June 27, 1961 H. SINCLAIR 2,989,851

HYDRAULIC TURBO-COUPLINGS

Filed March 31, 1954 3 Sheets-Sheet 1

Fig. 1.

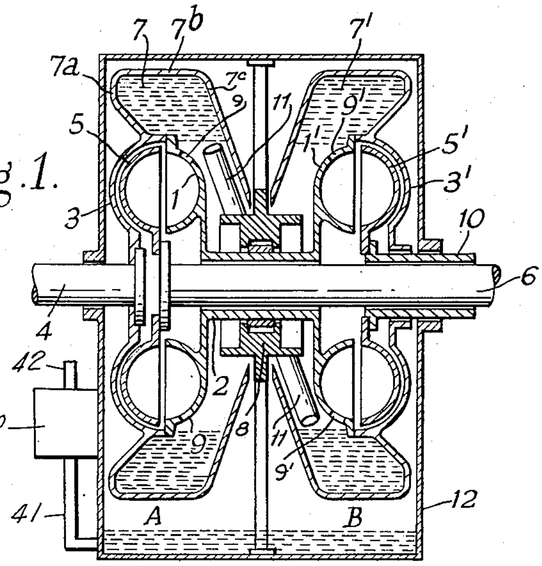


Fig. 2.

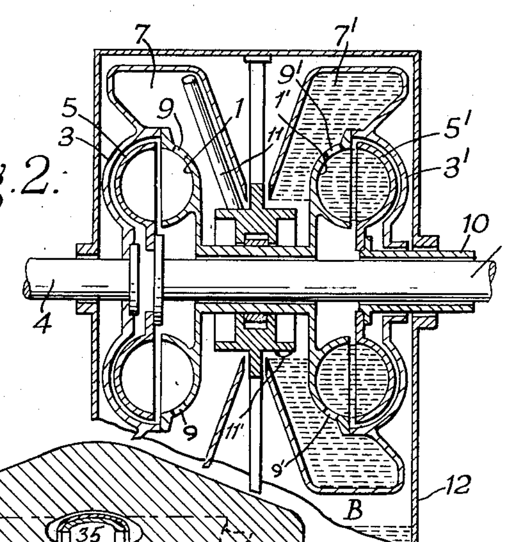
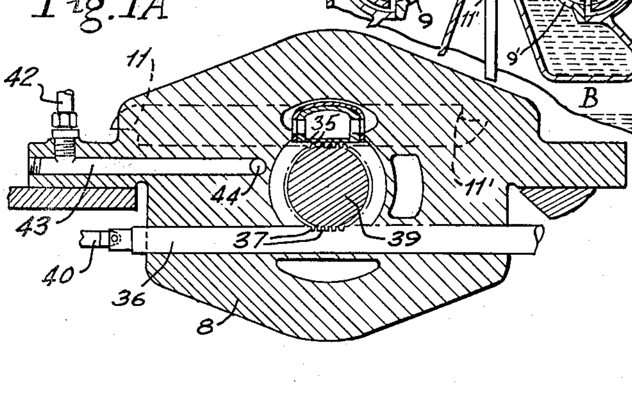


Fig. 1A



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HYDRAULIC TURBO-COUPLINGS

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Fig. 3.

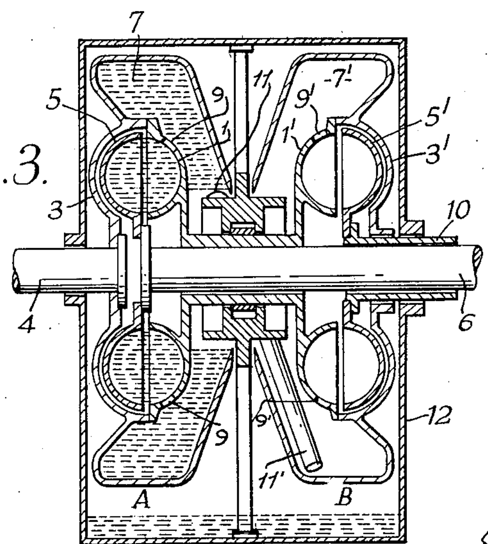

Fig. 6.

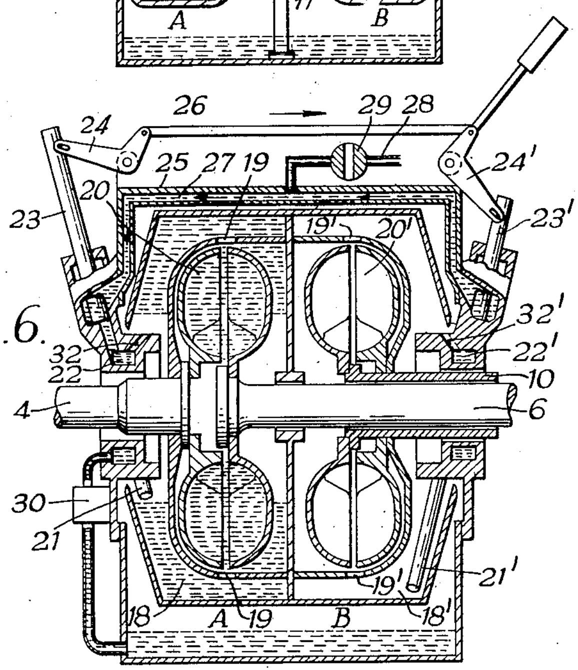

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Fig.4.

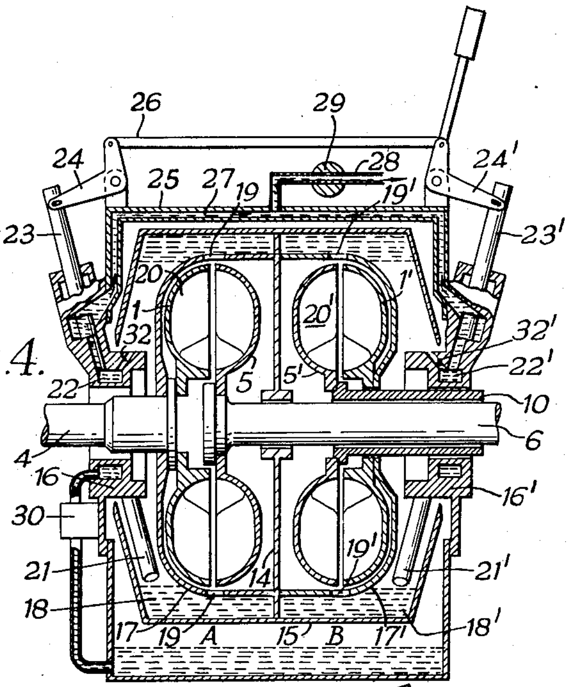
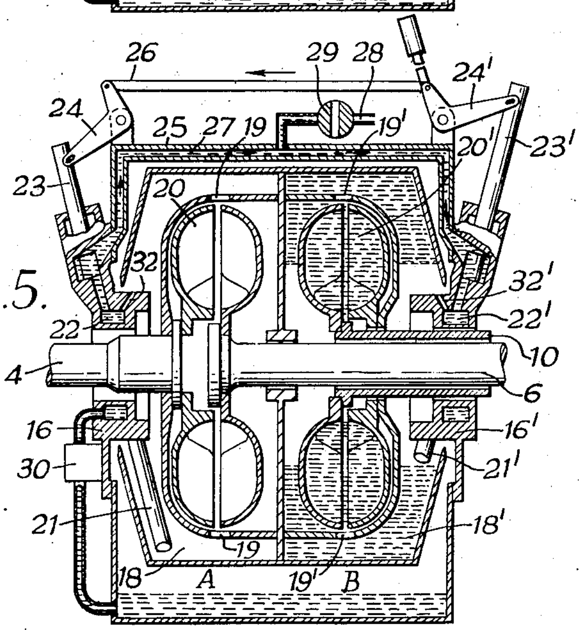


Fig.5.



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HYDRAULIC TURBO-COUPLINGS

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6 Claims. (Cl. 60—54)

This invention relates to hydraulic turbo couplings of the Föttinger type wherein means are provided for varying the filling of the working circuit during operation of the turbo coupling to vary the torque transmitting capability thereof.

Turbo couplings of the type referred to are known in which an adjustable scoop tube feeds working fluid from a rotating reservoir to a working circuit, and the working chamber of the coupling is provided with leak-off nozzles which permit working fluid to flow at a restricted rate from the working circuit to the reservoir. In a coupling of this type, which may be termed a "scoop control coupling" it is known to make the rotating reservoir about one third greater in diameter than the outer profile diameter of the working chamber so that the reservoir is capable of taking up all the fluid from the working circuit without overflow when the coupling is stationary, and also when the coupling is rotating and the scoop tube is fully retracted. The working circuit of a scoop control coupling can be filled relatively rapidly via the scoop tube, but the circuit can empty only relatively slowly due to the restriction imposed by the leak-off nozzles on the flow of fluid from the circuit. This disadvantage can be overcome by the provision of quick-emptying valves, but this measure complicates the otherwise simple construction of the coupling. It is a characteristic feature of such couplings that the rate of circulation through the working chamber and the leak-off nozzles varies with the degree of filling of the working circuit, and the rate of flow decreases as the filling of the working circuit is reduced.

Turbo couplings of the type referred to are also known in which the working chamber is in free communication with the scoop tube chamber or is provided with relatively large openings which are situated near the periphery of the chamber and permit an unrestricted flow of fluid out of the working chamber to the adjacent rotating scoop tube chamber which is about the same diameter as the outer profile diameter of the working circuit, and wherein an adjustable scoop tube is disposed which feeds fluid from the scoop tube chamber to a sump, a pump being provided which returns fluid from the sump to the working circuit. In such a coupling, which may be termed a "scoop trimming coupling" the emptying of the working chamber may be rapid, provided that a scoop tube of suitably large bore is employed, but since filling is effected by the pump the rate of filling is relatively low unless a pump of high capacity is employed.

In a scoop triming coupling the scoop tube is retracted to increase the filling (by allowing more fluid to accumulate in the coupling as a whole) and the scoop tube is inserted in order to reduce the filling (by transferring more fluid to the sump). A scoop trimming coupling has the advantage that the circulation of fluid can be at a constant rate irrespective of the degree of filling of the working chamber, since it is determined by the pump. On the other hand a separate tank and pump are required for its operation, whereas a scoop control coupling is a self-contained unit.

In a scoop control coupling the scoop tube is inserted into the fluid in the reservoir chamber in order to increase the filling of the working circuit (by transferring more oil from the reservoir to the working circuit) and is retracted in order to reduce the filling (by allowing more fluid passing through the leak-off nozzles to accumulate in the reservoir chamber).

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It will be seen therefore that each type of coupling has advantages and disadvantages with respect to the other type, and that neither type in its simplest form has the capacity of both rapid filling and rapid emptying of the working circuit.

The invention arises from the requirement of providing a power transmission system incorporating two turbo couplings which are adapted for being operated together and in such manner that the working circuit of one coupling is filled and the working circuit of the other coupling is empty; or conversely. Provision may be made for both working circuits to be partially or completely empty. Such a system may for example be employed for providing forward and reverse drive from a common prime mover, as in the system disclosed in patent specification No. 1,768,938, or for providing power transmission from a prime mover to a driven member through two power paths of different speed ratios, or for providing drive from a prime mover to two driven members, for example, fans, pumps or compressors.

In such systems, whichever of the previously described form of scoop trimming or scoop control coupling is employed, there will be the disadvantage that changeover from the condition in which one coupling is operative to the condition in which the other coupling is operative will necessarily be slow, since either the coupling which is to become operative will fill only slowly or the coupling which is to become inoperative will empty only slowly. If the couplings are so interconnected that changeover is effected by an actual flow of fluid from one coupling to the other as in the simplest form of the arrangement described in patent specification No. 2,187,656, then there will be relatively slow emptying and slow filling of both couplings. The object of the invention is to provide a turbo coupling which when associated with a second turbo coupling in a power transmission system as above-mentioned, enables the changeover time to be reduced very appreciably as compared with systems incorporating simple designs of couplings of known types, e.g. of the scoop control type or of the scoop trimming type previously described.

According to the invention there is provided a hydraulic turbo coupling provided with a rotatable reservoir chamber which is in free communication with, and is radially beyond the outer profile diameter of, the working circuit of the turbo coupling, and a scoop tube which leads to the exterior of the turbo coupling, and the scoop orifice of which is insertible into and retractable from said reservoir chamber.

According to the invention in a further form a power transmission system may incorporate two turbo couplings at least one of which is in accordance with the last preceding paragraph, the scoop tube of each coupling being arranged to lead either directly or via suitable ports and passages to the working chamber of the other coupling.

The effective volumetric capacity of the aforesaid reservoir chamber may be equal to or less than the full capacity of the working circuit. Alternatively the reservoir chamber may be of full volumetric capacity but the travel of the scoop tube may be suitably limited to transfer only the required volume of fluid from the reservoir chamber.

The two scoop tubes of the two couplings may be independently operable, or they may be mechanically or otherwise interconnected for uni-control. In some constructions the two scoop tubes may be provided in effect by a single double-ended scoop tube with a passage right through from end to end and the ends of which are both formed as scoop tube orifices which are adapted to project into the respective reservoir chambers of the two turbo couplings. For very rapid rates of transfer of liquid two or more double-ended scoop tubes of this type may conveniently be utilised.

In order that the invention may be clearly understood and readily carried into effect it will now be described in more detail with reference to the accompanying diagrammatic drawings, in which:

FIGS. 1 to 3 illustrate two similar turbo couplings according to the invention, with a scoop tube common to the two couplings,

FIG. 1A shows a practical form of the means that may be employed for actuating the scoop tube means in the embodiment of the invention diagrammatically illustrated in FIGS. 1 to 3, and

FIGS. 4 to 6 illustrate two similar turbo couplings according to the invention provided with individual, mechanically inter-connected scoop tubes.

FIGURES 1 to 3 show an arrangement comprising two turbo couplings A and B. The turbo coupling A comprises an impeller **1** fixed on a sleeve **2**, and rotatable with a casing **3** fixed on an input shaft **4**. The casing **3** encloses the runner **5**, which is fixed on an output shaft **6** on which the sleeve **2** is rotatably mounted. The turbo coupling A has a reservoir **7** which is rotatable with the impeller **1** and input shaft **4**, and which as can be seen projects radially well beyond the outer profile diameter of the working chamber of the turbo coupling A. The reservoir **7** comprises an annular end wall **7*a*** joined to the casing **3**, a cylindrical outer wall **7*b***, and a frusto-conical wall **7*c*** which projects towards and into near contact with a stationary housing **8** in which the scoop tube is slidably mounted. Large openings **9** in the back of the impeller **1** place the working chamber of turbo coupling A in unrestricted communication with reservoir **7**.

In the drawing the same reference numerals have been employed (with indices) for those parts of turbo coupling B which correspond to parts of coupling A. Coupling B is similar to coupling A except that the runner **5'** is fixed on an output sleeve shaft **10** rotatable relative to output shaft **6**.

The turbo coupling A is provided with a scoop tube **11**, and the turbo coupling B is provided with a scoop tube **11'**, the scoop tubes **11** and **11'** having oppositely directed scooping orifices, and being capable of being inserted into and withdrawn from the reservoirs **7** and **7'** respectively. The scoop tube **11** leads from the reservoir **7** to the exterior of the turbo coupling A, and the scoop tube **11'** leads from reservoir **7'** to the exterior of turbo coupling B, and the two scoop tubes are mechanically interconnected so that as either one of them is withdrawn from its associated reservoir the other is automatically inserted into its associated reservoir. In the arrangement shown in FIGS. 1 to 3 this mechanical interconnection is effected in a simple manner by forming the two scoop tubes as parts of a single, double-ended scoop tube which is mounted so as to be slidable longitudinally in the support **8**. The scoop tube **11** thus leads from reservoir **7** of coupling A directly to the reservoir **7'** of coupling B, via the scoop tube **11'**, and the scoop tube **11'** leads directly from the reservoir **7'** of coupling B to the reservoir **7** of coupling A, via the scoop tube **11**. Means are provided for displacing the scoop tubes longitudinally in the support **8**. The said means may comprise a rack provided on the scoop tubes and a pinion co-operating with the rack and provided with an operating lever.

The two turbo couplings A and B are mounted within a casing **12** the lower portion of which serves as a sump, the shaft **4** and shaft **10** being journalled in bearings in the end walls of the casing **12**.

The working chambers of the two turbo couplings have substantially the same volume, and the reservoirs **7** and **7'** each have the same volume as the respective working chambers.

The arrangement shown in FIGS 1 to 3 is suitable for use with a constant speed driving means which may comprise for example an A.C. induction motor or a diesel engine coupled to the input shaft **4**. It will be assumed that the output sleeve shaft **10** is drivably connected to a driven member via a forward gear train, and that the output shaft **6** is drivably connected to the same driven member via a reverse gear train.

The total quantity of working fluid (oil) in the rotating parts of the two couplings is rather more than the volume of one working chamber with its associated scoop tube chamber and reservoir chamber, the scoop tube chamber being regarded as that part of the reservoir chamber that is radially within the outer periphery of the working circuit.

FIG. 1 shows the neutral condition of the couplings, the scoop tubes **11**, **11'** being in a mid-position. In this mid-position the scooping orifices of the scoop tubes are approximately at the levels of the outer profile diameters of their associated working chambers, and both working chambers are empty, the reservoir chambers **7** and **7'** being full. In this condition no power is transmitted from the input shaft **4** either to the output sleeve shaft **10** or to the output shaft **6**.

When it is required to drive the driven member in forward direction, the scoop tubes **11** and **11'** are moved longitudinally to the positions shown in FIG. 2, wherein the scoop tube **11** is fully inserted into the reservoir **7**, and the scoop tube **11'** is fully retracted from the reservoir **7'**. Oil is rapidly transferred from reservoir **7** of turbo coupling A, via the scoop tubes **11** and **11'**, to the reservoir **7'** of turbo coupling B, and due to the free communication between the reservoir chamber **7'** and the working chamber of coupling B, the working circuit of the latter is rapidly filled. Since the scooping orifice of scoop tube **11'** is now at approximately the level of the inner profile diameter of turbo coupling B, no oil is transferred from reservoir **7'** to reservoir **7**. Consequently, reservoir **7'** and the working chamber of coupling B are full, but reservoir **7** and the working chamber of coupling A are empty. Under these conditions, power is transmitted from the input shaft **4** to the output shaft **10** via turbo coupling B, to drive the driven member in forward direction. No power is transmitted by the empty turbo coupling A.

In order to change to reverse drive, the scoop tubes are adjusted to the positions shown in FIG. 3, in which scoop tube **11'** is fully inserted into the reservoir **7'** of coupling B and the scoop tube **11** is fully withdrawn from the reservoir **7** of coupling A. Oil is rapidly transferred from reservoir **7'** to reservoir **7**, via the scoop tubes **11'** and **11**, until the reservoir **7'** and the working chamber of coupling B are empty and the reservoir **7** and the working chamber of coupling A are full. Under these conditions power is transmitted from the input shaft **4** to the output shaft **6** via the turbo coupling A, and the driven member is driven in reverse. No power is transmitted via the turbo coupling B.

The changeover from forward to reverse drive can be effected very quickly owing to the direct flow of oil from the working circuit of one coupling to the working circuit of the other coupling.

The sump provided by the stationary casing **12** serves to receive any leakage oil from the turbo couplings, and a small pump **30** is provided for returning the leakage oil from the sump into the rotating reservoirs. This pump, which may be of small capacity, is conveniently driven from the input shaft **4**. It also serves to return to the couplings oil that has drained into the sump when the couplings have been stationary. The inlet pipe **41** of the pump **30** communicates with the interior of the sump **12**, and the outlet pipe **42** of the pump communicates (see FIG. 1A) with a duct **43** in the housing **8**, which duct communicates via a port **44** with the working circuits of the couplings.

As shown in FIG. 1A, the scoop tube means **11**, **11'** is slidably mounted in the stationary housing **8**, and is provided with rack teeth **35**. A control rod **36**, also slidable in the housing **8**, is provided with rack teeth **37**, and a pinion **39** has its teeth in mesh with the rack teeth **35** and **37**. Longitudinal movement of the control rod **36** (which movement may be effected by hand or by means of a servo motor coupled to the link **40**) causes rotation of the pinion **39** and thus sliding movement of the scoop tube means **11, 11'**.

In the arrangement shown in FIGS. 4 to 6 two turbo couplings are again provided, their general arrangement being similar to that of FIGS. 1 to 3, but the couplings have individual scoop tubes which are interconnected by a mechanical linkage.

The impeller **1** of turbo coupling A is fixed on the input shaft **4**, and the runner **5** of coupling A is fixed on the output shaft **6**. The runner **5'** of turbo coupling B is fixed on sleeve shaft **10**, and the impeller **1'** is journalled on sleeve shaft **10**. An annular partition **14** is joined at its periphery to a casing **15** the end walls of which project inwardly towards stationary supoprts **16** and **16'**. An inner casing **17** is connected to the partition **14** and to the impeller **1** which is mounted on input shaft **4**, and an inner casing **17'** is connected to the partition **14** and, adjacent the shaft **10**, to the impeller **1'**, reservoir chambers **18** and **18'** thus being formed. The inner casings **17 17'** have large ports **19** and **19'** respectively which afford free communication between the reservoirs **18** and **18'** and the working chambers **20, 20'** respectively of the associated turbo couplings A and B.

The scoop tube **21** of turbo coupling A is slidable longitudinally in the support **16**, and is provided with a port which communicates with an annular duct **22** in the support **16**. At this upper end the scoop tube is provided with a rod **23** connected to one arm of a bell crank lever **24** pivotally mounted on a stationary outer casing **25** which serves as a sump. The arrangement of the scoop tube **21'** of turbo coupling B is similar to that of the scoop tube **21** of turbo coupling A, the rod **23'** of scoop tube **21'** being connected to one arm of a bell crank lever **24'** mounted on the outer casing **25**. The bell crank levers **24** and **24'** are interconnected by a link **26**.

The annular ducts **22** and **22'** in the supports **16** and **16'** are interconnected by a duct **27**, to the centre of which is connected a branch pipe **28** which leads via a valve **29** to the sump formed by the outer casing **25**. A small pump **30**, which may be driven from the input shaft **4**, serves to transfer oil from the sump to the annular duct **22**, and thence to the working chambers and reservoir chambers of the two turbo couplings.

The working chambers are of equal capacity. The capacities of the reservoir chambers **18** and **18'**, which are radially beyond the outer profile diameter of the working circuits, are equal to one another, but are each equal to about 60% of the volume of either of the working circuits **20** and **20'**.

The arrangement of FIGS. 4 to 6 is suitable for driving from a diesel engine through forward and reverse gears via couplings B and A respectively.

FIG. 4 shows the neutral condition, in which the link **26** is adjusted so that the two scoop tubes **21** and **21'** are within the respective scoop tube chambers and are not inserted into the reservoirs **18** and **18'**. In this neutral condition, the scooping orifices are slightly radially within the outer profile diameter of the couplings, and the oil filling is such that in this condition each reservoir **18** and **18'** is full, and each working circuit contains oil to 20% of its full capacity. The valve **29** is open to return to the sump the oil delivered by the pump **30**.

Assuming that the engine is idling, the slight drag torque due to the 20% filling of each working circuit is of no consequence, and no torque will be transmitted to the driven member since the runner **1** is connected to it via the reverse train and the runner **1'** is connected to it via the ahead train.

When it is required to drive the driven member in forward direction, the link **26** is moved to the left. This has the effect (FIG. 5) of fully inserting scoop tube **21** into the reservoir **18**, and of withdrawing the scoop tube **21'**. The 60% volume of oil in reservoir **18** is thereby transferred, together with the 20% volume in working circuit **20** of coupling A, to the right hand coupling B, via scoop tube **21**, annular duct **22**, pipe **27**, annular duct **22'**, and a port **32'**. Since the reservoir **18'** of coupling B was already full and the working circuit **20'** already had a 20% filling, the result of the transfer of oil from coupling A to coupling B is that the working circuit of coupling B rapidly becomes 100% full.

Power is thereby transmitted from the input shaft **4** to the driven member via turbo coupling B, shaft **10** and the forward gear train. No power is transmitted by the now empty turbo coupling A.

To change from forward to reverse drive, the link **26** is moved to the right so that, as shown in FIG. 6 the scoop tube **21'** is fully inserted into the reservoir **18'** and the scoop tube **21** withdrawn from the reservoir **18**. All of the oil in the turbo coupling B is thereby transferred to turbo coupling A, via scoop tube **21'**, annular duct **22'** duct **27**, annular duct **22** and a port **32**. Since the working circuit of turbo coupling A is now full and the working circuit of turbo coupling B is empty, power is transmitted from input shaft **4** to the driven member via turbo coupling A, output shaft **6**, and the reverse gear train. No power is transmitted by the empty coupling B.

When the system is set for forward or reverse drive, (FIGS. 5 and 6) the valve **29** is closed, as shown, for example by means mechanically connecting the valve to link **26**. The excess of oil delivered by the pump **30** into the rotating reservoirs **18** and **18'** overflows from the centre of the full coupling and returns to the sump.

I claim:

1. A power transmission system comprising an input shaft, two output shafts, a sump, two hydraulic turbo couplings each comprising a vaned impeller and a vaned runner defining a toroidal working circuit, the impellers of said couplings being drivably connected to said input shaft and the runners being drivably connected one to each of said output shafts, a pump for feeding working liquid from said sump to said turbo couplings, scoop tube means adjustable from a position to transfer working liquid from one coupling to the other coupling to a second position in which flow of working liquid between said couplings is minimized, a rotatable reservoir chamber in each coupling in free communication with the working circuit of the said coupling, each said reservoir chamber having a portion positioned radially beyond the outer profile diameter of the working circuit of the said coupling and the said portions of said reservoir chamber of both couplings having a combined capacity such that the working circuits of both couplings can be selectively filled and emptied depending on the setting of said scoop tube means in said reservoir chambers to effect flow of working liquid from one of said couplings to the other coupling and both working circuits can be substantially emptied to the said portions of said reservoir chambers when said adjustable scoop tube means are moved to said second position.

2. A power transmission system comprising an input shaft, two output shafts, a sump, two hydraulic turbo couplings each comprising a vaned impeller and a vaned runner defining a toroidal working circuit, the impellers of said couplings being drivably connected to said input shaft and the runners being drivably connected one to each of said output shafts, a pump for feeding working liquid from said sump to said turbo couplings, each coupling being provided with a rotatable reservoir chamber in free communication with the working circuit and a portion of which reservoir chamber is positioned radially beyond the outer profile diameter of the said working circuit, at least one scoop tube with scoop orifices at both ends, said scoop tube being adjustable to and between

two end positions, such that the movement of the scoop tube to one of said end positions serves to transfer working liquid from one coupling to the other coupling, and the movement of the scoop tube to the other of said end positions serves to transfer liquid from said other coupling to said one coupling, the said portions of said reservoir chambers radially beyond the outer profile diameters of said working circuits having a combined capacity such that with said scoop tube set to a predetermined position intermediate said end positions the working circuits of both couplings are substantially emptied to the said portions of said reservoir chambers.

3. A power transmission system comprising an input shaft, two output shafts, a sump, two hydraulic turbo couplings each comprising a vaned impeller and a vaned runner defining a toroidal working circuit, the impellers of said couplings being drivably connected to said input shaft and the runners being drivably connected one to each of said output shafts, a pump for feeding working liquid from said sump to said turbo couplings, each coupling being provided with a rotatable reservoir chamber in free communication with the working circuit and has a portion positioned radially beyond the outer profile diameter of the said working circuit, at least one scoop tube with scoop orifices at both ends, said scoop tube being adjustable to a plurality of positions comprising two end and a mid-position such that movement of the scoop tube away from said mid-position in one direction serves to transfer liquid from one coupling to the other coupling, and from said mid-position in the other direction serves to transfer liquid from the said other coupling to the said one coupling, the portions of said reservoir chambers radially beyond the outer profile diameters of their working circuits having a combined capacity such that with said scoop tube in said mid-position the working circuits of both couplings are substantially emptied to said portions of said reservoir chambers.

4. A power transmission system comprising a sump, two hydraulic turbo couplings each comprising a vaned impeller and a vaned runner defining a toroidal working circuit, each coupling having a rotatable reservoir, chamber in free communication with the working circuit of the said coupling and having a portion positioned radially beyond the outer profile diameter of the working circuit of said coupling, a pump for feeding working liquid from said sump to said turbo couplings, an adjustable scoop tube in each coupling in communication with the working circuit of the other coupling and adjustable from a position to transfer working liquid from one coupling to the other coupling to a second position in which flow of working liquid between said couplings is minimized, said portions of said reservoir chambers having a combined capacity such that said working circuits can be selectively filled and emptied depending upon the setting of the adjustable scoop tubes to effect flow of working liquid from one of said couplings to the other of said couplings and both working circuits can be substantially emptied to the said portions of said reservoir chambers when said adjustable scoop tubes are moved to said second position.

5. A power transmission system comprising a sump, two hydraulic turbo couplings each comprising a vaned impeller and a vaned runner defining a toroidal working circuit (each coupling being provided with a rotatable reservoir chamber in free communication with the working circuit and having a portion positioned radially beyond the outer profile diameter of the said working circuit, a pump for feeding working liquid from said sump to said turbo couplings, at least one scoop tube with scoop orifices at both ends, said scoop tube being adjustable to any of a plurality of positions including two end positions, such that the adjustment of the scoop tube to one of said end positions serves to transfer working liquid from one coupling to the other coupling and the adjustment of the scoop tube to the other of said end positions serves to transfer liquid from said other coupling to said one coupling, the portions of said reservoir chambers that are radially beyond the outer profile diameters of their working circuits having a combined capacity such that in a neutral setting of said scoop tube in which flow of liquid between the couplings is minimized the working circuits of both couplings are substantially emptied to the said portions of said reservoir chambers.

6. A power transmission system comprising a sump, two hydraulic turbo couplings each comprising a vaned impeller and a vaned runner defining a toroidal working circuit, each coupling being provided with a rotatable reservoir chamber in free communication with its working circuit and having a portion positioned radially beyond the outer profile diameter of the said working circuit, a pump for feeding working liquid from said sump to said turbo couplings, a scoop tube with scoop orifices at both ends, said scoop tube being adjustable to a plurality of positions including a mid-position such that movement of the scoop tube away from said mid-position in one direction serves to transfer liquid from one coupling to the other coupling, the movement of the scoop tube away from said mid-position in the other direction serves to transfer liquid from the said other coupling to the said one coupling, the portions of said reservoir chambers positioned radially beyond the outer profile diameters of their working circuits having a combined capacity such that with said scoop tube in said mid-position the working circuits of both couplings are substantially emptied to the said portions of said reservoir chambers.

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