ABSTRACT: The disclosure relates to a vehicle parking arrangement for automobiles and the like of the tower type in which vehicle support platforms are suspended in endless conveyor fashion between a pair of vertically disposed endless conveyors in the form of rigid links connected together in end to end relation and operating in vertically disposed guideways that maintain the links that are positioned between the ends of the conveyors in vertically disposed relation to form vertically disposed conveyor runs. The platforms are suspended from the respective conveyor links, with the conveyors themselves having no end pulleys or sprockets, but rather being supported through a motion transmitting connection adjacent the base of the respective conveyors. Each of the respective platforms are supported from a support member of each conveyor that includes a conveyor link, and each vehicle support platform is held against sway in moving about the system by a motion stabilizing arrangement which includes a three way parallel linkage that is arranged so that the vehicle support platforms are smoothly transmitted from one conveyor run to another on opposite sides of the system. Also disclosed are an improved mechanism for supporting and driving the conveyors by engagement with their links in a synchronized step by step manner, and a special arrangement for the vehicle load support platforms per se that simplifies design considerations.
STABILIZING AND GUIDE MEANS FOR ENDLESS VEHICLE PARKING SYSTEM

This application is a continuation-in-part and discloses improvements over those disclosed in my prior application Ser. No. 471,997, filed July 14, 1965 now U.S. Pat. No. 3,424,321 (the disclosure of which is hereby incorporated herein by this reference, and the effective filing date of which is claimed for all subject matter herein that is common thereto).

This invention relates to an apparatus for parking a number of automobiles or the like utilizing a comparatively small ground space, and more particularly, to a vehicle parking arrangement of the tower type that is adapted to provide capsulized vehicle storage units of uniform size and operating characteristics to supply the ever increasing demand for parking facilities.

Conventional vehicle parking arrangements other than the parking lot type traditionally have called for the construction of large buildings and complex handling equipment to enable an installation to handle as many vehicles, such as automobiles, as might possibly be stored in the area utilized. Examples are the multistoried buildings found in urban centers, and it is obvious that such structures require a tremendous capital investment as well as a large work force to operate and maintain them.

Some efforts have been made to depart from the need to provide a large building to install apparatus of this type, by the provision of conveyors vertically disposed in tower form which carry individual vehicle support platforms in spaced apart endless conveyor fashion, in which the conveyors are in the form of articulated linkage trained over end sprockets that drive and support the conveyor and its load. Experience with these arrangements has shown that the heavy loads the conveyor links carry subject them to undue fatigue and wear, particularly at the articulated joints, requiring frequent maintenance and adjustment to compensate for the tendency of the conveyor linkage to extend or lengthen due to the wear involved. Furthermore, the heavy supporting sprockets required at the top of the conveyor require a strong and complex supporting frame, with corresponding high investment expenses.

In spite of the number and size of vehicle accommodations available in urban areas, the vehicle parking situation continues to remain critical due to the wide spread use of one's own private automobile for commuting and other purposes. A must in the planning of any business or Governmental agency is due consideration to parking facilities to insure that the public and/or employees have ready access to the business or Governmental facilities that may be involved, and few businesses can afford the conventional multistoried parking facilities that have been traditionally employed to improve over parking lots in solving this problem.

A principal object of this invention is to provide a simplified capsulized vehicle parking arrangement that holds the maximum number of vehicles for the space occupied, and that is yet within the means of most business establishments.

Another principal object of the invention is to provide a push button control vehicle parking arrangement in which, for instance, as many as 21 or more cars can be parked in an area where, at ground level, ordinarily only two cars would be accommodated, and which is a self contained parking structure capable of retrieving from the system any car parked in same with push button control ease and minimum time delay.

Still another principal object of the invention is to provide a vehicle parking arrangement that is adaptable to mass production and mass fabrication techniques for providing modern capacity installations on a mass basis.

Another principal object of the invention is to provide a tower type vehicle parking arrangement having minimum ground space requirements and providing for complete control over the vertical movements of the vehicles carried thereby.

Further objects of the invention are to provide a low maintenance vehicle parking arrangement of the tower type in which the supporting conveyor is not subject to length extension problems due to wear, whereby the vehicle support plat-
FIGS. 12 and 13 are diagrams showing the manner in which the conveyor and stabilization linkage that the individual vehicle support platforms are associated with operates in being conveyed about the apparatus of FIG. 1, with the vehicle support platforms omitted for simplicity and the conveyors being shown in shortened form for ease of illustration; and

FIG. 14 is a fragmental view illustrating a detail of the guideways that are shown in FIGS. 12 and 13.

However, it is to be distinctly understood that the specific drawing illustrations supplied are provided primarily to comply with the requirements of the Patent Code, and that the invention may have other embodiments that will be obvious to those skilled in the art, and which are intended to be covered by the appended claims.

GENERAL DESCRIPTION

Reference numeral 10 of FIGS. 1 and 2 generally indicates one operating embodiment of this invention arranged for side conveying of vehicular and comprises a simplified tower structure 11 that mounts a pair of conveyor assemblies 14 (see FIG. 2) on either side thereof which are suspended in spaced apart and endless conveyor relation a plurality of vehicle support platforms, cages or pans 12.

The conveyor assemblies 14 each comprise an upright girders structure indicated at 18, and as indicated by FIGS. 1 and 5, each girders structure either side thereof defines a vertical guideway 20; each conveyor assembly 14 further comprises an endless conveyor 22 trained through the respective guideways 20 of, and about the length of each, girders structure, which conveyors each comprise a plurality of rigid links 24 and 24A pivotally connected together in alternating, end to end relation at their adjacent ends 26 by pins 28.

The links 24 and 24A are connected together to provide an articulated joint 29 at the pins 28 and form a continuous loop 30 about the respective girders structure 18. The conveyor links 24 and 24A at their joints 29 are provided with rollers 32 and 33 that cooperate with the guideways 20 to define the conveyors 22 into vertically extending runs 34 and 35 that extend the length of the respective guideways 20, and upper and lower connecting portions 36 and 38 that extend between the upper ends and lower ends of the respective guideways.

This is best brought out in the diagrammatic showing of FIGS. 12 and 13, which is a diagram of a conveyor assembly 14 in foreshortened form illustrating the manner in which the conveyor links 24 and 24A operate as the vehicle support platforms or pans 12 are moved about the system.

As indicated in FIGS. 3, 12 and 13, links 24, that together with alternating links 24A make up the respective conveyors 22, form a part of a vehicle support member 40 that takes the form of a truss structure 42 made up by a pair of arms 44 and 46 having their ends 48 and 50 respectively secured to the respective ends 26 of the link 24 as is involved, and having their other ends 52 and 54 joined together at an eye structure 56. The support members 40 of the respective conveyors 22 are arranged in horizontally aligned pairs, and the individual support platforms or pans 12 are suspended between such pairs. In the illustrated embodiment, the eye structures 56 of the respective support members 40 receive pins or stub shafts 58 that are fixed to hangers 60 which suspend the respective platforms or pans 12 from either end thereof (see FIGS. 2 and 9).

Operably associated with each support member 40 of each conveyor 22 is a stabilization device 62 which comprises a triangular structure 64 made up of links 66, 68 and 70 joined together at their ends to define eye structures 72, 74 and 76 that respectively receive pins 78, 80 and 82 which pivotally connect them to parallel links or arms 84, 86 and 88. The arms 84 and 86 are pivotally connected to the joints 29 at each end of a conveyor link 24 making up a vehicle support member 40, while the third link or arm 88 is made fast to the pin 58, which, as indicated, is in turn made fast to the hanger 60 that it supports.

The eye structures 56 of the support arms 40 pivot freely with respect to the pins 58.

As indicated in FIGS. 3 and 5, the triangular structure 64 of each device 62 includes rollers 92 and 94 that are journaled on the respective pins 78 and 80 for operation in guideways 20.

It will thus be seen that, insofar as the conveyors 22 are concerned, the links 24 and their associated stabilization devices 62 divide themselves into platform or pan suspension units 90 each comprising a support member 40 making up same, and a stabilizing device 62 for the support arm 40 made up of a triangular structure 64, and its associated parallel links 84, 86 and 88. Units 90 are separated about the respective conveyors 22 by links 24A.

As indicated in FIG. 5, the guideways 20 are respectively defined by a channel shaped structure 96 which defines on either side thereof the respective trackways 98 and 99 in which the respective sets of rollers 32 and 33, and 92 and 94, respectively, ride.

As indicated in FIGS. 12 and 13, the trackways 98 of the support member rollers end at 100 at the lower end of the system and at 102 at the upper end of the system, while the trackways 99 of the stabilization device 62 end at 104 at the lower end of the system and end at 106 at the upper end of the system.

As further indicated by FIGS. 12 and 13, the respective conveyors 22 are not trained over end pulleys or sprockets, and as a matter of fact, the connecting portions 36 and 38 of the respective conveyors 22 are unguarded across the open space between the adjacent end portions 100 and 102, respectively, at the lower and upper ends of the guideways 20, except as provided by the rigidity of links 24 and 24A and the confinement of the pivotal action at joints 29 to pivotal movement about a horizontal axis. The individual conveyors 22 and the loads they support are in turn supported by the novel drive apparatus 110 which is diagrammatically illustrated in FIGS. 4 and 6-8.

The apparatus 110 of each conveyor 22 generally comprises a plurality of prop members 112 journaled in spaced apart upright relation as at 114 on a drive chain 116 trained over end sprockets 118 and 120, with the sprocket 118 being driven by suitable motor 122 (FIGS. 1 and 2) coupled to drive shaft 124 that extends between both drives 110 and that in the form shown drives sprocket 118 of each drive 110 through the respective drive chains indicated at 126 and 128 that are a part of the chain drive diagrammatically illustrated in FIGS. 6 and 7.

Motor 122 is operated by push button control through a suitable panel such as that indicated at 130 of FIG. 1 to drive the chain 116 in either direction to effect movement of the respective conveyors 22 in either direction in accordance with this invention. The prop members 112 are each formed with a head portion 132 which is shaped to define on either side of the midportion thereof notches 134 and 136 that are adapted to cooperate with and engage the joints 29 of the conveyor links 24 and 24A. Operably associated with each prop member 112 are upper and lower guide rollers 138 and 140 which cooperate with appropriately shaped guide surfaces 142 and 144, and 146 and 148, of the drive apparatus to position the individual prop members 112 in the manner that is hereinafter described in detail. At this point, it is sufficient to point out that between the levels 150 and 152 (see FIGS. 4 and 6), at least one prop member 112 on either side of the drive is in engagement with a joint 29 of the respective conveyor run 34 and 35. If the drive as viewed in FIG. 4 is driven in a clockwise direction, the conveyor run 34 that is there illustrated will move upwardly thereby, the respective joint of the gravel in the other direction will move the run 34 downwardly. Members 112 are moved about the circuit defined by drive chain 116 in the timed sequence required to bring them into and out of engagement with the adjacent conveyor joints 29 in the step by step manner that insures the conveyor support platform spaced between levels 150 and 152 on either side of the gravel 110. Levels 150 and 152 are spaced apart the distance of links 24 and 24A between their joints 29 (links 24 and 24A are of equal lengths).
Relative movement of the respective components of each conveyor unit 90, when the drive 110 is operated to move platforms or pans 12 about the system, is diagrammatically illustrated in two positions showing provided by FIGS. 12 and 13, with the conveyor links 24 and 24A remaining in their vertically disposed rectilinear positions as to each run of the respective conveyors as they move upwardly or downwardly of the guideways 20, and the respective links 24 and 24A articulating at joints 29 to pass from one guideway 20 to the other of a particular girder structure 18; in so doing, the vehicle such as the triangular structures 64 of stabilizing devices 22 rock 180 degrees in a parallel linkage manner, with the links 84, 86 and 88 all being maintained in a vertical position regardless of the position of the respective units 90 along the conveyors 22.

The tower structure 11 includes the girders 18 as part of its basic frame 16, the frame 16 being formed to provide a driveway 160 through which vehicles, such as automobiles, move for parking onto the individual platforms or pans 12, and for driving off of them when the platforms 12 are positioned at the lowermost position shown in FIGS. 1 and 2. For the purposes of this disclosure, the entrance to driveway 160 will be assumed to be at 162 (see FIG. 2) and its exit at 164, though this may be reversed if so desired or alternatively that the vehicle may be driven into and backed out of the entrance to achieve the loading and unloading operation that is contemplated by this invention. Suitable retractable gates may be provided over the entrance 162 and exit 164, respectively, that are preferably operable under the push button controls contemplated by this invention.

The driveway 160 in the form shown is provided with a raised surface 166 having an elevation that is a fraction of an inch under the lowermost position that the respective platforms or pans assume in the operation of the apparatus, with surface 166 being suitably ramped as indicated at 168 for ready transfer of the vehicle to the vehicle support platform or pan that is positioned in the load receiving and discharge position shown in FIG. 1. However, any other suitable ramping arrangement will be satisfactory.

As indicated in FIGS. 1A, 2 and 2A, the apparatus 10 at the entrance and exit to the driveway 160 is provided with a vehicle load support platform end play limiting devices 170 disposed to be closely adjacent the projecting ends 172 of the respective vehicle platform support members 40 when the latter are moved to their lowermost positions of FIGS. 1 and 2. The devices 170 serve as abutments that prevent movement of the platform or pan 12 being loaded or unloaded longitudinally thereof under reaction forces generated by driving the vehicle onto or off of the platform or pan.

In accordance with this invention, all controls for drive 110 are incorporated in suitable circuiting which includes the control panel board 130, which preferably is of the push button control type that on operation will bring a predetermined vehicle support platform or pan 12 to the lowermost position shown in FIG. 1. The specific embodiment illustrated is provided with 21 platforms or pans 12, and consequently the panel 130 is wired so that there is a control button for each of the 21 platforms or pans 12, with the arrangement being such that when it is desired to bring a particular pan 12 to the loading or unloading position shown in FIG. 1, the number of that pan is punched on the panel 130 and drive 110 operates automatically to start up the system, operate conveyors to position the selected pan 12 where indicated, and then automatically shut off and brake the system against further movement until again actuated through control panel 130 or otherwise. Brake means of any suitable type (not shown) is operably associated with motor 122 to hold conveyors 22 against movement when motor 122 is not operating. The circuiting controlling motor 122 also preferably includes suitable sequencing controls arranged to dispose an empty pan 12 at the loading position of FIG. 1 as part of the operating sequence involved in moving a freshly loaded pan 12 to one of the other positions indicated that store the vehicle involved until retrieved from the system. The controls for the system also are preferably arranged so that the gates for entrance and exit 162 and 164 open automatically when a pan is positioned at the loading position of FIG. 1, and automatically close when the system is actuated to move the pans.

**OPERATION**

Assuming that a vehicle, such as an automobile, has been driven up to the entrance 162 of the apparatus 10 for parking on same and a pan 12 is disposed in the loading position of FIG. 1, the vehicle is driven onto the waiting pan 12, after which the driver leaves the vehicle (which he can readily do as the panel 12 being loaded is essentially at ground level and leaves the driveway 160 by way of the entrance 162 or exit 164). At this time, the apparatus is actuated (by pushing a "store" or "gate close" button on panel 130) to actuate the system to place another empty support pan or platform 12 in a loading position, whereby the gates are closed across the entrance and exit and drives 110 are actuated by motor 122 to move the freshly loaded pan up one conveyor run or the other and to move an empty pan 12 into loading position, whereby the gates are automatically open.

When the vehicle operator desires to retrieve his car from the system, he pushes the button on control panel 130 having the number of the pan on which he placed his vehicle, which then actuates drives 110 to return the particular pan 12 that is involved back to the lowermost position of FIG. 1 (the control circuiting being arranged in any suitable manner so that the pan in question is returned by the shortest direction, whether clockwise or counterclockwise of FIG. 1, for saving purposes), so that the vehicle operator can then enter his vehicle and drive it off the pan 12. The unloaded pan 12 then awaits the next vehicle to be stored.

The individual pan supporting units 90 operate in the manner suggested by FIGS. 12 and 13 as they move about the guideways 20 and between same at either end of the apparatus 10. The support arms 40 and the triangular structures 64 of the stabilizing devices 22 for same remain in their relation shown in either side of FIGS. 12 and 13 for the full length of the respective conveyor runs 34 and 35, and as they are transferred between the respective guideways 20, the arms 40 and triangular structures 64 of each unit rock in unison, under the guidance of the guideways involved, 180 degrees between the relative positions shown at either side of FIGS. 12 and 13.

For instance, assuming that the apparatus 10 is being operated so that the platforms are moving clockwise of FIGS. 12 and 13, the sequence of a unit 90 passing from the lower end of run 35 to the lower end of run 34 is as follows:

Assuming that the unit 90 is in the lower right hand position of FIG. 13, as the conveyors 22 continue to move clockwise of guideways 20, the roller 32 of the support member 40 in question and the roller 92 of its stabilizing device 62, reach the ends 100 and 104, respectively, of their respective trackways 98 and 99 on the run 35 side of the system, and the drawing action on leading end of the link 24 of the support arm 40 involved starts to rock the members 40 and 64 in a clockwise direction, with the member 40 in question rotating about the axis defined by its roller 33 and the structure 64 rotating about the axis defined by its roller 94, both of the latter still being retained within their respective trackways 98 and 99 on the run 35 side of the system. This action continues until the position at the lower portion of FIG. 12 is achieved, whereupon the rollers 32 and 92 enter the respective trackways 98 and 99 of the opposing guideway 20 (on the run 34 side of the system), while the rollers 33 and 94 leave the corresponding trackways 98 and 99 of run 35. The support member 40 involved and its stabilizing device structure 64 then rock another 90° in the same direction, about the centers of rollers 32 and 92, respectively, under the drawing action of the conveyor link 24 immediately preceding the unit 90, to position the parts involved in the manner shown at the lower left hand side of FIG. 13.
As the units 90 move upwardly of run 34 and over the top of
the system back to run 35, the transferring action involved is
similar, with the support arms and their stabilizing device tri-
angular structures 64 again rocking 180° in the sequence in-
dicated to position the parts as shown on the right hand side of
FIG. 13. During all this movement, links 84, 86 and 88 remain
vertically disposed.

As indicated in FIGS. 1, 2 and 3, the individual vehicle sup-
port platforms when disposed along the vertical runs of the
conveyor internets in that the upper platforms or pans 12 are
received between the hangers 60 of those immediately below
with the arrangement being such that as to the platforms or
pans 12 disposed along runs 34 and 35, the pins 58 thereof are
spaced apart a distance equal to the length defined by a rect-
linearly aligned pair of links 24 and 24A (which are equal in
lengths), measuring between the joints 29 at either end of
the selected pair. The interesting does not involve resting one
pan on another, however, and ordinarily there will be no
physical contact between adjacent pans or their hangers.

This internesting tends to restrain the pans or platforms
against endwise sway and the presence of the support arms
and their respective stabilizing devices 62 across the ends of
the respective pans block accidental discharge of a vehicle
from the platforms at the top of the system, the presence of the
hangers 18 serves this purpose, so that accidental discharge of
the vehicle from either end of a platform 12 could taken place
only as the platform or pan moves to or from the lowermost
position shown in FIG. 1.

The apparatus, 10, one commercial form of which has been
constructed in an area measuring approximately 20 by 22 feet
and a base of the apparatus, permits the parking of 21 vehicles
in an area that ordinarily would accommodate just two. Veh-
icles may be applied to and retrieved from the apparatus in any
sequence without disturbing the other vehicles carried thereby.

SPECIFIC DESCRIPTION

The framework 16 has the simplified nature illustrated and
ordinarily no other enclosure or the like is required. In the
form shown, the frame work 16 comprises a front frame 176
and a rear frame; the front frame 178 rests on legs 180 and
182 at the sides 184 and 186 of the apparatus 10, which at
their upper ends are suitably joined to a header beam 188 on
which the forward girder structure 18 rests. This girder struc-
ture is braced against lateral movement outwardly or for-
wardly of apparatus 11 by suitable A-shaped frame members
welded between the parts involved. Control panel 130 is
suitably fixed to leg 182 (in the form shown), out of the path
of movement of pans 12.

The frame 178 is similarly constituted, header 192 being
supported by legs 194 and 196, and in turn supporting the rear
girder structure 18 which is similarly braced by A-frame struc-
ture 198. Pairs of cross members 200 extend between the
girders 18 centrally of the apparatus 10 and between the
guide rails 20 of the respective conveyors 22, and at suita-
ble vertically spaced locations for bracing purposes. At the
sides of driveway 160, suitable screening may be applied
between frames 176 and 178 for safety purposes as indicated
in FIG. 2, where brace members 184A, 186A and 188A inter-
connect frames 176 and 178 at the sides of the driveway 160
and the planes of the respective pairs of legs 180, 194 and
182, 196.

The respective girder structures 18 are substantially identi-
cal in character, they each being composed essentially of two
channel members 96 fixed in back to back relation by spaced
apart web plates, as where indicated at 200 (see FIGS. 1 and
5), which in the form shown, are alternated with corrugated
sheets. However, for purposes of my invention, any struc-
tural arrangement suitably joining together the guide rails 20
for the respective conveyors 22 will serve the purpose.

As indicated in FIG. 5, the respective channel members 26
each comprise a back or web portion 204, side or flange por-
tions 206 and 208, which have their respective ends or edges
210 and 212 directed toward each other, as indicated, to
define the respective trackways 98 and 99 that the rollers of
the respective pan support units cooperate with. The
guide rails 20 extend from the top to the bottom of the respec-
tive conveyors and define the conveyor runs 34 and 35 of the
respectively conveyors. The turned over edges 210 and 212 are
excised at the upper and lower ends of the guide rails back to
the channel sides 206 and 208 to provide the trackway open-
ings that are indicated at 100 and 104 of FIGS. 12 and
13. The turned over portion 212 of flange 208 of the respec-
tive channel members 96, against which the rollers 32 and 33
of load support member 40 bear, may be suitably reinforced as
indicated at 214 in FIG. 5.

The front or front girder structure 18 has mounted thereon
the motor 122 (which preferably is hydraulically operated), and
as indicated both girder structures 18 include a drive
mechanism 110, with the drive of the rear girder struc-
ture 18 being operated by cross shaft 124. The drives 110 may
be operably associated with their associated girder structures
in any convenient manner between the members 96 thereof,
with the webs 204 of the respective channel members being
positioned in the areas of drives 110 to receive the head portions
132 of the drive prop members 112 for application to joints 29
of the respective conveyors 22.

The links 24 and 24A making up the respective conveyors
22 are similar, each comprising a pair of plates 220 and
222 joined together by a suitable web structure 224 and such other
reinforcement as may be considered desirable or necessary,
In the case of the members 24 (that form a part of the respec-
tive support members 40), a torque resisting member 226 is
designed along the plates 220 and 222 thereof between the
members 44 and 46 thereof, which in the form shown are
tubular members properly welded in place. At the ends
26 of the members 24, sleeves 226 (see FIG. 5) are fixed in
place to receive the pins 28.

The ends 26 of the links 24A are provided with sleeves 228
which likewise receive the respective pins 28 (See FIG. 5). It
is the sleeves 226 that are received in the notches or seats 134
and 136 of the drive prop members 112.

The channel members 96 each have fixed to their webs 204,
other than at the slots that accommodate the prop members
113, guide bars 229 that cooperate with the plates 220 and
222 of links 24 to maintain the positioning of the respective
conveyors 22 within the guide rails 20 wherein is indicated in rail
231 applied to the side 206 of the respective members 96,
which cooperate with pins 78 and 80 of stabilizing device
structure 64 for the same purpose.

With regard to the stabilizing devices 62, the triangular
structures 64 in practice may be of any suitable type, the bars
66, 68 and 70 illustrated being in the form of tubular members
suitably joined as by welding to the respective eye portions 72,
74 and 76. The structures 64 should be arranged so that the
respective arms 66, 68 and 70 are respectively parallel to the
corresponding arms 46, 24 and 44, respectively of the support
member 40 the particular device 62 cooperates with. Parallel
links or arms 84, 86 and 88 may be of any suitable character,
the link 88 forming a control arm for the vehicle support plat-
iform the arms 88 support.

THE VEHICLE SUPPORT PLATFORMS

The platforms or pans 12 that are illustrated each comprise a
platform structure 240 (see FIGS. 9—11) comprising a plu-
arity of channel-shaped members 242 extending transversely
of the pans and positioned in side by side abutting relation
to the side by side abutting relation between tubular side members 244 that each comprise an
upper plate 246 and a lower plate 248 provided with parallel
flange portions where indicated at 250, 252, 254 and 256 that
are fixed together as by welding in the relation indicated in
FIG. 11 to comprise the fabricated side members 244. The
flanges 250 define the upwardly facing surfaces 258 to which
the hangers 60 are attached, while the flanges 254, supported
by flanges 256, define a shelf structure 260 on which the ends of the channel members 242 rest in welded side by side relation. Adjacent members 242 are welded together at spaced points therealong in any suitable manner.

A tire pocket for the vehicle front wheels, indicated at 262, is defined by a channel shaped member 242A of the special configuration indicated in FIG. 10. The channel members 242 have their webs 243 slightly indented transversely thereof for reinforcement purposes and the ends 245 of their webs 247 are turned inwardly towards each other to define feet 264 that rest on the respective shelf structures 260 and provide further reinforcement for the respective channel shaped members 242.

At the ends of the platform structure 240, members 242B have their outer flanges 247 omitted and their webs are applied over the webs of end channel members 266 as at 268 along which point the members 242B and 266 are welded together.

The hangers 60 each comprise a tubular member 270 that extends from one side rail 244 to the other of the respective platforms 240, and defines a substantially C-shaped configuration. The members 27 are shaped to permit ready passage therethrough of the vehicles to be driven onto and off of platforms or pans 12, and at their bite portions 272 each has fixed thereto a sleeve 276 (see FIG. 3) that receives pin 58. Pin 58 is keyed to sleeve 276 in any suitable manner, as by employing a suitable shear pin arrangement.

Associated with each tubular member 270 of the respective hanger 60 is a tubular member 280 that is applied between the upper portion of the respective members 270 on either side thereof and the adjacent side rail structure 244 in the manner indicated in FIGS. 1, 3 and 9—11. Members 270 and 280 are applied to the respective side rails 244 by employing the suitable bracket structures where indicated at 282 and 284, respectively, and member 280 may be fixed to the respective members 270 in any suitable manner, as by welding at 286.

In use, the channel members 242, 242A, 242B and 266, all being physically united together and with the pan side frames 244, spread the loads they carry out along the side frames 244, which resist in tension the load supplied to same. In this manner, all of the structural members involved are relied upon to help support the load carried by the pan and transmitted to the hanger 60.

PAN END PLAY RESTRAINING DEVICES

The devices 170 illustrated each comprise an arcuate plate 290 fixed to the respective header members 188 and 192 in any suitable manner and reinforced by suitable web plates 292. The plates 292 are positioned so that their inwardly facing surfaces 294 will be disposed closely adjacent to the path of movement that the individual pan control arms 88 will make in moving to and from the pan loading and unloading position shown in FIG. 1; surfaces 294 may have applied thereto strips of wear resisting plastic (not shown) that the control arms contact when moved to the location of plates 290. The presence of the plate 290, which may extend substantially down to the pin 58 when the individual pans are in their positions of FIG. 1, provides substantial leverage on the suspended control arms 88 restraining endwise movement of the respective pans that tends to occur as a reaction to vehicles being driven onto and off of the respective pans.

Alternately, pan end play restraining devices may be operably associated with ramping 168 at the entrance and exit ends of driveway 160 and mounted for application against the respective ends of the pan 12 that is disposed in the load receiving position of FIG. 1. Preferably, in this form the end play restraining devices are operable automatically on operating the push button controls of the system to extend and retract such devices at the same time the entrance and exit gates are closed and opened.

THERM O THE CONVEYOR DRIVE

The drive 110 is more specifically illustrated in FIGS. 6—8A, and as has been already indicated, it comprises a plurality of elongate prop members 112 journalled in spaced apart upright relation as at 114 on a drive chain 116 trained over end sprockets 118 and 120.

Sprockets 118 and 120 are journalled in an appropriate housing structure generally indicated at 300, and in the specific form illustrated, the drive chain is of the dual chain type comprising a pair of chains 302 and 304 trained over pairs of spaced apart sprockets 118 and 120, respectively (see FIG. 7).

Sprockets 118 are driven to actuate the composite drive chain 116 by being coupled to drive shaft 124 through a drive chain 126 extending between a sprocket 306 keyed to shaft 124 and sprocket 310 that is keyed to shaft 310, with the drive from shaft 310 being communicated to sprockets 118 by pairs of drive chains 128 received over the individual sprockets 312 that are keyed to the shaft 310 and sprockets 314 that are keyed to the sprockets 118. In the form shown, the respective pairs of sprockets 118 and 314 shown in FIG. 7 are incorporated in unitary dual sprocket elements 316 as comcomitantly indicated at 318 and 320 and in any suitable manner and as indicated at 320 and 322, respectively. Shaft 124 is driven by motor 122 through a suitable coupling indicated at 324 that connects the shaft 124 to the drive shaft 326 of the motor 122.

As already indicated, motor 122 operates in either direction as commanded by its controls to drive or move chain 116 either clockwise or counterclockwise of FIG. 6 to effect movement of the respective vehicle support platform conveyors in either direction.

The prop members 112 are each formed with head portion 132 which is shaped to define on either side of the midportion thereof the notches 134 and 136 that are adapted to cooperate with and engage the joints 29 of conveyor links 24. In the diagrammatic showing of FIGS. 4 and 6, these joints are shown in block diagram form and are intended to include the sleeves 226 in which the pins 28 are received in the specific form of FIG. 5.

Operably associated with each prop member 112 are the upper and lower guide rollers 138 and 140 which cooperate with, on either side of the drive 110, surfaces 142 and 144, and 146 and 148, respectively, which are formed by suitable flange or edge forming surface structures 330 and 332.

As the prop members 112 move about the circuit defined by chain 116, the prop members move between the various positions indicated in FIGS. 4 and 6 and under a guidance arrangement provided by the surfaces 142, 144, 146 and 148 as well as control devices 334 and 336 that cooperate with the lower ends 340 of the respective prop members 112, which are forked or grooved as at 342 to define the indicated U-shaped cam surfaces 344.

As already indicated, the drive 110 is arranged so that on either side of the drive 110, at least one prop member 112 is engaged with a joint 29 of the respective conveyor runs 34 and 35 between the levels 150 and 152. The prop members 112 are guided so that as they move downwardly to the level 152, or upwardly to the level 150 (depending on the direction of movement of the drive 110 and the location of the prop member 112 being considered), they are guided to the position which will rest a joint 29 in the respective seats 134 and 136, the spacing of members 112 and conveyor joints 29 being arranged to insure the time sequence required at the traverse.

For instance, if the drive 110 is viewed as in FIG. 6 is being driven in a clockwise direction, the lower left hand prop member 112 will be moving upwardly and be tilted clockwise gradually so that by the time it reaches level 150, its notch 134 will seat firmly against the joint 29 adjacent it, in the manner indicated in FIG. 6. Similarly, the uppermost prop member 112 will be moving to the right and downwardly in the timed
relationship and positioning required so that as this prop member 112 reaches level 152, the joint of run 35 adjacent
same becomes seated in its notch 136.

Movement in the other direction involves a similar coor-
dinated movement of the prop members 112 with respect to
the conveyor runs 34 and 35 and the joints 29 then moving
past the drive 110.

The guidance device 334 at the lower end of the drive com-
prises a rectangular 341 mounted in housing 300 in the form
of a 343 fixed between spaced arms 345, with a sleeve 347
being journaled on the pin 343. Referring to FIG. 4A, as the
respective prop members 112 move to their lowermost posi-
tions, the cam surface 344 of their respective ends engages
the sleeve 347, and sleeve 347 slides therealong until the bite
portion 350 of surface 340 rests on sleeve 347, whereupon
the movement of the drive 116 swings the member 112 between
the positions illustrated. On further movement in the same
direction, the cam surface 344 remains in engagement with
the sleeve 347 until the rollers 138 engage guide surfaces 142
or 146, respectively (depending upon the direction of move-
ment involved).

As indicated in FIGS. 6 and 7, the prop members 112 each
comprise a plate element 351 perforated as at 353 for lightness
and journaled as indicated as at 114 on pins 352 which
are connected between the chains 302 and 304 making
up the dual chain 116. For each prop member 112, a guide
roller 140 is suitably journaled on the pin 352 on either side
of the prop member. Each prop member 112 also includes a pair
of the rollers 138 suitably journaled on same on either side
thereof, as indicated in FIG. 7, and the housing 300 is pro-
vided with cooperating sets of guide surfaces 142, 144, 146
and 148 for the respective sets of rollers 138 and 140 on either
side of the respective prop members. Sprockets 118 and 120
are suitably sprocketed as at 354 and 356 to accommodate the
pins 352 as well as pins 358 which pivot the chains links 359
and 361 together.

The guidance device 336 in the form shown is associated
with the journaling arrangement 360 for the sprockets 120
wherein the sprockets 120 are fixed to sleeves 362 that are
respectively journaled as at 364 for rotation about shaft ele-
ments 366 and 367, respectively. Shaft element 367 is in turn
journaled as at 368 within a sleeve 370 to rotate with respect
to the housing and has fixed to the inner end thereof a splayed
arm 372 defining a U-shaped cam surface 374 (see FIG. 8) in
which is a cam follower 376 that is fixed to a crank arm
378 journaled as at 380 for rotation with respect to the hous-
ing 300 in the plane of movement of the prop members 112.
Crank arm 378 carries a pin 382 on which is journaled a sleeve
384 that is adapted to engage the respective cam surfaces 344
of the respective prop member arms 112 at their respective
ends 340 in the manner indicated in FIGS. 6 and 8, to guide
the respective prop members 112 in being transferred
between conveyor runs 34 and 35 such that the prop mem-
bers 112 remain in the upright position indicated and are disposed
positionally and in the timed relation required to effect applica-
tion to or removal from the respective notches 134 and 136 of
the respective conveyor joints 29.

In the device 336 shown, cam member 372 rotates about
axis A and crank arm 378 rotates about axis B, which is spaced
from axis A by the distance indicated in FIG. 7. Cam follower
376 in being rotated about the axis B moves between the levels
C and D at its upper and lowermost positions respectively,
whereby a change of leverage relationship of the cam surface
374 acting on cam follower 376 is effected on rotation of the
cam member 372 with respect to the housing. This rotation is
effected by suitable sprocket chain 390 trained over sprocket
392 that is fixed with respect to shaft 367 and a sprocket 394
that is keyed to the shaft 310.

The cooperation of parts is such that the leverage acting on
crank arm 378 is at its shortest when the crank arm is in its
upright vertical position, and is at its longest when the said
crank arm is in its depending vertical position. Assuming that
the chain 116 is moving clockwise of FIG. 6 and the upper left
hand prop member 112 of the same FIG. has reached the point
where its notch 134 is at the level 152, pin 382 is moved
relatively quickly to engage the appropriate branch of cam
surface 344 (as indicated in FIG. 8) of the prop member 112
in question to hold same in its upright position as the joint 29
supported thereby moves upwardly therefrom, and as the prop
member involved moves to the position of the top prop
member 112 shown in FIG. 6, the movement of pin 384 slows
to its minimum, and then starts to increase in movement in
cooperating with the appropriate branch of cam surface 344
(as indicated in FIG. 8) to guide the positioning of the prop
member 112 in question so that its notch 136 will be disposed
to receive the conveyor link joint 29 that is approaching same
as both move down towards the level 152. This relation of
parts is shown diagrammatically in FIG. 8.

The guiding devices 334 and 336 thus insure that the prop
members moving between either side of the drive system are
appropriately disposed to leave and receive the respective
conveyor joints that are leaving or approaching same.

SUMMARY

It will thus be seen that my invention provides a number of
significant improvements in vehicle parking apparatus of the
tower type.

For instance, the conveyors 22 and the drives therefor are
arranged so that above the drives, the conveyor links 24 and
24A support the pans 12 in compression, so that above the
drives 110, the runs 34 and 35 of the respective conveyors act
as rectilinear columns to support the loads resting on them.
This greatly reduces wear at joints 29, especially since at the
upper end of the conveyors, the conveyor links are supporting
no weight as they transfer between the respective conveyor
guideways; at the lower end of the system, the links of the
respective conveyor runs below drives 110 support in tension
no more than one vehicle support platform.

The stabilizing devices 62 are associated with each
Vehicle support platform insure smooth transfer of the respec-
tive platforms or pans 12 between the respective sides (con-
veyor runs) of the system, and this together with the nesting
relation that the respective pans have with each other insures
that sway is prevented both laterally and longitudinally of the
respective pans.

The reduction in wear on the conveyor linkage joints not only
makes for low maintenance, but avoids the problem of having
to compensate for increased length of the conveyors due to
joint wear. This insures that the discharge and receiving level
of the system will remain the same after installation without
requiring that some means be built into the system to insure
this, to avoid having to periodically adjust surface 166.

Other factors contributing to low maintenance are that the
drive mechanism is easy to reach for inspection and servicing
purposes, and sprockets at the upper and lower ends of the
conveyors have been eliminated together with their attendant
maintenance problems. The result is a compact, highly
efficient vehicle parking tower unit that may be applied to a space
normally occupied in a parking lot by two cars to providing
parking accommodations for as many as 21 cars.

While the apparatus 10 can be arranged to have an odd or
even number of pans 12 the odd number arrangement is
preferred for the tower arrangement illustrated as when the
lowermost pan 12 is in its loading (or unloading) position, the
other pans will be evenly balanced on either side of the tower
(see FIG. 1).

The foregoing description and the drawings are given merely
to explain and illustrate my invention and the invention is
not to be limited thereto, except insofar as the appended
claims are so limited, since those skilled in the art who have
my disclosure before them will be able to make modifications
and variations therein without departing from the scope of the
invention.

I claim:

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1. In a vehicle parking arrangement including an endless conveyor defined by a plurality of elongate rigid links pivotingally connected together in end to end relation and trained to define spaced apart upright conveyor runs, a plurality of vehicle support members carried by said conveyor in consecutive relation therewith each supporting a vehicle load support platform, stabilizing means for maintaining said support platforms against sway, and means for selectively driving said conveyor in forward and reverse directions, the improvement wherein:

said support members each comprise a triangular truss structure comprising a base member formed by one of said links and a pair of arm members with said arm members having like ends thereof secured to the respective ends of the respective base members and their other ends joined together;

said stabilizing means comprising:

a triangular structure for each support member and oriented to have its sides substantially parallel to the respective support members base and arm members;
a linkage arm pivotally connected between like corners of said structures for the respective support members; and
means for guiding the movement of the respective stabilizing means triangular structures on movement of said conveyor to maintain said linkage arms of said stabilizing means in a predetermined position relative to the horizontal;

one of said link arms for the respective support members being made fast with respect to the vehicle support platform carried thereby.

2. In a vehicle parking arrangement including an endless conveyor defined by a plurality of elongate rigid links of equal lengths pivotally connected together in end to end relation and trained through spaced apart, vertically disposed guideways to define spaced apart vertically disposed conveyor runs, a plurality of vehicle support members carried by said conveyor in consecutive relation therewith each supporting a vehicle load support platform, stabilizing means for maintaining said support platforms against sway, and means for selectively driving said conveyor in forward and reverse directions, the improvement wherein:

said support members each comprise a triangular truss structure comprising a base member formed by one of said links and a pair of arm members, with said arm members having like ends thereof secured to the respective ends of the respective base members and their other ends joined together;

said links at their connected ends including roller means cooperating with the respective guideways;

said stabilizing means comprising:

a triangular structure for each support member and oriented to have its sides substantially parallel to the respective support members base and arm members;

with the side of said stabilizing means structure parallelizing the respective support member base members comprising a base portion;
a linkage arm pivotally connected between like corners of said structures for the respective support members; and

means for guiding the movement of the respective stabilizing means triangular structures on movement of said conveyor to maintain said linkage arms of said stabilizing means in a predetermined position relative to the horizontal;

said guiding means comprising roller means at either end of the respective stabilizing means structure base portions and a guideway surface for same parallelizing said guideways;

one of said linkage arms for the respective support members being made fast with respect to the vehicle support platform carried thereby.

3. The improvement set forth in claim 2 wherein:

said guideways terminate adjacent at the upper and lower ends of conveyor.

4. The improvement set forth in claim 2 wherein:

said predetermined position of said linkage arms of said stabilization means is a vertical position;
said triangular structures for each vehicle support platform rocking 180° in being transferred between the conveyor runs at the upper and lower ends thereof, on movement of said conveyor in either direction.

5. The improvement set forth in claim 4 wherein:

said guideways and said guiding surfaces are proportioned such that at least one corner of the respective triangular structure are in respective cooperation therewith as said triangular structures rock in being transferred between the conveyor runs.

6. In a vehicle parking arrangement including an endless conveyor defined by a plurality of elongate rigid links pivotally connected together in end to end relation and trained about spaced apart, vertically disposed guideways to define spaced apart, vertically disposed conveyor runs, a plurality of vehicle support members carried by said conveyor in consecutive relation therewith each supporting a vehicle load support platform, stabilizing means for maintaining said support platforms against sway, and means for selectively driving said conveyor in forward and reverse directions, the improvement wherein:

said guideways are rectilinear lengthwise thereof and are open at the ends thereof to accommodate transfer therebetwen of the links, said guideway intermediate said ends have vertically extending fore and aft edges at horizontally spaced locations in restraining relationship with said links, an end of one of said edges of said guideways terminating above an end of said edges of the other of said guideways, the ends of one of said edges being operative to guide said load support platforms during crossover movement between said conveyor runs, the ends of the other of said edges being operative to guide said stabilizing means during crossover movement between said conveyor runs;

said conveyor including abutment means at said links thereof and spaced equidistantly apart lengthwise of said conveyor for supporting said conveyor against gravity;

said means for selectively driving said conveyor comprising:

a plurality of prop members mounted to move in spaced apart relation about an endless circuit having vertically disposed runs that are respectively adjacent the respective conveyor runs;
said prop members each including a head portion formed to supportingly engage those of said abutment means of said conveyor that are disposed at the vertical level of said drive means circuit runs; and

means for moving and positioning said prop members in the timed relation such that consecutive of said prop members sequentially engage said disposed conveyor abutment means of the respective conveyor runs in the relation required to have at least one of said prop members on the respective drive means circuit runs supporting the respective conveyor runs through one of said disposed abutment means;

whereby supporting sprockets or pulley at the upper may be eliminated and said conveyor and the loads carried thereby may be supported by said drive means.

7. The improvement set forth in claim 6 wherein:
said prop members each include a head portion formed with seat means to engage said disposed abutment means of one of the conveyor runs when the respective prop members are in the run of said circuit that is adjacent same; said prop member head portions each being formed thereof with separate seat means to engage said disposed abutment means of the other conveyor run when the respective prop members are in the run of said circuit that is adjacent said other conveyor run; and wherein said prop member moving means includes means for positioning the respective prop member heads for said sequential engagement of said conveyor abutment means by the respective seats thereof.

8. The improvement set forth in claim 7 wherein:
said prop members each comprise an elongate element; said drive means further comprising drive chain means trained over sprocket means; said prop members being journaled on said drive chain means in spaced apart consecutive relation and intermediate their respective ends; said prop member positioning means including guide means cooperating with the respective prop members as they pass along said circuit runs to position the heads thereof for said sequential engagement.

9. The improvement set forth in claim 8 wherein: said drive means includes means for maintaining said prop members in upright position as they pass between the runs of said circuit.

10. In a vehicle parking arrangement including a pair of endless conveyors defined by a plurality of elongate rigid links pivotally connected together in end to end relation and trained in parallel planes to each define spaced apart upright conveyor runs, a plurality of vehicle support members carried by said conveyors in consecutive relation therewithout the support members of the respective conveyors being aligned horizontally and in horizontally aligned pairs of support members each supporting between them a vehicle load support platform, stabilizing means for maintaining said support platforms against sway, and means for selectively driving said conveyors in forward and reverse directions, the improvement wherein:
said support members of each conveyor each comprise a triangular truss structure comprising a base member formed by one of said links and a pair of arm members, with said arm members having like ends thereof secured to the respective ends of the respective base members and their other ends joined together; said stabilizing means comprising:
a triangular structure for each support member and oriented to have its sides substantially parallel to the respective support members base and arm members; a linkage arm pivotally connected between like corners of said structures for the respective support members; and means for guiding the movement of the respective stabilizing means triangular structures on movement of said conveyors to maintain said linkage arms of said stabilizing means in a predetermined position relative to the horizontal; one of said link arms for the respective support members of each conveyor being made fast with respect to the vehicle support platform carried thereby; said vehicle support platforms each comprising:
a platform structure including a plurality of transversely extending channel shaped members placed in side by side relation and extending between a pair of spaced apart members extending longitudinally of the respective platforms and each including continuous shelf means to which said channel shaped members are fixed at the ends thereof; a hanger structure at each end of the respective platforms including a pivot structure pivotally secured to the respective support members of the respective conveyors and a pair of arms fixed to the respective platform structure longitudinally extending members adjacent the ends thereof; said hanger structures of the respective platform structures diverging outwardly upwardly of the respective platforms; and a compression member extending between the respective arms of the respective platform hanger structures and the longitudinally extending members in bracing relation therewith; said pivot structures of the respective platforms being aligned to define a horizontally disposed pivotal axis for pivotal movement of said platforms relative to their respective support members as said platforms move between the respective runs of the respective conveyors.

11. The improvement set forth in claim 10 including:
means at the lower ends of said conveyors for holding said vehicle platforms against movement laterally of said planes when same are positioned at the lowestmost point of said conveyors; said vehicle support member position comprising the vehicle load and unloading position of said platforms; said holding means acting to restrain either end of the respective platforms against said movement when the respective platforms against said movement when the respective platforms are at said position to restrain same against said movement as a vehicle moves onto or off same.

12. In a vehicle parking arrangement including a pair of endless conveyors defined by a plurality of elongate rigid links pivotally connected together in end to end relation and trained in parallel planes to each define spaced apart upright conveyor runs, a plurality of vehicle support members carried by said conveyors in consecutive relation therewithout the support member of the respective conveyors being aligned horizontally and in horizontally aligned pairs of support members each supporting between them a vehicle load support platform, stabilizing means for maintaining said support platforms against sway, and means for selectively driving said conveyors in forward and reverse directions, the improvement wherein:
said support members of each conveyor each comprise a triangular truss structure comprising a base member formed by one of said links and a pair of arm members, with said arm members having like ends thereof secured to the respective ends of the respective base members and their other ends joined together; said stabilizing means comprising:
a triangular structure for each support member and oriented to have its sides substantially parallel to the respective support members base and arm members; a linkage arm pivotally connected between like corners of said structures for the respective support members; and means for guiding the movement of the respective stabilizing means triangular structures on movement of said conveyors to maintain said linkage arms of said stabilizing means in a predetermined position relative to the horizontal; one of said link arms for the respective support members of each conveyor being made fast with respect to the vehicle support platform carried thereby; said vehicle support platforms each comprising:
a platform structure including a plurality of transversely extending channel shaped members placed in side by side relation and extending between a pair of spaced apart members extending longitudinally of the respective platforms and each including continuous shelf means to which said channel shaped members are fixed at the ends thereof; a hanger structure at each end of the respective platforms including a pivot structure pivotally secured to the respective support members of the respective conveyors and a pair of arms fixed to the respective platform structure longitudinally extending members adjacent the ends thereof; said hanger structures of the respective platform structures diverging outwardly upwardly of the respective platforms; and a compression member extending between the respective arms of the respective platform hanger structures and the longitudinally extending members in bracing relation therewith; said pivot structures of the respective platforms being aligned to define a horizontally disposed pivotal axis for pivotal movement of said platforms relative to their respective support members as said platforms move between the respective runs of the respective conveyors.
said hanger structures of the respective platform structures diverging outwardly upwardly of the respective platforms;
and a compression member extending between the respective arms of the respective platform hanger structures and the longitudinally extending members in bracing relation therewith;
said pivot structures of the respective platforms being aligned to define a horizontally disposed pivotal axis for pivotal movement of said platforms relative to their respective support members as said platforms move between the respective runs of the respective conveyors.

16. The apparatus as set forth in claim 10 wherein said vehicle support platforms each comprise:
a platform structure including a plurality of transversely extending channel shaped members placed in side by side relation and extending between a pair of spaced apart members extending longitudinally of the respective platforms and each including continuous shelf means to which said channel shaped members are fixed at the ends thereof;
a hanger structure at each end of the respective platforms including a pivot structure pivotally secured to the respective support members of the respective conveyors and a pair of arms fixed to the respective platform structure longitudinally extending members adjacent the ends thereof;
said hanger structures of the respective platform structures diverging outwardly upwardly of the respective platforms; and a compression member extending between the respective arms of the respective platform hanger structures and the longitudinally extending members in bracing relation therewith;
said pivot structures of the respective platforms being aligned to define a horizontally disposed pivotal axis for pivotal movement of said platforms relative to their respective support members as said platforms move between the respective runs of the respective conveyors.

17. The apparatus as set forth in claim 12 wherein said vehicle support platforms each comprise:
a platform structure including a plurality of transversely extending channel shaped members placed in side by side relation and extending between a pair of spaced apart members extending longitudinally of the respective platforms and each including continuous shelf means to which said channel shaped members are fixed at the ends thereof;
a hanger structure at each end of the respective platforms including a pivot structure pivotally secured to the respective support members of the respective conveyors and a pair of arms fixed to the respective platform structure longitudinally extending members adjacent the ends thereof;
said hanger structures of the respective platform structures diverging outwardly upwardly of the respective platforms.