

PATENT SPECIFICATION

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DRAWINGS ATTACHED

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(54) AUTOMATIC ROPE TENSION CONTROL APPARATUS

(71) We, YUTANI JUKO KABUSHIKI KAISHA, a Japanese joint-stock company, of 1-3, Shinbashi 2-Chome, Minato-Ku, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention is concerned with automatic rope tension control apparatus, and more particularly, it relates to an automatic tension control apparatus for use with a rope winding drum driven by a steam engine and adapted to reduce the variation in the engine crank torque and to thereby maintain the tension in the rope to within a limited range.

As is well known, an automatic tension control apparatus, such as an automatic tension controlling mooring winch, is intended to automatically control the length or the tension of the rope during the mooring of a vessel in accordance with the changes in the draught of the vessel resulting from the loading and unloading of cargo on the vessel, and the changes in the attitude of the vessel relative to the wharf and in the distance of the vessel from the wharf due to the rise and fall of the tide. In case there occurs a change in the position of the vessel for the reasons such as mentioned above, it will be necessary to immediately adjust the tension of the rope in response to such changes in the position of the vessel. Heaving out of the rope successively from the vessel to conform to the changes in the position of the vessel relative to the wharf or the distance of the vessel therefrom is carried out to prevent the possible increase in the tension of the rope from taking place and to reduce the variation in the tension of the rope. On the other hand, in the case where the vessel moves in such a way as to produce a reduction in the tension of the rope to an extent below the force with which the rope is heaved in by the steam engine on the vessel, it will become necessary to arrange for this sagging rope to be automatically heaved in and to thereby automatically keep the balance

between the tension of the rope and the heave-in force afforded by the steam engine.

From the aspect of mooring a vessel, it will be understood necessary that the heave-out force afforded by the steam engine be greater than the heave-in force afforded thereby. However, the proportion of these two kinds of force will naturally be determined by the difference in the directions in which the tension of the rope is applied to the automatic tension controlling winch.

This proportion has been accepted in general to be 2:1. More specifically, during the heave-in operation, the output of the steam engine will work to act upon the rope through a drum shaft of the automatic tension controlling winch, whereas during the heave-out operation, conversely, the tension of the rope will work to act upon the steam engine through a drum shaft of the tension controlling winch. Thus, the tension of the rope will act in just the opposite way of the action of the output of the steam engine. Let us now assume that the mechanical efficiency is designated as η , the heave-in force (meaning the tension of the rope during the heave-in operation) as W , and the heave-out force (meaning the tension of the rope as it is heaved out) as T . By comparing these latter two factors, they are of the relationship as is expressed by the following equation:

$$\frac{T}{W} = \frac{1}{\eta^2}$$

In general, this η takes the value of about 0.75, and accordingly, there is obtained the following value:

$$\frac{T}{W} = \frac{1}{0.75^2} = \frac{1}{0.56}$$

In other words, the proportion of these two (T versus W) will be about 2:1.

On the other hand, in the steam engine of the two-cylinder double-acting type such as the one employed in one embodiment of the present invention, it is to be noted that the pressure of the steam supplied to it is constant. However, in view of the crank mechanism being included in the winch arrangement, the crank torque will vary with the changes occurring in the angle of the crank to be rotated, as shown in Fig. 3. The tension of the rope will accordingly vary with the changes occurring in the crank torque. However, during the period in which the tension of the rope is balanced with the crank torque while the vessel is in substantially the stationary state during the period in which the vessel is being moored, the changes which take place in the crank torque will impose an intensive effect upon the tension of the rope. On the other hand, the factor of safety of the rope which is employed in a tension controlling winch is accepted to lie in the order of 4 to 5 times the tension created at the time the rope is heaved in. In view of the fact, however, that the heave-out force will become about 2 times the heave-in force as has been discussed above, the factor of safety of the rope will become no greater than only about 2 times the safety factor which is expected during the heave-out operation. Therefore, it will not be desirable for the rope to be subjected further to the effect of the fluctuations occurring in the crank torque; in addition to the small factor of safety which the rope will possess during the heave-out operation. It is, therefore, desirable particularly during the period when the steam engine is operated at a low speed which will be usually so when the vessel is being moored by relying on an automatic tension controlling winch, that the variation in the engine crank torque be reduced.

For the sake of clarity, the terms "winding" and "paying-out" which will hereinafter be used in this specification are hereby defined. By the term "winding", it is meant that the rope is wound, whereas by the term "paying-out" it is meant that the rope is extended or delivered, both for the occasion wherein the tension of the rope of the vessel which is being moored is controlled manually. On the other hand, the terms "heave-in" and "heave-out" which are used also in this specification will mean that the rope is automatically wound and delivered, respectively, as required during the period of mooring wherein the tension of the rope is to be controlled automatically. It is to be understood that, during the "heave-out" operation, the steam engine tends to rotate in the direction same as that for the "heave-in" operation, and that the steam engine—during the heave-out operation—is rendered to the condition where it is forced to make the reverse rotation because the engine is subjected, at such a time, to the intensive pulling force of the rope, so that it may be said that the rope is

heaved-out under the engine brake condition of the engine.

It is therefore, the object of the present invention to ensure that the variation in the crank torque be always reduced irrespective of the angle to which the crank is rotated, and thereby to maintain the tension of the heaved-out rope to lie within the sufficiently safe range of load.

The present invention provides an apparatus for controlling the tension of a rope, comprising a steam passageway changeover valve means for changing the passageway of pressurized steam introduced thereto from a boiler through a stop valve, a steam engine (B) adapted to be operated by the pressurized steam supplied thereto through said steam passageway changeover valve means, and a drum means interlocked with the crank shaft of the steam engine and having the rope wound thereabout, wherein a part of the passageway of the steam supplied to said steam engine (B) is connected to a relief valve means, a cam member mounted for rotation by the crankshaft is provided for periodically altering the pressure of the steam escaping from the relief valve means, and the relief valve means are arranged to reduce the steam pressure for actuating the steam engine as the force of rotation of said crankshaft increases, whereby minimizing the resultant torque of the crank during the rotation of said crankshaft.

The present invention will become more readily apparent by reading the following detailed description in conjunction with the accompanying drawing which represents an embodiment of the automatic tension control apparatus according to the invention, in which:

Fig. 1 is a somewhat diagrammatic representation, partly in section, of the essential parts of the apparatus of the present invention;

Fig. 2 is a diagrammatic explanatory representation showing the changes in the resultant crank torque relative to the positions of the crankpin, 2A showing positions of the crankpin and 2B showing the resultant crank torque relative thereto for a two cylinder double acting steam engine;

Fig. 3 is a diagrammatic explanatory representation showing the relationship between the heave-in and heave-out operations and the crank torque (i.e. the tension of the rope); and

Fig. 4 is a diagrammatic explanatory representation, in an enlarged scale, showing the relationship between the crank torque regulating cam and the cam roller.

Referring now to the accompanying drawing which represents, by way of example, an embodiment of the present invention and which is arranged to be actuated by the crank mechanism of a steam engine utilizing the pressure of the steam coming from a boiler, the action of this crank being transmitted, to the winch drum, thereby effecting the heaving-in and the

heaving-out of the rope. Reference numeral 1 represents a crank torque regulating cam which is provided concentrically with the crank shaft A of the crank mechanism. This crank torque regulating cam is so structured that it has four bulging portions which are formed at (i), (ii), (iii) and (iv) in the drawing to act in such a way that the effects of the different diameters of the cam are transmitted to a relief spring to alter its initial load to thereby regulate the steam pressure which is applied to the piston of the steam engine. Each opposed pair of the bulging portions of the cam 1 is associated with one of two cylinders of the steam engine, which cylinders operate out of phase by 90° of crank rotation as will be understood from Fig. 3. Numeral 2 represents a valve casing containing a valve for controlling the steam pressure. This valve casing has, in one of its chambers, a steam inlet 2a communicating with the steam outlet B₁ side of the steam engine generally indicated at B of the steam-driven tension controlling winch and also has a relief valve 3 disposed intermediate of said casing and further has an outlet 2b in the other of said chambers. Numeral 4 represents the relief spring which is supported at one end of a relief valve stem 5 so as to be operated by the aforesaid relief valve 3 housed in said valve casing. Numerals 6 and 6a represent operating rod members coupled to each other to form a continuous combined operating rod which is disposed between said relief valve stem 5 and said crank torque regulating cam and which is supported midway of its length by an appropriate supporting means 8 and which is also provided, at the foremost end thereof, with a cam roller 7 adapted to be brought into engagement with said cam 1. Numeral 9 represents a spring attached to said combined operating rod to cause the returning movement of this rod. Numeral 10 represents a lever which is pivotably supported at a fulcrum 10a which is disposed at an appropriate position between the rear end of said operating rod members 6 and 6a and said relief valve stem 5 and which is coupled to these two members to operate them in different modes of stroke as required. This lever 10 is coupled to said relief valve stem 5 in such a manner that this valve stem is controlled for movement in its own axial direction by an adjustment handle 11 which is provided at the rear end of said relief valve stem 5. More specifically, the lever 10 is adapted to be controlled for tilting about the fulcrum 10a by the operation of the handle 11. Numeral 12 represents an indicator which is disposed at a position midway of said relief valve stem 5 and provided, at a position facing it, with pressure indicating graduations 13, said pressure representing the tension of the rope. In this embodiment, the portion of said relief valve stem 5 extending on the adjustment handle 11 side is rotatably coupled, in said

indicator section 12, to the portion of said stem extending on the other side of the indicator. Thus, it is possible to adjust the range of the rearward displacement of said lever 10 by turning, in screwing fashion, the handle 11. Numeral 14 represents a stopper for restricting the range of the forward displacement of said lever 10.

In the steam supply section, the letter C and the reference numeral 15 represent a valve intended for use in the manual winding and paying out of the rope and a valve for use during the automatic heaving-in and heaving-out of the rope, respectively. The functional arrangement in this section is such that the steam supplied from the boiler passes through either one of these two valves to communicate with the steam passageway changeover valve D. This valve C for use during the manual winding and paying out of the rope is of the conventional type of a large calibre, which is operated when it is intended to perform the winding and paying-out of the rope manually instead of using the automatic tension control apparatus. In the past, this valve C was used for the automatic tension controlling winch, in which case, however, the aperture of the valve was stopped down to a great extent.

The valve 15 which is of a smaller calibre and intended for use during the automatic heaving-in and heaving-out of the rope, on the other hand, is provided there especially for the apparatus of the present invention. It is to be noted that, during the period in which the vessel is being moored, the tension controlling winch is operated at a considerably slowed-down speed, and accordingly, steam can be supplied at a substantially reduced rate. It should be noted, however, that, particularly during the period in which the automatic tension control apparatus is in use, an excessively great rate of steam supply will result in a failure to sufficiently control the steam pressure which is applied to the piston, unless the capacity of the automatic tension control apparatus is increased to a substantial degree. It is possible, of course, to use said valve intended for the manual operation by stopping down the aperture to a certain degree. However, in view of the considerable difficulty which is encountered in adjusting the aperture of such a valve, there is provided the other valve exclusively intended for the automatic heaving-in and heaving-out of the rope.

The letter E represents a lever for operating the steam passageway changeover valve D. The letter F represents a slide valve which is coupled, by a connection rod G, to an eccentric wheel (not shown). The letter H represents a piston, and I represents a connecting rod.

Description will hereunder be made on the procedure and the manner in which the above-described apparatus is operated. For the period in which the vessel is subjected to the automatic tension controlling winch, the valve C

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which is used during the manual winding and paying-out of the rope is closed as the first step, which on the other hand the valve 15 intended for the automatic heaving-in and heaving-out of the rope is opened. When the lever E is tilted to the right side as viewed in Fig. 1, the steam passes through a chamber at the left of the slide valve F and a steam outlet B₁, so that the engine is then driven in the rope winding-in direction. Then, the lever 10 is tilted to the right side until it engages the stopper 14. It is to be noted that the aforesaid stopper is so positioned as will enable the cam roller 7 to be brought into engagement with the cam 1 at the bulging corners of the latter. After the position of the cam roller 7 relative to the cam 1 has been set in the foregoing manner, the adjustment handle 11 is turned, in screwing fashion, until the indicator 12 of the relief valve stem 5 comes to be located in the required position on the pressure indicating graduations 13. After the completion of the aforesaid procedure, the lever is relieved of the hold by the operator's hand. Whereupon, the reversing spring 9 will act so as to cause the cam roller 7 to move to the right until it engages the cam 1. During the operation of heaving-in the rope, the cam 1 rotates jointly with the crank shaft A which is rotated. Let us now assume that the crank is located in the position corresponding to the position (i) in which the resultant crank torque is of the smallest value as shown in Fig. 3. It is to be understood that, at this moment, the position of the cam 1 has been initially so determined as to be located, as seen in Fig. 4, in the position (i) which represents one of the maximum lifts of the cam 1. In this position, both the cam roller 7 and the operating rod members 6 and 6a are displaced to the extreme left, while the relief valve stem 5 is displaced to the extreme right via the lever 10. In this stage, the relief spring 4 retains its predetermined spring pressure, and the steam pressure is kept at the predetermined intensity. Now, as the crank rotates clockwise to a slight extent, the cam 1 will rotate simultaneously with the crank, progressively displacing the point of surface of the cam 1 contacted by the cam roller 7 from the position (i) toward the position (ii), thereby making the lift of the cam 1 less.

Along with this, both the cam roller 7 and the operating rod members 6 and 6a which are coupled to said cam roller 7 will be displaced toward the right, while the relief valve stem 5 will be displaced, via the lever 10, toward the left. Thus, the relief spring 4 will be progressively stripped of its initial load, and this, in turn, will reduce the pushing force of the relief valve 3. As a result, a part of the steam which communicates—through the steam outlet B₁ and the steam inlet 2a—with the steam which is applied to the piston H will pass through the relief valve 3 and the outlet 2b

to escape outside the system into the ambient atmosphere. Along with this, there will arise a reduction in the pushing force of the piston H, and accordingly, there will be a reduction in the power of rotation of the crankshaft.

When the resultant crank torque tends to increase in such a way as has been described above, there will be caused a reduction in the lift of the rotating cam 1 and this reduction in the lift, in turn, will reduce the initial load of the relief spring 4 supporting the relief valve 3 via the cam roller 7 which acts in response to the changes in the diameter of the cam 1 and also via the linking mechanism coupled to said cam roller, to cause some of the steam to escape outside from the system and to thereby reduce the pushing force of the piston. In this way, the variation in the crank effect is reduced at all times. Thus, the range of the tension of the rope during the heave-in operation is always restricted.

Next, when the foregoing condition of the rope and the vessel turns into the condition where there arises an increase in the tension of the rope, requiring the rope to be heaved out, this tension of the rope will actuate, via the crank, the piston against the steam pressure applied thereto. As a result, the piston will act like a compressor and will tend to alter the crank effect in the same way as has been described in connection with the aforesaid heave-in operation. During this operation, however, the steam pressure (i.e. the compression pressure) alters by the relief valve 3 so as to conform to the heave-out torque, with the result that the variation in the crank torque is reduced.

As has been stated above, the crank torque regulating cam has four bulging portions as shown in Figs. 1 and 4, and the shape of such cam is determined in such a way as to act to automatically regulate the compression force of the relief spring as to enable the amount of the compression afforded by said spring and the amount of the movement of said cam to reduce the variations of the crank torque. Also, the aforesaid bulging portions of the cam are of such shapes as will minimize, in association with said relief valve, the changes in the resultant crank shaft torque.

When it is intended to perform the manual winding and paying out of the rope, the procedure begins with returning the lever E to the neutral position, then the closing of the valve 15 intended for the automatic heave-in and heave-out operation, while opening the valve C intended for the manual winding and paying out operation. Then, the lever 10 is tilted up to the position in which it engages the stopper 14 and is set there by a pin (not shown), to keep the cam 1 from receiving the influence of the cam roller 7. Thereafter, in the manner similar to that usually employed in the steam-driven tension controlling winch in general, the control lever E is moved either

to the left hand or to the right hand, and thus, the operation of winding and paying out of the rope is carried out.

According to the present invention, there is reduced the inconvenience that the tension of the rope fluctuates with the changes occurring in the crank torque in accordance with the angle of the rotating crank, even where the pressure of the supplied steam is constant. The present invention also reduces the fluctuations to occur in the tension of the rope, by the adoption of the unique system of the present invention to control the steam pressure in conformity with the angle of the rotating crank to thereby reduce the variation in the crank torque. As a consequence, it becomes possible to elevate the level of the limit of tension on the rope during the winding operation beyond the level established for ropes of the same tensile strength, and thus, the object to accomplish the safe operation of the apparatuses of the aforesaid kind is attained.

WHAT WE CLAIM IS:—

1. An apparatus for controlling the tension of a rope, comprising a steam passageway changeover valve means for changing the passageway of pressurized steam introduced thereto from a boiler through a stop valve, a steam engine (B) adapted to be operated by the pressurized steam supplied thereto through said steam passageway changeover valve means, and a drum means interlocked with the crank shaft of the steam engine and having the rope wound thereabout, wherein a part of the passageway of the steam supplied to said steam engine (B) is connected to a relief valve means, a cam member mounted for rotation by the crankshaft is provided for periodically altering the pressure of the steam escaping from the relief valve means and the relief valve means are arranged to reduce the steam pres-

sure for actuating the steam engine as the force of rotation of said crankshaft increases, whereby minimizing the resultant torque of the crank during the rotation of said crankshaft.

2. An apparatus for controlling the tension of a rope according to claim 1 wherein the cam member has a substantially square profile.

3. An apparatus for controlling the tension of a rope according to claim 1 wherein means are provided for presetting the pressure of the steam escaping from the relief valve which is adapted to be operated by said cam member.

4. An apparatus for controlling the tension of a rope according to claim 1 wherein the steam engine is adapted to be operated manually by manually operating the steam passageway changeover valve means while retaining the relief valve means in its non-operation position.

5. An apparatus for controlling the tension of a rope according to claim 1 wherein the stop valve is one of a pair of stop valves connected in parallel whereby the switchover of the operation of the apparatus from automatic to manual mode can be effected by the changeover of the use of the two parallel stop valves from one of them to the other.

6. An apparatus for controlling the tension of a rope, substantially as hereinbefore described, with reference to, and as shown in Figs. 1 to 4 of the accompanying drawing.

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