ROTARY PUMP AND MOTOR HYDRAULIC TRANSMISSION

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Fig. 1

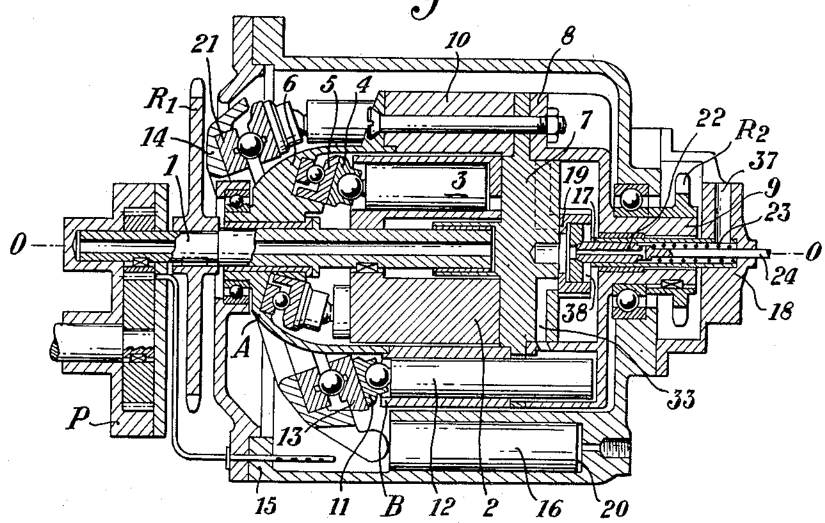
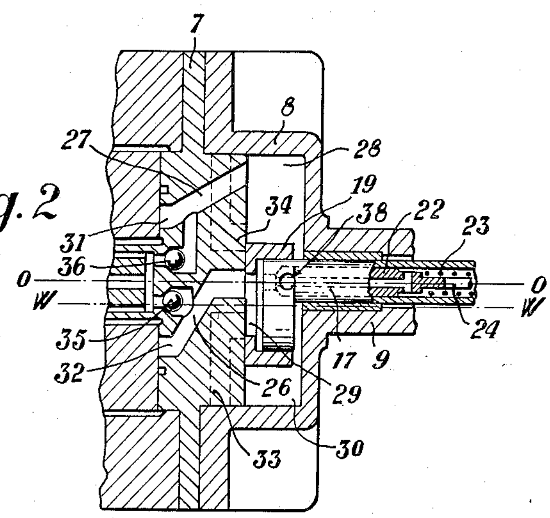


Fig. 2



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ROTARY PUMP AND MOTOR HYDRAULIC TRANSMISSION

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The invention relates to variable speed variable torque power transmission apparatus for transmitting power from a driving element to a driven element and employing a liquid as the power transmission medium.

The apparatus of the invention is of the type comprising a multi-cylinder pump and a multi-cylinder motor hydraulically connected to each other, wherein the cylinders of the motor surround the cylinders of the pump and are concentric therewith and wherein the pump cylinder body is fastened to the driving shaft and the motor cylinder body is fastened to the driven shaft and the pump piston rods are rotatably supported by a plate inclined at a fixed angle with respect to the driving shaft whereas the motor piston rods are rotatably supported by a swash plate having an inclination variable at will from the outside of the apparatus.

The apparatus of the invention is characterised in that the distribution of the liquid, preferably of the oil, to the cylinders of the motor is controlled by a ring valve plate eccentrically mounted at one end of a stationary spindle arranged inside the driven shaft and a valve is mounted inside said stationary spindle and hand-operable to place in short circuit the cylinders of the pump with those of the motor to render independent of the driven shaft the rotation of the driving shaft.

One form of the apparatus of the invention is illustrated in the accompanying drawing wherein:

Figure 1 is a longitudinal section through the apparatus arranged for installation in a motor vehicle of low power;

Figure 2 shows a detail of the distribution of the liquid to the cylinders of the apparatus of Fig. 1.

The apparatus referred to comprises a pump unit A and a motor unit B of the swash plate type each of which is formed of a plurality of cylinders.

The pump and the motor are hydraulically interconnected in a closed circuit and the cylinders of the pump are co-axial with and arranged radially in the cylinder block of the motor.

At one end of the driving shaft **1**, a gear R_1 is mounted which is made to rotate by a suitable prime mover. On the driving shaft **1** is keyed the body **2** of the pump cylinders.

In the cylinders of the pump A the pistons **3** reciprocate and at one end abut, through the slippers **4**, a backing plate **5**, which is supported by the end block **6**.

The cylinder body **2** of the pump bears on the distributing plate **7**. The cylinder body **10** of the motor is arranged about the cylinder body **2** of the pump and fastened to the end block **6** of the pump and to the distributing plate **7**. The cylinder block **10** is further fastened to the casing portion **8** which carries the driven shaft **9** of the apparatus; on the shaft **9** a gear R_2 is keyed for connection with the wheels of the motor vehicle.

The cylinder body **10** of the motor together with the end block **6** and the casing portion **8** forms an assembly fastened to and rotating with the driven shaft **9** which rotates with respect to the cylinder body **2** of the pump.

The slippers **11** of the pistons **12** of the motor cylinders

abut on the ring **13** which bears, by means of balls or rollers, on the swash plate **14**. The latter is pivoted at its sides on the housing **15** of the apparatus by means of two pivots (not shown) the axis of which lies under the longitudinal axis O—O of the apparatus. The inclination of the swash plate **14** is controlled by the piston **16** which reciprocates inside a cylinder **20**, made in the housing **15**. The driven shaft **9** is axially bored to receive a spindle **17** one end of which is keyed to the stationary flange **18** by means of pin **37** and at the other end eccentrically carries the distributing ring valve **19** (Fig. 2) which controls the distribution of the oil to the cylinders of the motor.

The eccentric of spindle **17** is provided with two bores **38** which permit the passage of the oil when a valve **22** (to be described later) is removed from its seat.

In the distributing plate **7** there are provided two ports and namely an output port **32** and a suction port **31** for the pump. These ports communicate with a chamber **28** formed between the distributing plate **7** and the casing portion **8**. The chamber **28** is divided into two portions by the distributing ring valve plate **19** and namely an inner portion **29** and an outer portion **30**. The port **32** communicates with the portion **29** of chamber **28** through the duct **26** and the port **31** communicates with the portion **30** of chamber **28** through the duct **27**.

In the distributing plate **7** there are also provided for each cylinder the ducts **34** and **33** which connect the chamber **28** with the cylinders of the motor B.

The axis W—W of the distributing ring valve plate lies in the plane including the axis O—O and the axis of the pivots (not shown) of plate **14**. In this plane, the axis W—W is spaced apart from the axis O—O and is parallel thereto.

Due to the eccentricity of ring valve plate **19**, the inlet ports **33** of the cylinders of the motor B and the output ports **32** of the cylinders of the pump A communicate with the inner portion **29** of chamber **28**, and the output ports **34** of the cylinders of the motor and the suction ports of the cylinders of the pump communicate with the outer portion **30** of the chamber **28**.

The operation of the apparatus is the following. Assuming the swash plate **14** of the motor B to be in the position shown in Fig. 1, when the driving shaft **1** rotates a certain amount of oil through the output port **32** of the pump A, the duct **26**, the portion **29** of chamber **28** and the duct **33** acts upon the input side of the motor B, causing the cylinder block **10** of the motor to rotate. Together with the cylinder block **10** of the motor also the end block **6**, the casing portion **8**, and the driven shaft **9** fastened to the latter rotate. In consequence of said rotation the volumetric displacement of the pump A is no more proportional per minute of the driving shaft **1** but said volumetric displacement is proportional to the difference between the revolutions per minute of the driving shaft **1** and the revolutions per minute of cylinder body of the motor, thus imparting to the driven shaft **9** a rotatory speed which corresponds to the given inclination of the swash plate **14** in Fig. 1.

By varying the inclination of the swash plate **14** the volumetric displacement of the motor cylinders is varied and hence the amount of oil entering the motor, thus varying the transmission ratio of the apparatus.

If the speed of the driving shaft **1** is kept constant, the speed of the driven shaft **9** will depend only upon the inclination of the swash plate **14** that is upon the ratio of the volumetric displacement of the motor B and that of the pump A. At the limit, when the volumetric displacement of the motor B is zero the transmission ratio will be 1:1 and the driving shaft **1** and the driven shaft **9** rotate in synchronism. In the intermediate positions the higher the inclination of the back plate **14** of the motor the higher is the transmission ratio.

The specific value of the volumetric displacements will only affect, the pressure being equal, the torque transmitted.

The torque available on the driven shaft **9** is the sum of the reaction torque of the pump and of the torque due to the motor. The first torque is given by the reaction engendered by the pump casing by the elements of the pump rotating with the driving shaft and this torque is invariable for any transmission ratio. The second torque is that one engendered by the motor in virtue of the oil which the motor receives from the pump and this torque varies from zero to a maximum value according to the inclination of plate **14**.

As already stated, the inclination of the swash plate **14** may be varied by means of the cylinder **20** by introducing therein or removing therefrom oil by means of a device not shown, which will not be described in detail.

When the swash plate **14** is in the position corresponding to the transmission ratio 1:1, that is when the volumetric displacement of the motor B is equal to zero (swash plate **14** perpendicular to the axis of the driving and driven shaft) there is no passage of oil from the pump to the motor.

The cylinder body of the pumps rotate together with the cylinder body of the motor and the parts connected thereto, and the thrust due to the pump pistons is received by the corresponding supports without causing losses of power.

In the motor B, on the contrary, the thrust of the pistons at one side are balanced by the pressure existing inside the chamber **29**, and at the other side are received by the thrust bearings of plate **14**.

The variable speed transmission apparatus disclosed is particularly suitable for motor vehicles of low power since the apparatus may be kept within very small dimensions particularly in longitudinal direction, although permitting the cylinders of the motor to have a noticeable length. The volumetric displacement being equal, in this apparatus there are decreased thrusts upon the ring **13** of the motor B without being compelled to impart excessive inclination to the swash plate **14**.

The yield is high especially when working at a transmission ratio near to 1:1 which is the most frequent in motor vehicles of low power.

In order to permit the driven shaft to become idle, a valve **22** is provided to bypass the inlet and the outlet of the pump through the bores **38** made in the eccentric of spindle **17**. The valve **22** is axially bored to equalize the pressure at the two ends of the valve, thus avoiding the necessity of making use of a very strong spring to reseat the valve. The valve **22** is biased toward its seat by the spring **23**, so that to unseat the valve it is necessary to exert a pulling force on the shank **24**. By releasing said shank suddenly the valve closes slowly and the reengagement of the driven shaft to the driving shaft takes place gradually since valve **22** has first to annul the dynamic thrust of the fluid coming out from the bypass opening.

The pump P has the purpose of returning the oil which leaks from the apparatus into circuit through the bore of shaft **1** and the ball valves **35** and **36**. Said valves allow the oil to return under low pressure into the transmission circuit, at the suction side, so that to prevent the forming of air bubbles and also to cause the pistons to move back without making use of springs or like devices, since they ensure the continuous abutment of the pump pistons against the backing plate during the suction phase.

What I claim is:

1. Hydraulic variable speed transmission suitable for traction purposes on small power motor vehicles particularly on two-wheel motor vehicles comprising a driving shaft and a driven shaft, a hydraulic multi-cylinder pump having the cylinder body which rotates with the driving shaft, a hydraulic multi-cylinder motor having the cylinder body which rotates with the driven shaft, the cylinder body of the motor surrounding the cylinder body of the pump and being concentric therewith, a stationary housing containing said multi-cylinder pump and motor, said pump and said motor being hydraulically interconnected in a closed circuit, a distributing valve plate interposed between the cylinder bodies of the pump and motor, said valve plate receiving in abutment the pump cylinder body and being fastened for rotation to the motor cylinder body, pistons reciprocating in the cylinders of the pump and motor, inlet and outlet ports for the liquid in the cylinders of the pump and motor, a first cap fastened to the motor cylinder body and having an inclined bottom against which the pump pistons abut for rotation, a swash plate pivoted to the stationary housing and receiving in rotatory abutment the motor cylinder pistons, a second cap fastened to the motor cylinder body opposite to the first cap, said second cap being provided with an extension axially bored and in the form of a driven shaft, the driving and the driven shaft each being journalled at one side of the stationary housing, said distributing valve plate and said second cap facing each other and being spaced apart from each other to form is distribution chamber for the liquid, the driving shaft being provided with an axial duct, an auxiliary pump mounted on the driving shaft to supply liquid under pressure to the hydraulic circuit of the multi-cylinder pump and motor through the said axial duct of the driving shaft, a spindle axially bored and located in the said bored extension of the second cap and provided at one end with an eccentric, a distributing ring valve for the oil to be conveyed to the motor mounted on the said eccentric, said ring valve being contained in the said distribution chamber and abuting against the said distributing valve plate and dividing the said distributing chamber in an inner and an outer portion, ducts in the said distributng valve plate which communicate the pump cylinders with the motor cylinders through the inner and the outer portions of the distribution chamber, the distributing ring valve being provided with radial ducts which communicate the said inner and outer portions of the distribution chamber, a spring biased stem valve slidably contained in the said axially bored spindle to keep closed the radial ducts of the said ring valve, said stem valve being axially bored to equalize the pressure at the two ends of the valve and being operable to open said radial duct against the action of the spring to by-pass the inlet and the outlet ports of the pump cylinders.

2. Hydraulic variable speed transmission as claimed in claim 1, wherein the outlet ports of the pump cylinders and the inlet port of the motor cylinders communicate with the inner portion of said distribution chamber, and the outlet ports of the motor cylinders and the inlet ports of the pump cylinders communicate with the outer portion of the distribution chamber, and wherein the distribution plate valve is further provided with ducts which put in communication the axial duct of the driving shaft with the hydraulic circuit of the multi-cylinder pump and motor, a valve ball being provided in each of the said last mentioned ducts of the plate valve.

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