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FILLING CONTROLLED HYDRODYNAMIC FLUID CIRCUIT

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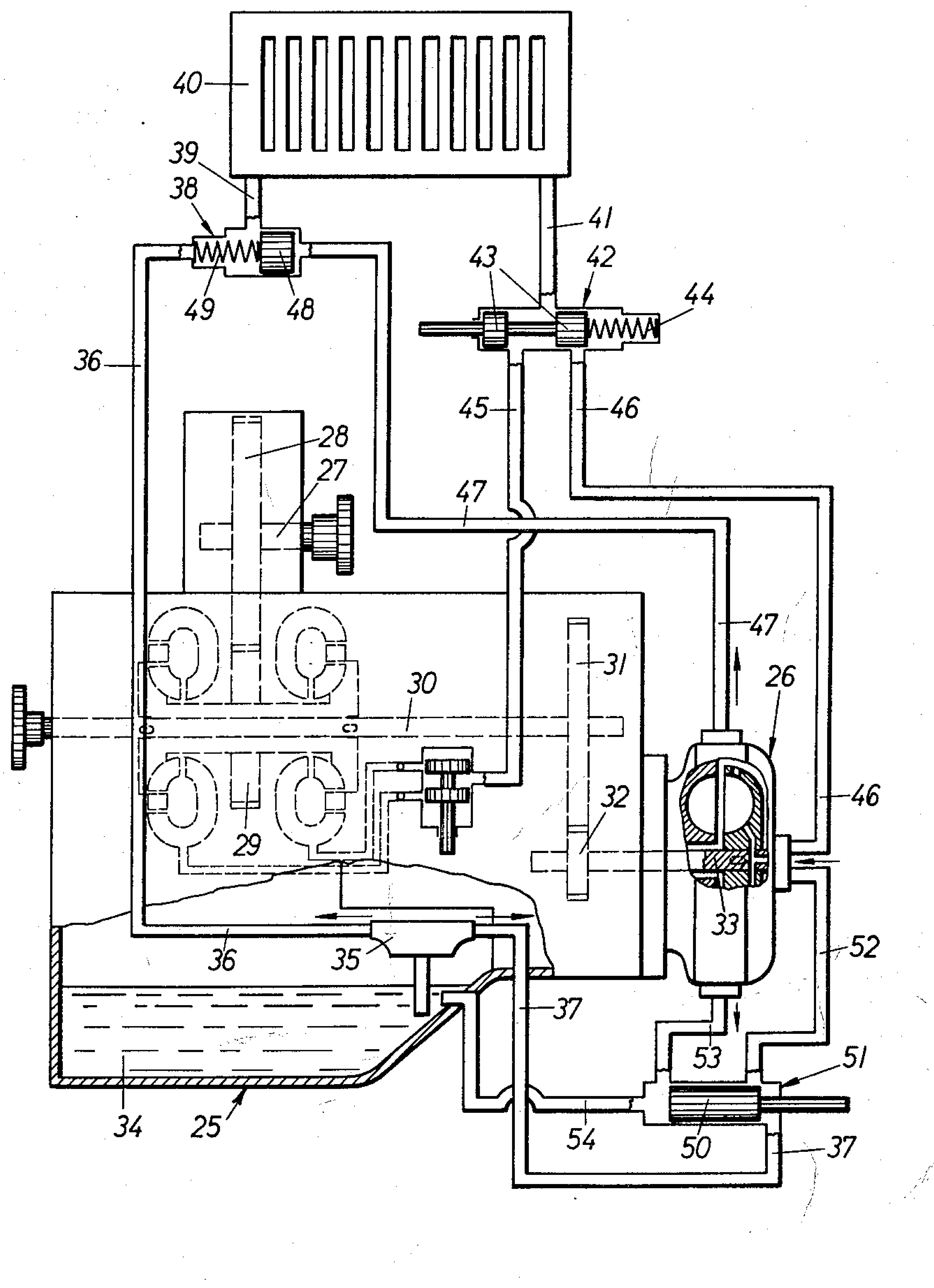

INVENTOR.
Helmut Müller
BY

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FILLING CONTROLLED HYDRODYNAMIC FLUID CIRCUIT

Helmut Müller, Heidenheim (Brenz), Germany, assignor to Voith-Getriebe KG., Heidenheim, Germany

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The present invention relates to filling controlled hydrodynamic working circuits. With working circuits of this type, such as torque converters, fluid couplings, and fluid brakes, a more or less heating up of the working fluid always occurs. The magnitude of this temperature increase depends on the conditions of operation and also on the type of the working circuit involved. Thus, the working circuit is for instance heated up to a relatively small extent when a torque converter operates with total filling and at a high degree of efficiency. On the other hand, a considerable temperature increase is involved when the torque converter has to operate in a range of low degree of efficiency or when a coupling operates not at its normal slip but with an increased slip. The slip always corresponds to the lost power which is completely converted into heat. Above all, with a fluid brake which during the braking operation by necessity has a continuously prevailing slip of 100%, the working fluid will be heated up considerably.

Therefore, a cooling is required in order to prevent a harmful overheating of the working fluid. To this end, the occurring heat was conducted away through the surface of the housing confining the working fluid and was conveyed to the surrounding medium, especially by means of additional cooling ribs on the housing. Such cooling, however, is not always sufficient. Therefore, for purposes of cooling the working fluid, in most instances an outer cooling circuit is provided according to which the working fluid is withdrawn from the working chamber, cooled in a cooler, and thereupon again conveyed to the working chamber. In most instances a pump is employed for circulating this cooling circuit. The delivery of such pump is determined in conformity with the maximum quantity of heat to be conducted away. With a fluid circuit having a non-variable filling, it has also been suggested to take advantage of the pumping effect of the rotating primary wheel, the cooling circuit starting at the point of highest pressure within the working chamber, namely approximately at the outer circumference thereof, and ending at a point of lowest pressure, approximately in the axial range thereof. In such an instance a separate circulating pump may become unnecessary.

If a filling controlled working circuit is involved which is controllable with regard to the torque conveyed from the primary side to the secondary side, a greater increase in temperature of the working fluid may occur because with a coupling with partial filling and consequently increased slip, more heat will be produced and furthermore the produced heat will heat up the now smaller quantity of fluid faster than with complete filling. The last mentioned drawback also applies to converters and fluid brakes. In instances in which the development of heat is still within permissible limits, it is known in connection with fluid couplings, with fluid brakes, and with a

recently suggested filling controlled fluid converter, to arrange the filling control circuit and the cooling circuit in series. However, a higher heat withdrawal is not required with this arrangement because the circulation by means of a pump or by the pumping effect of the primary wheel is primarily designed only for the requirements of the filling control, and the rotated quantity will vary depending on the degree of filling so that no safe heat withdrawal, let alone a considerable heat withdrawal, will be assured.

With couplings which have to meet high requirements with regard to heat withdrawal, it has also been suggested to provide a tiltable but otherwise stationary scoop in a chamber communicating with the working chamber of the coupling and to establish communication between said scoop and the oil sump through conduits and a cooler. A filling pump feeds the working fluid from the oil sump again into the working chamber of the coupling. The scoop serves in this instance as an adjustable overflow and, depending on its position, will determine the degree of filling of the coupling while the rotated quantity of fluid will primarily be determined by the delivery of the filling pump. The total number of structural elements is in this instance relatively high.

It is, therefore, an object of the present invention to provide a hydrodynamic working circuit, especially but not exclusively for a fluid brake, which will overcome the above mentioned drawbacks.

It is another object of this invention to provide a hydrodynamic working circuit as set forth in the preceding paragraph, which, in spite of relatively low cost of construction, will assure a proper withdrawal of the developed heat and will allow a safe control of the degree of filling of the working circuit.

It is another object of this invention to provide a filling controlled fluid brake, in which the braking effect can be controlled merely by a simple change in the degree of filling while nevertheless at all degrees of filling, the respective heat quantity occurring during the braking operation can be safely conducted away.

These and other objects and advantages of the invention will appear more clearly from the following specification in connection with the accompanying drawing diagrammatically illustrating a parallelly arranged cooling and control circuit according to the invention of a hydrodynamic brake combined with a fluid transmission, the cooler serving at the same time for cooling the working fluid of the fluid transmission.

Structural arrangement

Referring now to the drawings in detail and FIG. 1 thereof in particular, the arrangement shown therein comprises a housing 2 of a hydrodynamic brake which housing is connected to the stationary housing of a transmission 3. Transmission 3 has a shaft 4 which is to be braked. Connected to said shaft 4 is the primary wheel 2*a* of the hydrodynamic brake 1. The primary wheel 2*a* has two image symmetrical bladings 2*b* and 2*c* respectively cooperating with two oppositely located bladings 2*d* and 2*e* arranged on the stationary housing 2. Between said bladings 2*b*, 2*c*, 2*d* and 2*e* there is located the working chamber of the brake. When the primary wheel 2*a* rotates, the working fluid passes through bores 2*f* distributed over the outer circumference of the primary wheel into an annular passage $2g$ in which, due to the pumping effect of the primary wheel, the highest filling pressure within the brake housing 2 will prevail. Therefore, the discharge for the working fluid is provided within the range of said annular passage $2g$. At $2h$ the working fluid passes through a conduit 5 into a cooler 6 and from there through a conduit 7 into the axial range of the brake and further through passages $2k$ and $2i$ into the working chamber of the brake. Furthermore, the working fluid also passes at another area 21 at the outer circumference of the brake housing through a conduit 8 and through an open reservoir 9 and returns through a conduit 10 to the flow chamber of the brake and, more specifically, into the axial range of the brake. In each of the conduits 8 and 19 there is arranged a valve spool 11 and 12 respectively. These valve spools are manually operable for controlling the passage of the working fluid through conduits 8 and 10 respectively. Each of said valve spools 11, 12 is adjustable selectively from a full closing position to a full opening position. The first circuit represents the cooling circuit, whereas the second circuit represents the control circuit. Each of the two circuits is closed in itself. Both circuits merely meet within the flow chamber of the brake.

There is provided a further control piston or valve spool 13 of an automatic valve 17 which comprises a spring 14 continuously urging valve spool 13 into its left-hand end position, while pressure fluid, when acting on that side of valve spool 13 which is remote from spring 14, is able to move valve spool 13 into its right-hand end position against the thrust of spring 14. Valve spool 13 may by means of a control rod 18 be arrested in its right-hand position against the thrust of spring 14, in which position it blocks a connecting line 16 which connects the reservoir 9 with the working chamber of the brake. Conduit 15 is connected to conduit 8 at the exit of the control circuit from the brake and conveys the filling pressure to the left-hand face of the valve spool 13.

For purposes of controlling the braking operation, either valve spool 11 or valve spool 12 or both valve spools 11 and 12 are so controlled that a degree of filling will be obtained which corresponds to the desired braking power at a certain speed of shaft 4 to be braked. In this connection, the working fluid of the control circuit will enter conduit 8 at that point at which the highest pressure prevails within the flow chamber, namely at the outer circumference of the flow chamber. Correspondingly, the working fluid will enter the brake where the lowest pressure prevails within the flow chamber, namely in the axial range through conduit 10 which communicates through reservoir 9 with conduit 8. The occurring filling pressure will then bring about that valve spool 13 in spite of the thrust of spring 14 will occupy the position shown in FIG. 1.

When shifting to non-braking operation, the brake will be emptied. This is effected by first adjusting valve spool 12 so that it blocks conduit 10 whereby no further working fluid can pass from reservoir 9 into the axial range of the brake. At the same time, valve spool 13 will by means of control rod 18 be moved into and arrested in its right-hand end position so that no more fluid can pass from the reservoir into the working chamber of the brake. When the brake has been emptied, while the cooling circuit outside the brake still contains working fluid, expediently also valve spool 11 is moved into its closing position.

If it is now desired to shift to braking operation, it is necessary that the brake be filled quickly. This requirement would normally not be met if valve spool 12 alone would free the conduit 10, particularly when valve spools 11 and 12 were adjusted for the desired degree of partial filling. Therefore, also valve spool 13 is released so that spring 14 moves the latter into its left-hand end position with regard to FIG. 1. It will then be evident that the flow chamber will in addition to conduit 10 also be filled from reservoir 9 through conduit 16. For purposes of effecting a quick filling, i.e. so that the braking from driving operation can be effected quickly, for a certain period of time, the control circuit and the cooling circuit will be interconnected outside the flow chamber. As soon as a certain filling pressure has been established, this pressure will cause valve spool 13 to move against the thrust of spring 14 into its right-hand position in which it blocks the conduit 16. As a result thereof, the additional filling from reservoir 9 through conduit 16 will cease, and the control circuit and the cooling circuit will be separated from each other as was the case before.

Referring now to the drawing in detail illustrating a fluid flow transmission 25 with a hydrodynamic brake 26 flanged thereto, it will be noted that an input shaft 27 drives the primary parts of the fluid circuits through a step-up transmission (spur gears 28 and 29). The secondary parts of said fluid circuit are connected to a shaft 30 which represents the output shaft and which through spur gears 31 and 32, representing a step-up transmission, drives shaft 33. Shaft 33 is the shaft to be braked. Consequently, the primary wheel of brake 26 is connected to said shaft 33.

The fluid flow transmission 25 is equipped with an oil sump 34 in which is provided a filling pump 35 with two pressure conduits 36 and 37 connected to opposite sides thereof. Pressure conduit 36 leads through a control valve 38 and conduit 39 to a cooler 40 and from there through a conduit 41 to a manually operable three-way valve 42. Depending on the position of valve spool 43 of said valve 42, the cooled working fluid is either through conduit 45 passed through one circuit each of the circuits of the fluid flow transmission 25 or is passed through a conduit 46 into the working chamber of brake 26. The working fluid of the brake to be cooled will leave the latter at a point of highest pressure through a control valve 38 and conduit 39 to the cooler 40. In this instance the working fluid presses valve spool 48 against the thrust of spring 49 into its left-hand end position.

The other pressure conduit 37 of filling pump 35 leads through a control valve 51 and a conduit 52 to brake 26 while leading into the axial range of the brake similar to conduit 46. The control circuit passes through a conduit 53 and conveys the fluid leaving brake 26 through control valve 51 and conduit 54 into the oil sump 34. Control valve 51 has a manually adjustable and arrestable valve spool 50, which when blocking conduit 52 or 53, will release conduit 53 or conduit 52 respectively. When valve spool 50 occupies an intermediate position, either the effective mouth cross section of conduit 52 is decreased while simultaneously the effective mouth cross section of conduit 53 is enlarged, or vice versa.

At normal operation of the fluid flow transmission, the brake is empty. The valve spool 50 of control valve 51 occupies its right-hand end position and thus blocks the supply of fluid from the pump 35 to brake 26. The three-way valve 42 which allows two positions is shifted to "fluid flow transmission," i.e. the valve spool 43 occupies its left-hand end position shown in FIG. 2. Inasmuch as the brake is empty, it has no filling pressure and consequently valve spool 48 of control valve 38 occupies its right-hand end position shown in the drawing. The cooling circuit of the fluid flow transmission is effective with conduits 36, 39, 41 and 45 and cooler 40.

If it is now intended to brake the output shaft 30 of the fluid flow transmission, the valve spool 50 of control valve 51 is displaced toward the left to such an extent that the filling pump will be able to fill brake 26 through conduits 37 and 52. At the same time the three-way valve 42 is shifted to its right-hand end position—braking position. In this way fluid from filling pump 35 passes through conduits 36 and 39, through cooler 40 and conduits 41 and 46 into the brake. This, however, lasts only until the filling pressure has reached a certain value. As soon as this certain value has been reached, the filling pressure in conduit 47 moves valve spool 48 toward the left against the thrust of spring **49** and against the filling pump pressure in conduit **36**. Consequently, after obtaining a certain filling pressure during the braking operation, there exists a cooling circuit through conduits **47**, **39**, **41** and **46** and cooler **40** which is independent of the control circuit. The control valve **51** will permit a fine sensitive control. While through conduits **37**, **52**, **53** and **54** if desired only a relatively small quantity may pass and the filling pump may be dimensioned correspondingly small, in the separate cooling circuit a sufficient quantity of fluid may be circulated for the cooling of the working fluid. This circulation is brought about by the pumping effect of the brake.

If desired, the control circuit may also be so designed that instead of the conduits **37**, **52**, **53**, **54** and the control valve **51** a single conduit is provided between the pump **35** on one hand and the working chamber of brake **26** or the cooling circuit of the brake on the other hand. In this instance, it would be necessary to employ a reversible pump so that the desired degree of filling can be obtained by pumping fluid into the working chamber of the brake or by withdrawal of fluid from the working chamber.

The thus described arrangement with a fluid brake in combination with a fluid flow transmission comprising at least one fluid flow circuit, has several advantages. When providing a cooler common to the fluid flow brake and the fluid flow transmission, the reversible arrangement according to which selectively the cooling circuit of the brake or the cooling circuit of the fluid flow transmission or a combined cooling or control circuit passes through the cooler, does not require a complicated construction while on the other hand it can be designed very safe for operation. The design of the cooler will be effected in conformity with the requirements of the cooling circuit for the fluid flow brake. In this way a sufficient cooling reserve is available for the working fluid of the fluid flow transmission which does not require too great a cooling. A further advantage is seen in the common pump for the control circuit of the brake and the control circuit of the fluid flow transmission or the combined cooling and control circuit, whereby a second pump will become superfluous. When employing a common pump, it is self understood that also a common sump will have to be provided for the control circuit of the fluid flow brake and for the cooling or combined cooling and control circuit of the fluid flow transmission.

When combining fluid flow brake and fluid flow transmission, the conduit **36** between pump and cooler which represents a portion of the cooling or combined cooling and control circuit, may simultaneously serve as bypass conduit for bypassing the throttle **51** in the control circuit of the brake whereby the number of conduits will be reduced. This bypass conduit **36** will, as described above, permit a quicker filling and thereby a faster response of the brake, especially when the throttle member is adjusted for partial filling. A further conduit will be saved by employing conduit **47** between the exit of the cooling circuit from the brake and cooler not merely as a portion of the cooling circuit of the brake but also as control conduit for the control valve **38** which control valve will up to the development of a certain pressure in the working chamber of the brake permit a quicker filling through the bypass conduit **36** and will become effective when shifting from braking operation to non-braking operation and vice versa.

It may also be mentioned that the primary part of the fluid brake which together with the fluid flow transmission has in common a cooler and a pump does not under all conditions have to be rigidly connected to the output shaft of the fluid flow transmission but may also be operatively connected with the output shaft of an individual circuit of the fluid flow transmission or, with vehicles, with a desired driving axle.

It is, of course, to be understood that the present invention is, by no means, limited to the particular constructions shown in the drawings but also comprises any modifications within the scope of the appended claims.

What I claim is:

1. In a hydrodynamic system: a fluid flow transmission, a fluid brake drivingly connected to said fluid flow transmission and being operable selectively for braking the latter, said fluid brake having a fluid flow working chamber with fluid inlet means and fluid outlet means, control circuit means passing through said working chamber, filling control means interposed in said control circuit means for controlling the filling of said working chamber, cooling circuit means passing through said working chamber and forming a closed circuit from said outlet means to said inlet means, said control circuit means and said cooling circuit means having at least a section thereof arranged in parallel connection to each other, said filling control means being arranged in said parallelly connected section of said control circuit means, and cooler means arranged in said parallelly connected section of said cooling circuit means, said cooler means comprising a fluid inlet side and a fluid outlet side, said inlet side and said outlet side of said cooler means being also arranged in said parallelly connected section of said cooling circuit means, said fluid flow transmission having transmission circuit means, said transmission circuit means including a first and a second branch for cooling said transmission circuit means, said first branch being in communication with said inlet side of said cooler means and said second branch being in communication with said outlet side of said cooler means, first control valve means provided at said inlet side of said cooler means and second control valve means at said outlet side of said cooler means, said both control valve means being operable selectively for conveying fluid from said cooler means to said fluid flow transmission or to said fluid brake.

2. A hydrodynamic system according to claim 1, wherein said control circuit means and said cooling circuit means for said fluid brake are arranged entirely in parallel connection to each other outside said working chamber, and wherein said control circuit means and said first branch of said transmission circuit means have a filling source common to both of said two last mentioned circuit means for supplying filling fluid to said fluid brake and to said fluid transmission, said first control valve means being operable for purposes of quickly filling said working chamber of said fluid brake to establish fluid communication from said filling source to said working chamber through said cooling circuit means in addition to said control circuit means for said fluid brake only during filling operation of said fluid brake, said first control valve means being operable automatically in response to a certain rising pressure in said working chamber so as to interrupt said fluid communication.

3. A hydrodynamic system according to claim 1, wherein said control circuit means and said cooling circuit means for said fluid brake are arranged entirely in parallel connection to each other outside said working chamber, and wherein said control circuit means and said first branch of said transmission circuit means have a filling source common to both of said two last mentioned circuit means for supplying filling fluid to said fluid brake and to said fluid transmission, conduit means forming a part of said cooling circuit means between said outlet means of said fluid brake and said inlet side of said cooler means, said first control valve means being arranged at the junction of said first branch and said conduit means and being operable for purposes of quickly filling said working chamber of said fluid brake to establish fluid communication from said filling source to said working chamber through said cooling circuit means in addition to said control circuit means for said fluid brake only during filling operation of said fluid brake, said first control valve means being operable automatically under

the direct control of a certain rising pressure in said conduit means to interrupt said fluid communication.

4. A hydrodynamic system according to claim 1, in which fluid reservoir means is interposed in said control circuit means, first throttle means interposed between said reservoir means and said fluid brake inlet means, second throttle means interposed between said reservoir means and said fluid brake outlet means, and means operatively connected with said first and second throttle means and operable in response to a throttling action at one of said throttle means to bring about a decrease in the throttling effect at said other throttle means and vice versa, said reservoir means and said first and second throttle means being arranged in said parallelly connected section of said control circuit means.

5. A hydrodynamic system according to claim 4, in which said two throttle means comprise operatively interconnected valve spools.

6. A hydrodynamic system according to claim 4, in which said two throttle means comprise a single valve spool.

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ARTHUR L. LA POINT, *Primary Examiner.*

EUGENE G. BOTZ, *Examiner.*