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[54] **LIFTING MACHINE HAVING A PERMANENT RECIPROCATING MOTION**

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[51] **Int. Cl.** **F16h 39/46**

[58] **Field of Search** 60/372, 381, 382, 446, 60/907, 376, 378

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Primary Examiner—Edgar W. Geoghegan

[57] **ABSTRACT**

Lifting machine of particular utility for shifting the pump means of an oil well. The machine is adapted to impart to a load a permanent reciprocating motion. The load is connected to one end of flexible connecting means and a balancing counterweight is connected to the other end. The assembly consisting of the load, the connecting means and the counterweight is caused to reciprocate by a fluid motor through drive means. The motor is supplied with fluid by a variable-flow hydraulic pump and a control device acts on the pump so as to cause the pump to operate in accordance with a predetermined law by repeated reversals of the fluid delivered to the fluid motor.

8 Claims, 10 Drawing Figures

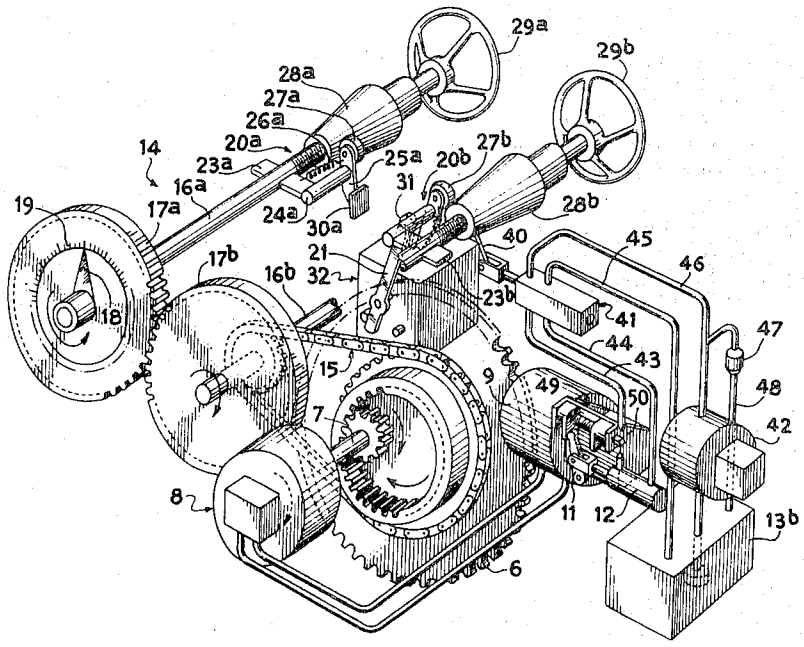


FIG. 1

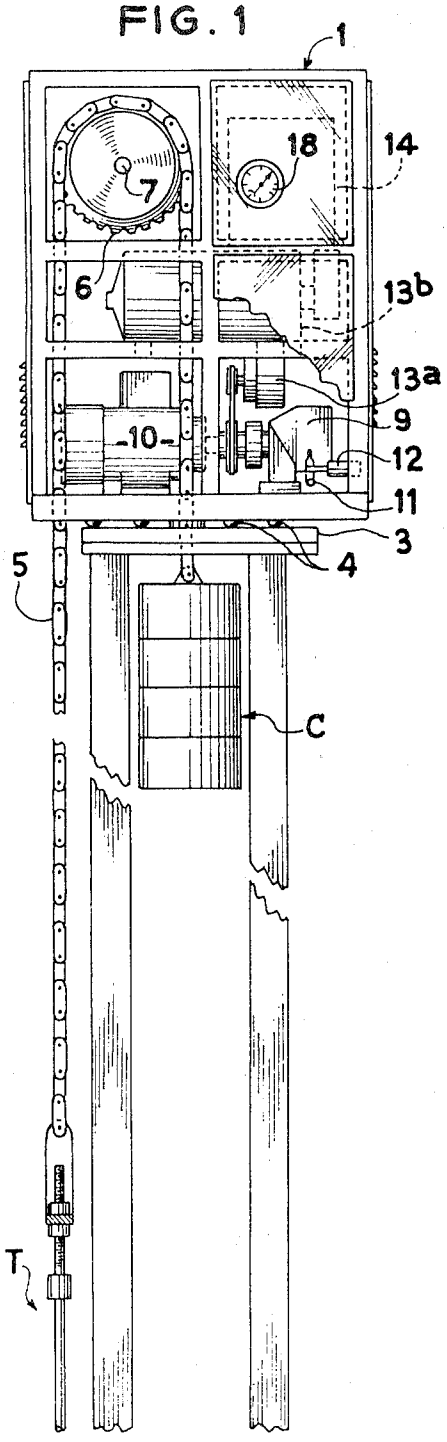


FIG. 2

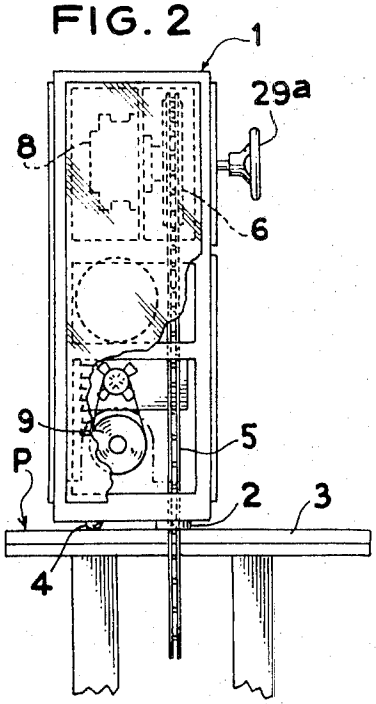
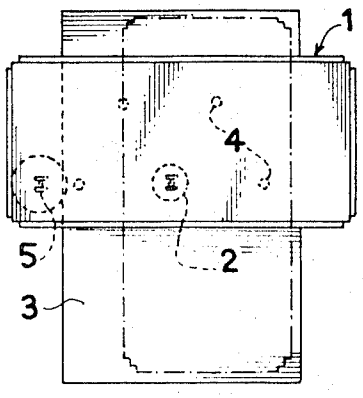
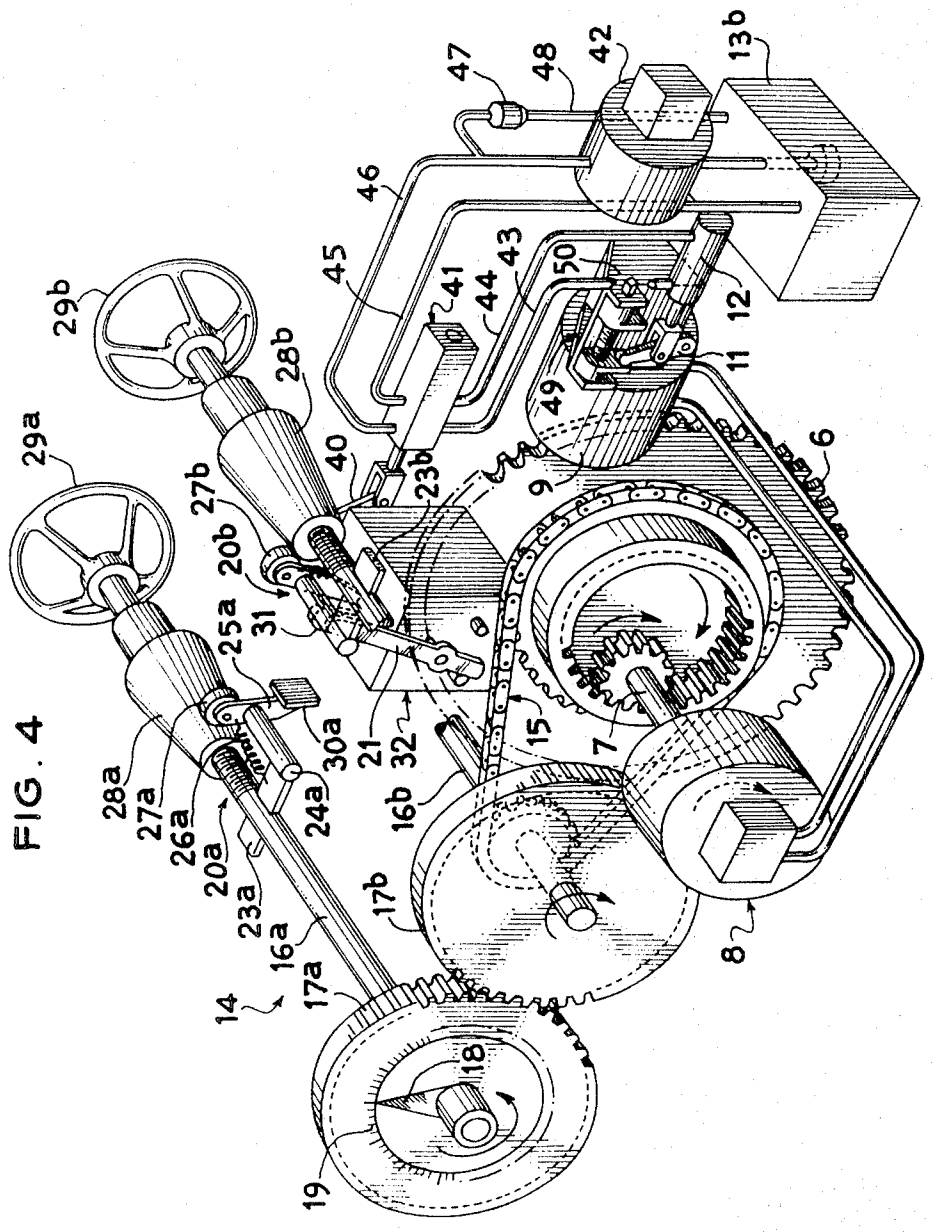


FIG. 3

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12
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28b
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9
27b
20b
31
25a
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7
28a
27a
26a
20a
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30a
21
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16b
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18
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8

FIG. 4

FIG. 6

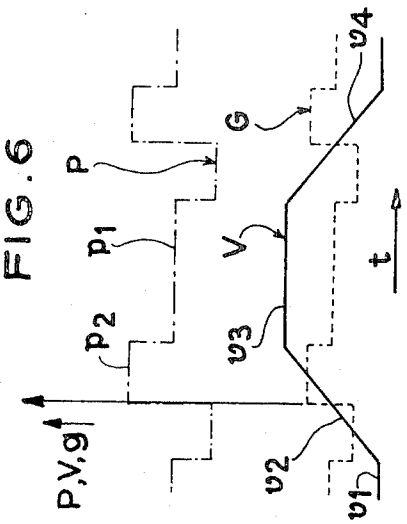


FIG. 7

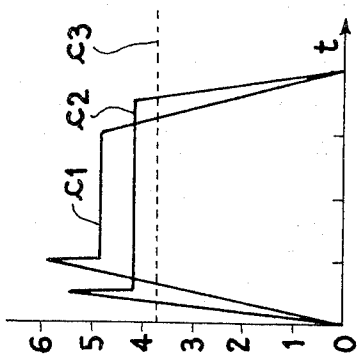


FIG. 5A

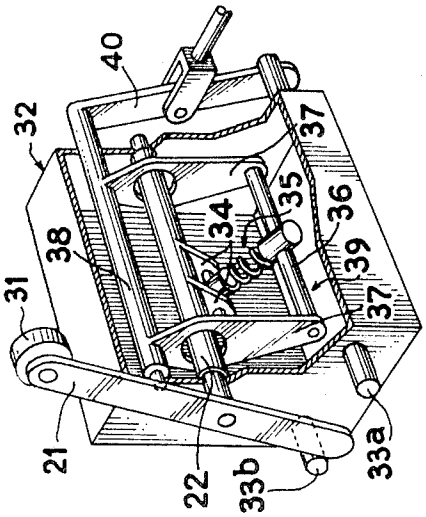


FIG. 5B

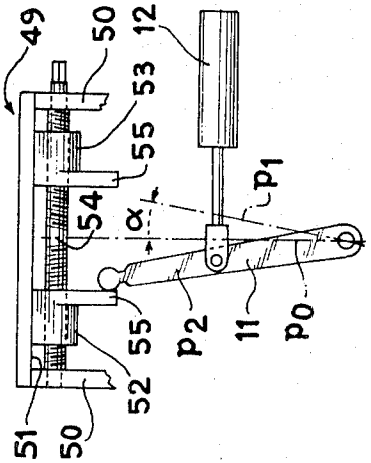
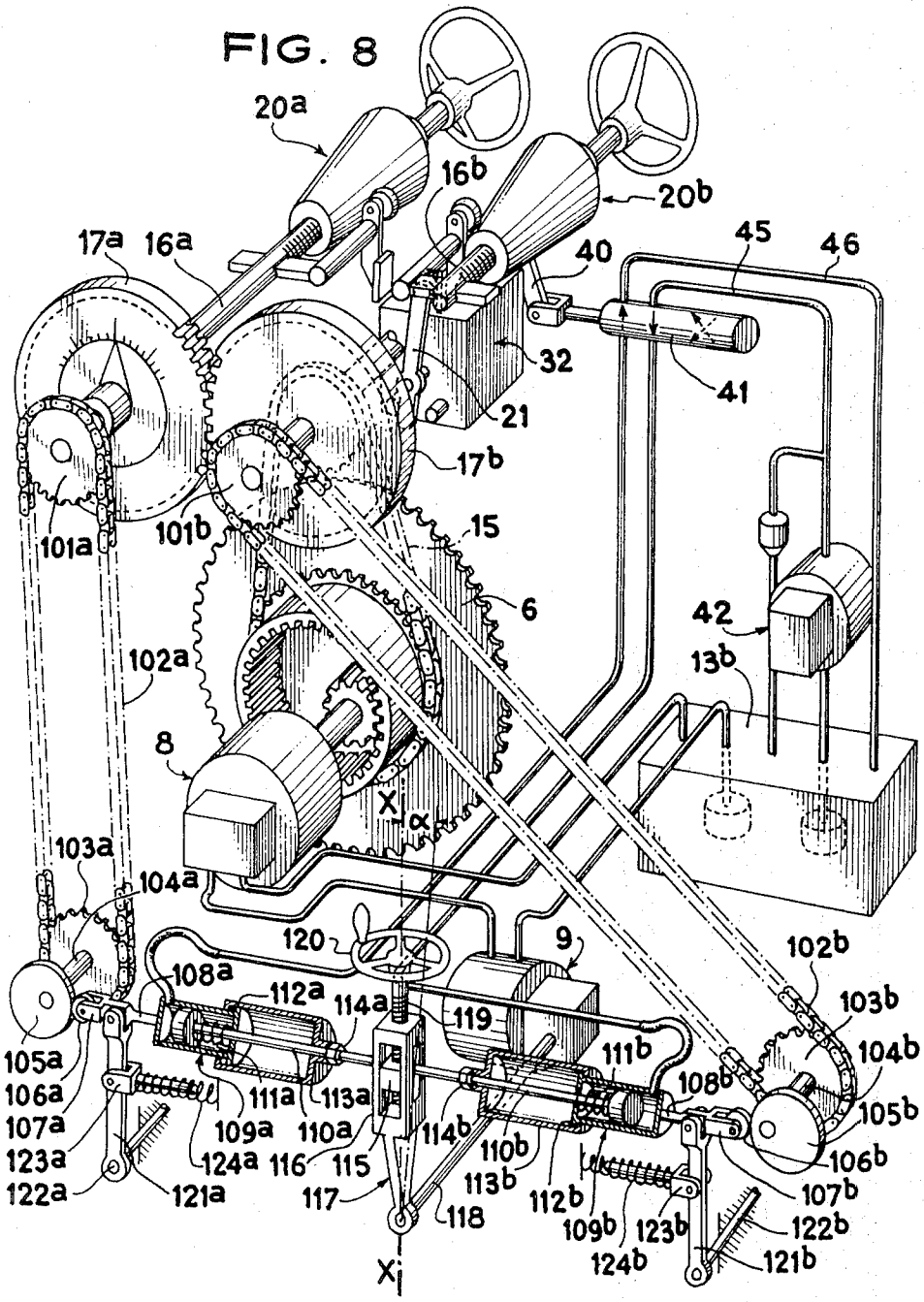


FIG. 8


20a
16b
20b
17a
16a
40
45
46
32
41
21
17b
101a
101b
15
6
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13b
102a
8
X
α
103a
104a
120
9
102b
108a
112a
114a
119
103b
111b
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110b
106b
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107b
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123b
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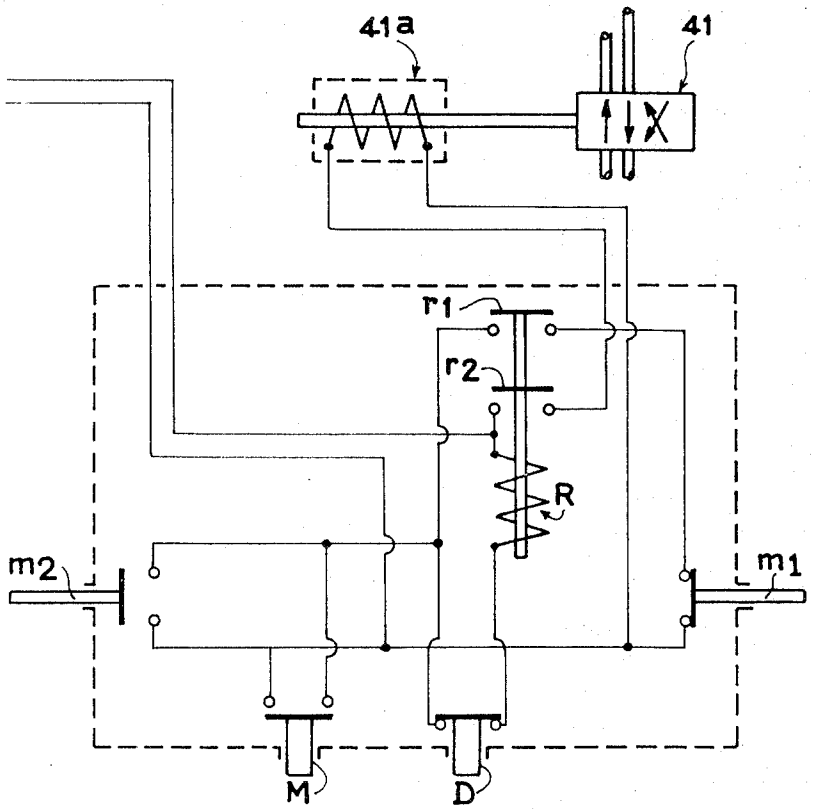
124b
121b
Xi

FIG. 9



LIFTING MACHINE HAVING A PERMANENT RECIPROCATING MOTION

The present invention relates to lifting machines and more particularly to such machines which are intended to impart to a load a permanent vertical reciprocating motion.

These lifting machines are employed in particular in oil pumping installations to which application the invention is related although it must be understood that it is in no way intended to be limited to this application.

In pumping installations for an oil well there is usually provided a pump which is located in the pumped well and is made to undergo reciprocating motion through the agency of a series of rods which extend up to the surface and to which is connected a reciprocating drive device.

Up to the present time such installations for pumped wells employ the well-known pump of the rocker type which is characteristic of oil fields. Now, although rocker pumps are very sure in operation it is nonetheless true that their overall size and weight are considerable.

This is a drawback which is all the more serious in that at the present time off-shore oil prospection has considerably developed and that these pumps must therefore be mounted on platforms emerging from the surface of the water. As the well heads may sometimes be located at a depth of 80–100 m it will be understood that it is essential to reduce as far as possible the weight and size of the parts of the pump mounted on the platform so as to reduce as far as possible the dimensions and consequently the weight of the latter.

The lifting machine according to the invention remedies the drawbacks of the known rocker pumps.

The invention provides a lifting machine adapted to impart to a load a permanent alternating motion in which the load is suspended from flexible connecting means to which is attached a balancing counterweight, the equipment constituted by the load, the counterweight and the connecting means being driven by a fluid motor through the agency of drive means, and the motor being fed with fluid by a hydraulic pump, wherein said pump is of the variable-flow type and further comprises a control device acting on said pump so as to cause the pump to operate in accordance with a predetermined law by a repeated reversal of the direction of flow of the fluid.

Owing to these features, it is possible to construct a very compact comparatively light lifting machine which is very reliable in operation.

According to another feature of the invention, the power of the variable-flow pump is calculated in accordance with a nominal value corresponding to the arithmetic means of the tensile forces exerted in the flexible connecting means during the two stages of the reciprocating motion, the balancing counterweight having a mass equal to said arithmetic mean.

This feature has been found to be very advantageous, since it permits in practice reducing to a minimum value the power of the energy transmitting train constituted by the fluid motor, the variable-flow pump and the drive device driving the latter.

Further features and advantages of the invention will be apparent from the ensuing description with reference to the accompanying drawings.

In the drawings:

FIG. 1 is an elevational view, partly in section, of the assembly of a lifting machine according to the invention applied to the exploitation of a pumped oil well;

FIG. 2 is a side elevational view of the machine;

FIG. 3 is a diagrammatic plan view showing how the lifting machine can be cleared away from the oil well when maintenance work is to be done on the latter;

FIG. 4 is a diagrammatic perspective view of a part of the machine according to the invention;

FIGS. 5A and 5B are perspective views, to an enlarged scale, of two details of the machine shown in FIG. 4;

FIGS. 6 and 7 are diagrams illustrating the operation of the machine according to the invention;

FIG. 8 is a diagrammatic perspective view of a control device for a lifting machine having a permanent reciprocating motion according to the invention, the moving equipment driven by the machine being omitted, and

FIG. 9 is a diagram of an electrical circuit which is a modification of the motion transmitting means employed in the embodiment shown in FIG. 1 for connecting the regulating element of the pump to the over-center device.

With reference to FIGS. 1–3, there will first be described the general arrangement of a preferred embodiment of a reciprocating-motion lifting machine according to the invention. It will be observed that the illustrated machine constitutes a particular application of the invention to the exploitation of a pumped oil well, the invention being of course of utility in other applications if desired.

The illustrated lifting machine comprises a frame 1 having the general shape of a cabinet and capable of being closed in the known manner by detachable fluid-tight panels (not shown). The frame 1 is mounted on a pivot 2 which bears on a base plate 3 rigidly secured to a platform P which emerges, for example, at the place of exploitation of "off-shore" oil, at around 10 meters below from the surface of the water. The frame 1 has a number of rolling means 4 which bear against the base plate 3 and ensure that the assembly rotates or pivots easily about the axis of the pivot 2 so as to be moved to one side of the oil well for example for maintenance purposes (see the dot-dash line in FIG. 3).

The central pivot 2 is provided with an axial passage through which extends flexible connecting means 5, such as a linked chain connected, on one hand, to a string or series of rods T of the pump proper (not shown) at the bottom of the well and constituting the load of the lifting machine and, on the other hand, to a balancing counterweight C. The chain 5 is engaged on a sprocket wheel 6.

The sprocket wheel 6 is driven directly in rotation by the shaft 7 of a reversible hydraulic motor 8 (FIG. 2) suitably mounted on the frame 1. If desired, this motor may drive the sprocket wheel 6 through a speed reducer (not shown). The hydraulic motor 8 is supplied with fluid by a variable-flow fluid pump 9 fixed at the bottom of the cabinet 1 and driven in rotation by an explosion proof electric motor 10 of conventional type against deflagration and to which the pump is connected directly. The motor 8 may be of the type manufactured and sold under N°2000—10P by the French Company POCLAIN.

The flow of the variable-flow pump 9 is controlled by a control lever 11 actuated by a cylinder device 12.

These elements will be described in detail hereinafter with reference to FIG. 4.

The power of the pump, and consequently of the hydraulic and electric motors, is calculated in accordance with a minimum value corresponding to the arithmetic mean of the tensile forces transmitted by the chain during the rise and descent of the string of rods T.

These tensile forces are as follows (P being the weight of the string of rods):

when rising, the load F representing the weight of the rods, the weight of the column of liquid, the delivery force and frictions due to the guiding;

when descending, the load R<P which results from the weight of the rods minus the frictions due to the guiding.

The counterweight C has a weight P' which ensures a balance, for the rise and descent, of the forces applied to the pump and to the motors.

For the rising, the resisting force is (F-P'), whereas, for the descent, it is (P'-R) and, in order that these two forces be equal, it is sufficient to establish the arithmetic mean, thus: $P' = F + R/2$.

Thus, for example, if the string of rods T has a real weight P of 1,200 kilograms ignoring the frictional forces, its apparent weight when rising is only 800 kilograms. When rising, the force to be exerted, that is the load F mentioned hereinbefore, is 4,000 kilograms for example, so that the value of the counterweight is:

$$P' = F + R/2 = 4{,}000 + 800/2 = 2{,}400 \text{ kgs.}$$

It must be understood that these values are given only by way of example. They depend in particular on the situation on the site, the depth of the well etc.

The electric motor also drives a fluid cooling device **13***a* through which flows the hydraulic fluid employed before it is discharged to a main tank **13***b*.

The frame **1** comprises a control device **14** which will be described in detail hereinafter with reference to FIGS. **4**, **5A**, **5B**.

The variable-flow pump may be of any appropriate type —preferably controlled by a pivotal lever whose angle of inclination about its pivot point is directly proportional to the outlet flow. A type of pump which is particularly appropriate is that manufactured and sold under N° SPV 23 by the French Company SAUER. As can be seen in FIG. **5B**, the pivotal lever **11** can be moved between two extreme positions p_1 and p_2 which preferably correspond to maximum flow in one direction or the other with an intermediate neutral position in which the flow is zero (line p_0 in FIG. **5B**). Thus, when the lever is for example in position p_1, the pump **9** supplies the motor **8** in a given direction for example corresponding to the rising direction. When it is in the position p_2, the motor **8** rotates in the opposite direction and this corresponds to the descent of the rods T. Further, on each side of the line p_0 corresponding to zero flow, the flow and therefore the speed of the motor **8** is proportional to the angle α of the lever **11** with respect to the line p_0.

The control device shown in FIGS. **4**, **5A** and **5B** permits imparting to the lever **11** a periodic motion ensuring a regular reciprocating motion of the rods T. In the illustrated embodiment, the law of the pump is that shown in FIG. **6** in which the curve V indicates the speed of the rods T with a low speed or plateau v_1 of negative speed representing the descent, a transitory part v_2 corresponding to reverse motion, an upper step v_3 of positive speed representing the rise of the rods T and, lastly, a transitory part v_4 corresponding to reverse motion at the upper end of travel.

The curve G corresponds to the acceleration of the rods T in the course of one period whereas the curve P represents the pressure, the step or plateau p_1 indicating the static pressure in the motor supply pipes and p_2 indicating the sum of static pressure and dynamic pressure in the course of the motion.

Thus it can be seen that the reciprocating motion of the lifting machine corresponds to a sudden reversal of the speed at the upper and lower points and consequently to a sudden reversal of the position of the lever **11** at the moment of reversal of the direction of motion.

However, the reversal of the speed cannot be immediate at these moments owing to kinematic and hydraulic inertias of the mechanisms. This is why the speed curve passes during each period through two transitory periods (parts v_2 and v_4), the slopes of the curve being made as small as possible owing to the effect of the mechanism of the control device which will now be described.

As seen in FIG. **4**, the control device **14** is connected to the output shaft **7** of the hydraulic motor **8** through a transmission **15** which may be of any appropriate type but includes a chain in the illustrated embodiment. The chain transmission **15** drives with an alternating motion of rotation two control shafts **16***a* and **16***b* which are suitably supported in the frame **1**, the transmission ratio being such that they effect slightly less than one rotation for each half of a period of motion of the string of rods T. The shafts **16***a* and **16***b* are interconnected by gear wheels **17***a* and **17***b*. The shaft **16***a* is connected to an index **18** which is visible in front of the lifting machine (FIGS. **1** and **4**) so as to permit supervising the operating procedure. The index **18** moves in front of a scale **19**.

The shafts **16***a* and **16***b* are respectively provided with a trip mechanism **20***a* and **20***b* which cooperates with a lever **21** pivotable about a shaft **22** (FIG. **5A**).

The shaft **16***a* is integral with a plate **23***a* carrying at one end a bar **24***a* parallel to the shaft **16***a*. A lever **25***a* is pivoted to one end of the bar **24***a* and biased to a given position by a return spring **26***a*. The lever **25***a* carries a roller **27***a* which rolls permanently along the outer face of a cone **28***a* which is fixed to rotate with the shaft **16***a*. The cone **28***a* is axially movable relative to the shaft **16***a* under the action of an adjusting wheel **29***a* the purpose of which will be explained hereinafter. The roller **27***a* is urged permanently against the conical face under the action of the spring **26***a*. The end of the lever **25***a* opposed to the roller **27***a* carries a trip member **30***a* which is capable of acting on a roller **31** mounted on the free end of the lever **21**.

The mechanism **20***b* comprises the same parts as the mechanism **20***a* and these parts carry in FIG. **4** the same reference numerals completed by the letter "*b*."

Thus by acting on the wheels **29***a* and **29***b* of the mechanisms **20***a* and **20***b* it is possible to modify, with respect to the angular position of the associated shaft **16***a* or **16***b*, the respective instants of contact of the trip members **30***a* and **30***b* on the roller **31** of the lever **21**. This has for effect to modify either the "upper" point of the travel of the string of rods T or the "lower" point of this travel, it being possible to make these adjust-

ments independently and in the course of normal operation of the machine.

FIG. 5A shows that the shaft 22 is mounted to rotate in a box 32 which is fixed to the frame 1 and has two abutments 33*a* and 33*b* defining the maximum possible movement of the lever 21 and determining the positions in which it is struck by the trip members 30*a* and 30*b*.

The shaft 22 has roughly midway of its length two plates 34 to which is pivoted a resiliently yieldable device 35 which is moreover pivoted to a pin 36 mounted to be parallel to the shaft 22. The pin 36 is integral with two side plates 37 which are perpendicular to the shaft 22 and pivotably mounted in the box 32 by a shaft 38 with which they are integral. The assembly comprising the shaft 22, the pins 36 and 38, the plates 34, the resiliently yieldable device 35 and the side plates 37, constitutes a device having an over-center operation indicated by the general reference numeral 39.

The shaft 38 is integral with an arm 40 which actuates a spool valve 41 (FIG. 4) controlling the cylinder device 12 which is connected to the control lever 11 of the variable-flow pump 9. The valve 41 permits connecting the two faces of the piston (not shown) of the cylinder device 12 to the pressure of a booster pump 42, which may form part of the pump 9, or to the tank 13*b* through respective pipes 43 and 46. The pressure controlling the booster pump 42 is set or rated at a maximum value of 15 bars, for example, owing to the provision of a calibrated valve 47 inserted between the pressure pipe 46 and the tank 13*b* through a pipe 48. Note that for the purpose of simplifying the drawing, the illustrated hydraulic circuit is incomplete, the cooling device and the safety devices in particular having been omitted.

As can be seen in particular in FIG. 5B, the movements of the lever 11 are limited by a setting device 49 constituted by a support 50 defining a slideway 51. Two nuts 52 and 53 guided by the slideway 51 are movable on a rotary shaft 54 having means for receiving a crank and two screwthreads screwed in opposite directions. Rotation of the shaft simultaneously moves the nuts 52 and 53 toward each other or away from each other. Each nut carries a stop 55 against either of which the free end of the lever 11 is capable of bearing. The setting device 49 permits determining the frequency of the reciprocating motion of the string of rods T since it determines the flow positions and therefore the speed positions of the lever 11.

The machine operates in the following manner:

The trip members 30*a* and 30*b* in turn actuate the mechanical reverser constituted by the lever 21 and the over-centre or snap-action device 39. In a first stage, the trip member 30*a*, for example, comes in contact with the roller 31 and compresses the resiliently yieldable device 35 through the agency of the lever 21. When the instant of unstable equilibrium of this resiliently yieldable device is reached, the latter, which was up till then resistant, suddenly starts to exert a driving force and rapidly brings the lever 21 into its extreme position of abutment which causes the rapid displacement of the spool member of the spool valve 41.

As has been explained hereinbefore, the valve 41 actuates the cylinder device 12 which urges the lever 11 from the position p_2 to the position p_1 for example. Consequently, the motion of the series of rods T is reversed at the end of a period of time which is a function of the response time of the pump 9.

When the opposite dead centre position of the movement is reached, it is the trip member 30*b* which acts on the lever 21 and this reverses the action of the valve 41, and the cylinder device 12, and therefore shifts the lever 11 from the position p_1 to the position p_2.

Note that the quickness of the reversal of the reciprocating motion can be determined by a suitably calibrated timing jet (not shown) which may be provided in the servo-control of the variable-flow pump 9 itself.

FIG. 7 shows in respect of one half period of the reciprocating motion (rise or descent of the rods T), the shape of the curves of the power absorbed by the electric motor 10 which drives the pump 9, the curves c_1 and c_2 respectively corresponding to the utilisation of two different jets mentioned hereinbefore. The dotted line c_3 indicates the mean power required in both cases. As can be seen, a peak of power is required at the start of the half period (acceleration of the string of rods T).

Owing to the invention, the variations in the value of the load when rising and descending does not affect the law of the reciprocating motion which is, on the contrary, imposed by the regulation of the flow of the pump and of the quickness of the reversal, which quickness is determined by the jet provided in the pump. This advantage is made possible owing to the fact that there is employed a hydrostatic transmission or, in other words, a direct transmission of energy between the variable-flow pump and the hydraulic motor by fluid under pressure in a closed circuit.

This arrangement thus permits the construction of an extremely compact very small and very light lifting machine. Note that the string of rods T can be replaced by any load which must undergo a regular reciprocating motion.

In FIG. 8 there is shown another embodiment of a permanent reciprocating-motion lifting machine according to the invention. There is shown in particular the sprocket wheel 6 to which an alternating motion is imparted through the agency of a hydraulic motor 8, the chain sprocket wheel driving the moving equipment comprising a chain to which is attached a load and a counterweight, these elements of the machine not being shown. The assembly of this mechanism is mounted on a suitable frame.

As in the first embodiment, the hydraulic drive motor 8, which is preferably of the aforementioned type, is supplied with fluid by a variable-flow pump also preferably of the aforementioned type. This pump is controlled by a control device which is responsive to the instantaneous position of the load and driven for this pupose by a transmission 15 which connects the gear wheels 17*a* and 17*b* to the output of the hydraulic motor 8. The gear wheels 17*a* and 17*b* are mounted on shafts 16*a* and 16*b* which are coupled to trip mechanisms 20*a* and 20*b* which act alternately on a lever 21 which is part of the snap-action over-centre device 32 hereinbefore described in detail with reference to FIG. 4 and 5A.

This device 32 co-operates with transmission means including a spool valve 41 inserted in the hydraulic circuit of a booster pump 32 associated with the main pump 9 and supplying fluid to the auxiliary circuits of the latter.

The variable-flow pump **9** is regulated by a lever whose movement is governed by that of the load through transmission means which comprise in addition to the aforementioned valve **41** a mechanism which will now be described in detail.

The shafts **16***a* and **16***b* of the corresponding trip mechanisms **20***a*, **20***b* comprise extensions to which are keyed sprocket wheels **101***a*, **101***b* which drive through chains **102***a*, **102***b* or other suitable means sprocket wheels **103***a*, **103***b* mounted on shafts **104***a*, **104***b* respectively which are mounted in the frame (not shown) of the machine. These shafts are connected to rotate with cams **105***a* and **105***b* whose profiles are designed in accordance with the law of motion required to be imparted to the load which is reciprocated by the lifting machine.

In the illustrated embodiment, these cams are simple discs which are eccentric on their respective shafts. Each of the cams **105***a*, **105***b* have a well-defined function, that is to say, one of them (**105***a*) controls the descent of the load and the other (**105***b*) governs the rise of the load.

The cam **105***a* co-operates with a roller **106***a* freely rotatable in a fork **107***a* which is integral with a rod **108***a* coaxially fixed to a single-acting cylinder device **109***a*. The piston of the latter is mounted on an axially slidable rod **110***a*, the side of the piston which is not exposed to the pressure acting as a support for a return spring **111***a* which moreover bears against the end wall of the body of the cylinder device. The latter has, at its end opposed to the rod **108***a*, a radial shoulder **112***a* retaining an axially adjustable abutment member **113***a* constituted by a cylindrical body coaxial with the sliding rod. This abutment member **113***a* is provided with an internally screwthreaded cylindrical extension cooperating with a screwthreaded portion of the sliding rod **110***a*.

The position of the abutment member **113***a* can thus be axially adjusted relative to the cylinder device **109***a* and locked in the adjusted position by a nut **114***a*.

The end of the sliding rod **110***a* opposed to the cylinder device **109***a* is integral with a block **115** mounted in a slideway **116.** The latter is part of the control lever **117** which is integral with a shaft **118** of the pump **9.** The angular position of the lever **117** determines the flow of tne pump **9** in a proportional manner. The lever **117** is pivotable between two extreme positions corresponding to maximum positive flow and maximum negative flow respectively in passing through an intermediate position in which this flow is nil (see line X—X in FIG. **8**).

The block **115** is engaged on a screwthreaded control shaft **119** with which a wheel **120** is integral.

The fork **107***a* carrying the roller **106***a* is pivoted to the end of a lever **121***a* pivoted to the frame at **122***a*.

The lever **121***a* is biased constantly in such direction that the roller **106***a* always resiliently bears against the cam **105***a* by the action of a fork **123***a* and a spring **124***a* which bears against the frame of the machine. The fork **123***a* is pivoted to the lever **121***a* roughly midway of the length of the latter.

The cam **105***b*, which governs the law of the motion of the load when rising, is associated with an assembly identical to that just described with reference to the descent cam **105***a*, the reference numbers of the corresponding elements of the two assemblies carrying the letters "a" and "b" respectively.

The cylinder devices **109***a* and **109***b* are supplied with fluid by the spool valve **41** through suitable pipes, the valve **41** being controlled, as in the first embodiment, by the snap-action over-centre device **32** through the agency of the lever **40.**

The valve **41** is supplied with fluid by the booster pump **42** via pipes **45** and **46,** the pump drawing in fluid in the tank **13***b* and the fluid being returned to the latter by way of the pipe **46.**

When the machine operates, the cylinder devices **109***a* and **109***b* are alternately put under pressure by the valve **41** which is controlled by the trip mechanisms **20***a* and **20***b* as described hereinbefore with reference to FIGS. **1–7.** Thus each assembly consisting of the rod, cylinder device, sliding rod (**108***a*, **109***a*, **110***a* or **108***b*, **109***b*, **110***b*) is alternately rigid or extensible, according as the pressure is applied to, or not applied to, the cylinder device. When the cylinder device creates a rigid assembly, the corresponding cam acts directly on the control lever **117** of the pump **9** whereas the other cam cannot act on this lever, since the assembly including the other cylinder device has become telescopic, the extension being thereafter obtained owing to the action of the return spring **111***a* or **111***b* incorporated in each cylinder device.

Therefore, when the machine is in operation, the lever **117** swings to each side of a point of zero flow and the speed of this motion is strictly governed by the profile of the cams **105***a* and **105***b*. Consequently, in view of the fact that this profile can have any shape, the law of variation of the flow or output of the pump **9,** and consequently the speed of rotation of the output shaft of the motor **8,** may be predetermined as desired. There may even be provided a set of cams having different profiles so as to obtain several laws of motion with a single machine.

When the cams are in the form of simple eccentric discs as in the illustrated embodiment, the motion is sinusoidal.

The purpose of the adjustable abutments or stops **113***a* and **113***b* is to regulate precisely the length of the corresponding rods-cylinder device assembly when the cylinder device is under pressure. The regulation is such that the lever **117** can never remain stationary in the zero flow position (axis X—X) but that, in the uppermost and lowermost positions of the load, the lever **117** is slightly offset from the axis X—X at an angle α from the zero flow position. Thus this regulation determines the starting speed each time the motion of the load changes direction.

The wheel **120** associated with the control shaft **117** of the pump **9** regulates the frequency of the reciprocating motion since it acts on the block **115** and thus on the effective leverage of the lever **117.**

Note that the levers **121***a* and **121***b* have such length that said movements of rotation imparted to the rollers **106***a* and **106***b* about the pivot pins of these levers can be likened to movements of translation with a satisfactory approximation.

FIG. **9** is an electrical circuit diagram which constitutes a modification of the part of the control device of the machine shown in FIGS. **1–7** and in FIG. **8.** In this modification, the over-center device **32** and the transmission means are replaced by this electrical system which therefore affords electrically the connection be-

tween the spool valve 41 and the trip mechanisms 20*a* and 20*b*.

In this case, the trip members of these mechanisms act not on the lever 21 but on two suitably placed switches m_1 and m_2 so as to be actuated alternately by the trip members in the same way as the lever 21 in either of these two positions. The switch m_1 is normally closed whereas the switch m_2 is normally open. Their actuation by the trip members is instantaneous, that is to say, they immediately return to their normal position after their actuation by the trip members.

The valve 41 is, in this case, controlled electrically by means of the coil or solenoid 41*a* (FIG. 9) having a return spring.

The switches m_1 and m_2 are connected in the following manner:

The circuit shown in FIG. 9 is supplied with voltage by a source which is part of the machine. The switch m_1 is connected in series with the relay contact r_1 controlled by a coil or solenoid R to which this contact is connected through a manual descent pushbutton D. The switch m_2 is shunt connected to a manual rise pushbutton M and to a series connection of the contact r_1 and the switch m_1. The relay coil R is connected to the source of voltage.

Connected in series between the terminals of this source is a second relay contact r_2 controlled by the coil R and coil or solenoid 41*a* controlling the distributing valve 41. The latter acts on the control lever of the variable-flow pump either through the hydraulic means of the first embodiment or through the transmission means just described.

The switch m_1 and m_2 control the supply of voltage to the relay coil R. The contact r_1 is the self-supply contact of this relay and the contact r_2 controls the coil of the spool valve 41.

The pushbuttons M and D enable the initial adjustments to be made.

The system operates in the following manner:

At the end of the descent, for example, the trip member of one of the trip mechanisms acts on the switch m_2 and this supplies the relay R with voltage. The latter closes its contacts r_1 and r_2 and energizes the control coil 41*a* of the valve 41. The valve 41 is thus put into the "rise" position. As soon as the rising motion starts, the switch m_2 opens since it is no longer actuated by the corresponding trip member. However, the relay R remains energized by the action of the contact r_1 so that the valve 41 remains in the "rise" position.

At the end of the rise, the trip member co-operating with the switch m_1 opens the latter and de-energizes the relay R and thus opens the circuit of the control coil of the valve 41.

The valve 41 is thus put into the "descent" position by its return spring. When the descent motion starts, the switch m_1 is closed since it is no longer actuated by the corresponding trip member. However, the relay R remains de-energized because the contact r_1 remains open.

Note that the electrical circuit described hereinbefore does not permit stopping the machine. For this purpose, there is provided on the hydraulic circuit of the pump 9 and the motor 8 a by-pass valve which is closed when the machine is started. It will be understood that, in practice, this circuit is completed by indicator and safety means the design of which is within the knowledge of one skilled in the art.

Having now described our invention, what we claim as new and desire to secure by Letters Patent is:

1. A lifting machine for imparting a permanent reciprocating motion to a load between an extreme upper position and an extreme lower position, comprising a balancing counterweight, flexible connecting means for connecting the load to the counterweight, the load, the connecting means and the counterweight constituting an assembly, a fluid motor, drive means for drivingly connecting the fluid-motor to said assembly for imparting said motion to said assembly, a hydraulic variable-flow pump connected to the fluid motor for supplying actuating fluid to the fluid motor, and a control device associated with the pump for causing the pump to operate in accordance with a predetermined law by repeated reversals of the flow of actuating fluid delivered by the pump to the fluid motor, the pump comprising a movable regulating element whose position is proportional to the output flow of the pump and consequently to the speed of the fluid motor, the control device comprising actuating means connected to be driven by the drive means, and an over-center device connecting the actuating means to the regulating element, the actuating means being operative at said extreme upper position and said extreme lower position of the load, said actuating means comprising two shafts connected to be driven in rotation by the drive means and two trip means respectively connected to the two shafts to be driven by the two shafts, whereby the over-center device comprises a pivotal input lever pivotable between two extreme positions respectively corresponding to said extreme upper position and said extreme lower position of the load, the two trip means being respectively capable of coming in contact with the pivotal input lever in said two extreme positions of the pivotal input lever.

2. A lifting machine as claimed in claim 1, wherein the actuating means comprise adjusting means capable of independently adjusting said extreme upper position and extreme lower position of the load undergoing reciprocating motion, the shafts are parallel to each other and located on each side of the pivotal inlet lever which is pivotable in a plane perpendicular to the two shafts, the adjusting means comprise means for varying the positions of the trip means with respect to the shafts and consequently the positions in which the trip means come in contact with the pivotal inlet lever.

3. A lifting machine as claimed in claim 2, wherein each trip means comprises a second lever mounted on the corresponding shaft to be rotated by the corresponding shaft, the second lever being pivotable about an axis intermediate the ends of the second lever and parallel to the corresponding shaft, a roller rotatably mounted on one end of the second lever and a trip member mounted at the opposite end of the second lever and the means for varying the position of the trip means comprise for each shaft, means defining a frustoconical face which is coaxial with the corresponding shaft and prevented from rotating and axially movable, resiliently yieldable means for biasing the second lever to cause the roller to bear against the frustoconical face, and means for adjusting the position of the frustoconical face axially of the corresponding shaft so as to vary the distance of the trip member from the axis of the corresponding shaft.

4. A lifting machine for imparting a permanent reciprocating motion to a load between an extreme upper

position and an extreme lower position, comprising a balancing counterweight, flexible connecting means for connecting the load to the counterweight, the load, the connecting means and the counterweight constituting an assembly, a fluid motor, drive means for drivingly connecting the fluid-motor to said assembly for imparting said motion to said assembly, a hydraulic variable-flow pump connected to the fluid motor for supplying actuating fluid to the fluid motor, and a control device associated with the pump for causing the pump to operate in accordance with a predetermined law by repeated reversals of the flow of actuating fluid delivered by the pump to the fluid motor, the pump comprising a movable regulating element whose position is proportional to the output flow of the pump and consequently to the speed of the fluid motor, the control device comprising actuating means connected to be driven by the drive means, and an over-center device connecting the actuating means to the regulating element, the actuating means being operative at said extreme upper position and said extreme lower position of the load, said over-center device being connected to said regulating element through transmission means comprising at least two cam mechanisms whose movements are controlled by those of said actuating means, each of the cam mechanisms controlling one of the directions of flow of the fluid in the circuit of said pump by acting on said regulating element, each of said cam mechanisms comprising a cam which is rotatably mounted, a follower roller, and a telescopic connection connecting the roller to said regulating element, the telescopic connection being capable of being selectively rendered rigid as a function of the direction of motion of said load.

5. A lifting machine as claimed in claim **4,** wherein each telescopic connection comprises a cylinder device having a body and a rod which are respectively connected to said regulating element and said roller.

6. A lifting machine as claimed in claim **5,** comprising a spool valve connected to the cylinder device and controlled by said over-center device and adapted to put the cylinder device selectively under pressure in accordance with the position of said load in the course of its reciprocating motion.

7. A lifting machine as claimed in claim **6,** wherein said regulating element comprises a lever pivoted to the body of said pump and capable of pivoting between two extreme positions of maximum positive flow and maximum negative flow in passing through an intermediate position, a regulating mechanism connecting said rods of the cylinder devices to said lever whereby it is possible to modify the leverage of said lever.

8. A lifting machine as claimed in claim **6,** wherein each cylinder device comprises means for regulating its degree of extension so as to determine, upon each reversal of motion of said load, a given starting speed through the medium of said regulating element.

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