HYDRAULICALLY-CONTROLLED SKI LIFT

Filed July 24, 1967

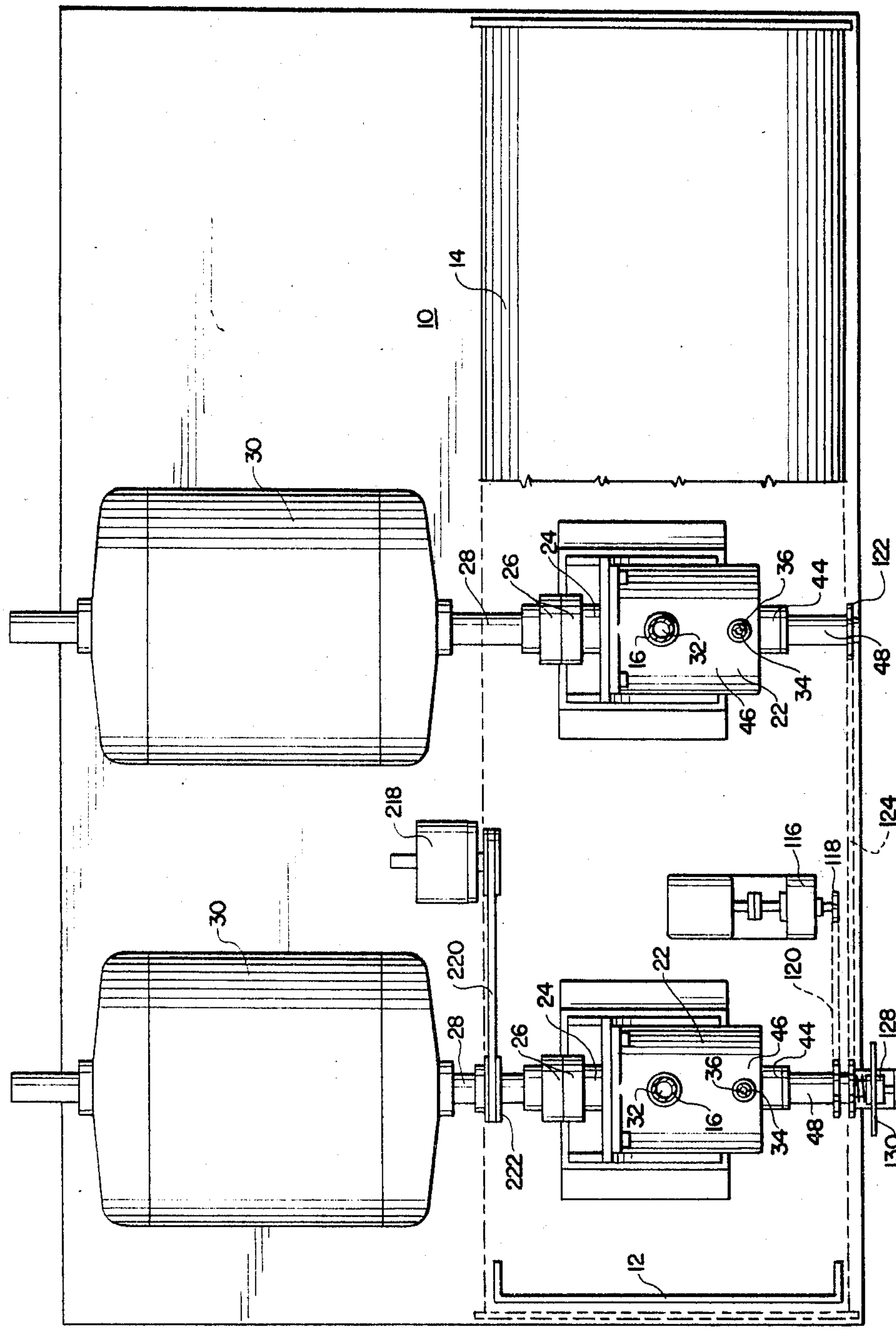

FIG. 1

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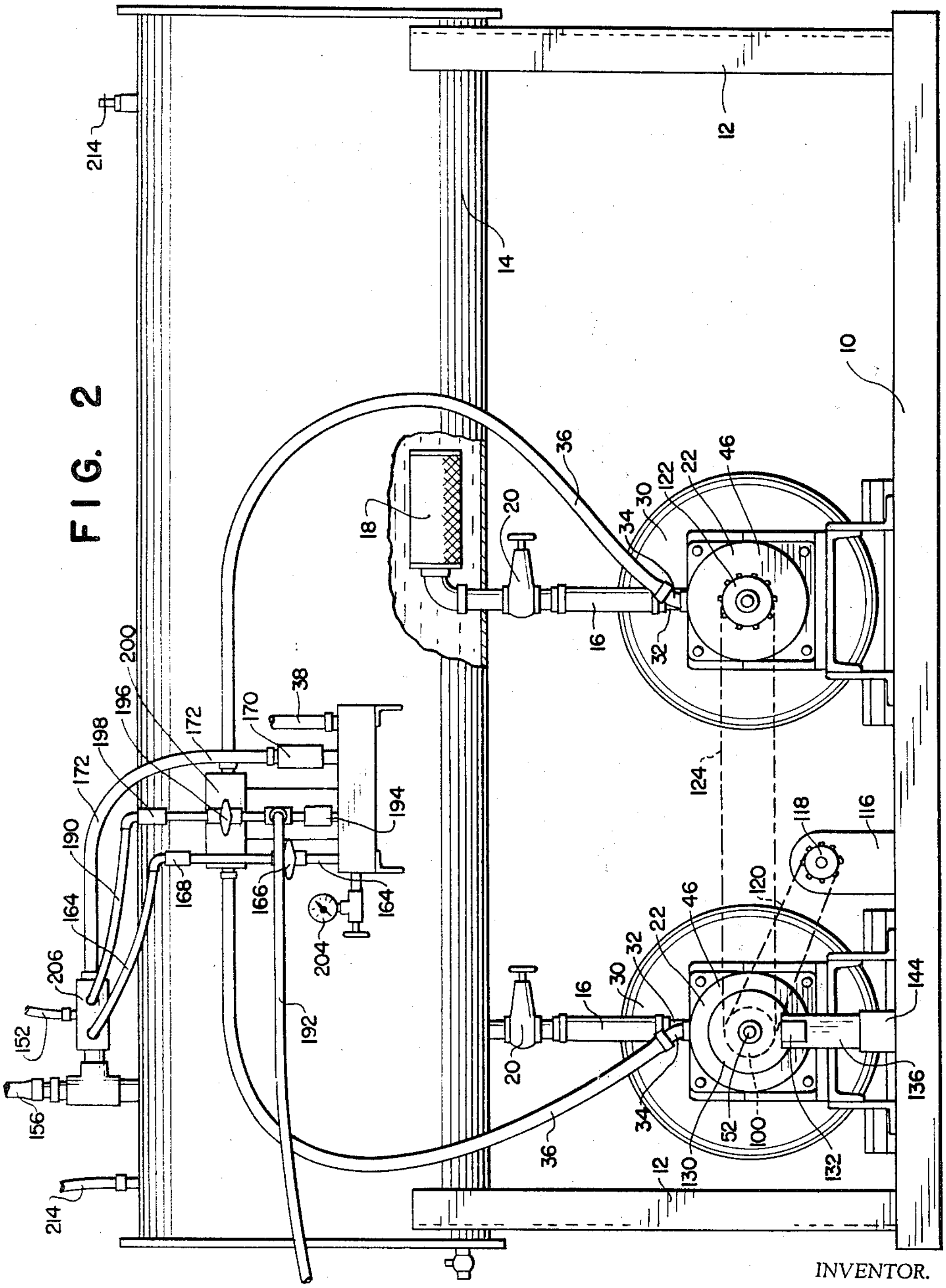
FIG. 2



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HYDRAULICALLY-CONTROLLED SKI LIFT

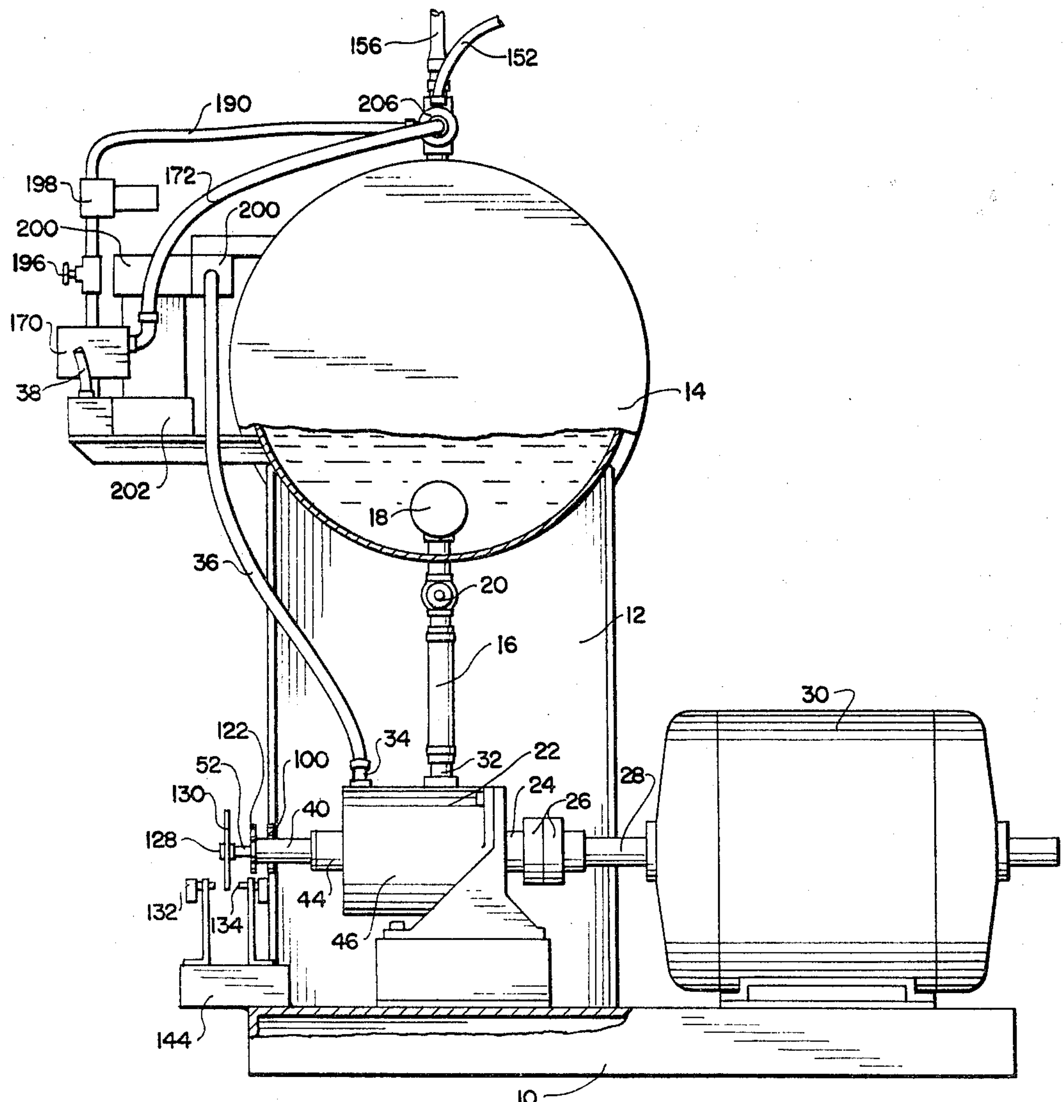

FIG. 3

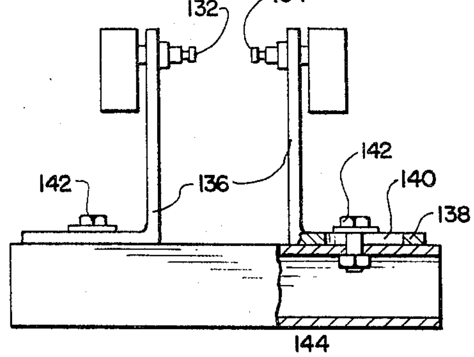

FIG. 4

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HYDRAULICALLY-CONTROLLED SKI LIFT

Filed July 24, 1967 Sheet 4 of 5

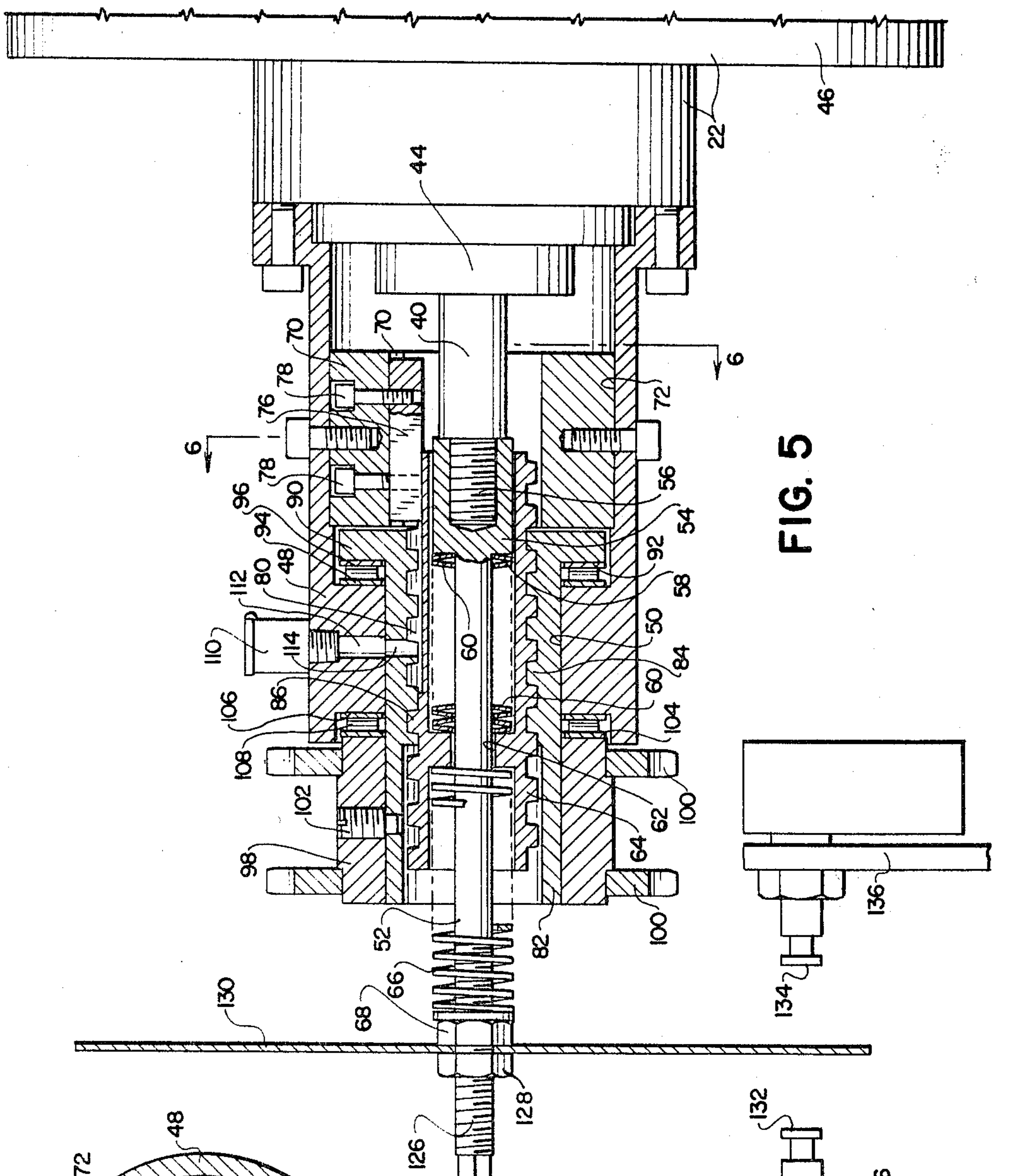
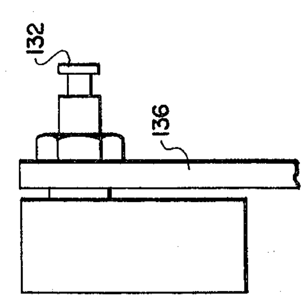


FIG. 5



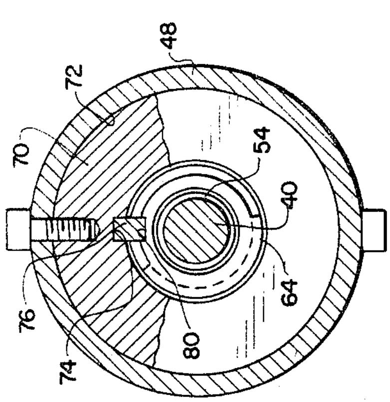


FIG. 6

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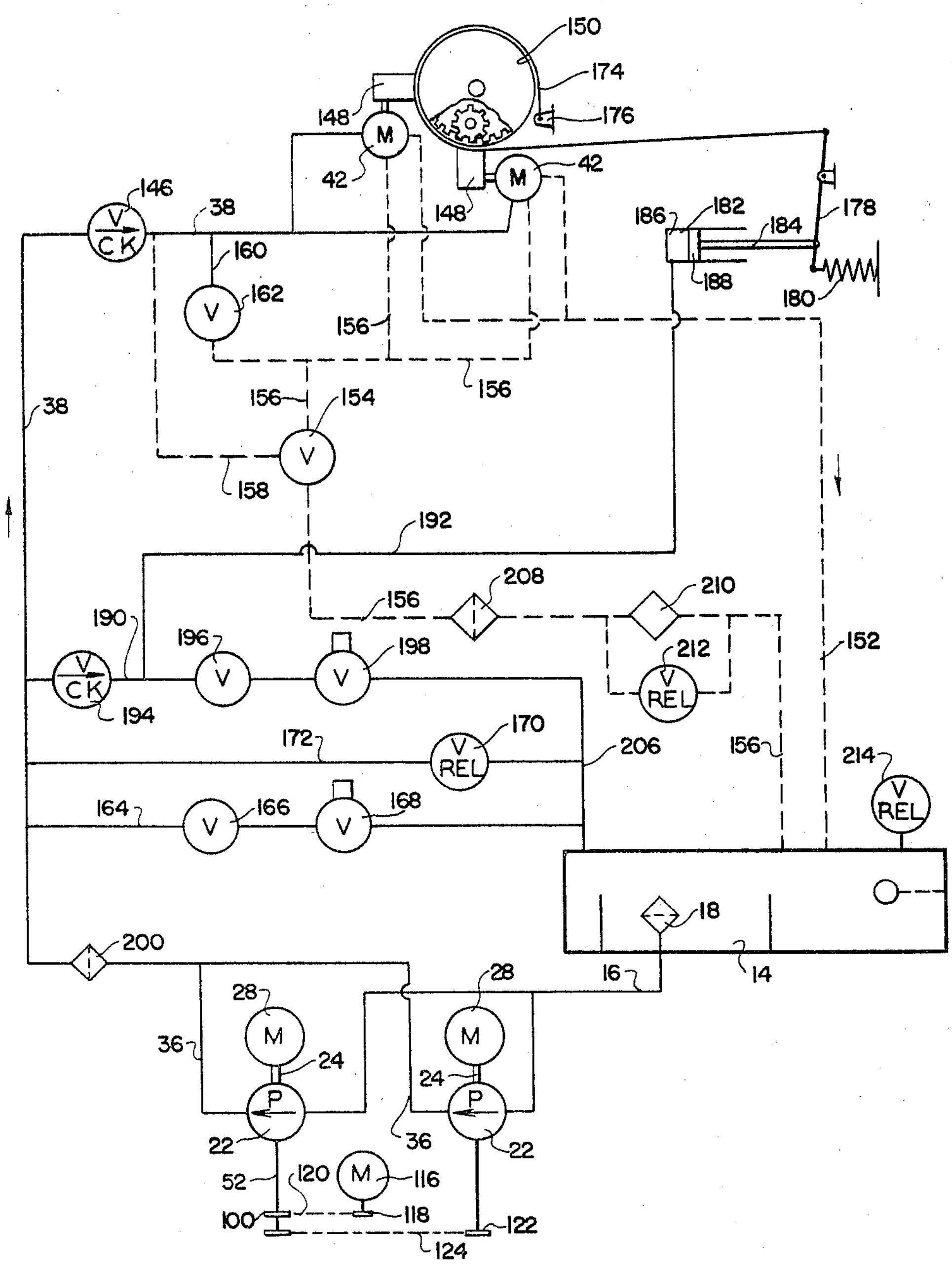

FIG. 7

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United States Patent Office 3,440,819
Patented Apr. 29, 1969

3,440,819

HYDRAULICALLY-CONTROLLED SKI LIFT

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Int. Cl. F16h *39/46;* B61b *11/00*
U.S. Cl. 60—52 17 Claims

ABSTRACT OF THE DISCLOSURE

This invention relates to a variable-speed ski lift drive that incorporates one or more motor-driven hydraulic pumps, the output of which is varied and controlled between adjustable maximum and minimum limits by a control circuit that operates a servo-motor connected to the volume control of the pumps. The output of the pumps is fed to at least one hydraulic motor which, in turn, drives the lift. Between the pumps and motors are connected no less than three valve-controlled braking circuits which act independently of one another or in combination to vary the time interval required to bring the lift to a complete stop. Check valves in the circuit prevent the lift from running backward under load.

The ski lift of the present invention offers many advantages unavailable in the conventional mechanically- or electrically-driven lifts of the type found on most ski slopes here in the United States and abroad. One of the most important advantages is that of continuous operation at any line speed from a mere creep to a maximum of several hundred feet a minute. This is made possible through the use of a hydrostatic transmission consisting of one or more variable-volume hydraulic pumping units driving at least one hydraulic motor that is, in turn, connected to the bull wheel of the lift through a suitable gear reducer. Since the speed of the hydraulic motor is directly proportional to the rate of flow of the hydraulic fluid, the speed of the lift is determined by controlling the volume of hydraulic fluid pumped.

Another advantage directly attributable to the use of a hydraulic system and its associated controls is that of automatic speed regulation. For example, an overhauling load which would normally tend to increase the speed of the lift acts in this instance to reduce the hydraulic motor inlet pressure and cause the governor valve to restrict the flow from the motor outlet thus maintaining the line speed fairly constant at a predetermined level. The foregoing holds true even though the magnitude and direction of the load varies between a maximum uphill load and a permissible downhill load.

The check valve on the inlet side of the hydraulic motor functions to prevent the lift from running in reverse so that it can be said to include automatic braking as well as automatic speed regulation. Even the governor valve on the motor outlet prevents forward motion of the lift and, for this reason, can be considered part of an automatic braking system.

One of the prime advantages of the system is that of controlled acceleration and deceleration rates. Here, by adjusting the speed of the servo unit that controls the output volume of the pumps, the acceleration and deceleration rates of the lift line can be regulated, adjusted independently of one another and varied to suit the particular operating conditions. For instance, a lift located on a practice slope can be regulated to start up slowly and run at a moderate to slow speed consistant with the needs of the beginning skier. The lift line to an expert area may, on the other hand, accelerate rapidly to a high speed because of the advanced skills of those skiers making use of such a facility. Conversely, even on a practice hill lift, it may be desirable to decelerate rapidly so as to enable small children and others totally unfamiliar with boarding and riding a lift to use same.

Certainly, one of the most outstanding advantages of a hydraulic lift is the versatility with which it can be braked. With the instant lift, three different braking rates are provided, two of which are purely hydraulic while the third is a combination of hydraulic and mechanical braking. In the first, or so-called "normal" stop, the volume of fluid issuing from the pumps is merely dropped to zero thus permitting the lift line to come to rest. The second braking rate is that of the "fast stop" capable of handling most emergencies wherein the pressure in the manifold is dumped by means of a solenoid valve through an adjustable restriction that enables the rate to be controlled while at the same time reducing the output of the pump to zero as in the "normal" stop situation. The last of the three stop procedures is that of the "panic" or "emergency" stop which combines the actions of the "normal" and "fast" stop with a mechanical braking action wherein a hand brake is applied directly to the bull wheel. This last type of stop can be initiated manually by the lift personnel and, in addition, is initiated automatically upon signal from the safety system or failure of the electrical system. Even the manual application of the hand brake can take place several ways, i.e. through actuation of the hydraulic system and operation of a hand brake.

One of the more significant advantages of the lift that has not been previously mentioned is that of being able to run it in reverse so as to unload same in an emergency situation. To accomplish this end, the check valve on the inlet side of the motor is by-passed and a mechanical stop is removed to allow the unit to run backwards so that the skiers can be returned to the loading point.

It is, therefore, the principal object of the present invention to provide a novel and improved hydraulic ski lift drive system.

A second objective of the invention herein disclosed and claimed is to provide a ski lift that can be continuously operated at any speed from just barely moving up to its maximum.

Another object is the provision of a lift of the type aforementioned wherein the speed is automatically regulated within narrow predetermined limits regardless of the magnitude and direction of the load.

Still another objective is to provide a hydraulically-operated ski lift that includes automatic braking features that will prevent the unit from moving either forward or backward in an emergency or whenever the lift is stopped for any reason and, in addition, semi-automatic and manual braking systems that can bring the unit to a controlled stop at any one of three different stopping rates.

An additional objective is to provide a ski lift wherein the rates of acceleration and deceleration can be controlled, varied and otherwise adjusted independently of one another.

Further objects are the provision of a ski lift that is rugged, economical to operate, versatile, safe, dependable, easy to use, efficient and readily adaptable to various operating conditions.

Other objects will be in part apparent and in part pointed out specifically hereinafter in connection with the description of the drawings that follows, and in which:

FIGURE 1 is a top plan view, portions of the hydraulic fluid reservoir having been broken away to reveal the structure therebeneath, showing the variable volume pumps, pump drives and servo-motor pump control;

FIGURE 2 is a front elevation of the apparatus of FIGURE 1 with portions of the tank shown broken away to reveal the filter;

FIGURE 3 is an end elevation of the apparatus of

FIGURES 1 and 2 with the tank again shown broken away to reveal the interior construction;

FIGURE 4 is a fragmentary detail to an enlarged scale, portions of which have been broken away and shown in section, showing the adjustable mount for the maximum and minimum flow control switches of the pump control;

FIGURE 5 is a considerably enlarged fragmentary detail, most of which has been shown in diametrical section, detailing the servo-actuated pump controller;

FIGURE 6 is a section taken along line 6—6 of FIGURE 5; and,

FIGURE 7 is a schematic flow control diagram of the hydraulic system including elements of the mechanical bull-wheel brake.

Referring now to the drawings for a detailed description of the present invention and, initially, to FIGURES 1–3 and 7 for this purpose, reference numeral **10** has been used to designate a base having uprights **12** at opposite ends thereof that support a hydraulic fluid reservoir **14** in superimposed relation. Connected into the interior of this reservoir or tank are a pair of hydraulic fluid supply lines **16** containing strainers **18** on their inlets and conventional shut-off valves **20**. The outlet ends of these supply lines **16** deliver fluid from the reservoir to the inlets of variable-volume hydraulic pumps **22**.

Pumps **22** of the type shown and described in U.S. Patent No. Re. 25,850, reissued Sept. 7, 1965, to P. G. Stewart and assigned to Applied Power Industries, Inc., are preferred for purposes of the instant invention. Reference should be made to the above patent for details concerning the construction and operation of the pumps **22** because only brief reference need be made thereto for purposes of the present description. The input shafts **24** of the pumps are connected by suitable shaft couplings **26** to the output shafts **28** of motors **30**. These pump drive units may either be squirrel cage induction motors as shown or, if desired, internal combustion engines can be substituted for the electric motors.

Inlet ports **32** of the pumps receive fluid from the reservoir through supply lines **16** and discharge same under pressure through outlet ports **34** into delivery lines **36** that ultimately connect together and form a single common line **38**. Characteristic of the pump is the fact that the output volume can be varied from zero to a maximum by shifting a cam member axially inside a socket located within the opposite end of drive shaft **24** so as to vary the amount of fluid being by-passed. This cam element is identified by reference numeral **55** in Re. 25,850 and its function is fully described therein beginning at line **21** of column **3**. It should suffice to point out that while cam member **55** is connected by means of a spline to shaft **25** (shaft **24** of the present application) and, therefore, turns therewith, it is the axial movement of this cam member that brings about the variation in output volume of the pump. Now, in the aforesaid patent, an assembly consisting of nut **68**, externally threaded shaft **71** and knob **67** are operatively connected to the end of cam member **55** and they function upon actuation to shift the latter axially. In the instant construction, shaft **40** performs the identical function of shaft **71** in Re. 25,850 insofar as moving cam member **55** (not shown) axially back and forth to bring about variations in output volume even though it does not screw in and out or, in fact, rotate at all to accomplish this end as is the case with its counterpart above-mentioned. Thus, by moving shaft **40** axially in and out of the pump **22**, the volume of fluid passing out through lines **36** into common line **38** is, therefore, regulated as is the speed of hydraulic motors **42** (FIGURE 7), the speed of the latter being exactly proportional to the rate of flow of the hydraulic fluid pumped therethrough.

At this point it would, perhaps, be advisable to interrupt the detailed description of the drawings briefly and explain the parallel pump and parallel motor set up shown schematically in FIGURE 7. In lifts where the power requirement does not exceed approximately 75 horsepower, a unit employing only a single pump and a single motor will generally suffice. Where larger loads are to be handled, the power requirements are obviously considerably greater and two or more pumps, along with a corresponding number of motors, must be used to satisfy these greater needs. A hydraulic drive unit of the type shown herein is ideally suited for use to power a ski lift because of this fact that any number of pump-motor subassemblies can be connected together to answer the requirements of a particular lift. Non-hydraulic drives are not nearly as versatile in this respect.

For purposes of the present description, only two pumps **22** have been shown connected in parallel with one another along with two motors **42** that are similarly connected; however, the same arrangement would be used for three or more pump-motor combinations. All of the pumps feed their output into a common supply line and the latter, in turn, supplies all the motors. While not specifically illustrated, the motors, after passing through a gear reducer, are connected in driving relation to a single bull wheel but at different points of its periphery.

One of the most significant features of the present invention is the control mechanism by which the lift operator controls the speed of the lift by varying the pump output. Included within this control mechanism is a speed-limiting mechanism that permits the maximum and minimum lift speeds to be set at various rates and automatically maintained. While all of the figures of the drawing show certain elements of this control mechanism, FIGURES 5 and 6 to which reference will now be made show the details thereof.

Attached to the portion **44** of the main pump housing **46** that mounts cam actuator **40** for reciprocating movement is a control rod housing **48**. Axial bore **50** therein receives the cam actuator **40** as well as the control rod **52** that is threadedly attached to the end of said actuator to form an extension thereof. The hollow internally-threaded socket **54** on the end of the control rod that screws onto the threaded end **56** of actuator **40** includes a shoulder **58** facing outwardly against which the inner end of compressible spring member **60** abuts. The outer end of the latter spring member abuts annular abutment **62** on the inside of hollow externally-threaded sleeve **64** that loosely encircles rod **52** as shown. Spring member **60** allows externally-threaded sleeve **64** to move to the right or inwardly toward the pump as viewed in FIGURE 5 even though control rod **52** and the cam actuator **40** to which the latter member is attached have reached the end of their inwardly-directed stroke. A similar compression spring member **66** mounted between the outwardly-facing shoulder formed by annular abutment **62** and nut **68** threaded onto the end of rod **52** provides an identical strain-relief function for outwardly-directed movement of sleeve **64** once rod **52** and cam actuator **40** have reached the limit of their stroke in the opposite direction. Spring **60** is under some compression at al times so as to normally bias rod **52** and the cam actuator associated therewith inwardly counterbalancing the opposing bias exerted thereon by spring **66** along the bias exerted on cam member **55** by compression spring **58** (see FIGURE 1 of Re. 25,850).

A collar **70** is bolted inside bore enlargement **72** from outside the casing. This collar contains a keyway **74** and a key **76** is held therein by recessed bolts **78**. Key **76** projects radially into keyway **80** milled into the externally-threaded surface of sleeve element **64** thus guiding the latter axially along the rod and cam actuator while, at the same time, preventing rotation relative thereto. Axial movement of sleeve element **64**, of course, acts through rod **52** and cam actuator **40** to vary the flow from the pump, pushing said assembly all the way in acting to decrease the flow to zero while pulling it out brings about maximum flow. Actually, although outward movement of sleeve **64** brought about by rotation of internally-threaded member **82** results in rod **52** and the cam actuator **40** being pulled away from the cam member as will be explained in detail presently, movement of said cam member is accomplished by compression spring **58** (FIGURE 1 of Re. 25,850) once said rod-cam actuator subassembly is backed off.

Internally-threaded screw member **82** has a cylindrical outer surface that turns within bore **50** which maintains same in coaxial alignment with the remaining elements of the speed control assembly. The threaded internal surface **84** of member **82**, of course, mates with the external threads **86** on tubular member **64** so that rotation of the former screws the latter in and out of the bore. An annular flange **90** on the inner end of member **82** projects into bore enlargement **72** and presents an outwardly-facing shoulder **92** that opposes inwardly-facing shoulder **94** to produce an annulus in which roller bearing **96** is seated.

The end of member **82** projects out beyond the end of housing **48** where the hub **98** of double sprocket gear **100** is attached thereto by means of set screw **102**. The inwardly-facing end **104** of hub **98** and the outer end **106** of the casing **48** define a second annulus for the reception of roller bearing **108**. Thus, it will be seen that rotation of sprocket **100** will operate through internally-threaded member **82** to screw tubular member **64** in and out so as to vary the volumetric output of the pump **22** between zero flow and maximum. A grease cup **110** atop the casing communicates with the threads through alignable openings **112** and **114**.

Actual operation of the volume control is accomplished by means of reversible electric motor **116** which carries a sprocket **118** on its drive shaft that is connected in driving relation to one of the dual sprockets **100** by means of chain **120**. Now, in instances where only a single pump **22** is used in the system, only one sprocket **100** is needed; whereas, in the two-pump embodiment shown, one of the sprockets **100** is driven from motor **116** while the other drives sprockets **122** on the other pump through chain **124**.

Once reversible motor **116** is energized by the lift operator in a direction to either slow down or speed up the lift, it would ordinarily continue to run until some action was taken to stop it again or the speed control mechanism above-described reached the end of its stroke and something broke. Obviously, therefore, some automatic shut-off mechanism must be provided in the control circuit to eliminate the need for manual control over this function as well as preventing damage to the system. The automatic shut-off system of the instant invention which will soon be described not only deenergizes motor **116** shortly after the control mechanism has closed the pump down to zero volume but, in addition, it provides a means for setting the maximum speed of the lift at any desired level below the maximum at which the system is capable of operating. This automatic speed-limiting mechanism is most clearly revealed in FIGURES 1, 3, 4 and 5 to which reference will now be made.

Rod **52** on one of the pumps **22** projects out well beyond the hub **98** of the dual sprocket **100** where it is provided with a threaded section **126** of substantial length. Nut **68** that forms one abutment for spring **66** already described is screwed onto threaded section **126** as is a second nut **128** that cooperates with nut **68** to adjustably fasten plate **130** therebetween. Plate **130** functions as a switch operator capable of actuating either of two switches **132** and **134** mounted in the path thereof on the vertical legs **136** of adjustable L-shaped brackets. The horizontal legs **138** of these brackets contain elongated slots **140** (FIGURE 4) by which fasteners **142** fasten same to base member **144** for adjustable movement toward and away from one another along an axis normal to the plane of the switch operator **130** and essentially parallel to the axis of movement of rod **52**.

Now, switch **134** is positioned by adjusting its bracket on base **144** such that switch operator **130** contacts and actuates same to open position shutting off motor **116** shortly after both cam actuators **40** have pushed their respective volume control cams (**55** in Re. 25,850) all the way in to their "zero flow" positions. To insure that the flow from both pumps **22** has, in fact, stopped completely, switch **134** is preferably set so that it closes after externally-threaded member **64** has overtraveled a bit and compressed spring **60** even though the rod **52**, cam actuator **40** and flow control cam have reached the limit of their stroke and stopped. In addition to insuring that both pumps have shut off their delivery of fluid to the system, the above-described "overtravel feature" takes care of any differences in the points at which the two pumps shut off. In other words, if one of the pumps shuts off before the other, this feature insures that both will be completely shut off before the motor **116** is deenergized.

The other limit switch **132**, likewise, functions upon actuation to deenergize motor **116**; however, in this instance it does not do so when the output of the pumps has dropped to zero and the lift has stopped, but instead, switch **132** controls the maximum speed of the lift. In other words, the longer motor **116** is allowed to operate in the direction necessary to pull cam actuator **40** out of the pump housing, the faster the lift will go due to the greater volume of fluid being supplied by the pumps. In most instances, the ski area operator has no desire to run the lift at or even close to its maximum speed for safety reasons; therefore, the sets switch **132** by moving bracket **136** to the right on base **144** as seen in FIGURES 3, 4 and 5 so as to stop cam actuator **40** before it has drawn the cam member all the way out and let the pump operate at its maximum capacity. Obviously, this maximum allowable lift speed can be changed at the will of the operator to accommodate instances of peak activity. Even when the lift is operated at its maximum speed, switch **132** should be positioned to shut off motor **116** and prevent overtravel of the pump-cam-control subassembly. Note, however, that if the motor **116** were to continue to turn sleeve **64** after rod **52** and cam actuator **40** had reached the end of their withdrawal stroke, no damage would occur immediately because compression spring **66** would compress and allow shaft **52** to stop while the tubular member continued to thread its way back out of member **82**. Of course, once spring **66** has compressed to its limit, the unit must either be actuated manually to shut off motor **116** or switch **132** must do so automatically; otherwise, some damage to the unit is bound to occur.

Attention is now directed to FIGURES 2, 3 and 7 for further details of the system. The combined output of pumps **22** passes through supply line **38** and check valve **146** where it is, once again, divided and delivered to hydraulic motors **42** (FIGURE 7). The drive shafts of these motors are connected to gear reducers **148** and the latter are connected directly to the bull wheel **150** in driving relation. A portion of the fluid leaving the motors is returned to the reservoir through return line **152** while the remainder of the fluid passes through governor valve **154** and a second return line **156**, the location and functions of which will be set forth in detail presently.

Motors **42** are of the multiple-reciprocating piston type operated by a rotating cam plate. Motors of the design forming the subject matter of U.S. Patent 3,139,038 issued June 30, 1964, to Applied Power Industries, Inc., have been found especially effective and reliable for purposes of this instant invention.

Now, with regard to governor valve **154**, it is of the reciprocating spool type normally spring-biased into closed position. Fluid is, however, bled off the supply line **38** downstream of check valve **146** but ahead of the motor inlets and delivered to the left side of the spool so as to shift same toward its open position against the spring bias exerted thereon in a direction to keep it closed. Thus, when the lift is stopped, the load, which is usually much greater on the uphill side, will be acting in a direction to operate motors 42 as pumps attempting to force fluid back into the supply line 38. Check valve 146, of course, prevents this from taking place and the lift will stop because line 158 dead ends at governor valve 154 so no fluid can escape by that path.

Occasions may arise, however, in which it becomes necessary to allow the lift to run in reverse so as to unload the skiers at the boarding point. To provide for such an eventuality, a by-pass line 160 containing a manually-operable valve 162 is connected between the inlet and discharge ends of the motors 42, i.e. from supply line 38 beyond check valve 146 and into line 156 ahead of governor valve 154. When an emergency demands that the lift be run backwards, valve 162 is opened; whereupon, the normal uphill load on the bull wheel 150 will tend to back-drive same thus running motors 42 as pumps to circulate the fluid out into line 38, through by-pass 160 and valve 162 and back into the motors through return line 156. Governor valve 154 will be closed at this point due to the balanced fluid pressure on both ends thereof which allows it to move to its normally-closed positions under the bias of its spring (not shown).

In those rare situations where the downhill load exceeds the uphill load, governor valve 154 acts as a speed governor and prevents the lift from running away. This so-called "overhauling load" situation also causes the motors 42 to act as pumps, but in a direction to assist rather than oppose the action of pumps 22. As motors 42 attempt to suck fluid from supply line 38, the pressure in line 158 drops so that governor valve 154 can move toward its normally-closed position. The resulting restriction in the flow of fluid through return line 156 will slow down motors 42 and build up the pressure in line 158 until a balanced condition is achieved.

During normal lift operation, governor valve 154 operates to maintain the lift speed relatively uniform. For instance, under high loads, the pressure at the motor inlets is at a high level and line 158 will sense this pressure to force governor valve open. Conversely, under light loads, valve 154 will move toward closed position and restrict the return flow to the reservoir.

Next, with reference to FIGURE 7, the details of the braking system will be set forth in detail. As previously mentioned, the lift includes three braking systems which are additive in their net effect and which result in a relatively faster stop. The first of these systems is that which has been denominated the "slow stop" in which the volume of fluid issuing from the pumps 22 is reduced to zero by actuating servo-motor 116 as has already been described in considerable detail. The rate at which the lift decelerates and comes to a complete stop is, of course, a function of the speed of reversible motor 116 as is the rate of acceleration. Usually, the lift will decelerate and stop in a few seconds by this method which is adequate for all but emergency or potential emergency condition.

The second or "fast stop" braking system combines the above-described "slow stop" operation of reducing the pump volume to zero by actuating motor 116 with dumping the pressure in supply line 38 through by-pass 164 that contains an adjustable needle valve 166 and a normally-closed solenoid valve 168. By-pass line 164 connects the supply line 38 at a point upstream of check valve 146 with the reservoir 14. A pressure relief valve 170 is connected in parallel with valves 166 and 168 in line 172 as shown. Actuation of solenoid valve 168 to its open position simultaneously energizes motor 116 in the direction to shut off the supply of fluid from the pumps 22.

The third or "emergency stop" system combines the "slow stop" operation of reducing the pump volume to zero and the "fast stop" mode of dumping the pressure through solenoid valve 170 at a controlled rate determined by the flow restriction set in needle valve 166 with the application of a hand brake 174 directly to the bull wheel 150. This hand brake 174 partially encircles the bull wheel and has one extremity dead-ended at abutment 176 while the other end is connected to brake lever 178. Brake lever 178 is, in turn, connected to spring member 180 that functions to normally bias the brake band into frictional braking engagement with the bull wheel.

Now, brake band 174 is maintained in a normally inoperative condition free of any frictional contact with bull wheel 150 by means of a hydraulic servo-motor 182 that has its piston rod 184 connected to the brake lever 178 and acts to overcome the bias exerted on the latter element by spring member 180. Fliud to pressurize the cylinder 186 of the servo-motor 182 and extend the piston 188 is bled off supply line 38 through lines 190 and 192. Line 190 interconnects supply line 38 with reservoir 14 in parallel relation to lines 172 and 164. Check valve 194 is connected into line 190 ahead of the point at which line 192 connects therein. Beyond check valve 194 and the point at which line 192 connects into by-pass line 190, the latter contains an adjustable needle valve 196 and a normally-closed solenoid valve 198.

It will be apparent from an examination of FIGURE 7 that the high pressure fluid bled off supply line 38 will pass check valve 194 in line 190, move on into line 192 and pressurize cylinder 186 of the servo-motor 182 so as to extend the piston and release the brake band by overcoming the bias exerted upon brake lever 178 by spring 180. This fluid cannot return to the supply line 38 because of the check valve 194; therefore, it can only move out through needle valve 196 and normally-closed solenoid 198. Accordingly, servo-motor 182 will remain operative to hold the brake in released condition until such time as the solenoid valve 198 is actuated so as to bleed the fluid off behind piston 188 permitting spring 180 to actutae the brake lever in the direction to apply the brake. As long as line 192 remains isolated by check valve 194 and solenoid valve 198, all other functions of the lift drive may be carried out without setting hand brake 174. This is true of malfunctions in the system except, of course, one that results in loss of fluid pressure in line 192 or an unintentional opening of valve 198.

In closing, certain incidental, but nonetheless important, features of the lift drive will be set forth in connection with FIGURES 1, 2, 3 and 7. The lines 36 that are connected to receive the fluid from the pumps actually connect into a filter 200 shown in FIGURES 2 and 3 as well as being represented schematically in FIGURE 7. This filter 200, in turn, delivers the fluid to a manifold 202 (FIGURES 2 and 3) from which emanate main supply line 38, fast-stop by-pass line 164, emergency stop by-pass line 190, and line 172 which contains relief valve 170 that relieves any excessive pressure developing in the supply system. FIGURE 2 also reveals a pressure gauge 204 connected into the manifold.

The three parallel by-pass lines 172, 190 and 164 that lead from manifold 202 rejoin in a second manifold 206 which connects directly back into the reservoir 14. Line 192 shown in FIGURES 2 and 7 is, of course, the line that delivers fluid to the hydraulic servo-motor 182, the latter having been omitted from FIGURE 2.

As for the return lines, the main one is line 156 by means of which the controrl over the exhausted fluid is exerted. This line includes a filter 208, a heat exchanger 210 and a relief valve 212, the latter elements being connected in parallel with one another, in addition to governor valve 154. Line 152 is actually only a drain hose for the motor cases and it has no functional relationship to the system. The same is true of line 214 connected into the reservoir and shown in FIGURE 2. This line is used to pressurize the reservoir. FIGURES 2 and 7 also show a relief valve 214 on the reservoir and FIGURE 7 shows a float-type fluid level control 216 therein.

About the only remaining element that has not already been described is alternator 218 in FIGURE 1. This alternator is connected by means of belt 220 to pulley 222 mounted on motor shaft 28. Such a unit is employed in the present system as a separate source of electrical energy for the safety devices found on the towers, at the unloading points and at the control stations.

Having thus described the several useful and novel features of my hydraulically-controlled ski lift, it should be apparent that the many worthwhile objectives for which it was developed have been realized. While but a single specific embodiment of the invention has been illustrated and described herein, I realize that certain changes and modifications will occur to those skilled in the art within the broad teaching hereof; hence, it is my intention that the scope of protection afforded hereby shall be limited only insofar as said limitations are expressly set forth in the appended claims.

What is claimed is:

1. The hydraulic ski lift drive which comprises: a source of hydraulic fluid; a hydraulic fluid supply line; one or a plurality of variable-volume hydraulic pumps connected to receive fluid from the source thereof and deliver same under pressure to the supply line, each of said pumps including volume control means operative upon actuation to vary the pump output between zero and maximum flow; drive means connected to each pump in driving relation; a reversible electric servo-motor; volume-control adjusting means interconnecting the reversible servo-motor with the volume control means of each pump operative to shift same between its extreme positions; first normally-closed switch means connected to the reversible servo-motor and positioned in the path of one of the volume control means as the latter moves in the direction to reduce the pump output, said switch being responsive to movement of said volume control means to a position where the pump output is zero so as to open and shut off said reversible servo-motor; second normally-closed switch means connected to the reversible servo-motor and adjustably mounted in the path of one of said volume control means as it moves in the direction to increase the pump output, said second switch means being responsive to movement of said volume control means so as to open and shut off said servo-motor at predetermined flow rates between zero and maximum selected by varying the location of said switch means; one or a plurality of hydraulic motors connected into the supply line to receive the output from the pump or pumps; a check valve connected into the supply line between the one or more pumps and motors adapted to prevent reverse flow therebetween; and, a return line connected to receive the fluid exhausted from the motor or motors and return same to the source thereof.

2. The hydraulic ski lift drive as set forth in claim 1 in which: a bull wheel is connected to the output of the motor or motors in driven relation thereto; a normally-closed governor valve is mounted in the return line and connected to sense the supply line pressure ahead of the motor or motors, said supply line pressure being operative to bias said valve toward its open position, and said valve being responsive to fluctuations in supply line pressure so as to vary the restriction to return line flow and maintain the motor speed relatively constant irrespective of the magnitude and direction of bull wheel loads.

3. The hydraulic ski lift drive as set forth in claim 1 in which: a first by-pass line interconnects the supply line between the pump or pumps and check valve with the return line, and in which said first by-pass line includes a normally-closed valve operative upon actuation into open position to shunt the hydraulic fluid around the hydraulic motor or motors so as to stop the lift.

4. The hydraulic ski lift drive as set forth in claim 1 in which: a second by-pass line interconnects the supply line between the pump or pumps and check valve with the return line, and in which said second by-pass line includes a normally-closed pressure relief valve automatically opertive to shunt fluid directly to the source thereof when the fluid pressure exceeds a predetermined level.

5. The hydraulic ski lift drive as set forth in claim 1 in which: friction brake means is mounted adjacent the bull wheel for movement between a released position in frictional contact therewith; spring means are connected to the friction brake means normally biasing same into engaged position; hydraulic servo-motor means are connected to the friction brake means operative upon actuation to overcome the bias exerted thereon by the spring means and move said brake means into released position; a third by-pass line interconnects the supply line between the pump or pumps and check valve with the return line; a servo-motor supply line interconnecting the third by-pass line and the servo-motor for actuating the latter; a normally-closed valve connected in the third by-pass line downstream of the servo-motor supply line, said valve when closed causing the fluid pressure in the third by-pass line and the servo-motor supply line to remain at a level sufficient to keep the servo-motor actuated and the friction brake means released, and said valve upon actuation into open position being operative to deactuate said servo-motor and permit the spring means to actuate said friction brake means into engaged position; and, a check valve connected in the third by-pass line ahead of the servo-motor supply line adapted to prevent return flow in a direction other than to the source.

6. The hydraulic ski lift drive as set forth in claim 1 in which: at least two pumps are used connected in parallel with one another.

7. The hydraulic ski lift drive as set forth in claim 1 in which: at least two hydraulic motors are used connected in parallel with one another.

8. The hydraulic ski lift drive as set forth in claim 1 in which: the volume control means comprises an axially-movable shaft projecting from the pump; and, in which the volume control adjusting means includes a hollow cylindrical housing encircling the axially-movable shaft in coaxial radially-spaced relation thereto, an internally-threaded tubular member journalled for rotation within the housing in fixed axial position, an externally-threaded tubular member threaded inside the externally-threaded tubular member, key means interconnecting the housing and externally-threaded tubular member limiting the latter to axial movement in response to rotational movement of the internally-threaded tubular member, power transmission means operatively interconnecting the internally-threaded tubular member with the reversible electric servo-motor, and yieldable means operatively interconnecting the externally-threaded tubular member and the axially-movable shaft, said yieldable means being operative to transmit axial motion imparted to the externally-threaded tubular member to the axially movable shaft yet allow the latter element to stop at the end of its stroke while the former continues to move.

9. The hydraulic ski lift drive as set forth in claim 2 in which: a fourth by-pass line interconnects the supply line downstream of the check valve with the return line upstream of the governor valve; and, in which a normally-closed valve is connected in the fourth by-pass line operative upon actuation into open position to permit the lift device to run in reverse under the influence of an up-hill load with the pump output at zero.

10. The hydraulic ski lift drive as set forth in claim 3 in which: a variable flow control valve is connected in the first by-pass line, said flow control valve being operative to vary the rate at which the lift drive comes to a stop when the normally-closed valve is actuated into open position.

11. The hydraulic ski lift drive as set forth in claim 5 in which: a variable flow-control valve is connected in the fourth by-pass line downstream of the check valve and connection with the hydraulic servo-motor supply line, said valve being operative to vary the rate at which the friction brake means engages the bull wheel when the normally-closed valve is opened.

12. The hydraulic ski lift drive as set forth in claim 5 in which: a second-by-pass line interconnects the supply

line and return line parallel to said fourth-pass line; a normally-closed valve is connected in said second supply line operative upon actuation to open position to shunt fluid around the motor or motors so as to stop the lift; and, in which control means operatively interconnects the normally-closed valve in the second by-pass line with the normally-closed valve in the fourth by-pass line so as to simultaneously actuate both of said valves upon actuation of the latter.

13. The hydraulic ski lift drive as set forth in claim **8** in which: axially-movable shaft has an outwardly-facing abutment; the externally-threaded tubular element is mounted on the axially-moavble shaft so as to define a continuous annular cavity therebetween, said tubular element including an annular abutment spaced axially outward from the shaft abutment; and, in which the yieldable means comprises a compression spring mounted in the annular cavity with its opposite extremities in engagement with the opposed abutments.

14. The hydraulic ski lift drive as set forth in claim **13** in which: the axially-movable shaft includes a second abutment spaced outwardly of the first and the abutment on the externally-threaded member; and, in which the yieldable means includes a second compression spring mounted on the axially-movable shaft with the extremities

thereof engaging said second abutment and the abutment carried by said externally-threaded member.

15. The hydraulic ski lift drive as set forth in claim **14** in which: the second abutment is adjustable along the axially-movable shaft.

16. The hydraulic ski lift drive as set forth in claim **14** in which: the second abutment means is positioned and adapted to actuate the reversible electric servo-motor control switches.

17. The hydraulic ski lift drive as set forth in claim **15** in which: the second abutment means is positioned and adapted to actuate the reversible electric servo-motor control switches.

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