March 30, 1965 W. A. PAULSSEN 3,175,722

STACKER CRANE

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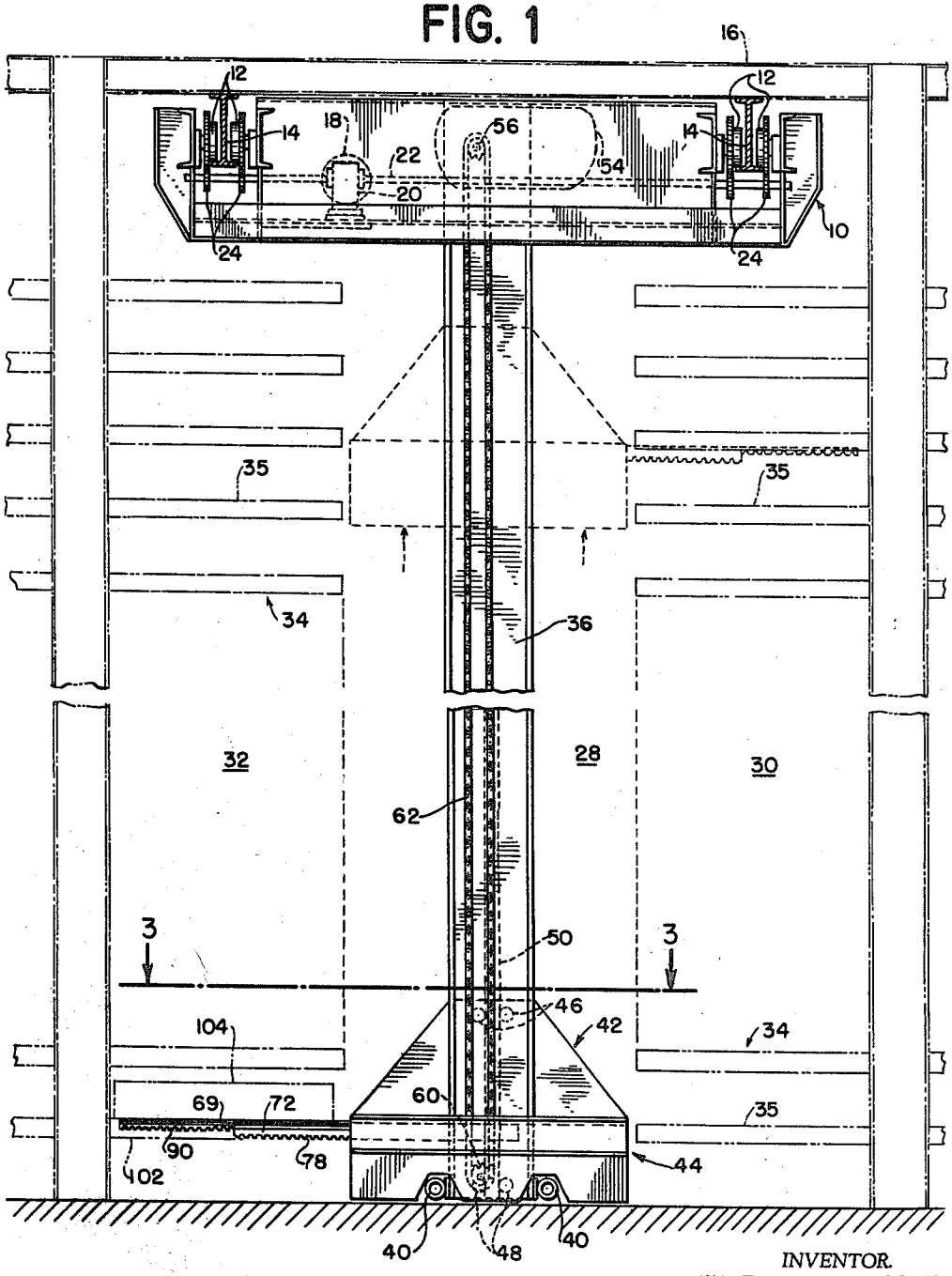
FIG. 1



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STACKER CRANE

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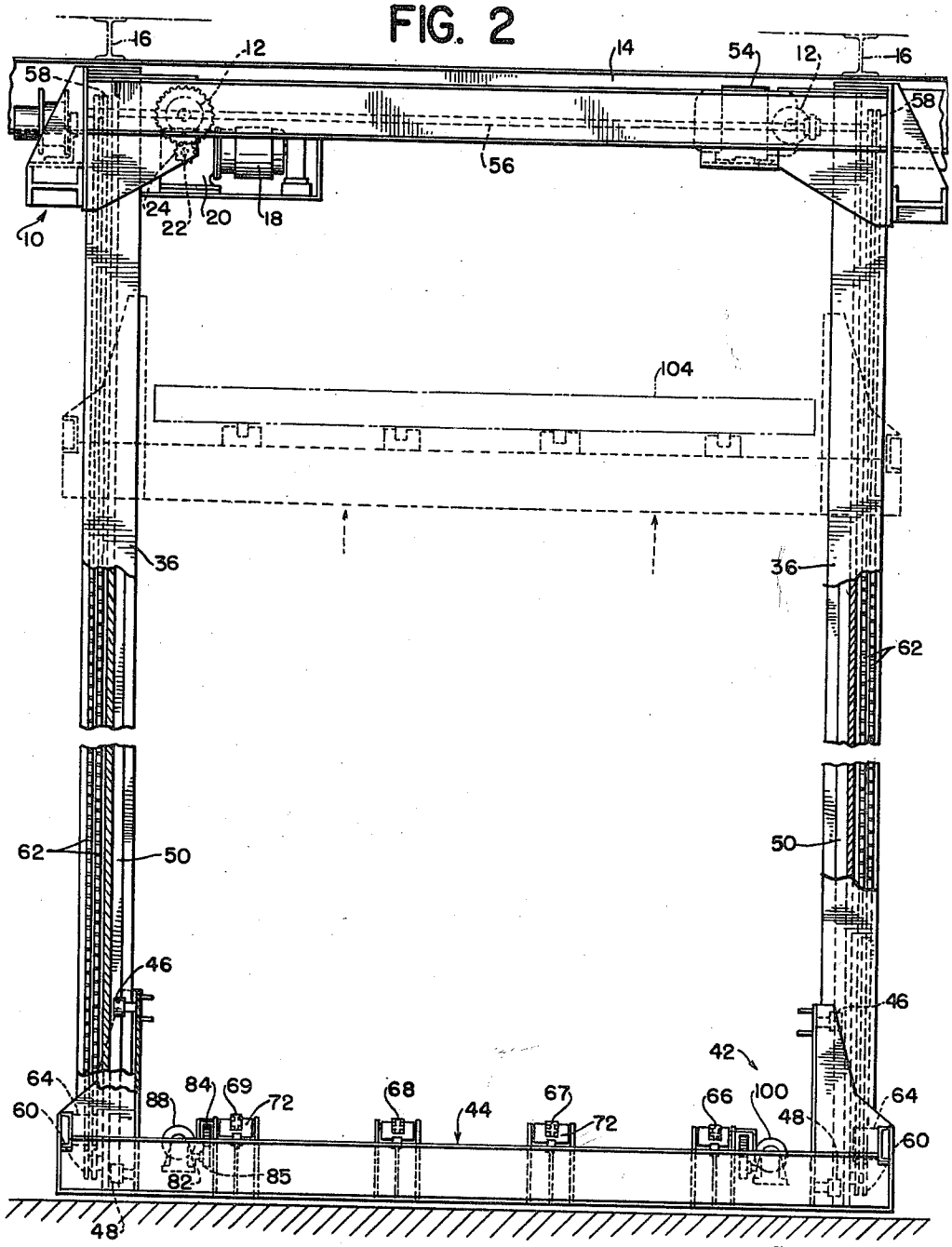
FIG. 2



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STACKER CRANE

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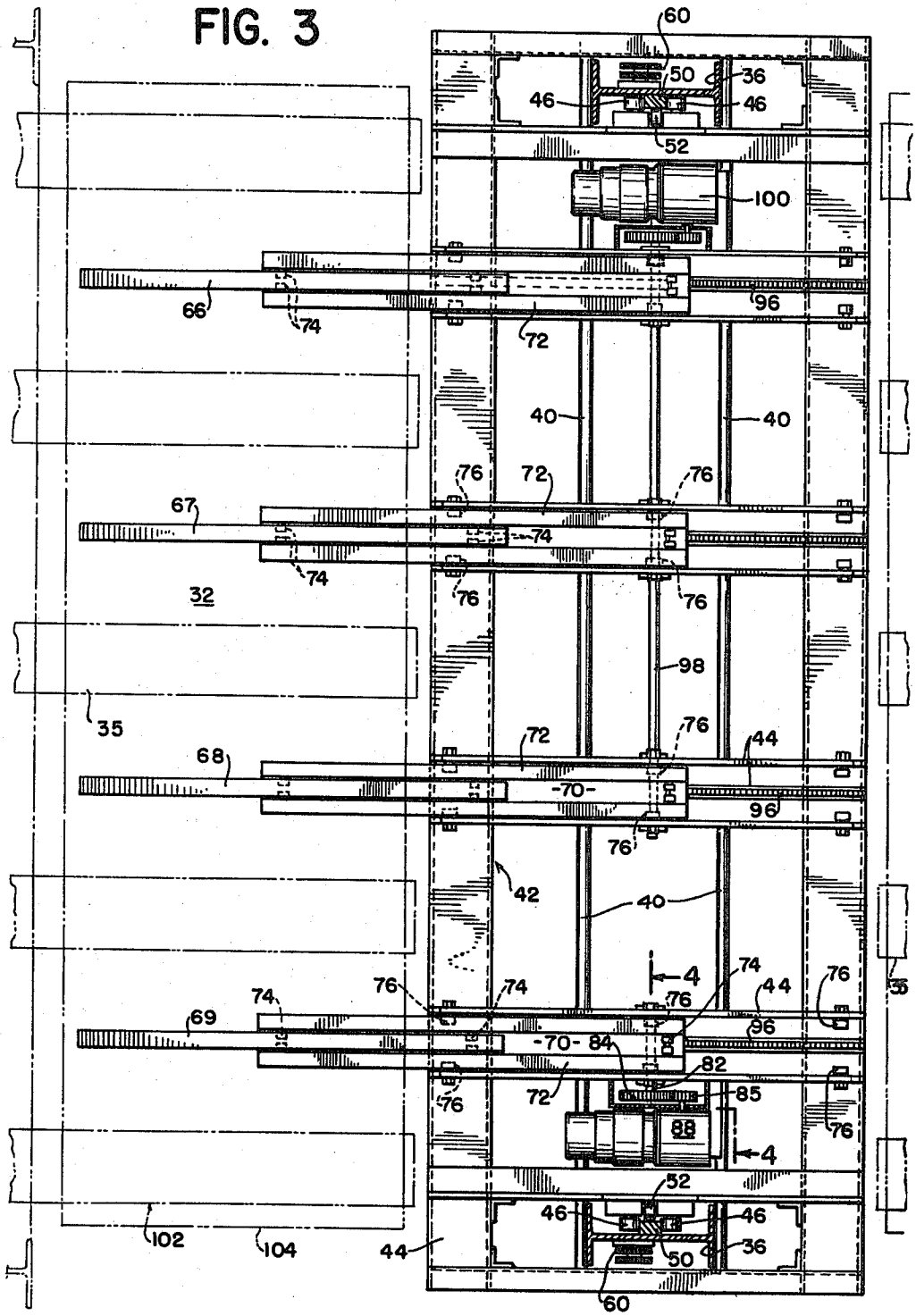
FIG. 3



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STACKER CRANE

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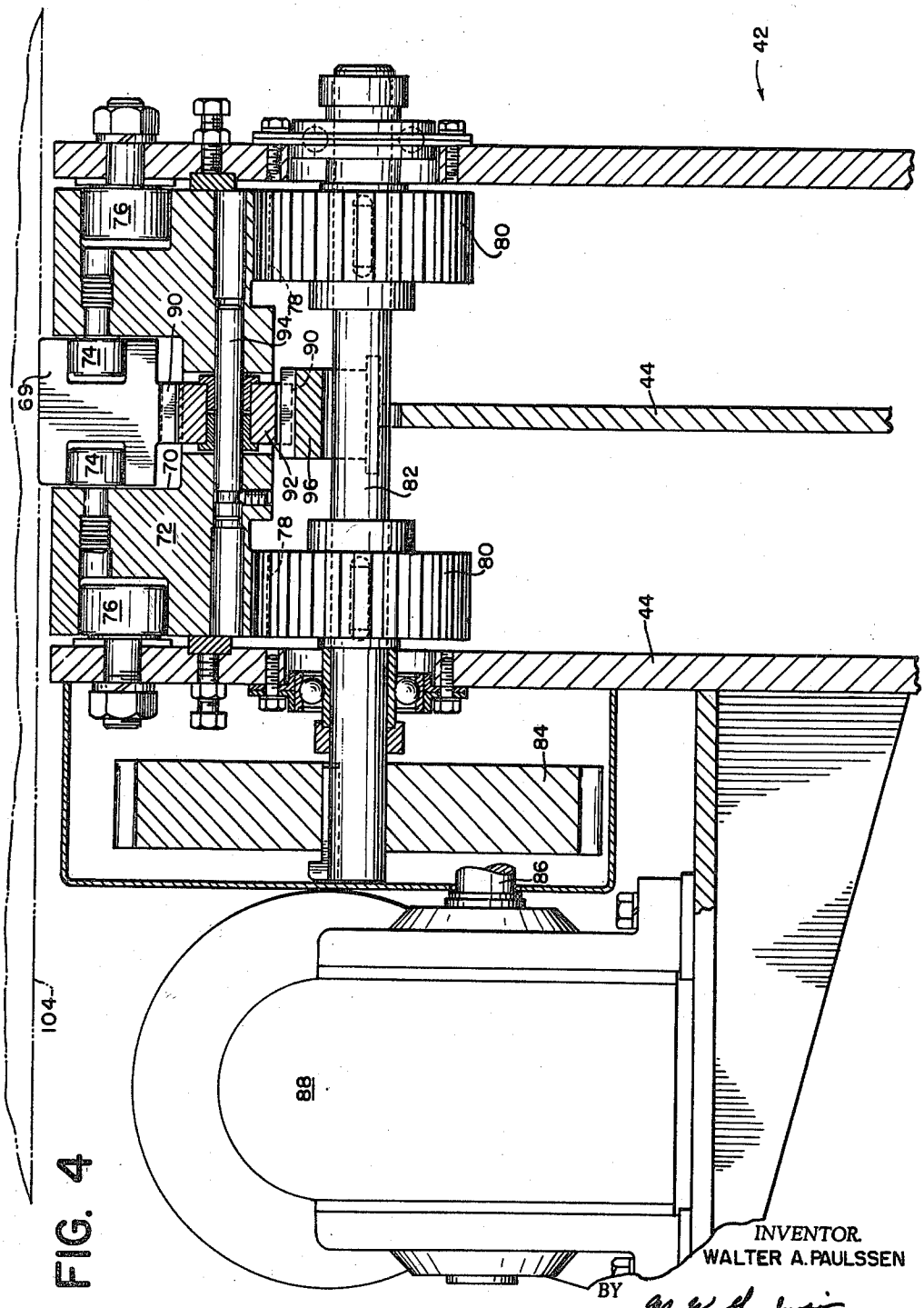

FIG. 4

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3,175,722

STACKER CRANE

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3 Claims. (Cl. 214—731)

This invention relates to material handling equipment and more particularly to cranes of a type often referred to as stacker cranes.

An exemplary stacker crane may comprise an overhead bridge structure mounted for movement in a horizontal direction and carrying a trolley or the like movable in a second horizontal direction at right angles to the direction of movement of the bridge. The trolley may carry a platform or elevator mounted for vertical movement relative to the bridge. The elevator may mount one or more forks or material supporting members. The bridge may be mounted for movement along a row of bins or the like comprising a plurality of side by side columns of vertically arranged storage spaces in the form of bins or racks. In use, the trolley is moved into alignment with a vertical column of bins, and the elevator is positioned in registry with one of the bins. The trolley is then moved toward the bin to locate the forks underneath material contained within the bins. The forks are then elevated slightly in order to lift the material off the floor of the bin so that upon retraction of the trolley, the material will be removed from the bin. The elevator may then be moved into registry with another bin and the trolley moved toward the bin to deposit the material therein.

In some installations for material storage the storage spaces are arranged so that there are oppositely facing rows of the same on opposite sides of an aisle. The crane moves longitudinally of this aisle between the oppositely facing rows of storage spaces and must service both rows. One manner of accomplishing this objective is to mount the fork assembly or elevator on a mast which is rotatable, such as in shown in Patent No. 2,765,928, issued October 9, 1956; however, such an arrangement may require more aisle width than is desirable inasmuch as sufficient aisle width must be provided to permit rotation of the load within the aisle. Obviously, in such an arrangement, the aisle width must be at least twice the width of the load.

The primary objective of the present invention is to provide a novel and improved stacker crane for servicing oppositely facing rows of storage areas which requires a materially reduced aisle width for operation thereof thereby increasing the available and useful storage area within a given floor area. While stacker cranes have been designed which utilize a non-rotatable fork assembly including forks which extend alternately to opposite sides of a storage aisle, the forks of such cranes depend upon the racks being serviced for support of the forks when in extended positions. Such cranes also require precise positioning of the forks relative to the racks to be serviced and require cooperating structure on the racks to effect transfer of material on the racks to the forks. Accordingly, included within the aforementioned object is the object of providing a stacker crane in which the fork means does not depend upon the racks being serviced for support of the forks or for any cooperation in effecting transfer of material from the racks to the forks.

Other objects will be in part obvious, and in part pointed out more in detail hereinafter.

The invention accordingly consists in the features of construction, combination of elements and arrangement

of parts which will be exemplified in the construction hereafter set forth and the scope of the application of which will be indicated in the appended claims.

In the drawings:

FIG. 1 is an end elevational view of a stacker crane incorporating the present invention and mounted for endwise movement between a pair of oppositely facing rows of vertically arranged storage areas;

FIG. 2 is a front elevational view of the crane of FIG. 1;

FIG. 3 is an enlarged cross sectional view substantially along the line 3—3 of FIG. 1; and

FIG. 4 is an enlarged, fragmentary, cross sectional view substantially along the line 4—4 of FIG. 3.

With reference to the drawings, and particularly FIGS. 1 and 2, a stacker crane of the present invention comprises an overhead support or trolley assembly **10**. The trolley assembly generally comprises a structural steel frame on which are mounted wheels or rollers, such as indicated at **12**, which are supported on rails in the form of I-beams **14**. The rails **14** are carried by a fixed supporting structure **16** forming a part of the material storage structure serviced by the crane. It will be understood, however, that the rails **14** could be mounted on any fixed supporting structure desired or that the trolley could be otherwise suitably supported for the desired movement thereof such as in association with a gantry structure. The trolley is driven longitudinally of the rails **14** by means of a drive motor **18** which through reduction gearing **20** and intermediate gearing is connected to a drive shaft **22**. The drive shaft **22** is connected at its opposite ends to gears **24** which, as shown in FIG. 1, may be mounted coaxially of the wheels **12** for movement therewith.

As shown in FIG. 1 the trolley **10** is mounted for movement longitudinally of an aisle **28** separating a pair of oppositely facing rows **30**, **32** of storage spaces in the form of racks. In the particular storage structure shown in FIG. 1, each row of racks comprises a plurality of side by side vertically arranged columns of storage spaces or racks **34** adapted to support sheet metal or the like. As most clearly shown in FIG. 3 each rack **34** comprises a plurality of supporting members or arms **35** extending toward the aisle **28** and spaced apart longitudinally of the aisle in order to permit access to the under side of the material in the rack, as will be more fully described hereinafter.

Depending from the opposite ends of the trolley **10** are a pair of support members or masts **36**. The masts are fixed at their upper ends to the trolley and are suitably supported at their lower ends to provide a rigid structure. In the particular embodiment shown in FIG. 1, the lower ends of the masts are connected by a pair of elongated members **40** in order to stiffen the mast structure and prevent swaying of the bottom of the masts. It will be understood that other suitable means could be used to stiffen and prevent swaying of the masts such as by suitable use of the elevator or fork assembly **42** which is mounted for movement on the mast and which will now be described.

With reference to FIGS. 1–3 of the drawings, a fork assembly or elevator generally indicated at **42** is mounted for movement vertically of the masts **36**. The fork assembly comprises a frame **44** on the ends of which are mounted a plurality of vertically spaced apart pairs of rollers **46** and **48**. As best shown in FIG. 3 each pair of these rollers is engaged on opposite sides of a rail or guide **50** mounted on the web of the I-beam forming the associated mast **36** and extending vertically of the mast; thus, the frame **44** is guided for vertical movement and lateral movement of the frame is prevented. In order to prevent

endwise movement of the fork assembly frame, additional rollers, as indicated at 52 in FIG. 3, are mounted on the ends of the frame 44 with their axes extending at right angles to the horizontal path of movement of the fork assembly and with the rollers in engagement with the inner faces of the guides 50.

In order to position the fork assembly vertically of the masts, a drive motor and reduction gear assembly 54 is mounted on the trolley 10 and is drivingly connected to a shaft 56 extending longitudinally of the trolley and between the masts 36. The shaft 56 is journaled on the trolley 10 and the masts 36 and mounts at each of its opposite ends a pair of sprockets 58. A second pair of sprockets 60 are rotatably mounted on the lower ends of each of the masts 36 in respective registry with the upper sprockets 48. A pair of endless drive chains 62 are engaged with each overlying pairs of sprockets 58 and 60. As best shown on FIG. 2 a single, corresponding course of each pair of chains 62 is fixed, such as by bolting, to a plate or bracket 64 which is rigidly mounted on the frame 44 of the fork assembly 42. Therefore, when the sprockets 58 are driven in the proper direction by the motor 54, the fork assembly will be raised from the full line position shown in FIGS. 1 and 2 toward the broken line position shown in these figures. Correspondingly, when the sprockets are driven in the opposite direction, the fork assembly will be lowered.

With reference to FIGS. 3 and 4, the fork assembly 42 comprises a plurality of material supporting members or forks 66–69 which are movable laterally of the fork assembly and at right angles to the direction of travel of the bridge. The forks are extendable selectively to either of the opposite sides of the fork assembly so as to service both of the opposite rows 30, 32 of racks 34. The means for mounting and driving each of the forks 66 to 69 is substantially the same. Accordingly, in the interests of brevity, only the structure with regard to the mounting of the forks 69 will be described in detail. The fork or rail 69 is mounted for movement in a channel 70 extending longitudinally of an elongated slide 72. More particularly, the fork is received partially within the channel 70 with the top surface of the fork being disposed above the top surface of the slide. The fork is supported along its opposite sides by rollers or bearings 74 journaled on the slide 72 and engaged within grooves or channels extending longitudinally along the opposite sides of the fork. The slide 72 is in turn supported by rollers or bearings 76 which are supported on side plates forming part of the frame 44 of the fork assembly. The rollers 76 are engaged within channels or grooves extending longitudinally of the slide. The slide is movable between the full line position shown in FIG. 3 laterally of the fork assembly to a corresponding position on the opposite side of the assembly whereby the slide projects beyond the frame toward the opposite row of racks. As shown in FIG. 4, the slide has a pair of parallel spaced apart racks 78 extending longitudinally of and along its under side. These racks mesh with a pair of gears 80 mounted for rotation with a shaft 82 journaled on the frame 44. The shaft 82 also mounts for rotation therewith a drive gear 84. The drive gear 84 is engaged with a pinion (not shown) mounted on a shaft 86 extending from a drive motor-gear reduction unit 88 which is mounted on the fork assembly frame 44. Accordingly, when the drive motor 88 is energized, the slide will be driven longitudinally of itself between the extreme laterally extended positions described above.

With further reference to FIG. 4, rack 90, integral with the fork 69, extends longitudinally of and along the bottom surface of the fork. The rack 90 meshes with a gear 92 rotatably mounted on a shaft 94 fixed relative to and carried by the slide 72. The gear 92 is received within a cutout or opening in the slide 72. The gear 92 also meshes with a rack 96 which is fixed relative to the frame 44 of the fork assembly and extends longitudinally of the slide and rail along the under surface of the slide. It should be noted that the rack 96 does not extend laterally beyond the sides of the frame 44.

Accordingly, as the slide is driven longitudinally of itself and laterally of the frame of the fork assembly, the interaction between the fork rack 90, fixed rack 96 and intermediate gear 92 will cause the fork to be moved longitudinally of and relative to the slide. At the same time the fork will be advanced with the slide. With the single intermediate gear 92 the total rate of advance of the fork relative to the frame will be twice that of the slide. The fork and slide are initially positioned relative to each other so that when the slide is centered relative to the frame 44, the fork will be centered relative to the slide. Also, both the slide and fork are preferably dimensional so that in their centered positions they do not extend laterally beyond the frame 44. Thus, when the motor 88 is energized to move the slide and thus the fork, from their full line positions shown in FIG. 3 to a corresponding position of the opposite side of the fork assembly, the fork will overtake the slide until it is in registry therewith when both elements are centered on the frame of the fork assembly. Continued driving of these elements in the same direction will cause the fork to advance beyond the slide at the same time as the slide is moving in a corresponding direction until both elements are in the relative extended positions shown in FIG. 3 but on the opposite side of the fork assembly.

It is to be noted that the slide and fork are each of a length approximately equal to the width of the frame 44 and that when the fork and slides are in fully extended positions, less than one-half of the length of the fork and slide extend beyond the slide and frame respectively. Also, it is to be particularly noted that a pair of fork supporting rollers 74 are located on the slide next adjacent each end thereof with at least one additional pair of such rollers located intermediate the ends of the slide where they will engage the fork adjacent the inner end thereof when the fork is fully extended relative to the slide. Also, the slide supporting rollers 76 are located next adjacent the outer sides of the frame with at least an additional pair of such rollers located between the outer rollers wherein they will engage the slide next adjacent the end thereof when the slide is in its fully extended position. The support of the fork and slide as aforedescribed when the same are in their fully extended position provides sufficient strength and rigidity to the fork assembly that the fork need not be supported by any external structure when it is fully extended and particularly when it supports a load. In other words the fork is fully self supporting and as shown in FIG. 3, when it is extended to a work receiving and transporting position, it is completely out of contact with any of the structure forming the storage spaces to be serviced. This eliminates the need for structure at each storage space for incorporation with the fork to support the same when it is extended or to cooperate with the fork to effect transfer of material from the storage area to the forks such as by camming the fork upward as it is extended in order to lift the material out of engagement with the storage rack.

The structure associated with the forks 66-68 for effecting relative movement between the forks and the respective slides is the same as just described in connection with the fork 69. However, as shown in FIG. 3 the slides of the forks 66-68 are driven by a common shaft 98 which is in turn driven by a common drive motor-gear reduction unit 100. In this manner the movement of the forks 66-68 and their respective slides will be simultaneous upon energizing of the motor-gear reduction unit 100. It is contemplated that all of the forks 66-69 may be actuated simultaneously, and in a synchronized manner, by suitable synchronizing of the drive motors 88 and 100, or if desired, the motors 88 and 100 may be operated independently of each other so as to

provide operation of the fork **69** independently of the forks **66-68** and vice versa.

With reference to FIG. 1 in a typical cycle of operation of the stacker crane described above, the fork assembly is vertically and horizontally positioned in registry with the lower row rack **102** of a column of racks in the row **32**. The slides are then extended toward the registering storage area and the forks will correspondingly be extended in the same direction in response to movement of the slides. As shown on FIG. 3 in their extended positions the forks and slides are extended into the storage space and between the supporting elements **35** of the racks. The forks will underlie the work **104** located in the rack so that upon vertical movement of the fork assembly, the work will be lifted from the supporting arms **35** by the forks. The forks and slides are then retracted to center them, and the work carried by the forks, on the fork assembly. The fork assembly may for example then be raised to the broken line position shown in FIG. 1 and the trolley moved down the aisle **28** as necessary until the fork assembly is in registry with a selected storage space in the opposite row of racks. The fork and slides may then be extended to the right as viewed in FIG. 1 whereupon the work will be inserted into the selected space in the row **30** and the fork assembly lowered to transfer the work from the forks to the supporting arms of the rack. The forks and slides may then be retracted for another cycle to service other racks. It will of course be understood that the work may be transferred between any two selected storage spaces in the rows thereof.

Thus, it will be seen that there has been provided a novel and improved stacker crane in which material may be quickly and with facility transferred between a plurality of bins or racks of a pair of oppositely facing rows of the same. The aisle space requirement between racks approaches the depth of the storage spaces serviced by the crane. While clearance requirements and the like may require that the aisle space be somewhat greater than the depth of the storage spaces or width of the material transported, it will be apparent that the aisle space requirement may be substantially less than twice the depth of the storage areas or width of the work handled. In another manner of speaking, the fork length or more particularly the distance the fork extends beyond the frame in either of its extreme positions approximate a maximum width of the width to be handled by the fork. Inasmuch as the fork is preferably contained within the confines of the frame **44** with the fork centered on the frame, the aisle width can be seen to be substantially less than twice the distance that the fork extends beyond the frame in its extreme positions. This reduction in aisle space will of course permit more effective use of storage area and will materially increase the volume of storage per unit area thus improving the overall efficiency and economics of the storage operation. The operation of the various drive motors of the crane may be controlled from a remote position by means of a flexible cable leading to a suitable control whereby the operator manually selects the storage areas to be serviced. However, it should also be noted that the crane is adapted to be controlled automatically through a suitable tape control or the like so that a series of cycles may be programmed in advance, with subsequent crane operation proceeding automatically. Importantly, there has been provided such a novel and improved stacker crane in which the fork assembly is fully self supporting and does not require cooperating structure in association with each of the storage areas being serviced to provide supplemental support of the forks when they are extended during a material transferring operation. The lack of requirement for any cooperating structure on the supporting racks for supporting the forks and for assisting in transfer of material from the racks to the forks eliminates any requirement for precise registering of the forks with the storage areas during a work transfer cycle. Also, of course, the self supporting feature of the forks of the crane results in a marked economy and simplification in the overall construction particularly of the storage areas.

As described above, means have been provided in the specific embodiment shown for effecting movement of certain of the forks and respective slides independently of the remaining forks and slides and vice versa. The purpose of this arrangement is to permit the selective use of less than the total number of forks where the work to be handled or the storage space width is such that simultaneous actuation of all of the forks is either impractical or undesirable. It will be understood, however, that suitable means may be provided for the independent actuation of any number of the forks independently of the others as desired for a particular installation and that the invention is not limited merely to the particularly selection described and shown herein. Also, it will be understood that while the invention has been shown and described in terms of work supporting components in the form of forks which are particularly adapted for the handling of sheet material and boxes, crates or the like, other suitable material supporting components could be utilized within the scope of this invention where necessary or desirable for the handling of material of a particular configuration.

Inasmuch as many changes could be made in the above construction and many apparently widely different embodiments of the invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the language in the following claims is intended to cover all of the generic and specific features of the invention herein described and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

I claim:

1. A stacker crane comprising an overhead support assembly mounted for movement in a horizontal direction, a pair of spaced apart parallel masts depending from and movable with said support assembly, a fork assembly disposed generally between said masts, means mounting the fork assembly on the masts for movement with said masts in said horizontal direction and relative to said masts in a vertical direction, means for positioning said fork assembly vertically relative to said masts, the fork assembly including a frame, a plurality of parallel slides spaced apart in said horizontal direction, each of said slides being supported on said frame for horizontal translational movement laterally of said horizontal direction between a first position wherein the slide extends outwardly beyond one side of the frame and a second position wherein the slide extends outwardly beyond the opposite side of said frame, drive means for selectively effecting said translational movement of certain ones of said slides independently of the remainder of the slides, second drive means for selectively effecting said translational movement of said remainder of the slides independently of said certain ones of the slides, an elongated fork supported on each of said slides for movement therewith and longitudinally relative thereto, and means responsive to translational movement of each slide for effecting movement of the respective fork relative to the slide and frame at a rate substantially in excess of the rate of movement of the slide relative to said frame.

2. A stacker crane comprising an overhead support assembly movable in a horizontal direction, a pair of parallel spaced apart masts depending from said support assembly, a fork assembly disposed generally between said masts, means mounting the fork assembly on the masts for movement in said horizontal direction and in a vertical direction relative to the masts, the fork assembly

including a frame, a plurality of parallel elongated slides spaced apart in said horizontal direction, means mounting said slides on said frame for longitudinal movement laterally of said horizontal direction and providing the sole support of the slides during operation of the crane, each slide having a pair of parallel racks extending longitudinally of and along the underside thereof, a plurality of pairs of gears rotatably mounted on said frame and respectively engaged with the pairs of racks on each slide, means for driving said pairs of gears, each slide having an elongated channel in the top surface thereof extending longitudinally of the slide and disposed between the racks on the underside of the slide, an elongated fork disposed partially within each channel, means on each slide supporting the respective fork for movement longitudinally of the slide, each fork having a rack extending longitudinally thereof along the underside of the fork, means providing an opening in each slide communicating with the fork receiving channel and with the underside of the slide, a gear disposed in each said opening and rotatably carried by the respective slide, said gear being engaged with the rack on the respectively associated fork, and a second rack respectively associated with each fork, said second rack being fixed relative to the frame and extending longitudinally of and under the slide between the pair of racks on the underside of the slide and engaging the gear carried by the respectively associated slide, each of the forks being centered relative to its respective slide when the slide is centered relative to the frame.

3. A stacker crane comprising a fork assembly, means mounting the fork assembly for movement in a horizontal direction and in a vertical direction, the fork assembly including a frame, a plurality of elongated self-supporting slides mounted on said frame for longitudinal movement laterally of said horizontal direction, each slide having a channel in the top surface thereof extending centrally and longitudinally thereof, an elongated fork partially received within said channel with the top surface of the fork being disposed above the slide, a plurality of rollers on each side of each slide spaced apart longitudinally thereof and engaged in grooves extending longitudinally of the opposite sides of the respective fork with the fork being supported solely

by said rollers for movement longitudinally of and relative to the slide, each fork having a rack extending longitudinally of and along the bottom surface thereof, each slide having an opening therein extending between the channel in the slide and the underside of the slide, a gear disposed in said opening in and rotatably carried by each slide and engaged with the rack of the respectively associated fork, a plurality of racks fixed relative to said frame and extending longitudinally of the slides, said plurality of racks being respectively associated with the gears carried by said slides and being respectively engaged with said gears whereby as each slide is moved relative to the frame the respective rack fork will be moved relative to the slide, and drive means for moving each slide laterally of said horizontal direction between a first position wherein the slide extends laterally beyond one side of said frame at right angles to said horizontal direction and a second position wherein the slide extends laterally beyond the opposite side of the frame, each fork extending longitudinally beyond the respective slide and outwardly of the frame in both said first and second positions of the slide, said drive means comprising a pair of parallel spaced apart racks carried by and extending along the underside of each slide on opposite sides of said opening in the slide a pair of gears respectively engaged with each pair of racks, means rotatably mounting each pair of gears on said frame, and means carried by said frame for rotating each of said pair of gears.

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