HYDRAULIC LIFTS

John Inglis.
Code Consultant, Killara, Australia.

ABSTRACT.
In recent times the number of hydraulic lifts installed has dramatically increased compared with traction lifts. This paper will review the types of hydraulic drive systems being employed and highlight the advantages and disadvantages of each type. The paper will also consider the suitability of hydraulic lifts compared with traction lifts in particular situations.

HISTORY OF HYDRAULIC LIFTS

Water

The original form of hydraulic lift used water as the fluid medium and many forms of hydraulic systems were invented in the 1800's, water pumps driven by steam engines provided the power required. Later on the introduction of firstly the DC electric motor started the new era of drives for the water systems around 1887. And AC motors were employed about 1889.

Low pressure oil.

Traditionally the United States of America have used what would be considered as low pressure systems around 20 to 30 bars (max. 500 PSI). In recent times the pressure has been increasing partly due to the use of equipment from Europe such as telescopic rams and 1:2 roped systems.

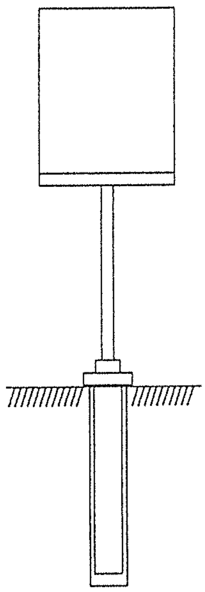
High pressure oil.

The lift industry has been increasing pressures over the last 20 years up to about 70 bars and in some cases 100 bars (about 1500 PSI). These pressures would be considered low pressures in the general hydraulic industry who use 200 or 300 bars as the norm and much higher in special cases.

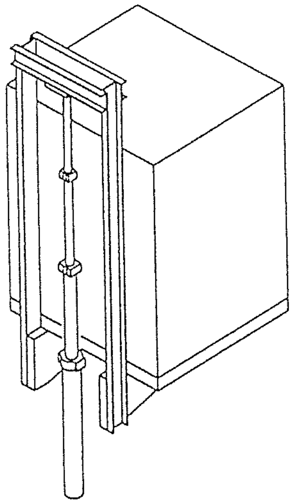
TYPES OF HYDRAULIC SYSTEMS.

Central ram.

The central ram under the lift car is the simplest arrangement for the lift contractor, it uses a standard form of car frame that can be balanced to reduce shoe loadings. This is not available when using side hung cars. This central arrangement on the other hand does require a pit and caisson hole under the car, the depth of such excavation would be about two metres more than the travel of the lift if using a single stage ram unit.

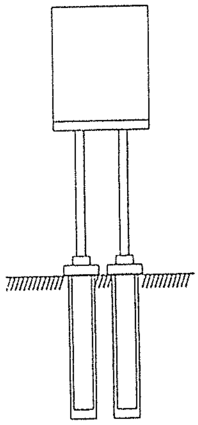


Side rams direct.
For side ram units it is possible to avoid caisson holes below the pit floor where the travel does not exceed twelve metres and a multi stage telescopic ram unit is employed.

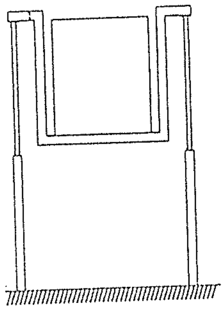


Twin rams direct.
The application of two direct rams can be either under the car in central position or at the side. When situated under the car it is usually to cater for large loads without manufacturing a single very large cylinder unit. It can also help to reduce the size of frame members by locating the rams some distance apart.
The twin direct side application is where holes in the ground are to be avoided and the car is very wide. Wide cars over about 1800 mm should not be supported by a single side ram. Arrangements must also be made for synchronising the two cylinders during operation and in the event of the pipe rupture valve operation.

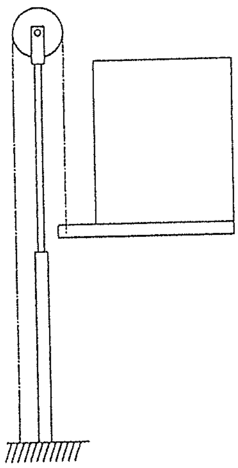
TWIN RAM
DIRECT
CENTRAL



TWIN RAM
DIRECT
SIDE

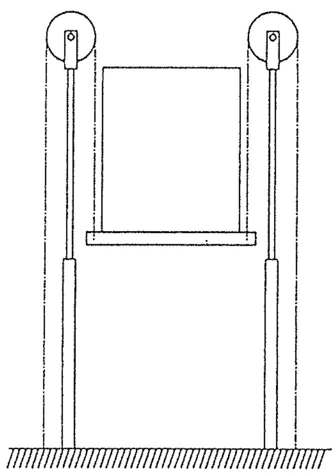


Side ram indirect (roped).
This form of machine to move the car has advantages in that higher rises can be achieved without expensive telescopic rams and deeper pits, rises up to 20 metres are common and many case exceed this. The disadvantages are that the lift now requires safety gear, and a means of operating the safety gear in the event of broken rope or over speed. In some countries the overspeed protection can be by the use of a flow restriction valve at the cylinder.



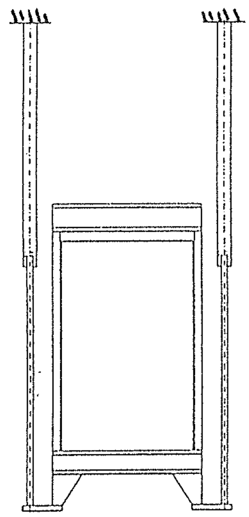
Twin ram indirect (roped).

The main things in common between the twin direct and twin roped are the ability to lift higher loads, the suitability for wider car platforms, and reduced pit depths. But like the single roped system safety gear has to be fitted to the car frame.



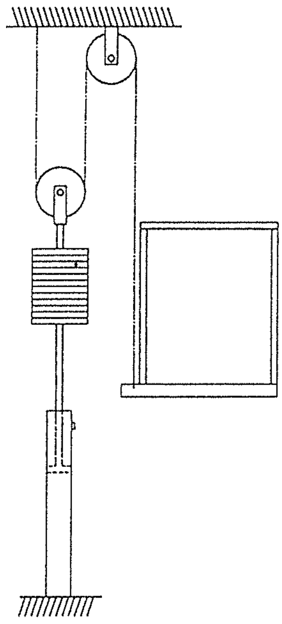
Boot strap units.

The name boot strap unit is a way of explaining the term being pulled up by your boot straps. This can be seen in Fig;.... where the rams are in tension and therefore can be reduced considerably in diameter.



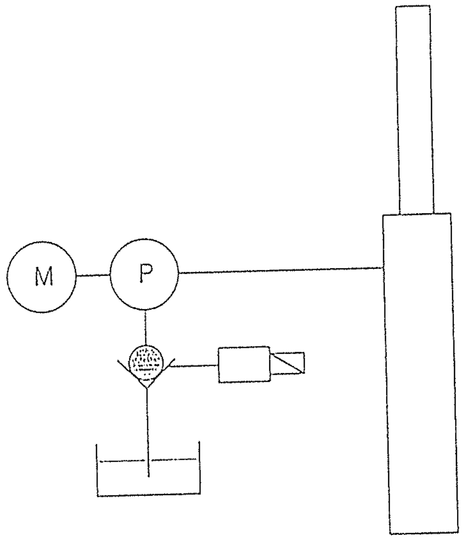
Pull down system.

Over recent years there has been an increased emphasis on reducing power requirements, and lifts are no exception. In the case of the normal hydraulic arrangement the motor has to lift the complete load of car and duty load,therefore this is not as efficient as the roped traction lifts with counterweights. To improve this situation designers have manufactured hydraulic lifts with counterweights similar to the roped electric traction lifts. This arrangement reduces the power to move the lift by pulling the counterweight down with the double acting cylinder.As the counterweight is roped 2:1 there is space under the counterweight for the cylinder.



Valveless.

The present system of lift fluid control to move a lift is through a control valve that changes the flow rate to the cylinder for both up and down direction. The motor only runs during the up direction of travel. With the advent of the VF drive system a new era in design has started, that is the valveless control. This system only has a pilot operated check valve to hold the lift at any point in the shaft and prevent downward movement, the motor controls the rate of fluid flow to and from the cylinder.



HOLELESS HYDRAULIC'S

Why do we consider this method;

- Cost savings as no hole drilling is required nor do we require a caisson in the ground.
- Less risk of corrosion to cylinder or caisson
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What are some disadvantages of this method;

- For travels over about 4 m, either 1:2 roped or telescopic rams will be required.
- Cantilever car frames (rucksack) are required
- It is no longer possible to balance the car shoe loadings.
- Roller guide shoes are usually required in place of sliding shoes.
- Access to cylinder head for replacing packing is difficult
- This side ram arrangement requires more well space than central rams.
- Requires one wall to have structural loading.

EQUIPMENT CONSIDERATIONS.

Preferred load variations

The most preferred load condition is that the no load / full load differential be kept to a minimum, but the effect of this is that excess power will be used moving the car frame and cabin weight. The advantage is that the motor pump and valve system can maintain better performance over the load and temperature changes if the differential is a minimum.

Extending the range of hydraulic's beyond their limits.
Because of the inherent simplicity of the hydraulic lift systems the price and installation times can be kept to a minimum. Today we find that designers and installers are extending the boundaries beyond that of this simple product and introducing application conditions that are really more suited to electric traction lifts.

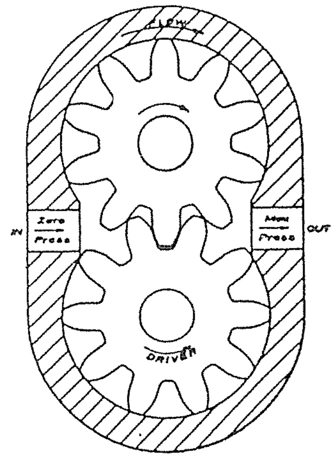
Ram and cylinder types.
Single direct acting displacement rams are usually solid in the small sizes but due to the excessive weight, tubular in the larger diameters and longer lengths eg;200 mm diameter and 20 metres long.
Multi stage rams usually called telescopic rams of the constant velocity type. These units usually incorporate synchronisation of the internal oil control or external mechanical linkage usually of the chain type, these chains are not considered suspension chains therefore there is no requirement to fit safety gear to the lift car.
Piston type cylinders where the piston rod is connected to a piston inside the cylinder, these can be used as single or double acting units but in most cases are applied in the lift industry as single acting units with the piston rod in tension.

Future travel allowance.
Where a building is to be built in two or three stages, that is to add additional floors some time in the future, the specification may ask for the ram and cylinder unit to be suitable for the future travel. This is usually an unwise choice because, one, it may never happen, two, it may be so long after the initial installation that the unused surface of the ram is badly pitted through oil contamination. Thus necessitating repair or replacement, three, the final travel extension may changed.
Travel extension usually requires a faster speed which must be considered at the time of the initial installation.

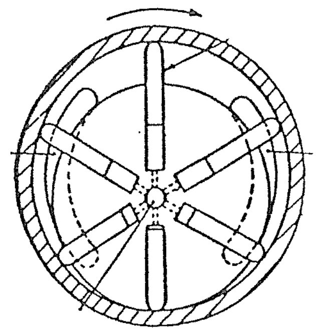
Travel restriction stops.(in up direction)
When using rams with excess length the travel may need to be restricted in some way to either provide the man clearance on top of the cabin for a service mechanic or prevent the car platform passing the top floor an excessive distance. There are two choices firstly provide stops inside the cylinder which is acceptable for single stage rams but not advisable for multi stage rams. Secondly provide external stops in the lift well to stop the car. This method must ensure that the stops do not cause a danger to the service mechanic or overload the car frame or building structure. In the case of stops either inside or outside the cylinder being used for speeds over 0.5 m/s some form of cushion stop should be employed.

PUMPS.
Pumps are usually selected on the following criteria; price, noise, and in many cases the choice on price alone has caused problems due to the noise of the lift being unacceptable to the customer and the pump has had to be changed.

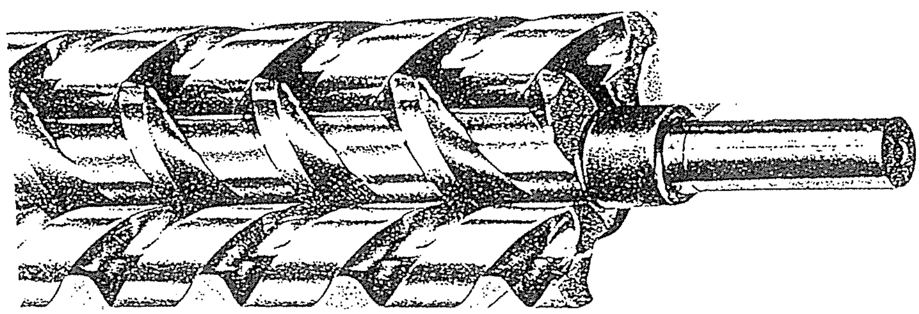
Gear pump. The gear pump is the cheapest form of pump available, but is also one of the noisiest. It is more popular in the industrial hydraulic areas and agricultural machinery.



Vane pump.
Vane pumps are considerably quieter than the gear type but are usually arrange for the vanes to extend to the outer casing after the pump reacher a certain speed. This feature allows for a noload startup. This can cause a bump in the start up of an hydraulic lift. To avoid this use a vane motor as a pump, the control valve will provide the noload start condition instead of the pump. The noise level of these pumps is not low enough if run at 3000 rpm.



Screw Pump.
The most popular pump used on hydraulic lifts today is the triple screw unit shown in sketch below, this illustration only shows the three screw without their housing. The centre screw is driven by the motor causing the two idler screws to transport the oil along in the screw voids. This arrangement has a very low noise and pulsation characteristic over a range of pressures up to about eighty (80) bars. It is available to higher pressures but the unit price increases considerably. Also the most common cylinders used for lifts both in single stage and telescopic are designed for operating pressures up to sixty five bars (65). The screw pumps are manufactured in two main configurations, for external foot or flange mounted or internal flange mounted. The latter being flange mounted to an underoil electric motor.
Under oil screw pumps can be run at 3000 rpm without any noise problems.



VALVES SYSTEMS.

Valve systems generally control the flow of oil to and from the cylinder, in the up direction the valve has little control over the full speed of the lift as this is fixed by the constant flow from the pump, the valve only controls the up acceleration and deceleration then the up levelling speed. In the down direction all speed control is from the valve for down acceleration and deceleration, fast speed and levelling speed. The main variations in speed is caused by temperature or load variations.

Solenoid.

The solenoid operated valve unit is the most common unit on todays hydraulic lifts, it is basically simple to adjust and is economically priced. Manufacturers employ different coil arrangements varying from two to four coils. The most common would be up fast speed, up slow speed / stop, down fast speed, down slow speed / stop The solenoids operate pilot flow lines which in turn control the main valve pistons. Some of todays solenoid valves also incorporate pressure compensation which improves performance.

Motor control.

There have been many forms of motor control used in the past to provide variable flow of oil to and from the cylinder. These systems have usually controlled the main oil flow directly and not via a pilot system. Most motor control valves had no compensation for pressure or temperature, until recently when some stepping motors were used inconjunction with feedback circuits that monitored car speed.

Electronic.

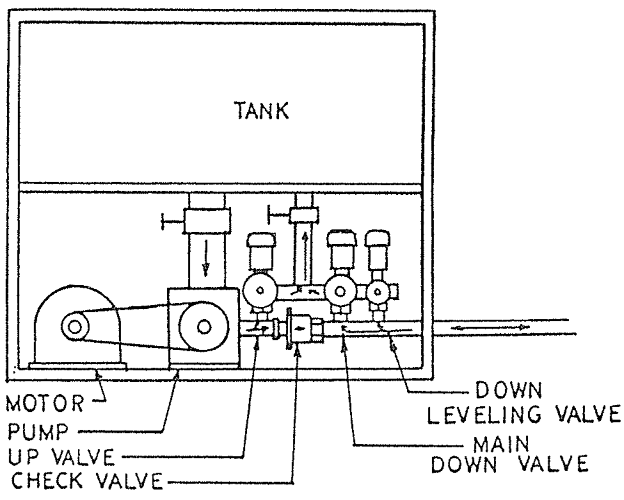
The electronic valves have additional features that are not usually available on other valves. These features include feedback signals for pressure changes and flow variations due to temperature variations in the oil.

The combination of feedback signals and electronic circuitry can control the main valve in such a way that the lift speed pattern is uniform under varying conditions.

TANK UNIT ARRANGEMENTS.

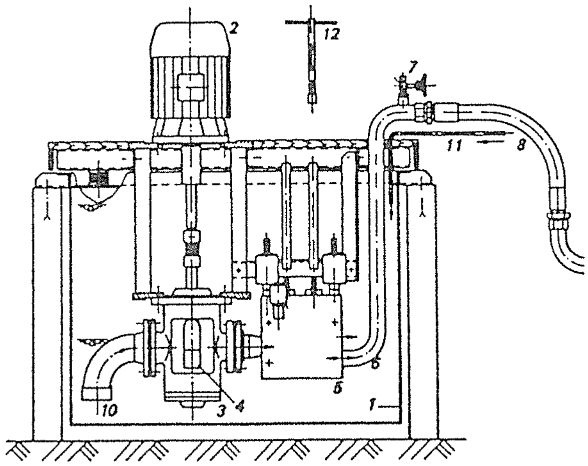
Tank above pump, motor and valves.

This arrangement has the advantage of being able to drive the pump via a vee belt system, this allows the pump to be run at a specific speed. The disadvantages of the arrangement are, there is a very confined space for piping of the pump, and valve to the bottom of the tank. This also creates many potential leak points and expensive pipe fittings.



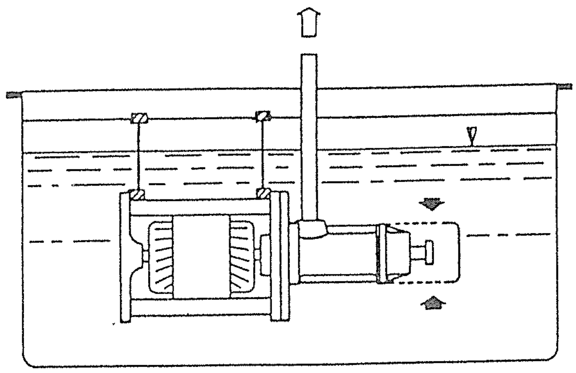
Tank with pump inside tank and motor above.

When pumps were first placed inside the tank underoil motors were not available so the pumps were placed in the vertical position and the motor mounted above the tank.

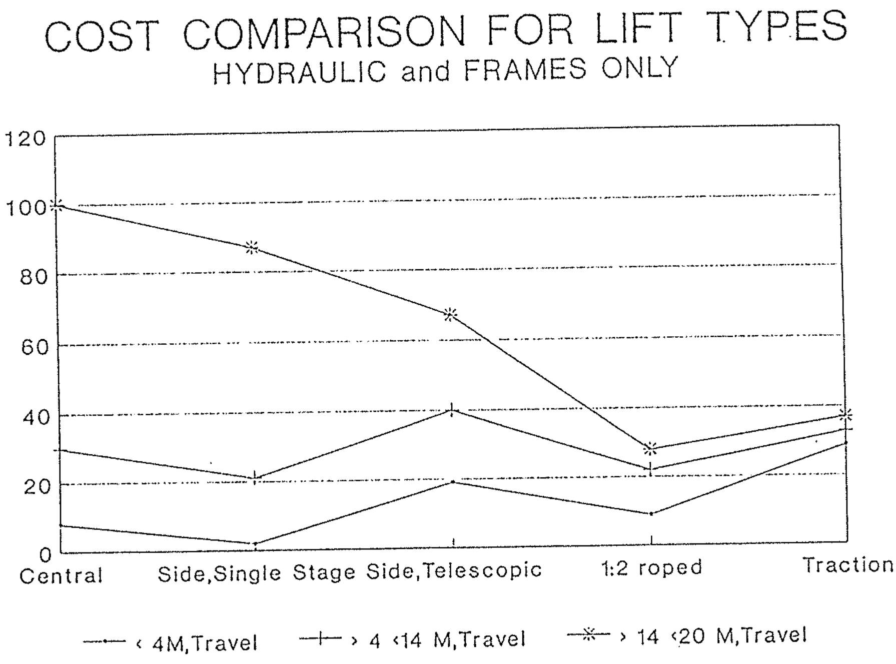


Tank with pump and motor immersed in oil.

Under oil units have provided the industry with a very compact unit with the minimum of piping and leak points. Any leaks now will remain inside the tank. There have been two methods of mounting the valve firstly inside the top of the tank under the cover or secondly on top of the cover, the latter being more accessible for service and allowing more active oil in a similar size tank to the internal valve.



COST COMPARISONS



Traction shown for comparison

HYDRAULIC VERSES TRACTION.

Hydraulic has;

Multi speed range due to valve / good for accurate stop.
All loading can be on pit floor (except for Pull down System).
Machine room location flexible.
Reduced installation times for basic types.
Speed is limited to 1.0 m/s (in most countries).
Lift well space is smaller for most types by about 10%.
Limited in travel to about seven stops.

Electric Traction has;

More suitable arrangement for high rise.
No speed limit.
Lower power consumption.
Higher starts per hour possible.
Easier to extend travel in the future.

SPEEDS AROUND THE WORLD.

The increase in speed has been brought about by those wishing to use the hydraulic lifts to satisfy the low end of the traction market, but this move has had its problems. These have mainly been in the area of higher kilowatt ratings of motors and higher differential temperatures of the oil.

NOISE LEVELS

There are two main conditions that are to be dealt with the first is air born noise and the second is vibration or pulsation.

Outside the machine room.

The noise outside the machine room can be reduced by selecting a more suitable door panel and frame seal. The ventilation of the machine room should be directed to a less critical area and not through vents in the door panel.

In the lift car.

The problems that relate to the car or cabin noise on hydraulic lifts is usually only from the hydraulic system and does not concern air turbulence experienced in fast speed traction lifts. The lift cabin can become a sounding box that amplifies any vibration / pulsation coming from the pumping and valve equipment. The use of flexible lines, mufflers or expansion chambers has in most cases improved the situation. There have been cases where just replacing the pump with the same type of pump has made a remarkable improvement to the noise level. The use of guide shoes incorporating resilient material either as part of the shoe or its mounting along with isolation of the ram connection to the car frame has improved the noise in the cabin.

Methods of reducing noise level.

The reduction of noise can be by insulation or isolating the equipment, this can be very time consuming and costly. The choice of higher quality components can reduce or eliminate the noise at the source.

Some noise reduction systems increase temperature.
There have been many cases where manufacturers have reduced the noise by enclosing or containing the noise in an enclosure of some kind. This has ended up in increasing the temperature and resulting in performance problems.
Initially it may appear to be the cheapest way around the problem, but it is very difficult to service equipment that has been enclosed. In many cases the covers are removed and not replaced.

MOTOR STARTING SYSTEMS.

Direct on line starting system.
The preferred system of starting is Direct on Line (DOL) but this can rarely be done for motors over 20 KW due to supply authorities limits on starting currents. This means alternative means must be selected. The most common second choice is star delta switching as this is the cheapest alternative to DOL. Methods other than DOL increase the up starting time due to the delay in switching prior to starting to close the valve for up acceleration.

Star / Delta starting system.
There is a slight misconception regarding the low current starting when using star delta switching. It has been found that when switching from star to delta peak currents nearly as high as DOL can occur depending on the timing of the switch over to delta.

Resistance starting system.
Several designers have employed starting resistance as a efficient means of reducing high currents experienced with DOL. There are usually one or two stages of resistance reduction, all of which would be completed in less than one seconds.

Reduced voltage starting systems.
There is an increasing number of reduced voltage starting systems coming onto the market, but it is very expensive to apply and possibly unwarranted on low kw rating motors.

VF systems in future.
The current trends to develop VF drive systems for pumps on hydraulic lifts will permit better control of current surges during starting and also the opportunity to use a valveless control by driving the pump in both directions.

SPECIAL DEVICES OR EQUIPMENT.

Double cylinder jacket.
Where cylinders are to be placed in the ground and there is a possibility of external corrosion taking place, it would be advisable to use a cylinder with an outer jacket. This type of unit allows leakage to be detected in time to take corrective action.

Emergency lowering device.
The use of emergency lowering systems is being requested in more specifications due to the number of cases where persons have been trapped due to power failure, or equipment faults. These emergency lowering devices can be arranged for manual or automatic operation. Usually the manual operation is carried out by a mechanic in the machine room, this means the emergency communication system must be in operation to call for assistance.

Re levelling or corrective levelling.
Because of the possibility of oil leakage taking place on this type of lift equipment and the situation of the landing doors being left open or blocked open, it must be fitted with re levelling equipment to return it to floor level when at any upper floor. There are three basic types of equipment used to detect the car movement and actuate the re levelling.
* Magnetic switches on the lift car and vanes at each floor.
* Mechanical switches on the car and actuating cams at each floor.
* Wiping contacts on the car and contact cams at each landing.

Pawl devices.
Pawl devices are mainly used in Europe, they consist of mechanical catches attached to the car frame and are arranged so they can be retracted during normal lift operation. These pawl devices only operate in the down direction if the car sinks below a floor level by more than 100 mm and the landing doors are open. When in operation they can support the fully loaded car. They have two other features, firstly they can incorporate an oil cylinder to cushion the severity of the stop and secondly this pawl devise and oil cylinder can be used for pit buffers. One disadvantage of the device is that after it has operated the lift must be moved in the up direction to release to pawls before a down run can be made.

Low pressure valve on roped units.
It is important that a low pressure valve be fitted and adjusted on all roped / indirect hydraulic lifts. This vale is arranged to prevent the ram being lowered if the car is in the safety gear. Lowering of the ram under these conditions may cause slack rope to become tangled in lift well equipment and then possibly damage the ropes or other equipment when the ram is pumped up to lift the car out of the safety gear. This low pressure valve must be so placed that neither the main valve or the manual lowering valve can allow the unloaded ram to retract back into the cylinder.

MONITORING SYSTEMS.

Motor thermistors.
The use of thermistors embedded in the motor winding and connected to a control relay is one of the most common and appropriate means of protecting the motor winding from over temperature. The use of oil temperature detectors is not effective when the motor is overloaded and the oil is at low temperature. It is not possible to heat a large volume of oil in about 20 to 30 seconds. The thermistor that is in direct contact with the motor winding can detect the temperature rise very quickly and shut the power off.

Over pressure.
Might be considered a cheap form of load weighing or overload protection, but the truth is that it is a very inaccurate method of monitoring the load. The ram friction in the gland and the types of guide shoes can create a very large difference in readings. The repeatability of a reading depends on to many variables, eg; last direction of travel, load in the car, oil condition, and type of seals, and in addition if the ram is multi stage.
For accurate load monitoring platform sensors is the most reliable or crosshead strain gauges.

Oil temperature.
A slow increase in oil temperature can be detected by some thermal type switch in the oil, such switch can startup the cooling system at some predetermined setting. The thermal type switch can also act as an indicator of low oil level, as low oil level will heat up faster.

Earthquake.
There is a growing need for protection against running a lift if components have been dislodged due to an earthquake. Japan and New Zealand have been requiring varying forms of protection for some time and other countries are starting to follow their lead. The main points being considered are retaining machine room equipment in its correct position and in the shaft detecting if the car becomes dislodged from the guide rails due to failure of components or deflection of guide rails.

Desirable oil temperature differential.
Although most valves can operate with oil temperatures as low as 15 deg.C and as high as 70 deg.C, it is important to limit the differential temperature to about 25 to 30 deg.C for best performance. This is done by employing heating or cooling equipment to suit the site conditions.

Potential damage during construction.

Unprotected rams hit by foreign objects
Accidental welding contact with ram surface
Sand blowing onto oiled surface of rams
Water leaking into oil tank containing motor and pump
Protective coatings on cylinders being damaged

WHAT IS THE IMPORTANT CRITERIA FOR A HYDRAULIC LIFT.

	1st	2nd
For the developer	Cost	Delivery
For the consultant	Performance	Reliability
For the user	Reliability	Suitability

Biographical notes;
John Inglis, OAM, has been in the lift industry for over fifty three years, the last thirty years he has been a member of the Australian Standards Lift Code committee's. Several of the sub-committee's and working groups are still chaired by him. His formal education was carried out at Sydney Technical College. He has been involved in all facets of the industry in both electrical and mechanical design, manufacturing and construction. He has been granted patents for several mechanical and hydraulic components, including fire doors. For the past twenty five years he has been involved in the design, manufacture and testing of fire doors for lifts. John has been a member of the International Association of Elevator Engineers since 1986 and appointed Worldwide Membership Co-ordinator in 1990 and a member of the IAEE Steering Committee in 1993.