MULTIPLE RAM ASSEMBLY AND RECUPERATIVE DRIVE SYSTEM FOR HYDRAULIC LIFT

A set of substantially identical rams (2), held mechanically in series but hydraulically in parallel, raise and lower elevator car (1). The rams are disposed side by side and offset forces are taken up by: internal rollers bearing between each piston rod and its associated cylinder; external rollers carried by one cylinder and bearing on an adjacent cylinder; and guide rails attached to the elevator shaft and slidingly engaged by guide blocks carried by the rams. Hydraulic energy to raise the elevator comes from a high pressure hydraulic accumulator (6). On descent of the lift hydraulic energy can be recuperated. In one arrangement fluid is returned to a low pressure accumulator (4). Thus energy is saved when it is used as a fluid source for a pump that recharges the high pressure accumulator. In another arrangement the energy of the fluid returning to a tank at atmospheric pressure is used to drive a motor which powers a pump that recharges hydraulic fluid to the high accumulator immediately.
FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

| AT | Austria     | FR | France      | MR | Mauritania |
| AU | Australia   | GA | Gabon       | MW | Malawi     |
| BB | Barbados    | GB | United Kingdom | NE | Niger      |
| BE | Belgium     | GN | Guinea      | NL | Netherlands |
| BF | Burkina Faso| GR | Greece      | NO | Norway     |
| BG | Bulgaria    | HU | Hungary     | NZ | New Zealand |
| BJ | Benin       | IE | Ireland     | PL | Poland     |
| BR | Brazil      | JP | Japan       | PT | Portugal   |
| BY | Belarus     | KP | Democratic People's Republic of Korea | RO | Romania |
| CA | Canada      |   |             | RU | Russian Federation |
| CF | Central African Republic |   |             | SD | Sudan |
| CG | Congo       | KR | Republic of Korea | SE | Sweden |
| CH | Switzerland | KZ | Kazakhstan  | SI | Slovenia |
| CI | Côte d'Ivoire | LI | Liechtenstein | SK | Slovak Republic |
| CM | Cameroon    |LK | Sri Lanka   | SN | Senegal |
| CN | China       | LU | Luxembourg  | TD | Chad |
| CS | Czechoslovakia | LV | Latvia     | TG | Togo |
| CZ | Czech Republic | MC | Monaco   | UA | Ukraine |
| DE | Germany     | MG | Madagascar | US | United States of America |
| DK | Denmark     | ML | Mali        | UZ | Uzbekistan |
| ES | Spain       | MN | Mongolia    | VN | Viet Nam |
MULTIPLE RAM ASSEMBLY AND RECUPERATIVE
DRIVE SYSTEM FOR HYDRAULIC LIFT

Background of the Invention

This invention relates, in general terms, to an improved form of lift or elevator system, and to parts of and components therefor. More particularly, but not exclusively, the invention relates to a lift or elevator system, and an overall drive means therefor, which is responsible for a substantial saving in power input and energy use, and accordingly cost, when compared with the known art. The invention also relates to a multi-stage hydraulic cylinder system which is especially suited for use in lift or elevator systems of the aforementioned type, but is adaptable for use in other contexts.

Throughout the ensuing description, for ease of explanation reference will be made to a so-called hydraulic lift. It must be realised, however, that the present invention is not to be considered to be restricted solely to such types of lifts and in fact in certain aspects of the present invention need not even be restricted to the field of lifts. More especially, the present invention will be equally suitable for use with:

(1) traction elevators;
(2) hydraulic elevators wherein motion is achieved through the operation of a ram or cylinder; and
(3) any drive system that uses hydraulic fluid under pressure.

Hydraulic lifts as currently in use employ a pump and a drive means or motor to deliver oil under pressure to a cylinder and associated piston, thereby giving rise to linear motion as a result of extension of the cylinder. Such linear motion, initially in a vertical direction, allows for movement of a lift car or carriage between pre-arranged storeys or levels of any given structure. Of course once the lift car or carriage is moved upwardly, it ultimately becomes necessary to allow for movement downwardly. In accordance with the known art the majority of lifts are made to move in a downwards direction by the utilisation of appropriate valving for venting of the
oil or other hydraulic fluid, which is under pressure, back to a
storage tank for such fluid, which is generally speaking at
atmospheric pressure. In practical terms it should therefore be
realised that power or energy is necessary in order to actuate or
operate such a hydraulic system whereby to allow for upward
movement of the lift or carriage. Such hydraulic fluid under
pressure is a source of potential energy, in practical terms
representing a reservoir of stored energy. Unfortunately, however,
in accordance with known apparatus practices and techniques, such
stored energy is, to all intents and purposes, totally dissipated and
lost as a result of venting of the oil to atmosphere on what might be
termed the down stroke. Put simplistically, therefore, hydraulic lift
systems of this known type require energy input to produce vertical
upward movement but then rely in effect on gravity to produce
subsequent downward movement. In terms of moving a dead
weight between vertical storeys of a building or the like structure,
the energy or power input necessary therefore can be quite
substantial. Furthermore, large electric motors are invariably needed,
since the car is not counterweighted, and this requires substantial
electrical wiring. As such, because of the power input needed, the
plant required in accordance with the known art has been bulky,
space-consuming and expensive.

Again in accordance with the known art, lift or elevator
systems currently in use for the transport of passengers or plant
between spaced-apart levels utilise or employ three basic methods or
means of achieving the desired motion and control thereof. These
three methods are:

(1) electrical traction drives;
(2) a combination of electrical means and screw drives;
and
(3) hydraulic cylinder-ram drives.

The hydraulic ram configuration generally includes a single
or multiple-element piston in an appropriate housing, with the piston
itself moving in direct proportion to input flow and having a stroke
length somewhat less than the retracted length. In accordance with
known techniques such a hydraulic ram can be mounted either underneath the lift car or carriage, or alternatively along-side that car or carriage, dependent upon the amount of space available. One disadvantage associated with a configuration wherein the ram is mounted underneath the car or carriage resides in the need for the provision of a caisson, with no such caisson actually being required in an arrangement utilising a ram mounted along-side the car or carriage.

When the required length of travel for the lift or elevator is longer than the maximum available retracted length of the ram, as is quite often the case, then in accordance with the known techniques it has become necessary to rely on a compound and complicated design or configuration termed "a phasing telescopic cylinder" and involving a sleeving assembly. Such a configuration utilises telescopic or telescoping rods, one inside the other, of a suitable number whereby to bring about the desired length of travel for the overall lift car or carriage. In a practical sense, however, in order to achieve constant car speed, avoiding jerky motion, each rod or tube must be what is termed "phased". In other words, each sleeve must be adapted to move at the same time. In hydraulic terms such can be achieved by feeding the annulus fluid from each rod section to the full cross-sectional area of the next inner cylinder. The diameter is calculated in order to achieve constant relative speeds between adjacent tubes. Other methods, such as for example phasing by connecting each stage through a series of chains or slings, could also be used. Again in practical terms, in order to bring about constant speed and smooth travel of lift or car, all tubes must reach the end of their stroke together.

With such arrangements rephasing checks are required in each tube section. In practical terms such configurations have been found to work relatively satisfactorily. By the same token, however, such prior art arrangements have been determined to suffer from several important disadvantages. First of all, the rather complicated telescoping cylinder arrangement is difficult and accordingly expensive to manufacture. Secondly, such a configuration requires
in effect two distinct sealing areas for each telescoping or telescopic section. Thirdly, such a configuration has been found to be inordinately bulky. Fourthly, such a configuration has been found to require special machinery to manufacture. All these factors give rise to their own problems, and the end result is an overall arrangement which, apart from being rather complicated in operation, is expensive in manufacture, installation and maintenance. Such expensive configurations have resulted in a limitation on the exploitation of such an arrangement.

Object of the Invention

It is therefore an object of the invention to provide an improved drive system, hydraulically operated, for use in an elevator or the like. This is achieved, in general terms, by the use of pressure accumulators whereby to allow for recycling of oil (fluid) and recovery of energy for subsequent re-use, thereby giving rise to substantial savings in electrical energy input to drive a given system.

It is a further object of the present invention to provide a multi-barrel cylinder, for use in operating a lift or elevator of any given type, which uses a series of substantially identical barrels or piston-cylinder arrangements, assembled side-by-side, thereby to produce a multi-stage hydraulic cylinder. Such a cylinder is compact, energy efficient and has a large range of lifting capacities and strokes available.

The present invention seeks to overcome the problems and disadvantages associated with the prior art by providing an improved form of lift or elevator system which is simple in construction, when compared with the known art, easier to both install and maintain, again when compared with the known art, and accordingly much less expensive than the prior art configurations. The arrangements in accordance with the present invention thus lend themselves to utilisation in a variety of different contexts, contexts which have not previously been pursued, primarily because of the cost factor.

Description of Drawings

In order that the invention may be more clearly understood and put into practical effect there shall now be described in detail
preferred embodiments of a lift or elevator system, and a drive means therefor. The ensuing description is given by way of non-limitative example only and is with reference to the accompanying drawings, wherein:

Fig. 1 is a schematic view of an improved elevator system in accordance with the present invention;

Fig. 2 is a general assembly view, in side elevation, of a constant speed multiple ram assembly in accordance with the present invention, to be used for purposes of moving a lift car or carriage between vertically spaced-apart levels or storeys of any given structure;

Fig. 3 is a front elevational view of the arrangement of Fig. 2;

Fig. 4 is a perspective view of a two-stage hydraulic cylinder arrangement in accordance with the present invention;

Fig. 5 is an exploded view of the two-stage hydraulic cylinder arrangement of Fig. 4;

Fig. 6 is a view similar to Fig. 5, but of a three-stage hydraulic cylinder arrangement;

Figs. 7, 8 and 9 are schematic views of three alternative embodiments of an accumulator drive system in accordance with the present invention;

Fig. 10 is a perspective view of a general arrangement of an accumulator drive system in accordance with the invention, to be installed on or in relation to a lift car or carriage or the like; and

Fig. 11 is a schematic or diagrammatic representation of a preferred embodiment of a lift or elevator including an accumulator drive system in accordance with the invention.

Description of Preferred Embodiments

With reference firstly to Fig. 1 of the drawings, one embodiment of a lift or elevator system in accordance with the present invention is illustrated therein schematically. The main components of the system are as follows.

An elevator car 1 of any given type is arranged for movement as desired between levels of a multi-storey structure. To
give rise to such controlled movement a multi-stage hydraulic
cylinder system 2 in accordance with the invention is employed, such
system allowing for not only improved control over the direction and
speed of movement, but also in practice allows for greater speeds of
movement to be achieved, this when compared with the known art.
The hydraulic cylinders of the system 2 are thus in flow connection,
via suitable oil lines 3 of any given type, and with the interposition
of a valve or controller 7, to respective high pressure and low
pressure accumulators 6 and 4 and a pump motor 5 (again of any
given type). In accordance with the present applicant’s arrangement,
the use of high and low pressure accumulators 6 and 4 gives rise to
a substantial saving in power input for operating the lift system -
again when compared with the known art. This in turn means that
the overall size (dimensions) of the operating system of a lift
configuration in accordance with the present invention is markedly
reduced when compared with the prior art conventional
arrangements - an important practical advantage.

With reference now to Figs. 2 to 6 of the drawings, there
are illustrated therein embodiments of a multiple ram or cylinder
assembly in accordance with the invention. The embodiment as
illustrated in Figs. 2, 3 and 6 includes three ram assemblies, generally
designated 10, 20 and 30 respectively, all being connected
hydraulically in parallel, whilst the embodiment of Figs. 4 and 5
includes merely two such assemblies, 10 and 20. This in itself is in
marked contrast to the prior art arrangements, which generally
speaking employ a plurality of rams connected both hydraulically
and mechanically in series. In that regard it should be realised that,
with an arrangement wherein the various ram assemblies are
positioned co-axially or in series, then in a practical sense the overall
diameter of the ram assembly must vary from ram to ram,
accordingly giving rise to commensurate changes in piston area.
Such known prior art arrangements, as stated earlier, are
complicated, inordinately large, bulky and heavy and expensive and
also have other engineering limitations in terms of construction,
installation, maintenance and overall operation.
With the arrangement of the present invention, as illustrated in Figs. 2 to 6, the outer rod 11 of a cylinder of a first stage 10 is connected, via a support member and associated transfer plate 12, to a gland of a second stage 20, the outer rod 21 of that second stage 20 in turn being connected, via a second support member 22, to a gland of a third stage 30. Preferably the inner rods 13, 23 and 33 of each stage, all of the same cross-sectional area, are chromed. In a practical sense the number of stages arranged in parallel is virtually unlimited, and in that regard it should be realised that, whilst in the preferred embodiment illustrated there includes only three and two respectively such parallel-arranged rams or stages, the invention should not be in any way considered to be limited to just such an arrangement. With the present applicant's arrangement the various stages or ram assemblies 10, 20 and 30 are connected hydraulically in parallel, but mechanically in series. Each stage includes an inner rod 13, 23 and 33 having the same surface area. The arrangement is such as to provide constant car or carriage speed by either extending one by one and using cushioning means at the end of each extension so as to provide a smooth changeover, or alternatively by coupling the extensions together mechanically, as for example by a simple cable or chain system (not shown), making all extensions or ram assemblies move together. In the especially preferred embodiments illustrated a flexible coupling means 14 of any given type may be employed and located at the topmost portion of all except the final stage or extension.

With reference once again to Figs. 2 to 5 of the drawings, since the relevant forces no longer act co-axially, then a bearing guide or wheel, designated 40, will be employed between the housings of adjacent ram assemblies 10, 20 and 30, such wheel or bearing 40 being intended to negate forces generated by the subsequent moment force of the various support members 12, 22 interconnecting the adjacent ram assemblies 10, 20, 30.

In an especially preferred embodiment of the present invention there is provided one or more guide rails, generally designated 15, which in a practical sense is or are adapted to be
mounted either on the wall of the elevator shaft or within the frame of the elevator. Such guide rail 15 represents the most effective and economical means of ensuring controlled travel of the overall lift incorporating such a multiple ram assembly, and serves to steady the top of each stage as it is being extended. In the especially preferred embodiment of Fig. 4 the or each guide rail 15 will have associated therewith a guide block 16, which may be fixed in any known manner to the transfer plate(s) 12, 22 and adapted to run along the guide rail 15. Again with reference to Fig. 4 each stage will include toward the base thereof, a ram holding bracket 16 intended, in use, to stop the base of each stage from moving away from the preceding stages. At or in the vicinity of the base of each stage is an inlet/outlet port or means 17 allowing for in-flow and out-flow of fluid (oil) as desired.

The principle of operation of the multiple ram assembly as illustrated in Figs. 2 to 6 is as follows.

When oil, or indeed any suitable hydraulic fluid, is pumped into an inlet port 17 of the first stage or ram assembly 10, then a force will be applied to connection plate 12 which in turn applies a resultant force to ram assembly 20, which in turn applies such a force to all adjacent ram assemblies. The resultant moment generated by the offset forces acting on the connection plates 12, 22 etc. are balanced or compensated for by the aforementioned wheels or bearings 40 and guide rails 15. At the same time, the inlet oil pressure of the ram assembly 10 is in fact directed to the top of the piston rod thereof and is then fed through to the housing of ram assembly 20, which is in turn connected through to ram assembly 30, and so on. All ram assemblies 10, 20, 30 etc. can thus be seen to be connected hydraulically in parallel. In an especially preferred embodiment means may be associated with each ram assembly to give rise to a hydraulic cushioning effect, whereby to provide for soft or smooth transition conditions, or in other words uninterrupted or substantially uninterrupted motion of the overall assembly. The guide rail assembly 15, apart from acting as or providing a means for controlling the direction of movement, provides the overall structure
with resistance to buckling. In an especially preferred embodiment the tube assemblies extending between adjacent ram assemblies 10, 20, 30, etc. may be equipped with air bleed means 18 of any known type, such bleed means 18 being disposed as appropriate.

Turning now to Figs. 7, 8 and 9 of the drawings, there are illustrated therein preferred embodiments of an accumulator drive system for a lift or elevator in accordance with the present invention. In that regard it should be understood that, whilst in the ensuing description, for ease of explanation reference is made in particular to the use or utilisation of such an accumulator drive system with a lift or elevator of the hydraulic ram type, in practical terms an accumulator system in accordance with the present invention is equally suitable for use with all types of currently commercially available lifts or elevators, regardless of the methods or means employed for activation thereof, and in fact with any other drive system which utilises hydraulic fluid under pressure. In other words, and in the field of lifts, the accumulator drive system in accordance with the present invention is equally suitable for use in lieu of hydraulic DC or AC electric traction elevators, or with hydraulic ram or cylinder elevators and/or ball screw type elevators.

In accordance with the known art hydraulic ram or cylinder-type elevators include a ram or cylinder-piston assembly operatively connected to a lift car or carriage which in turn is, or may be, driven by a hydraulic power pack. The car or carriage is driven upwardly, as a result of power or energy input, but as stated earlier a bleeding to atmosphere effect is utilised to achieve or give rise to downward motion. Such arrangements do not employ any counter-weight and, in the result, energy is irretrievably or non-recoverably lost on the downward motion step or stage.

The accumulator drive system of the present invention is functional regardless of whether or not the overall lift or elevator is of a traction or ram design. In actual fact the principle of operation will still be the same, as explained hereinafter.

Three-phase or single-phase electrical power is converted into hydraulic energy through an electric motor/hydraulic pump
combination of any given type. The hydraulic energy may be stored in a hydraulic accumulator which is then released into a rotary or linear actuator via any given means, such as for example a proportional valve or a variable displacement hydraulic motor. When the energy from the actuator is regenerative, it is distributed via another valve to either a low pressure accumulator or a larger displacement motor, (fixed or variable in volume), and then back to a storage tank or reservoir. In the second of the systems illustrated in Figure 8, a primary pump is thus actuated, charging the high pressure accumulator but at a reduced volume.

The second system will require the electric motor to be switched on to recharge the high pressure accumulator from the lower pressure accumulator, but the required energy from the electric motor will be less as the pressure compared to atmospheric inlet will be much less. This results in a saving of energy and manufacturing costs. The electric motor is switched on to recharge the accumulator and works independently from the operation of the overall elevator.

Yet another means or mechanism for achieving rotary movement, not illustrated, could be by utilising the torque provided as a result of angular change/displacement of a swash-plate or the like in an axial piston motor or the like equipment. In such an arrangement the angle of inclination of the swash-plate is changeable in order to allow for variation of the actual direction of hydraulic flow. Such a motor incorporates a mechanism which alters torque versus exposed pressure differential and would provide the same result as a fixed torque/differential pressure design with a proportional metering valve, but would exhibit improved or enhanced efficiency. Such a configuration will require some degree of control of the torque altering mechanism in terms of parameters such as acceleration, speed and position, via a suitable electronic or pilot controller - operating preferably in a closed loop configuration.

With such an arrangement the differential pressure between the respective low and high pressure accumulators is a function of the entrapped oil volume and also the inert gas precharge levels. In an elevator structure in accordance with the present invention this
differential pressure varies at all floor levels and will require constant regulation of the torque altering mechanism in order to achieve the required speed/position performance. An arrangement to bring about such a result is illustrated schematically in Fig. 9.

Fig. 10 depicts a preferred embodiment of an accumulator drive system for an elevator in accordance with the present invention, being an embodiment wherein the hydraulic system itself is totally enclosed within a pronal bladder, together with a submersed electric motor. With such an embodiment, since most of the hydraulic fluid (oil) is in fact stored in the accumulator or ram, then the size of stored reservoir required is substantially reduced, especially when compared to current, and conventional systems.

With reference now to Fig. 11, in the arrangement depicted therein hydraulic fluid (e.g. oil) is stored in a pressure vessel 50 at a predetermined pressure (e.g. 1000 p.s.i.). When the lift car is "called" from a foyer, for example, or a person enters the car and presses the button for a particular floor or storey, the following sequence of operations occurs.

(1) The proportional valve 51 and accumulator poppet valve 52 are energised and fluid flows, at say 1000 p.s.i., from the pressure vessel 50 through the door lock valve 54 and hose burst valve 53 into cylinder 55. The car will then move in an upward direction.

(2) Nitrogen, or other inert gas, will flow from balancing tank 56 to maintain the pressure within the pressure vessel 50 at 1000 p.s.i., or thereabouts.

(3) The lift car will stop at the preselected floor.

It should be noted that, during this sequence of steps or operations, the motors and pumps do not have to run if the accumulator is charged. When the lift car is required to travel in a downwards direction, the sequence of operations is as follows.

(1) The proportional valve 51 and door lock valve 54 are energised and fluid will flow out of the cylinder 55 and back via a variable displacement motor to recharge the accumulator 50 at a reduced volume.
The electric motor may be required to top up the accumulator for lost energy.

(2) The car will then descend and stop at the selected floor.

(3) The electrical motor may be required to be switched on during such descent, or possibly immediately thereafter to top up the high pressure accumulator. The motor and pump system energise and return the fluid from the low pressure accumulator to the high pressure accumulator at, say, 1000 p.s.i.

(4) Nitrogen (or other inert gas) is then displaced as the pressure vessel 50 recharges, and is driven back to the balancing tank 56.

It can therefore be seen that, with such an arrangement, the motors operate only when the pressure vessel needs charging, and not necessarily when the elevator works. This fact alone means that, in a practical sense, the power output needed from such motors is much reduced when compared with conventional elevator systems, since the motor does not have to meet peak conditions. Since a smaller motor is thus required, then overall bulkiness of the system is substantially reduced, as is both installation and manufacture, as well as maintenance and operating costs.

The present applicant's arrangement, in contrast to conventional drive systems for lifts or elevators - which pump oil direct into an elevator cylinder and then dump it to atmospheric pressure on the downstroke - captures the oil or fluid under pressure on the downstroke and recycles the energy stored or retained thereby. The present applicant's arrangement stores exhaust oil in an accumulator pressure vessel at a pressure just a little less than the original working or operating pressure. A small capacity (and size) pump then operates to restore such fluid to working pressure and stores it in a high pressure accumulator, ready for use on the next ride or operation of the elevator.

The arrangement in accordance with the present invention is responsible for a number of advantages when compared with the
known prior art. These advantages may be summarised as follows:

(1) economical to construct, with it being estimated that the cost involved will be no more than 25% of phasing telescopic design and no more than 50% of mechanical phasing design configurations, dependent upon the stroke load and actual production methods;

(2) the present applicant's arrangements require very simple machinery to manufacture, this in contrast to the known art;

(3) the spatial arrangement in accordance with the present invention lends itself to modular assembly on site, with there being in effect no need for cranes or other heavy lifting equipment;

(4) the arrangements in accordance with the present invention are remarkably simple to maintain when compared with the known art, with a low inventory of spare parts being necessary;

(5) by virtue of the reduced sealing area required, and also by virtue of the fact that striction forces of each sealing member are non-additive due to the parallel arrangement, a high performance can be expected, again when compared with the known art;

(6) because the pump operates only when the car is not moving upwardly, this means a smoother and quieter operation - in other words enhanced performance; pump size is no longer a function of the car speed, but rather of the duty cycle; it is envisaged that even a high duty elevator will require an electric motor pump combination which is of a size of the order of 25% that used in current designs;

(7) the present applicant's system will continue to function, even after power failure, until such time as the accumulator pressure vessel has exhausted its pressure advantage; this will mean that, even in the instance of power failure, a lift in accordance with the present invention will still be able to deliver passengers to the next floor, eliminating the possibility of passengers being trapped by a power failure (provided back-up power is available to operate essential circuitry);

(8) in some situations, dependent upon expected load, etc., it may even be possible to use single phase power to operate a
lift in accordance with the present invention.

(9) with the present applicant's arrangement, and once
again in contrast to the known art, there will be no need for
accumulators, silencers, etc. with in effect all low and high frequency
noises generally associated with on-line pump systems of hydraulic
lifts of the traditional type being eliminated, since with the
applicant's arrangement substantial laminar flow is easily achieved
and readily maintained;

(10) by virtue of the reduced input power requirements,
not only will the overall size of a lift system be significantly reduced,
but the actual physical size of ancillary equipment - mains power
supply lines, etc. - will also be reduced;

(11) major energy efficiencies of up to 75% over
conventional equipment, by using low and high pressure
accumulator pressure vessels;

(12) large reduction in motor, pump and component sizes
- the pump and motor will utilise the time when the lift is stationary
or moving down to charge the high pressure accumulator, and use
of higher operating pressures (up to 120 bars) will also assist in
reducing component and hose sizes;

(13) reduced oil requirements, since this is a sealed system
with little waste heat, and oil requirements will be a fraction of
convention systems which dump the oil to atmosphere in a large
tank;

(14) down stream savings, since the pump and motor are
approximately one quarter the size of conventional equipment, and
in-coming electrical mains and the overall power allocation to the
elevator will be greatly reduced;

(15) waste heat generated by dumping oil under pressure
back to atmosphere will be virtually eliminated, greatly reducing the
need to mechanically ventilate the elevator motor room;

(16) ability to use the elevator in a power failure, since
using battery back up, the system will continue to operate (up or
down) whilst the high pressure accumulator is charged, systems
which can only operate in the down direction;
(17) reduced flow rates for the same elevator performance - this design can run at 1m/sec at a flow rate of 200 litres/min, which is approximately half the flow required of conventional telescopic designs because the design is based upon the strength of the most slender member, yet their flow pressure are determined by the size of the lower (largest) member across sectional area; and

(18) keeps hydraulic line sizes and control valve sizes to 20 mm (3/4") for virtually all load/speed combinations - offering large savings over larger, conventional designs.

In closing, it should be realised that the foregoing description refers merely to preferred embodiments of the present invention, and that variations and modifications will be possible thereto without departing from the spirit and scope of the invention, the ambit of which is to be determined from the following claims.
Claims

1. A multi-stage hydraulic ram assembly including a plurality of piston-cylinder arrangements connected hydraulically in parallel but mechanically in series, the respective piston-cylinder arrangements being disposed in a substantial side-by-side relationship.

2. The assembly as claimed in claim 1, wherein all pistons and cylinders in said assembly exhibit substantially the same cross-sectional area.

3. The assembly as claimed in claim 2, including hydraulic cushioning means associated with each piston-cylinder arrangement and adapted, in use, to ensure substantially uninterrupted transmission of hydraulic fluid and generated force therebetween, thereby ensuring in turn smooth, uninterrupted operation of said assembly.

4. The assembly as claimed in claim 3, including means for controlling the direction and speed of movement of adjacent stages of said assembly, said means being in the form of an elongate means or guide rail extending in the direction of movement of said piston-cylinder arrangements, and to which each said assembly is adapted to be slidably attached.

5. The assembly as claimed in claim 4, including means associated with the base of each cylinder to ensure and maintain interconnection in use between adjacent cylinders, said means being in the form of a bracket fixedly attached to one cylinder and movably or slidably connected to the adjacent cylinder.

6. The assembly as claimed in claim 5, wherein each cylinder includes an outer wall or housing and an inner rod movable relative thereto, with each cylinder including, at or in the vicinity of the base thereof, a internal rolling means associated with said inner rod and serving to control and guide movement of said inner rod under pressure relative to said housing.

7. The assembly as claimed in claim 6, wherein means are provided for guiding upward movement of adjacent cylinders relative to one another, said means being in the form of rolling means
adapted, in use, to travel upwardly or downwardly in substantially continuous contact with the housing of an adjacent cylinder.

8. An accumulator drive system for use in moving elevators or the like between storeys of any multi-storey structure, said system including: a source of power; high pressure accumulator means; low pressure accumulator means; pump means for directing hydraulic fluid between said high and low pressure means; a reservoir for hydraulic means; and control means for controlling the speed and direction of flow of said fluid as desired.

9. The accumulator drive system as claimed in claim 8, including valve means, preferably in the form of proportional valves, for controlling the direction and volume of flow of hydraulic fluid.

10. The accumulator drive system as claimed in claim 9, including rotary or linear actuator means for receiving stored hydraulic energy and releasing said energy for effecting movement of a lift car, carriage or the like.

11. The accumulator drive system as claimed in claim 10, including a variable displacement hydraulic motor for directing said stored hydraulic energy to said rotary or linear actuator.

12. An elevator assembly adapted to transport personnel and/or equipment between storeys of a multi-storey structure, said assembly including: means for receiving and carrying said personnel and/or equipment; means for imparting movement to said carrying means; means for controlling the direction and speed of movement of said load-carrying means.

13. The elevator assembly as claimed in claim 12, wherein said means for imparting movement to said carrying means includes a multi-stage hydraulic ram assembly adapted, in use, to extend between said storeys of said structure, said assembly including a plurality of piston-cylinder arrangements connected hydraulically in parallel and mechanically in series, disposed in a substantial side-by-side relationship.
High Pressure Accumulator

Electric Motor

Pump

Valve

Tank

Low Pressure Accumulator

Valve

III. 7.

Hydraulic Motor

Electric Motor

Pump

Valve

Tank

III. 8.

High Pressure Accumulator

Electric Motor

Pump

Valve

Controller

Variable Displacement Actuator of Hydraulic Motor

Tank

Low Pressure Accumulator

III. 9.

SUBSTITUTE SHEET
A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. 5 B66B 9/04; F15B 15/14, 1/02
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
IPC B66B 9/04; F15B 15/14, 1/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU : IPC as above

Electronic data base consulted during the international search (name of data base, and where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to Claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>CH-A, 418560 (MARTIN NENCKI AG) 28 February 1967 (28.02.67) See, in particular, Figs 1 and 5.</td>
<td>1-5,12,13</td>
</tr>
<tr>
<td>X</td>
<td>DE-A, 2655135 (WEMHONER) 9 February 1978 (09.02.78) See, in particular, Figs 1 and 3.</td>
<td>1,2,12,13</td>
</tr>
<tr>
<td>P</td>
<td>GB-A, 2255804 (NESBIT EVANS HEALTHCARE LTD) 18 November 1992 (18.11.92) See, in particular, sketch 1.</td>
<td>1,2,12,13</td>
</tr>
</tbody>
</table>

Further documents are listed in the continuation of Box C.

See patent family annex.

<table>
<thead>
<tr>
<th>*</th>
<th>Special categories of cited documents :</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;A&quot;</td>
<td>document defining the general state of the art which is not considered to be of particular relevance</td>
</tr>
<tr>
<td>&quot;E&quot;</td>
<td>earlier document but published on or after the international filing date</td>
</tr>
<tr>
<td>&quot;L&quot;</td>
<td>document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</td>
</tr>
<tr>
<td>&quot;O&quot;</td>
<td>document referring to an oral disclosure, use, exhibition or other means</td>
</tr>
<tr>
<td>&quot;P&quot;</td>
<td>document published prior to the international filing date but later than the priority date claimed</td>
</tr>
</tbody>
</table>

X | later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention |

X | document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone |

Y | document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art |

& | document member of the same patent family |

Date of the actual completion of the international search 30 November 1993 (30.11.93)

Date of mailing of the international search report 14 DEC 1993 (14.12.93)

Name and mailing address of the ISA/AU
AUSTRALIAN INDUSTRIAL PROPERTY ORGANISATION
PO BOX 200
WODEN ACT 2606
AUSTRALIA

Authorized officer
IAN KILBEY
Telephone No. (06) 2832115
<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate of the relevant passages</th>
<th>Relevant to Claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>WO,A, 87/05081 (RIPPELTON N.V.) 27 August 1987 (27.08.87) See, in particular, the abstract.</td>
<td>1</td>
</tr>
<tr>
<td>A</td>
<td>US,A, 4095677 (JOHANNSON) 20 June 1978 (20.06.78)</td>
<td>4</td>
</tr>
<tr>
<td>X</td>
<td>DE,A, 2106792 (JACOBS) 19 October 1972 (19.10.72)</td>
<td>12</td>
</tr>
<tr>
<td>A</td>
<td>US,A, 4731997 (HAGIN) 22 March 1988 (22.03.88) See, in particular, Figure 1.</td>
<td>2-7,13</td>
</tr>
<tr>
<td>X</td>
<td>US,A, 4745745 (HAGIN) 24 May 1988 (24.05.88) See, in particular, Fig 1.</td>
<td>8-11</td>
</tr>
<tr>
<td>X</td>
<td>WO,A, 88/03123 (STROMSHOLMENS MEKANISKA VERKSTAD AB) 5 May 1988 (05.05.88) See, in particular, the abstract.</td>
<td>8-11</td>
</tr>
<tr>
<td>X</td>
<td>US,A, 4215545 (MORELLO) 5 August 1980 (05.08.80) See, in particular, the abstract.</td>
<td>8-11</td>
</tr>
<tr>
<td>X</td>
<td>DE,A, 3834918 (VEB KOMBINAT UMFORMTECHNIK &quot;HERBERT WARNKE&quot;) 13 July 1989 (13.07.89) See, in particular, the Figure.</td>
<td>8-11</td>
</tr>
</tbody>
</table>
**Box I**
Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)

This international search report has not established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. □ Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2. □ Claim Nos.:
   because they relate to parts of the international application that do not comply with the
   prescribed requirements to such an extent that no meaningful international search can be
   carried out, specifically:

3. □ Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and
   third sentences of Rule 6.4(a).

**Box II**
Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. Claims 1-7 and 13 are directed to an hydraulic ram assembly with a plurality of rams which are connected
   hydraulically in parallel but mechanically in series.
2. Claims 8-11 are directed to an accumulator drive system which has high and low pressure accumulator means for
   storing hydraulic fluid.
3. Claim 12 is directed to an "elevator assembly" which need not be hydraulic nor have any sort of "accumulator
   drive."

1. □ As all required additional search fees were timely paid by the applicant, this international
   search report covers all searchable claims
2. □ As all searchable claims could be searched without effort justifying an additional fee, this
   Authority did not invite payment of any additional fee.
3. □ As only some of the required additional search fees were timely paid by the applicant, this
   international search report covers only those claims for which fees were paid, specifically
   claims Nos.:
4. □ No required additional search fees were timely paid by the applicant. Consequently, this
   international search report is restricted to the invention first mentioned in the claims;
   it is covered by claims Nos.:

Remark on Protest

□ The additional search fees were accompanied by the applicant’s protest.
□ No protest accompanied the payment of additional search fees.