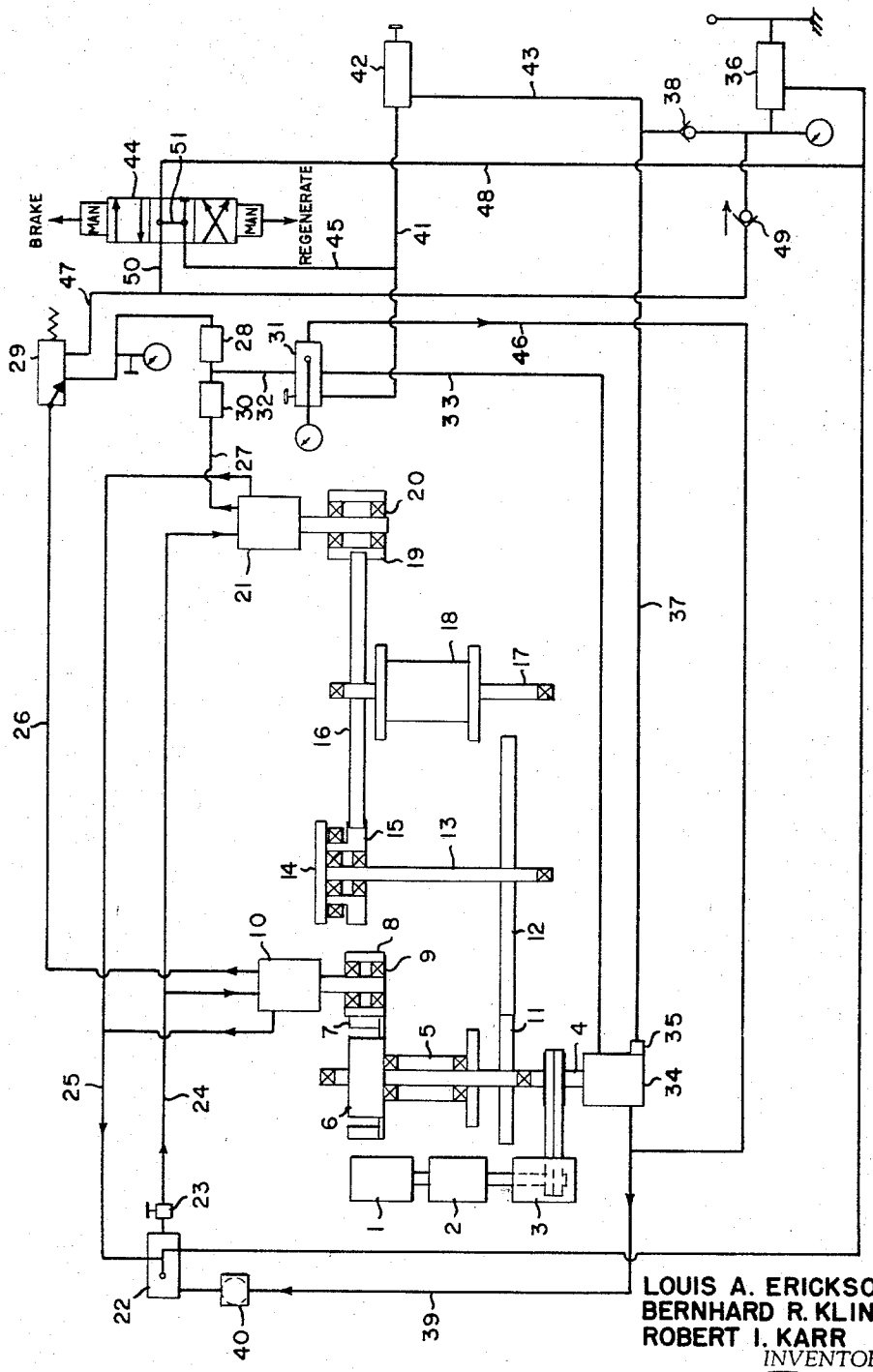
Oct. 10, 1967 L. A. ERICKSON ET AL 3,346,237

POWER BRAKING AND REGENERATIVE SYSTEM

Filed March 25, 1966 2 Sheets-Sheet 1

FIG. 1




LOUIS A. ERICKSON
BERNHARD R. KLINKE
ROBERT I. KARR
INVENTOR.

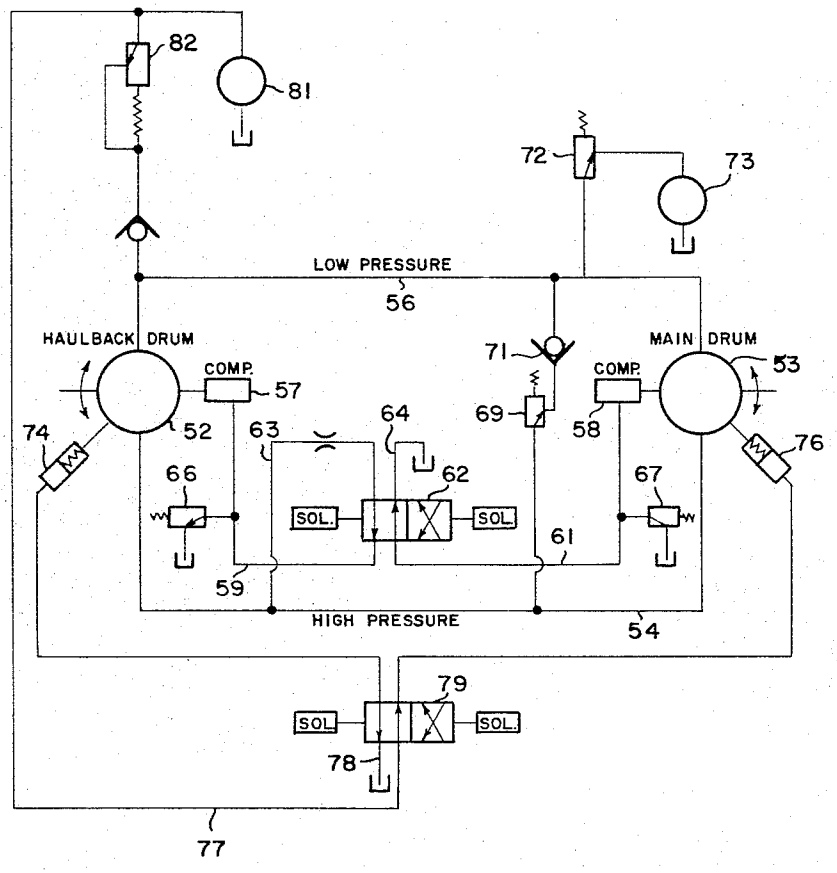
BY Seed & Berry

ATTORNEYS

POWER BRAKING AND REGENERATIVE SYSTEM

Filed March 25, 1966 2 Sheets-Sheet 2

FIG. 2




LOUIS A. ERICKSON
BERNHARD R. KLINKE
ROBERT I. KARR
INVENTORS

BY Seed & Berry

ATTORNEYS

United States Patent Office

3,346,237

Patented Oct. 10, 1967



3,346,237

# POWER BRAKING AND REGENERATIVE SYSTEM

Louis A. Erickson, Bernhard R. Klinke, and Robert I. Karr, Seattle, Wash., assignors to Smith-Berger Manufacturing Corporation, Seattle, Wash., a corporation of Washington

Filed Mar. 25, 1966, Ser. No. 537,413
10 Claims. (Cl. 254—185)

This invention relates to power regenerative systems and more particularly to a hydraulic regenerative braking system for cable hauling apparatus wherein two drums are operated by a geared driving connection from a single power source with a cable or other line being spooled or pulled in on one drum and unspooled or paid out from the other drum. The invention relates most directly to logging yarders or the like having a main line winding drum and a haulback winding drum with a geared driving connection whereby the cable may be wound in on either drum and paid out on the other with the out-haul drum being braked in order to maintain the cable under tension to eliminate slack while the cable is being hauled.

The principal object of the present invention is to provide a versatile hydraulic power regenerative system with a simplified control which is operable to feed back power, created by braking the out-haul drum, back to the power train of a yarder or other cable hauling device.

Further objects and advantages reside in the use of hydraulic pumps and motors and pressure control valves arranged in the hydraulic circuit for accomplishing the power regeneration or braking alone and for rendering the hydraulic circuit ineffective for either braking or power regeneration.

The means by which the foregoing objects and other advantages which will be apparent to those skilled in the art are accomplished are set forth in the following specification and claims and illustrated in the accompanying drawings wherein:

FIG. 1 is a schematic illustration of a first embodiment of the invention; and

FIG. 2 is a schematic illustration of a second embodiment of the invention.

Referring now to FIG. 1, a hydraulic regenerative system is illustrated as applied to a well known type of logging yarder wherein **1** designates a suitable power source such as an internal combustion engine which is connected through a torque converter **2** and chain drive transmission **3** to drive the supporting and driving shaft **4** of the haulback drum **5** of the yarder. The drum **5** is selectively clutched to the drive shaft **4** by means of a clutch **6** so as to haul in or spool the cable or is declutched to allow the cable to be freely unspooled from the drum. The drum **5** is provided with a drive gear **7** to drive a step-up gear **8** supported through an overrunning clutch **9** to drive a hydraulic pump **10**. Through this arrangement, the pump **10** is driven only when the haulback drum **5** is rotated by the cable being unspooled.

The drum shaft **4** also mounts and drives a gear wheel **11** that is in operative mesh with a similar drive gear **12** fixed to one end of a revolvably mounted power transmission shaft **13**. The shaft **13** is also provided with a clutch mechanism **14** for driving the step up gear **15** to drive a relatively large gear wheel **16** mounted on the supporting drive shaft **17** of the main line drum **18**. The gear **16** operates through a step up gear wheel **19**, mounted by an overrunning clutch **20**, to drive a hydraulic pump **21**. The main drum **18** may thus be selectively driven through the clutch **14** to haul in the main line cable or



be allowed to freely pay out the main line cable when the haulback drum **15** is winding in. The pump **21** is only driven through the overrunning clutch **20** when the drum **18** is being rotated by the main line cable being unspooled.

The pumps **10** and **21** are connected to draw fluid from a reservoir **22** through a cock valve **23** in the line **24**. In the event that piston type pumps are used for the pump units **10** and **21**, a common drain line **25** may be connected back to the reservoir **22** as illustrated. It may be unnecessary to use such a drain line with different types of hydraulic pumps.

The pump **10** when driven delivers pressure fluid to the pressure line **26** and the pump **21** delivers pressure fluid to the pressure line **27**. The pressure line **26** is connected to a check valve **28** via a remote control relief valve **29** presently to be described, and the pressure line **27** is connected to a second check valve **30** in such a manner that reverse flow from the operating to the inoperative pump is prevented. Pressure fluid delivered past the check valves **28** and **30** may be delivered to a second remote control relief valve **31** through a common conduit **32**. The purpose and function of the relief valves **29** and **31** will be presently described in detail.

Depending on the setting of the valve **31**, the pressure fluid is delivered through the conduit **33** to a variable displacement motor **34** which may be of the piston type with compensator **35** for variable control of the output of the motor. Since the motor is pressure compensated, it will automatically seek a displacement that will absorb the total hydraulic flow at compensator pressure. The motor **34** is connected so as to deliver power to the shaft **4** of the power train of the yarder. The actual adjustment of the compensator **35** and therefore the amount of motive power put back into the power train of the yarder system is controlled by a manually operable brake control valve **36** through which the system pressure on the compensator **35** is varied. The compensator **35** is connected with the brake control valve **36** through the conduit **37** and a conventional check valve **38**. A return line **39** delivers the spent pressure fluid from the motor back to the reservoir **22** via a conventional filter **40**.

Returning now to a consideration of the remote control relief valve **31**, the valve is of the type known as a remotely controlled pressure balanced valve which remains in the closed position as long as the vent line **41** is connected to the system pressure and blocked off from the reservoir or return line. As shown in the drawings, the vent line **41** is in communication with the system pressure through the safety relief valve **42** and line **43**. The line **41** may be opened to the reservoir or tank by means of the four-way selector valve **44** and the line **45**. When the valve **31** is in the closed position, the return line **46** is blocked and direct communication is established between the conduits **32** and **33** so that the pressure fluid is delievered directly to the motor **34**. When the valve is opened by manual operation of the selector valve **44**, the line **46** is opened to the valve to dump pressure fluid directly back to the reservoir **22**.

The remote control relief valve **29** is similar in structure and function to the valve **31** and constitutes a modified pressure balanced remote control relief valve. The valve **29** normally remains open so as to establish a direct and unrestricted flow path from the line **26** to the check valve **28**. The open condition of the valve is maintained as long as the conduit **47** is maintained in communication with the return line or reservoir line **48** through the selector valve **44**. When the valve **44** blocks the line **47**

from the reservoir, the valve becomes unbalanced by pressure build-up so as to close the flow path to the check valve 28 and a new flow path is established through the valve to the conduit 47. The new flow path includes conduit 47, check valve 49, brake control valve 36 and from thence to the reservoir 22. In this manner, the flow of fluid may be controlled through the manually operated brake control valve 36.

The selector valve 44 is a conventional four-way manual or power operated valve having three positions with the center position shown in FIG. 1 rendering the system inoperative for either simple braking or power regeneration. As viewed in FIG. 1, movement of the valve from the center position downwardly conditions the system for power regeneration from either drum since pressure fluid from the pump 10 or from the pump 21, depending upon which way the cable is being moved, is delivered to the motor 34 which feeds power back into the power train of the yarder. If the valve 44 is moved upwardly from the center position shown, the system is conditioned for braking only the haulback drum with no regeneration, which is desirable during yarding operation on a steep downhill slope when it is desirable to furnish a braking action on the haulback drum without regenerating power as will be understood by those skilled in the art.

Considering now in detail the various functions of the system, FIG. 1 illustrates the condition wherein the valve 44 is in the center position with the result that no braking and no regeneration is accomplished. As may be seen, the valve control line 47 for the valve 29 is in communication with the return line 48 through the line 50 such that the valve 29, as previously explained, remains in the open position establishing a direct flow path between the line 26 and the check valve 28. As long as this condition prevails, pressure fluid will be delivered directly to the relief valve 31 which is also, at this time, in the open position so as to allow pressure fluid to pass directly to the return line 46 and back to reservoir. This condition prevails because the line 45 is connected to the return line 48 through the cross passage 51 in the body of the valve 44. Thus, regardless of which one of the pumps 10 or 21 is driven, the pressure fluid is dumped directly back to the reservoir without effect on the system.

In the event that power regeneration is desired, the valve 44 is moved downwardly as viewed in FIG. 1 so that the line 45 is now blocked from the return line 48 while the line 47 remains in communication with the return line 48. With this condition prevailing, the valve 29 remains open so as to pass fluid directly to the valve 31 which now is closed since the line 45 is blocked and the system pressure is acting so as to balance the valve. With the valve 31 closed, the return conduit 46 is blocked off and fluid pressure is pumped directly to the motor 34. As afore mentioned, the system pressure may be regulated by manually controlling the valve 36 which determines the system pressure for controlling the compensator 35. A gage or the like may be provided for visual monitoring of the system pressure. Controlling the adjustment of the compensator 35 by means of the brake control valve 36, of course, determines the amount of motive power put back into the power train of the yarder.

To establish a braking effect on the haulback drum for steep downhill yarding where power regeneration is unnecessary and undesirable, the valve 44 is moved upwardly from the position shown in FIG. 1 so as to block the line 50 from reservoir and to open line 45 to the reservoir via the return line 48. When the selector valve 44 is in this position, the line 45 is vented so as to unbalance the valve 31 which opens so as to direct any pressure fluid received in the return line 46 without passing through the motor 34. With the selector valve 44 in this position, the line 50 is blocked and pressure is built up in the line 47 through the valve 29 to the point that the valve becomes unbalanced and closes the passage between the line 26 and the valve 31. A new flow path is established including the line 26, the line 47, the check valve 49 and the brake control valve 36. The amount of flow permitted and hence the pressure or resistance in the line 47 may then be controlled by the valve 36 to accomplish variable braking on the haulback drum as cable is unspooled.

Referring now to the FIG. 2, a second embodiment of the invention is illustrated wherein the system consists of hydraulic units on both the haulback and the main line drums. It will be understood, of course, that a prime mover and power transmission means similar or identical to that shown in FIG. 1 will be employed to selectively drive either the main or haulback drum. Each of the units is a piston type reversible hydraulic unit which can be either a pump or a motor, depending upon the operational requirements. Thus, when the main line drum is being powered, the hydraulic unit on the haulback drum is conditioned to operate as a pump which delivers fluid to the hydraulic unit on the main line drum which operates as a motor to supplement the power delivered to the main line drum. In reverse operation, when the haulback drum is being driven, the hydraulic unit on the main drum becomes a pump and the hydraulic unit on the haulback drum becomes a motor receiving pressure fluid from the hydraulic unit on the main line drum.

Referring now to FIG. 2, the closed system for the hydraulic regenerative braking installation is illustrated schematically. As shown, a reversible hydraulic unit 52 is connected with the haulback drum and a second hydraulic unit 53 is connected with the main drum. A high pressure line 54 connects the hydraulic units 52 and 53 on one side and a low pressure line 56 connects the units on the other side. Each of the units 52 and 53 may be a piston type driven unit and it will be understood that step-up gears or the like on both the main and haulback drums (not shown) will be used to bring the speed of the hydraulic units up to an operating range.

The units 52 and 53 are provided with compensator devices 57 and 58 respectively, the setting of which determines the output capability of the units when driven as hydraulic motors in a well known manner. Each of the compensators 57 and 58 may be connected to the high pressure line 54 by means of the conduits 59 and 61 respectively through a selectively operable solenoid valve 62. The valve 62 is a two-position four-way valve whereby the compensator on a particular device being used as a motor may be put in communication with the high pressure side of the system and the compensator on the hydraulic unit used as a pump may be connected with the tank or reservoir. Thus, with the setting shown in FIG. 2, the compensator 57 is connected to the pressure line 54 through the conduit 63 and valve 62 and the compensator 58 is connected to tank through the conduit 64 and the valve 62. The setting of the compensators may be effected by the control valves 66 and 67 respectively. A system relief valve 69 associated with the check valve 71 is also provided between the high pressure line 54 and the low pressure line 56. The relief valve 59 serves to dump excess pressure in the system to the low pressure side and from thence over the low pressure relief valve 72 and back to tank through the filter 73.

The units 52 and 53, when functioning as motors, are provided with various pitch wobble plates controlled by the compensators in a well known manner. When a unit is to be used as a pump, its compensator is deactivated as described through the selector valve 62 and the wobble plate is locked in a fixed position so as to convert the hydraulic unit to a fixed displacement pump. For this reason, the locking cylinders 74 and 76 are provided for the hydraulic units 52 and 53 respectively with each cylinder being selectively connected to either a pressure line 77 or to tank through the line 78. The selector valve 79 may be a two-position four-way solenoid valve which, in the position shown in FIG. 2, unlocks the cylinder 74 and locks the cylinder 76 through the pressure line 77 con-

nected with a charging pump **81** with a relief valve **82** maintaining a constant predetermined pressure in the line **77**.

With the valves positioned as shown in FIG. 2, the hydraulic unit **52** will function as a motor since the compensator **57** is connected to the high pressure line **54** through the valve **62** and the wobble plate of the unit is unlocked since the cylinder **74** is connected to tank pressure. The unit **53** is being used as a fixed displacement pump since the compensator **58** is connected to tank pressure through the valve **62** and the lock cylinder **76** is locked into predetermined position by fluid pressure in line **77**. In this maner the main drum will be braked by the pump **53** and the pressure fluid thus generated by the pump **53** will be delivered to drive the motor **52** to aid in powering the haulback drum. When the spooling of the cable is reversed, such that braking is desired on the haulback drum and additional power is desired on the main drum, the valves **62** and **79** are repositioned so as to disconnect the compensator **57** and lock the cylinder **74** so that the unit **52** acts as the pump and the compensator **58** is connected to line pressure and the cylinder **76** is unlocked so that the unit **53** functions as a motor.

From the foregoing, it will be apparent to those skilled in the art that the present invention provides novel and useful improvements in regenerative brake systems. The arrangement and types of srtuctural components utilized in the present invention may be subject to numerous modifications well within the purview of this invention and applicants intend only to be limited to a liberal interpretation of the specification and appended claims.

What is claimed as new and novel and desired to be secured by Letters Patent is:

**1.** A power regenerative braking system for converting the energy produced by braking a first moving element into power for supplementing the driving force for driving a second moving element comprising in combination; fluid pump means connected to be driven by said first element, fluid motor means drivingly connected to supplement the driving force for said second member, conduit means for delivering pressure fluid from said pump means to said motor means, and means in said system for selectively controlling the output of said motor.

**2.** The combination according to claim **1** wherein; said first and second moving elements constitute first and second cable winding drums respectively, cable means extending between said drums, said cable means being adapted to be wound onto said second drum and simultaneously unwound from said first drum, and power means drivingly connected to provide the driving force for said second drum to selectively rotate said drum, said motor means being connected to supplement the driving force of said power means.

**3.** The combination according to claim **2** wherein; said power means includes a source of power, power transmission means, means to selectively connect said transmission means to either one of said drums, second pump means connected to be driven by said second drum, overrunning clutch means connecting each of said drums to the associated pump means, and check valve means in said conduit means to prevent flow of pressure fluid from one pump means to the other, said motor means being drivingly connected to said transmission means, whereby the non-driven drum will be braked through the associated overrunning clutch and pump means and the pressure thus generated will be delivered to said power transmission means to supplement the driving force of the other drum.

**4.** The combination according to claim **3** including selectively operable control valve means in said conduit means for directing pressure fluid from either of said pump means to said motor for power regeneration and for diverting pressure fluid from only one of said pump means at a selectively variable pressure directly to system reservoir to obtain braking of the drum associated with said one pump means.

**5.** The combination according to claim **3** including; first relief valve means in said conduit means between said motor and said check valve means, said first relief valve having a first position for directing pressure fluid to said motor for power regeneration and a second position for dumping fluid to the system reservoir when regeneration is not desired.

**6.** The combination according to claim **5** wherein; said first relief valve constitutes a fluid pressure balanced valve including a vent line, said first relief valve being held in the first position when said vent line is blocked from the system reservoir and held in the second position when the vent line is connected to the system reservoir, and selector valve means for selectively blocking said vent line and connecting said vent line to reservoir.

**7.** The combination according to claim **6** including a second relief valve means in said conduit means between one of said pump means and said check valve means, a return conduit connecting said second valve to the system reservoir, said second relief valve having a first position for directing pressure fluid to said check valve means and a second position for directing pressure fluid to said return conduit, the means for controlling the output of said motor including a manually operable system relief valve for controlling the fluid pressure in said system, said system relief valve being located in the return line between said second relief valve and the system reservoir to selectively control the flow of fluid and the fluid pressure in said return line.

**8.** The combination according to claim **7** wherein said second relief valve constitutes a fluid pressure balanced valve and said return line includes a by-pass vent line, said second relief valve being held in the first position when said by-pass vent line is connected to the system reservoir and being held in the second position when said by-pass vent line is blocked, said selector valve means including means for selectively blocking said by-pass vent line and connecting the same directly to reservoir.

**9.** The combination according to claim **2** wherein; said power means includes a source of power, power transmission means, means to selectively connect said transmission to either one of said drums, said pump constitutes a first reversible hydraulic unit, a second reversible hydraulic unit drivingly connected to said second drum, each of said first and second hydraulic units being operable as a pump when driven by the associated drum and operable as a fluid motor when driven in the opposite direction by fluid pressure, and selectively operable control valve means in said conduit means to condition said hydraulic units to function as either pump or motor units alternately.

**10.** The combination according to claim **2** wherein; said power means includes a source of power, power transmission means, means to selectively connect said transmission means to either one of said drums, said pump constitutes a first reversible hydraulic unit, a second reversible hydraulic unit drivingly connected to said second drum, each of said first and second hydraulic units being operable as a pump when driven by the associated drum and operable as a fluid motor when driven in the opposite direction by fluid pressure, said conduit means constituting a first conduit means and including a high pressure line and a low pressure line connecting like ports of said hydraulic units respectively, a pressure control valve and a pressure compensator connected to each hydraulic unit to control the output of the respective unit when functioning as a motor, fluid pressure responsive locking means connected to each unit to fix the capacity of the associated unit when functioning as a pump, a source of fluid presure, second conduit means for transmitting pressure fluid to said locking means, first selector valve means in said first conduit means for selectively connecting the pressure control valve and compensator for one of said units to the high pressure line and the control valve and

compensator for the other of said units to the system reservoir, and second selector valve means in said second conduit means for connecting the pressure responsive locking means of said one hydraulic unit to system reservoir and the pressure responsive locking means of said other hydraulic unit to said fluid pressure source, whereby said units may be operated alternately as pump and motor units depending upon which drum is powered.



**References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 2,147,062 | 2/1939 | Rosener | 254—187 |
| 2,867,760 | 1/1959 | Huggard | 254—173 |


EVON C. BLUNK, *Primary Examiner.*

H. C. HORNSBY, *Assistant Examiner.*