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Trott

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[54] **MEANS FOR DISPLACING STRUCTURES**

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[51] **Int. Cl.** **E01g 3/00**

[58] **Field of Search** 61/84, 85, 42, 45; 299/31, 299/33

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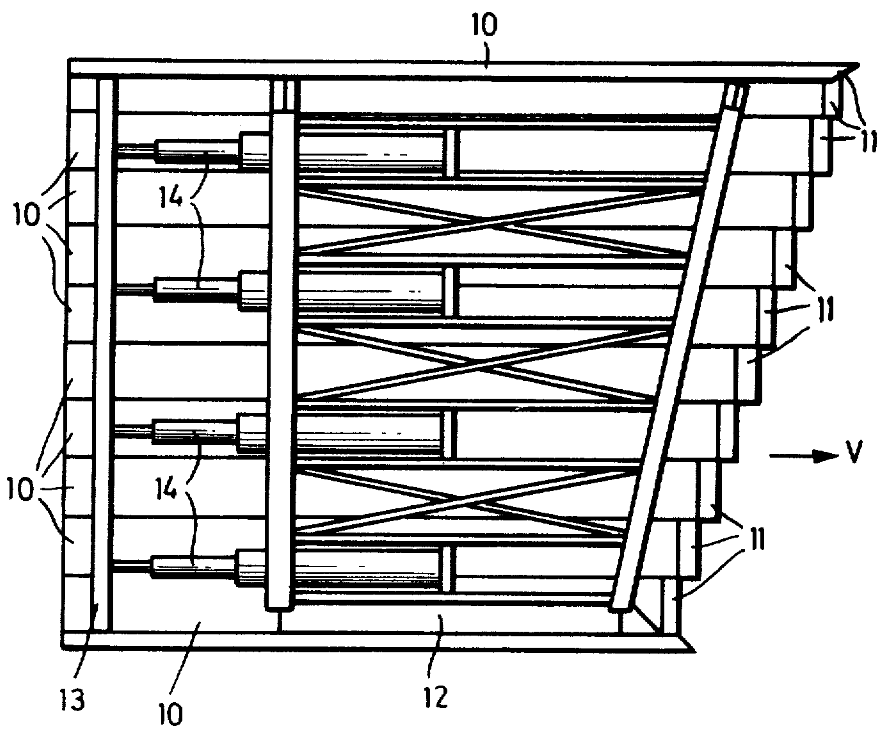
[57] **ABSTRACT**

Means for displacing heavy structures such as a tunnel driving shield, a bridge span or a building comprises a plurality of hydraulic cylinders assembled in two or more groups, each group having its own hydraulic circuit.

9 Claims, 7 Drawing Figures



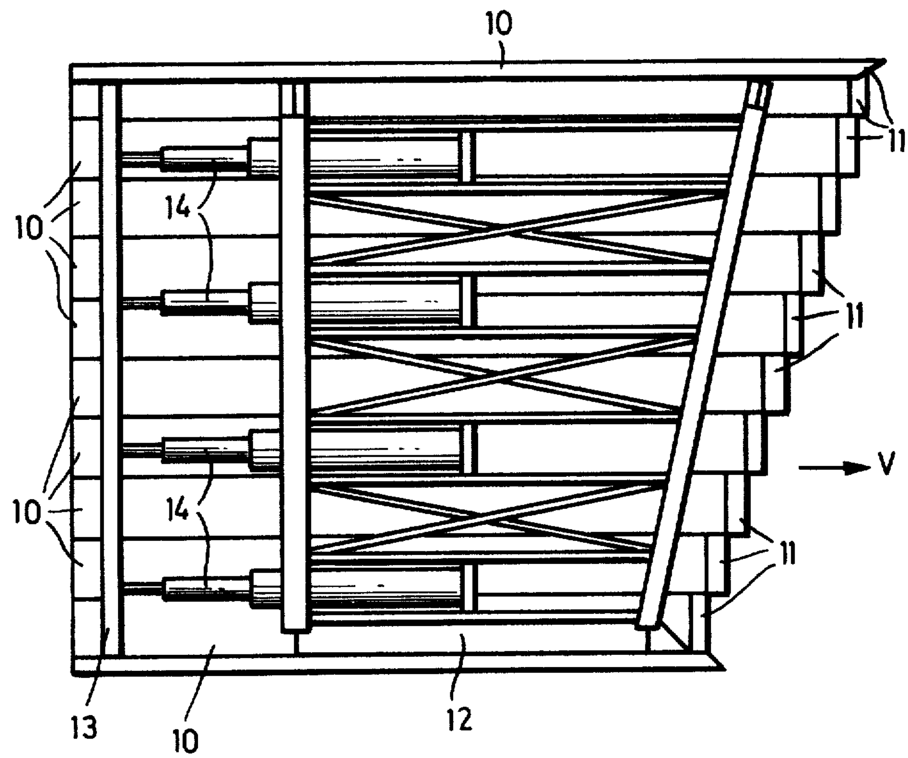


FIG.1

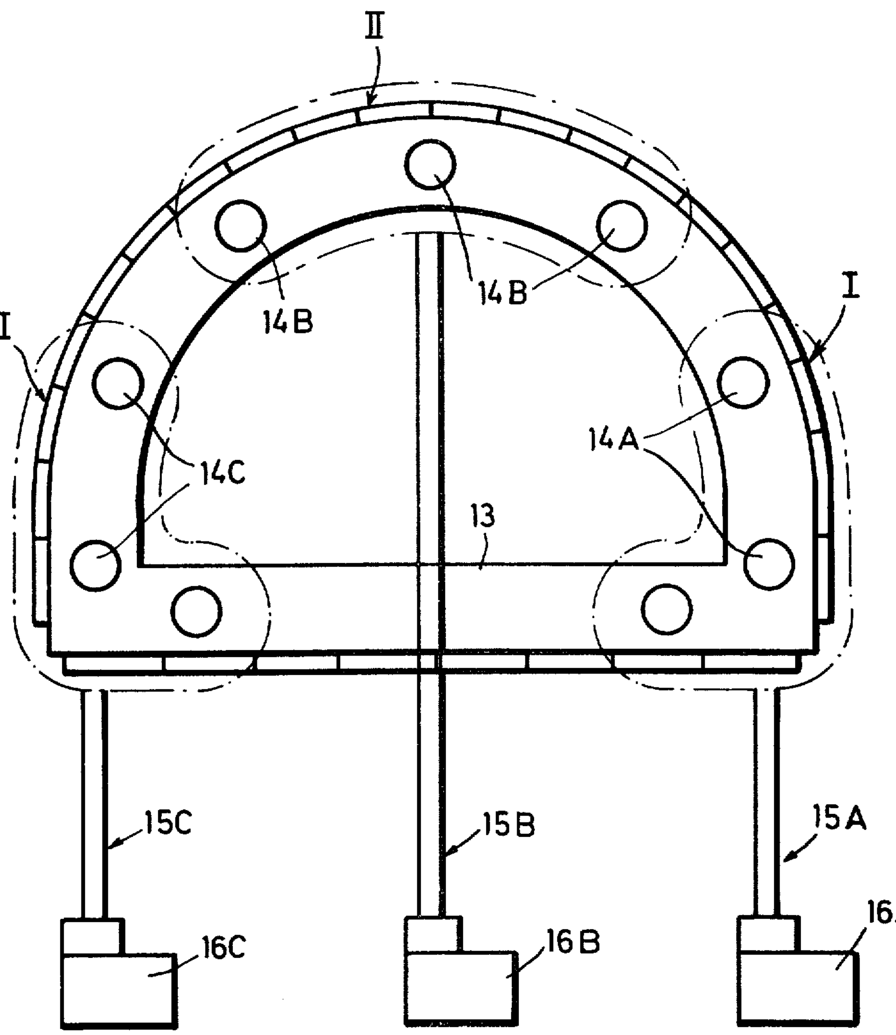


FIG.2

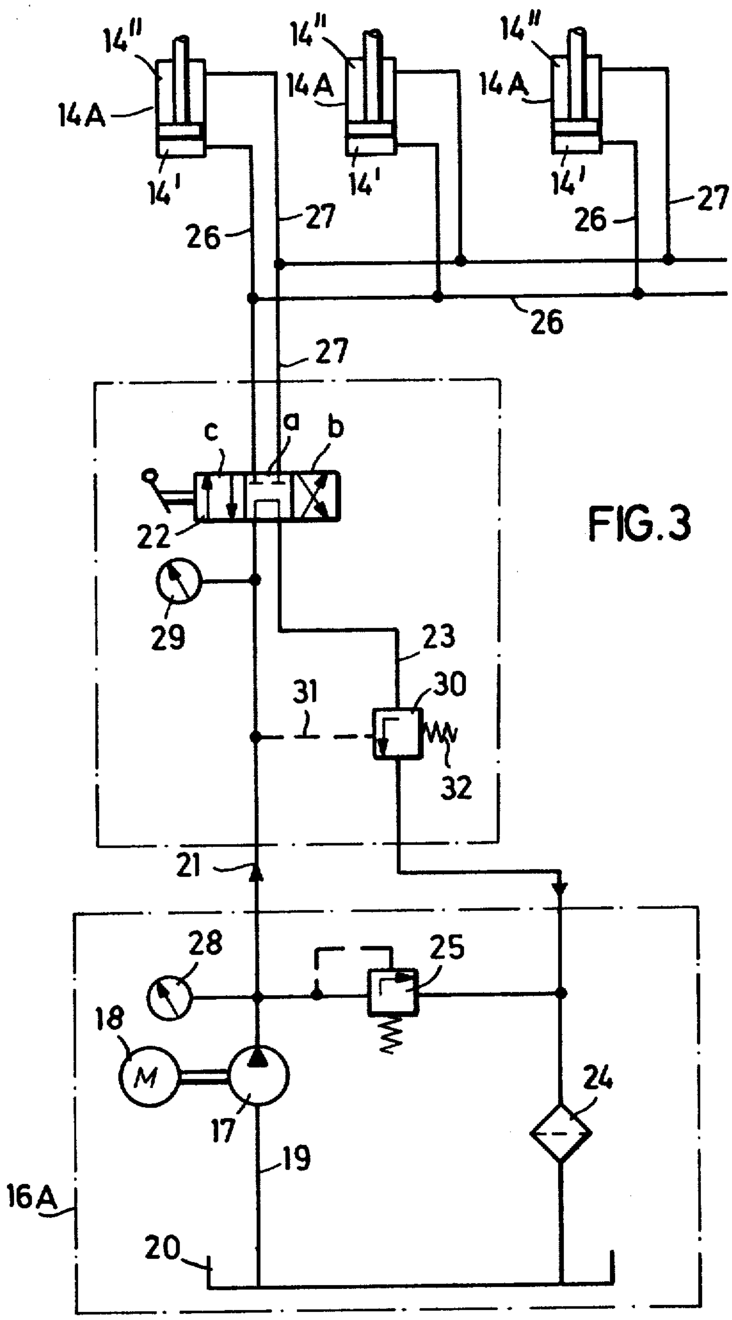

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FIG.3

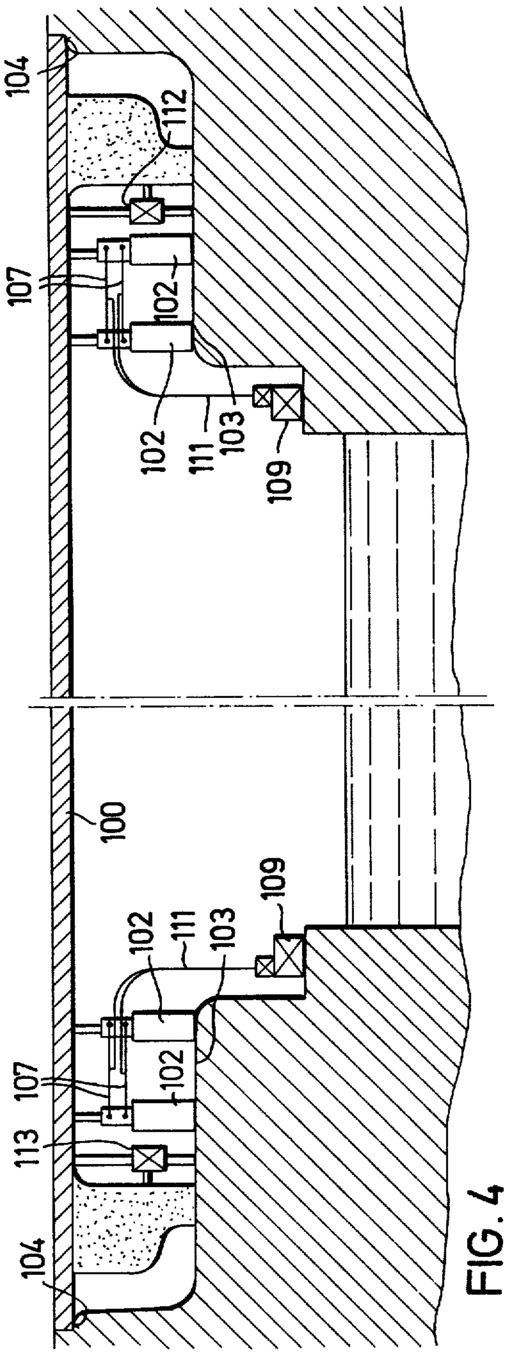

FIG. 4

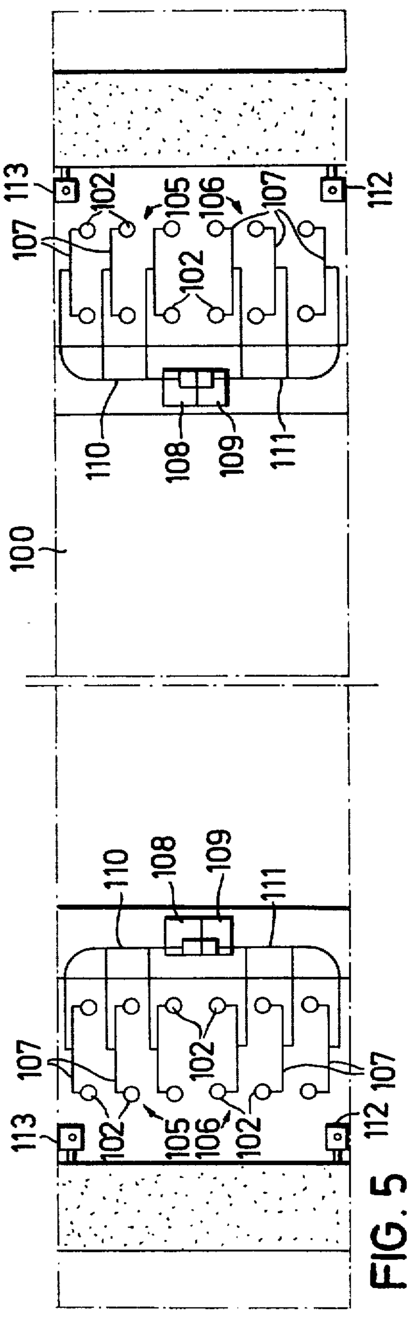

FIG. 5

FIG. 6

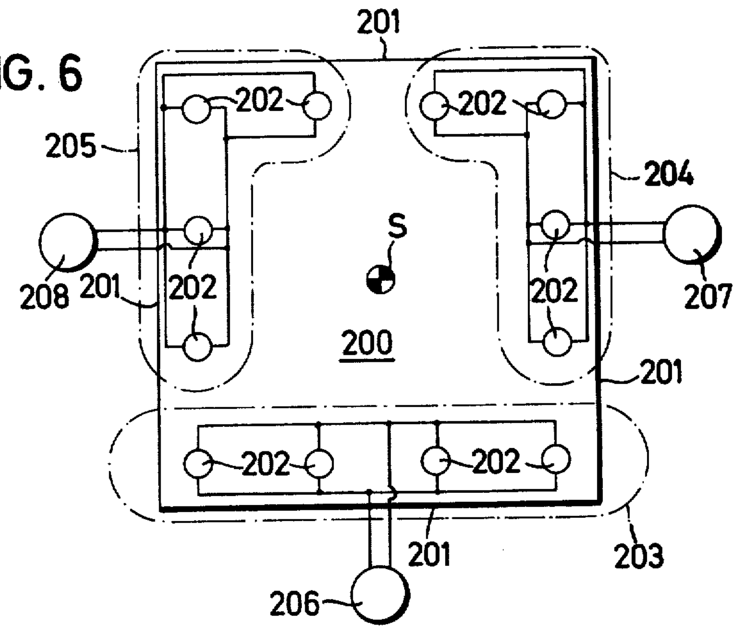
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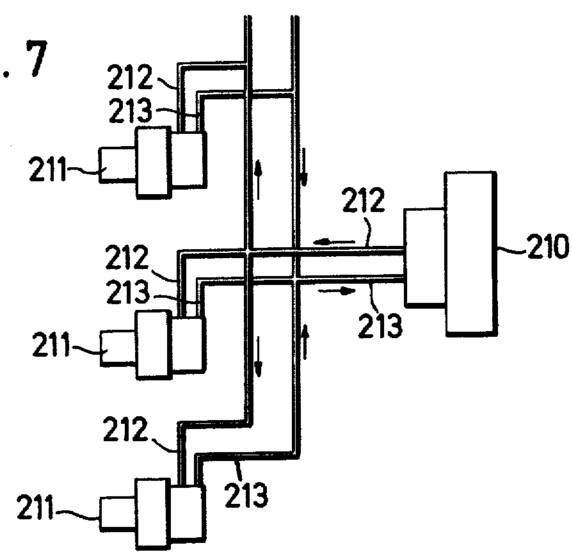
FIG. 7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MEANS FOR DISPLACING STRUCTURES

BACKGROUND OF THE INVENTION

It is known to use sets of hydraulic piston and cylinder units, or jacks, to displace heavy structures. This principle may be utilised in a number of different contexts. For example, it may be applied in connection with a tunnel driving shield of the type having a peripheral wall made up from a number of elongate, sharp-ended elements which are supported on the periphery of a two-part frame. One part of the frame can be anchored in place in the tunnel or adit under construction while the other part is thrust forward hydraulically and carries with it one of the shield elements or a group consisting of a selected small number of elements. The last-mentioned frame, which may be termed the driving frame, is then retracted and has a further element or group of elements connected to it ready for another advance. Eventually, when all of the elements have been advanced, the anchor frame is released and drawn up so that the procedure described above may be repeated.

Since no more than a small proportion of the total number of elements are advanced at any one time, the resulting thrust which is applied by the driving frame takes effect at different points and eccentrically of the centre of gravity of the driving frame. The changes of position of this eccentric force may result in twisting or tipping of the driving frame, even when the jacks are arranged uniformly around the whole circumference of the shield, and all the jacks are supplied with fluid at the same rate. When the driving frame tends to overturn, the advancing sharp-ended elements serve as a fulcrum and the jacks which are positioned at a distance from this fulcrum move forward at an increased rate. The unevenly distributed forces which the jacks apply may cause trouble and result in the driving frame becoming distorted or even jammed in the tunnel, especially if the latter has a large diameter.

It is also known to use this principle for lifting structures, such as the span of a bridge or a building. Accordingly, hydraulic jacks are equipped with monitoring and control instruments which control the operation of the jacks with regard to the selected height to which the structure has to be lifted in such a manner that all of the jacks complete one stroke in the course of an operating cycle, the stroke of each jack being at least theoretically identical or being related to the others by a particular ratio. Because of local variations in the strength of the structure or its foundations and possibly also in the foundations to which the jacks are anchored, this method of control cannot ensure that even when each of the jacks has completed a full stroke all of the jacks will be loaded identically. For this reason, the structure has hitherto been enclosed in a rigid load transmitting casing and a rigid auxiliary foundation has been provided in the ground to serve as a common abutment for all of the lifting jacks.

The jacks are then arranged at predetermined distances apart in the space between the auxiliary foundation and the load carrying casing. During lifting, the jacks are either pressurised uniformly to complete the same stroke or, if the structure should become inclined as a result of ground irregularities, the jacks are pressurized non-uniformly taking into account the inclination of the structure so that the jacks complete strokes of appropriately different lengths. The inclination of the structure being moved then serves to control and rectify the relative strokes performed by the jacks using, for example, spirit or other level indicators, in such a way that the jacks supporting the lowest parts of the structure perform strokes of increased length.

An object of the present invention is to provide a means for displacing heavy structures which enables a substantially distortion- and tilt-free displacement to take place to thereby obtain a better utilisation of the cylinders.

A further object of the invention is to provide an inexpensive arrangement in which the cost of automatic monitoring and control instrumentation is kept to the minimum.

SUMMARY OF THE INVENTION

According to the present invention, the hydraulic jacks are arranged in several mutually spaced groups, each of which groups is provided with a respective separate pressure medium supply line. Within each group the cylinders are however interconnected. Generally, division of the jacks into three groups is sufficient since three groups is the minimum necessary to constitute a statically definite support or anchoring system.

As stated, every group of jacks is provided with a separate line for the pressure medium which serves to supply each group with pressure medium at a definite rate of supply. It is possible to provide for all three groups a common pump set with control means to ensure the delivery to each jack group of a preset amount of the pressure medium. In the general case, the amount of pressure medium supplied to each group of jacks is the same as that supplied to each of the others. However, it is also possible to provide each group of jacks with its own pumping set which is connected exclusively to the hydraulic circuit of that group.

By providing three groups of jacks as described, a statically defined and stable support or advance system is obtained which is a prerequisite for completing the lift or advance without twisting or tilting while all jacks operate synchronously and participate actively. Since in each group of jacks all individual cylinders are interconnected their pressure load is at all times the same. The jacks therefore develop the same thrust upon the advanced or lifted structure though the strokes of each may be slightly different. The thrusts individually imparted by the jacks of each group may be resolved and regarded as being applied to the structure at a single point. The points at which the various resultant forces are applied may then be spaced from one another by a predetermined distance. This has the advantage that at all times the three groups of jacks transmit the forces upon the advanced or lifted structure without internally distorting or overturning it, even though the average stroke paths of every one of the three groups of jacks are different or kept intentionally different by an unequal supply of the pressure medium.

The arrangement according to this invention has advantages compared with the known advancing and lifting means in which for every jack a separate pumping circuit is required with its associated controls. The means according to this invention requires only three or at most four pumping circuits, each with a control valve, a fact which represents a material reduction of costs.

Another feature of this invention consists in the provision of a variable resistance to the motion of the groups of jacks. This is achieved by a throttle or braking valve in the return line for fluid leaving the ram chamber ahead of the piston, the passage through which valve being controlled in relation to the pressure prevailing in the pressure supply line, the throttle cross section being smaller, the lower is the pressure in the pressure supply line to the jacks. The adoption of these braking valves reduces also the risk of the driving frame of a tunnelling shield being tilted or distorted while the jacks are operated synchronously because the braking valves prevent the forward movement of a certain jack at an increased rate in the direction of advance when the tendency to overturn develops. Such an accelerated advance is now precluded by the back pressure prevailing in the joint discharge line from the cylinders. This effectively suppresses development of a tilting moment. The invention ensures therefore an effective synchronised operation at reduced investment costs and a trouble free advance or lifting movement. It affords at the same time a better utilisation of the equipment used.

Although only three jacks groups are needed for lifting buildings or advancing tunnelling shields and the like, the hydraulic jacks are preferably arranged in four groups for lifting and/or shifting bridge structures. The jacks in each group are again interconnected, each lifting group being provided with a separate pressure supply line of its own or a separate pressure generating unit. This may be effected either by providing one pressure pumping set for the medium common to all cylinders in groups and separate feed lines to each group with its own regulating valves; or by equipping each jack group with its own separate pressure pumping set. The output of these individual pressure pumps is adjustable to suit conditions. It is also possible to provide each group of jacks with an appliance for monitoring and controlling the stroke length.

Since according to this invention the distribution of pressure to the individual groups of jacks serves to regulate the piston stroke and lifting thrust it is possible to achieve continuous advance along relatively long lifting paths while eliminating relatively wide stroke differences between the individual groups of jacks without the need for complex and expensive monitoring and control systems. The supply of the pressure medium to the individual groups of jacks is effected with regard to the intended lifting path and/or in relation to the number of jacks in each group.

DESCRIPTION OF DRAWINGS

FIG. **1** is a diagrammatic side view of a tunnelling shield with sharp ended shield elements, its anchoring frame, the driving frame and advancing jacks;

FIG. **2** is a side view of the driving frame and the arrangement of advance jacks along the frame periphery, the advancing jacks being combined into groups with their own pumps and hydraulic circuits;

FIG. **3** is a hydraulic circuit of a jack group for the tunnelling shield shown in FIGS. **1** and **2**;

FIGS. **4** and **5** are a sectional elevation and plan view of a bridge structure with a lifting means according to this invention;

FIG. **6** is a diagrammatic plan view of means for lifting a building or the like according to this invention;

FIG. **7** is a layout of a diagrammatic pipeline within the group of lifting jacks for an appliance shown in FIG. **6**.

DESCRIPTION OF FIRST PREFERRED EMBODIMENT

Referring to FIGS. **1** to **3**, a tunnelling shield comprises an anchoring frame **12** and a driving frame **13** which is connected to the anchoring frame by a plurality of double acting hydraulic piston and cylinder units or jacks **14.** The two frames define an arch and support a plurality of elongate roof support elements or planks **10** which extend in the longitudinal direction of the shield and are provided at their forwards ends with sharp cutting edges or knives **11** so that as the planks are forced in the direction V, the planks bite into the face.

The planks can be secured releasably, for example by bolts, pins or the like, to one or other of the frames. In operation, a selected plank or a group of planks is advanced relative to the others. To this end, the anchoring frame is secured in place in the tunnel by means not shown and the plank or group of planks to be advanced is secured to the advancing frame with the latter in its rearward position, that is, with the jacks **14** retracted. The jacks **14** are then pressurised to extend them and the plank or group of planks to be advanced is thrust in the direction **3.** Thereafter, the advanced plank or group of planks is disconnected from the driving frame and connected to the anchoring frame, and the driving frame retracted to enable another plank or group of planks to be advanced in the same way. When all of the planks of the shield have been advanced by the same distance equal to the length of stroke of the jacks **14,** the driving frame is secured to all the planks and the connection between them and the anchoring frame released. The jacks **14** are now retracted so that the anchoring frame is advanced in the direction of V.

Thereafter, the procedure is repeated.

To ensure that the driving frame does not diverge from the desired direction of advance, the jacks **14** should be distributed evenly around the periphery of the frame **13,** and these jacks should be pressurised uniformly during operation. However, the forces applied by the jacks resolve into a resultant force in the longitudinal direction which is spaced from the centre of gravity of the frame system. This may give rise to a tilting moment in the advancing driving frame, and some of the jacks **14** may move forward at an increased speed in consequence of a lowered resistance to motion. As a result, a uniform loading of all of the jacks does not exist. This tendency of the frame to overturn results not only in an irregular distribution of forces produced by the jacks but may also cause the driving frame to become distorted or to jam.

To avoid this problem, the jacks **14** are arranged in three groups around the periphery of the frame **13,** and in the illustrated case, each group consists of three jacks, group I consisting of the jacks **14*a*** group II consisting of the jacks **14*b*,** and group III consisting of the jacks **14*c*.** The jacks within each group are hydraulically interconnected and each group of jacks has its own hydraulic supply system designated as **15*a*, 15*b*** and **15*c*** with its own pump **16*a*, 16*b*** and **16*c*.**

Because the jacks in each group are hydraulically interconnected and each apply the same force onto the frame **13,** the forces pertaining to each group of rams can be resolved into a single resultant force which at any time is located somewhere between the outermost jacks of each group. The lines of force applied by the three groups of jacks should be spaced equally distantly around the periphery of the frame.

FIG. 3 illustrates a hydraulic circuit of a single group of jacks, namely the jacks **14A** of group I. The other groups of jacks have identical hydraulic circuits. The pumping set **16A** of the hydraulic circuit consists of a pump **17** which is driven by an electric motor **18** and draws hydraulic fluid through a suction line **19** from a storage tank **20**. The fluid is pumped through a pressure line **21** in which is interposed a control valve **22**. The valve **22** has three positions, namely an inoperative first position (a) in which it is shown, in which the pressure fluid is returned through a return line **23** to the tank by way of a filter **24**. The lines **23** and **21** are interconnected through a pressure release valve **25** which limits the maximum operating pressure in the hydraulic circuit.

In the position (*b*) of the control valve, the pressure line **21** is connected to a line **27** opening into the chambers **14''** of the jacks **14A** while in the position (*c*) of the valve **22**, the line **21** is connected to a line **26** opening into the chamber **14'** of each of the cylinders. In each of these last two positions of the control valve, the other of the chambers **14'** and **14''** as the case may be is connected to the return line **23**. Pressurisation of the chambers **14'** serves to advance the jacks, while pressurisation of the lines **27** serves to retract the jacks. The pressure in the line **21** can be monitored by means of a pressure gauge **28** and **29**. As will be seen from the Figure, a direct connection exists between all of the chambers **14'** on the one hand and all of the chambers **14''** on the other.

Because the cylinders of the jacks in each group are interconnected, all of the three jacks apply the same force to the frame **13**. Of course, all of the three groups of jacks are acting simultaneously.

Operation of the jacks is effected by adjusting their respective control valves **22**.

As the discharge of all three pumping sets is the same, and all three control valves **22** may be open simultaneously, all of the jacks **14A** operate synchronously so that the frame **13** is advanced without diverging from its intended line of advance.

The synchronisation of all of the jacks and their active participation in the advance of the planks is improved still further by the use of a throttle valve **30** which is interposed in the return line **23** and is held in the throttling position by a spring **32** but is displaceable into its open position by pressure supplied through a pilot connection **31** from the line **21**. The valve **30** operates so as to increase the resistance to the movement of the pistons of the jacks **14A** depending on the pressure in the line **21**. When any one group of jacks encounters a reduced resistance because of the tendency of the frames **13** to tilt, or because it is accelerated by the overturning frame while driving its planks forward, the resulting drop of pressure in the line **21** leads to the valve **30** moving to throttle the return flow through line **23**. The increased resistance in the return line **23** and in the chamber **14''** connected thereto counteracts the effect of the tilting movement and contributes to a regular distribution of the forces developed by all of the jacks.

When the direction of advance of the tunnel being constructed must be adjusted, this is easily achieved by suitable adjustment of the rate at which the pumps of the various groups are working or by operating the valves **22** of certain groups of jacks after a suitable delay time. In this way, it is possible to control accurately the advance of the individual groups of jacks and thereby the movement of the whole driving frame without the risk of distorting or tilting torques developing.

It is possible to make use of a number of jacks different from that in the illustrated embodiment, but it is preferable to have the same number of jacks in each group.

When large tunnelling shields are used, they may be provided with two or more driving frames, each of which is associated in the described manner with three groups of jacks.

DESCRIPTION OF SECOND PREFERRED EMBODIMENT

FIGS. **4** and **5** depict the use of the invention for lifting a bridge span **100** from its pillars **103**. Two groups of hydraulic lifting jacks **102** are positioned on the pillars and are fixed to the bridge span **100**. The lifting jacks associated with each of the pillars are divided into two groups **105** and **106** arranged symmetrically with respect to the longitudinal centre line of the bridge span. In the illustrated embodiment, each group contains six jacks **102** which are interconnected by pressure fluid lines **107**. The two groups of lifting jacks are also associated with pumps **108, 109** from which lines **110** and **111**, respectively, extend to the lines **107**. Because it is intended to lift the bridge uniformly, the same number of lifting jacks are provided in each group and for the same reason both pumping sets **108, 109** are adjusted to supply hydraulic fluid at the same rate. Each group of lifting jacks is provided with a monitoring device **112** or **113** to measure the height to which the span has been lifted from its pillar, the stroke of the rams being monitored continuously during the lifting stage.

As the cylinders of each group of jacks are interconnected, the force they apply is independent of possible different loading conditions or local flexibility of the bridge span or its supporting pillars, and all lifting jacks in a group provide an identical lifting or supporting force.

However, the bridge span **100** may instead be lifted asymmetrically by a suitable adjustment of the rate at which hydraulic fluid is supplied to the groups of jacks.

DESCRIPTION OF THIRD PREFERRED EMBODIMENT

FIG. **6** shows how the invention may be applied to lift a building **200**. The main walls **201** would be supported by a plurality of lifting jacks **202** collected into three groups **203, 204** and **205**, the cylinders in each group of jacks being interconnected and supplied from a respective one of three pumps **206, 207** and **208** respectively. In the illustrated instance, it is intended to lift the building symmetrically so that an identical number of jacks is provided in each group thereof and the pumps are set to deliver fluid at the same rate. Two of the groups of jacks are arranged in a triangle so that the resultant force for each of these groups is near the apex of the triangle and as a result near a corner of the building. The resultant force pertaining to the other group is substantially midway along the length of the opposite wall. The building is thus supported at three suitable points, the resultant forces so far as is possible being arranged to be at the same distance from the centre of gravity S of the building.

FIG. 7 illustrates the hydraulic system in respect of the jacks of one group which is applicable to the groups **105** and **106** and **203** to **205**. A pump **210** is connected to the jacks **211** by way of a pressure line **212** and a return line **213**. Interconnection of all the cylinders of the jacks of the group is effected by a common section **212** of the circuit and a common return section **213**. The rate of delivery of the pump is adjustable.

What is claimed is:

1. In combination, a tunnel driving shield comprising an anchor frame and a driving frame interconnected for relative movement longitudinally of the frames, a plurality of elongate, sharp ended shield elements connectable selectively to each of said frames, and hydraulic means including a plurality of hydraulic jacks connected between said frames, said jacks being arranged in at least three groups, each of which groups is associated with a hydraulic system comprising a pump, a control valve, a pressure line extending between the pump and the control valve, a return line extending between the control line and a tank from which hydraulic fluid is drawn by the pump, a first supply line connecting the control valve and a first chamber of each of the jacks and a second supply line connecting the control valve and a second chamber of each of the jacks, the control valve being positionable to connect the pressure line to either of the said supply lines and the return line to the other supply line, to extend or retract the jacks as required, the resultant forces pertaining to each group of jacks acting along a line located at a position intermediate the endmost jacks in each group, the lines of force applied by the at least three groups of jacks being equally spaced around said shield.

2. The combination of claim **1**, wherein the return line includes a throttle valve which is operable in accordance with the pressure in a pilot line connected to the pressure line, whereby a reduction in the resistance to

the movement of the jacks results in a fall in pressure in the pressure line and consequent throttling of the return line to restore the resistance.

3. In combination, a tunnel driving shield comprising two relatively movable frames for supporting elongate shield elements, and a hydraulic system for advancing the shield comprising a plurality of cylinders connected betweeen the frames, the cylinders being grouped together and forming at least three groups, the cylinders of each group having a common pressure medium supply line so that the cylinders of each group operate together and independently of the other groups, each group applying to the shield a resultant line of force, the said resultant lines of force being spaced equally from the center of gravity of the shield.

4. The combination as claimed in claim **3**, wherein the resultant forces applied by the various groups of cylinders are substantially equidistant from each other.

5. The combination as claimed in claim **3**, wherein each group of cylinders has a separate pump and its own hydraulic circuit leading from said pump.

6. The combination of claim **5**, wherein a return line from each group of cylinders includes a throttle valve operable by pressure in a pilot line connected to the circuit leading from the pump, whereby a reduction in the resistance to the movement of the cylinders results in a fall in pressure in the pressure line and consequent throttling of the return line to restore the resistance.

7. The combination as claimed in claim **3**, wherein each group has a pressure fluid return line provided with a throttle valve.

8. The combination as claimed in claim **7** including a pilot line connected with the main pressure line and supplying pressure fluid to control the throttle valve.

9. The combination as claimed in claim **3**, wherein the lines of resultant force are disposed at the apices of an imaginary triangle.

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