ABSTRACT OF THE DISCLOSURE

A pumping unit having a polished rod driven with vertical reciprocation by a pair of chains each having one end connected to a beam supporting the rod and an opposite end connected to a bolt which is driven along a closed path having ascending and descending portions by a pair of endless chains in turn driven in synchronism from a drive means through a speed reducer.

BRIEF SUMMARY OF THE INVENTION

The invention relates to a pumping unit for the mechanical drive of a bottom-hole pump in an oil well or the like. The pumping unit has a pumping rod string which is reciprocally driven with constant speed through substantially its entire length of stroke. The stroke of the string must be adjustable within wide limits.

Pumping units are known in which the driving system comprises two parallel closed chain transmissions, coupled by a bolt which carries a second closed wire rope transmission which in turn carries a secondary counterweight at one end performing a vertical reciprocating motion at the down-stroke, acting upon a main counterweight, fixed at the end of an open wire rope transmission pair which has, at its other end, the polished rod. This mechanism transforms the continuous motion of the closed chain transmission to a reciprocating motion of the polished rod.

This driving system has the disadvantage of requiring a great number of transmissions, of which the closed transmissions are subjected to supplementary perpendicular forces. Also, due to the reciprocating vertical motion of the counterweights, inertia forces are produced which overload the transmissions.

A pumping unit is also known which has a driving system consisting of a closed chain transmission and a flat counterweight, which during the down-stroke moves in a vertical guide, and during the upward stroke moves in an inclined guide, the guides being discontinuous at the extremities of the strokes. The ends of the wire ropes of two vertical open wire rope transmissions are fixed to the counterweight. At the other ends of the two wire rope transmissions, the polished rod is fixed, which thus is driven in reciprocal vertical motion.

This pumping unit type has the disadvantage that the counterweights are held by a lateral stop member and it cannot be used for medium and large loads on the polished rod and also, due to the discontinuous guides, at the stroke ends, shock forces are produced in the carrying chain, as the necessary power is not equal in both directions of the stroke.

The pumping unit according to the invention, overcomes these shortcomings by an arrangement which comprises a vertical assembly which supports two vertical closed chain transmissions, operating in two parallel planes, two open chain or wire rope transmissions, operating in two vertical planes, parallel to the first said transmission, and a speed reducing transmission, which has two outlet axles, on which are mounted the lower wheels of the two closed transmissions, which are driven thereby with continuous synchronous motion at uniform and equal velocities. The two closed transmissions define a free space between them, in which travels a horizontal coupling bolt which couples together the chains of the two closed transmissions. The connection between the bolt and the chains is achieved by means of spherical joints which allow relative axial displacement of the bolt. Each one of the ends of the open chain transmissions is secured to the bolt by similar spherical joints, whereas the other end, after passing over a pair of chain wheels, is connected to a horizontal beam, at the middle of which the pumping rod is suspended. Due to the constant speed of movement of the coupling bolt by the closed transmissions, a reciprocatory vertical motion is given to the chains of the open transmission and therefore to the horizontal beam and to the pumping rod connected thereto. The load on the rod is counterbalanced by a set of adjustable counterweights mounted on the coupling bolt, the weights being therefore moved with a constant speed together with the bolt. At the ends of the coupling bolt are mounted freely rotatable wheels which roll in a pair of continuous guides, consisting of inside and outside rails. The guides resist any components of forces acting on the coupling bolt which are inclined to the axis of the closed chain transmissions. Thus the loads on these chains are reduced.

Each of the two closed chain transmissions consists of an endless chain and two wheel chains with identical teeth layout on which the endless chain is mounted, the latter consisting of a plurality of segments of roller and link members of equal length, each connected by a pair of connection links having a larger pitch than that of the roller and link members. The connecting links are such that those two links have at one end sizes which correspond to those of the assembling of the roller and link members of the chains, and at the other end, i.e. where they assemble together, they have larger dimensions, so that they are assembled by a bushes (instead of a bolt as in a normal chain), the bushes being large enough to allow the introduction of a spherical bearing to support the bolt which couples the two closed transmissions together as a unit. The chain wheels have at least one pair of notches symmetrically placed at their periphery to receive the connection links as the chains and wheels are driven. This assures the correct mounting of the connecting links on the wheels, so that the axis of the bushes of the two links of each connecting link pair is received on the division cylinder of the wheels, when the pair of connection links passes on one of the wheels. On this division cylinder are to be found also the axes of the links of the bolts which constitute the members of the roller and link chain segments, when they are engaged in the wheels.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a perspective view diagrammatically showing the drive arrangement of a pumping unit;

FIG. 2 is a sectional view of the pumping unit taken along line A—A in FIG. 3, and broken in length;

FIG. 3 is a front view of the pumping unit, partly in section along line B—B in FIG. 2;

FIG. 4 is a sectional view along line C—C in FIG. 3; and

FIG. 5 is an enlarged detailed view of the assembly of the bolt with the transmission chains as seen in section along line D—D in FIG. 2.

DETAILED DESCRIPTION

The pumping unit, according to the invention, comprises a metallic slide 1 carrying an electric motor 2,
which drives a speed reducing transmission 3, the transmission elements of which are disposed in an arrangement of U shape as seen in FIGS. 1 and 4 and are provided with two inwardly directed outlet axles a which face one another in spaced relation so as to define a free space b therebetween. The drive connection between the electric motor and the speed reducer 3 is obtained by an elastic coupling 4, as shown in FIG. 4, or by a transmission with V-belts 5, as shown in FIG. 1. On the slide 1 are mounted two metallic vertical beam 6 connected at their upper end by a frame 7. The vertical beams 6 can be constructed in several parts, in order to accommodate variation of the stroke length of the piston rod by removal or addition of one or several parts. The assembling of the frame 7, the vertical beams 6, and the speed reducer 3 therebetween is made by screws, and the assembly of the vertical beams 6 and the speed reducing transmission includes two hinges 8 for each vertical beam. For rigidity, two counter-brace members 9 are respectively connected at one end with the vertical beams 6 and at the other end with the slide 1.

On each of the two outlet axles a of the speed reducing transmission 3, there is rigidly mounted a chain wheel 10, some of the teeth of which are removed, and in replacement thereof are notches c. Each wheel has two such notches disposed at 180°. On each of the vertical beams 6, at their upper end is mounted an axle 11 supporting a freely rotatable upper chain wheel 12. The wheel 12 has an identical tooth arrangement as that of the wheels 10. The chain wheels 10 and 12 for each vertical beam are mounted in the same vertical plane and have parallel axes. Each pair of chain wheels 10, 12, together with a closed or endless chain 13, constitute a drive transmission. The closed chain 13 comprises a plurality of roller and link chain parts 14, equal in length and connected together with a pair of connecting links having a bigger pitch than the links of the chain parts 14. Each connecting link comprises two inside link-plates 15, a bushing 16, two outside link-plates 17 and a bushing 18 with a locking device. The inside pair of link-plates 15 is assembled with the outside pair of link-plates 17 by the bushing 18, instead of a bolt as in parts 14. The length of each roller and link chain part 14 is such that the number of links thereof is equal to the number of teeth of the chain wheels between the two notches c, so that whenever a connecting link arrives at wheels 10 or 12, it will be inside a notch c.

The two closed chains are connected by a horizontal coupling bolt 19, which passes through the bushings 18 of the connecting links and is supported in these bushings by means of self-aligning ball bearings 20 or the like. At each of the ends of the coupling bolt 19 is freely mounted a rolling wheel 21, which can run on inside rails 22 or outside rails 23, the clearance between the rolling wheels 21 and the rails 22 and 23 being relatively small. The space between the inside rails 22 and the outside rails 23 has a symmetrical axis which is parallel to the axis of the closed chain and aligned therewith. The pairs of rails 22 and 23 are fixed to respective vertical beams 6, the straight portions of the rails being constituted of separate parts, so that, by removing or by adding separate parts, the rail lengths can be adjusted, according to the length of a stroke of the rod 37.

On the coupling bolt 19, two chains 26 are fixed, each by means of a bushing with ears 24 and a self-aligning ball bearing 25. Two pairs of chain wheels 27 are freely mounted on axles 28 and support chains 26 to form two open chain transmissions which operate in two vertical planes which are parallel to the planes in which the closed chain transmissions travel. The ball bearings 25 are fixed on the fastening of the bolt ends 29 and the chain wheels 27, as is seen in FIG. 2, are so placed that the vertical plane which contains the upper and the lower chain wheel axles 12 and 10, is tangent to the wheels 27 placed nearer to this plane. The open chains 26, at the end remote from the bolt 19, each have a coupling 32 with a stem with right-hand thread, on which an elongated nut 33 is threadably engaged and by which connection is made with eye bolts having a left-hand thread. The eye bolts are secured by bolts 35 to a beam 36, from which smooth, polished rod 37 is suspended. The elongated nut 33 is locked in the desired position by means of right-hand nuts 38 and left-hand nuts 39.

Mounted between the two open chains 26, on the coupling bolt 19, are several counterweights, each consisting of an upper counterweight 40 and a lower counterweight 41, coupled together by a pair of screws 42, nuts 43 and pins 44.

On the input axle of the speed reducing transmission 3, at the end opposite the input drive, is an electromagnetic brake 45.

The operation of the pumping unit is as follows:

According to the diagram in FIG. 1, the electric motor 2 drives the speed reducer 3 via V-belt transmission 5 (or clutch 4), whereby the lower chain wheel 10, mounted on the axles a of the transmission, are driven in synchronous rotation. Thereby, the closed chains 13 are driven together with the coupling bolt, which performs a continuation at constant speed and in fixed attitude relative to the axes of the closed chains 13. Thus, the coupling bolt travels along a closed circuit and in alternating ascending and descending paths. The motion of the coupling bolt 19 controls the motion of the open chains 26, to which a reciprocating motion is impressed. The chain under the wheels 27, which have their ends connected to the coupling bolt 19, undergo a reciprocating motion along the tangent of this chain portion with the respective wheels 27. The ends of the open chains 26, to which the beam 36 is connected, are driven with reciprocating vertical motion and the polished rod 37, suspended from the beam, will also have the same reciprocating vertical motion. The components of the forces, which act on the coupling bolt 19, which have a direction different from that tangent to the direction of the chain axis of the transmissions with closed chains, are transmitted to the vertical beams 6 by the rolling wheels 21, which are at the ends of the connecting bolt 19 and are accommodated in the space between inside rails 22 or outside rails 23, according to the direction of the strains, the loads on these chains thus being reduced to a minimum.

Due to the spherical couplings between the coupling bolt 19 and the closed chains 13 and the open chains 26, the coupling bolt 19 can be inclined to the horizontal, if the expansion of the two closed chains is not equal. For the same purpose, the ball bearings 20 and 25 are respectively mounted in the bushings 18 of the closed chains and in the ear-bushings 24 of the open chains to allow axial displacement of the ball bearings therein.

The adjusting of the position of the beam 36 to achieve horizontality thereof, in the event of a different elongation of the open chains 26, is achieved by rotating the elongated nuts 33. The number of double strokes per minute of the polished rod is adjusted by varying the speed of rotation of the lower wheels 10. If the electric motor 2 is coupled to the speed reducing transmission 3, via the elastic coupling 4, the stroke variation is obtained with the speed reducing transmission, which is provided with several speed steps. If the transmission of the drive from the electric motor 2 to the speed reducing transmission 3 is achieved by a V-belt drive, variation of the stroke rate is obtained by changing the belt wheel pairs.

The pumping unit is provide with the possibility of increasing the output of the closed chains 13. In the arrangement in which the vertical beams 6 are constituted of a plurality of separate parts, extension of the length is obtained by introducing an additional part.
In the arrangement in which the vertical beams 6 are single parts, the axles 11 are fixed upon a displaceable plate which can be fixed to the vertical beams 6. Elongation is achieved by displacing the plate on the vertical beams and fixing it by bolts and nuts at the corresponding position with the extended closed chains.

Variation of the length of stroke of the polished rod is achieved by reducing the distance between the axes of the lower chain wheels 10 and upper chain wheels 12. This is obtained by shortening the vertical beams 6, i.e. by removing one or more beam parts or, when the vertical beams are single parts, variation of the length of stroke is achieved by displacing the plate on which the axles 11 of the upper chain wheels 12 are fixed, along the vertical beams towards axles 10 and by fixing axles 11 at the position corresponding to the required stroke length. The difference between two strokes must be a non-fractional multiple of the length of two roller and link chain parts 14 plus the length of two connecting links, because if a correct matching between the closed chains 13 and the respective wheels 10 and 12 is desired, the shortening of the closed chain must be achieved by taking away two roller and link chain parts 14 and also two pairs of connecting links.

The pumping unit, according to the invention, has the following advantages:
- It insures obtaining a stroke length as large as necessary;
- It can be used for heavy loads on the polished rod;
- The necessary pumping power is very small and practically constant;
- The load of the carrying parts is very small.

What is claimed is:

1. A pumping unit comprising drive means, a first transmission driven by said drive means, said first transmission including a pair of endless chains disposed in parallel vertical planes and driven along a closed path having ascending and descending parallel portions, a bolt coupled to said chains for being driven thereon, along said closed path, a pair of spaced rails for each chain having a central axis therebetween which is parallel and aligned with the associated chain, wheels on the ends of said bolt rollably engaged between respective pairs of rails, a second transmission coupled to said support means for traveling therewith, said second transmission including a flexible elongated transmission element having one end secured to said support means and an opposite free end, rod means connected to said free end of the flexible elongated transmission element, and a counter-weight mounted on said bolt for travel therewith to counterbalance said rod means and cause the rod means to undergo vertical reciprocatory movement as the support means travels along said closed path.

2. A unit as claimed in claim 1, wherein said rails have upper and lower ends, said first transmission comprising a pair of sprocket wheels at said upper and lower ends of each pair of rails, each chain passing around a respective pair of sprocket wheels, and including a plurality of segments of equal length and connectors joining said segments, said sprocket wheels having notches therein, and including teeth between said notches in engagement with said chain, the length of said segments being related to the spacing between the notches to cause the connectors to enter the notches as the wheels and chains are driven.

3. A unit as claimed in claim 2, wherein said second transmission includes a second transmission element extending parallel to the first said element thereof, the latter elements having a first vertical portion extending from said support means and a second vertical portion secured to said rod means and spaced from said first vertical portion whereby as the bolt travels along its closed path, the transmission elements in said vertical portions undergo up and down reciprocatory movement.

4. A unit as claimed in claim 3, wherein said segments of said chains of the first transmission include connected roller and link parts, and said connectors each comprises link plates and a bushing connected together, said bushing being adapted to receive said bolt, said link plates being connected with a link part of a segment.

5. A unit as claimed in claim 4 comprising self-aligning spherical bearings between said bushing and said bolt permitting relative axial movement of said bolt and connector.

6. A unit as claimed in claim 5 comprising self-aligning spherical bearings between said bolt and said chains of the second transmission permitting relative axial movement of said bolt and the latter chains.

7. A unit as claimed in claim 3, wherein said second transmission includes two pairs of sprocket wheels on which the transmission elements successively pass, said pairs of sprocket wheels being in horizontally spaced relation, the wheels of the first pair on which the transmission elements pass being disposed so that a vertical line passing through the centers of a pair of sprocket wheels of the first transmission is tangential to the wheels of said first pair.

8. A unit as claimed in claim 1 comprising a speed reducing transmission between said drive means and said first transmission.

9. A unit as claimed in claim 8, wherein said speed reducing transmission includes a pair of outlet shafts respectively coupled to said endless chains to drive the same in synchronism.

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