# PATENT SPECIFICATION

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## (54) CARRIAGES HAVING WALKING MECHANISMS FOR TRANSPORTING ARTICLES


(71) We, MITSUI SHIPBUILDING & ENGINEERING CO., LTD., a corporation organized and existing under the laws of Japan of 6-4, Tsukiji 5-chome, Chuo-ku, Tokyo, 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:—


This invention relates to a truck or carriage which can be designed for transporting extremely heavy articles or structures such as prefabricated blocks for constructing ships in a dockyard.

A conventional carriage is provided with a plurality of wheels or caterpillar tracks wherein the ground pressure is calculated by dividing the sum of the weight of the carriage and that of the load supported thereon by the effective ground-engaging area, so that there is a limit for the weight of the article that can be safely transported. More particularly, where an extremely heavy structure is loaded on the carriage the ground-engaging pressure of the wheels becomes very large so that the ground surface is required to be prohibitively strong or the carriage is required to have a large member of wheels capable of supporting the huge weight. However, the ratio of the ground-engaging arc of the wheels is limited to a very small value in view of the power efficiency. Also in the case of a carriage equipped with caterpillar tracks the effective ground support surface is limited to the area under the influence of the track supporting wheels. Moreover, the direction of movement of the conventional carriage is limited to the direction of the running wheels so that in order to vary the direction of movement of the carriage it is necessary to change and adjust the direction of the wheels by a complicated mechanism. To move the carriage in any direction not only is it necessary to give extremely complicated command signals but also the slip of the wheels at the time of turning, which is inevitable owing to the width of the wheels, results in a detrimental effect upon the ground surface and the wheels so that it is difficult to provide a fine and accurate movement of the carriage.

Accordingly, it is an object of this invention to provide a carriage that can safely transport extremely heavy objects and can be moved or adjusted accurately.

A further object of this invention is to provide an improved carriage having a much larger grounding surface than the conventional carriage thus eliminating the necessity of constructing running ways having a large load supporting capacity.

A still further object of this invention is to provide an improved carriage that can be moved or adjusted in three dimensions.

Another object of this invention is to provide an improved carriage capable of safely transporting or adjusting the position of heavy articles in a narrow space.

According to this invention there is provided a carriage for transporting articles comprising a base frame in the form of an inverted box, a plurality of supporting legs secured to the lower surface of the base frame adjacent the periphery and adjacent the centre of the base frame, a plurality of vertical fluid pressure cylinders connected to the lower surface of the base frame, a plurality of shoes, each connected to the lower end of the piston rod of one of the vertical fluid pressure cylinders through a pair of cooperating slide members, one of the slide members being disposed to be slidable in the longitudinal direction and the other to be slidable in the transverse direction of the shoes, and a plurality of fluid pressure piston-cylinder assemblies for moving the shoes in the transverse and longitudinal directions of the base frame. Preferably the base frame is rectangular.

The invention will be further described


[Price 25p]

Price 75p

with reference to the accompanying drawings which illustrate, by way of example, a carriage in accordance with the invention. In the drawings:—

Figure 1 is a top plan view of the carriage, with a base frame partly broken away to show underneath structure,

Figure 2 shows a front elevation view of the carriage shown in Figure 1, partly in section,

Figure 3 is a detail perspective view to an enlarged scale showing oil pressure cylinders and a running shoe assembly at one supporting point of the carriage,

Figure 4 is a diagrammatic top plan view of the sub-assembly shown in Figure 3,

Figures 5 to 9 are diagrammatic front elevation views of the carriage to illustrate motion to illustrate the motion of the carriage in various steps of its advancement,

Figure 10 is a front elevation of a composite wheel having a plurality of small auxiliary wheels and

Figure 11 is a side view of the wheel shown in Figure 10.

With reference to Figs. 1 and 2, the carriage embodying the invention comprises an inverted box shaped base frame 1 of rectangular welded structure, a plurality of supporting legs 2 provided at the four corners and adjacent the centre of the base frame 1, each leg having a ground-engaging area sufficient to carry the load. Four points 3 are selected in the area of the base frame 1 and four vertical cylinders 4 are secured to the lower surface of the frame 1 at these points. The lower ends of pistons received in the cylinders 4 are coupled to transverse slides 6 through universal couplings 5. Each of the transverse slides 6 is slidably received in a slidable metal block 7 which is slidably mounted on a longitudinal slide table 8. Each slide table 8 is formed with an integral shoe 9 which is supported directly on the ground surface with a sufficiently large plane ground-engaging area.

The shoes 9 of each adjacent pair are interconnected by two links 10 and 11 in the transverse as well as longitudinal directions so that these shoes may be nearly maintained at a predetermined spacing. The inner ends of the opposing links 10 and 11 are connected together by means of a shaft 12 provided with composite wheels 13 having part-spherical surfaces. As best shown in Figs. 10 and 11, each composite wheel 13 comprises a boss 14 rotatively mounted on a shaft 12 and a plurality of auxiliary wheels 15 with their supporting shafts journalled in the boss 14 along a circle encircling the shaft 12, so that the composite wheel 13 does not resist the movement of the shaft 12 in any direction. As shown in Fig. 3, the inner ends of piston rods 19 and 20 respectively received in a longitudinal cylinder 17 and a transverse cylinder 18 are connected to each shoe 9 through universal knuckle joints 16, and also the clevis end of each cylinder is connected to a member 22 depending from the base frame 1 by means of a universal joint 21 shown in Fig. 2. The base frame 1 contains a power unit, not shown, in the form of an internal combustion engine or the like. The power unit is used to drive an oil pump, for supplying pressurized oil to all oil pressure systems, as well as an electric generator for supplying control power to all electric apparatus.

The running operation of the carriage will now be described with reference to Figs. 5 to 9. Upon receiving an "advance" command signal, the piston rods of the vertical cylinders 4 are elevated with the same stroke to slightly raise the respective shoes 9 above the ground surface as shown in Fig. 5. At this time, the four longitudinal cylinders 17 are operated simultaneously to extend the piston rods in the forward cylinders and to retract the piston rods in the rearward cylinders so that the shoes 9 are advanced to the foremost positions, as shown in Fig. 6. Then the piston rods of the four vertical cylinders 4 are moved downwardly to urge the four shoes 9 against the ground surface as shown in Fig. 7. Thereafter, the downward movement of the piston rods is continued to lift up the base frame 1 on the four shoes 9. Then the longitudinal cylinders 17 are operated in the opposite direction to advance the base frame 1 by the sliding movement of the blocks 7 along the longitudinal slide tables 8 of the shoes 9. At the end of the forward stroke, the piston rods of the cylinders 4 are moved upwardly to raise the shoes 9 with the result that the base frame 1 is lowered onto the ground surface as shown in Fig. 9. The piston rods are moved further upwardly to raise the shoes 9 from the ground surface thus resuming the condition shown in Fig. 5.

Rearward movement of the base frame is accomplished by reversing the order of operations of the longitudinal cylinders 17. In the same manner, the transverse cylinders 18 are operated appropriately for moving the base frame in either transverse direction. Where both transverse and longitudinal cylinders are operated simultaneously at a constant speed ratio, the base frame will be moved obliquely in a linear sense. Where the strokes of the piston rods of four longitudinal cylinders 17 and four transverse cylinders 18 are varied at such a correct ratio that the four points 3 are rotated about the centre of the base frame while it is lifted above the shoes 9, the base frame 1 of the carriage can be rotated with respect to the former position. Furthermore, where the four vertical cylinders correctly respond to appropriate command signals it

is possible to provide three dimensional attitude controls for the carriage.

The longitudinal cylinders 17 and the transverse cylinders 18 with their piston rods pivotally connected to respective shoes are so mounted that the axes of these cylinders mutually intersect at right angles when the shoes are brought to the neutral position with respect to the base frame 1 as shown in Fig. 4. Where the carriage is displaced $\Delta y$, by the operation of the longitudinal cylinders 17 it is necessary to displace the carriage by $\Delta x$ by operating the transverse cylinders 18. More particularly, the operation of the cylinder in one of three directions is related with the other two directions and should be performed in a complicated functional relationship for turning or otherwise moving the carriage. For running and attitude controls of the carriage, a geometrical analogue calculation is performed by using a model to provide length command signals to respective cylinders so as to control them by an oil pressure servomechanism. Thus, the effective length of the piston rods of respective cylinders is constantly measured and supervised and the measured length is fed back to the servomechanism.

As above described, according to this invention there is provided an improved carriage having a much greater ground-engaging area than the conventional carriage designed with wheels or tracks to run directly on the ground surface, so that the present carriage can safely transport extremely heavy articles, such as prefabricated blocks for building ships, without the necessity of considering severe conditions imposed upon the ground-engaging surfaces of the wheels of the carriage and upon the axes of the wheels and constructing running ways having a large load carrying capacity. Furthermore, the present carriage can be adjusted or moved in three dimensions which can never be attained by the conventional carriage supported by rolling wheels, thereby increasing the operational flexibility of the carriage. Thus, the carriage is particularly suitable for transporting heavy articles in a narrow space and to adjust the position or attitude thereof.

WHAT WE CLAIM IS:—

1. A carriage for transporting articles comprising a base frame in the form of an inverted box, a plurality of supporting legs secured to the lower surface of said base frame adjacent the periphery and adjacent the centre of the base frame, a plurality of vertical fluid pressure cylinders connected to the lower surface of said base frame, a plurality of shoes, each connected to the lower end of the piston rod of one of said vertical fluid pressure cylinders through a pair of cooperating slide members, one of said slide members being disposed to be slidable in the longitudinal direction and the other to be slidable in the transverse direction of said shoes, and a plurality of fluid pressure piston-cylinder assemblies for moving said shoes in the transverse and longitudinal directions of said base frame.

2. A carriage according to claim 1 wherein said base frame is rectangular.

3. A carriage according to claim 1, wherein each shoe comprises an integral slide bed extending in the longitudinal direction of said shoe, one of said slide members is slidably mounted on said slide bed and is provided with a groove extending in the transverse direction of said shoe for slidably receiving the other slide member, and the lower end of the piston rod of one of said vertical fluid pressure cylinders is connected to said other slide member through a universal joint.

4. A carriage according to claim 1, wherein pairs of said fluid pressure piston-cylinder assemblies are provided between adjacent shoes in the longitudinal and transverse directions of said base frame, one end of the piston rod of each piston-cylinder assembly is pivotally connected to the corresponding shoe whereas the opposing ends of the cylinders of each pair of fluid pressure piston-cylinder assembly are pivotally connected to said base frame.

5. A carriage according to claim 1, wherein the shoes of each adjacent pair thereof are interconnected by means of links in the longitudinal and transverse directions of said base frame.

6. A carriage according to claim 5, wherein the ends of said links remote from the shoes are interconnected through a shaft disposed transversely of the interconnected links and carrying a plurality of composite wheels, each composite wheel including a boss rotatably mounted on said shaft and a plurality of auxiliary wheels with axes journalled in said boss along a circle encircling said shaft.

7. A carriage for transporting articles as claimed in claim 1 and substantially as hereinbefore described with reference to any of the figures of the accompanying drawings.

is possible to provide three dimensional attitude controls for the carriage.

The longitudinal cylinders 17 and the transverse cylinders 18 with their piston rods pivotally connected to respective shoes are so mounted that the axes of these cylinders mutually intersect at right angles when the shoes are brought to the neutral position with respect to the base frame 1 as shown in Fig. 4. Where the carriage is displaced $\Delta y$, by the operation of the longitudinal cylinders 17 it is necessary to displace the carriage by $\Delta x$ by operating the transverse cylinders 18. More particularly, the operation of the cylinder in one of three directions is related with the other two directions and should be performed in a complicated functional relationship for turning or otherwise moving the carriage. For running and attitude controls of the carriage, a geometrical analogue calculation is performed by using a model to provide length command signals to respective cylinders so as to control them by an oil pressure servomechanism. Thus, the effective length of the piston rods of respective cylinders is constantly measured and supervised and the measured length is fed back to the servomechanism.

As above described, according to this invention there is provided an improved carriage having a much greater ground-engaging area than the conventional carriage designed with wheels or tracks to run directly on the ground surface, so that the present carriage can safely transport extremely heavy articles, such as prefabricated blocks for building ships, without the necessity of considering severe conditions imposed upon the ground-engaging surfaces of the wheels of the carriage and upon the axes of the wheels and constructing running ways having a large load carrying capacity. Furthermore, the present carriage can be adjusted or moved in three dimensions which can never be attained by the conventional carriage supported by rolling wheels, thereby increasing the operational flexibility of the carriage. Thus, the carriage is particularly suitable for transporting heavy articles in a narrow space and to adjust the position or attitude thereof.

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4. A carriage according to claim 1, wherein pairs of said fluid pressure piston-cylinder assemblies are provided between adjacent shoes in the longitudinal and transverse directions of said base frame, one end of the piston rod of each piston-cylinder assembly is pivotally connected to the corresponding shoe whereas the opposing ends of the cylinders of each pair of fluid pressure piston-cylinder assembly are pivotally connected to said base frame.

5. A carriage according to claim 1, wherein the shoes of each adjacent pair thereof are interconnected by means of links in the longitudinal and transverse directions of said base frame.

6. A carriage according to claim 5, wherein the ends of said links remote from the shoes are interconnected through a shaft disposed transversely of the interconnected links and carrying a plurality of composite wheels, each composite wheel including a boss rotatably mounted on said shaft and a plurality of auxiliary wheels with axes journalled in said boss along a circle encircling said shaft.

7. A carriage for transporting articles as claimed in claim 1 and substantially as hereinbefore described with reference to any of the figures of the accompanying drawings.

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