therein in order to obtain primary regulation of the braking action, and to obtain secondary regulation by adjusting a valve 26 in the discharge line.

In order to obtain such regulation, a closed tank or container 27 is provided having a stand pipe or riser 28 which is vented at its top to the atmosphere. The lower end of the pipe or riser extends downwardly into the tank to a depth below the lowest point which the level of the liquid in the tank may reach in operation. Thus, a confined space is provided in the top of the tank which is sealed from the atmosphere because the lower end of the pipe or riser 28 is always submerged in liquid. The top of the tank is preferably at the level of the inlet to the brake and the top of the stand pipe at a level slightly higher than the discharge outlet from the top of the brake.

The inlet to the brake is connected by a pipe 30 to the bottom of the tank, a valve 31 being provided so that the brake may be shut off from the tank. The outlet from the brake is connected by a pipe 32 to the stand pipe at a point preferably above the level of the top of the brake so that liquid discharging therefrom may be returned to the tank. To control the amount of liquid discharging from the brake, valve 26 is appropriately adjusted.

The braking effort developed by the brake for a given rotor speed depends primarily upon the amount of liquid confined in the brake and secondarily upon the amount of liquid discharging therefrom. Since the amount of liquid in the brake is dependent upon the level of the liquid in the stand pipe it follows that primary regulation of the braking action may be obtained by controlling the level of the liquid in the pipe.

In order to control the liquid level in the pipe, means are provided for superposing an artificial head or pressure on the liquid in the tank. The liquid level may be conveniently adjusted by introducing air, under pressure, to the tank. A convenient way of providing such air pressure is to utilize an air pump 34, preferably a manually operated plunger pump. By operating the pump and forcing air into the tank through a pipe 35, the liquid level will rise in the stand pipe and in the brake to equal levels. By varying the air

pressure, the levels may be adjusted from a point where the brake is empty to the point where the brake is full. By placing a gauge glass 36 on the stand pipe, the level of the liquid in the brake may be determined by observation.

If the level in the stand pipe is high and it is desired to lower the same, air may be exhausted from the tank. To provide for exhausting or reducing the air pressure in the tank, a two-way cock 37 is provided in line 35 between the pump and the tank. By turning the valve to one position, air flows from the tank to the atmosphere, and to another position, air may be forced by the pump into the tank.

If the liquid level in the brake and the stand pipe is at X for example (the brake being only partially full) and the rotor is driven in the direction of arrow 38 by the descending load W, the braking effort developed will be of a predetermined value when the rotor speed is at a predetermined value. That is, for a given amount of liquid in the brake, whether full or only partially full, the load will increase in speed until the power absorbed by the brake is equal to the kinetic energy of the load. When the kinetic energy is equal to the power absorbed by the brake, the speed of the load will remain constant.

The braking action is caused by the rotor pockets collecting slugs or small bodies of liquid and throwing these bodies, under the action of centrifugal force, to the outer ends of the rotor pockets which are shaped to direct them across the spaces between the sides of the rotor and the stator in the form of high velocity jets. When these high velocity jets strike the stator pockets they are deflected to the inner ends thereof and thence back to the rotor pockets. The direction in which these slugs move is indicated by vectors in Fig. 1. The acceleration of these slugs of liquid in the rotor, the cutting of the high velocity jets by the stator vanes as they sweep across the stator vanes, the deceleration thereof in the stator, and the friction between the liquid and the surfaces of the rotor and stator pockets, produces the braking action required to hold the speed of the load in check. This absorption of power causes the liquid to be heated. If the heat developed in the liquid is too great, the discharge valve is opened to permit a certain amount of the liquid to be circulated and recirculated from the tank through the brake, thereby dissipating the heat in the liquid and maintaining the temperature of the liquid delivered to the brake within operating limits.

The larger the slugs or bodies of water which are thrown from the rotor pockets to the stator pockets, the greater will be the braking action. It therefore follows that the greater the quantity of liquid in the brake, the greater will be the braking action for a given rotor speed.

The operation of the brake may be described as follows: If the brake has been filled with liquid to the desired level, the remainder of the brake, if not full of liquid, will be filled with air, the discharge valve being either fully open or partly open. When the rotor starts to rotate in the direction of arrow 38, the liquid in the brake is caused to circulate between the rotor and stator pockets as described above. Part of the liquid is thrown out to the rim of the stator where it seals off the discharge port so that the air near the center of the brake cannot escape. Therefore the original volume of air will remain in the brake.

As the rotor continues to rotate, liquid is discharged from the brake and returned to the tank via the discharge line 32. Such discharge of liquid tends to create a partial vacuum in the brake, causing liquid to flow from the tank into the brake to replace the quantity of liquid discharged. Thus the quantity of liquid and the volume of air in the brake are maintained at a constant value regardless of how wide open or how nearly closed the discharged valve may be.

If the discharge valve is opened wide, the flow of liquid out of the brake permits considerable leakage between the outside circumference of the rotor and stator, thus reducing the quantity of the liquid thrown from the rotor pockets to stator and reducing the braking resistance.

If the discharge valve is completely closed, the liquid around the outside of the rotor would form a solid wall and prevent any leakage between the outside circumference of rotor and the stator. The liquid will then be thrown from rotor to stator with maximum velocity and the maximum resistance obtained.

By varying the air pressure in the tank, the quantity of liquid confined in the brake may be varied over a wide range whereby a wide range of braking effort may be obtained. A wide range of braking effort also permits of a wide range in the speed at which the load W may be dropped. The maximum braking effort is obtained when the brake is full of liquid and void of air, the discharge valve being completely closed. However, where a considerable amount of power is absorbed by the liquid, the discharge valve should be open to permit sufficient circulation through the brake to prevent the temperature of the liquid from rising beyond a certain value, say 180 to 190 degrees F. If steam should be generated in the brake, the braking action may be impaired, but no damage would result to the brake because the pressure thus developed would merely cause the liquid and steam to flow back into the tank through the inlet pipe 30.

If load W falls a great distance, say 5,000 feet or more, and the brake is absorbing considerable power, the temperature of the liquid passing through the brake will be raised. Since the heated liquid is discharged from the brake and returned to the tank via stand pipe 28, the temperature of the liquid in the tank will rise. The rise in temperature of the liquid causes the air and liquid in the tank to expand, whereby the pressure of the air is increased. Since the air and the liquid in the tank expand, the liquid level in the stand pipe and in the brake is raised, thereby automatically increasing the braking effort developed by the brake.

Such automatic increase in braking action may be particularly useful in some applications where the cable spooled from the reel materially increases the load tending to drive the shaft on which the brake is mounted.

For example, if the brake is applied to the draw works of rotary drill rigs, the total weight which the brake must hold in check increases rapidly as the load is lowered, thereby increasing the energy absorbed by the brake and the temperature of the liquid discharged therefrom. The heat of the discharged liquid, as stated above, varying with the increase in load, automatically increases the quantity of liquid in the brake, and consequently automatically increases the braking action.

Thus by controlling the air pressure in the supply tank, the level of the liquid in the brake may be adjusted to that value which will give the brak-

ing action desired. The regulation of the braking action, as affected by the air pressure in the tank, provides the primary form of control, adjustment of the discharge valve 26 gives a secondary form of control, and the increasing temperature of the liquid discharging from the brake gives automatic increase in resistance through the primary control, if this is desired.

It may also be desirable to provide means whereby the braking effort developed by the brake may be suddenly increased, in case it should be necessary to decelerate the load quickly. A means for accomplishing this result is illustrated as comprising a storage tank T, having air or compressible fluid therein under pressure, for example, a pressure of 25 or 30 pounds per square inch, connected to tank 27. A valve V is utilized to normally shut off tank T from tank 27. When it is desired to rapidly increase the braking action, valve V is opened thereby increasing the pressure in tank 27, and raising the level of the liquid in the brake quickly. The quantity of liquid being increased rapidly the braking action is increased correspondingly whereby the load is decelerated at a high rate. In practice, it has been found that by suddenly applying air, under pressure, to tank 27 that the load may be decelerated quickly almost to the point of stopping.

From the above description, it will be appreciated that we have provided an hydro-dynamic brake which will function as a brake when either partially full or completely full of liquid and that we have also provided means whereby the volume of the liquid in the brake may be accurately adjusted to give the desired control of the speed at which the load W is permitted to fall. The means illustrated insures that a predetermined quantity of liquid may be introduced to the brake and that this quantity will be maintained constant even though the discharge control valve is wide open or nearly completely closed.

In the system shown, the pipe leading from the brake to the tank and the tank itself serve as a cooling system for the discharged liquid which maintains the liquid at a temperature well below the critical value above which the braking action would ordinarily be impaired.

In the system shown the level of the liquid in the stand pipe is controlled by air pressure. This could be accomplished in a number of other ways. For example, the level could be varied by introducing a weight into the tank, thus displacing the fluid to the required level. In Fig. 5 such an arrangement is shown. If a weight is used to variably displace liquid in tank 27, pump 34 and the connections therefor, and pressure tank T and valve V may be omitted, and a weight 40 substituted in lieu thereof.

Weight 40 may be disposed in a pipe or cylinder 41 that extends through and opens into the top of the tank, and be suspended from a cable forming part of a windlass 42 mounted on top of the pipe. Thus, by operating the windlass, weight 40 may be lowered or raised, displacing more or less liquid in the tank, thereby raising or lowering the level of the liquid and correspondingly regulating the amount of active liquid in the brake.

In cases where the load on the brake remains practically constant, it may not be necessary to pump air into the tank. Instead, the tank may be filled with liquid until the level rises in the stand pipe to the point where the brake contains sufficient liquid to produce the braking action required. If operated in this manner, tank 27 and stand pipe 28 form, in effect, an open tank. The braking resistance may be regulated by draining the tank until the liquid level is reduced to the desired point, or by adding liquid until the level is raised to the proper height.

If it were desired to run the brake full of liquid but to have the discharge valve open so as to permit circulation, the resistance of the brake may be further increased by increasing the pressure on the liquid at the brake inlet. This may be accomplished by having the stand pipe 28 and the discharge pipe 32 extend as high as required in order to secure the head desired. The pressure may be regulated within the range made possible by the height of the stand pipe by varying the liquid level in the stand pipe in the manner previously described.

While various modifications and changes may be made in the method for controlling the liquid level in the brake and in the apparatus for carrying out such method, without departing from the spirit or the scope of the invention, it is to be understood that only such limitations shall be placed on the invention as are imposed by the prior art and the appended claims.

What we claim as new and desire to secure by Letters Patent is:

1. The method of controlling the braking action in hydro-dynamic brakes that consists in providing a source of supply of liquid, connecting said supply to the brake, superposing on said source a supply of compressible fluid under pressure, and adjusting said pressure until the head of liquid in the brake is of the desired value.

2. The method of controlling the braking action in hydro-dynamic brakes that consists in providing a source of supply of liquid, connecting said supply to the brake, superposing on said source a supply of compressible fluid under pressure, adjusting the level of the liquid in the brake by adjusting the pressure of the fluid acting on the supply source, and discharging liquid from the brake to supply source in accordance with the braking action desired.

3. The method of controlling the braking action in hydro-dynamic brakes that consists in providing a source of supply of liquid, connecting said supply to the brake, superposing on said source a supply of compressible fluid under pressure, adjusting the level of the liquid in the brake by adjusting the pressure of the fluid acting on the supply source, discharging liquid from the brake to supply source in accordance with the braking action desired, and varying the rate of discharge of liquid from the brake to the supply source.

4. In combination, an hydro-dynamic brake comprising a stator having a rotor therein, a closed container having a supply of liquid therein, means placing the interior of the container in communication with the interior of the brake, and means for introducing a compressible fluid pressure to said container of such value that a predetermined quantity of liquid is delivered to said brake.

5. In combination, an hydro-dynamic brake comprising a stator having a rotor therein, a closed tank having a supply of liquid therein, means placing the interior of the tank in communication with the interior of the brake, means for introducing a compressible fluid under pressure to said tank of such value that a predetermined quantity of liquid is delivered to said brake, and means to indicate the level of the liquid in the brake.

6. In combination, an hydro-dynamic fluid friction brake comprising a stator having a rotor

therein adapted to be driven by an over-hauling load, a closed container having a supply of liquid therein, a stand pipe extending into said container, said pipe having its lower end submerged in the liquid therein and its upper end vented to the atmosphere, a connection from said container to the inlet of said brake, a connection from the outlet of the brake to the upper portion of the stand pipe for returning liquid discharged from the brake to the container, and means for introducing a charge of compressible fluid to said container, in the space between the top thereof and the liquid.

7. In combination, an hydro-dynamic fluid friction brake comprising a stator having a rotor therein adapted to be driven by an over-hauling load, a closed container having a supply of liquid therein, a stand pipe, extending into said tank, said pipe having its lower end submerged in the liquid therein and its upper end vented to the atmosphere, a connection from said container to the inlet of said brake, a connection from the outlet of the brake to the upper portion of the stand pipe for returning liquid discharged from the brake to the container, and means for introducing fluid to said container under variable pressure to vary the liquid level in the brake in accordance with the braking action desired.

8. In combination, an hydro-dynamic fluid friction brake comprising a stator having a rotor therein adapted to be driven by an over-hauling load, a closed tank having a supply of liquid therein, a stand pipe extending into said tank, said pipe having its lower end submerged in the liquid therein and its upper end vented to the atmosphere, a connection from said tank to the inlet of said brake, a connection from the outlet of the brake to the upper portion of the stand pipe for returning liquid discharged from the brake to the tank, means for introducing a charge of compressible fluid to said tank in the space between the top thereof and the liquid, and means to regulate the rate at which liquid is discharged from the brake.

9. In combination, an hydro-dynamic brake having an inlet and an outlet through which liquid may discharge, a closed tank having liquid and a charge of compressible fluid therein under pressure, and connections from said tank to the inlet of the brake and from the outlet of the brake to the tank, the heat developed in the liquid passing through the brake heating the compressible fluid in the tank to expand the same, thereby raising the liquid level in the brake and increasing the braking action thereof.

10. In combination, an hydro-dynamic brake comprising a stator and a rotor, said stator having an inlet for liquid and outlet through which liquid may be discharged, a source of supply liquid connected to the inlet to the stator and means responsive to the heat absorbed by the liquid passing through the brake for automatically increasing the quantity of liquid introduced to the brake and thereby automatically increasing the braking effort developed thereby.

11. In combination, an hydro-dynamic fluid friction brake comprising a stator and a rotor, said stator having an inlet and outlet for, respectively, introducing liquid to the brake and discharging liquid therefrom, a source of supply of liquid connected to the inlet, and means adapted to automatically increase the quantity of friction absorbing liquid in the brake and thereby increase the braking effort developed by the brake in response to increasing loads being imposed on the brake.

12. A fluid friction brake, a source of supply for said fluid, connecting means between the brake and fluid supply, means for varying the level of the liquid in the brake to thereby regulate the resistance of the brake, and means for discharging liquid from the brake into the fluid supply.

13. The method of controlling the braking action in hydro-dynamic brakes of the liquid friction type that consists in providing a source of supply of liquid, connecting said supply to the brake, returning the liquid discharged from the brake to the source of supply and regulating the level of the liquid at the source to increase or decrease the quantity of active liquid in the brake.

14. A liquid friction brake, a tank containing the supply of liquid for said brake, means for connecting the tank to brake and circulating liquid therethrough, and means for varying the liquid level in the tank for varying the level of the liquid in the brake.

15. The method of controlling the braking action in hydro-dynamic brakes that consists in providing a source of supply of liquid, connecting said supply to the brake, superposing a variable pressure on the source, and adjusting said pressure until the level of the liquid in the brake is of the desired value.

16. The method of controlling the braking action in liquid friction brakes that consists in providing a source of supply of liquid, connecting said supply to the brake, superposing a variable pressure on the source, and adjusting said pressure until the level of the liquid in the brake is of the desired value.

17. In combination, a liquid friction brake comprising a stator having a rotor therein, a closed container having a supply of liquid therein, means placing the interior of the container in communication with the interior of the brake, and means for introducing a compressible fluid, to said container, under pressure of such value that a predetermined quantity of liquid is delivered to said brake.

18. In combination, a liquid friction brake having an inlet and an outlet through which liquid may discharge, a closed tank having liquid and a charge of compressible fluid therein under pressure, a connection from said tank to the inlet of the brake, and means for utilizing the heat developed in the liquid in the brake and imparted to said fluid for varying the liquid level in the tank and brake to thereby vary the braking action of the brake in response to changes in temperature of said compressible fluid.

19. A liquid friction brake, a tank having therein a supply of liquid for the brake, means for connecting the tank to the brake and circulating liquid therethrough, and means coacting with the liquid in the tank for regulating the active quantity of liquid in the brake.

20. A liquid friction brake having an inlet, through which liquid may enter the brake, an outlet from which liquid may discharge, a source of supply of liquid connected to the inlet, means for controlling the quantity of active liquid in the brake independently of the rate at which liquid is being discharged therefrom, and means for regulating the rate of discharge.

21. In combination, a liquid friction brake, having an inlet and outlet for liquid, a tank having a connection with the inlet of the brake, there being a discharge pipe connected to the outlet of the brake arranged to return liquid to the tank

at a point above the liquid level therein and a substantially constant volume of liquid in the tank, brake and connections therebetween, and means for adjustably displacing liquid in the tank to vary the active quantity of liquid in the brake.

22. In combination, a liquid friction brake, a tank having a supply of liquid therein, means for connecting the tank to the brake and circulating liquid therethrough, and means for varying the level of the liquid in the tank to adjust the braking effort developed by the brake.

23. In combination, a liquid friction brake, having an inlet and outlet for liquid, a tank having a connection with the inlet of the brake, there being a discharge pipe connected to the outlet of the brake arranged to return liquid to the tank at a point above the liquid level therein and a substantially constant volume of liquid in the tank, brake and connections therebetween, and means for varying the level of the liquid in the tank to adjust the braking effort developed by the brake.

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