Jan. 25, 1966 P. D. HARRYMAN ET AL 3,230,782

PUMPING UNIT

Filed Nov. 19, 1963 4 Sheets-Sheet 1

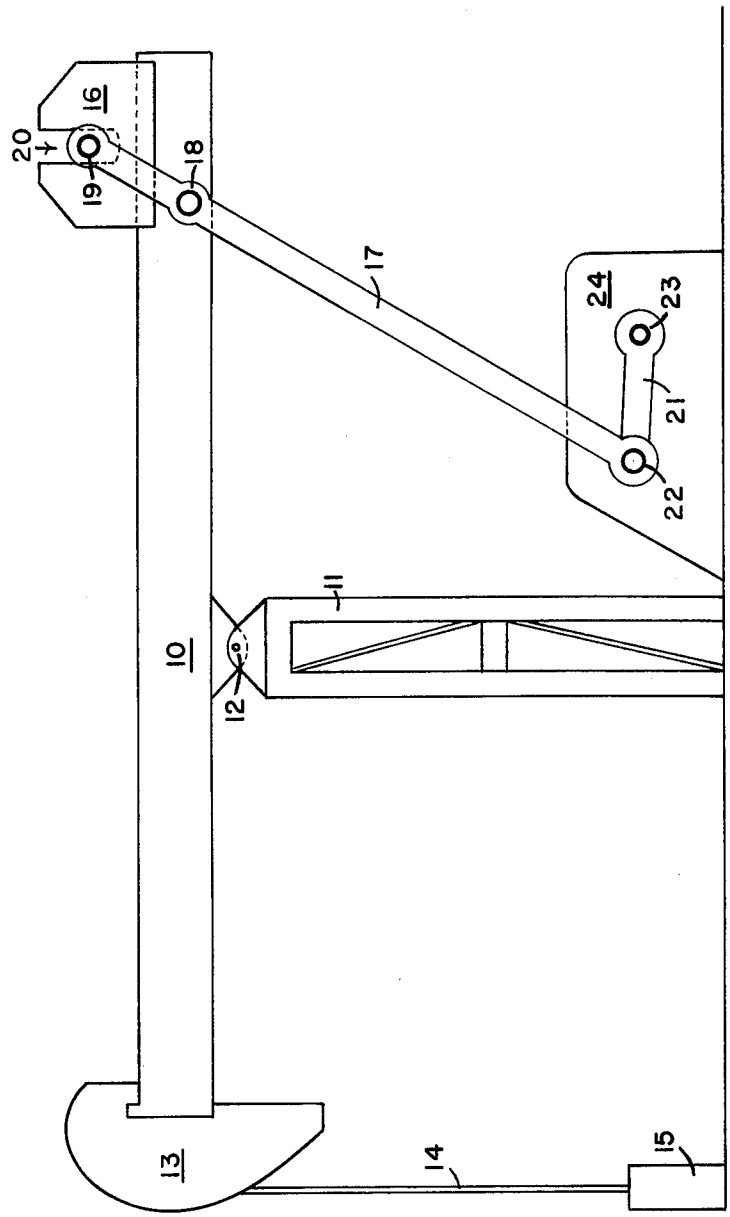

FIG. 1

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Filed Nov. 19, 1963 4 Sheets-Sheet 2

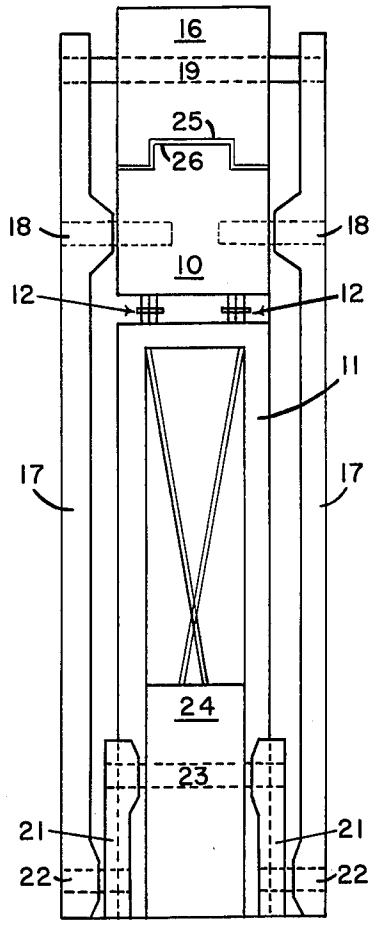

FIG. 2

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Filed Nov. 19, 1963 4 Sheets-Sheet 3

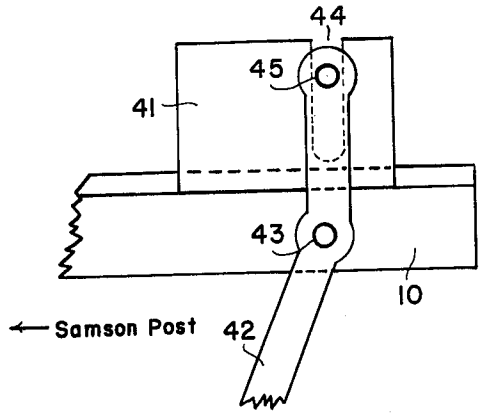

FIG. 3

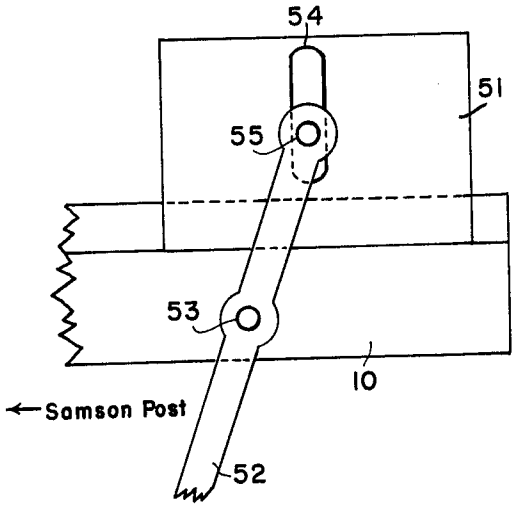

FIG. 4a

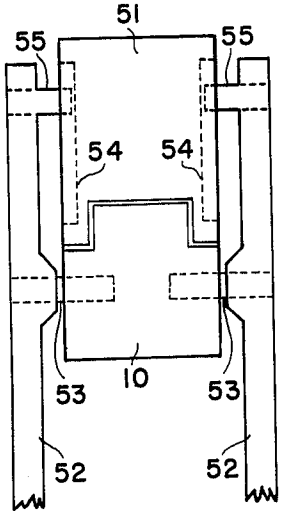

FIG. 4b

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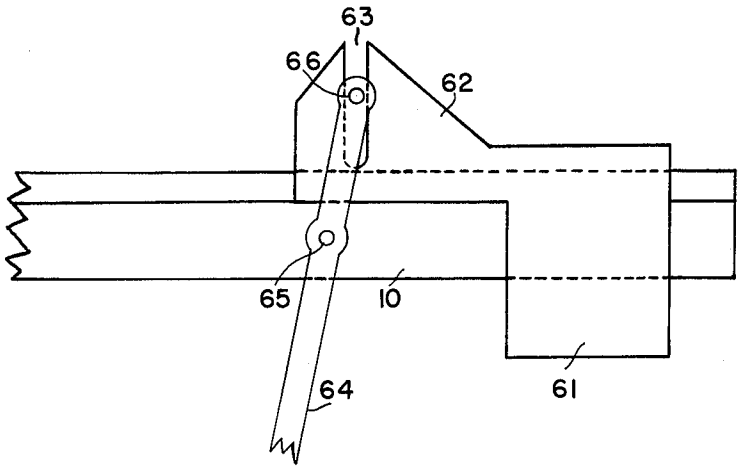

FIG. 5a

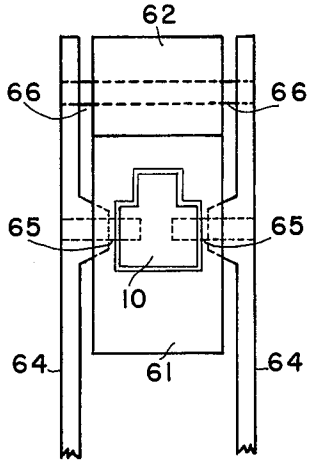

FIG. 5b

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3,230,782

PUMPING UNIT

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Filed Nov. 19, 1963, Ser. No. 324,713
5 Claims. (Cl. 74—41)

The present invention relates to the pumping of liquids to the earth's surface from subterranean liquid-bearing formations. More particularly the present invention relates to a pumping unit for pumping liquids to the earth's surface from subterranean liquid-bearing formations.

Various types of artificial lifts are used to bring liquids to the surface of the earth when the pressure of the liquid-bearing reservoir is insufficient to produce the liquids by natural means. The most common type of artificial lift is one comprising a downhole rod pump reciprocably driven through a sucker rod string by a pumping jack located at the earth's surface. Most often the pumping jack consists of a walking beam pivotally affixed to a Samson Post and connected at one end to the sucker rod string and at the other end to a prime mover which supplies the energy for producing the reciprocating motion of the sucker rod string. Generally, the prime mover consists of an internal combustion engine or electric motor. The cost of this prime mover as well as its operation and maintenance is, in many instances, a significant factor in the economics of producing liquids from subterranean liquid bearing reservoirs. For this reason it is desirable to find methods of operating pumping units and also new and improved pumping units which may be operated with less expensive prime movers and at less operating and maintenance expense.

It is an object of the present invention to provide a pumping unit of new and novel design. Another object of the present invention is to provide a new and novel pumping unit for bringing liquids to the earth's surface from subterranean liquid-bearing resenvoirs. Yet another object of the present invention is to provide a new and novel pumping unit for pumping liquids from subterranean formations with a more efficient utilization of the energy used to drive the pumping means. Additional objects will become apparent from the following description of the invention herein disclosed.

The pumping unit which fulfills these and other objects comprises a vertically disposed supporting member having pivotally attached thereto a substantially horizontally disposed walking beam having at one end a means for attaching a sucker rod string and at the opposite end a slidably connected movable counterbalance weight, a substantially vertically disposed lever slidably engaged in a substantially vertical direction at its upper end with said movable counterbalance weight and rotatably attached at its lower end to a revolving axis through which power is applied and rotatably attached at a mid point of said lever to said walking beam such that as said lower end of said lever is caused to traverse the circle described by said revolving axis, said lever revolves on said mid point of attachment to said walking beam thereby imparting vertical movement to the walking beam and imparting to the opposite upper end of said lever a curved movement, the horizontal component of said movement being opposite in direction to that of the lower end, causing said movable counterbalance weight to move in a direction parallel to the surface of said walking beam in a direction opposite to the direction of the horizontal component of the movement of the lower end of said lever.

The present invention provides two very distinct advantages when compared with conventional pumping units employing fixed counterbalance weights. The peak torque is significantly reduced by the present pumping unit as is the work required in a particular situation. When the novel pumping unit of the present invention is compared with one having a fixed counterbalance weight of substantially the same weight, the peak torque on the gears of the pumping unit will be 5 to 8 percent lower with the present invention. The work required to complete one stroke of a pumping unit such as taught and claimed herein is found to be 6 to 9 percent less than for a similar unit counterbalanced with a conventional fixed beam counterbalance of substantially the same weight.

In order to more fully explain and to illustrate the present invention and its several embodiments, reference is made to the accompanying diagrammatic drawings of different views and embodiments of the present invention.

FIGURE 1 is an elevational view of a surface pumping apparatus and FIGURE 2 is an elevational view of the surface pumping apparatus of FIGURE 1 as viewed from the end.

FIGURES 3, 4, and 5 are drawings of other embodiments of the present invention.

Referring first to FIGURE 1, walking bear **10** is pivotally attached to a vertical support member **11**, hereinafter referred to as a Samson Post, so as to pivot on center bearing **12**. At the front end of walking beam **10** is shown horsehead **13** connected thereto. To the horsehead **13** is attached a rod string **14** which extends into wellhead **15** and downhole to the reciprocating subsurface pump (not shown). At the other end of walking beam **10**, a counterbalancing weight **16** is slidably attached thereto. This counterbalancing weight is attached to walking beam **10** in a manner to facilitate longitudinal movement along the surface of the walking beam. The actual method of slidably attaching the counterbalance weight to the walking beam is well within the ability of those skilled in the art. A particularly useful method of attachment is illustrated in FIGURE 2 hereinafter described. A substantially vertically disposed lever **17**, hereinafter referred to as a pitman arm, is rotatably attached to walking beam **10** so as to rotate on tail bearing **18**. At its upper end, pitman arm **17** slidably engages counterbalance weight **16** by means of a connecting bar **19** attached perpendicularly to the pitman arm. Counterbalance weight **16** contains a vertical slot **20** laterally disposed for receiving connecting bar **19**. The lower end of pitman arm **17** is rotatably connected to lever arm **21**, hereinafter referred to as a crank, by means of pitman bearing **22**. Crank **21** is then connected to a power source **24** by means of a crankshaft **23**. In the operation of the present invention the power source **24**, which may be a gasoline engine, electric motor or the like, supplies rotational energy to crankshaft **23**, which rotates crank **21** on an axis described by crankshaft **23**. The rotation of crank **21** rotates pitman arm **17** on pitman bearing **22** while revolving the axis described by the center of pitman bearing **22** in a circle around an axis represented by crankshaft **23**. The circular movement of the base of pitman arm **17** around the axis of crankshaft **23** produces a reciprocating vertical movement in pitman arm **17** which is imparted to walking bear **10** through tail bearing **18**. This reciprocating motion pivotally rotates walking beam **10** on centerbearing **12** thereby producing a reciprocal vertical movement in rod string **14**, thereby activating the reciprocating pump down in the wellhole. As the base of pitman arm **17** revolves around the axis of crankshaft **23**, the upper end of pitman arm **17** and connecting bar **19** attached thereto move in a curved path, the horizontal component of which movement is in a direction opposite to that of the pitman arm base. As

connecting bar **19** moves it engages the sides of slot **20** causing counterbalance weight **16** to move along the longitudinal surface of walking beam **10** in the direction of the horizontal component of the movement of connecting bar **19**. Thus, as the base of pitman arm **17** revolves around crankshaft **23**, so as to produce a downward vertical movement, or downstroke of pitman arm **17** and the rear of walking beam **10** and to produce an upward vertical movement in rod string **14**, the weight of counterbalance **16** is caused to shift further to the rear of walking beam **10** thereby decreasing the power needed to drive crankshaft **23** through the downstroke. Conversely, as the base of pitman arm **17** revolves past the downstroke movement and into the upstroke movement of pitman arm **17**, the counterbalance weight **16** is caused to shift forward thereby reducing the power needed to drive crankshaft **23** through the upstroke. Therefore, as previously stated, the present invention significantly reduces the size of the power source needed as well as the cost of operating and maintaining the power source.

Referring now to FIGURE 2, in which the same reference characters are used to identify the corresponding elements in FIGURE 1, walking beam **10** is shown pivotally attached to Samson Post **11** by means of center bearings **12**. Counterbalance **16** is slidably attached to walking beam **10** by means of slot **25** in the under surface of counterbalance weight **16** and raised guide or track **26**. Raised guide **26** is shown on the upper surface of walking beam **10** with receiving slot **25** being shown within counterbalance weight **16**. The position of raised guide **26** and slot **25** can, if desired, be reversed with raised guide **26** being on the under surface of counterbalance weight **16** and receiving slot **25** being on the upper surface of walking beam **10**. The sliding contact of the adjacent surfaces of counterbalance weight **16** and walking beam **10** may be facilitated by the use of lubricants, roller bearings or other friction reducing means well within the ability of those skilled in the art. Two pitman arms **17** are shown in FIGURE 2 attached to the sides of walking beam **10** by means of tail bearings **18**. The upper ends of pitman arms **17** are connected by connecting bar **19** which is positioned in laterally disposed vertical slot **20** in counterbalance weight **16**. The lower ends of pitman arms **17** are connected by means of pitman bearings **22** to cranks **21** which are connected to a common crankshaft **23** which is driven by a power source **24**.

FIGURE 3 is another embodiment of this invention and shows an elevational view of a portion of the walking beam to which the counterbalance weight is attached. In this embodiment the pitman arm is curved or bent at its upper end such that the axis of connecting bar **45** does not intersect the major axis of pitman arm **42**. In FIGURE 3, counterbalance weight **41** is slidably attached to walking beam **10** to which is rotatably attached pitman arm **42**, at tail bearing **43**. The upper end of pitman arm **42** is shown bent toward the point of attachment of walking beam **10** to the Samson Post. It is within the scope of the present invention that the pitman arm may be curved at its upper end either toward or away from the point of attachment of walking beam **10** to the Samson Post according to the circumstances of the particular application of the present invention. Pitman arm **42** is shown to be slidably engaged with counterbalance weight **41** by means of connecting bar **45** and vertical slot **44**.

FIGURES 4A and 4B illustrate another embodiment of the present invention. FIGURE 4A shows an elevational view of a portion of the walking beam to which the counterbalance is attached and FIGURE 4B shows an end elevational view of the portion of the walking beam shown in FIGURE 4A. In this embodiment, vertically disposed grooves in the sides of the counterbalance weight are used rather than the laterally arranged vertical slot shown in FIGURES 1 and 3. In FIGURES 4A and 4B, counterbalance weight **51** is shown slidably attached to walking beam **50** which is rotatably affixed by means of tail bearings **53** to pitman arm **52**. At the upper end of pitman arm **52** a short bar **55** extends perpendicular to the pitman arm into groove **54** where it engages counterbalance weight **51**. To facilitate movement of short bar **55** in groove **54** a sliding shoe may be rotatably attached to the end of short bar **55** to slide in groove **54**.

FIGURES 5A and 5B show another embodiment of the present invention. In the invention as depicted by this figure, the counterbalance weight is both above and below the walking beam with the walking beam passing through the counterbalance weight. FIGURE 5A is an elevational view of a portion of the walking beam to which the counterbalance is attached and FIGURE 5B is an end elevational view of the portion of the walking beam shown in FIGURE 5A. To walking beam **10** is slidably attached counterbalance weight comprising upper weight **61** and lower weight **62**. Pitman arm **64** is rotatably attached to walking beam **60** by tail bearing **65**. At its upper end pitman arm **64** has attached thereto connecting bar **66** which slidably engages the laterally disposed vertical slot **63** in the upper portion of counterbalance weight **62**.

In addition to the embodiments shown by the accompanying drawings, it will be immediately apparent to those skilled in the art that many other embodiments exist. Such variations, so long as they provide for a movable counterbalance weight slidably attached to the walking beam which is caused by the pitman arm to move toward the Samson Post on the upstroke of the pitman arm and away from the Samson Post on the downstroke of the pitman arm are within the spirit and scope of the present invention.

What is claimed is:

1. In the pumping of liquid from subterranean liquid-bearing formations with pumping units comprising a subsurface reciprocating rod string pump, a sucker rod string for reciprocating said rod string pump, a walking beam pivotally attached to a vertical support and attached at one end to said sucker rod string and at the other end to a pitman for supplying pivotal motion to said walking beam, said pitman being attached to a power means, the improvement which comprises a movable counterbalance weight slidably attached to said walking beam on the end of said walking beam to which said pitman is attached, said pitman being slidably connected at one end thereof to said movable counterbalance weight, rotatably connected intermediate its ends to said walking beam and rotatably connected at its other end to a rotatable crank arm on said power means.

2. In the pumping of liquid from subterranean liquid-bearing formations with pumping units comprising a subsurface reciprocating rod string pump, a sucker rod string for reciprocating said rod string pump, a walking beam pivotally attached to a vertical support and attached at one end to said sucker rod string and at the other end to a pitman for supplying pivotal motion to said walking beam, said pitman being attached to a power means, the improvement which comprises a movable counterbalance weight slidably attached to said walking beam on the end of said walking beam to which said pitman is attached, said pitman being slidably connected at one end thereof to said movable counterbalance weight at a point directly above the point of attachment of said pitman to said walking beam when said pitman is in a vertical position, said pitman being rotatably connected intermediate its ends to said walking beam and rotatably connected at its other end to a rotatable crank arm on said power means.

3. In the pumping of liquid from subterranean liquid-bearing formations with pumping units comprising a subsurface reciprocating rod string pump, a sucker rod string for reciprocating said rod string pump, a walking beam pivotally attached to a vertical support and attached at one end to said sucker rod string and at the other end to a pitman for supplying pivotal motion to said walking

beam, said pitman being attached to a power means, the improvement which comprises a movable counterbalance weight slidably attached to said walking beam on the end of said walking beam to which said pitman is attached, said pitman being slidably connected by means of a substantially horizontal connecting bar at one end thereof to said movable counterbalance weight, said pitman being rotatably connected intermediate its ends to said walking beam and rotatably connected at its other end to a rotatable crank arm on said power means, said pitman being bent at its upper end such that the horizontal axis of said connecting bar does not intersect the longitudinal axis of that portion of the pitman connecting said crank arm to said walking beam.

4. In the pumping of liquid from subterranean liquid-bearing formations with pumping units comprising a subsurface reciprocating rod string pump, a sucker rod string for reciprocating said rod string pump, a walking beam pivotally attached to a vertical support and attached at one end to said sucker rod string and at the other end to a pitman for supplying pivotal motion to said walking beam, said pitman being attached to a power means, the improvement which comprises a movable counterbalance weight slidably attached to said walking beam on the end of said walking beam to which said pitman is attached, said pitman being slidably engaged at one of its ends with said movable counterbalance weight by means of a connecting bar positioned such as to be perpendicular to said pitman, which connecting bar engages said counterbalance weight in a laterally disposed vertical slot in said counterbalance weight, said pitman being rotatably

connected intermediate its ends to said walking beam and rotatably connected at its other end to a rotatable crank arm on said power means.

5. In the pumping of liquid from subterranean liquid-bearing formations with pumping units comprising a subsurface reciprocating rod string pump, a sucker rod string for reciprocating said rod string pump, a walking beam pivotally attached to a vertical support and attached at one end to said sucker rod string and at the other end to a pitman for supplying pivotal motion to said walking beam, said pitman being attached to a power means, the improvement which comprises a movable counterbalance weight slidably attached to said walking beam on the end of said walking beam to which said pitman is attached, said pitman being slidably engaged at one of its ends with said movable counterbalance weight by means of a bar perpendicularly attached to said pitman and slidably engaged with a vertically disposed groove in said counterbalance weight, said pitman being rotatably connected intermediate its ends to said walking beam and rotatably connected at its other end to a rotatable crank arm on said power means.

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