

STACKER CRANE

5 The present invention relates to a stacker crane
for an automatic warehouse for the temporary storage of
loads, and particularly to a stacker crane which can
shorten the operating cycle time.

10 For the temporary storage of products and articles
to be processed in a factory or a warehouse, an
automatic warehouse may be used which comprises a
series of shelves having a plurality of faces arranged
in a matrix fashion and a stacker crane which moves in
front of the series of shelves to carry loads back and
forth. The stacker crane comprises a travel truck
15 which travels along a track and an elevatable platform
which moves up and down a mast which stands upright on
the travel truck. The platform is provided with a
shuttle fork, by which loads are delivered between the
frontages and the platform which travels and is moved
20 up and down with loads placed on the fork. The
acceleration of the platform is adjusted so that loads
on the fork do not collapse due to the shock at the
time of acceleration and deceleration during the
travelling and the upward and downward movement.

25 As described above, it is necessary, in the
stacker crane, to limit its acceleration during the
movement thereof so that the loads do not collapse or
become crushed. This limitation affects the cycle time
of operation of the stacker crane.

30 It is therefore an object of the present invention
to provide a stacker crane which is capable of
shortening the cycle time of operation if circumstances
allow.

35 For achieving the aforesaid object, the present
invention provides a stacker crane comprising:

a movable truck;

at least one mast;

a platform movable on said at least one mast;

5 motor means arranged to drive the truck and the platform;

load detection means for detecting the presence or absence of a load on the platform;

and control means comprising memory means storing a plurality of moving speed patterns for the crane, the
10 control means being arranged to select from said plurality of patterns a pattern determined by a signal from said load detection means and to actuate the movement of the crane in accordance with the selected pattern.

15 In the stacker crane, the load detection means may comprise a weight detection sensor capable of outputting values continuously according to the weight of a load, and then said control means selects a moving speed pattern from said plurality of patterns in
20 dependence upon the value output from the weight detection sensor.

Furthermore, in a preferred embodiment of the stacker crane, a control stop means for detecting speed-reduction docks near each end of a travel route
25 of the crane is arranged to stop the travel of the crane and is provided with an operating delay means for starting the speed reduction only after travelling a given distance from a position at which said speed-reduction docks were detected.

30 With the above-described structures, the present invention has the functions as noted below.

The stacker crane is provided with a load detection means to detect whether a load is present or not on the stacker crane. A signal from the load
35 detection means is sent to a control means. The

control means sets an appropriate moving speed pattern for the stacker crane in accordance with whether or not a load is present on the stacker crane. The moving speed pattern represents variations in speed patterns between start and stop and includes factors such as an accelerating time, a magnitude of maximum speed, a travelling time at the maximum speed, a staged braking

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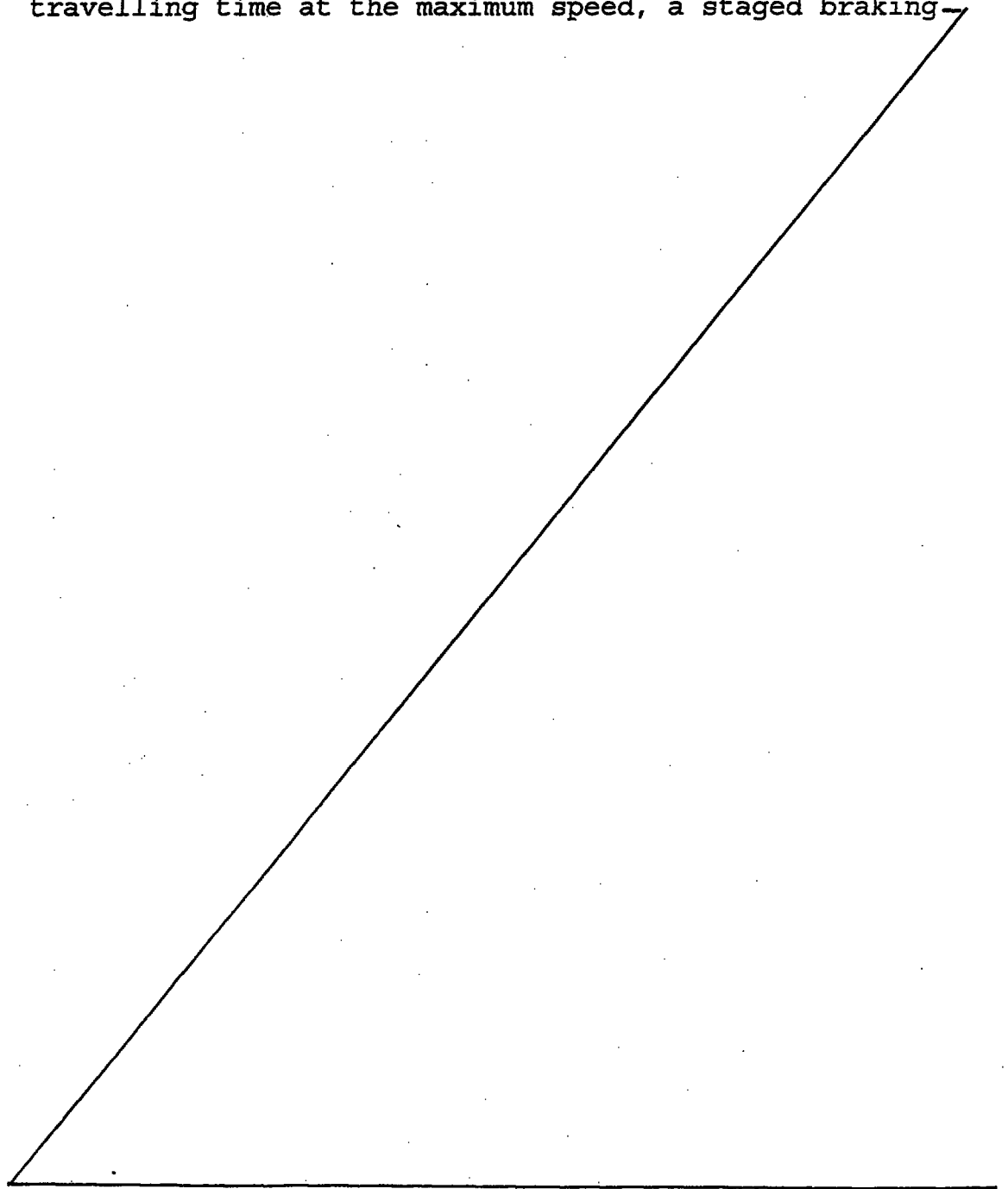
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at the deceleration, etc. If a load is not present, possible load collapse need not be taken into consideration. Specifically, the appropriate moving speed pattern is the rough moving speed pattern such that the stacker crane is accelerated at high acceleration to reach a high speed in a short period of time, and the stacker crane is rapidly braked immediately before a target position. If a load is present, the stacker crane starts being moved at a relatively low acceleration, and is operated at a moving speed pattern so as to be slowly decelerated at the time of stopping to prevent loads from being collapsed.

In the stacker crane, the load detection means may be a weight detection sensor capable of outputting values continuously in accordance with the weight of a load. This weight detection sensor can detect the weight of a load in addition to the presence or absence of the load. Generally, the more the weight of a load increases, the more the load on a motor increases. Therefore, the control means sets a moving speed pattern so that the rate of acceleration decreases as the weight of a load increases. The moving speed pattern is set by selecting it from a plurality of stages of moving speed patterns or changing it so that there are no separate stages.

The stacker crane travels back and forth in front of a series of shelves. In the vicinity of both ends of a travel route, speed-reduction docks are preferably arranged, to prevent an overrun of the stacker crane and to stop it at a given position. The stacker crane is preferably provided with a control stop means which decelerates the travel of the stacker crane immediately when detecting the speed-reduction docks. The speed-reduction docks are arranged at a

position where the stacker crane starts deceleration from the normal maximum speed and stops at a given position. With the structure described above, the speed-reduction docks can sometimes be detected in accordance with different moving speed patterns. In this case, the operating delay means travels a suitable distance from a position where the speed-reduction dock is detected and thereafter starts a deceleration to reduce as much as possible the distance for which it travels at a low speed.

In order that the invention may be fully understood, a number of embodiments will now be described with reference to the accompanying drawings, in which:

Fig. 1 is a schematic plan view showing an automatic warehouse including a first embodiment of a stacker crane according to the present invention.

Fig. 2 is an enlarged perspective view showing an elevatable platform of the stacker crane according to the first embodiment.

Fig. 3 is a block diagram showing essential portions of a control system of the stacker crane according to the first embodiment.

Fig. 4 is a flow chart showing the control process of the stacker crane according to the first embodiment.

Figs. 5a and 5b show the relationship between speed and time, and show moving speed patterns for the travelling and the elevating in the first embodiment.

Fig. 6 shows the relationship between speed and time showing the mode of deceleration after a speed-reduction dock is detected.

Fig. 7 is a perspective view showing an elevatable platform of a second embodiment of a stacker crane according to the present invention.

Fig. 8 is a block diagram showing essential portions of a control system of the stacker crane according to the second embodiment.

5 Fig. 9 is a flow chart showing the control process of the stacker crane according to the second embodiment.

Fig. 10 shows the relationship between speed and time showing moving speed patterns for both travelling and elevating in the second embodiment.

10 In Fig. 1 a stacker crane 2 travels along a rail 3 in front of a series of shelves 1 of an automatic warehouse. An input/output station 4 is arranged near one end of the series of shelves 1.

15 The stacker crane 2 comprises a travelling truck 5, two masts 6, 6 set vertically on the travelling truck 5, and a mobile platform 7 which moves up and down the two masts 6, 6. The platform 7 is provided with a fork 8 for movement of a load W between the front of the series of shelves 1 and the
20 input/output station 4. The stacker crane 2 is operated automatically by a control device 9 provided on the stacker crane.

Fig. 2 is an enlarged perspective view of the mobile platform 7 shown in Fig. 1. The platform 7 is
25 provided with a light emitter 10 and a light receiver 11. When a load W is placed on the fork 8, an optical beam L emitted by the light emitter 10 is intercepted by the load W so that an input to the light receiver 11 disappears. Thus one can determine whether the load W
30 is present or absent.

Fig. 3 is a block diagram showing the construction of a control system including the control device 9 of the stacker crane 2 shown in Fig. 1. The control device 9 controls a travel motor 12 for driving
35 the travelling truck 5 and an elevating motor 13 for

elevating the platform 7. The rotation of the travel motor 12 and of the elevating motor 13 is detected by encoders 14 and 15 respectively, and this information is fed back to the control device 9. To the control device 9 are connected the light receiver 11, a photoelectric sensor 17 for detecting speed-reduction docks 16, 16, and a communication device 18 to exchange information with a central control device (not shown) on the ground. To the control device 9 is also connected a memory device 19 for storing moving speed patterns. In practice, a memory in a board of a CPU plays the role of this memory device.

The stacker crane 2 having the control system as described above receives a carrier command from the central control device through the communication device 18 and drives the travel motor 12 and the elevating motor 13 in accordance with the carrier command to move between the designated frontage and the input/output station 4 to perform the delivery of a load W.

Fig. 4 is a flow chart showing the process of control of the stacker crane 2 utilising the control system shown in Fig. 3.

When the stacker crane 2 receives the carrier command and begins the load delivery operation by the fork 8, the stacker crane 2 drives the travel motor 12 and the elevating motor 13 to move the platform 7 to the target position. Before moving, the control device 9 recognizes whether the load W is present on the fork 8 or not according to whether the light receiver 11 is ON or OFF (Step 1). If the load W is present, the control device 9 reads pattern A out of two moving speed patterns stored in the memory device 19. If the load W is absent, it reads pattern B (Step 2). The travel motor 12 and the elevating motor 13 are then driven in accordance with the read pattern to move the

platform 7 to the target position (Step 3).

Figs. 5a and 5b show examples of the moving speed patterns of the travelling truck 5 and of the platform 7 respectively.

5 Fig. 5a shows one example of a moving speed pattern for the travel of the travelling truck 5. Pattern A and pattern B are represented by solid lines A and B respectively. In the case of pattern A, the travelling truck 5 is accelerated at a given
10 acceleration from a standing start to a high speed v_2 , is decelerated at a given deceleration near the target position and stops via a low speed v_3 and a lower final speed v_4 . In pattern B, the travelling truck 5 is accelerated at a higher acceleration than that of
15 pattern A, travels at a high speed v_1 , higher than v_2 , and is decelerated at a higher deceleration. The patterns of the deceleration after the low speed v_3 are the same.

20 It is found from a comparison between the two moving speed patterns A and B that both the acceleration and deceleration of pattern B are higher than those of pattern A. Accordingly, in the case where a load is actually present, the acceleration and the maximum speed are less in order to prevent the load
25 from being crushed or collapsing due to the shock on the load. On the other hand, in the case where a load is not present, no considerations of load collapse are necessary, and thus the travelling truck can travel at a higher acceleration and a higher maximum speed. As a
30 result, in the case of pattern B, it is possible to reduce the time required for the movement from time t_A to time t_B .

35 Again in Fig. 5b, the mode after the low speed v_7 is similar to that before and again the acceleration and high speed v_5 of pattern B is higher

than the acceleration and high speed v_6 of pattern A. Therefore, in pattern A there is less shock on the load W, but in pattern B the moving time is less.

5 As described above, in the stacker crane 2 according to the present embodiment, the presence or absence of a load is detected by the light emitter 10 and the light receiver 11, on the basis of which the control device 9 reads a suitable moving speed pattern from the memory device 19, and the travel motor 12 and
10 the elevating motor 13 of the stacker crane 2 are driven in accordance with the thus read pattern. Thereby, the platform 7 can be moved without load collapse where a load is present and it can be moved in a shorter time in the case where a load is absent.
15 With this, the time required for movement where a load is absent can be shortened, and the cycle time for an operation can be shortened.

The maximum speed and acceleration of the moving speed patterns stored in the memory device 19
20 can be changed by rewriting the data. In particular, in pattern A where a load is present, the maximum speed and acceleration can be adjusted to maximum levels at which no load collapse occurs due to factors such as weight W or the type of loads handled in the automatic
25 warehouse, so that the cycle time can be reduced as much as possible.

To deal with the presence of different maximum speeds, it is necessary to change the timing of a controlled speed reduction. As shown in Fig. 1,
30 controlled speed-reduction docks 16, 16 are arranged near both ends of the rail 3 for the stacker crane 2. The controlled speed-reduction docks 16, 16 are shield plates standing upright on the floor surface. The controlled speed-reduction docks 16, 16 are detected by
35 a shield-type photoelectric sensor 17 (see Fig. 3)

provided on the side of the stacker crane 2.

Fig. 6 shows the change of the travelling speed of the stacker crane 2 after the speed-reduction docks 16, 16 have been detected. Suppose that the shield-type photoelectric sensor 17 detects the speed-reduction dock 16 at a time t_s , when the stacker crane passes at speed v_2 , then the control device 9 immediately causes it to begin deceleration. The stop position is a load delivery position in the input/output station 4 on the right-hand side as viewed in Fig. 1, and on the left-hand side the load delivery position is at the left front end of the series of shelves 1.

If the deceleration starts immediately, when the speed-reduction dock 16 is detected while travelling at the speed v_1 , higher than the speed v_2 , a low speed and a final speed is reached considerably earlier than the fixed stop position. Therefore, the time for travelling at low speed increases. In this case, the control device 9 measures the distance from when the speed-reduction dock 16 has been detected by the encoder 14 for detecting the rotation of the travel motor 12, and starts deceleration at time t_s' after travelling a predetermined distance, whereby the time for which the truck travels at high speed is increased and the cycle time is shortened. While the distance is detected by the encoder 14, it is to be noted that a timer is connected to the control device 9 so that a given time is counted so as to delay the start of deceleration.

Fig. 7 is a perspective view showing a second embodiment of platform for the stacker crane of the present invention. The platform 20 can be installed in an automatic warehouse as shown in Fig. 1, similarly to the first embodiment.

The platform 20 is provided with a weight sensor 22 below a fork 21 as a load detection means. The weight sensor 22 detects a weight applied to the fork 21 thereby to detect whether a load has been placed on the fork or not and outputs the magnitude of the weight as a continuous value.

As shown in Fig. 8, the weight sensor 22 is connected to a control device 23, and a memory device 24 with a plurality of moving speed patterns stored therein is connected to the control device 23. Other structural members are similar to those described in the first embodiment.

Fig. 9 is a flow chart showing the process of control in the second embodiment. This is substantially the same as that shown in Fig. 4. However, in this embodiment, if in Step 1 it is determined that a load is present, the control device 23 receives a measured value of the weight outputted by the weight sensor 22 (Step 4), and a speed pattern suitable for the purpose is selected from the moving speed patterns stored in the memory device 24 and is read in accordance with the measured value (Step 5).

Fig. 10 shows one example of selectable moving speed patterns for a travelling truck in the second embodiment. Similarly to the example shown in Fig. 5a, when a load is not present, the truck travels according to pattern B, and when a load is present the truck travels according to pattern A. When the weight of the load is large, a pattern A' is selected. In pattern A', the acceleration is less than that of pattern A, and the high speed v_2' is also less. This is because, generally, the larger the weight of load, the larger the load on the drive motor. The carrier time $t_{A'}$ increases, but the acceleration and high speed are controlled according to the weight of load in order

to make the load on the motor substantially constant. If the load is heavier, the acceleration and high speed decrease. If the load is light, the acceleration and high speed increase. The performance of the motor is always brought into full play whereby the carrying is performed in a short period of time. The moving speed pattern for the elevation of the platform is set in like manner.

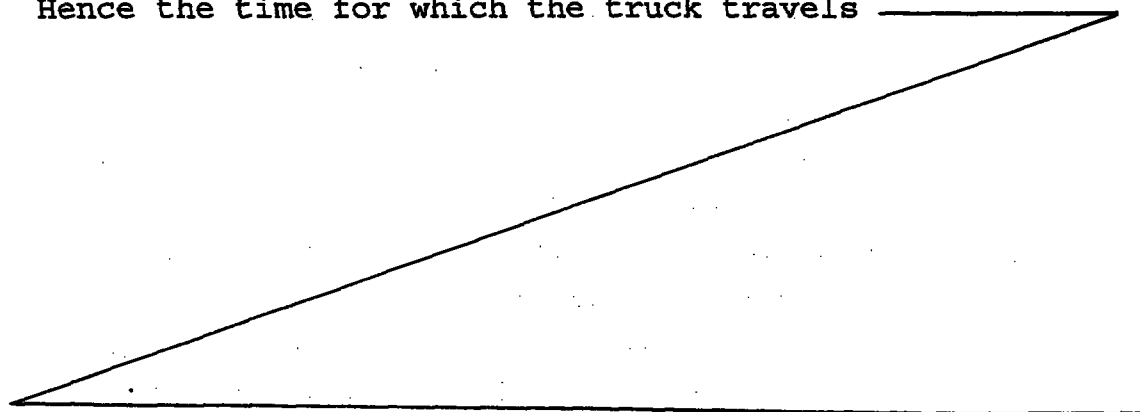
With the stacker crane of the present invention, its speed pattern changes depending upon the presence or absence of loads detected by the load detection means. Hence, when a load is not present the carrying time can be shortened as compared with the case where a load is present, thereby shortening the cycle time.

According to the second embodiment of stacker crane of the present invention, the weight detection sensor detects the weight of a load in addition to the presence or absence of a load and sets a moving speed pattern according to the weight of the load. Hence, the minimum carrier time which can be attained without load collapse can be obtained, whereby the carrier time where a load is present can be shortened to shorten the cycle time.

Furthermore, operation delay means can delay the operation of the speed-rotation means according to the truck speed when the speed-reduction dock is detected. Hence the time for which the truck travels

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at the maximum speed can be made as long as possible,
thereby shortening the carrier time.

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CLAIMS:

1. A stacker crane comprising:
a movable truck;
at least one mast;
5 a platform movable on said at least one mast;
motor means arranged to drive the truck and the platform;

load detection means for detecting the presence or absence of a load on the platform;

10 and control means comprising memory means storing a plurality of moving speed patterns for the crane, the control means being arranged to select from said plurality of patterns a pattern determined by a signal from said load detection means and to actuate the
15 movement of the crane in accordance with the selected pattern.

2. A stacker crane according to claim 1, wherein said load detection means comprises a weight detection sensor capable of outputting values continuously
20 according to the weight of a load, and said control means selects a moving speed pattern from said plurality of moving speed patterns in dependence upon the value from the weight detection sensor.

3. A stacker crane according to claim 1 or 2,
25 wherein a control stop means for detecting speed-reduction docks near each end of a travel route of the crane is arranged to stop the travel of the crane and is provided with an operating delay means for starting the speed reduction only after travelling a given
30 distance from a position at which said speed-reduction docks were detected.

4. A stacker crane substantially as hereinbefore described with reference to Figs. 1 to 6 or Figs. 7 to 10 of the accompanying drawings.