Oct. 23, 1945. T. O. DAVIDSON ET AL 2,387,245

SPOOLING DEVICE

Filed July 12, 1943 3 Sheets-Sheet 1

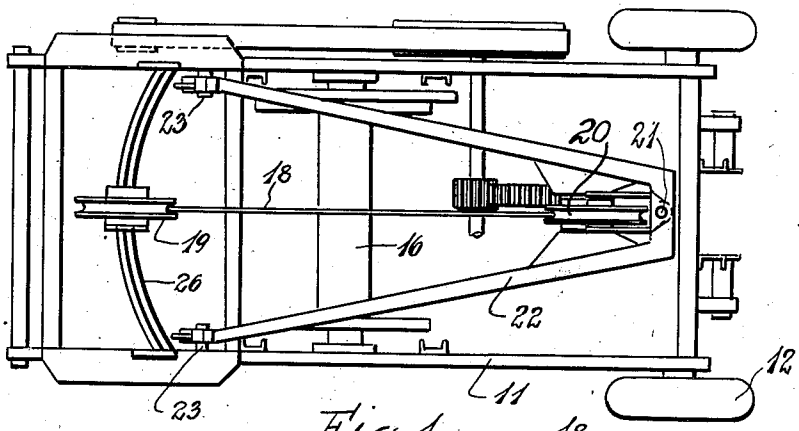


Fig. 1.

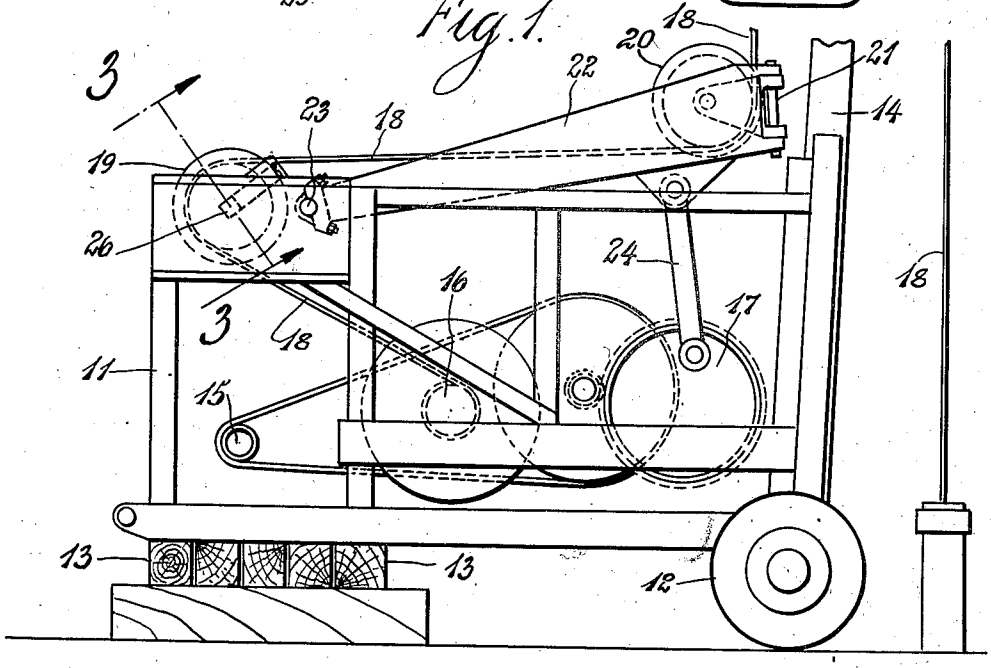


Fig. 2.

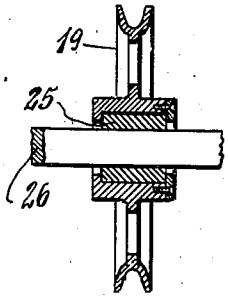


Fig. 3.

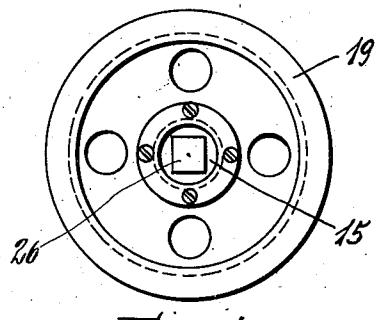


Fig. 4.

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SPOOLING DEVICE

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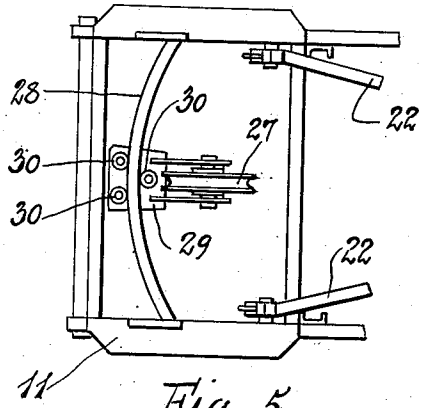


Fig. 5.

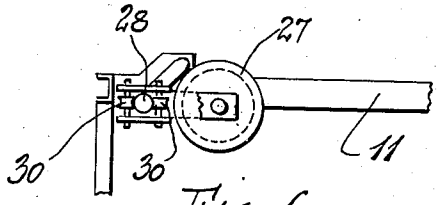


Fig. 6.

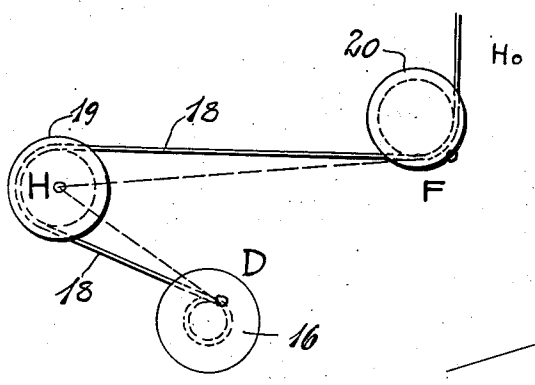


Fig. 7.

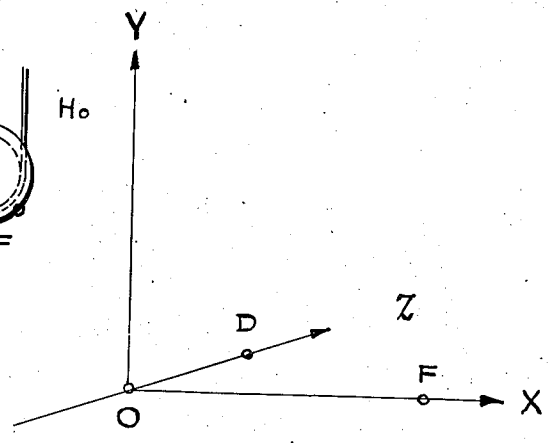


Fig. 8.

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SPOOLING DEVICE

Filed July 12, 1943 3 Sheets-Sheet 3

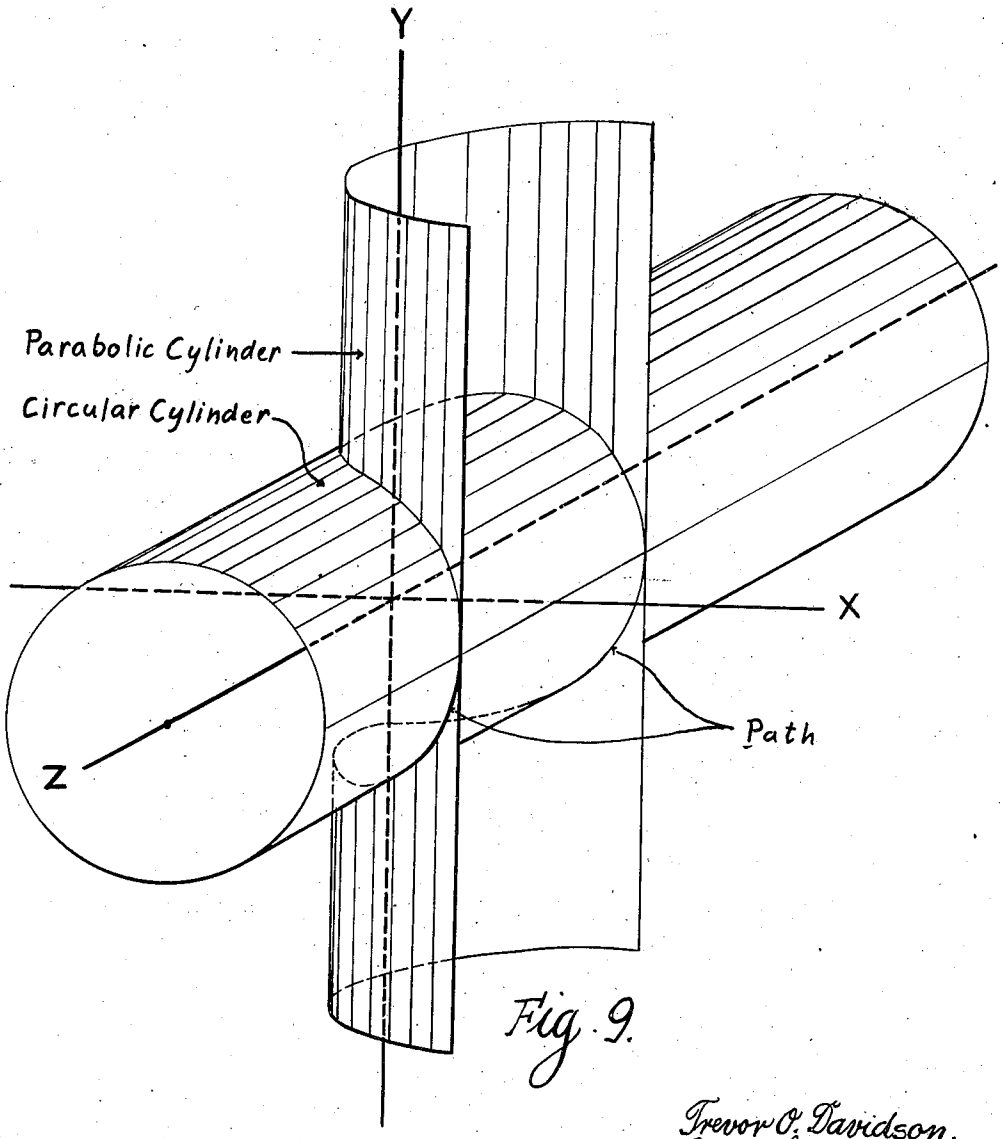


Fig. 9.

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Patented Oct. 23, 1945 2,387,245

UNITED STATES PATENT OFFICE

2,387,245

SPOOLING DEVICE

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Application July 12, 1943, Serial No. 494,280

11 Claims. (Cl. 254—190)

Our invention relates to new and useful improvements in spooling devices, primarily but not necessarily for cable-tool drills.

Such drills, per se, are well known.

In such drills a rope passes, from a winch drum on the main frame, around a heel sheave at or near the pivot of a spudding beam, thence under a sheave at the oscillating end of the spudding beam, thence over a sheave at the upper end of a mast and thence vertically downward into the hole which is being drilled in the ground. At the lower end of this rope is a string of percussion drilling-tools. The spudding beam is oscillated by a pitman, actuated by a rotating crank.

As the rope is payed out to lower the tools as the hole grows deeper, or is taken in to withdraw the tools for any reason, it is desirable that the reach of rope from the winch-drum to the heel sheave shall move from side to side, always in a plane perpendicular to the axis of the drum, spooling the lays of the rope evenly off of or onto the drum; and that the heel sheave shall move from side to side and change its orientation, so as always to lie substantially in the plane defined by the two reaches of rope which run from this sheave.

Accordingly it is the principal object of our invention to devise a mounting for the heel sheave, such that the heel sheave will automatically thus move and thus orient itself, under the influence merely of the tension in these two reaches of rope.

In addition to our principal object, above stated, we have worked out a number of novel and useful details, which will be readily evident as the description progresses.

Our invention consists in the novel parts and in the combination and arrangement thereof, which are defined in the appended claims, and of which two embodiments are exemplified in the accompanying drawings, which are hereinafter particularly described and explained.

Throughout the description, the same reference number is applied to the same member or to similar members.

Figure 1 is a plan view of a drill embodying our invention.

Figure 2 is a side elevation of the same drill.

In these two figures, the associated parts of the drill have been shown very schematically, and much of the drill (well known to the art) has been omitted.

Figure 3 is a slightly enlarged vertical section of the heel sheave, taken along the lines 3—3 of Figure 2.

Figure 4 is a side elevation of that sheave, to the same scale as Figure 3.

Figure 5 is a plan view of part of a drill embodying a second variant of our invention. The rest of the drill is the same as in Figure 1.

Figure 6 is a side elevation of the heel sheave and associated parts of Figure 5.

Figure 7 is a diagram to indicate the geometrical basis for the mathematical analysis of the problem involved in our invention.

Figure 8 illustrates the coordinate system involved in that mathematical analysis.

Figure 9 illustrates the geometrical intersection of the two surface equations involved in my invention.

Referring now to Figures 1 and 2, we see that 11 is the main frame of a drill, supported by wheels 12, and during drilling by blocks 13.

The frame 11 supports a mast 14 (called "derrick" in the art), a motor (not shown) the pulley of which is designated as 15, a winch 16, a spudding gear 17, and associated driving connections, not numbered.

From the winch 16, a rope 18 runs around a heel sheave 19, thence under a spudding-sheave 20, thence over a sheave (not shown) at the top of the derrick 14, thence down to the drilling tools (not shown).

The spudding gear 17 is clutched to and unclutched from a driving connection with the motor 15, by means of a clutch (not shown).

The spudding-sheave 20 is mounted (preferably by means of an offset substantially vertical pivot 21, preferably approximately in line with the upper reach of rope 18) on the free end of a spudding-beam 22, which in turn is pivoted on horizontal pivots 23 on the frame 11.

The spudding-beam is rocked up and down by the rotation of the spudding gear 17, acting through pitman 24.

The winch 16 is controlled by means of a conventional drive, clutch, brake, and hand-levers (not shown).

The operation of all these conventional parts will be readily understood.

Heel sheave 19 is journaled for free rotation on a cylindrical bushing 25, which in turn is cored to slide freely, without turning, on bar 26, which extends transversely from one side of the drill to the other.

To prevent the bushing 25 from turning on the bar 26, the bushing must be keyed to the bar in some manner. As shown in Figures 3 and 4, this keying is accomplished by making square in cross-section both the rod and the hole in the bushing,

but other equivalent keyings could be substituted. In order to prevent the bushing from wobbling on the bar, both the bar and the hole in the bushing are curved in a circular arc. This curvature approaches sufficiently closely to the optimum curvature (to be hereinafter discussed) so as to be practically indistinguishable therefrom. The proper orientation of the plane defined by the curved bar will also be discussed hereinafter, but considerable departure therefrom is permissible.

The second variant of our invention is shown in Figures 5 and 6, in which heel sheave **27** takes the place of heel sheave **19**; and bar **28** (preferably now of circular cross-section) takes the place of bar **26**; and carriage **29** takes the place of bushing **25**. Carriage **29** is held to slide on bar **28**, without wobbling, by means of rollers **30**.

In this variant, bar **28** can have exactly the optimum curvature, namely that defined by the equations hereinafter set forth, rather than a plan circular arc; though here again the circular arc would be quite satisfactory for all practical purposes.

Turning now to Figure 7, we see a representation of winch-drum **16**, rope **18**, heel sheave **19**, and spudding sheave **20**. Mathematically, it is convenient to deal in points. Accordingly point H (which takes the place of the heel sheave **19**) is the floating center of that sheave. We shall use the term "mean surface of the winch" to designate the cylindrical surface of the rope on the winch when the winch is half filled. Point D (which takes the place of winch **16**) is a point moving along an element of the mean surface of the winch, which element is defined by the line of tangency of a plane through point H (when that point is in its mid position to that mean surface. Roughly it is the topmost element of the mean surface of the winch; although, if the winch were wound in a direction opposite to that shown, it would be roughly the bottommost element. Point F (which takes the place of spudding sheave **20**) is roughly the intersection of the extensions of those two reaches of rope **18** which are adjacent to sheave **20**.

It is obvious from Figure 7 that point D could be conceived of as sliding along another line parallel to the axis of the drum, and that points H and F could be conceived of as located at other places near their respective sheaves, than the line and the points chosen, without introducing any error much more appreciable than that involved in our original selection of this line and these points to define the broken line DHF. None of the approximations, utilized later herein, introduce even so much error as this. Accordingly we may, in the claims, call the line along which D moves broadly the drum, rather than any particular line on the drum; and the point F the spudding sheave, rather than any particular point thereon; and the point H the floating sheave, rather than the center thereof.

Turning now to Figure 8, the Z-axis is the line defined by the movement of point D. The origin, O, is the mid-point of that line. The X-axis extends from the origin through point F. The Y-axis extends, perpendicular to the other two axes, in the general direction of point H, the coordinates (x, y, z) of which determine the equations of optimum curvature and orientation of the rod **26**.

For convenience, we shall call the distance from the drum to the spudding sheave: r. And the width of the drum: $2a$.

Then the coordinates of extreme position of D, shown in Figure 8, are: O, O, a. The coordinates of the mid point of H we shall call: x_0, y_0, O. The coordinates of F, which is fixed are: r, O, O.

It can be mathematically demonstrated that the optimum path for the moving point H is the intersection of the following two surfaces.

1. A circular cylinder, the axis of which is the Z-axis:

$$x^2+y^2=x_0^2+y_0^2$$

2. A parabolic cylinder, symmetrical with respect to the X-axis, and having its generating lines perpendicular to the XZ plane.

$$z^2=2r(x-x_0)$$

Turning to Figure 9, we see these two cylinders graphically illustrated. This figure is merely illustrative, and does not purport to be proportioned exactly in accordance with the specific value of the constants in the other figures.

The circular cylinder, the parabolic cylinder, and the path defined by their intersection, are all labeled in words on the figure. The three coordinate axes are also shown.

That part of the path which is utilized in our invention is a very small and substantially flat portion of the upper left-hand reach thereof.

It can be mathematically demonstrated that the path of intersection is perpendicular to both HD and HF (see Figure 7). Hence a sheave **19** constrained so that its hub exactly follows this path would lie exactly in the plane of the two adjacent reaches of rope **18**; and a sheave constrained so that its hub follows substantially this path would lie substantially in that plane.

This path, within the range of actual travel of heel sheave **19**, very closely approximates a plane parabola. The approximate location of the plane of this curve is determined as secant to the above defined circular cylinder, and as passing through that element (in the mathematical sense) of this cylinder which contains the mid location of the point H, and also as passing through an element of the cylinder lying two-thirds of the way along the surface of the cylinder from the first mentioned element to that element which contains the two extreme positions of the point H. Such plane may be roughly described as being substantially perpendicular to a mean line DH.

The above-mentioned parabola, within the range of actual travel of heel sheave **19**, closely approximates that circular arc which has a four-point tangency with its apex. Accordingly we have chosen this circular arc as the approximation to the ideal path for the moving point H.

Our invention can, of course, be used for a spooling device on winches other than those of a cable-tool drill.

Having now described and illustrated two forms of our invention, we wish it to be understood that our invention is not to be limited to the specific form or arrangement of parts herein described and shown, except in so far as required by limitations in our claims.

We claim:

1. A spooling device, comprising: a first sheave; a fixed position drum; a floating sheave; and means, including a rope extending from the drum around the floating sheave and thence around the first sheave, constraining the floating sheave to follow a path which is substantially the curve of intersection between a circular cylinder, the equation of which is $x^2+y^2=x_0^2+y_0^2$, and a parabolic cylinder, the equation of which is $z^2=2r(x-x_0)$;

the X-axis being a perpendicular dropped on the drum from the first sheave, the origin of coordinates being the foot of this perpendicular, the Z-axis being the drum, the Y-axis extending perpendicular to the other two axes in the general direction of the floating sheave, the point x_0, y_0, O being one position of the floating sheave, and r being the length of the perpendicular.

2. A spooling device, comprising: a first sheave; a fixed position drum; a floating sheave; and means constraining the floating sheave to follow such a path that, with a rope extending from the drum around the floating sheave and thence around the first sheave, the reach of rope from the drum to the floating sheave will always lie substantially in a plane perpendicular to the axis of the drum, and the floating sheave will always lie perpendicular to its path and substantially in the plane of the two reaches of rope which extend from it: the constraining means comprising a properly curved and oriented rod; and a bushing for the floating sheave to rotate upon, said bushing having a central hole, curved to fit the rod, and keyed to the rod for sliding thereon but constrained against rotation thereabout.

3. A spooling device, according to claim 2, characterized by the fact that the rod and the hole in the bushing are polygonal in cross-section.

4. A spooling device, according to claim 2, characterized by the fact that the rod and the hole in the bushing are curved in a circular arc.

5. A spooling device, according to claim 2, characterized by the fact that the rod and the hole in the bushing are curved in a circular arc, and are polygonal in cross-section.

6. A spooling device, comprising: a first sheave; a fixed position drum; a floating sheave; a curved bar; a hollow bushing for the floating sheave, said bushing being externally shaped for a close rotational fit within the floating sheave, and being internally shaped for a close sliding fit about the bar, and being slidably keyed to the bar to prevent rotation thereabout; the sheaves, the drum, and the bar, being so relatively proportioned and positioned that a rope, extending from the drum around the floating sheave and thence around the first sheave, will be properly spooled onto and off of the drum.

7. A spooling device, comprising: a first sheave; a fixed position drum; a floating sheave; a curved bar, a polygonal cross-section; a hollow bushing for the floating sheave, said bushing being externally shaped for a close rotational fit with the floating sheave, and being internally shaped for a close sliding non-rotational fit about the bar; the sheaves, the drum, and the bar, being so relatively proportioned and positioned that a rope, extending from the drum around the floating sheave and thence around the first sheave, will be properly spooled onto and off of the drum.

8. A cylindrical sheave bushing, having a lengthwise curved hole of polygonal cross-section.

9. A sliding sheave assembly, comprising: the sheave; a curved bar; and a hollow bushing, externally shaped for a close rotational fit within the sheave, and internally shaped for a close sliding fit on the bar, and slidably keyed to the bar to prevent rotation thereabout.

10. A spooling device, comprising: a first sheave; a fixed position drum; a floating sheave; a carriage for the floating sheave; the floating sheave and the first sheave, in that order, being capable of spooling a line off of and onto the drum; and a track for the carriage, constraining the floating sheave to follow a path which is substantially the curve of intersection between a circular cylinder, having its axis along the drum, and a parabolic cylinder, the focal distance of which is equal to one half the distance between the first sheave and the drum, and the generating lines of which are perpendicular to the plane defined by the drum and by a perpendicular dropped on the drum from the first sheave.

11. A spooling device, comprising: a first sheave; a fixed position drum; a floating sheave; a carriage for the floating sheave; the floating sheave and the first sheave, in that order, being capable of spooling a line off of and onto the drum; and a track for the carriage, constraining the floating sheave to follow a path which is substantially the curve of intersection between a circular cylinder, having its axis along the drum, and a parabolic cylinder, the focal distance of which is equal to one half the distance between the first sheave and the drum, and the generating lines of which are perpendicular to the plane defined by the drum and by a perpendicular dropped on the drum from the first sheave; said track and carriage constraining the axle of the floating sheave to tangency with said curve.

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