CROWN AND TRAVELING BLOCK AND A REEVING SYSTEM THEREFOR

Filed Jan. 17, 1947

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This invention relates to a reeving system for cooperating blocks of the type used for lifting heavy loads and is particularly directed to improvements in crown blocks and traveling blocks as employed in oil field drilling operations.

As the search for oil is carried to lower and lower strata, the drilling and hoisting apparatus and related equipment must be increased in capacity in order to handle the extremely heavy loads incident to inserting and withdrawing a long string of drill pipe into the hole. A traveling block which is adapted to move vertically in the derrick is suspended by means of a flexible cable from a crown block position at the top of the derrick. One end of the cable which is reeved between the sheaves of the block extends downwardly from the crown block to a hoisting mechanism, and the other end extends downwardly from the crown block and is dead-ended near the base of the derrick. The drill string is supported from the traveling block within the derrick.

The drill pipe, which carries the bit at its lower end, must be withdrawn at intervals during the drilling operation for replacing the bit, and the customary practice is to store unjouled sections of the drill pipe within the derrick, as it is being withdrawn, section by section, from the derrick. In a very deep drilling operation, the total amount of drill pipe to be stored within the derrick becomes so great that the space available for movement of the traveling block within the derrick may be considerably restricted. Thus, it becomes essential to provide a traveling block of narrow width in order that adequate clearances may be maintained between the traveling block and the pipe racked within the derrick.

Long strings of drill pipe require that heavy duty blocks be employed. Therefore, the requirement of narrowness is complicated by the necessity of providing a high capacity block to handle the extremely heavy loads. In order to meet these conflicting requirements, it has been proposed to use a double-deck traveling block in which two groups of sheaves are employed, one above the other. In this way, heavy duty, high capacity sheaves and bearings may be employed while maintaining a relatively narrow overall width. Accordingly, double-deck traveling blocks and companion crown blocks have been used in actual operations. These blocks have employed a conventional reeving system, in which a continuous cable is reeved progressively from right to left over adjacent sheaves, so that the high speed sheave is on one side of the block and the low speed sheave is on the other side of the block. Serious disadvantages result from this type of reeving, however, since it causes the traveling block to cant or tilt during vertical movement in the derrick, and it causes the traveling block to turn about its vertical axis. These canting and rotating motions are objectionable since they reduce the clearance available between the moving traveling block and pipe racked in the derrick and, in severe cases, may result in fouling of the cable.

The principal object of my invention is to provide a crown or traveling block in which alternate sheaves are progressively reeved with a lead in one direction and the remaining sheaves are progressively reeved with a lead in the other direction in order that tilting or canting of the block in operation, as well as turning movement about its vertical axis, may be minimized.

Another object is to provide a crown and traveling block arrangement in which each of the blocks is provided with a plurality of sheaves arranged in two groups, the cable being progressively reeved from left to right around one of the groups of sheaves and then being progressively reeved from right to left around the other group of sheaves, whereby the fastest and slowest speed sheaves are on one side of the block and an intermediate speed sheave is on the other side of the block.

Another object is to provide such a crown and traveling block assembly in which the sheaves in one group are of relatively large size and the sheaves in the other group are of relatively small size.

Other objects and advantages will appear hereinafter.

In the drawings:

Figure 1 is a diagrammatic illustration showing a front elevation of a block assembly and reeving system, embodying my invention;

Figure 2 is a side elevation of the apparatus shown in Figure 1;

Figure 3 is a perspective reeving diagram, showing fourteen line reeving for the traveling block;

Figure 4 is a view similar to Figure 3, showing twelve line reeving for the traveling block;

Figure 5 is a sketch employed in connection with the computation of the relative stability of a traveling block employing the reeving system embodied in my invention; and

Figure 6 is a view similar to Figure 5 relating to a traveling block having conventional over-and-over reeving.

Referring to the drawings, a crown block 20 is adapted to be supported at the top of a derrick upon beams 21 and 22. A stationary shaft supports a primary group of relatively large, independently rotatable sheaves 1, 3, 5 and 7. This
group of sheaves is rotatable about a common axis. A secondary group or relatively small diameter sheaves 8, 10, 12 and 14 is supported on an upper stationary shaft and is independently rotatable about a common axis. The axis of rotation of sheaves 3, 5 and 7 is parallel to the axis of rotation of the sheaves 9, 11, 13 and 15. For convenience, the primary group of relatively large sheaves will be designated 23 and the secondary group of relatively small sheaves will be designated 24.

In a similar manner, the traveling block 25 includes a lower stationary shaft for supporting the primary group 26 of relatively large diameter sheaves 2, 4 and 6 which are independently rotatable about a common axis. A secondary group 27 of relatively small diameter sheaves 8, 10, 12 and 14 is supported on an upper stationary shaft for rotation about a common axis. The axis of rotation of the primary group 26 is parallel to the axis of rotation of the secondary group 27.

A becket 28 is provided on the lower end of the traveling block 25 for connection with a load carrying member, not shown.

It will be observed that the relatively large diameter sheaves 1, 3, 5 and 7 are disposed in alternating relation on the derrick floor, and the relatively small diameter sheaves 15, 13, 14 and 9. In a similar manner, the traveling block sheaves 2, 4 and 6, of large diameter, are disposed in alternating relation with the relatively small diameter sheaves 8, 10, 12 and 14.

In accordance with my invention, the sheaves of one group are reeved with a lead in one direction and the sheaves of the other group in each block are reeved with a lead in the other direction. Thus, the high speed line 29 of the continuous cable 30, which extends to a hoisting mechanism on the derrick floor, not shown, passes first over the large diameter sheave 1 on one side of the crown block 20. The cable then passes under the large diameter sheave 2 on the traveling block 25 and the reeving progresses around sheaves 3, 4, 5, 6 and 7 in that order. It is thus apparent that the secondary group of sheaves in each block is reeved progressively in a direction from left to right, as shown in Figure 1 of the drawings.

The line part leading from the sheave 1 on the crown block 20 then passes under the relatively small diameter sheave 9 of the traveling block 25 and then extends upwardly and is anchored near the derrick floor, not shown. It will be understood that the reeving of the secondary groups 27 and 24 proceeds progressively from the sheave 8 in a direction from right to left and that, therefore, the sheave 15 is the lowest moving sheave in the reeving system. Indeed, the sheave 15 is referred to as the "dead" sheave, since it does not rotate so long as the dead-line 31 remains anchored, but its motion is confined to an oscillatory one brought about by extension and contraction of the cable, as the load is applied to and removed from the traveling block 25.

The high speed sheave 1 is thus adjacent the low speed or "dead" sheave 15, while the sheave 7 on the other side of the crown block 20 rotates in an intermediate speed. In like manner the relatively high speed sheave 2 in the traveling block is adjacent the relatively low speed sheave 4, and the sheave 8 on the other side of the traveling block 26 rotates at an intermediate speed. If the sheaves were arranged in the conventional over-and-over system, the sheaves all could be of the same diameter and the reeving would proceed in the following order: 16, 14, 12, 10, 8, 4, 2, 13, 12, etc., and the sheave 7 would be the slow speed or "dead" sheave. The disadvantage of such over-and-over reeving is first: (1) The traveling block 25 turns about its vertical axis and hangs at an angle in the derrick; (2) the traveling block 25 is caused to tilt or cant as it is being elevated or lowered within the derrick; and (3) line clearances are diminished.

The reason for the tilt or cant is that the mechanical efficiency of each sheave and its cooperating portion of the cable is not 100%. In other words, not all of the line tension on one side of a particular sheave is transmitted to the line on the other side of that sheave when the sheave is rotating. The friction loss in the supporting bearing of the sheave and the friction loss due to flexing and unflexing of the cable, as it passes around the sheave, reduces the available tension from one side of the sheave to the other to a figure below 100%. From consideration of this matter it has been determined that the line efficiency per sheave under operating conditions is approximately 96%. For example, if the active end 29 of the cable 30 is being spooled on a hoisting drum, not shown, to cause the traveling block 25 to move upwardly, the tension in that portion of the line extending between the sheaves 1 and 2 is only 96% of the tension in the active end 29. Similarly, the tension in the line leading from the sheave 2 to the sheave 3 is only (96 x 96) or 92.2% of the tension in the active end 29.

In the device shown in Figure 1, there are fourteen lines supporting the traveling block and, therefore, the tension in the dead-line 31 when the block 25 is being raised is only about (90 x 90) or 54% of the tension in the active end 29. The non-uniform tension in the various parts of the lines supporting the traveling block 25 is responsible for the cant or tilt of the block in operation.

A method now will be described for calculating the traveling block's stability provided by the conventional over-and-over reeving system, as compared to the stability provided by the reeving system embodying my invention.

In Figure 5 the sheaves of the traveling block and sheaves of the crown block are represented by parallel straight lines. The upper portion of Figure 5 diagrammatically represents a plan view of the sheaves in the crown block while the lower portion of Figure 5 diagrammatically represents a plan view of the sheaves in the traveling block. The traveling block is not illustrated directly under the crown block since this would cause confusion of the lines. It will be recognized at the outset that the most desirable condition exists when the resultant of all of the vertical forces applied to the traveling block by the line parts passes through the geometric center of the block. If this condition were true there would be no tilting or canting of the traveling block in motion.

The three large sheaves 2, 4 and 6 on the traveling block 25 are represented by relatively long straight lines carrying the same identifying numerals. Similarly, the four small sheaves 8, 10, 12 and 14 are represented by relatively short, straight lines positioned in alternate relation with the longer lines. Uniform lateral spacing is
assumed and the letter "a" is used to designate this spacing. This spacing may or may not be employed. The crown block where the short lines are designated 5, 11, 13 and 15 to correspond with the small crown block sheaves, and the long lines which are positioned in alternate relation are designated 1, 3, 5 and 7 to correspond with the large diameter crown block sheaves. If the tension in the fast line 25 of the cable (see Figure 1) is assumed to equal "P," then the tension in the line part connecting sheaves 1 and 2 will be "P/2" where "k" is the efficiency of the sheave. For purposes of this analysis "k" will be assumed to be 96%. The tension in the line part connecting sheaves 3 and 4 is P/3, and the tension in the line part connecting sheaves 4 and 5 is P/6, etc. Since there are fourteen lines supporting the traveling block, the tension in the last line part connecting sheaves 14 and 15 is P/14. The tensile forces acting on the block has been indicated by the proper symbol adjacent the end of each of the straight lines.

The point "W" is the point where a single force could be applied to the traveling block to have the same effect on the traveling block as the individual tensions in the line parts of the cable. The lateral location of the point W may be established by taking moments about the straight line 14, as follows:

\[ WX = Pa(\frac{k - 2}{k}) + \frac{3(k^2 - k + 1)}{4(k^2 + 2k + 2)} \]

When "k" equals 96%, \[ WX = 31.84 \text{ Pa} \]

It can be shown that:
\[ W = \frac{k - 1}{h} \]

where "h" is the number of lines supporting the traveling block. In this case \[ h = 14 \]

Hence,
\[ W = 10.45 \text{ Pa} \]

and
\[ X = 3.05 \text{ Pa} \]

In other words, the traveling block is very nearly balanced; the fully balanced condition would occur if X equaled 3a.

A similar calculation to determine the stability of a traveling block reeved by the conventional over-and-over system will now be made. Referring to Figure 6, the eight sheaves of the crown block are designated 1h, 2h, 3h, 4h, 5h, 6h, 7h, 8h, 13h, 14h and 15h and the seven sheaves of the traveling block are designated 1h, 2h, 3h, 4h, 5h, 6h, 7h, 10h, 12h and 14h. As heretofore explained, the continuous cable is reeved progressively over adjacent sheaves with a lead in one direction only. Thus, the cable may be reeved progressively over sheaves 1h, 2h, 3h, 4h, 5h, etc., up to 15h. Hence, the fast sheave 1h is on one side of the crown block and the dead sheave 15h is on the other side of the crown block. If the tension in the fast line from the hoist is again assumed to be P, the tension in the line part connecting sheaves 1h and 2h is P/2. Similarly, the tension in the line part connecting sheaves 2h and 3h is P/3, and between sheaves 3h and 4h is P/6, etc. The distance X to the location of the resultant force W, which has the same effect on the block as the summation of the individual tension forces may be calculated from the equation:

\[ X = 27.95 \frac{P}{W} \]

which is derived from the following relationship:

\[ WX = Pa(\frac{k^3 + k^2 - 2(k^2 + k) + 3(k^2 + k)}{4(k^2 + 2k + 2)} + \frac{5(k^2 + k)}{4(k^2 + 2k + 2)} + \frac{6(k^2 + k)}{4(k^2 + 2k + 2)}) \]

and since W equals 10.45P

\[ X = 2.67a \]

In other words, the distance to the position of the resulting force W from the outermost sheave of the traveling block fails to correspond with the geometric center of the block where X equals 3a. The location of the resultant force W is 3.05a away from the center of the block with conventional over-and-over reeving. This figure compares to 3.8a away from the center of the block when the reeving system embodying my invention is employed, as shown above. From this comparison, it is to be understood that the conventional over-and-over reeving applies a resultant load on the traveling block, which is more than six times as far away from the center line of the block as is the resultant force applied when the reeving system embodying my invention is employed. The canting or tilting movement of the block in operation is therefore largely overcome when my reeving system is used.

The feature which makes possible the reeving of some of the sheaves with a lead in one direction and the reeving of the other sheaves with a lead in the opposite direction is the provision of relatively large and relatively small sheaves.

Reference to Figure 2 will show that the line parts connecting primary groups 23 and 26 are spaced from the corresponding line parts connecting the secondary groups 24 and 27 by an amount corresponding to the difference in diameter of the sheaves. The only exception is the single line part connecting the primary sheave 7 with the secondary sheave 8. It will be noted that this line part is positioned at the extreme edge of the blocks and therefore the danger of fouling is minimized. The lateral spacing between adjacent sheaves provides lateral line clearance on the same order of the clearance provided between the line parts by reason of the difference in diameter of the sheaves, as shown in Figure 2.
of, and the primary group of the traveling block being positioned below the secondary group there-of, the cable being progressively reeved from a large end-sheave of the crown block around the primary group of sheaves in each block to the other large end-sheave of the crown block, and then reeved from a small end-sheave of the traveling block positioned vertically therebelow, and then around the remaining secondary group of sheaves in each block.

In combination, a pair of blocks, each block having a plurality of parallel sheaves, a cable progressively reeeved between the blocks with a lead in one direction around alternate sheaves in each block, then from an end-sheave on one of the blocks to a sheave directly therebelow on the other of the blocks, and then reeved with a lead in the other direction around the remaining sheaves in each block, whereby in operation adjacent sheaves on one side of the block rotate at the fastest and slowest speeds and a sheave on the other side of the block rotates at an intermediate speed.

3. In apparatus of the class described having a traveling block suspended from a crown block by a cable rove between the blocks, the improvement comprising, in combination: a plurality of relatively large diameter sheaves positioned in parallel alternating relationship with a plurality of relatively small diameter sheaves on the same block, the sheaves being independently rotatable and laterally spaced with substantial uniformity to provide lateral clearance between line parts of the cable extending from the sheaves of the block, the large sheaves being interleaved with the small sheaves so that the upper portions of the large sheaves extend above the lower portions of the small sheaves, the difference in diameter between large diameter sheaves and small diameter sheaves being sufficient to provide side clearance between the line parts on the order of magnitude of the lateral clearance so that the cable may be reeeved with a lead in one direction around the large diameter sheaves and in the opposite direction around the small diameter sheaves.

4. In a traveling block, the combination of a plurality of parallel sheaves, alternate sheaves being rotatable about two parallel axes vertically spaced, the alternate sheaves being interleaved so that the sheaves rotatable about one axis overlap the sheaves rotatable about the other axis, the diameter of the sheaves rotatable about the lower axis being larger than the diameter of the other sheaves to establish clearance between line parts of a continuous cable supporting the block and reeeved with a lead in one direction around the large diameter sheaves and in the opposite direction around the other sheaves.

5. In apparatus of the class described having a traveling block suspended from a crown block by a cable rove between the blocks, the improvement comprising, in combination: a primary group of relatively large diameter coaxial sheaves and a secondary group of relatively small diameter coaxial sheaves parallel thereto on each block, the cable being reeeved between the blocks so that it passes over a large end-sheave of the crown block and then around the remaining large sheaves in each block to the other large end-sheave of the crown block, and thence to a small end-sheave of the traveling block positioned vertically therebelow, and then around the remaining small sheaves in each block to the small end-sheave of the crown block adjacent the first said large end-sheave, whereby the primary groups of sheaves are reeeved with a lead in one direction and the secondary groups of sheaves are reeeved with a lead in the other direction.

6. In combination, a crown block, a traveling block, a cable suspending the crown block from the traveling block, each block having a primary group of relatively large diameter coaxial sheaves and a secondary group of relatively small diameter coaxial sheaves parallel thereto, the primary group of the crown block being positioned above the secondary group thereof, the primary group of the traveling block being positioned below the secondary group thereof, the traveling block having a greater number of sheaves in its secondary group than in its primary group, the two groups of sheaves in the traveling block being interleaved, the upper portions of the large sheaves in the primary group extend above the lower portions of the small sheaves in the secondary group, the cable being reeeved between the blocks so that it passes over an end-sheave in the primary group of the crown block and then around the remaining sheaves in the primary group in each block to the other end-sheave in the primary group of the crown block, and thence to an end-sheave in the secondary group of the traveling block positioned vertically therebelow, and then around the remaining sheaves in the secondary group in each block to the end-sheave in the secondary group of the crown block adjacent the first said end-sheave, whereby the primary groups of sheaves are reeeved with a lead in one direction and the secondary groups of sheaves are reeeved with a lead in the other direction.

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