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(54) HYDROMECHANICAL TRANSMISSION AND CONTROLS

(71) We, ZAHNRADFABRIK FRIEDRICHSHAFEN AKTIENGESELLSCHAFT, of Friedrichshafen-on-the-Bodensee, Federal Republic of Germany, a Joint-Stock Company organised under the laws of the Federal Republic of Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a hydromechanical transmission, comprising a hydrostatic transmission having a hydraulic motor and a hydraulic pump, which transmission is followed by a gearbox including hydraulically operated clutches for changing gear under load, wherein an adjusting piston arranged in a ratio controller adjusts the displacement of the hydraulic pump coupled to the controller and adjusting pressure is applied to the adusting piston via a shift valve which is operated in dependence on signals from the clutches which are to be shifted, the ratio adjustment of the transmission being used for the follow-up control for compensating for the jump in speed of rotation when a gear shift is made.

In known hydromechanical transmissions of this kind (German Offenlegungsschrift No. 2,307,550) the adjusting pump of the hydrostatic transmission is used for follow-up control for adjusting the speed of rotation of the driven and driving part of the clutch which is to be shifted in the on-load shift gearbox in accordance with the step jump of the ratio which is to be shifted. In the adjusting device known from German Offenlegungsschrift No. 2,307,550 the adjusting pump of the hydrostatic transmission is adjusted by an adjusting piston which acts on the ratio controller and which is operated via a shift valve by rotational speed pick-ups which at every moment during the shifting of the clutches signal to the adjusting device of the shift valve the rotational speed of the clutch measured on the driving and driven sides. In operation it has, however, been found that this kind of follow-up control of the hydrostatic transmission has disadvantages. Without taking into account the actual load transfer in the period of time from the shift command until the clutch is synchronised, the rotational speed pick-ups provide the shift valve with pressure for the displacement of the adjusting piston. It has been found in operation that in the shifting of on-load shift gearboxes, particularly those of group construction, the positive or negaitve overlap of load variations from the disengaged to the engaged clutch is of decisive importance for a smooth gear shift.

From German Auslegeschrift No. 2,237,535 it is also already known for the clutch shift pressures to come into action in the controller immediately at the moment of the gear shift, without taking into account the chronological load change pattern between two clutches being shifted. This control is then unable to prevent follow-up control by the adjusting pump while the phase of constraint (positive shift overlap of the shift clutches) exists on load transfer from one clutch to the other. This adjustment of the adjusting pump for the purpose of follow-up control is thus also transmitted to the mass attached to the gearbox, that is to say the vehicle, and thus results in heavy shift shocks.

In the follow-up control of the hydrostatic transmission known from German Auslegeschrift No. 1,817,764 shift shocks also occur in the shifting of the on-load shift gearbox, since adjustment takes place only when the clutch which is to be engaged has already been fully loaded with the clutch shift pressure and the clutch which is to be disengaged has not yet been relieved of load.

The present invention therefore takes as its starting point the problem of improving the follow-up control of the hydrostatic transmission when changing gear, in the case of hydrostatic transmissions followed by gearboxes changing gear under load, and taking into account the actual transfer of load.

Accordingly, the present invention consists in a hydromechanical transmission com-

prising a hydrostatic transmission having a hydraulic motor and a hydraulic pump, which drive is followed by a gearbox including hydraulically operated clutches for changing gear under load, wherein an adjusting piston arranged in a ratio controller adjusts the displacement of the hydraulic pump coupled to the controller and adjusting pressure is applied to the adjusting piston via a shift valve which is operated in dependence on signals from the clutches which are to be shifted, the ratio adjustment of the transmission being used for the follow-up control for compensating for the jump in speed of rotation when a gear shift is made, characterised in that the filling and emptying pressure of the working fluid supplied to the clutches which are to be shifted is fed to the shift valve for operating the shift valve and pressure modulation valves in the flow and return pipes of the clutches which are to be shifted determine the pressure pattern in the filling or emptying of the clutch, so that the follow-up control of the hydrostatic transmission is effected during the gear shift outside the constraint of the gearbox (positive shift overlap of the shift clutches) in dependence on the pattern of the load transfer in the disengaged and engaged clutches.

When a gear change is made in accordance with the invention the filling pressure of the clutch which is to be engaged and th emptying pressure of the clutch which is to be disengaged are fed to the shift valve and used for operating the adjusting device of the hydrostatic transmission, while in adaptation to determined running and load conditions which are to be expected, pressure modulation valves in the flow and return pipes of the clutches which are to be shifted determine the pressure pattern for the filling and emptying of the respective clutches.

The invention makes it impossible to effect the follow-up control of the hydrostatic transmission during the constraint of the gearbox, that is to say in the phase in which one clutch is still engaged while the other is already taking over torque. Constraint may, for example, occur when two clutches shifted at the same moment of time have a "natural" overlap. In the case of multi-disc clutches, for example, this depends on the load and speed of rotation occurring in the clutch, and also on the size of the clutches which have to be shifted. Through the use of pressure modulation valves, in conjunction with control dependent on the clutch shift pressure, it is here made possible for shift operations to be intentionally controlled in the shifting of clutches in on-load shift gearboxes.

In order that the invention may be more readily understood, reference is made to the accompanying drawing which illustrates diagrammatically and by way of example one embodiment of the invention.

A hydrostatic transmission 1, which is driven by a propulsion engine and which consists of a hydrostatic motor and a hydrostatic pump, drives an on-load shift gearbox 2. The gear ratios are shifted by means of hydraulically operated clutches 3 and 4.

By means of a gear lever 13, valves 9 and 10 associated with the respective clutches are controlled with the aid of contacts 14 and 15.

The valve 9 shifts clutch 4 of the first gear speed and the valve 10 shifts the clutch 3 of the second gear speed. Between the valve 9 or 10 and the respective clutch 4 or 3 there are provided pressure modulation valves 9*a* and 10*a*, which in a manner known *per se* modulate or damp the supply pressure from an auxiliary pump 8 to the clutches 3 or 4, but on the other hand permit return from the clutch unthrottled.

When a gear change is made the pressure of the working fluid supplied to the two clutches 3 and 4 which are to be shifted is transmitted through an engaging valve 11 to appropriate adjusting devices of a control valve 5, which in a control device associated with the hydrostatic transmission 1 initiates the follow-up control of the latter for the purpose of equalising the speed of rotation of the driven and driving part of the clutch during the gear change.

The pressure modulation valves 9*a* and 10*a* in the flow and return pipes of the clutches 4 and 3 which are to be shifted determine the pressure pattern in the filling or emptying of the clutch, so that the follow-up control of the hydrostatic transmission is effected during the gear shift outside the constraint of the gearbox (positive shift overlap of the clutches 3, 4) in dependence on the pattern of the load transfer in the disengaged and engaged clutches.

By means of a switch 17 the follow-up control of the hydrostatic drive is interrupted when the necessary adjustment has been completed. The switch 17 can, for example, be controlled by sensing the adjustment path in the adjustment of the hydrostatic transmission by means of limit switches or by comparison of speeds of rotation between the driven and driving part of the clutch which is to be shifted, switching-off being effected when the speeds of rotation are equal.

The follow-up control of the hydrostatic transmission is expediently effected hydraulically; a pump 12 necessary for this purpose may be the filling pump of the hydrostatic transmission. The orifices 6 and 7 damp the speed of flow of the liquid flowing back. The incoming liquid can, however, enter the control device undamped by way of an appropriate non-return valve. As shown in

the drawing, the energy source 16 for operating the valve for a shift may be an electric battery. Pneumatic or hydraulic means may also be used.

WHAT WE CLAIM IS:—

1. A hydromechanical transmission comprising a hydrostatic transmission having a hydraulic motor and a hydraulic pump, which drive is followed by a gearbox including hydraulically operated clutches for changing gear under load, wherein an adjusting piston arranged in a ratio controller adjusts the displacement of the hydraulic pump coupled to thecontroller and adjusting pressure is applied to the adjusting piston via a shift valve which is operated in dependence on signals from the clutches which are to be shifted, the ratio adjustment of the transmission being used for the follow-up control for compensating for the jump in speed of rotation when a gear shift is made, characterised in that the filling and emptying pressure of the working fluid supplied to the clutches which are to be shifted is fed to the shift valve for operating the shift valve and pressure modulation valves in the flow and return pipes of the clutches which are to be shifted determine the pressure pattern in the filling or emptying of the clutch, so that the follow-up control of the hydrostatic transmission is effected during the gear shift outside the constraint of the gearbox (positive shift overlap of the shift clutches) in dependence on the pattern of the load transfer in the disengaged and engaged clutches.

2. A hydromechanical transmission, substantially as herein described with reference to and as shown in the accompanying drawing.

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1590981 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*