May 19, 1953 F. B. YINGLING 2,638,798

RAILROAD LOCOMOTIVE

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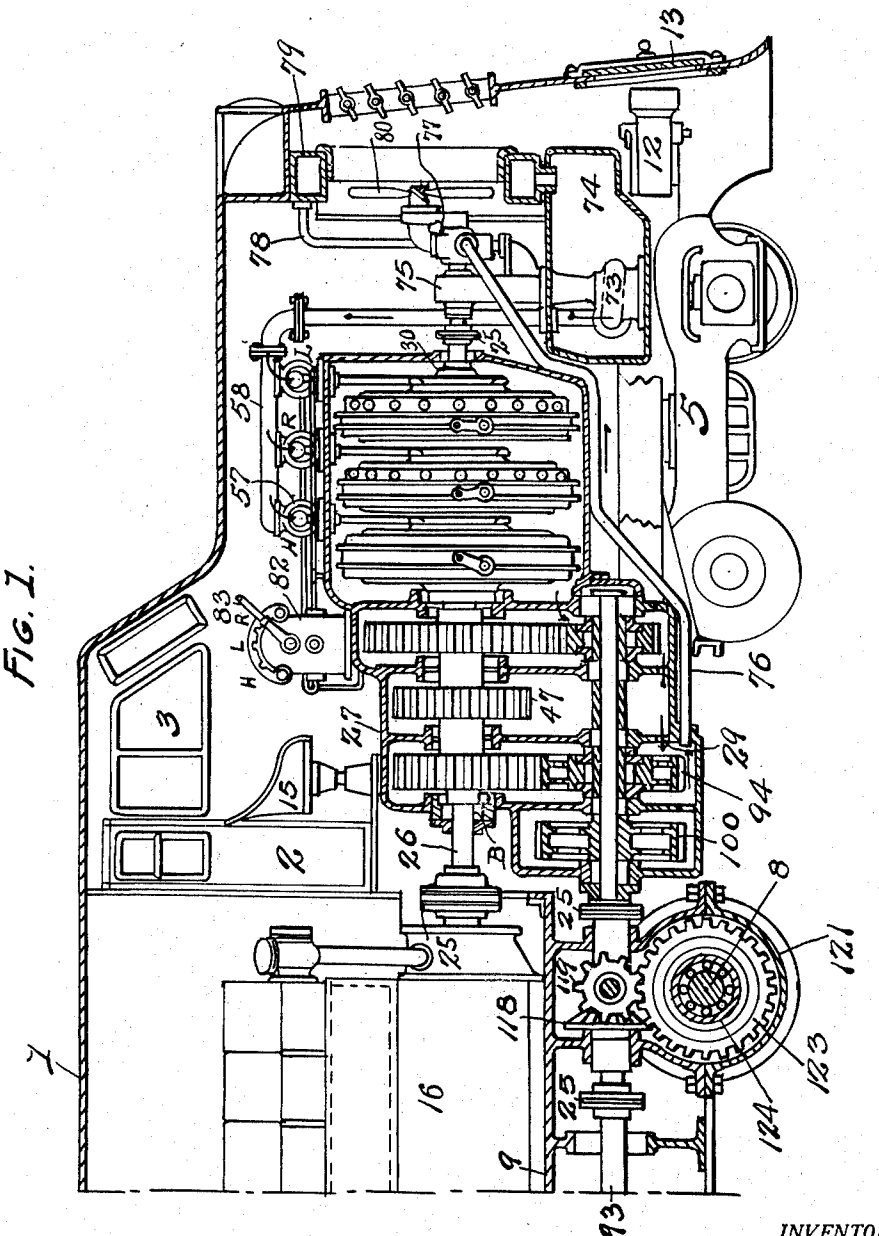

FIG. 1.

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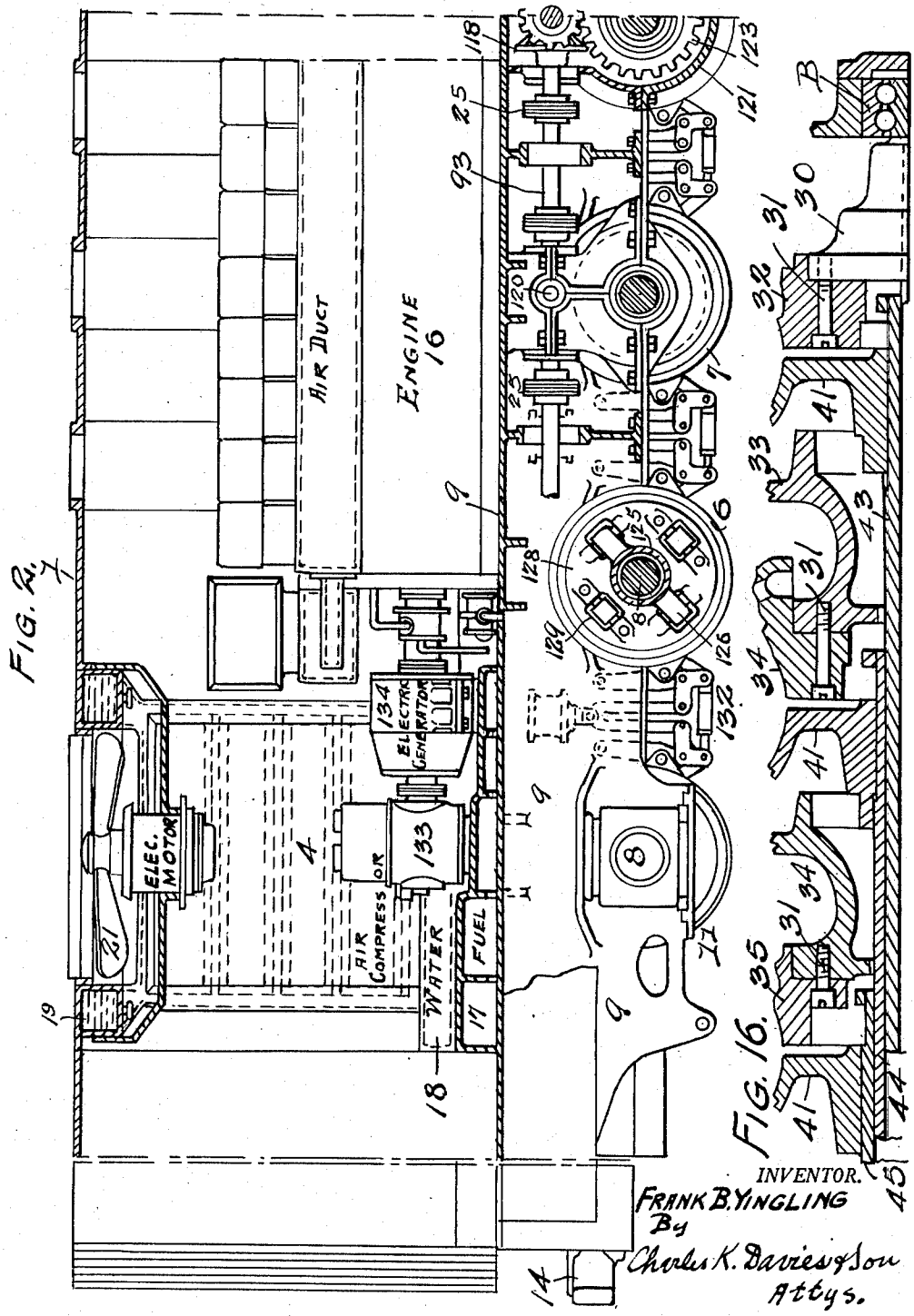

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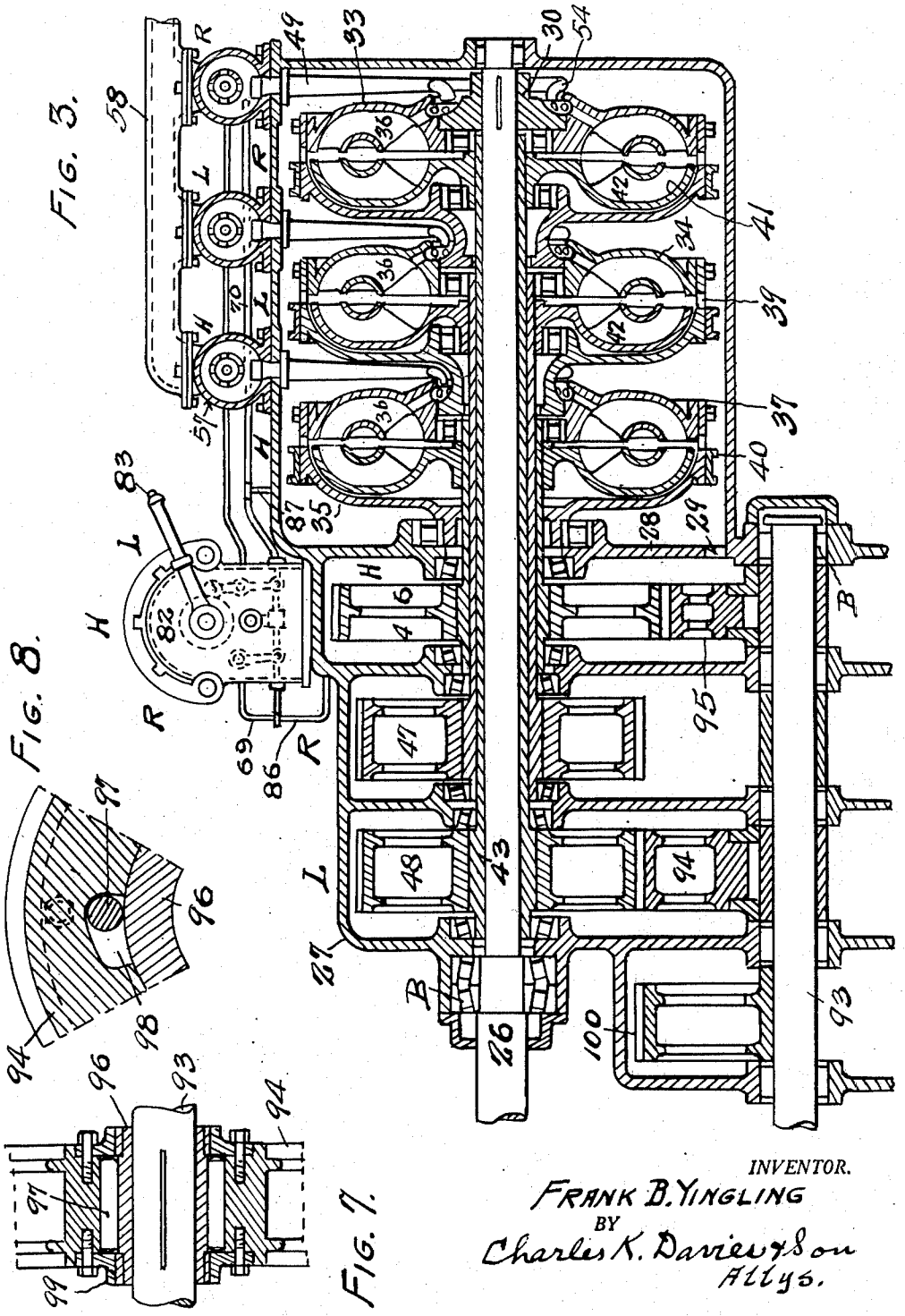

FIG. 3.

FIG. 8.

FIG. 7.

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RAILROAD LOCOMOTIVE

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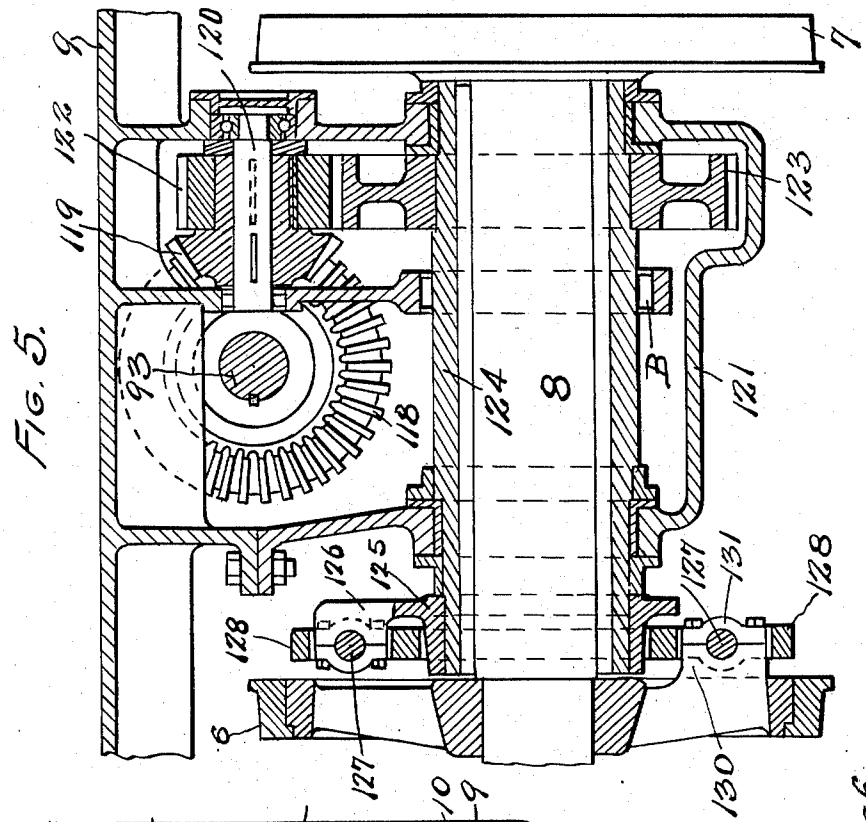

FIG. 5.

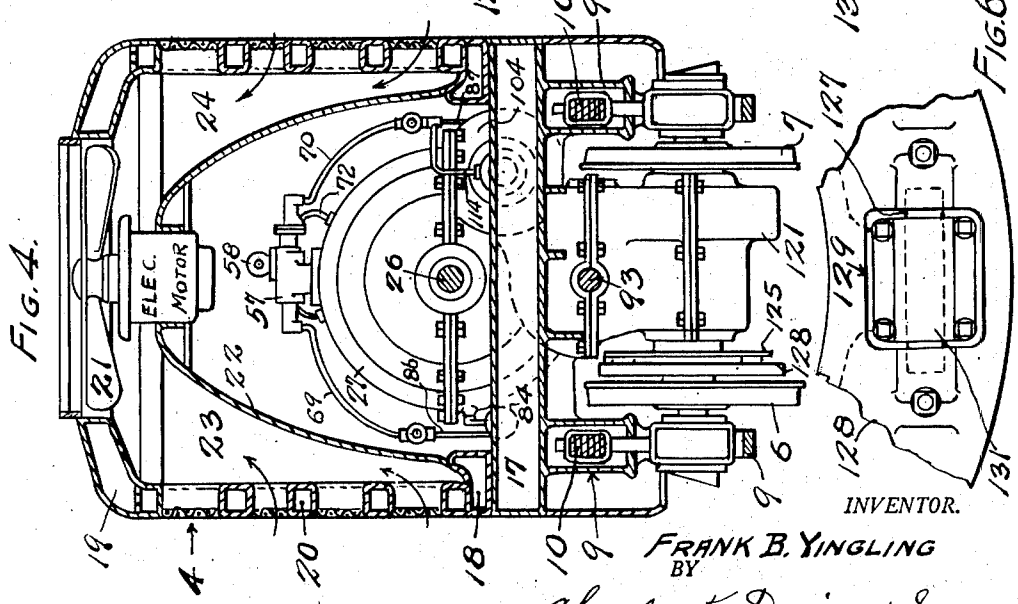

FIG. 4.

FIG. 6.

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FIG. 11.

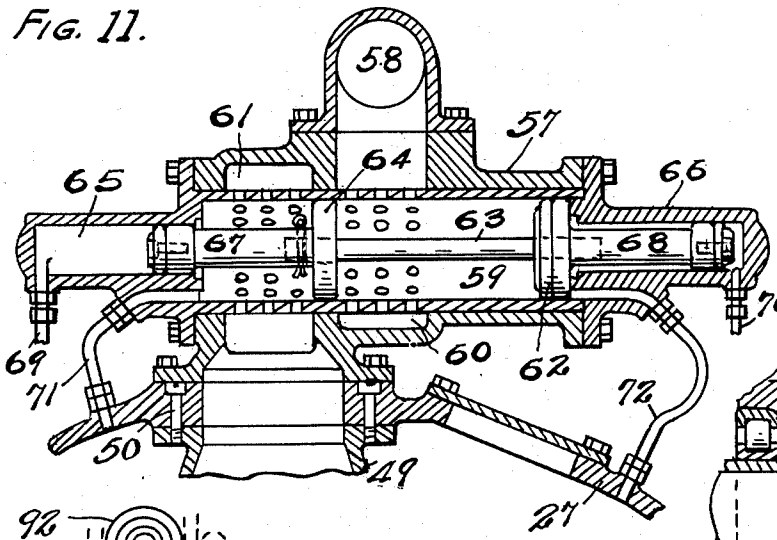
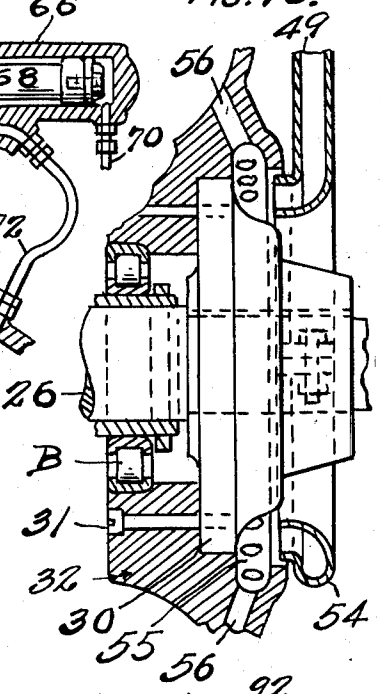


FIG. 10.



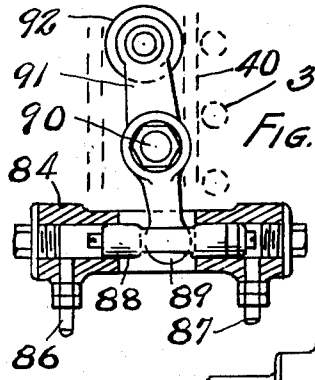


FIG. 12.

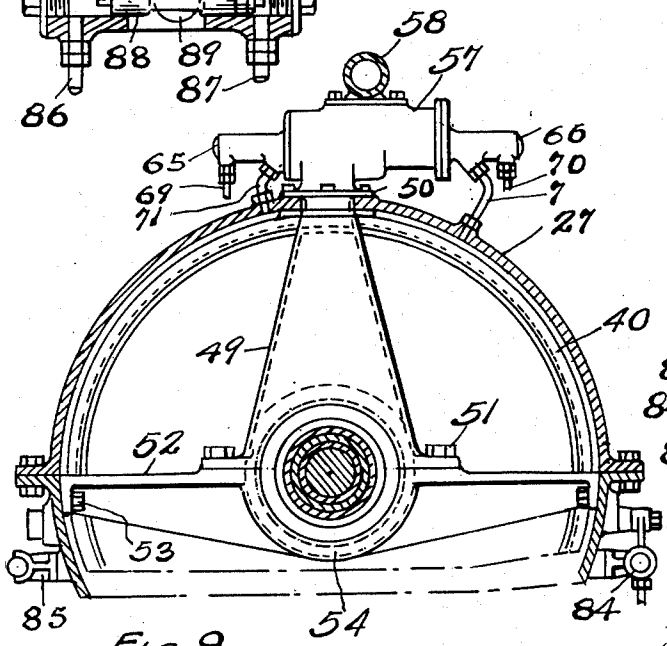


FIG. 9.

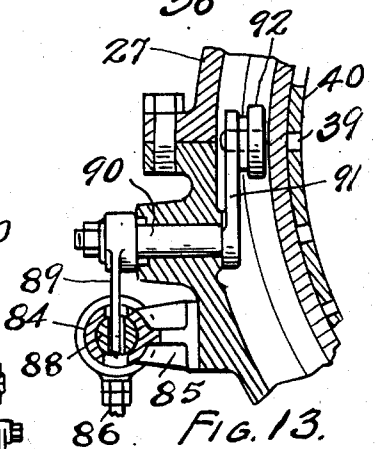


FIG. 13.

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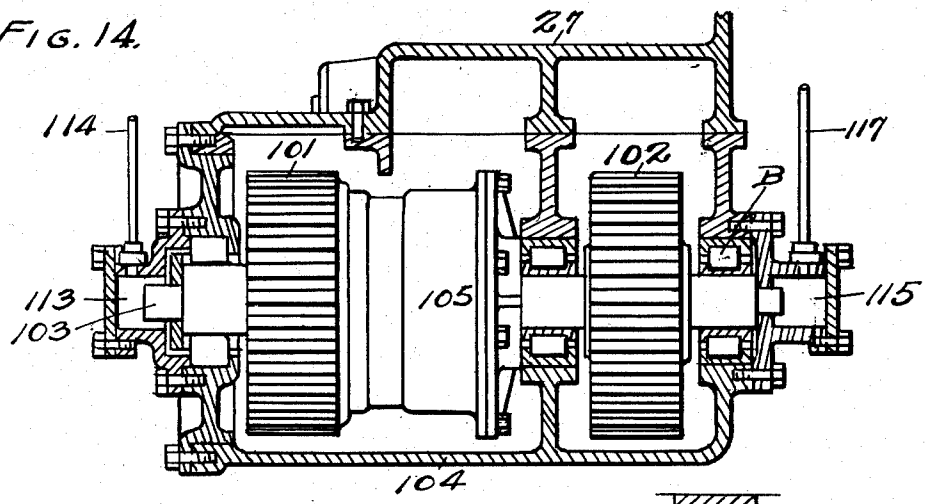
FIG. 14.



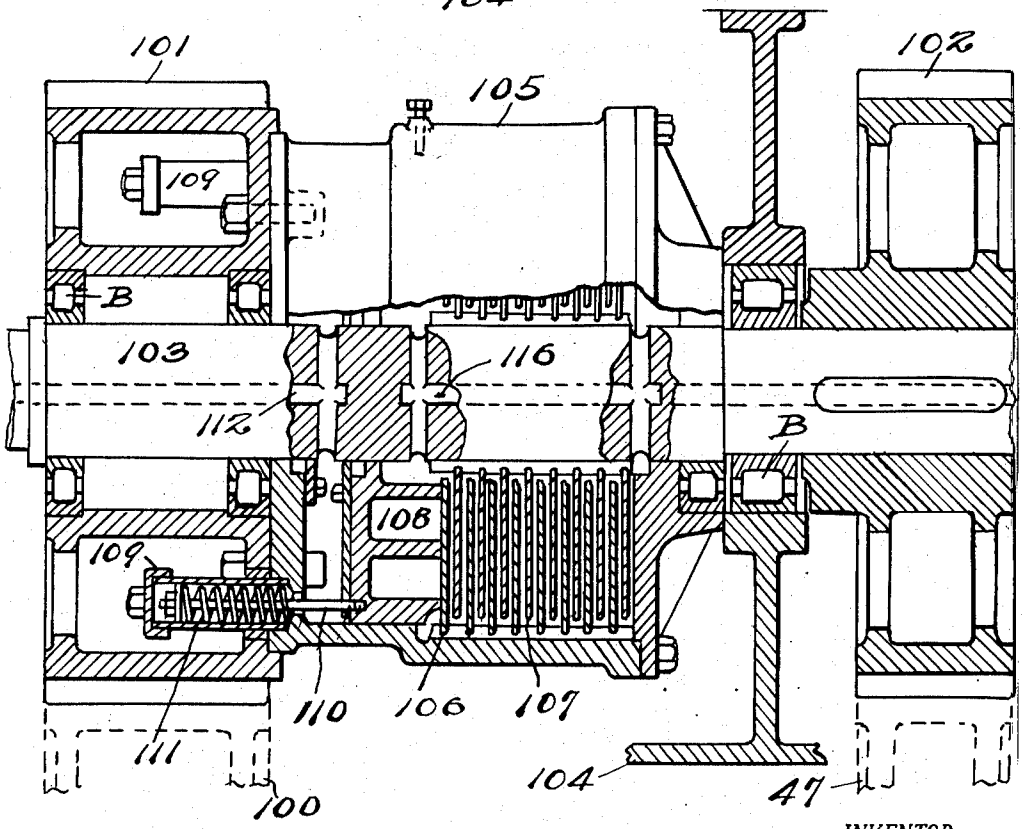


FIG. 15.

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Patented May 19, 1953 2,638,798

UNITED STATES PATENT OFFICE

2,638,798

RAILROAD LOCOMOTIVE

Frank B. Yingling, Hamilton, Ohio; The First National Bank and Trust Company of Hamilton, Hamilton, Ohio, executor of said Frank B. Yingling, deceased

Application August 6, 1947, Serial No. 766,821

6 Claims. (Cl. 74—732)

1

My present invention relates to improvements in railroad locomotives of the main line type which are adapted for use in both passenger service and freight service, but it will be understood that the power plant of the locomotive, including the transmission mechanism, may also be utilized for driving rail-cars as well as for other purposes, as for instance in marine installations, traction equipment, and in some industrial plants.

This application for patent is a continuation, in part, of my pending application for patent Serial Number 440,093, filed April 22, 1942, for Railroad Locomotives, now abandoned.

In carrying out my invention I preferably employ a two-cycle internal combustion engine, or diesel engine, as the prime mover of the power plant, and the power plant involves a novel method of and hydromechanical rotary operating parts for transmitting rotary motion and power from the prime mover to the several driving units that include pairs of driving or traction wheels. The rotary power transmission of the hydromechanical locomotive involves a longitudinally extending drive shaft forming a front extension of the crank shaft or engine shaft, a group (here shown as three) of torque couplings of the hydraulic type for transmitting rotary power from the engine drive shaft through selected impeller shafts and each having constantly meshed single-ratio gearing to the driven shaft or propeller shaft, which shaft is located in the same vertical plane with but below the drive shaft, and extends longitudinally of the locomotive. From the propeller shaft, or driven shaft, power is distributed to a group of rotary driving units, here shown as four in number; and each driving unit includes a flexible driving wheel or traction wheel.

As hereinafter described the locomotive has a variable speed between the first or low speed and the second or high speed, and in addition, the locomotive has one speed in reverse; but it will be understood that the speeds may be varied and the ratios changed from the disclosures shown in the drawings.

The hydromechanical drive interconnecting gears and pinions of the transmission mechanism are constantly in mesh, and the transmission of power to the driving units on the rails is accomplished by smooth, continuous, and uniform rotary operations of the gearing. The presence of the series of hydraulic or torque transmitters in the power transmission mechanism permits idling speeds of the engine when required without necessity for breaking the connection between the load of the train of cars and the power of the prime

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mover, and the utilization of the hydraulic couplings relieves the engine or prime mover of shocks and strains.

Where rigidity is required, as in the main supporting frame of the locomotive, the prime mover or engine is rigidly mounted on top of the frame; and parts of the gear casings, or gear boxes, are fashioned integral with the frame structure, or deck of the locomotive for reinforcing the underframe. The lower detachable parts of the housings, gear boxes, and the gear casings complementary to rigid parts of the main frame, are fashioned and installed so as to readily permit dropping of the individual driving units when repairs or replacements are required and the locomotive is standing over a repair pit.

To relieve the power transmission mechanism of strains and stresses when the locomotive is operating at full capacity, and especially to facilitate assembling and disassembling of the spaced driving units on the rails, various flexible joints are interposed between adjoining rotating parts, which joints also absorb angularity and relative movements of parts to insure smooth and uniform transmission of motion and power to the traction units or drive wheels of the locomotive.

By the use of the hydraulic torque transmitters or hydraulic couplings in the power transmission mechanism, the engineer is enabled to accomplish a smooth and gradual start without jerks for the train and with an easy and rapid pick-up, and as substantially all of the rotary operating parts of the transmission mechanism are enclosed within gear cases or gear boxes, and run in an oil bath, unusual operating sounds or noises are avoided, and the locomotive travels with a minimum noise in action.

A manual control station is installed in the cab of the locomotive, which is simple in construction and operation, for manipulation by the engineer in conjunction with air pressure from the standard air brake system of the locomotive, to automatically activate servo-motors that selectively control and operate the oil supply valves used with the hydraulic coupling as well as the transmission valves of the hydraulic couplings.

Because of the simplicity in construction and operation, and in the compact arrangement of the rotary parts of the locomotive transmission, the cost of production of the locomotive of my invention is substantially reduced as compared with diesel-electric locomotives, and other similar locomotives; and due to the rugged, strong, and reinforced construction of the frames, gear boxes, and rotary parts employed, repairs and

replacements are infrequent and the cost of maintenance is comparatively inexpensive.

Inasmuch as all of the rotary gearing of the transmission preserves a constant arrangement and engagement, and therefore a minimum of friction is created in the operating parts, except for a slight slipping of oil, in the hydraulic couplings when starting the locomotive, it will be apparent that a minimum degree of heat is generated in the continuously circulating lubricating oil and in the transmission of motive fluid oil. Such heat in the motive fluid oil is continuously dissipated, as is also the heat from the lubricating oil, by radiation when the locomotive is running, and therefore the operating parts are not subjected to excessive heat. This absence of overheating enables the locomotive to maintain to full capacity its superior efficiency, especially when pulling heavy loads at high speed on long runs.

The invention consists in certain novel features and combinations and arrangements of parts in a hydromechanical locomotive having a prime mover and a plurality of spaced driving-wheel units, together with intermediate rotary power-transmitting mechanism including a rotary drive shaft receiving power from the prime mover. A group or series of hydraulic torque transmitters or hydraulic couplings selectively interconnect the drive shaft through single-ratio gearing with a driven or propeller shaft, and the propeller shaft distributes or divides the transmitted power and applies the power to the spaced driving-wheel units.

While the drawings disclose one complete example of a physical embodiment of my invention, it will be understood that various changes and alterations are contemplated and may be made in the exemplifying drawings and structures, within the scope of my appended claims, without departing from the principles of the invention.

Figure 1 is a vertical longitudinal sectional view of the front portion of a locomotive with the torque transmission casing and some of the single-ratio rotary gearing in section, illustrating the transmission of power at high speed from the prime mover, and the distribution of power to a forward driving-wheel unit, and also disclosing by arrows the closed circuit of the motive fluid oil through the transmission parts and including the oil pumps, storage tank, heat exchange for oil, and other component parts.

Figure 2 is a sectional view complementary to Fig. 1 showing the rear interior of a freight locomotive as distinguished from a passenger locomotive of Fig. 1 illustrating the distribution of power from the propeller shaft and its application to the driving-wheel units, the rear end of a two cycle internal combustion engine or prime mover mounted on the main frame rearwardly of the torque couplings, and also the radiator means for cooling water in the circulating system from the water jacket of the engine.

Figure 3 is a longitudinal vertical sectional view through the torque couplings of the selective hydromechanical transmission of the locomotive, with the drive shaft as an extension of the engine shaft, tubular impeller shafts concentrically mounted on the drive shaft, and the complementary single-ratio spur gears, the transmission indicating two speeds forward, the reversing unit being omitted.

Figure 4 is a vertical transverse sectional view through the locomotive showing the longitudinally extending drive shaft at the rear of the torque transmission casing, one of the driving-wheel units, and also disclosing the water-cooling radiators together with a ventilating fan and flues for cooling the radiators.

Figure 5 is an enlarged vertical sectional view of a driving unit including a flexible drive wheel and a conventional drive wheel, together with a bevel gear couple from the propeller shaft to the driving unit.

Figure 6 is a fragmentary exterior face view detailing a portion of the flexible drive wheel.

Figure 7 is a vertical transverse sectional view at the hub portion of a gear in the hydraulic transmission with an overrunning clutch mounted on the propeller shaft; and

Figure 8 is an enlarged detail of one of the cam rollers of the overrunning clutch.

Figure 9 is a transverse vertical sectional view through the torque casing, with the drive shaft and three concentric tubular impeller shafts in cross section, with one of the oil-supply nozzles and delivery ring of a valve device.

Figure 10 discloses the impeller-head with the nozzle ring in section and delivering oil to the interior of the impeller-housings.

Figure 11 is an enlarged detail vertical longitudinal sectional view of one of the three main pneumatically operated oil-supply valves, in closed position, the servo-motor of which the valve forms a part being mounted on top of the torque casing, and this view also shows the upper portion of the three nozzles that selectively deliver an oil supply to the hydraulic couplings.

Figure 12 is a vertical longitudinal sectional detail view of one of a pair of pneumatic servo-motors, and its lever device for shifting an exterior hydraulic valve on its impeller housing.

Figure 13 is a sectional detail view of a hydraulic transmission valve and mounted on an impeller housing, together with one operating lever and roller and the servo-motor therefor, it being understood that a pair of diametrically arranged servo-motors and lever devices are provided for each transmission valve.

Figure 14 is a longitudinal vertical sectional view with operating parts in elevation of the detached reversing unit including a friction clutch automatically controlled and operated by pneumatic pressure from the air-brake system of the locomotive.

Figure 15 is an enlarged detail vertical longitudinal sectional view showing the reversing unit and including the pneumatically operated multi-disk friction clutch.

Figure 16 is a vertical longitudinal sectional view showing central portions of the three rigidly united impeller housings, the driving head, and the three tubular concentric shafts.

In the assembly views Figs. 1, 2 and 4 I have shown a mainline locomotive with a streamlined housing 1, side door 2, windows 3, and side ventilators 4; and the locomotive is equipped with a front swiveled bogie or pilot truck 5.

Four driving wheel units are shown, each unit including a flexible driving wheel 6 and a conventional drive wheel 7, which are journaled by their axles 8 in pockets of the main frame 9; and equalizing springs 10 (Fig. 4) are shown together with a rear two-wheel pony truck 11.

The weight of the locomotive is thus equally supported to insure stability, and the power is uniformly distributed to the several driving wheel units. The longitudinally extending main frame 9 in all of the views is a single unitary

casting that is fashioned with heavy channels, angles, and plates, and the side sills of the frame are provided with pockets that permit the journal assemblies of the driving wheel units to be dropped or removed from beneath the locomotive, when replacements or repairs are required.

Within the housing, at the front of the main frame an adjustable coupler 12 (Fig. 1) is shown as supported in retracted position, and this coupler may be projected through an opening in the front end of the housing, when the slide doors 13 are opened, for use when required.

At the rear of the locomotive in Fig. 2 a standard type of coupler 14 is indicated so that the locomotive may be coupled to a train of cars, or, if required, this locomotive may be coupled to another streamlined unit, it being understood that both the single unit and the double or duplex units of the locomotive are under control of the engineman or engineer who occupies a chair 15 shown in the cab in Fig. 1.

While I have shown only the pneumatic control station in Fig. 1, it will of course be understood that the control devices for other operating parts of the locomotive are also mounted in the cab where they are readily accessible to the engineman occupying the chair 15.

As best seen in Figs. 1 and 2, the prime mover of the locomotive power plant is indicated by the numeral 16 as a two cycle internal combustion engine, or multi-cylinder diesel engine, that is mounted directly and rigidly upon the main frame 9 forming the deck of the locomotive. In Figs. 2 and 4 a fuel tank 17 for supplying fuel oil to the engine is fabricated in combination with the main frame 9 so that the top of this reservoir or tank also forms the floor or deck of the locomotive, and this reservoir may be replenished as required through a filling connection located on the exterior of the locomotive.

For cooling the heated water-coolant from the engine, as seen in Figs. 2 and 4, the hot water is circulated through heat-exchange appliances including side radiators 18 along the floor or deck, and through upper radiators 19 located near the roof of the locomotive housing, as well as through intermediate radiator sections 20, in the sides of the housing.

These horizontally disposed radiator sections are built in the side walls of the housing, and they are connected to and communicate with complementary vertically disposed water-sections, to form rectangular radiators or heat-exchange structures connected to the water jacket and the circulating system of the engine. The air-cooled radiators are arranged about the two air-intake openings in the opposite side walls of the locomotive housing, and they are protected from the exterior by the reticulated screens or grids of the ventilators 4.

A ventilating fan 21 is located in position to impel air currents upwardly through an upper roof vent-opening, and an electric motor for the fan is mounted in the top wall or apex of an interior arched housing 22, which, as best seen in Fig. 4 forms duplex air flues 23 and 24, one for each lateral radiator at the sides of the locomotive housing. These enclosed upright flues are open at their lower ends to the atmosphere, while their upper ends merge in the clerestory of the housing where the fan 21 is located, in order that the air currents from the flues may be expelled to the atmosphere without entering the interior of the housing of the locomotive. In this manner the heat extracted from the circulating water system is dissipated to the atmosphere through the vented roof and undesired heating of the interior of the locomotive housing is eliminated.

In Fig. 1 power is conveyed from the shaft of the engine or power plant through a flexible coupling 25 to an axially alined longitudinally extending drive shaft 26 that forms a forward extension of the engine shaft, and from this main drive shaft 26 power is transmitted and distributed to the several driving wheel units of the locomotive.

The drive shaft 26 with its flexible couplings or joints is journaled in bearings B in a sectional gear box 27, and it will be understood that the letter B indicates roller bearings, thrust bearings and other anti-friction bearings throughout the drawings, while the number 25 is employed in like manner to designate flexible joints between shaft sections and driving units.

The sectional gear casing or box 27, which is rigidly mounted on the main frame 9 of the locomotive, is separated into compartments that are occupied by the various rotating parts of the transmission mechanism, and the casing or box is made up of sections that are bolted together to form a closed structure having interior reinforcing webs or flanges 28, some of which are fashioned with ports 29 to permit circulation of lubricating oil, and the interior of the casing or box is sealed against leakage of oil.

Thus all rotating parts of the transmission mechanism within the communicating compartments of the gear casing 27 continuously operate in and are lubricated by an oil bath, the oil being constantly circulated while the locomotive is running.

In the drawings, the letters L and H applied to various hydraulic couplings or torque transmitters, gear sets, controls, and other parts, indicate, respectively, low or first speed forward, and a high or second speed forward of the mechanism of the locomotive, while the letter R designates parts involving reverse movement of the transmission and the locomotive. Thus, in order to provide the two forward speeds, and also the reverse travel of the locomotive, I provide a forwardly extending drive shaft 26 with three spaced circular impeller housings, which are rigidly joined to or united with the drive shaft and rigidly joined to each other in order that the housings may revolve with the drive shaft 26.

In Figs. 10 and 16 a driving head 30 is keyed on the forward end of the shaft 26 and the head is united by bolts 31 to the bearing hub 32 of a low speed impeller housing 33; housing 33 is also united by a series of bolts 31 to the hub of the reverse impeller housing 34; and the high speed impeller housing 35 is bolted at 31 to the hub of the adjoining reverse impeller housing 34.

Each of these three housings is provided with an interior annular series of radially extending impeller blades 36 integral with the housing or shell, and each housing also includes a complementary half shell having a central hub and an exterior annular flange 37 that is bolted at 38 in Fig. 3 to the respective impeller housings. Thus the group of three drive-sections, which form housings for three impellers, are united to revolve with the drive shaft 26 and with each other.

Each of the impeller-housings, or drive-sections of the torque transmission, are provided with substantially wide exterior annular faces on their flanges 37, and the flanges are each drilled with an annular series of ports 39 extending around the approximate center line of

the housing. In Fig. 3 all of the ports are shown as open, and they provide communication for oil, or other motive fluid, into as well as outwardly from the interior of the housing. With the ports open and the torque transmitter revolving any oil within the interior of the housings will be expelled therefrom by centrifugal force created by the rotating member.

Each of these annular series of oil ports or outlets from the housings is closed or opened by means of a laterally shiftable hydraulic valve 40, in the form or shape of a ring which is channel-shape in cross section that fits snugly around the flat or smooth exterior face of an annular flange of a housing. Three of these valves are shown, one for each of the low and high speeds, and one for reverse travel of the locomotive and operation of the torque transmitter, and these valves are operated as will hereinafter be described.

In Fig. 3 it will be seen that the three housings, with their series of vanes or blades 36 at one side, also provide at the opposite side of each housing, an open chamber in which is enclosed a turbine-runner 41 equipped with radial vanes 42 complementary to the vanes 36 of the impellers or impeller housings. The pump vanes 36 and the turbine-vanes 42 of each hydraulic coupling are located at opposite sides of the transverse central vertical line of the impeller housings, and the interior of the housings communicates directly with the interior of the casing 27 through the annular series of ports of the housings.

Like the impellers, the three turbine runners 41, 41, 41, are of identical construction, and each runner is fashioned with a comparatively large hub by means of which they are separately keyed on three tubular shafts 43, 44, and 45, concentrically journaled on the central drive shaft 26. These turbine-runners 41 are keyed on the front ends of the respective turbine-runner shafts 43, 44, and 45, and roller bearings B are interposed between the tubular turbine shafts and the hubs of the impeller housings, as well as between the central hubs of the turbine runners and the housings.

The concentrically arranged tubular turbine shafts, or runner shafts 43, 44, and 45 are loose or free running on the drive shaft 26, or power output shaft, and free running with relation one to another; and they extend rearwardly toward the prime mover or engine 16, within the gear casing or box 27, the different shafts varying in length to adapt their forward ends to the turbine runners within the impeller housings. At their rear ends these tubular turbine shafts have keyed thereon three spaced transmission spur gears 46, 47, and 48, of which gear 46 on the outer and largest tubular shaft 45 transmits power at high speed; gear 47 on the intermediate tubular turbine shaft 44 transmits rotary motion to the reversing unit as will be described; and gear 48 on the end of the smallest tubular shaft 43 is included in the first or low speed of the variable speed torque converter.

The three concentric tubular turbine or runner shafts and the drive shaft 26, together with the spaced impeller housings, and their pump vanes, the enclosed turbine runners with their radial vanes, and the three transmission spur gears 46, 47 and 48 all rotate in one and the same direction as driven by the prime mover or diesel engine 16.

Each of the three hydraulic couplings forming the torque transmitters in the power transmission mechanism is provided with a separate source of oil supply, from a common reservoir, the oil for the power transmission being delivered to each hydraulic coupling through a flat fan-shaped spout 49, and these three spouts project downwardly in the gear casing 27 one between the casing and a housing and the other two between adjoining housings.

Inasmuch as these three oil-feed, or oil-delivery devices are of similar construction and operation, the illustration in detail of one device, as in Figs. 1, 3, 9, 11, will suffice for the three. The sectional outwardly flaring oil spout is built into the gear case 27 as at 50, in the top portion of the case, and the sectional spout is detachably mounted for ease in disassembling by bolts 51 threaded through flanges into the two outspreading arms 52 of a transverse brace that is bolted at 53 to the inner surface of a lower section of the gear box 27.

Each spout is thus supported within the gear casing at three points, and the lower end of the sectional spout terminates in an open ring or laterally projecting delivery nozzle 54.

One of these open annular delivery nozzles 54 encircles and surrounds the impeller head 30 and delivers oil at the hub of the housing 33; a second nozzle located between housings 33 and 34 delivers oil to housing 34; and the third nozzle between housings 34 and 35 delivers oil to the high speed housing 35.

Each of these delivery nozzles opens into the throat of an annular recess 55 fashioned in the nature of a groove at the side of the hub portion of each of the respective impeller housings, and from this annular intake groove an annular series of radially arranged ports or ducts 56 extend to and open onto the interior of each of the housings. These fixed delivery nozzles project at all times into the rotary intake recesses and the selected nozzles are capable of quickly delivering the necessary motive fluid to a selected hydraulic coupling; and the centrifugal force of a revolving impeller assures flow of the delivered oil into the working chamber of the impeller housing.

The supply of oil to the three torque transmitters is controlled by three servo-motors each designated as 57 in Figs. 3 and 11 particularly, and connected with an oil supply pipe 58; and since the motors are of similar construction and operation, a description of one will suffice for all.

Each servo-motor is selectively operated by air pressure and includes a housing extending transversely of the drive shaft 26 and mounted on top of the gear casing 27, and the housing encloses a perforated cylinder or lining 59 that forms two interior oil chambers 60 and 61.

Intake oil chamber 60 receives oil under pressure from the supply pipe 58, and the outlet chamber 61 receives oil from the interior of the perforated cylinder and supplies oil to the spout 49 of an impeller housing. The flow of oil from supply pipe 58, and from the intake oil chamber 60 through the perforated cylinder and into the outlet chamber 61 is controlled by a piston-valve 62 of the double-acting air-operated servo-motor which valve includes a stem 63 and an oil-piston 64 rigid with the stem and air piston-valve 62 for reciprocation in the perforated cylinder.

As shown in Fig. 11 the oil supply to the delivery spout 49 is cut off by the oil valve 64 in the cylinder, with the valve positioned between the intake chamber 60 and the outlet chamber 61 surrounding the perforated cylinder.

Projecting from the outer ends of the oil cylinder are two air cylinders 65 and 66, of less diameter than the oil cylinder and axially alined therewith, and the ends of these air cylinders remote from the perforated cylinder are closed as shown. Within the air cylinders of the servo-motor are two reciprocable pistons 67 and 68, the latter rigid with the valve-piston 62 and the former rigid with the oil piston 64 so that these parts will reciprocate simultaneously.

Air under pressure through pipe 69 to the outer end of the air cylinder 65 has moved these parts to the right to close the spout 49 from an oil supply; and the pipe 70 connected with the outer end of air cylinder 66 has performed the functions of an exhaust pipe in venting air from the cylinder 66.

To supply oil under pressure through the spout 49, the air pipe 70 supplies pressure to the cylinder 66, pipe 69 vents the air cylinder 65, the double acting pistons and valves are moved to the left in Fig. 11 so that the oil-valve 64 will occupy a position against the open inner end of the air cylinder 65, and the piston-valve 62 will occupy a position just to the right of the perforated portion of the cylinder 63. Under these conditions oil is passed through the intake chamber and the outlet chamber of the servo-motor to the spout 49 for delivery to a selected hydraulic torque transmitter, as for instance to the high speed housing 35 in Figs. 1 and 3, the oil transmission valve 40 of which has been closed.

Oil supplied to the hydraulic couplings as motive fluid is also employed for lubricating the operating parts within the gear box or casing 27, and for this purpose the servo-motor is equipped with two oil pipes 71 and 72, one communicating with and receiving oil from each end of the oil cylinder, and both pipes connected to the gear casing or box. The gear casing and its several compartments are sealed against leakage of oil, and these three pairs of pipes 71, and 72 supply lubricating oil for circulation in a closed circuit. Oil is supplied through pipe 58 from a centrifugal oil pump 73, which as seen in Fig. 1 is located at the front of the locomotive, within an oil reservoir or tank 74, and the pump is operated by gears in a gear case 75 from an extension of the drive shaft 26, one of the flexible joints 25 being shown between the extension shaft and the pump case.

As indicated by the arrows in Fig. 1, after flowing through the interior compartments of the sectional gear box 27, by way of ports 29, the used oil is recovered and returned through a suction pipe 76 to another oil pump 77, and from this pump the oil is forced through pipe 78 to a heat exchanger or radiator 79, cooled by a fan as 80, and located just back of the ventilated front of the housing of the locomotive. The oil may be filtered, if desired, before it is returned to the reservoir or storage tank 74, and of course the supply of oil in the reservoir is replenished when necessary.

Compressed air for motive fluid in the servo-motors comes from an air reservoir, not shown, by suitable connections with the air brake system of the locomotive or train, and in Fig. 1 an air pipe 81 from the reservoir is connected to an air control station, or appliance, 82, located in the cab of the locomotive where it is readily accessible for the engineer seated in the chair 15, and the hand lever 83 is manipulated from its neutral position shown to the selected low, high, or reverse positions for selectively supplying air pressure through pipes 69 and 70 to the servo-motors.

For selectively reciprocating each of the transmission oil-valves 40 of the three torque transmitters across the annular series of ports 39 of the housings, and thus open and close the ports, I also employ three pairs of pneumatic motive fluid servo-motors shown in detail in Figs. 12 and 13, which are operated by mechanism under control of the hand lever 83, by the engineer, and simultaneously in cooperation with a selective servo-motor 57 that furnishes oil to the selected coupling.

One of these valve-operating servo-motors, as indicated, is located at each side of the gear casing for co-action with a valve 40, the motors being mounted outside the casing, and each motor includes a slotted air cylinder 84 supported by brackets 85, and extending longitudinally of the casing or gear box. At the opposite ends of the cylinder are attached two air-pipes 86 and 87 that are connected to a complementary pair of air pipes 69 and 70 of an oil-supply servo-motor 57.

Within the slotted air cylinder 84 is mounted a slotted reciprocable power-piston 88, and an actuating lever arm 89 has its free lower end operatively engaged in the slot of the piston in order that the arm may be swung on its pivot 90 by movement of the power piston. The pivot pin 90 is journaled in the wall of the gear box 27 and extends through the wall, with the actuating arm 89 on the exterior of the box and a valve-operating arm 91 fixed on the pin and located within the interior of the gear box.

An anti-friction roller 92 is journaled at the free end of the operating arm 91, and this roller is located within the channel of the valve ring 40 between its spaced flanges and it will be seen that when power piston is oscillated or reciprocated such movement is translated to the lever arms 89 and 91 to shift the oil transmission valve for opening and closing the oil ports 39 of an impeller housing. Thus as the outlet ports 39 are closed, the oil supply valve of a servo-motor 57 is opened to admit oil into a coupling for motive fluid, and these operations are also reversed, under control of the hand lever 83 in the engineer's cab.

Power through rotary motion is transmitted from the drive shaft 26, through the driven concentric or tubular turbine shafts and their spur gears 46, 47, and 48 to a horizontal longitudinally extending propeller shaft 93 disposed below the drive shaft with its forward end journaled in bearings B within the gear box 27, and its rear portion journaled in bearings B of the main frame 9 of the locomotive.

In Figs. 1 and 5 it will be noted that the low speed spur gear 48 on tubular turbine shaft 43 meshes with a complementary gear 94 on the propeller shaft 93, and the high speed gear 46 on tubular shaft 45 meshes with a smaller gear 95 on the propeller shaft. These two gears 94 and 95 are free wheeling, or run loosely, with relation to the propeller shaft in one direction, and an overrunning cam clutch is provided for each wheel or gear so that the gears are made rigid with and transmit power in the opposite direction.

For forward drives of the propeller shaft these overrunning clutches of the gears are selectively engaged, and as illustrated in Figs. 6 and 7, particularly, the clutch of gear 94 includes a bearing bushing 96 keyed on the propeller shaft 93, and an annular series of cam rollers 97 surround

the bushing. These rollers are retained in cam grooves 98 fashioned in the bore of the hub of the gear, by means of two side rings 99 bolted to the hub.

The overrunning clutches are duplicated in the two gears 94 and 95, and the clutches operate in conventional manner so that either high speed or low speed forward may be transmitted to the propeller shaft 93 through the respective clutches.

In Figs. 1 and 3 a spur gear 100 is keyed on the propeller shaft within the gear box 27, and reverse drive for the locomotive is transmitted from reverse gear 47 on turbine shaft 44 through a laterally disposed reversing unit to this reverse gear 100 on the propeller shaft. The reversing unit is best shown in Figs. 14 and 15 where it will be evident that the spaced gears 101 and 102, respectively, mesh with the spur gears 100 and 47 of the propeller shaft and drive shaft. Gear 101 is mounted in bearings B loosely on the reverse shaft 103, and gear 102 is keyed on the reverse shaft, which as shown, is journaled in bearings B in the reverse unit housing 104 made up in sections and bolted to the main gear box 27.

The loose gear 101 is bolted to a multi-disk friction clutch casing 105 and the casing is mounted at its free end on bearings B of the clutch shaft 103, so that this rigidly connected gear 101 and the clutch casing 105 are normally loosely journaled on the shaft.

The clutch includes two series of alternately arranged disks 106 and 107, the former keyed at their outer peripheries on keys of the casing, and the latter keyed at their inner peripheries on keys of the clutch shaft 103. These two series of disks or friction rings are pushed into frictional contact by means of a multi-ring annular slide 108 that surrounds the clutch shaft and is reciprocable in the clutch casing, and the slide is automatically retracted or held out of engagement with the disks by means of a series of spring devices 109.

The required number of these spring devices is mounted partially within the hollow gear 101 and partly in an end wall of the clutch casing, each spring device being equipped with a retaining bolt 110 that extends through a hole in the casing wall and has its threaded end anchored in the end wall of the slide. Springs 111 of these devices expand to free the clutch, and air under pressure is supplied through an axial air duct 112 of the clutch shaft to the interior opposite ends of the clutch casing. Thus, air pressure within the casing forces the slide to contact the two series of disks or rings, to engage the clutch for rotating the shaft 103, and when the pressure is released the springs 111 disengage the clutch.

In Fig. 14 an air chamber 113 is provided at one end of the clutch housing or casing 105, and the air duct 112 of the clutch shaft is open to this chamber, while a pipe 114 also communicates with the chamber to supply air under pressure for engaging the clutch. This pipe 114 is connected with a reverse valve device in the station-housing 82 in the engineer's cab, and the admission of air to engage the clutch is under control of the hand lever 83.

For lubricating the clutch parts an oil reservoir 115 opens to the clutch shaft in the reversing casing at its end opposite to the air chamber 113, and the clutch shaft is bored to form an oil duct 116 that opens to the interior of the clutch for supplying lubricating oil from the reservoir through the oil duct to the clutch. An oil pipe 117 supplies the lubricating oil to the reservoir, and this pipe is connected with the oil supply system, as 71, 72, that supplies motive fluid oil and lubricating oil to the torque transmitters, and other operating parts of the transmission.

The four driving wheel units shown in Figs. 1, 2, 4, and 5 each receives power and rotary motion from the longitudinally extending propeller shaft 93, which projects rearwardly from the transmission casing or gear box 27, and is provided with spaced flexible couplings 25 between sections. Each driving unit includes a flexible drive wheel 6 and a rigid or non-flexible wheel 7, arranged in pairs, and as the construction and operation of the units are similar, a description of one will suffice for all of them.

The rear portion of the propeller shaft with its flexibly jointed sections transmits power to the various driving wheel units, and each unit includes a bevel drive gear 118 keyed on the propeller shaft as seen in Fig. 5, and this bevel gear meshes with a complementary pinion 119 keyed on a jackshaft 120 extending transversely of the propeller shaft, and journaled in bearings B in the gear box 121 of the unit. Like the gear box 27, the gear boxes of the driving units are made up in bolted sections to form rigid structures, which are bolted to the main frame 9, in order that the sections may readily be disassembled or dropped down for access to the interior parts.

A spur gear 122 on the jackshaft meshes with a larger gear 123 that is keyed on a cylindrical or tubular axle 124 that surrounds anti-friction roller bearings B on the wheel-axle 8, and the two driving wheels 6 and 7 are rigid with axle 8. The flexible power wheel 6 is connected with and receives power from the tubular axle 124 through a universal joint or coupling that includes a drive hub 125 having a pair of integral radial arms 126 each having a seat for a solid cylindrical and tangentially arranged pin 127. A suitable number, as four, of these pivot or hinge pins are mounted in an open center annular plate or ring 128 which surrounds the hub 125, and this flat plate is fashioned with four diametrically arranged pairs of opposed sockets that receive the ends of the pins which bridge or span the space across the complementary holes 129 that extend through the flat ring.

The flexible power wheel of each driving unit is also fashioned with two diametrically arranged integral bearing lugs 130 having semi-circular seats for two of the pins, and cap plates 131 are bolted to these lugs to insure stable and substantial joints between the annular bearing plate and the power wheel.

Bearing caps 131 are also bolted to the other two lugs 126 of the driving hub to complete the journals for the pins between the bearing plate and the hub 125. The four tangential pins are thus journaled in four diametrically arranged bearings to provide the universal or flexible joint through which power is transmitted from the tubular driving axle 124 to the power wheel 6. The power wheel 6 and the traction wheel 7 are rigid with the solid axle 8 and the journal ends of the axle 8 exterior of the wheels are mounted in the usual bearing boxes located in the pockets of the integral longitudinal sills of the main frame 9 at the opposite sides of the locomotive.

In connection with the springs 10 of the journal boxes, the flexible joints between the sections of the propeller shaft 93, the oversize tubular driving axle 124 surrounding the wheel axle 8, and the universal joint between the tubular axle and

the power wheel 8, relative angular movement between these parts is absorbed when the locomotive is operating full power at any speed on the rails, as well as when passing over irregularities in the railroad track that might cause relative vertical movements of the parts.

In Figure 2 a portion of the usual brake rigging is indicated at 132, which forms part of the standard airbrake equipment for the locomotive and a train of cars, and the air brake pumps of the equipment provide the motive fluid that is controlled through the cab-station 82 to the torque transmitters, it will, however, be understood that other provision may be made and other means employed in the manual control of these and other parts.

No attempt has been made to illustrate all of the parts of a locomotive in the drawings, although in Fig. 2 at the rear of the prime mover an air compressor is indicated at 133 to supply air pressure for various appliances; and an electric generator is indicated at 134 to furnish power for the electric motor of the fan 21 of the ventilator, and other appliances, as for starting with batteries, and lighting equipment.

In Fig. 3, where the locomotive is not running under power, the three transmission valves 40 are open, and the hydromechanical transmission mechanism is not "in gear"; and so also if the engine 16 is idling with the oil transmission valves open, the shaft 26 and the three impeller housings 33, 34, and 35 will be rotating idly. Under these conditions the forward extension of the drive shaft 26 may be operating the two oil pumps 73 and 77 to circulate oil for lubricating purposes, as well as for driving the fan 80, and the oil circulating system is thus prepared to supply motive fluid for a selected one of the torque transmitters when needed.

While I have shown the locomotive as a single unit adapted as a mainliner for passenger and freight trains, it will be apparent that for heavier loads another streamlined locomotive or unit, provided with air equipment and oil installations, and other similar appliances, may be employed with the first illustrated unit.

The ratios of the gearing involved in the hydro-mechanical transmission mechanism are adapted for high speeds in passenger locomotives; and to lower speeds, but added pulling power in freight locomotives, as will readily be understood.

Assuming that the prime mover 16 is idling, or it may be running at a higher speed, a noiseless and gradual start may be accomplished with an easy pick-up of the locomotive by moving the lever 83 to the L or low speed forward notch of the control box 82 in the cab of the locomotive.

The first or low-speed servo-motor operates to open the oil valve 40 so that oil under pressure is delivered through the spout and nozzle to the interior of the rotating low-speed impeller-housing 33. At the same time the low-speed air valves are shifted to actuate the servo-motor or operating mechanism for closing its low-speed hydraulic transmission valve 40, thus confining the delivered oil in the working chamber of the low-speed impeller housing.

The gear ratio for low-speed may be within a range from one to sixty miles per hour, the latter speed being attained when the hydraulic coupling has reached its normal capacity and rating, and the prime mover is operating at approximately nine hundred revolutions per minute, or the normal working speed.

With the first or low speed torque transmitter "in gear" the second or high speed gear and the reversing gear are "out of gear," i. e. the H coupling and the R coupling remain disengaged. Although the impeller housings 34 and 35 are rotating with housing 33, the couplings H and R may or may not revolve, and as their valves 40 are open the interiors of the housings 34 and 35 are emptied of any previously contained oil through their outlet ports 39 to the interior of the gear casing 27.

Because the pneumatic operated friction clutch of the reversing unit is open or disengaged and due to the presence of the overrunning clutch in the high speed gear 95, the reversing hydraulic coupling and the high speed coupling are ineffective when the low or first speed coupling is effective up to its minimum speed.

The lever 83 is moved forward, for high speed forward, to the H notch of the control segment, with the result that the high speed oil valve 40 is closed, and the oil supply valve 64 of the high speed servomotor is moved to the right and opened in Fig. 11 to admit oil to the housing 35. This action of the lever 83 also serves to close the oil supply valve 64 of the low speed servomotor and to open the oil transmission valve 40 of the low speed coupling L, thereby permitting ejection under centrifugal force of motive fluid oil from this coupling through ports 39 to the interior of the gear box 27. Motive fluid is supplied through a spout 49 to its nozzle ring 54 and thence through inlet ports 56 to the interior of the housing 35 and the high speed coupling H thus becomes effective to take up the load in accord with its ratio and capacity. The speed of the locomotive now increases from say sixty miles per hour (or a maximum of the low-speed ratio) to one hundred or more miles per hour, depending upon the ratio of the gears in the transmission mechanism, and the capacity of the prime mover.

When the lever 83 is moved forward to the high speed segment notch there is a delayed action in ejection of oil from the low speed housing L so that the high speed housing H and its coupling take effect without reducing the speed of the locomotive, when changing from low speed to high speed. Thus the locomotive will continue to accelerate its speed when changing speeds, say from low to high, and the speed will not drop off by release and ejection of oil from the low speed coupling L before the power of the high speed coupling H becomes effective.

In changing from high speed to low speed, if and when the lever 83 is shifted the timing of the ejection of oil from the coupling H, and the injection of oil into the interior of the coupling L is immaterial, for the reason that the deceleration of coupling H brings its speed down to the low speed, and then the coupling L becomes effective if, when, and after the power and speed are required.

When traveling at high speed and it is desired to reduce the speed of the locomotive below sixty miles per hour, the high speed oil transmission valve 40 of the impeller housing 35 is opened, and the valve 40 of the low speed housing 33 is closed, whereupon the train load is shifted from the high speed coupling H to the low speed coupling L, and the locomotive will now travel at a low speed within the range of one mile per hour to sixty miles per hour, depending upon the speed of the closed oil transmission valve to gradually empty its torque transmitter.

For gradually arresting and bringing the loco-

motive to stationary position, the reversing unit may be employed, in connection with the propeller shaft, and in opposition to the reversing coupling or housing 34; and this braking condition, when desired, may be released by throwing the reverse unit out of gear with the torque transmission gears.

Various changes and alterations may be made in the exemplifying drawings and structures, as for instance the air-operated friction clutch in the reversing unit might be omitted, and the reversing unit might idly spin while the locomotive is traveling forward; but it is preferable that the reverse coupling R remain idle, and this condition is achieved by the use of the pneumatic operated, automatically controlled friction clutch.

While I have referred to the prime mover 16 as a multi-cylinder two-cycle internal combustion engine, it will be understood that the usual four-cycle diesel or gasoline engine may be employed, especially in smaller locomotives. For heavy torque transmission and economy in large locomotives, the two-cycle internal combustion, compression-ignition engine is preferable.

In this type of locomtive where all of the gearing is enclosed by and operates in an oil bath, a comparatively small quantity of heat is generated, except for that created by the slight slippage between the impeller and the runner when the mechanism is started, and the radiator 79 at the front end of the locomotive dissipates the heat from the circulating oil.

This desirable condition existing throughout the transmission mechanism of the locomotive permits the employment of substantially all of the available horse-power of the prime mover, without the menace of excessive heat, or overheating, of operating parts that would otherwise slow down the speed of the locomotive. Thus, in this compact combination and arrangement of parts as shown a maximum concentration of horse-power is available in a minimum space, and the transmission mechanism is especially efficient when the locomotive is engaged in a long and hard pull of a heavy load at high speed.

Various adjustments may be made in the power plant, as for instance, the size and capacity of the hydraulic couplings may be varied to adapt them for light duty, and for heavier duties; different adjustments may be made for the oil transmission valves to vary the quantity of motive fluid released from, or confined in the interior of the housings for different degrees of torque conversion, and the number of hydraulic couplings may be varied. The ratios of gearing may also be increased or decreased to suit variable speed requirements; and the number of driving wheel units employed for dividing and distributing the applied power from the propeller shaft may also be varied in accord with the size and capacity of a locomotive.

For convenience of illustration I have shown bevel gears and spur gears in the drawings, but it will be understood that different types of gear wheels may be installed in the hydromechanical power transmitting mechanism to suit different requirements, and in some cases a different type of reversing unit may be used to reverse the drive between the drive shaft and the propeller shaft.

Having thus fully described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In a hydraulic transmission, the combination with a plurality of united impeller housings having bearing hubs, and a solid drive shaft rigid with the housings and extended through said hubs, of a plurality of superimposed driven shafts concentrically mounted on the drive shaft extending through and therminating in complementary hubs, a turbo-runner enclosed in each housing and having a hub rigid with a driven shaft, journal bearings interposed between complementary housing-hubs and runner-hubs, and journal bearings interposed between each housing and a driven shaft.

2. In a hydraulic transmission, the combination with a drive shaft and its head, an impeller housing encircling the shaft and having an integral hub at one side bolted to said head, an exterior flanged hub at the opposite side of the housing, a second housing encircling the shaft and bolted to said flanged hub, and a bearing on said second housing, of a pair of tubular superimposed driven shafts each terminating in a different one of said impeller housings concentric with the drive shaft, a turbo-runner having a hub enclosed in each housing and rotatable with a driven shaft, anti-friction bearings interposed between said housings and the ends of complementary driven shafts, said runners each having a bearing hub, and anti-friction bearings interposed between complementary housing-hubs and runner-hubs.

3. In a hydraulic transmission, the combination with an enclosing casing, an impeller housing having a central hub formed with a lateral, annular recess opening to the interior of the housing, and a solid drive shaft journaled in the casing rigid with and extending through said hub, of a fixed radial delivery spout exterior of the housing and supported within the casing having an annular injecting nozzle encircling the shaft and opening to said recess, and means for controlling flow of motive fluid through the spout.

4. In a hydraulic power transmission mechanism, the combination with a solid drive shaft and a plurality of united impeller-housings longitudinally spaced along, encircling, and rotatable with the shaft, of a plurality of concentric tubular shafts superimposed in the drive shaft, a turbo-runner within each impeller-housing and rigid with a tubular shaft, journal bearings between adjoining housings and runners, journal bearings between each impeller-housing and the tubular shaft of its complementary runner, each of said housings having a peripheral series of outlet ports and a valve for controlling said ports, manually controlled means for injecting motive fluid into the housings, and cooperating means for closing said valves.

5. In a hydromechanical power transmission mechanism including an alined engine shaft and rotary drive shaft, and a parallel propeller shaft, the combination with a pair of rigidly united couplings surrounding the drive shaft and one of which couplings is supported on and rotatable with the drive shaft, each coupling having an interior impeller and a complementary turbine-runner, of a tubular shaft rigid with each runner and concentric with the drive shaft, a driving gear rigid with each tubular shaft and mounted adjacent the couplings, a complementary pair of driven gears mounted on the propeller shaft, and an overrunning clutch embodied in each driven gear for coaction with the propeller shaft.

6. In a hydromechanical power transmission mechanism including an alined engine shaft and rotary drive shaft, and a parallel propeller shaft, the combination with three rigidly united rotary torque couplings surrounding the drive shaft, one of said couplings being rigidly supported on

the drive shaft to rotate therewith, each coupling having an interior impeller and a complementary turbin-runner, and a tubular shaft for each runner concentrically mouted on the drive shaft, of a driving gear rigid with each tubular shaft and mounted adjacent the couplings, three spaced driven gears mounted on the propeller shaft for coaction with the drive gears, an overrunning clutch embodied in each of two of the driven gears, and a rotary reversing unit geared to transmit power from a third driving gear to a complementary driven gear.

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