

TRAVELLING WIRE ROPE WINDING SYSTEM AND TRAVELLING MECHANISM FOR EXTERNAL LOWER TROLLEY OF CONVENTIONAL QUAY CRANE

TECHNICAL FIELD

5 **[0001]** The present disclosure relates to the technical field of novel efficient container loading and unloading equipment, and in particular, to a travelling wire rope winding system and travelling mechanism for an external lower trolley of a conventional quay crane.

BACKGROUD

10 **[0002]** At present, the most widely used quay crane at home and abroad is a conventional single-trolley quay crane, which adopts a manner of loading and unloading containers by a single trolley, in such a way, the loading and unloading efficiency of the single quay crane reaches the limit, but the demand of a wharf for the loading and unloading efficiency still cannot be met. In the face of large container ships, a manner of increasing the number of operations of
15 the quay crane is almost adopted to increase the every-hour loading and unloading efficiency of the ship, but demands of shipping clients for the every-hour loading and unloading efficiency of the ship cannot be met by simply increasing the number of the operations of the quay crane due to an operation interval of the quay crane. If the conventional single-trolley quay crane is directly abandoned and replaced with a newly-built more advanced quay crane system, people
20 will face huge investment cost and great waste of existing resources. Therefore, in order to reduce the investment cost and improve the loading and unloading efficiency of the conventional quay crane, there is a need to break through the traditional thinking and upgrade the conventional quay crane. First of all, an existing quay crane girder is upgraded into a double-trapezoidal four-track girder, that is, an original upper-trolley running track is laid on an
25 inner side of the girder, and an original upper trolley travels on the track on the inner side of the girder. A newly-added lower-trolley running track is laid on an outer side of the girder, and the newly-added lower trolley is suspended upside down on the track on the outer side of the girder to travel.

30 **[0003]** During the upgrading, there are some technical difficulties in mounting positions and layout manners of a lower-trolley travelling mechanism and a travelling wire rope winding system that are newly added, which are mainly reflected in the following aspects: a machine room of the conventional quay crane is limited in space, so problems of limited upgrading space, complex structure and high cost may occur if a new machine room is added; and the original

upper trolley of the conventional quay crane has a simple structure and a small size, and can achieve travelling only with a simple travelling wire rope winding system, but the newly-added lower trolley has a complex structure. Therefore, there is a need to design a wire rope winding system that can ensure the stable travelling of the lower trolley.

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SUMMARY

[0004] An objective of the present disclosure is to provide a travelling wire rope winding system and travelling mechanism for an external lower trolley of a conventional quay crane, by means of smart structure design, the problem of disposing the travelling mechanism and the like can be solved without reconstructing the machine room; in addition, a travelling steel wire rope winding system for adding a lower trolley is designed, thereby ensuring that the lower trolley travels along an outer side of the girder.

[0005] In order to solve the above technical problem, the following technical solution is adopted in the present disclosure.

[0006] A travelling wire rope winding system and travelling mechanism for an external lower trolley of a conventional quay crane is provided, an upper-trolley travelling mechanism of an upper trolley being provided in a quay crane machine room. In the present disclosure, a lower-trolley travelling mechanism and a lower-trolley travelling winding system are included, and the lower-trolley travelling mechanism is configured to drive a lower trolley to travel along a double-trapezoidal four-track girder by means of the lower-trolley travelling winding system. The lower-trolley travelling mechanism is also provided in the machine room, wherein the lower-trolley travelling mechanism includes a lower-trolley travelling mechanism A and a lower-trolley travelling mechanism B, and the lower-trolley travelling mechanism A and the lower-trolley travelling mechanism B are provided on a left side and a right side of the upper-trolley travelling mechanism, respectively. Since the machine room is limited in space, in the present disclosure, a lower-trolley travelling mechanism A and a lower-trolley travelling mechanism B that are newly added can be disposed without the need to build a new machine room and reduce the upgrading cost, so that the remaining space of the original machine room is sufficiently utilized, the utility rate of space is increased, and the stable operation of the newly-added lower trolley can also be guaranteed. Through the special structural design of the lower-trolley travelling mechanism and the lower-trolley travelling winding system, the lower-trolley travelling mechanism and an upper-trolley travelling mechanism are effectively staggered without mutual interference, and the lower-trolley travelling winding system and an

upper-trolley travelling winding system are effectively staggered without mutual interference. At the same time, the lower-trolley travelling winding system and a lower-trolley hoisting winding system are effectively staggered without mutual interference.

[0007] In the travelling wire rope winding system and travelling mechanism for an external lower trolley of a conventional quay crane, the lower-trolley travelling mechanism includes a travelling drum A, a motor and a speed reducer, wherein one side shaft of the speed reducer is connected to the motor, and the other side shaft of the speed reducer is connected to the travelling drum A; and the lower-trolley travelling mechanism includes a travelling drum B, a motor and a speed reducer, wherein one side shaft of the speed reducer is connected to the motor, and the other side shaft of the speed reducer is connected to the travelling drum B.

[0008] In the travelling wire rope winding system and travelling mechanism for an external lower trolley of a conventional quay crane, the lower-trolley travelling winding system includes a lower-trolley travelling winding group A and a lower-trolley travelling winding group B, the lower-trolley travelling mechanism A drives the lower trolley to travel forward by means of the lower-trolley travelling winding group A, and the lower-trolley travelling mechanism B drives the lower trolley to travel backward by means of the lower-trolley travelling winding group B.

[0009] In the travelling wire rope winding system and travelling mechanism for an external lower trolley of a conventional quay crane, the lower trolley includes a first horizontal support, a second horizontal support, a first vertical support A and a second vertical support B, wherein one end of the second horizontal support is vertically provided with the first vertical support A, the other end of the second horizontal support is vertically provided with the second vertical support B, the first horizontal support is arranged above and parallel to the second horizontal support, one end of the first horizontal support is connected to the first vertical support A, and the other end of the first horizontal support is connected to the second vertical support B. The lower-trolley travelling winding group A includes a forward travelling wire rope, further includes a first quay crane redirecting pulley and a second quay crane redirecting pulley mounted on two sides of the quay crane, further includes a first girder redirecting pulley block and a second girder redirecting pulley block mounted on two sides of the double-trapezoidal four-track girder, further includes a first lower-trolley redirecting pulley block and a second lower-trolley redirecting pulley block mounted on left and right sides of the first horizontal support, and further includes a lower-trolley redirecting pulley a and a lower-trolley redirecting pulley b mounted on left and right sides of the second horizontal support, wherein one end of

the forward travelling wire rope is wound on the travelling drum A, and the other end of the forward travelling wire rope, after being first wound through the first girder redirecting pulley block, then wound through the first quay crane redirecting pulley to be redirected by 180°, then wound through the first lower-trolley redirecting pulley block to be redirected vertically downward, wound through the lower-trolley redirecting pulley a, then wound through the lower-trolley redirecting pulley b to be redirected vertically upward, wound through the second lower-trolley redirecting pulley block to be redirected, then wound through the second quay crane redirecting pulley to be redirected by 180°, wound through the second girder redirecting pulley block, is finally wound on the travelling drum B.

10 **[0010]** In the travelling wire rope winding system and travelling mechanism for an external lower trolley of a conventional quay crane, the lower-trolley travelling winding group B includes a reverse travelling wire rope, further includes a third quay crane redirecting pulley and a fourth quay crane redirecting pulley mounted on the two sides of the quay crane, further includes a third lower-trolley redirecting pulley block and a fourth lower-trolley redirecting pulley block mounted on the left and right sides of the first horizontal support, and further includes a lower-trolley redirecting pulley c and a lower-trolley redirecting pulley d mounted on the left and right sides of the second horizontal support, wherein one end of the reverse travelling wire rope is wound on the travelling drum A, a winding direction of the reverse travelling wire rope is opposite to that of the forward travelling wire rope, and the other end of the reverse travelling wire rope, after being first wound through the third quay crane redirecting pulley to be redirected by 180°, wound through the third lower-trolley redirecting pulley block to be redirected vertically downward, then wound through the lower-trolley redirecting pulley c, then wound through the lower-trolley redirecting pulley d to be redirected vertically upward, wound through the fourth lower-trolley redirecting pulley block, then wound through the fourth quay crane redirecting pulley to be redirected by 180°, is wound on the travelling drum B. The forward travelling wire rope, the reverse travelling wire rope and a hoisting wire rope group are wound on the lower trolley without mutual interference.

30 **[0011]** In the travelling wire rope winding system and travelling mechanism for an external lower trolley of a conventional quay crane, a first tension device is further provided above the first girder redirecting pulley block, and the first tension device includes a hydraulic cylinder and a push rod, wherein an end portion of the hydraulic cylinder is pivotally connected to one end of the push rod; the first girder redirecting pulley block includes a first pulley, a second tension pulley and a third tension pulley, wherein the first pulley and the third tension pulley are arranged in tandem at an equal height, the second tension pulley is provided above

the first pulley and the third tension pulley, the second tension pulley is fixed to the other end of the push rod away from the hydraulic cylinder, and the second tension pulley is capable of moving back and forth under the action of the push rod; wherein the forward travelling wire rope is first wound through the first pulley from below, goes vertically upward to be wound through the second tension pulley, and is redirected by 180° to go vertically downward to be wound through the third tension pulley. When the running time of the quay crane is too long, the travelling wire rope may be too tight or too loose, in this case, the travelling wire rope can be adjusted through the first tension device. In addition, if a container hoisted by the lower trolley slightly deflects, a hoist of the lower trolley can be tilted by adjusting the first tension device to complete a container matching operation.

[0012] In the travelling wire rope winding system and travelling mechanism for an external lower trolley of a conventional quay crane, a second tension device is further provided above the second girder redirecting pulley block, and the second tension device includes a hydraulic cylinder and a push rod, wherein an end portion of the hydraulic cylinder is pivotally connected to one end of the push rod; the second girder redirecting pulley block includes a fourth pulley, a fifth tension pulley and a sixth pulley, wherein the fourth pulley and the sixth pulley are arranged in tandem at an equal height, the fifth tension pulley is provided above the fourth pulley and the sixth pulley, the fifth tension pulley is fixed to the other end of the push rod away from the hydraulic cylinder, and the fifth tension pulley is capable of moving back and forth under the action of the push rod; wherein the forward travelling wire rope is first wound through the sixth pulley from below, goes vertically upward to be wound through the fifth tension pulley, and is redirected by 180° to go vertically downward to be wound through the fourth pulley. When the running time of the quay crane is too long, the travelling wire rope may be too tight or too loose, in this case, the travelling wire rope can be adjusted through the second tension device. In addition, if a container hoisted by the lower trolley slightly deflects, a hoist of the lower trolley can be tilted by adjusting the second tension device to complete a container matching operation.

[0013] In the travelling wire rope winding system and travelling mechanism for an external lower trolley of a conventional quay crane, the first lower-trolley redirecting pulley block includes a seventh pulley, an eighth pulley, a ninth pulley and a tenth pulley, wherein the forward travelling wire rope is first wound through the seventh pulley from below, is redirected by 180° to be horizontally wound through the eighth pulley, is then wound through the ninth pulley arranged perpendicular to the eighth pulley, then goes vertically downward to be wound through the tenth pulley, and continues to go downward to be wound through the lower-trolley

redirecting pulley a. The second lower-trolley redirecting pulley block includes an eleventh pulley, a twelfth pulley, a thirteenth pulley and a fourteenth pulley, wherein the forward travelling wire rope is first wound through the eleventh pulley, goes vertically upward to be wound through the twelfth pulley, is then wound through the thirteenth pulley, is then wound through the fourteenth pulley arranged perpendicular to the thirteenth pulley, and is redirected by 180° to be wound through the second quay crane redirecting pulley.

[0014] In the travelling wire rope winding system and travelling mechanism for an external lower trolley of a conventional quay crane, the third lower-trolley redirecting pulley block includes a fifteenth pulley, a sixteenth pulley, a seventeenth pulley and an eighteenth pulley, wherein the reverse travelling wire rope is first wound through the fifteenth pulley from below, is redirected by 180° to be horizontally wound through the sixteenth pulley, is then wound through the seventeenth pulley arranged perpendicular to the sixteenth pulley, then goes vertically downward to be wound through the eighteenth pulley, and continues to go downward to be wound through the lower-trolley redirecting pulley c. The fourth lower-trolley redirecting pulley block includes a nineteenth pulley, a twentieth pulley, a twenty-first pulley and a twenty-second pulley, wherein the reverse travelling wire rope is first wound through the nineteenth pulley, then goes vertically upward to be wound through the twentieth pulley, continues to be wound through the twenty-first pulley arranged perpendicular to the twentieth pulley, is then wound through the twenty-second pulley arranged perpendicular to the twenty-first pulley, and is redirected by 180° to be wound through the fourth quay crane redirecting pulley.

[0015] In the travelling wire rope winding system and travelling mechanism for an external lower trolley of a conventional quay crane, the third quay crane redirecting pulley and the fourth quay crane redirecting pulley are arranged in parallel at an equal height and arranged in front of the lower-trolley travelling mechanism; the first girder redirecting pulley block and the second girder redirecting pulley block are arranged in parallel at an equal height and arranged behind the lower-trolley travelling mechanism; the first quay crane redirecting pulley and the second quay crane redirecting pulley are arranged in parallel at an equal height and arranged behind the lower-trolley travelling mechanism; and the first girder redirecting pulley block is provided between the travelling drum A and the first quay crane redirecting pulley, and the second girder redirecting pulley block is provided between the travelling drum B and the second quay crane redirecting pulley.

[0016] In the travelling wire rope winding system and travelling mechanism for an

external lower trolley of a conventional quay crane, the first lower-trolley redirecting pulley block, the second lower-trolley redirecting pulley block, the third lower-trolley redirecting pulley block and the fourth lower-trolley redirecting pulley block are arranged at an equal horizontal height, the first lower-trolley redirecting pulley block and the second lower-trolley redirecting pulley block are arranged on a rear side of the lower trolley, and the third lower-trolley redirecting pulley block and the fourth lower-trolley redirecting pulley block are arranged on a front side of the lower trolley; wherein the lower-trolley redirecting pulley a, the lower-trolley redirecting pulley b, the lower-trolley redirecting pulley c and the lower-trolley redirecting pulley d are arranged at an equal horizontal height, the lower-trolley redirecting pulley a and the lower-trolley redirecting pulley b are arranged on a rear side of the lower trolley, and the lower-trolley redirecting pulley c and the lower-trolley redirecting pulley d are arranged on a front side of the lower trolley.

[0017] In the travelling wire rope winding system and travelling mechanism for an external lower trolley of a conventional quay crane, an outer side surface of the second horizontal support is further provided with a plurality of rope dragging frames, and the travelling drum A and the reverse travelling wire rope are arranged on the rope dragging frames, respectively.

[0018] Compared with the prior art, the present disclosure has the following advantages.

[0019] 1. Since the machine room is limited in space, in the present disclosure, a lower-trolley travelling mechanism A and a lower-trolley travelling mechanism B that are newly added can be disposed without the need to build a new machine room and reduce the upgrading cost, so that the remaining space of the original machine room is sufficiently utilized, the utility rate of space is increased, and the stable operation of the newly-added lower trolley can also be guaranteed.

[0020] 2. Through the special structural design of the lower-trolley travelling mechanism and the lower-trolley travelling winding system, the lower-trolley travelling mechanism and an upper-trolley travelling mechanism are effectively staggered without mutual interference, and the lower-trolley travelling winding system and an upper-trolley travelling winding system are effectively staggered without mutual interference. At the same time, the lower-trolley travelling winding system and a lower-trolley hoisting winding system are also effectively staggered without mutual interference. Specifically, the forward travelling wire rope, the reverse travelling wire rope and the hoisting wire rope group are wound on the lower trolley without mutual interference.

[0021] 3. When the running time of the quay crane is too long, the travelling wire rope may be too tight or too loose, in this case, the travelling wire rope can be adjusted through the first tension device. In addition, if a container hoisted by the lower trolley slightly deflects, a hoist of the lower trolley can be tilted by adjusting the first tension device to complete a container matching operation. When the running time of the quay crane is too long, the travelling wire rope may be too tight or too loose, in this case, the travelling wire rope can be adjusted through the second tension device. In addition, if a container hoisted by the lower trolley slightly deflects, a hoist of the lower trolley can be tilted by adjusting the second tension device to complete a container matching operation.

[0022] In summary, according to the travelling wire rope winding system and travelling mechanism for an external lower trolley of a conventional quay crane, by means of smart structure design, the problem of disposing the travelling mechanism and the like can be solved without reconstructing the machine room; in addition, a travelling steel wire rope winding system for adding a lower trolley is designed, thereby ensuring that the lower trolley travels along an outer side of the girder.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] Fig. 1 is a structural schematic diagram of a quay crane according to the present disclosure;

[0024] Fig. 2 is a layout structure diagram of a machine room according to the present disclosure;

[0025] Fig. 3 is a structural schematic diagram of a lower-trolley travelling mechanism according to the present disclosure;

[0026] Fig. 4 is a structural schematic diagram of a lower-trolley travelling winding system according to the present disclosure; and

[0027] Fig. 5 is also a structural schematic diagram of the lower-trolley travelling winding system according to the present disclosure.

[0028] Meanings of reference numerals: 1: double-trapezoidal four-track girder, 2: upper trolley, 3: lower trolley, 4: machine room, 5: lower-trolley travelling mechanism, 6: lower-trolley travelling winding system, 7: upper-trolley travelling mechanism, 8: lower-trolley travelling mechanism A, 9: lower-trolley travelling mechanism B, 10: third quay crane redirecting pulley, 11: travelling drum A, 12: fourth quay crane redirecting pulley, 13: first

tension device, 14: second tension device, 15: forward travelling wire rope, 16: first quay crane redirecting pulley, 17: reverse travelling wire rope, 18: second quay crane redirecting pulley, 19: first lower-trolley redirecting pulley block, 20: second lower-trolley redirecting pulley block, 21: third lower-trolley redirecting pulley block, 22: fourth lower-trolley redirecting pulley block, 23: first girder redirecting pulley block, 24: rope dragging frame, 25: second girder redirecting pulley block, 26: lower-trolley travelling winding group A, 27: lower-trolley travelling winding group B, 28: motor, 29: speed reducer, 30: lower-trolley redirecting pulley a, 31: lower-trolley redirecting pulley b, 32: travelling drum B, 33: lower-trolley redirecting pulley c, 34: first horizontal support, 35: lower-trolley redirecting pulley d, 36: second horizontal support, 37: first vertical support A, 38: second vertical support B, 101: first pulley, 102: second tension pulley, 103: third pulley, 104: fourth pulley, 105: fifth tension pulley, 106: sixth pulley, 107: seventh pulley, 108: eighth pulley, 109: ninth pulley, 110: tenth pulley, 111: eleventh pulley, 112: twelfth pulley, 113: thirteenth pulley, 114: fourteenth pulley, 115: fifteenth pulley, 116: sixteenth pulley, 117: seventeenth pulley, 118: eighteenth pulley, 119: nineteenth pulley, 120: twentieth pulley, 121: twenty-first pulley, 122: twenty-second pulley.

[0029] The present disclosure will be further described below with reference to the accompanying drawings and specific embodiments.

DETAILED DESCRIPTION

[0030] Embodiment 1 of the present disclosure: As shown in Fig. 1 to Fig. 5, in a travelling wire rope winding system and travelling mechanism for an external lower trolley of a conventional quay crane, an upper-trolley travelling mechanism 7 of an upper trolley 2 is provided in a quay crane machine room 4. In the present disclosure, a lower-trolley travelling mechanism 5 and a lower-trolley travelling winding system 6 are included, and the lower-trolley travelling mechanism 5 is configured to drive a lower trolley 3 to travel along a double-trapezoidal four-track girder 1 by means of the lower-trolley travelling winding system 6. The lower-trolley travelling mechanism 5 is also provided in the machine room 4, wherein the lower-trolley travelling mechanism 5 includes a lower-trolley travelling mechanism A 8 and a lower-trolley travelling mechanism B 9, and the lower-trolley travelling mechanism A 8 and the lower-trolley travelling mechanism B 9 are provided on a left side and a right side of the upper-trolley travelling mechanism 7, respectively. Since the machine room 4 is limited in space, in the present disclosure, the lower-trolley travelling mechanism A 8 and the lower-trolley travelling mechanism B 9 that are newly added can be disposed without the need to build a new

machine room and reduce the upgrading cost, so that the remaining space of the original machine room 4 is sufficiently utilized, the utility rate of space is increased, and the stable operation of the newly added lower trolley can also be guaranteed. Through the special structural design of the lower-trolley travelling mechanism 5 and the lower-trolley travelling winding system 6, the lower-trolley travelling mechanism 5 and an upper-trolley travelling mechanism 7 are effectively staggered without mutual interference, and the lower-trolley travelling winding system 6 and an upper-trolley travelling winding system are effectively staggered without mutual interference. At the same time, the lower-trolley travelling winding system 6 and a lower-trolley hoisting winding system are effectively staggered without mutual interference.

[0031] Further, the lower-trolley travelling mechanism A 8 includes a travelling drum A 11, a motor 28 and a speed reducer 29, wherein one side shaft of the speed reducer 29 is connected to the motor 28, and the other side shaft of the speed reducer 29 is connected to the travelling drum A 11; and the lower-trolley travelling mechanism B 9 includes a travelling drum B 32, a motor 28 and a speed reducer 29, wherein one side shaft of the speed reducer 29 is connected to the motor 28, and the other side shaft of the speed reducer 29 is connected to the travelling drum B 32. The lower-trolley travelling winding system 6 includes a lower-trolley travelling winding group A 26 and a lower-trolley travelling winding group B 27, the lower-trolley travelling mechanism A 8 drives the lower trolley 3 to travel forward by means of the lower-trolley travelling winding group A 26, and the lower-trolley travelling mechanism B 9 drives the lower trolley 3 to travel backward by means of the lower-trolley travelling winding group B 27.

[0032] Furthermore, the lower trolley 3 includes a first horizontal support 34, a second horizontal support 36, a first vertical support A 37 and a second vertical support B 38, wherein one end of the second horizontal support 36 is vertically provided with the first vertical support A 37, the other end of the second horizontal support 36 is vertically provided with the second vertical support B 38, the first horizontal support 34 is arranged above and parallel to the second horizontal support 36, one end of the first horizontal support 34 is connected to the first vertical support A 37, and the other end of the first horizontal support 34 is connected to the second vertical support B 38. The lower-trolley travelling winding group A 26 includes a forward travelling wire rope 15, further includes a first quay crane redirecting pulley 16 and a second quay crane redirecting pulley 18 mounted on two sides of the quay crane, further includes a first girder redirecting pulley block 23 and a second girder redirecting pulley block 25 mounted on two sides of the double-trapezoidal four-track girder 1, further includes a first lower-trolley

redirecting pulley block 19 and a second lower-trolley redirecting pulley block 20 mounted on left and right sides of the first horizontal support 34, and further includes a lower-trolley redirecting pulley a 30 and a lower-trolley redirecting pulley b 31 mounted on left and right sides of the second horizontal support 36, wherein one end of the forward travelling wire rope 15 is wound on the travelling drum A 11, and the other end of the forward travelling wire rope 15, after being first wound through the first girder redirecting pulley block 23, then wound through the first quay crane redirecting pulley 16 to be redirected by 180°, then wound through the first lower-trolley redirecting pulley block 19 to be redirected vertically downward, wound through the lower-trolley redirecting pulley a 30, then wound through the lower-trolley redirecting pulley b 31 to be redirected vertically upward, wound through the second lower-trolley redirecting pulley block 20 to be redirected, then wound through the second quay crane redirecting pulley 18 to be redirected by 180°, wound through the second girder redirecting pulley block 25, is finally wound on the travelling drum B 32. The lower-trolley travelling winding group B 27 includes a reverse travelling wire rope 17, further includes a third quay crane redirecting pulley 10 and a fourth quay crane redirecting pulley 12 mounted on the two sides of the quay crane, further includes a third lower-trolley redirecting pulley block 21 and a fourth lower-trolley redirecting pulley block 22 mounted on the left and right sides of the first horizontal support 34, and further includes a lower-trolley redirecting pulley c 33 and a lower-trolley redirecting pulley d 35 mounted on the left and right sides of the second horizontal support 36, wherein one end of the reverse travelling wire rope 17 is wound on the travelling drum A 11, a winding direction of the reverse travelling wire rope 17 is opposite to that of the forward travelling wire rope 15, and the other end of the reverse travelling wire rope 17, after being first wound through the third quay crane redirecting pulley 10 to be redirected by 180°, wound through the third lower-trolley redirecting pulley block 21 to be redirected vertically downward, then wound through the lower-trolley redirecting pulley c 33, then wound through the lower-trolley redirecting pulley d 35 to be redirected vertically upward, wound through the fourth lower-trolley redirecting pulley block 22, then wound through the fourth quay crane redirecting pulley 12 to be redirected by 180°, is wound on the travelling drum B 32. The forward travelling wire rope 15, the reverse travelling wire rope 17 and the hoisting wire rope group are wound on the lower trolley 3 without mutual interference.

[0033] Specifically, a first tension device 13 is further provided above the first girder redirecting pulley block 23, and the first tension device 13 includes a hydraulic cylinder and a push rod, wherein an end portion of the hydraulic cylinder is pivotally connected to one end of the push rod; the first girder redirecting pulley block 23 includes a first pulley 101, a second

tension pulley 102 and a third tension pulley 103, wherein the first pulley 101 and the third tension pulley 103 are arranged in tandem at an equal height, the second tension pulley 102 is provided above the first pulley 101 and the third tension pulley 103, the second tension pulley 102 is fixed to the other end of the push rod away from the hydraulic cylinder, and the second tension pulley 102 is capable of moving back and forth under the action of the push rod; wherein the forward travelling wire rope 15 is first wound through the first pulley 101 from below, goes vertically upward to be wound through the second tension pulley 102, and is redirected by 180° to go vertically downward to be wound through the third tension pulley 103. When the running time of the quay crane is too long, the travelling wire rope may be too tight or too loose, in this case, the travelling wire rope can be adjusted through the first tension device 13. In addition, if a container hoisted by the lower trolley 3 slightly deflects, a hoist of the lower trolley 3 can be tilted by adjusting the first tension device 13 to complete a container matching operation.

[0034] More specifically, a second tension device 14 is further provided above the second girder redirecting pulley block 25, and the second tension device 14 includes a hydraulic cylinder and a push rod, wherein an end portion of the hydraulic cylinder is pivotally connected to one end of the push rod; the second girder redirecting pulley block 25 includes a fourth pulley 104, a fifth tension pulley 105 and a sixth pulley 106, wherein the fourth pulley 104 and the sixth pulley 106 are arranged in tandem at an equal height, the fifth tension pulley 105 is provided above the fourth pulley 104 and the sixth pulley 106, the fifth tension pulley 105 is fixed to the other end of the push rod away from the hydraulic cylinder, and the fifth tension pulley 105 is capable of moving back and forth under the action of the push rod; wherein the forward travelling wire rope 15 is first wound through the sixth pulley 106 from below, goes vertically upward to be wound through the fifth tension pulley 105, and is redirected by 180° to go vertically downward to be wound through the fourth pulley 104. When the running time of the quay crane is too long, the travelling wire rope may be too tight or too loose, in this case, the travelling wire rope can be adjusted through the second tension device 14. In addition, if a container hoisted by the lower trolley 3 slightly deflects, a hoist of the lower trolley 3 can be tilted by adjusting the second tension device 14 to complete a container matching operation.

[0035] In addition, the first lower-trolley redirecting pulley block 19 includes a seventh pulley 107, an eighth pulley 108, a ninth pulley 109 and a tenth pulley 110, wherein the forward travelling wire rope 15 is first wound through the seventh pulley 107 from below, is redirected by 180° to be horizontally wound through the eighth pulley 108, is then wound through the ninth pulley 109 arranged perpendicular to the eighth pulley 108, then goes vertically downward

to be wound through the tenth pulley 110, and continues to go downward to be wound through the lower-trolley redirecting pulley a 30. The second lower-trolley redirecting pulley block 20 includes an eleventh pulley 111, a twelfth pulley 112, a thirteenth pulley 113 and a fourteenth pulley 114, wherein the forward travelling wire rope 15 is first wound through the eleventh pulley 111, goes vertically upward to be wound through the twelfth pulley 112, is then wound through the thirteenth pulley 113, is then wound through the fourteenth pulley 114 arranged perpendicular to the thirteenth pulley 113, and is redirected by 180° to be wound through the second quay crane redirecting pulley 18. The third lower-trolley redirecting pulley block 21 includes a fifteenth pulley 115, a sixteenth pulley 116, a seventeenth pulley 117 and an eighteenth pulley 118, wherein the reverse travelling wire rope 17 is first wound through the fifteenth pulley 115 from below, is redirected by 180° to be horizontally wound through the sixteenth pulley 116, is then wound through the seventeenth pulley 117 arranged perpendicular to the sixteenth pulley 116, then goes vertically downward to be wound through the eighteenth pulley 118, and continues to go downward to be wound through the lower-trolley redirecting pulley c 33. The fourth lower-trolley redirecting pulley block 22 includes a nineteenth pulley 119, a twentieth pulley 120, a twenty-first pulley 121 and a twenty-second pulley 122, wherein the reverse travelling wire rope 17 is first wound through the nineteenth pulley 119, then goes vertically upward to be wound through the twentieth pulley 120, continues to be wound through the twenty-first pulley 121 arranged perpendicular to the twentieth pulley 120, is then wound through the twenty-second pulley 122 arranged perpendicular to the twenty-first pulley 121, and is redirected by 180° to be wound through the fourth quay crane redirecting pulley 12.

[0036] Further, the third quay crane redirecting pulley 10 and the fourth quay crane redirecting pulley 12 are arranged in parallel at an equal height and arranged in front of the lower-trolley travelling mechanism 5; the first girder redirecting pulley block 23 and the second girder redirecting pulley block 25 are arranged in parallel at an equal height and arranged behind the lower-trolley travelling mechanism 5; the first quay crane redirecting pulley 16 and the second quay crane redirecting pulley 18 are arranged in parallel at an equal height and arranged behind the lower-trolley travelling mechanism 5; and the first girder redirecting pulley block 23 is provided between the travelling drum A 11 and the first quay crane redirecting pulley 16, and the second girder redirecting pulley block 25 is provided between the travelling drum B 32 and the second quay crane redirecting pulley 18.

[0037] The first lower-trolley redirecting pulley block 19, the second lower-trolley redirecting pulley block 20, the third lower-trolley redirecting pulley block 21 and the fourth lower-trolley redirecting pulley block 22 are arranged at an equal horizontal height, the first

lower-trolley redirecting pulley block 19 and the second lower-trolley redirecting pulley block 20 are arranged on a rear side of the lower trolley 3, and the third lower-trolley redirecting pulley block 21 and the fourth lower-trolley redirecting pulley block 22 are arranged on a front side of the lower trolley 3; wherein the lower-trolley redirecting pulley a 30, the lower-trolley redirecting pulley b 31, the lower-trolley redirecting pulley c 33 and the lower-trolley redirecting pulley d 35 are arranged at an equal horizontal height, the lower-trolley redirecting pulley a 30 and the lower-trolley redirecting pulley b 31 are arranged on a rear side of the lower trolley 3, and the lower-trolley redirecting pulley c 33 and the lower-trolley redirecting pulley d 35 are arranged on a front side of the lower trolley 3. An outer side surface of the second horizontal support 36 is further provided with a plurality of rope dragging frames 24. Specifically, each side may be provided with two rope racks 24. The forward travelling wire rope 15 and the reverse travelling wire rope 17 are arranged on the rope dragging frames 24, respectively.

[0038] Embodiment 2: As shown in Fig. 1 to Fig. 5, in a travelling wire rope winding system and travelling mechanism for an external lower trolley of a conventional quay crane, an upper-trolley travelling mechanism 7 of an upper trolley 2 is provided in a quay crane machine room 4. In the present disclosure, a lower-trolley travelling mechanism 5 and a lower-trolley travelling winding system 6 are included, and the lower-trolley travelling mechanism 5 is configured to drive a lower trolley 3 to travel along a double-trapezoidal four-track girder 1 by means of the lower-trolley travelling winding system 6. The lower-trolley travelling mechanism 5 is also provided in the machine room 4, wherein the lower-trolley travelling mechanism 5 includes a lower-trolley travelling mechanism A 8 and a lower-trolley travelling mechanism B 9, and the lower-trolley travelling mechanism A 8 and the lower-trolley travelling mechanism B 9 are provided on a left side and a right side of the upper-trolley travelling mechanism 7, respectively. Since the machine room 4 is limited in space, in the present disclosure, the lower-trolley travelling mechanism A 8 and the lower-trolley travelling mechanism B 9 that are newly added can be disposed without the need to build a new machine room and reduce the upgrading cost, so that the remaining space of the original machine room 4 is sufficiently utilized, the utility rate of space is increased, and the stable operation of the newly-added lower trolley can also be guaranteed. Through the special structural design of the lower-trolley travelling mechanism 5 and the lower-trolley travelling winding system 6, the lower-trolley travelling mechanism 5 and an upper-trolley travelling mechanism 7 are effectively staggered without mutual interference, and the lower-trolley travelling winding system 6 and an upper-trolley travelling winding system are effectively staggered without mutual interference. At the same time, the lower-trolley travelling winding system 6 and a lower-trolley hoisting

winding system are also effectively staggered without mutual interference.

[0039] The working principle of the present disclosure is as follows. The present disclosure provides a travelling wire rope winding system and travelling mechanism of a lower trolley located on an outer side of a girder, which is configured for the motion of the lower trolley along the girder after upgrading of the conventional quay crane, without any interference with an upper trolley. Specifically, the girder of the conventional quay crane is upgraded into a double-trapezoidal four-track girder 1, a lower trolley 3 is suspended upside down on tracks on outer sides of the girder, and the lower-trolley travelling mechanism 5 in the machine room 4 drives the lower trolley 3 to move upward along the girder by means of the lower-trolley travelling winding system 6.

[0040] The lower-trolley travelling mechanism 5 is specifically as follows. The lower-trolley travelling mechanism 5 includes a lower-trolley travelling mechanism A 8 and a lower-trolley travelling mechanism B 9 arranged on two sides of the upper-trolley travelling mechanism 7. The travelling wire rope is led out by the lower-trolley travelling mechanism A 8 and the lower-trolley travelling mechanism B 9, and is effectively staggered from a wire rope of the upper-trolley travelling mechanism 7 without any interference. Arrangement positions of the lower-trolley travelling mechanism A 8 and the lower-trolley travelling mechanism B 9 in the machine room 4 are determined by an arrangement width of the girder of the original quay crane. The travelling wire rope is arranged along an outer side of the double-trapezoidal four-track girder 1 of the quay crane.

[0041] The lower-trolley travelling winding system 6 is specifically as follows. As shown in Fig. 5, the lower-trolley travelling mechanism 8 drives the lower trolley 3 to travel forward by means of the lower-trolley travelling winding group A 26. Specifically, one end of the forward travelling wire rope 15 is wound on the travelling drum A 11, and the other end of the forward travelling wire rope 15 is first wound through the first pulley 101 from below, goes vertically upward to be wound through the second tension pulley 102, and is redirected by 180° to go vertically downward to be wound through the third tension pulley 103, is then wound through the first quay crane redirecting pulley 16, is then redirected by 180° to be wound through the seventh pulley 107 from below, is redirected by 180° to be horizontally wound through the eighth pulley 108, is then wound through the ninth pulley 109 arranged perpendicular to the eighth pulley 108, then goes vertically downward to be wound through the tenth pulley 110, is redirected to go vertically downward to be first wound through the lower-trolley redirecting pulley a 30, is then wound through the lower-trolley redirecting pulley b 31, is redirected to go vertically upward to be first wound through the eleventh pulley 111,

goes vertically upward to be wound through the twelfth pulley 112, is then wound through the thirteenth pulley 113, is then wound through the fourteenth pulley 114 arranged perpendicular to the thirteenth pulley 113, is redirected by 180° to be wound through the second quay crane redirecting pulley 18, is redirected by 180° to be first wound through the sixth pulley 106 from below, goes vertically upward to be wound through the fifth tension pulley 105, is redirected by 180° to go vertically downward to be wound through the fourth pulley 104, and is finally wound on the travelling drum B 32.

[0042] The lower-trolley travelling mechanism B 9 drives the lower-trolley 3 to travel backward by means of the lower-trolley travelling winding group B 27. Specifically, one end of the reverse travelling wire rope 17 is wound on the travelling drum A 11, and a winding direction of the reverse travelling wire rope 17 is opposite to that of the forward travelling wire rope 15, and the other end of the reverse travelling wire rope 17 is first wound through the third quay crane redirecting pulley 10, is redirected by 180° to be first wound through the fifth pulley 115 from below, is redirected by 180° to be horizontally wound through the sixteenth pulley 116, is then wound through the seventeenth pulley 117 arranged perpendicular to the sixteenth pulley 116, then goes vertically downward to be wound through the eighteenth pulley 118, is then redirected to go vertically downward to be wound through the lower-trolley redirecting pulley c 33, is then wound through the lower-trolley redirecting pulley d 35, is redirected to go vertically upward to be first wound through the nineteenth pulley 119, then goes vertically upward to be wound through the twentieth pulley 120, continues to be wound through the twenty-first pulley 121 arranged perpendicular to the twentieth pulley 120, is then wound through the twenty-second pulley 122 arranged perpendicular to the twenty-first pulley 121, is redirected by 180° to be wound through the fourth quay crane redirecting pulley 12, and is redirected by 180° to be wound on the travelling drum B 32. The forward travelling wire rope 15, the reverse travelling wire rope 17 and the hoisting wire rope group are wound on the lower trolley 3 without mutual interference. In the present disclosure, through the lower-trolley travelling mechanism 5 and the lower-trolley travelling winding system 6 that are unique, the lower-trolley travelling winding system 6 is effectively staggered from the wire rope of the upper trolley 2 without mutual interference, and drives the lower trolley 3 to travel along the girder to realize independent travelling, so that the two trolleys operate independently at the same time, thereby improving the efficiency of the quay crane.

WHAT IS CLAIMED IS:

1. A system comprising:

a travelling wire rope winding system and travelling mechanism for an external lower trolley of a conventional quay crane;

an upper trolley (2) comprising an upper-trolley travelling mechanism (7);

a quay crane machine room (4); and

a double-trapezoidal four-track girder (1),

wherein the upper-trolley travelling mechanism (7) of the upper trolley (2) is provided in the quay crane machine room (4),

wherein the travelling wire rope winding system and travelling mechanism comprises a lower-trolley travelling mechanism (5) and a lower-trolley travelling winding system (6), and the lower-trolley travelling mechanism (5) is configured to drive a lower trolley (3) to travel along the double-trapezoidal four-track girder (1) by means of the lower-trolley travelling winding system (6);

wherein the lower-trolley travelling mechanism (5) is also provided in the machine room (4), wherein the lower-trolley travelling mechanism (5) comprises a lower-trolley travelling mechanism A (8) and a lower-trolley travelling mechanism B (9), and the lower-trolley travelling mechanism A (8) and the lower-trolley travelling mechanism B (9) are provided on a left side and a right side of the upper-trolley travelling mechanism (7), respectively;

wherein the lower-trolley travelling mechanism A (8) comprises a travelling drum A (11), a motor (28) and a speed reducer (29), wherein one side shaft of the speed reducer (29) is connected to the motor (28), and the other side shaft of the speed reducer (29) is connected to the travelling drum A (11); and the lower-trolley travelling mechanism B (9) comprises a travelling drum B (32), a motor (28) and a speed reducer (29), wherein one side shaft of the speed reducer (29) is connected to the motor (28), and the other side shaft of the speed reducer (29) is connected to the travelling drum B (32);

wherein the lower-trolley travelling winding system (6) comprises a lower-trolley travelling winding group A (26) and a lower-trolley travelling winding group B (27), the lower-trolley travelling mechanism A (8) drives the lower trolley (3) to travel forward by means of the lower-trolley travelling winding group A (26), and the lower-trolley travelling mechanism B (9) drives the lower trolley (3) to travel backward by means of the lower-trolley travelling winding group B (27);

wherein the lower trolley (3) comprises a first horizontal support (34), a second horizontal support (36), a first vertical support A (37) and a second vertical support B (38), wherein one end of the second horizontal support (36) is vertically provided with the first vertical support A (37), the other end of the second horizontal support (36) is vertically provided with the second vertical support B (38), the first horizontal support (34) is arranged above and parallel to the second horizontal support (36), one end of the first horizontal support (34) is connected to the first vertical support A (37), and the other end of the first horizontal support (34) is connected to the second vertical support B (38); and

the lower-trolley travelling winding group A (26) comprises a forward travelling wire rope (15), further comprises a first quay crane redirecting pulley (16) and a second quay crane redirecting pulley (18) mounted on two sides of the quay crane, further comprises a first girder redirecting pulley block (23) and a second girder redirecting pulley block (25) mounted on two sides of the double-trapezoidal four-track girder (1), further comprises a first lower-trolley redirecting pulley block (19) and a second lower-trolley redirecting pulley block (20) mounted on left and right sides of the first horizontal support (34), and further comprises a lower-trolley redirecting pulley a (30) and a lower-trolley redirecting pulley b (31) mounted on left and right sides of the second horizontal support (36), wherein one end of the forward travelling wire rope (15) is wound on the travelling drum A (11), and the other end of the forward travelling wire rope (15), after being first wound through the first girder redirecting pulley block (23), then wound through the first quay crane redirecting pulley (16) to be redirected by 180°, then wound through the first lower-trolley redirecting pulley block (19) to be redirected vertically downward, wound through the lower-trolley redirecting pulley a (30), then wound through the lower-trolley redirecting pulley b (31) to be redirected vertically upward, wound through the second lower-trolley redirecting pulley block (20) to be redirected, then wound through the second quay crane redirecting pulley (18) to be redirected by 180°, wound through the second girder redirecting pulley block (25), is finally wound on the travelling drum B (32).

2. The system of claim 1, wherein the lower-trolley travelling winding group B (27) comprises a reverse travelling wire rope (17), further comprises a third quay crane redirecting pulley (10) and a fourth quay crane redirecting pulley (12) mounted on the two sides of the quay crane, further comprises a third lower-trolley redirecting pulley block (21) and a fourth lower-trolley redirecting pulley block (22) mounted on the left and right sides of the first horizontal support (34), and further comprises a lower-trolley redirecting pulley c (33) and a lower-trolley redirecting pulley d (35) mounted on the left and right sides of the second horizontal support (36), wherein one end of the reverse travelling wire rope (17) is wound on the travelling drum A

(11), a winding direction of the reverse travelling wire rope (17) is opposite to that of the forward travelling wire rope (15), and the other end of the reverse travelling wire rope (17), after being first wound through the third quay crane redirecting pulley (10) to be redirected by 180°, wound through the third lower-trolley redirecting pulley block (21) to be redirected vertically downward, then wound through the lower-trolley redirecting pulley c(33), then wound through the lower-trolley redirecting pulley d (35) to be redirected vertically upward, wound through the fourth lower-trolley redirecting pulley block (22), then wound through the fourth quay crane redirecting pulley (12) to be redirected by 180°, is wound on the travelling drum B (32).

3. The system of claim 2, wherein a first tension device (13) is further provided above the first girder redirecting pulley block (23), and the first tension device (13) comprises a hydraulic cylinder and a push rod, wherein an end portion of the hydraulic cylinder is pivotally connected to one end of the push rod; the first girder redirecting pulley block (23) comprises a first pulley (101), a second tension pulley (102) and a third tension pulley (103), wherein the first pulley (101) and the third tension pulley (103) are arranged in tandem at an equal height, the second tension pulley (102) is provided above the first pulley (101) and the third tension pulley (103), the second tension pulley (102) is fixed to the other end of the push rod away from the hydraulic cylinder, and the second tension pulley (102) is capable of moving back and forth under the action of the push rod; wherein the forward travelling wire rope (15) is first wound through the first pulley (101) from below, goes vertically upward to be wound through the second tension pulley (102), and is redirected by 180° to go vertically downward to be wound through the third tension pulley (103).

4. The system of claim 3, wherein a second tension device (14) is further provided above the second girder redirecting pulley block (25), and the second tension device (14) comprises a hydraulic cylinder and a push rod, wherein an end portion of the hydraulic cylinder is pivotally connected to one end of the push rod; the second girder redirecting pulley block (25) comprises a fourth pulley (104), a fifth tension pulley (105) and a sixth pulley (106), wherein the fourth pulley (104) and the sixth pulley (106) are arranged in tandem at an equal height, the fifth tension pulley (105) is provided above the fourth pulley (104) and the sixth pulley (106), the fifth tension pulley (105) is fixed to the other end of the push rod away from the hydraulic cylinder, and the fifth tension pulley (105) is capable of moving back and forth under the action of the push rod; wherein the forward travelling wire rope (15) is first wound through the sixth pulley (106) from below, goes vertically upward to be wound through the fifth tension pulley (105), and is redirected by 180° to go vertically downward to be wound through the fourth

pulley (104).

5. The system of claim 4, wherein the first lower-trolley redirecting pulley block (19) comprises a seventh pulley (107), an eighth pulley (108), a ninth pulley (109) and a tenth pulley (110), wherein the forward travelling wire rope (15) is first wound through the seventh pulley (107) from below, is redirected by 180° to be horizontally wound through the eighth pulley (108), is then wound through the ninth pulley (109) arranged perpendicular to the eighth pulley (108), then goes vertically downward to be wound through the tenth pulley (110), and continues to go vertically downward to be wound through the lower-trolley redirecting pulley a (30); and

the second lower-trolley redirecting pulley block (20) comprises an eleventh pulley (111), a twelfth pulley (112), a thirteenth pulley (113) and a fourteenth pulley (114), wherein the forward travelling wire rope (15) is first wound through the eleventh pulley (111), goes vertically upward to be wound through the twelfth pulley (112), is then wound through the thirteenth pulley (113), is then wound through the fourteenth pulley (114) arranged perpendicular to the thirteenth pulley (113), and is redirected by 180° to be wound through the second quay crane redirecting pulley (18).

6. The system of claim 5, wherein the third lower-trolley redirecting pulley block (21) comprises a fifteenth pulley (115), a sixteenth pulley (116), a seventeenth pulley (117) and an eighteenth pulley (118), wherein the reverse travelling wire rope (17) is first wound through the fifteenth pulley (115) from below, is redirected by 180° to be horizontally wound through the sixteenth pulley (116), is then wound through the seventeenth pulley (117) arranged perpendicular to the sixteenth pulley (116), then goes vertically downward to be wound through the eighteenth pulley (118), and continues to go vertically downward to be wound through the lower-trolley redirecting pulley c (33); and

the fourth lower-trolley redirecting pulley block (22) comprises a nineteenth pulley (119), a twentieth pulley (120), a twenty-first pulley (121) and a twenty-second pulley (122), wherein the reverse travelling wire rope (17) is first wound through the nineteenth pulley (119), then goes vertically upward to be wound through the twentieth pulley (120), continues to be wound through the twenty-first pulley (121) arranged perpendicular to the twentieth pulley (120), is then wound through the twenty-second pulley (122) arranged perpendicular to the twenty-first pulley (121), and is redirected by 180° to be wound through the fourth quay crane redirecting pulley (12).

7. The system of claim 6, wherein the third quay crane redirecting pulley (10) and the fourth quay crane redirecting pulley (12) are arranged in parallel at an equal height and arranged in

front of the lower-trolley travelling mechanism (5); the first girder redirecting pulley block (23) and the second girder redirecting pulley block (25) are arranged in parallel at an equal height and arranged behind the lower-trolley travelling mechanism (5); the first quay crane redirecting pulley (16) and the second quay crane redirecting pulley (18) are arranged in parallel at an equal height and arranged behind the lower-trolley travelling mechanism (5); and the first girder redirecting pulley block (23) is provided between the travelling drum A (11) and the first quay crane redirecting pulley (16), and the second girder redirecting pulley block (25) is provided between the travelling drum B (32) and the second quay crane redirecting pulley (18).

8. The system of claim 7, wherein the first lower-trolley redirecting pulley block (19), the second lower-trolley redirecting pulley block (20), the third lower-trolley redirecting pulley block (21) and the fourth lower-trolley redirecting pulley block (22) are arranged at an equal horizontal height, the first lower-trolley redirecting pulley block (19) and the second lower-trolley redirecting pulley block (20) are arranged on a rear side of the lower trolley (3), and the third lower-trolley redirecting pulley block (21) and the fourth lower-trolley redirecting pulley block (22) are arranged on a front side of the lower trolley (3); wherein the lower-trolley redirecting pulley a (30), the lower-trolley redirecting pulley b (31), the lower-trolley redirecting pulley c (33) and the lower-trolley redirecting pulley d (35) are arranged at an equal horizontal height, the lower-trolley redirecting pulley a (30) and the lower-trolley redirecting pulley b (31) are arranged on a rear side of the lower trolley (3), and the lower-trolley redirecting pulley c (33) and the lower-trolley redirecting pulley d (35) are arranged on a front side of the lower trolley (3).

9. The system of claim 8, wherein an outer side surface of the second horizontal support (36) is further provided with a plurality of rope dragging frames (24), and the forward travelling wire rope (15) and the reverse travelling wire rope (17) are arranged on the rope dragging frames (24), respectively.