July 1, 1930. H. SINCLAIR 1,768,938

HYDRAULIC POWER TRANSMITTING APPARATUS

Filed Oct. 5, 1926 4 Sheets-Sheet 1

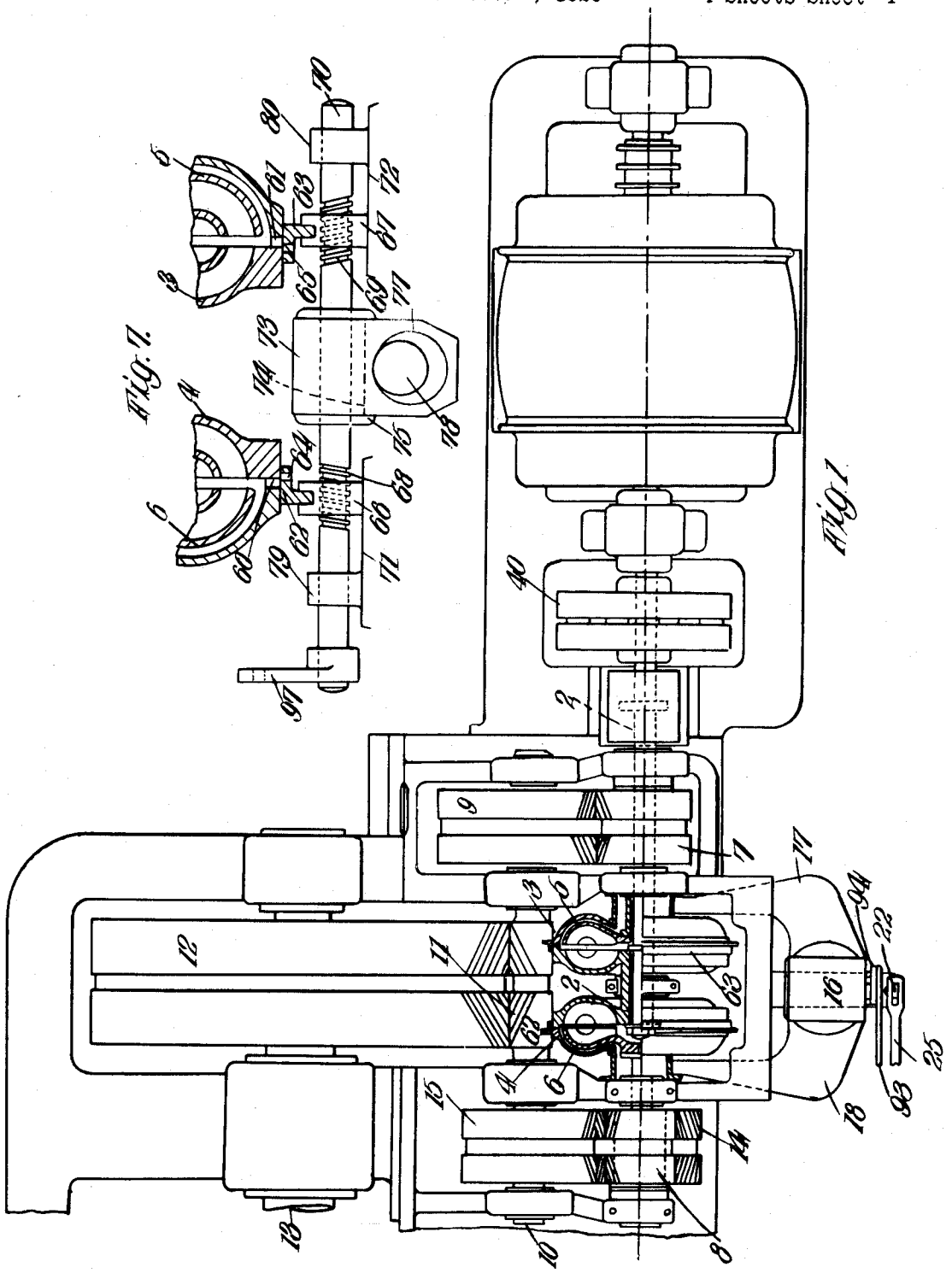


Fig. 1.

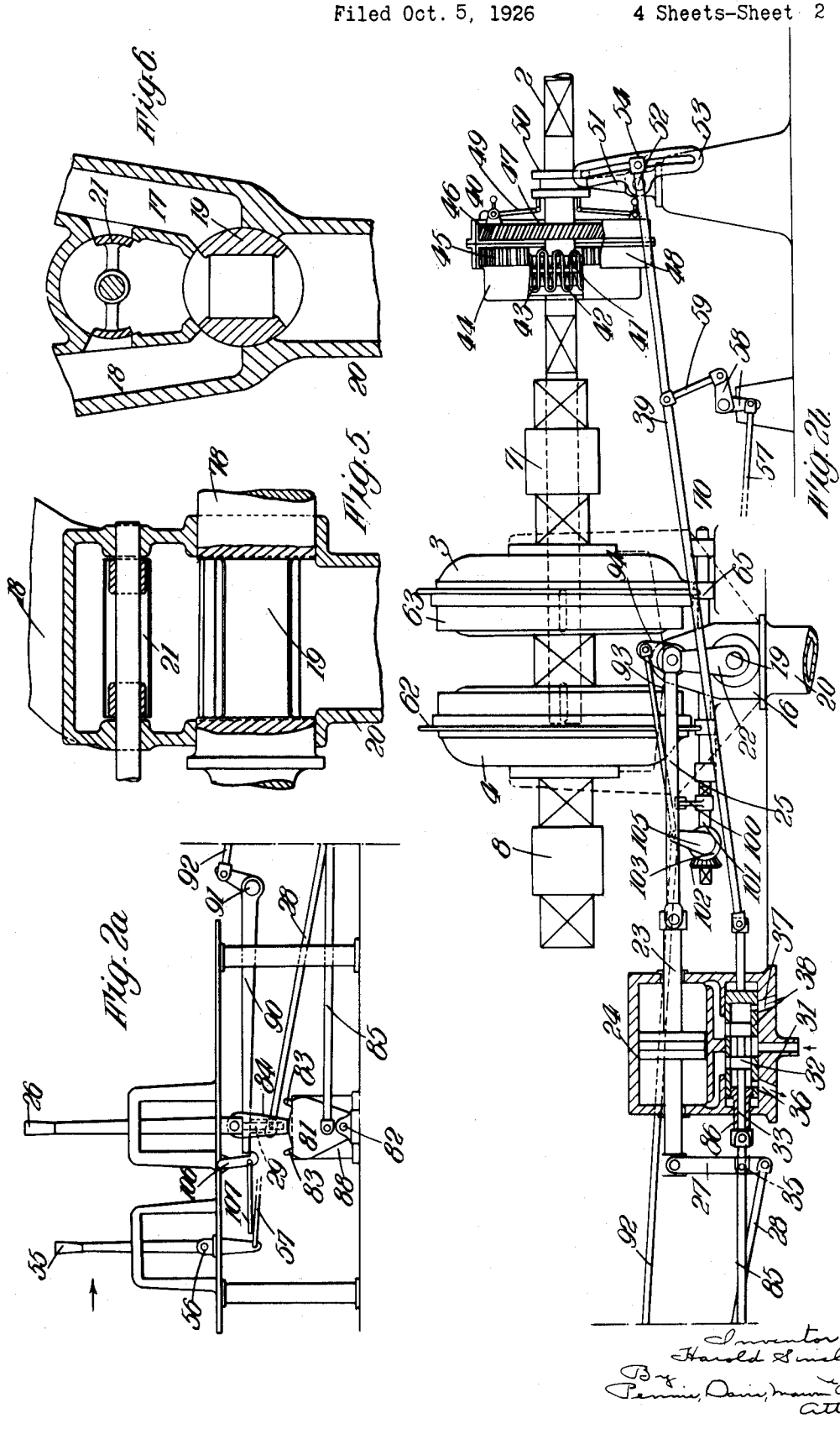
Fig. 7.

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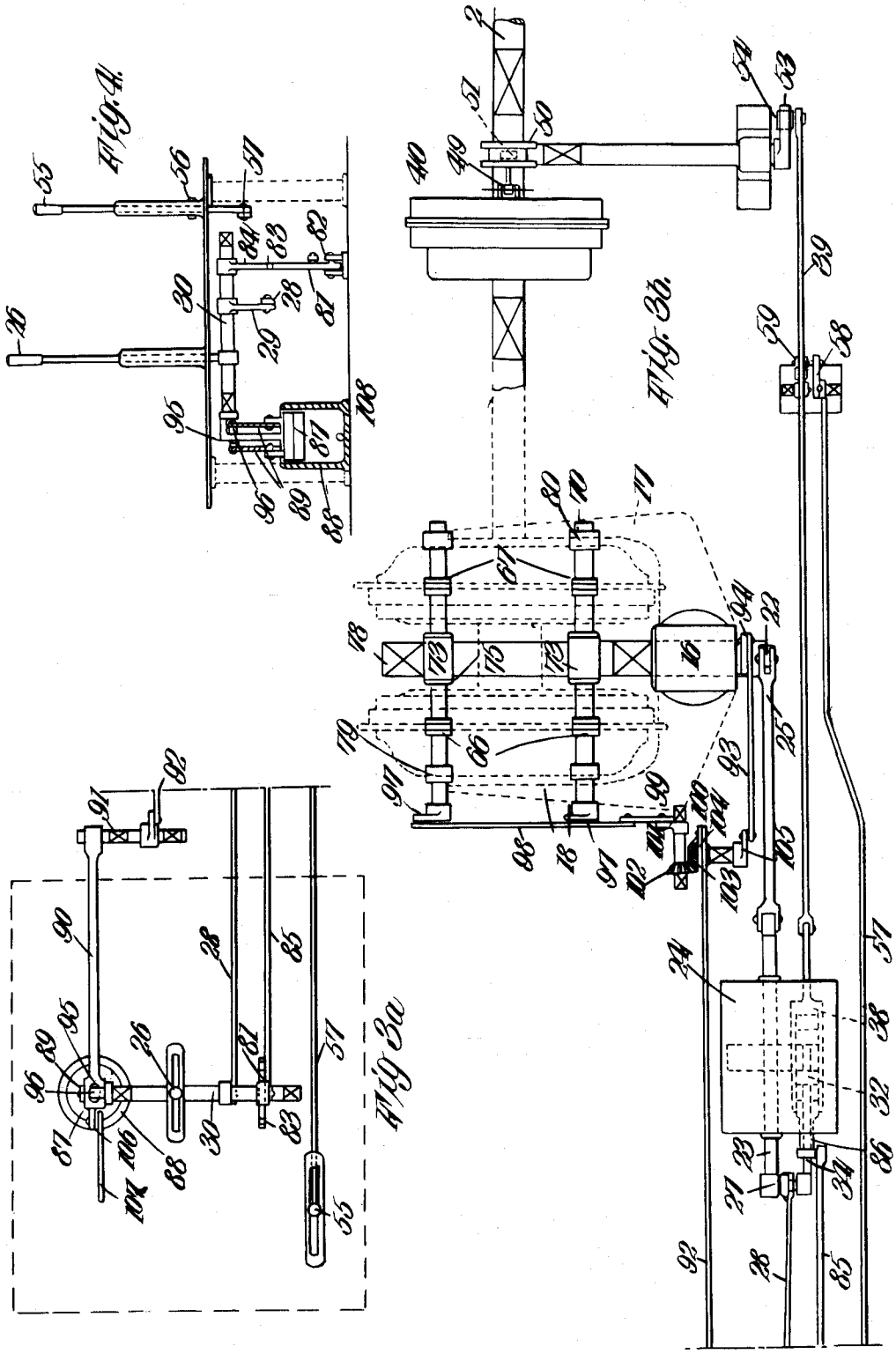
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HYDRAULIC POWER TRANSMITTING APPARATUS

Filed Oct. 5, 1926 4 Sheets-Sheet 3



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HYDRAULIC POWER TRANSMITTING APPARATUS

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Fig. 8.

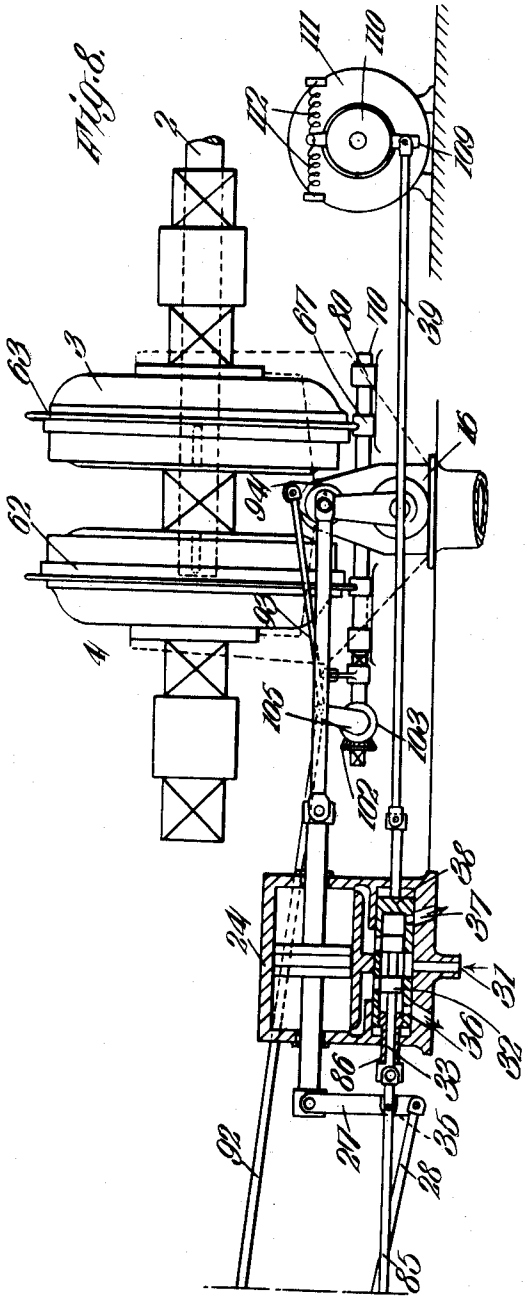
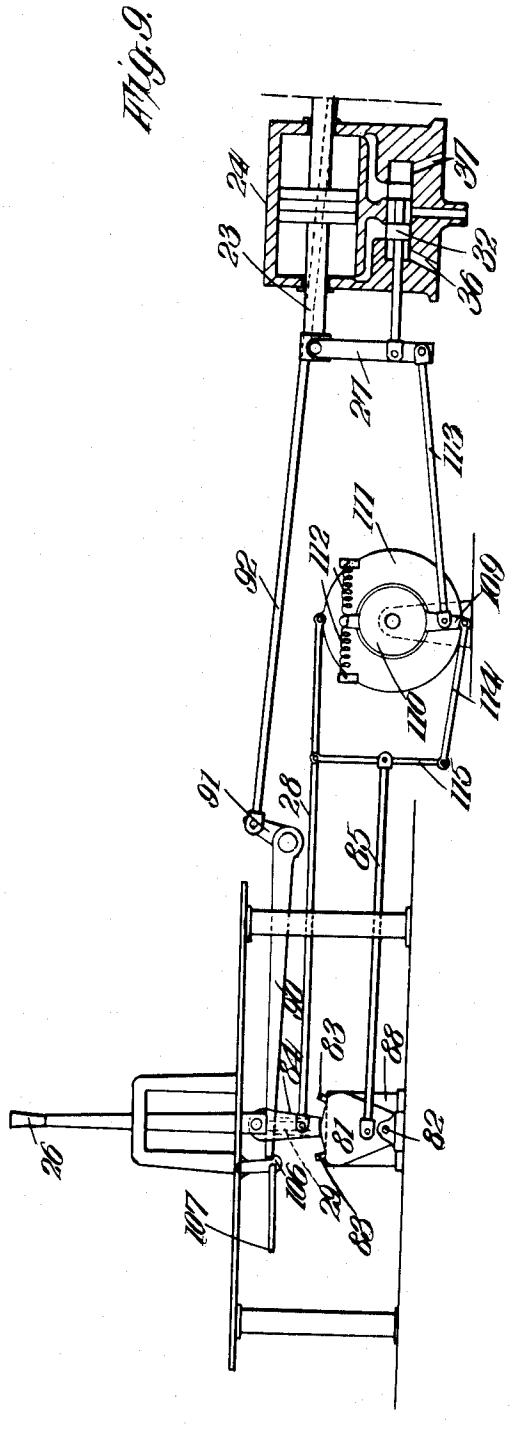


Fig. 9.



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UNITED STATES PATENT OFFICE

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HYDRAULIC POWER-TRANSMITTING APPARATUS

Application filed October 5, 1926, Serial No. 139,744, and in Great Britain October 8, 1925.

The present invention relates to hydraulic power transmission apparatus intended for use between a continuously running motor and mechanism, such as winding engines, haulages or rolling mills in which it is normally required to accelerate a shaft from rest to full speed under load and wherein frequent reversals are also required.

In winding mechanism for mine cages, haulages and the like it has been proposed to insert between the winding drum and the driving motor which may run continuously in one direction a hydraulic variable ratio gear of the type in which reciprocating parts are employed and the power is transmitted through liquid at high pressure acting on plungers fitted in cylinders or against vanes fitted in a rotor mounted eccentrically in a casing, control being provided for determining the gear ratio and direction of drive by adjustment of the volume and direction of flow of the liquid delivered by a pump unit to a hydraulic motor unit.

Such mechanism is necessarily complicated and on account of the high pressures used in order to limit the size and cost and to maintain the efficiency, and in view of the number of closely fitting working parts and internal bearings employed, such gears are inherently liable to breakdown. Further, it is found that in sizes necessary to transmit the power required for large winding engines under modern mining conditions, apparatus of this type becomes unduly and even prohibitively unwieldy and costly and it is primarily to overcome these disadvantages and to produce winding mechanism of increased simplicity and reliability that the present invention has been evolved.

According to this invention the drive is transmitted through a hydraulic coupling or speed transformer of the Föttinger or other turbine type, for example as described in Patent No. 1,199,359, in which the torque is transmitted kinetically and the driving pressure of the liquid is comparatively low, and wherein there are no internal working parts, or bearings or fine running clearances under high pressure. The above mentioned disadvantages of the high pressure transmission apparatus are thus avoided, whilst direct driving of the coupling by an inexpensive, compact, high speed prime mover may conveniently be employed, and furthermore ease of control with simple mechanism is obtained by filling or emptying the coupling, and effective braking either by the application of power or even in the event of failure of power may be secured.

In a coupling or transformer of the kind referred to there are two elements, one (termed the impeller) rotated continuously by the prime mover, and the other (termed the runner) coupled to the mechanism to be driven, a torque being transmitted from one element to the other hydraulically when water or other liquid is admitted to the casing. The liquid picked up by the rotating impeller is discharged at high velocity from its periphery into the runner where it impinges on the vanes of the runner to cause the latter to rotate, the liquid being discharged from the runner near its centre and returned to the inlet of the impeller. The torque exerted by the runner varies with the quantity of liquid in the casing and with the speed of the runner according to the resistance of the driven mechanism, the control being effected by control inlet and outlet valves. In apparatus such as winding engines or the like the simple opening and closing of the said valves is not ideal for the control of the hydraulic unit when connected to the drum and cages which possess considerable inertia and wherein the time taken for acceleration is correspondingly important. The rate of inflow of the liquid might be restricted so that the casing fills relatively slowly, with the object of giving time for acceleration of the driven shaft without unduly loading the prime mover (such as would occur if the casing were filled up rapidly), but with a restricted inflow of liquid there is an undesirably long interval of time between the instant of opening of the inlet valve (and the closing of the outlet valve) and the instant at which the quantity of liquid admitted is sufficient to transmit the requisite torque to start the load from rest, and in order to reduce to a negligible amount the said interval of time and effect

the subsequent acceleration of the load without overloading the prime mover we provide according to this invention a control gear by which the inlet is first opened widely so as to cause the liquid to flow rapidly into the casing of the hydraulic unit and by which, as soon as the requisite high torque has been developed to start the mechanism from rest, the inlet is restricted to complete the filling in a relatively slow manner so as to spread the acceleration period over any desired short interval of time. For this purpose the inlet valve may be under the conjoint control of a hand lever and a device responsive to the torque developed or other mechanism designed to give the desired variation of valve opening, the hand lever serving to open the valve initially and the said device serving automatically to vary the opening in accordance with the requirements.

In carrying out the invention, two of the aforesaid clutches or couplings may be used, the primary elements of the two hydraulic units being driven in the same direction from the driving motor, while the secondary element of the first unit would be geared to the drumshaft, and the secondary element of the second unit would drive the drumshaft through an intermediate gear wheel to give the desired reverse direction of motion. In a convenient form of this type of apparatus both hydraulic units may be combined in a single structure having a common primary element.

In order that the invention may be clearly understood and readily carried into effect it will now be described by way of example with reference to the accompanying drawings which illustrate its application to a winding engine, and in which:—

Figure 1 shows in plan view a general arrangement of the driving motor, hydraulic couplings and mechanical gearing,

Figures 2^a and 2^b illustrate in side elevation and

Figures 3^a and 3^b in plan the hydraulic couplings with their control gear,

Figure 4 is an end view of Figure 2^a in the direction of the arrow in the latter figure showing the relative positions of the control levers,

Figures 5 and 6 are respectively longitudinal and transverse sections of the main and auxiliary inlet valves to the hydraulic couplings,

Figure 7 is a fragmentary view on a large scale of the means employed for operating the outlet valves of the hydraulic couplings and

Figures 8 and 9 respectively depict modified forms of control gear.

Referring to Figure 1, an electric motor 1 or other form of driving mechanism is connected by a shaft 2 to the two driving members 3 and 4 of the hydraulic couplings, the corresponding driven members 5 and 6 being fitted respectively with pinions 7 and 8. The pinion 7 serves for forward drive by engagement with a gear wheel 9 mounted on a shaft 10 which also carries a pinion 11 meshing with a gear wheel 12 on the main winding drum shaft 13. Reverse drive is obtained from the pinion 8 which meshes with an idler gear wheel 14 beneath it engaging in turn a gear wheel 15 on the shaft 10. Liquid supply to the hydraulic coupling is by means of a main and auxiliary valve designated generally by the numeral 16, the supply to the forward and reverse couplings being respectively through conduits 17 and 18.

Referring to the control mechanism illustrated in Figures 2 to 7, the valve 16 comprises, as indicated in Figures 5 and 6, a main inlet member 19 adapted to admit liquid from the supply pipe 20 to either coupling, and an auxiliary inlet member 21 for the purpose of admitting liquid simultaneously to both couplings. In the setting of the members 19 and 21 shown, inlet from the supply pipe 20 is entirely cut off and and it will be seen that, on the member 19 being rotated in one direction or the other, liquid will be supplied to the corresponding coupling by one of the conduits 17 or 18. On the other hand, oscillation of the member 21 serves to admit liquid simultaneously to both conduits, resulting in the simultaneous filling of both couplings for braking purposes. The member 19 is rotated by a crank 22 operated from the piston rod 23 of a servo-motor 24 by means of a connecting rod 25. The piston rod 23 is also connected with a hand control lever 26 by means of a hunting lever 27, connecting rod 28 and lever 29 mounted on a way-shaft 30 on which the control lever 26 is also fixed. Fluid under pressure is supplied to the servo-motor 24 through the inlet passage 31 and a piston valve 32, the rod 33 of which is, by means of a short extension 34, jointed at 35 to the hunting lever 27. Outlet of fluid pressure from the servo-motor 24 is by means of one of the ports 36 or 37. Fluid inlet and outlet is also under the control of a sleeve valve 38 having ports as indicated and connected by means of a connecting rod 39 with mechanism 40 interposed in the driving shaft 2 and responsive to the torque transmitted by that shaft. Such a torque-responsive device may be constituted by a flexible coupling of the well-known "Wellman-Bibby" type which commonly comprises discs 41, 42 on the driving and driven shafts respectively provided with external projections around which a sinuous spring 43 is fitted, this spring being normally retained in place by a cylindrical steel casing 44 attached to one of the discs, for example the driven disc. In carrying out the invention, teeth 45, the direction of which may be parallel to the shaft axis, are formed on the outside of the cylindrical steel

casing 44 and corresponding teeth 46, which, however, are helical, are formed on the periphery of a third disc 47 carried by the driving shaft 2. These two series of teeth are connected by an external ring 48 on the internal periphery of which are cut teeth corresponding in pitch and direction with those on the cylindrical steel casing 44 and the disc 47 respectively. Thus, as torque is transmitted through the coupling there will be a proportional slight relative angular displacement between the driving and driven discs 41 and 42, resulting in axial motion of the external ring 48 proportional in amount to the torque transmitted. By means of suitable multiplying levers 49, pivoted to the disc 47, and fitted with centrifugal flyweights (or a spring) to cause the ring 48 to be forced continuously to the left (as seen in Figure 2[b]) so as to take up any backlash, this motion may be transmitted to a sleeve 50 adapted to slide on the driving shaft 2 and from this sleeve by such means as a lever 51, mounted on a spindle 52 to which is fitted a curved link 53 wherein a block 54, carried by the connecting rod 39, is adapted to be moved in order to produce reverse motion in the well-known manner. This is necessary since the torque-responsive device 40, which is always rotated in the same direction, is required to give opposite movements of the valve sleeve 38 depending on whether the drive is to be transmitted through the forward or reverse coupling. The block 54 is oscillated along the curved link 53 by means of a reversing lever 55, pivoted at 56 and connected to the rod 39 by a link 57, bell crank lever 58 and link 59.

As indicated in Figures 1 and 7 outlet from the hydraulic couplings is by means of a series of apertures 60, 61 in the driving members 3 and 4. These apertures are adapted to be closed by axially movable rings 62, 63 encircling the driving members and having apertures 64, 65 adapted to be brought respectively into or out of register with the apertures 60, 61. In the normal non-operative position these series of apertures are, in both couplings, slightly in register in order to allow the couplings to drain. When, however, it is desired to fill either coupling the corresponding ring 62 or 63 is moved axially to bring the two series of apertures in that coupling completely out of register. To this end each ring 62 and 63, as indicated, is formed with a peripheral flange adapted to be embraced at one or more points around the circumference by fork-shaped members 66, 67. These respectively engage with oppositely threaded portions 68 and 69 on a spindle 70 and are prevented from rotating by bearing on guiding surfaces 71, 72, on which they are adapted to slide. The spindle 70 is embraced by a block 73 having an aperture 74 formed therein for this purpose and mounted between collars 75, 76 on the spindle 70. The block 73 is formed with a circular aperture adapted to engage an eccentric 77 mounted on a spindle 78, which is formed as an extension of the valve member 19. The spindle 70 is mounted in bearings 79, 80 in which it is free both to rotate and to move longitudinally. Thus, on the valve member 19 being rocked in one direction or the other to fill one of the couplings, the spindle 70, is by the above described mechanism, moved longitudinally, thus closing the outlet openings of the corresponding coupling and completely opening those of the other coupling. As indicated in Figure 3[b], in the apparatus illustrated two spindles 70 with their corresponding valve mechanism are adapted to be actuated by a single spindle 78 extending from the main inlet valve member 19.

The sequence of operations in employing the above described control mechanism during a typical winding cycle is as follows:— Assuming the hand control lever 26 to be moved from the mid-neutral position shown to or toward full "forward" in the direction to raise the loaded cage, this movement serves, by means of the link 28, to rock the hunting lever 27 about its joint with the piston rod 23, thus moving the piston valve 32, say, to the left. Fluid under pressure is then admitted through the inlet 31 to the left-hand side of the servo-motor piston whereby it is moved toward the right, with the result that the piston valve 32 cuts off the supply of fluid pressure to the servo-motor cylinder. This motion of the servo-motor piston, however, serves to open the main valve 19 widely, so that liquid is admitted from the supply pipe 20 by means of the conduit 17 to the forward hydraulic coupling, which, therefore, begins to transmit power. Due to this fact, the torque-responsive device 40 comes into operation as above described, with the result that the curved link 53 is deflected by an amount depending on the torque transmitted. This gives rise, owing to the fact that the block 54 would be located at that end of the link 53 corresponding to forward drive, to motion of the valve sleeve 38, in this case toward the left, whereby fluid is admitted to the right hand side and exhausted from the left-hand side of the servo-motor piston, resulting in partial closure of the main inlet valve 19. Hence, as a result of the movement of the hand control lever 26 to or toward the full "forward" position, a rapid initial filling of the forward hydraulic coupling has been effected followed by completion of the filling at a reduced rate, the reduction depending on the torque transmitted through the driving shaft 2. When the wind has been completed the hand control lever 26 is returned to its neutral position, whereby the piston valve 32 is moved towards the right, admitting fluid under pressure to the right-hand

side of the servo-motor piston and allowing exhaust through the outlet port 36. The piston is thereby centralized with the result that the piston valve 32 cuts off fluid supply from the servo-motor cylinder and the main inlet valve 19 is closed. At the same time, by means of the mechanism above described, the outlet valve of the forward coupling is opened so that the coupling is emptied. A similar sequence of events occurs when running in the reverse direction, and it will be seen that the winder may readily be controlled and manœuvred by "forward" and "reverse" movements of the hand control lever. The practical advantage of the acceleration control obtained automatically with the use of a torque-responsive device is that a given maximum horsepower is available for acceleration, irrespective of load, with the result that the normal load is accelerated in the normal designed period; whereas heavier loads, due to working unbalanced, for example, would be accelerated in a slightly longer period (and lighter loads proportionately faster) without exceeding the normal maximum horsepower—such as would occur if a fixed rate of acceleration were maintained.

A characteristic of the control gear which is of special importance in the case of winding engines is that the maximum torque which may be transmitted to the winding drum bears a definite relationship to the position of the lever 26, the torque increasing in amount as the lever is moved from neutral towards the full forward or reverse positions. It will be seen that when both the hand levers 26 and 55 have been put over in the same direction to give, say, forward running and a substantial torque is being transmitted, the lever 26 might be brought back through the neutral position and into reverse position without corresponding motion of the lever 55, an action which would give rise to incorrect relative setting of the piston valve 32 and sleeve valve 38 which would result in an action different from that desired and possibly dangerous. In order to prevent this, means is provided whereby, when the lever 26 has been moved from the neutral position in one direction or the other, it cannot, while substantial power is being transmitted, be brought back through the neutral position into such a position as to effect reversal. This means is constituted by the provision of a member 81 adapted to rock about a pivot 82 and provided with stops 83 adapted to cooperate with a lever 84 depending from the way-shaft 30. The rocking member 81 is connected with the torque-responsive device in such a way that, on the transmission of torque, it is rocked so that one of its stops 83 follows up the motion of the lever 84 and thereby prevents return motion of the hand control lever 26 beyond a certain point until the value of the torque has dropped below a predetermined amount. For this purpose the rocking member 81 may be connected by a link 85 with an extension 86 of the sleeve valve 38, the piston rod 33 being arranged to pass freely through this extension.

For the purpose of providing emergency braking means, it is possible, by means of the auxiliary valve 21, to allow liquid to be admitted simultaneously to both hydraulic couplings, the outlet valves of both couplings being at the same time closed. For this purpose brake weights 87 working in a dash-pot 88 are suspended by links 89 from a bell crank lever 90, pivoted at 91 and connected by links 92 and 93 to a crank 94 on the spindle of the auxiliary inlet valve 21. As shown in Figure 3ª, the lever 90 is formed with an aperture 95 surrounding a depending tail-piece 96 on the way shaft 30; thus, on descent of the brake weights, the hand control lever 26 is automatically centralized and power cut off by allowing the hydraulic coupling in operation to be emptied. In emergency braking, to close the outlet apertures of both couplings simultaneously it is necessary that the spindles 70 shall be rotated, thus simultaneously moving the rings 62 and 63 in such a direction axially as to close both sets of apertures. This is accomplished by providing on each spindle 70 a crank 97, these cranks being connected together by a link 98 which is joined by a second link 99 to a crank 100 on a spindle 101, having a bevel wheel 102 engaging a second bevel wheel 103 adapted to be rotated from the link 92 by means of a crank 104. Rotating with this crank 104 is a second crank 105 jointed to the link 93 whereby the auxiliary valve 21 is rocked. The brake weights 87 are normally held in the raised position shown in Figure 4 by a detent 106 (Figures 2ª and 9) adapted to engage the end of the lever 90, but connected by a link 107 with the emergency trip gear normally provided in such a manner that, on operation of this gear, the detent is withdrawn thus allowing the brake weights 87 to descend in the dash-pot 88. An outlet 108 is provided near the bottom of the latter and may be fitted with a valve whereby the rate at which air can escape and therefore the rate of descent of the brake weights may be regulated. Further, when it is desired again to raise the brake weights, this may be accomplished by applying air pressure through the aperture 108. It will be realized that, on release of the detent 106, the air in the dash-pot 88 being at atmospheric pressure, the descent of the brake weights 87 is at first at a rapid rate and subsequently at a reduced rate; thus the auxiliary valve 21 is completely opened immediately on release of the weights 87, but continuance of its rotation results in its partial closure so that there is an initial rapid simultaneous filling of the couplings followed by completion of the filling at a reduced rate, an action which

is desirable in emergency braking conditions as well as in the normal operation of the apparatus.

In Figure 8 there is depicted a modification in which the mechanical torque-responsive device 40 is replaced by electrical mechanism performing a similar function. The figure corresponds to Figure 2b, and it will be seen that the link 39 jointed to the sleeve valve 38 is hinged at its other end to a lever 109 fast on the rotor 110 of an electrical device, which may be similar in general features to an ordinary induction motor. The stator 111 is excited in proportion to the load on the motor 1, for example, by means of a series transformer inserted in the motor circuit. Thus a torque will be applied to the rotor in accordance with the torque from the motor 1, but the rotor is only allowed to rotate through an angle corresponding to the latter owing to the presence of centering springs 112 connecting the stator and rotor as indicated. In order that the torque applied to the rotor may have a direction corresponding to that in which power is being transmitted, a reversing switch is inserted in the stator circuit, being operated by means of the hand control lever 26 to excite the stator in one direction or the other according as this lever is moved toward the "forward" or "reverse" position.

In the modification shown in Figure 9 an electrical torque-responsive device is also employed, but it is inserted between the hand control lever 26 and the servo-motor 24. In this case both the rotor 110 and the stator 111 are capable of rotation about their common axis, the link 28 which is directly moved by the hand control lever 26 being jointed to the stator and the rotor being connected with the hunting lever 27 by a link 113. The lever 109 carried by the rotor is also connected by a link 114 with a hunting lever 115, to a point intermediate of which the link 85 jointed to the rocking member 81 is connected. On movement of the hand control lever 26 from the neutral position in either direction, the stator 111 will be correspondingly rocked and, since the motor 1 is running under conditions of no load or light load, the excitation of the stator is insufficient to overcome the pressure exerted by the centering springs 112; consequently the rotor 110 rocks through the same angle as the stator 111, thus opening the piston valve 32 with the result that the filling action of the corresponding hydraulic coupling is commenced as above described. On increase of torque transmitted, however, the stator 111 becomes excited to such a degree and in such a direction, owing to the interposition of a reversing switch operated by the hand control lever 26, that sufficient torque is exerted on the rotor 110 to produce a relative displacement between it and the stator 111 in a direction opposite to that in which they were jointly rocked. The effect of this is to move the piston valve 32 in a direction opposite to that in which it was originally moved, whereby the piston of the servo-motor 24 is returned somewhat toward its neutral central position, thereby partially closing the main inlet valve 19 and reducing the rate at which the filling of the corresponding coupling is completed. It will be seen that, since the link 85 is connected to the hunting lever 114 approximately at the mid point of the latter, no substantial motion of the rocking member 81 will occur on movement of the hand control lever 26 from its neutral position. As, however, the torque transmitted increases, producing relative angular movement between the rotor 110 and the stator 111, the member 81 is rocked in such a direction as to prevent return of the lever 26 toward or through its neutral position until the torque transmitted has fallen to a predetermined value. It will be observed that in this modification, since both the motion of the hand control lever 26 and that due to the torque-responsive device are transmitted to the hunting lever 27, the sleeve valve 38 may be dispensed with, the piston valve 32 serving to perform both its own functions and those of the sleeve valve.

It will be appreciated that the servo-motor may be fitted with centering springs or rams; such devices, being of ordinary construction, have for simplicity's sake been omitted from the drawings. Further, in the case of plants of comparatively small power it may be feasible to omit the servo-motor altogether. In that case the hand control lever and the torque-responsive device would, by such means as links, be connected to opposite ends of a hunting lever, to an intermediate point on which the link 25 operating the main inlet valve 19 would be jointed.

Braking may be obtained by movement of the control lever from forward into reverse, which causes the forward coupling to be exhausted of liquid and the reverse coupling to be filled. This is an important practical feature of the control as applied to electric winding, for in this manner reverse power braking in any degree up to the maximum "pull-out" torque of a continuously forward running synchronous or asynchronous motor can be applied to stop the winder. It is for example a well-known characteristic of reverse current braking on three-phase winders that there is a liability of a run-away occurring, in cases where the load tends to speed up the winder, e. g., when bringing to rest a descending load. Under such conditions, if the motor speed is allowed to increase by a very small percentage only, during the interval of time in which reversal is effected,

the braking power available becomes reduced, and actually falls off to an increasing degree as the lever is moved further into reverse.

With the hydraulic system described, on the other hand, the effect of filling the reverse clutch is merely to apply the power of the motor in the contrary direction to that in which the winder is running, the braking power thus available being of a very high order irrespective of the winding speed and having a definite value according to the position of the lever 26. Correspondingly, the working speed may be increased with safety, and the sense of security to the driver in conditions of emergency is improved.

The operation of lowering a load at full speed is effected regeneratively for the reason that, as soon as the load has been accelerated by the filling of the requisite coupling, the load commences to over-run due to the action of gravity, and power is consequently transmitted from the drum through the "driving" coupling to the motor, tending to increase the speed of the latter which therefore acts as a generator returning energy to the line, whilst maintaining constant the speed of the descendidng load. Towards the end of this lowering operation, the driver would reverse his lever, so as to apply the power of the motor against the load, and bring the winder to rest, the great braking power available enabling this to be done with safety. Should it be desired to lower an awkward load, at reduced speed, this would be done by applying reverse power from the motor against the load during the complete operation.

An emergency condition may occur with a winder if the power supply were to fail when the cages were approaching bank at full speed, i. e. at the moment retardation ought normally to commence. In such a circumstance, the post brakes would automatically be applied by the action of the brake magnet, but, owing to the high drum speed, the mechanical brakes might not, (unassisted by reverse power) be capable of bringing the winder safely to rest. With the hydraulic winder in such circumstances liquid would automatically be admitted to both the forward and reverse sides of the hydraulic couplings simultaneously by the mechanism previously described, this resulting in a powerful hydraulic braking effect (due to the secondary elements 5 and 6 rotating in opposite directions whilst power is cut off from the impellers 3 and 4) to assist the mechanical brakes in bringing the winder rapidly to a standstill.

In describing the mechanical torque-responsive gear, mention has been made of the combination of a flywheel with the prime mover. Where the latter is an induction motor, it will be requisite to include a slip regulator or resistance in the rotor circuit so that the motor may slow down slightly during peak load conditions and permit of the flywheel giving up part of its stored energy to equalize the demand on the power supply system in the manner of the well known Ilgner winding system. In the event of failure of power with such an equipment, the stored energy in the flywheel would be available for braking purposes.

When the prime mover is a continuously running steam engine, turbine or internal combustion engine the coupling of a flywheel to the driving shaft together with the use of a governor of suitable loadspeed characteristics will enable the peak loads incidental to winding operations to be equalized with resulting decrease in size of the prime mover and where the latter is steam driven, substantial decrease in the size of the boiler plant and improved efficiency, due to the equalization of the steam demands thereon.

In cases where a flywheel is coupled to the driving motor it is desirable in the event of stoppage on emergency being required to disconnect the flywheel from the drive of the winder and the descent of the brake weights 87 is therefore arranged to open the exhaust ports 60 and 61 of both the forward and reverse couplings and thus disconnect the flywheel. In such cases the auxiliary valve 21 is not required to secure emergency hydraulic braking as described and would not be provided.

In the above description and in the following claims, wherever the term "hydraulic coupling" is used, it is to be understood as including hydraulic speed transformers.

What I claim and desire to secure by Letters Patent of the United States is:—

1. Power transmission apparatus comprising in combination a driving shaft, a driven shaft, and intermediately of said shafts, a hydraulic coupling of the turbine type wherein energy is transmitted kinetically, inlet and exhaust valves for said coupling, means for closing said exhaust valve and for first opening said inlet valve widely whereby the coupling is rapidly partially filled and for then partly closing said inlet valve whereby completion of the filling operation takes place at a reduced rate.

2. Power transmission apparatus comprising in combination a driving shaft, a driven shaft, and intermediately of said shafts, a hydraulic coupling of the turbine type wherein energy is transmitted kinetically to rotate said driven shaft in one direction, a second hydraulic coupling of the turbine type to rotate said driven shaft in the opposite direction, and braking mechanism comprising inlet valve means to both hydraulic couplings and means for first opening said inlet valve widely whereby both couplings are

simultaneously rapidly partially filled and for then partly closing said inlet valve whereby completion of the filling operation takes place at a reduced rate.

3. Power transmission apparatus comprising in combination a driving shaft, a driven shaft, and intermediately of said shafts, a hydraulic coupling of the turbine type wherein energy is transmitted kinetically to rotate said driven shaft in one direction, a second hydraulic coupling of the turbine type to rotate said driven shaft in the opposite direction and braking mechanism comprising means whereby both hydraulic couplings may be simultaneously filled with liquid initially at a rapid rate and finally at a reduced rate.

4. Power transmission apparatus comprising in combination a driving shaft, a driven shaft, two hydraulic couplings of the turbine type wherein energy is transmitted kinetically rotated by said driving shaft and connected with said driven shaft, a series of outlet apertures around each hydraulic coupling, an axially movable ring around each of said series of apertures, means for moving said rings together in one direction or the other for the purpose of covering one or other of said series of apertures and for moving said rings relatively to each other into positions in which both of said series of apertures are covered.

5. Power transmission apparatus comprising in combination a driving shaft, a driven shaft, two hydraulic couplings of the turbine type wherein energy is transmitted kinetically rotated by said driving shaft and connected with said driven shaft, a series of outlet apertures around each hydraulic coupling, an axially movable ring around each of said series of apertures, a spindle having right- and left-hand threaded portions, members respectively mounted on said portions and engaging said rings and means for imparting longitudinal and rotational motion to said spindle.

6. Power transmission apparatus comprising in combination a driving shaft, a driven shaft, two hydraulic couplings of the turbine type wherein energy is transmitted kinetically rotated by said driving shaft and connected with said driven shaft, a main inlet valve for admitting liquid to either of said hydraulic couplings, a supplementary inlet valve for admitting liquid simultaneously to both of said hydraulic couplings, an outlet valve fitted to each of said hydraulic couplings, means for opening or closing said outlet valves separately and simultaneously opening said main inlet valve to the one of said hydraulic couplings in which, for the time being, said outlet valve is closed and means for simultaneously opening or closing said outlet valves and correspondingly closing or opening said supplementary inlet valve.

7. Power transmission apparatus comprising in combiantion a driving shaft, a driven shaft, two hydraulic couplings of the turbine type wherein energy is transmitted kinetically rotated by said driving shaft and connected with said driven shaft, a main inlet valve for admitting liquid to either of said hydraulic couplings, a supplementary inlet valve for admitting liquid simultaneously to both of said hydraulic couplings, an outlet valve fitted to each of said hydraulic couplings, means for opening or closing said outlet valves separately and simultaneously opening said main inlet valve to the one of said hydraulic couplings in which, for the time being, said outlet valve is closed and means for simultaneously opening or closing said outlet valves and correspondingly closing or opening said supplementary inlet valve comprising brake weights co-operating with an air-filled dashpot whereby said supplementary inlet valve is opened to admit liquid initially at a rapid rate and finally at a reduced rate.

8. Power transmission apparatus comprising in combination a driving shaft, a driven shaft and, intermediately of said shafts, a hydraulic coupling of the turbine type wherein energy is transmitted kinetically, inlet and exhaust valves for said coupling, a controlling lever for said valves and a connection between said lever and said valves comprising means for initially opening said inlet valve by an amount corresponding to the movement of said lever and a torque-responsive device for partially closing said inlet valve subsequently to said opening operation.

9. Power transmission apparatus comprising in combination a driving shaft, a driven shaft and, intermediately of said shafts, a hydraulic coupling of the turbine type wherein energy is transmitted kinetically, inlet and exhaust valves for said coupling, a controlling lever for said valves and a connection between said lever and said valves, whereby on a given movement of said lever said inlet valve is first opened to a corresponding extent and is then partially closed by an amount dependent upon the torque being delivered to said driven shaft.

10. Power transmission apparatus comprising in combination a driving shaft, a driven shaft, and, intermediately of said shafts, forward and reverse hydraulic couplings of the turbine type wherein energy is transmitted kinetically, inlet and exhaust valves for each of said couplings, a controlling lever for said valves and a connection between said lever and said valves of such a nature that, on said controlling lever being set to its extreme forward or reverse position, in respect of the corresponding coupling said outlet valve is closed and said inlet valve is first fully opened and is then partially closed.

11. Power transmission apparatus comprising in combination a driving shaft, a

driven shaft, and, intermediately of said shafts, forward and reverse hydraulic couplings of the turbine type wherein energy is transmitted kinetically, inlet and exhaust valves for each of said couplings, a controlling lever for said valves and a torque-responsive device in association with said lever and said valves whereby, on said controlling lever being set to its extreme forward or reverse position, in respect of the corresponding coupling said outlet valve is closed and said inlet valve is first fully opened and is then partially closed by an amount in accordance with the torque being delivered to said driven shaft.

12. Power transmission apparatus comprising in combination a driving shaft, a driven shaft and, intermediately of said shafts, a hydraulic coupling of the turbine type wherein energy is transmitted kinetically, inlet and exhaust valves for said coupling, dual control means for said valves comprising in combination a controlling lever and a torque-responsive device in association with said driving and driven shafts, said controlling lever being adapted on movement from the zero position to produce corresponding opening of said inlet valve, and said inlet valve being then partially closed by said torque responsive device by an amount in accordance with the torque being delivered to said driven shaft.

13. Power transmission apparatus comprising in combination a driving shaft, a driven shaft and, intermediately of said shafts, a hydraulic coupling of the turbine type wherein energy is transmitted kinetically, inlet and exhaust valves for said coupling, dual control means for said valves comprising in combination a controlling lever and a torque-responsive device connecting said driving and driven shafts, said torque-responsive device comprising two discs mounted respectively on said driving and driven shafts, teeth cut in the periphery of each disc and respectively making different angles with the axis, an external ring in engagement with said teeth on both of said discs and means operatively connecting said ring with said inlet valve whereby motion of said ring in an axial direction is caused to vary the degree of opening of said inlet valve.

14. Power transmission apparatus comprising in combination a driving shaft, a driven shaft and, intermediately of said shafts, a hydraulic coupling of the turbine type wherein energy is transmitted kinetically, inlet and exhaust valves for said coupling, dual control means for said valves comprising in combination a controlling lever and a torque-responsive device connecting said driving and driven shafts, said torque-responsive device comprising two discs mounted respectively on said driving and driven shafts, a flexible coupling associated with said torque-responsive device, teeth cut in the periphery of each disc and respectively making different angles with the axis, an external ring in engagement with said teeth on both of said discs and means operatively connecting said ring with said inlet valve whereby motion of said ring in an axial direction is caused to vary the degree of opening of said inlet valve.

15. Power transmission apparatus comprising in combination a driving shaft, a driven shaft and, intermediately of said shafts, a hydraulic coupling of the turbine type wherein energy is transmitted kinetically, inlet and exhaust valves for said coupling, a controlling lever for said valves, stops to limit movement of said controlling lever when the torque delivered to said driven shaft is above a certain value and means for removing said stops from the path of said controlling lever when said torque is below said value.

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